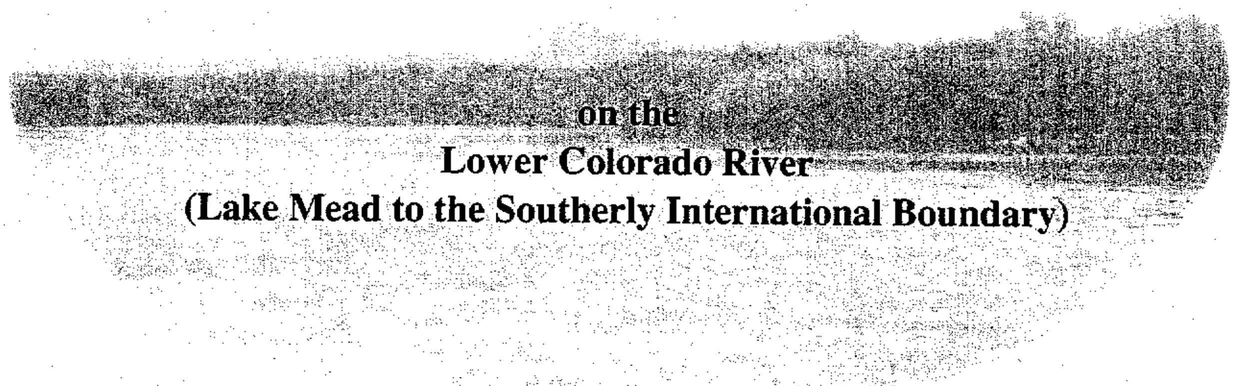
State Water Resources Control Board
Hearing Name IID Transfer - Phase 2
Exhibit: 59
For Ident: _____ In Evidence: _____

Biological Assessment

for

Proposed
Interim Surplus Criteria,
Secretarial Implementation Agreements for California Water Plan Components and Conservation Measures



on the
Lower Colorado River
(Lake Mead to the Southerly International Boundary)

US Bureau of Reclamation
Lower Colorado Region

08/30/00
Final

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I. INTRODUCTION

The Secretary of the Interior (Secretary) serves as Water Master for managing the beneficial use of Colorado River water under a legal framework known collectively as the *Law of the River*. The Secretary is considering the adoption and implementation of proposed water management actions related to the delivery of water in Arizona, California and Nevada. These proposed actions are (1) adoption of Colorado River Interim Surplus Criteria (ISC) (USBR, 2000) and (2) execution of Secretarial Implementation Agreements (SIAs) for those components of California's Colorado River Water Use Plan (CA Plan)(May, 2000) that would require Secretarial approval. Additionally, biological conservation measures are proposed as part of these actions.

The ISC would provide for additional predictability with respect to the prospective existence of surplus conditions and the potential quantity of water available for release from Hoover Dam on an annual basis through 2015. The ISC would also assist planning and operations of the entities that receive surplus Colorado River water pursuant to contracts with the Secretary. The SIAs would provide for a new upstream delivery point for up to 400,000 acre feet (400 kaf) of water annually over the next 75 years. The point of delivery would be moved up stream to Lake Havasu from Imperial Dam. Water transferred under these SIAs will meet needs in the San Diego and Los Angeles basin areas and provide 16,000 acre feet of water for the San Luis Rey Indian Settlement. The associated biological conservation measures, which are described herein, are permanent for the length of the covered projects.

Through the *Law of the River*, the Lower Division States of Arizona, California and Nevada are apportioned a total of 7.5 million acre feet (maf) per year of Colorado River water; with California allotted 4.4 maf, Arizona 2.8 maf, and Nevada 300 thousand acre feet (kaf). The proposed ISC would be used annually by the Secretary to determine the availability of Colorado River water in excess of 7.5 maf and available for use by the three States. Entitlements to the variable amounts of surplus water that may be available in any given year have also been divided among the Lower Division States, with 50 percent allocated for use in California, 46 percent for use in Arizona, and 4 percent for use in Nevada. Unused apportionments can be made available to another State by the Secretary on an annual basis. The States divert their allotment of Colorado River water directly from Lake Mead or, following release through Hoover Dam, from existing facilities on the lower Colorado River (Figure 1). Until recently, Arizona and Nevada have not used their entire basic apportionment, and California's annual use of Colorado River water has averaged 5.2 maf, which is above its apportionment.

The water resources of the lower Colorado River are vital to these three Lower Division States. Over twenty million people in the three States benefit from use of this water. Arizona and Nevada have recently developed the need and means to use their full apportionment. Seven counties in southern California, with a current population of about 17 million (more than half the state's population), depend on Colorado River water for municipal, industrial, and agricultural purposes. Use of this water represents about 64 percent of the total water used in southern California.

Within California, an agreement has governed the use of Colorado River water among seven parties having rights to it. Recently, these parties negotiated a *Quantification Settlement Agreement* (QSA) that is consistent with the CA Plan and when fully implemented, would allow California to live within its basic 4.4 maf apportionment. Some of the CA Plan components involve the transfer of water among the California parties, which requires a change in the point at which the Secretary would deliver Colorado River water to the California entities. Under the SIAs, water previously diverted at Imperial Dam would be diverted at Lake Havasu (Figure 1).

This Biological Assessment (BA) has been prepared for compliance with Section 7 of the Endangered Species Act (ESA). It contains a description of the action under consultation, environmental baseline with species ecology and biology, and an analysis of potential effects of the ISC, SIAs, water administration and conservation measures on threatened or endangered species and designated critical habitat along the lower Colorado River, Lake Mead to the Southerly International Boundary (SIB). Additional detail is provided in the following overview.

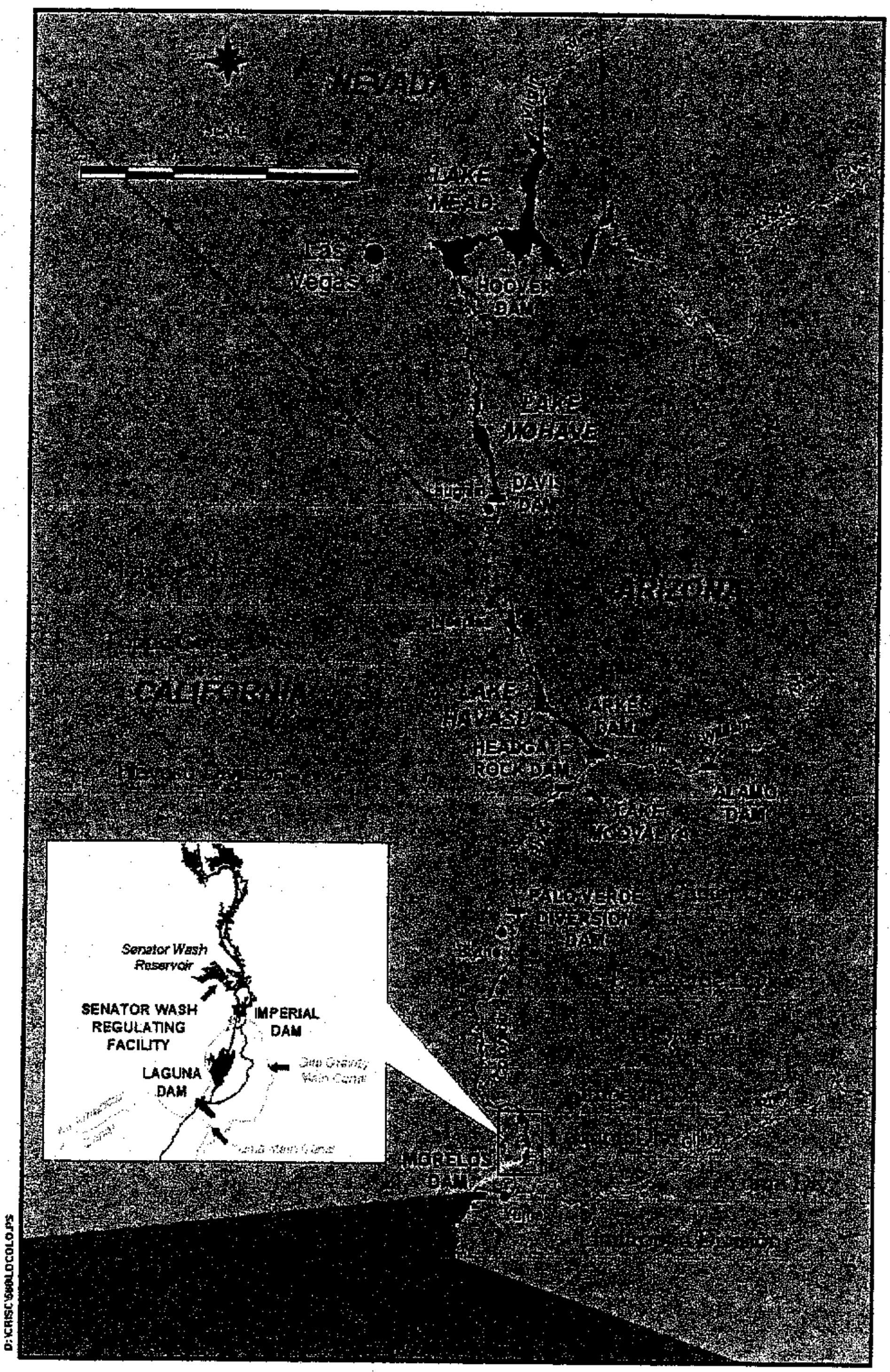

Figure 1. Overview Map of the Colorado River Dams and Divisions.

II. BIOLOGICAL ASSESSMENT OVERVIEW

This BA provides an analysis of impacts to special status and federally-listed threatened and endangered species and critical habitat from Reclamation's discretionary actions implementing the ISC for the lower Colorado River and SIAs with Southern California entities. The physical impacts which are under analysis include:

1. Change in point of diversion (CPD) of up to 400 kaf of water annually from Imperial Dam to Parker Dam.

2. Change in median levels of Lakes Mead and Powell of up to 24 and 21 feet respectively which may result from releasing water at various elevations determined by the ISC.

3. Reduction in probability of flood flow releases from Lake Mead as a result of implementing the ISC.

Specific ISC are being proposed pursuant to Article III(3)(b) of the *Criteria for Coordinated Long-Range Operation of the Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968* (Long-Range Operating Criteria [LROC]). The ISC would be used annually to determine whether the conditions exist under which the Secretary may declare the availability of surplus water, as defined, for use within the states of Arizona, California and Nevada. The criteria must be consistent with both the Decree entered by the U.S. Supreme Court in 1964 in the case of *Arizona v. California* (Decree) and the LROC. The ISC would remain in effect for a period of 15 years, subject to five-year reviews, concurrent with the LROC reviews, and applied each year as part of the Annual Operating Plan. Presently 4 alternatives have been proposed for these criteria. The analysis contained in this BA focuses on the California Alternative (not to be confused with the CA Plan) because it is the most liberal of the probable criteria to be adopted. Specifics and a description of the criteria is found in "Colorado River Interim Surplus Criteria Draft Environmental Impact Statement" (ISC DEIS) (USBR, 2000).

The SIAs are for various Components of the CA Plan and associated QSA which require the Secretary of the Interior's approval. These SIA's are intended to be in force for a period of 75 years. The purpose of the CA Plan is to provide Colorado River water users with a framework by which programs, projects and other activities will be coordinated and cooperatively implemented, allowing California to most effectively satisfy its annual water supply needs within its annual apportionment of Colorado River water. The framework specifies how California will transition and live within its annual basic apportionment of 4.4 million acre feet of Colorado River water.

The geographical area included in this BA includes Lake Powell to the SIB (Figure 1). On the lower Colorado River, the area includes the River's 100-year flood plain and Lakes Mead, Mohave, and Havasu to full pool elevations.

Any off-river effects in the United States attributable to the actions will obtain ESA compliance through either the consultation or permit provisions of section 7 of ESA for Federal actions and/or section 10 permitting provision of ESA for non-Federal actions. Such compliance would be effected prior to implementation of specific projects. This concept of providing ESA compliance for off-river effects, prior to site specific implementation, has been discussed with two Fish and Wildlife Service regions.

III. FEDERAL ENVIRONMENTAL COMPLIANCE FOR PROPOSED ACTIONS

While the proposed ISC and SIAs are distinct water actions they are also important components of the CA Plan and QSA that address southern California's short- and long-term water use of Colorado River water. The proposed ISC also affect surplus water deliveries to Arizona and Nevada. These and related conservation actions require compliance with the ESA and the National Environmental Policy Act (NEPA). The Bureau of Reclamation (USBR) is the lead Federal agency for compliance with these environmental laws.

The regulatory provision of ESA provides for the recognition of non-Federal applicants, who are parties that initiate the proposed action that requires formal approval by the Federal action agency (USBR). For purposes of the SIAs portion of this section 7 consultation, Coachella Valley Water District (CVWD), Imperial Irrigation District (IID), Metropolitan Water District of Southern California (MWD), San Diego County Water Authority (SDCWA), and the San Luis Rey Tribes (SLR) are considered applicants.

The NEPA process for the Secretary's adoption of ISC involves the preparation of an Environmental Impact Statement (EIS). The ISC DEIS was released for public review on July 7, 2000. Appropriate portions of analyses from that document are referenced in this BA.

SIAs are proposed as a means to approve components of the CA Plan and QSA that involve a new point of delivery of Colorado River water by Reclamation. The water involved is California's allotment and the SIAs would approve a new point of delivery for diversion by California. The specific components of the CA Plan requiring secretarial approval are summarized in Table 1. This table also provides a column that indicates the level of NEPA/CEQA documentation, if any, that is necessary for each identified action. An Environmental Assessment (EA) and EIS/EIR(s) are being prepared for the SIAs concurrent with preparation of this BA.

Entities responsible for implementing components of the CA Plan and QSA are also responsible for complying with State environmental laws -- the California Environmental Quality Act (CEQA) and California Endangered Species Act (CESA). Therefore, environmental compliance for components of the CA Plan and QSA that also require Federal action can involve preparation of a combined CEQA and NEPA document, which may be an Environmental Impact Report and EIS (EIR/EIS), or an EIR and EA (EIR/EA). For components where it is not possible to analyze site-specific impacts of proposed actions, the type of impacts that may occur are more generally discussed. In these instances, programmatic documents are prepared, such as a Programmatic Environmental Assessment and/or EIR (PEA and/or PEIR). Programmatic documents will be followed by additional analyses when more specific plans are proposed. It is the purpose of this BA to effect Federal ESA compliance for proposed ISC and SIAs, including related water administration and conservation actions.

It is not the purpose of this BA to provide for any non-Federal compliance with ESA, or California State requirements of the CEQA or CESA. However, the information herein can be used, as appropriate, to help effect compliance with the California environmental acts.

Figure 2 illustrates some of the principal components and sub-components of the California Plan and how those with a Federal nexus, i.e., requiring SIAs, will undergo NEPA and ESA compliance. A complete listing of the CA Plan components is provided in Appendix C.

This BA will serve as a combined assessment of the effects of ISC and SIAs actions, and related conservation measures on listed species and critical habitat.

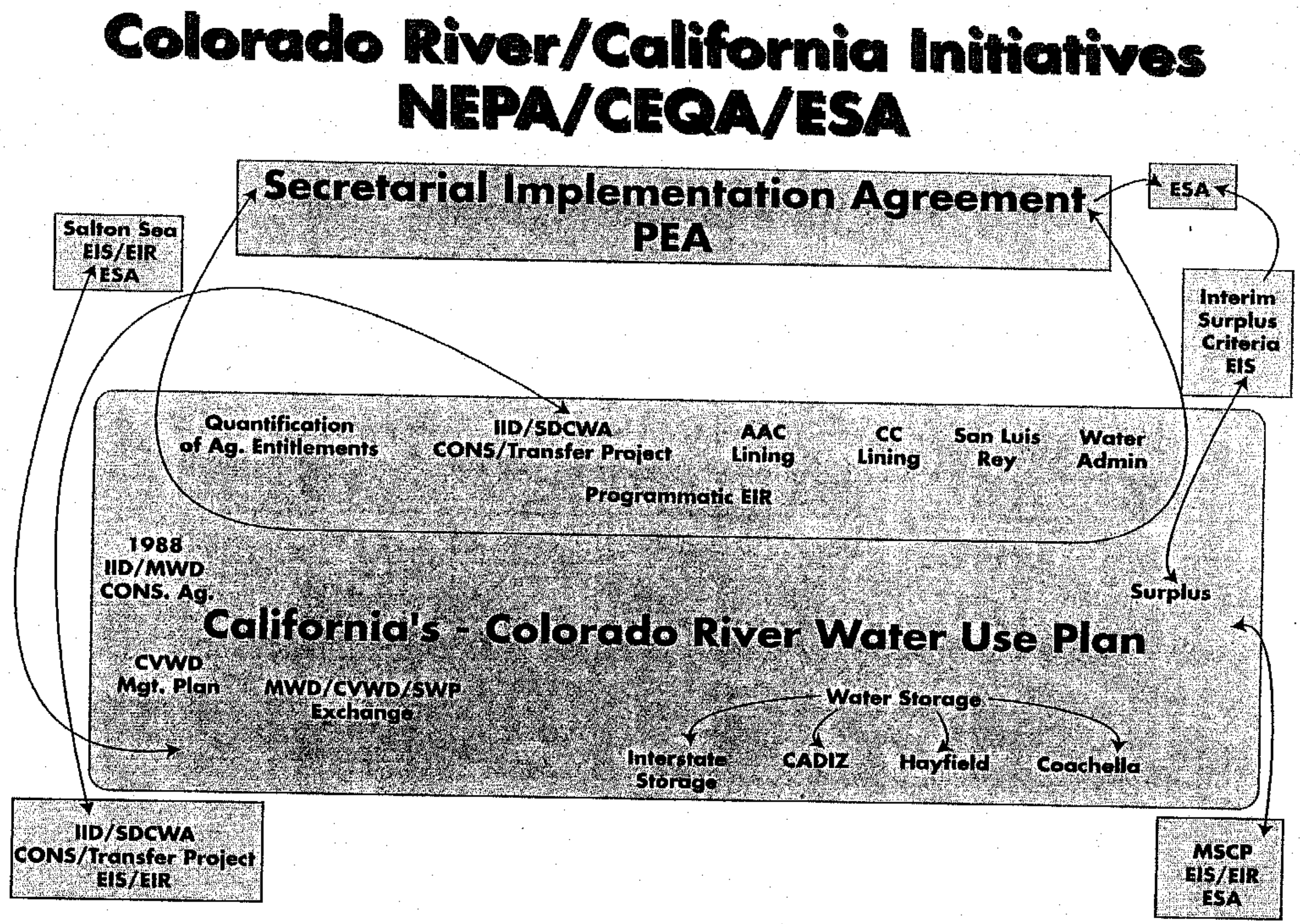

Figure 2. Relationships of Various components of California's Colorado River Water Use Plan covered by this Biological Assessment and Reclamation NEPA documents.

Table 1 - Components of California's Colorado River Water Use Plan That Are Subject to SIAs and Are Undergoing NEPA Compliance Actions.

Type of Component	Specific Components Requiring Secretarial Approval	Type of CEQA/NEPA Documentation
Water Transfers	• IID/SDCWA Water Conservation and Transfer Program • IID/CVWD/MWD Water Conservation and Transfer Program • MWD/CVWD Exchange	• EIR/EIS
Other Integrated Sources of User Supply	• All-American Canal Lining Project • Coachella Canal Lining Project	• Final EIS/EIR • EIS/EIR
Water Supply to Others (Non-Colorado River Water Rights Users)	• San Luis Rey Indian Water Right Settlement Parties	• Separate EA
Improved River and Reservoir Management and Operations	• Colorado River Interim Surplus Criteria	• EIS

IID - Imperial Irrigation District; SDCWA - San Diego County Water Authority; CVWD - Coachella Valley Water District; MWD - Metropolitan Water District

IV. DESCRIPTION OF ACTIONS

A. Interim Surplus Criteria.

The ISC are proposed to define the terms upon which the Secretary may declare the existence of surplus conditions in managing the lower Colorado River for the 15 years after the adoption of an ISC. The criteria must be in accordance with the decree entered March 9, 1964, by the United States Supreme Court in *Arizona v. California*, known as the Decree. The ISC must also be consistent with *Long Range Operating Criteria* which have been developed pursuant to the Colorado River Basin Project Act of 1968 and the Decree. The purpose of adopting the ISC is to afford mainstem users of Colorado River water a greater degree of predictability with respect to the likely existence of surplus conditions on the river in a given year. This increased level of predictability will aid in the planning and operations of those entities that receive Colorado River water pursuant to contracts held with the Secretary.

Pursuant to Article II(B)2 of the Decree, if there exists sufficient water available in a single year for pumping or release from Lake Mead to satisfy annual consumptive use in the States of California, Nevada, and Arizona in excess of 7.5 maf, such water may be determined by the Secretary to be made available as surplus water. The Secretary is authorized, and therefore has discretion, to determine the conditions upon which such water will be made available to the States.

In developing its ISC DEIS, Reclamation considered four alternatives in addition to the No Action (Baseline) Alternative (USBR, 2000). The action alternatives are the Flood Control Alternative, Six-States Alternative, California Alternative, and Shortage Protection Alternative. The amounts of surplus water that would be made available under each alternative in any given year varies. All alternatives were developed in terms of parameters that could be used in a mathematical model used to plan operation of the river system. A baseline condition was established against which the impacts of each of the action alternatives are compared, in order to accommodate the dynamic nature of the No Action Alternative. Each alternative designates specific water elevations or methodologies that have been shown as the water elevation on Lake Mead at which a surplus determination is triggered. The elevations and methodologies to determine a surplus differ among the alternatives. The California and Six-States Alternatives establish various levels (also referred to as tiers) of availability and specify the uses to which surplus water could be delivered as the water surface elevation at Lake Mead decreases to the specified trigger elevation. Table 2 summarizes the elevations that would trigger a determination of surplus for each of the alternatives. For complete descriptions of the alternatives see Appendix B.

Table 2 - Interim Surplus Criteria Alternatives and Lake Mead Trigger Elevations.

DEIS Alternatives	Surplus Trigger Elevation on Lake Mead
No Action - 75R Baseline Condition	75R = 75% Spill Avoidance Strategy under which the trigger rises from 1,194 to 1,196 ft from year 2001 through 2015
Flood Control Alternative	Required flood control releases = surplus conditions
Six States Alternative	3 Tiers (Levels) that trigger surpluses at the following elevations: above the 75R line, 1,145 ft, and 1,125 ft
California Alternative	3 Tiers (Levels) that trigger surpluses at the following elevations: 1,160, 1,116, and 1,098 ft
Shortage Protection Alternative	Trigger elevation determined for each year on maintaining Lake Mead storage to provide Lower Basin normal supply plus the storage necessary to provide an 80% probability of avoiding future shortages.

Reclamation does not identify a preferred alternative in the ISC DEIS. To facilitate consultation with the Fish and Wildlife Service (FWS), the California Alternative described in the ISC DEIS is evaluated as the Proposed Action in this BA. This alternative was selected because it represents the plan that the California Parties have proposed as part of their CA Plan. It also includes a range of water releases between the most conservative (Flood Control) and most liberal (Shortage Protection Alternative). As the EIS alternatives are refined, a preferred alternative is identified, the final EIS is prepared, and a Record of Decision is made, some changes may be made to the proposed action.

Figure 3 is a graph from the ISC DEIS that shows the levels in Lake Mead proposed by the tier elevations of the California Alternative in relation to those defined for the No Action (75R trigger line), and Flood Control Alternatives.

1. No Action (Baseline)

The No Action Alternative represents future annual operating plan determination that would be developed without ISC. Surplus determinations consider such factors as end-of-year system storage, potential runoff conditions, projected water demands of the Basin States and the Secretary's discretion in addressing year-to-year issues. However, the year-to-year variation in the conditions considered by the Secretary in making surplus water determinations makes projections of surplus water availability highly uncertain. As mentioned above, analysis of the hydrologic aspects of the ISC alternatives required use of a computer model that simulates specific operating parameters and constraints. To accommodate use of the No Action alternative in establishing a baseline against which to compare impacts of proposed alternatives, Reclamation selected a specific operating strategy which could be described mathematically in a model. The baseline conditions were developed using a 75R spill avoidance operating strategy. The effect of simulating operation with the 75R operating strategy would be that surplus conditions would be determined when Lake Mead is nearly full. The R strategy was first developed in 1986 for use in distributing surplus water and avoiding spills (USBR, 2000). The strategy assumes a particular percentile historical runoff, along with normal depletion projections, for the next year. The 75R strategy used for the No Action alternative of the ISC DEIS assumes an annual runoff of 18.1 maf. Applying these values to the current reservoir storage, the projected reservoir storage at the end of the next year is calculated. If the calculated space available at the end of the next year is less than the space required by flood control criteria for Lake Mead, then a surplus condition is declared.

2. California Alternative

The California Alternative specifies Lake Mead water surface elevations to be used for an interim period through 2015 for determining the availability of surplus water. The elevation ranges are coupled with uses of surplus water in such a way that, if Lake Mead's surface elevation declines, the permitted uses of surplus water would become more restrictive, thereby reducing deliveries of surplus water. This combination of tiered surplus trigger elevations would limit the use of surplus water to junior priority municipal and industrial (M&I) needs at lower water levels. The trigger elevations for each tier are not static, but are expressed by lines as discussed below (Figure 3). The California Alternative also provides for periodic adjustment of the triggering line elevations in response to changes in Upper Basin water demand projections through calendar year 2015, as described below.

The Lake Mead elevations at which surplus conditions would be determined under the California Alternative are indicated by a series of tiered, sloping lines from the present to 2015. Each tiered line would be coupled with stipulations regarding the purposes for which surplus water may be used at that tier. Each tier is defined as a trigger line that rises gradually year by year through 2015, in recognition of the gradually increasing water demand of the Upper Division States. Each tier under the California Alternative would be subject to adjustment during the interim period based on changes in Upper Basin demand projections or other factors during the five-year reviews or as a result of actual operating experience.

The following sections describe the California Alternative tiers. Notwithstanding the restrictions mentioned in the description of these tiers, when flood control releases are made, any and all beneficial uses would be met, including unlimited off-stream groundwater banking and additional water for Mexico as specified in the Treaty. Further details and use schedules on this alternative can be found in the ISC DEIS.

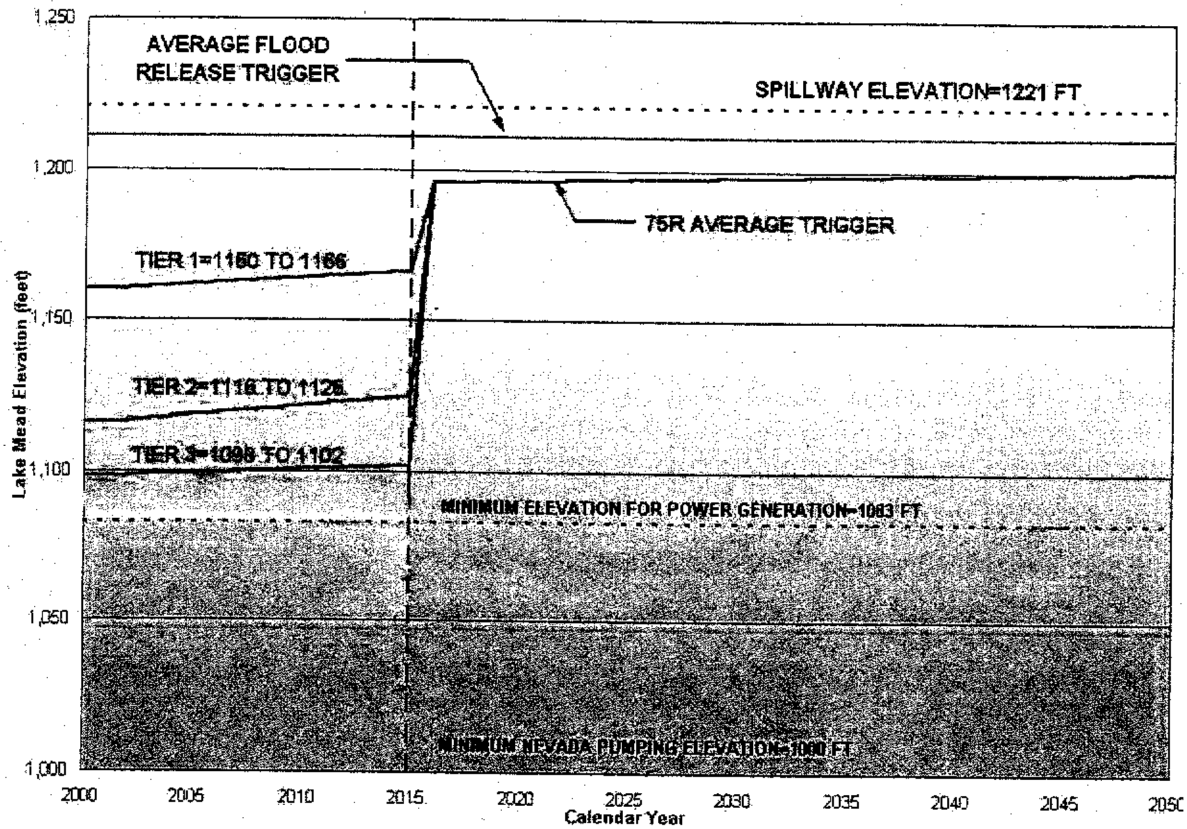

Figure 3. California surplus alternative showing tier elevations for Lake Mead.

- **California Alternative Tier 1** - Lake Mead surplus trigger elevations range from a current elevation of 1,160 feet mean sea level (msl) to 1,166 feet msl in 2015 (based on 1998 Upper Basin demand projections). Lake Mead water surface elevations at or above the Tier 1 trigger line would permit surplus water diversions by the Lower Division States.

- **California Alternative Tier 2** - Lake Mead surplus trigger elevations range from 1,116 feet msl to 1,125 feet msl (based on 1998 Upper Basin demand projections). Lake Mead water surface elevations at or above the Tier 2 line (and below the Tier 1 line) would permit surplus water diversions as outlined in applicable use schedules.

- **California Alternative Tier 3** - Lake Mead surplus trigger elevations range from 1,098 feet msl to 1,102 feet msl (based on Upper Basin demand projections). Lake Mead water surface elevations at or above the Tier 3 line (and below the Tier 2 line) would permit surplus water diversions. When Lake Mead water levels are below the Tier 3 trigger elevation, surplus water would not be made available.

B. Secretarial Implementation Agreements (SIAs).

The SIAs are intended to establish a framework for the Secretary to release Colorado River water in a way that will help California to satisfy its annual water supply needs within its basic annual apportionment (4.4 maf) of Colorado River water. Water deliveries will be made in accordance with the California Plan and its accompanying QSA. Actions covered by the SIAs will be implemented over the next 75 years, with some actions starting as soon as 2002.

When fully implemented, these modifications in Colorado River water delivery will result in a change in point of diversion of up to 400 kaf. Releases would be diverted above Parker Dam from Lake Havasu and would no longer be delivered to and diverted at Imperial Dam. Implementation of actions under the SIAs would result in Reclamation changing the point of delivery of the up to 400 kaf of California's water from Imperial Dam to Lake Havasu, thereby reducing flows between Parker and Imperial Dams by that amount.

A summary of the components of the CA Plan that will require an accounting of effects under the ESA and NEPA are listed in Table 3. The SIA will address these actions by providing a framework for the Secretary to release and deliver Colorado River water in a way that will allow California to satisfy its annual water supply needs within its basic annual apportionment of 4.4 maf of Colorado River water.

Up to 400 kaf of water is subject to a change in point of delivery and diversion and is summarized as follows:

• Priority 3: IID/SDCWA Water Conservation and Transfer	200,000 af
• IID/CVWD/MWD Conservation Program	100,000 af
• All American Canal Lining: For MWD	56,200 af
• Coachella Lining Project: For MWD	21,500 af
• San Luis Rey Water Settlement: water from canal linings	16,000 af
Total:	393,700 af

For purposes of this BA, the total amount of water used in the effect analyses has been rounded up to 400 kaf. However, the total amount of water that could be transferred over the 75 years of the intended actions could be less, depending on the execution and timing of numerous supporting events within California. For example if CVWD retains the 100 kaf of the conservation program water, then none of it would be subject to delivery to MWD at Parker Dam and Lake Havasu.

In terms of the CA Plan, several actions will affect the amount of Colorado River water that will be available to various California entities. The activities, programs, and projects (Tables 3 and 4) that will help to implement the CA Plan are described in Appendix C. Together, Figure 2, Table 3, Table 4 and Appendix C should provide both an overview of the CA Plan and its components with a Federal nexus (SIAs). The Federal actions are a subset of the many actions identified by the CA Plan and QSA to reduce California's use of Colorado River water downward towards its 4.4 maf allocation. The focus of this BA as it relates to the SIAs is a change in the point of delivery of up to 400 kaf of California's Colorado River water from Imperial Dam upstream to Parker Dam. The overall purpose of these actions is to move water presently used in the agricultural areas of the Imperial and Coachella Valley areas into urban areas of the coastal plain of Southern California. In addition the SIA's would provide the basis for moving a portion of the water conserved through lining of the AAC and CC through the CRA as part of the San Luis Rey Indian Settlement.

Table 3 - Secretarial Implementation Agreements Water Transfers

Activity	Quantities of Water Involved
Priority 3 Entitlements: • IID/SDCWA Transfer Project	• 130,000 to 200,000 af to SDCWA; starting 2002 with up to 20,000 af ea subsequent yr for 10 yrs
IID/CVWD/MWD Conservation Program	• Up to 100,000 af to CVWD/MWD

Table 4 - Secretarial Implementation Agreements / Canal Lining Projects

All-American Canal (AAC) Lining	• 56,200 af to MWD
Coachella Canal (CC) Lining	• 21,500 af to MWD
Conserved Water to San Luis Rey Indian Settlement: • AAC Lining • CC Lining	 • 11,500 af to San Luis Rey • 4,500 af to San Luis Rey

C. Conservation Measures

Table 5 identifies conservation measures included as part of the proposed action to offset projected impacts to the species and habitat. These measures were developed following the impact analysis.[1]

Table 5. Conservation Measures

Title	Species benefitted	Description
Occupied Southwestern Willow Flycatcher Habitat Monitoring, Restoration and Enhancement	Southwestern Willow Flycatcher	Restore, protect and/or enhance approximately 124 acres of riparian habitat primarily for Southwestern Willow Flycatcher (within 5 years). Monitor 372 acres of existing occupied habitat and restore, protect and/or enhance areas of equal value to those determined to be adversely affected. [2]
Backwater Construction/Restoration	Yuma Clapper Rail, California Black Rail, Razorback Sucker, Bonytail Chub	Construct or restore 62 acres of backwaters.
Razorback Sucker re-introduction	Razorback Sucker	Re-introduce and monitor 20,000 sub-adult Razorback Sucker below Parker Dam
Lake Mead Razorback Sucker Study	Razorback Sucker	Continue on-going study on Lake Mead for an additional 4 years to determine reasons for persistence of a Razorback Sucker population.
Bonytail Chub Broodstock Capture	Bonytail Chub	Conduct life history studies on extant bonytail populations in the lower Colorado River.

[1] Specifics of implementing these conservation measures will be developed among the affected entities including project beneficiaries and State and Federal agencies.

[2] This can be accomplished either by direct restoration, or enhancing existing habitat with various management practices such as flooding, creating patches of mixed native/non native vegetation within the areas, fire control, and so forth.

V. ENVIRONMENTAL BASELINE

The environmental baseline for this assessment includes effects of past and ongoing human and natural factors leading to the current status of the species or its habitat and ecosystem (FWS, 1994b). Additional baseline information on species abundance and distribution is provided in Section V.

A. Historic and Present Biological Communities on the Lower Colorado River

1. Historic

Prior to development, the Colorado River flowed unimpeded some 1,700 miles, with a vertical elevation drop of more than 14,000 feet, from its beginnings in the Rocky Mountains to its terminus at the Gulf of California (Ohmart et al., 1988). The Colorado River, in its natural state, was a highly dynamic system. Historically, the seasonal hydrograph and tremendous sediment loads associated with the lower Colorado River were dominating factors driving the physical and biological attributes of the ecosystem. Recorded flows at Yuma ranged from 18 cubic feet/second (cfs) to 250,000 cfs with sediment loads averaging more than 10^8 metric tons per year (USGS, 1973). These flow regimes could affect a portion of the river but rarely disturbed the entire system. Sediment loading occurred in some areas causing degradation of the river channel, aggradation in other reaches, and the shifting of the river channel itself in still others. Riparian, marsh, and aquatic communities had to be adaptive.

The geomorphology of the river helped dictate where soil deposition, degradation, and aggradation occurred. The lower Colorado River was a series of narrow canyons interspersed with wide valleys. Water and sediment moved rapidly through the narrow canyons in all but the most dry years. These rapid, sediment-filled flows prevented the establishment of most riparian plant communities within the canyons. Conversely, once the water and sediment were released from a narrow canyon into one of the broad valleys, soil deposition occurred. The rate of aggradation was dependent on flow rate and sediment loading. It was within these large valleys that native plant communities became established. The riparian belt extended away from the river for up to several miles where the water table was relatively shallow. Sporadic large flows caused the river channel to meander and created or reconnected oxbows and backwaters. At its mouth was an alluvial delta containing vast marshes, riparian forests and backwaters (Ohmart, 1982).

Historically, the lower Colorado River represented a unique aquatic habitat, ranging from a swift-flowing, turbid river during the annual runoff period (May-July) with flows exceeding 100,000 cfs to a gentle meandering river during late fall and winter periods with flows of 5,000 cfs or less (Grinnell, 1914; Carothers and Minckley, 1981). Remarkably high sediment loads accompanied floods and seasonal runoff from the Rocky Mountains. In all but those places where the river breached hard-rock barriers, the bottom continuously shifted as bedload was transported (Minckley, 1979). Where the stream occupied broad alluvial valleys, sediment was deposited and wide, shallow, braided channels developed. As meanders matured, they were cut off to form oxbow lakes and backwaters. Extensive, although transitory, marshes were formed, only to be obliterated by vegetative succession, or more rapidly destroyed by currents and transported sediments during floods (Minckley, 1979). Some of the larger historic backwaters and/or oxbows were persistent enough to be given names, these included Beaver Lake, Lake Su-ta-nah, Duck Lake, Spears Lake, Powell Slough (now part of Topock Marsh), and Lake Tapio. All were located between present day Bullhead City and Topock (Ohmart et al., 1975).

Seasonal flooding resulted in the creation of several distinct communities of plants and animals. High water occurred around June with low flows occurring during the winter months. Riparian communities were in a constant state of succession as the river, on a seasonal basis, was constantly depositing new sediment, shifting its channel, and creating and destroying habitat. Floodplain communities developed in areas that were seasonally, or only intermittently, inundated.

Marsh communities developed in areas prone to extended periods of inundation, and the aquatic community evolved consisting of a main channel with separate or connected oxbows and backwaters. With the exception of the lower Colorado River delta area, historic evidence suggests that backwater marshes that lasted several years seldom were very large along the lower Colorado River. Freeland

(1973) stated that before completion of Parker and Imperial Dams, marshes along the river below Davis Dam were 1,000 acres or less in area.

The hydrology of the river created a series of terraces and bottoms along its route. Grinnell (1914) identified seven river associated communities. Five of these were specifically flood-plain in nature including: 1) Cottonwood-Willow association; 2) Arrowweed association; 3) Quail-bush association; 4) Mesquite association; and 5) Saltbush association. Grinnell discussed two other communities, the River and Tule association (Ohmart et al., 1988). Figure 4 illustrates typical historic floodplain terraces and associated vegetation communities occurring along the lower Colorado River. Figure 5 illustrates a reconstruction of historic native plant community placement and principal species composition from original surveyor notes and plats along the lower Colorado River in 1879[1].

2. Chronology of development along the lower Colorado River

Native American tribes have called the lower Colorado River home for centuries. The first European explorers were Spanish priests and military expeditions whose main goals were obtaining gold, silver, and land for Spain (Ohmart, 1982). Journals left by these early Spanish explorers mainly noted the things of concern to the explorers: the native inhabitants and natural resources of immediate use to the Spanish. From the discovery of the Colorado River in 1540 by Hernando de Alarcon until the acquisition of the lower Colorado River by the United States after the Mexican-American War in 1848, European settlers had little effect on the native habitats found along the Colorado River.

Expeditions conducted by the United States military in the mid-1800s evaluated the region for mineral wealth, navigable waterways, and overland routes to California. Although several of the early explorers believed that the Colorado River had limited value (Ives, 1861), prospectors began to arrive by the mid-1800s. In 1861, silver was discovered at Eldorado Canyon and gold was found at Laguna de la Paz, creating the Colorado River Gold Rush of 1862 (Lingenfelter, 1978).

The Gold Rush fueled the fledgling steamboat trade along the Colorado River. Initially, downed, dried mesquite, cottonwood, and willow were utilized as fuel by the steamboats (Ives, 1861). However, increased river traffic soon utilized all of the available wood debris so crews began cutting down large quantities of cottonwoods, willows, and mesquites. By 1890, most of the large cottonwood-willow stands and mesquite bosques had been cut over (Ohmart et al., 1988; Grinnell, 1914). Natural flood events still enabled regeneration to occur, however.

Major changes to the lower Colorado River ecosystem really began with the advent of large-scale agriculture. European settlers first began diverting water from the Colorado River in 1877 to irrigate agricultural lands in the Palo Verde Valley near Blythe, California. By 1901, water was being diverted for large-scale agriculture in the Imperial Valley via the Alamo Canal at Yuma, Arizona (USBR, 1996). In 1902, the United States Congress passed the Reclamation Act which established the U.S. Reclamation Service. The Reclamation Service began to plan large-scale irrigation projects throughout the west, especially along the lower Colorado River (LaRue, 1916). Additional emphasis was placed on flood control along the lower Colorado River after the floods of 1905-07, which inundated over 330,000 acres and created the Salton Sea after breaching the diversion structure at the head of the Alamo Canal (Ohmart et al., 1988; USBR, 1996). The solution to the growing needs for water, flood control, and power was to build a series of dams along the lower Colorado.

The Laguna Diversion Dam was the first dam completed on the Colorado River in 1909. Water diverted at Laguna Dam and transported through the Yuma Main Canal irrigated 53,000 acres in the Yuma Valley and 14,700 acres in the Reservation Division in California. An additional 3,500 acres of agricultural land was irrigated from water diverted at Laguna Dam and transported to the Gila Valley via

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[1] The General Land Office, now known as the Bureau of Land Management, initiated the original township surveys or cadastral mapping along the river in 1855. Not all the land was surveyed during the same period of time. Figure No.5 shows a reconstruction of the general vegetative types below Blythe, California in 1879 derived by interpreting floral descriptions contained in original field notebooks and then transferring these to the original field plats (Ohmart et. al., 1977 in Importance, Preservation and Management of Riparian Habitat: A Symposium, USDA Forest Service, General Technical Report RM-43)

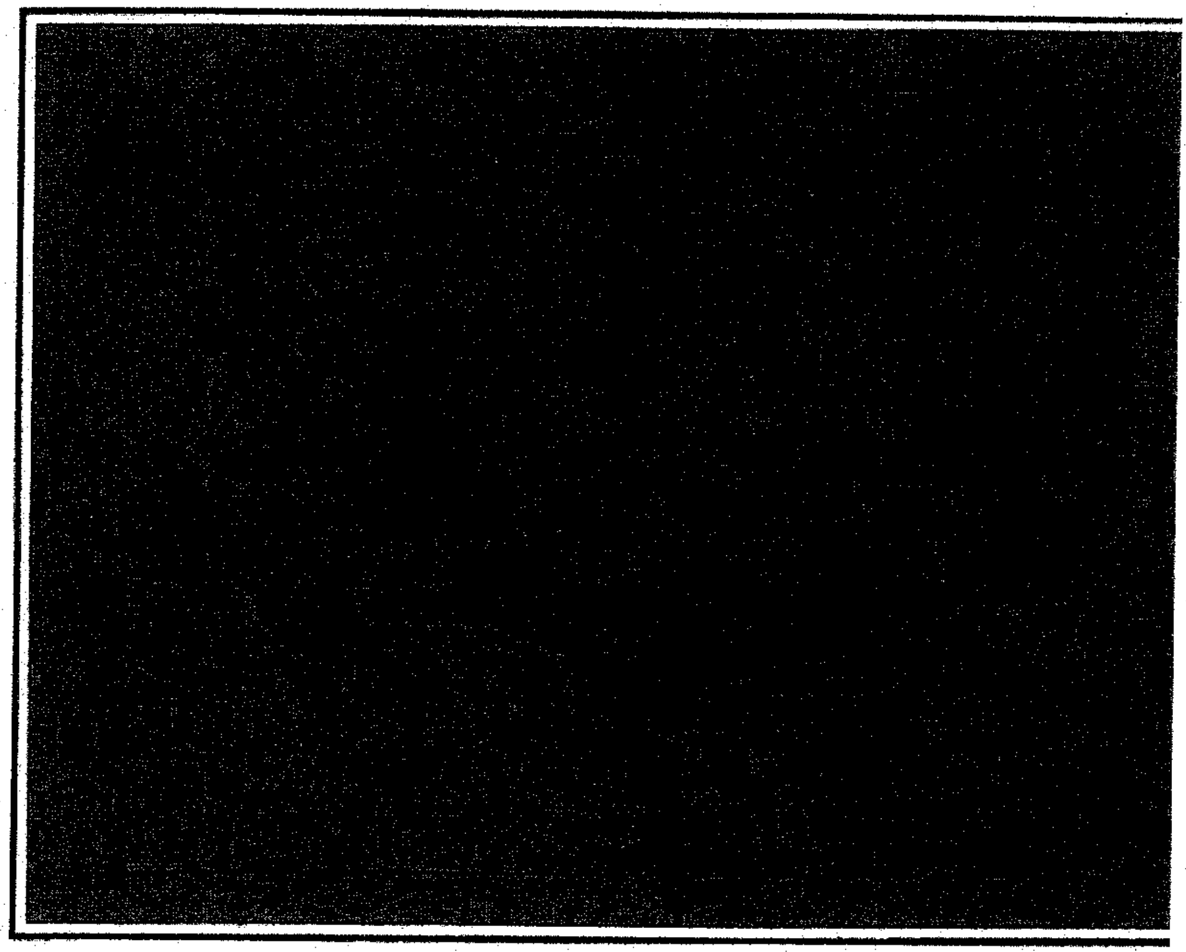

Figure 4. Historic lower Colorado River flood plain and associated vegetation communities

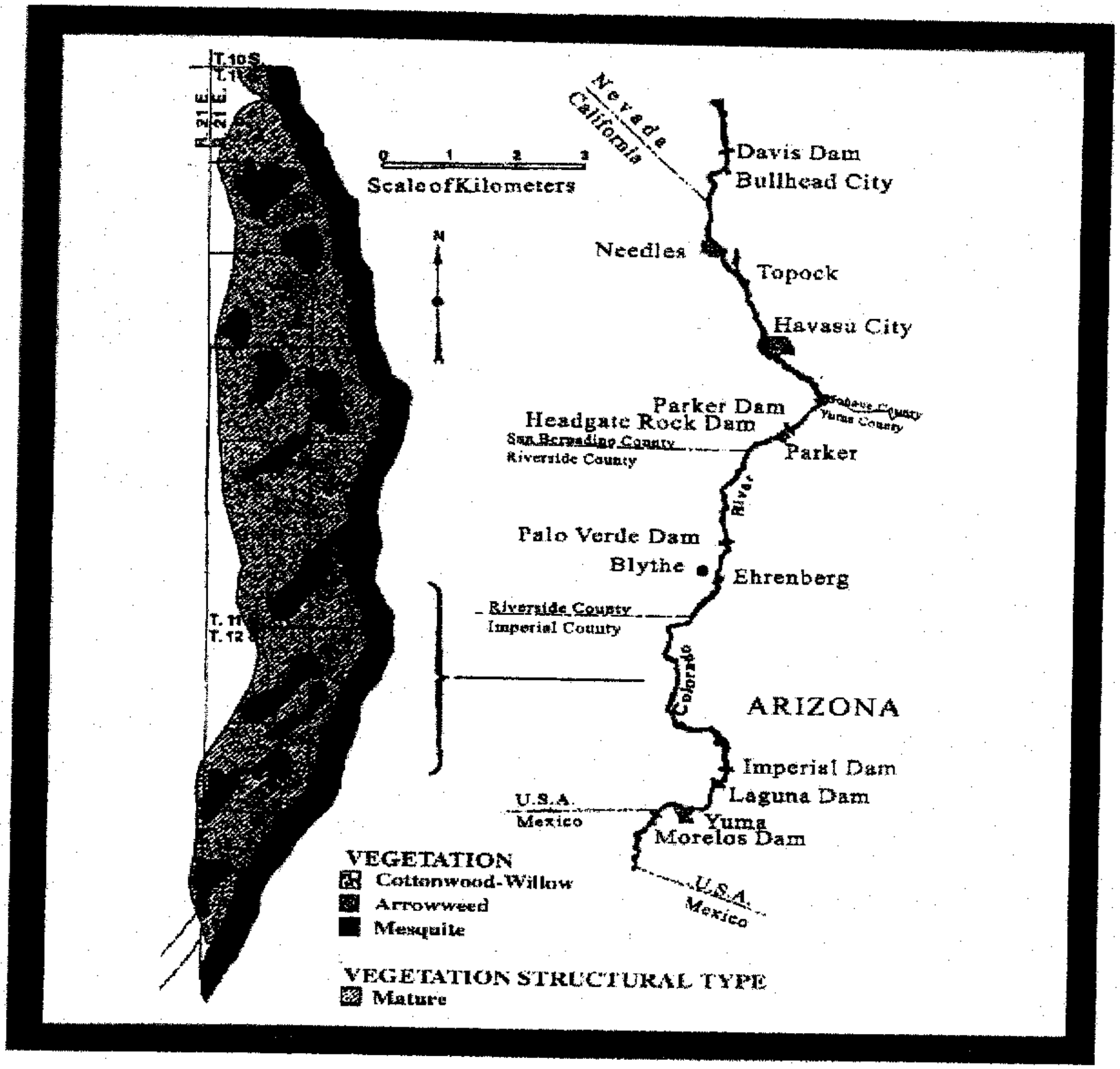

Figure 5. Reconstruction of native plant community placement and species composition from original surveyor notes and plats along the lower Colorado River in 1879 (Ohmart et. al., 1977).

the North Gila Canal (USBR, 1996). The large sediment loads historically found in the Colorado River caused Laguna Dam to silt in almost immediately. From 1913 to 1927, irrigated acreage increased along the lower Colorado River to 95,000 acres (Wilber and Ely, 1948).

In 1918, Arthur P. Davis, Reclamation's Director and chief engineer, proposed a dam of unprecedented height to be built in Black Canyon, between Nevada and Arizona, to control the Colorado River. In 1928, Congress passed the Boulder Canyon Project Act, authorizing the construction of Hoover Dam. Construction began with the diversion of the Colorado River around the dam site in 1932. Construction of Hoover Dam was completed on May 29, 1935. In subsequent years, Parker Dam (1938), Imperial Dam (1938), Headgate Rock Dam (1941), Morelos Dam (1950), Davis Dam (1953), Palo Verde Diversion Dam (1957), and Glen Canyon Dam (1963) have all been constructed along the Colorado River. Detailed accounts of the operations of each of these facilities can be found in the *Description and Assessment of Operations, Maintenance, and Sensitive Species of the Lower Colorado River, Biological Assessment* (USBR, 1996).

The overall ecosystem of the lower Colorado River today is quite different from that which existed prior to modern day use and development. The *Description and Assessment of Operations, Maintenance, and Sensitive Species of the Lower Colorado River, Biological Assessment* (USBR, 1996) includes a more complete description of the Colorado River. Table 6 summarizes the chronology of the lower Colorado River development which has, in part, resulted in the current ecosystem.

Table 6. Chronology of Lower Colorado River Development.

1700-1800	Exploration of lower Colorado River by Spanish priests and military, culminating with the establishment of a mission at Yuma in 1774 and its subsequent destruction by Yuma Indians in 1781 (Ohmart et al., 1988).
1848	Acquisition of lower Colorado River area north of the Gila River by the United States.
1840-1870	Exploration of lower Colorado River by U.S. military. Most of the early expeditions were exploring possible transportation routes through the area. Notes on the geology, flora, and fauna of the lower Colorado River were made. Tamarisk introduced into the United States as an ornamental tree and escaped cultivation by the late 1800s. Expansion of range rapid by the early 1900s, especially between 1935 and 1955 along the Colorado River (DeLoach, 1989).
1850	Fort Yuma established by U.S. Army.
1852	First steamboat, the "Uncle Sam" captained by James Turnbull, travels up the Colorado River to re-supply Fort Yuma. Marks beginning of the steamboat trade which would eventually have profound effects on the mature riparian areas along the river (Lingenfelter, 1978).
1854	Gadsden Purchase consummated, extending U.S. territory south of the Gila River to the present international boundary with Mexico.
1857	Lower Colorado River from Yuma, Arizona, north to present site of Hoover Dam explored by J.C. Ives; region reported to be valueless.
1862	Colorado River Gold Rush begins. 1861 silver strike at Eldorado Canyon and the 1861 gold strike at Laguna de la Paz created what is known as the Colorado River Gold Rush of 1862 (Lingenfelter, 1978). Gold rush fueled steamboat trade along lower Colorado River. Initially, downed, dried cottonwood, willow, and mesquite were utilized as fuel for the steamboats (Ives, 1861). Increased river traffic soon utilized all of the available wood debris, and crews began cutting down large quantities of cottonwoods, willows, and mesquites. By 1890, most of the large cottonwood-willow stands and mesquite bosques had been cut over (Ohmart et al., 1988; Grinnell, 1914). Natural regeneration continued to establish new stands with each annual flood event.

1869	Colorado River from Green River in Utah to the Virgin River confluence explored by John Wesley Powell.
1877	Southern Pacific Railroad completes line over the Colorado River at Yuma. First diversion of water from lower Colorado River by European settlers for irrigating the Palo Verde Valley near Blythe, California.
1883	Second rail line crosses river. Together with the crossing at Yuma, the crossing at Needles by the Atlantic and Pacific Railroad in 1883 sounded the death knell of steamboat trade along the lower Colorado River (LaRue, 1916). Declines in mining further reduced steamboat commerce, and by 1887, steamboats no longer went above Eldorado Canyon (Lingenfelter, 1978).
1885	First documented improvements on the lower Colorado River. Lieutenant S.W. Roessler hired a barge and crew to make improvements at Six Mile Rapids and Mojave Crossing for navigation; first recorded instance of alteration of river (Smith, 1972). Carp known established in the lower Colorado River ecosystem; first alteration of the native fish fauna (Minckley, 1973).
1892	Channel catfish stocked into Colorado River by Arizona Game and Fish (LaRivers, 1962)
1895	Construction begins on Alamo Canal at Yuma to irrigate Imperial Valley.
1901	Alamo (Imperial) Canal completed; water diverted near Yuma and conveyed through Mexico to irrigate the Imperial Valley in California; canal supplied 700 miles of lateral canals, enabling irrigation of 75,000 acres.
1902	Reclamation Act passed establishing U.S. Reclamation Service. U.S. government began planning large scale irrigation projects. (LaRue, 1916).
1905	Flood on Gila River breaks through temporary diversion structure at Alamo Canal heading and Colorado River flows into Salton Sink.
1907	Southern Pacific Railroad repairs dike and redirects river back to correct channel. Salton Sea accidentally created from Colorado River floodwaters; 330,000 acres inundated; flooding increased the political pressure to dam the Colorado River.
1909	Laguna Diversion Dam completed; water diverted through the Yuma Main Canal to irrigate 53,000 acres in the Yuma Valley, Arizona, and 14,700 acres in the Reservation Division in California, and through the North Gila Canal to irrigate 3,500 acres in the Gila Valley, Arizona.
1910	Joseph Grinnell leads 3-month expedition from Needles to Yuma to collect data on mammals, birds, and associated habitats. Expedition provides one of first detailed accounts of the flora and fauna of the lower Colorado River. Grinnell observed carp and catfish, documented effects of Laguna Dam on the ecosystem, and documented loss of riparian habitat to agriculture (Grinnell, 1914).
1913	Estimated acreage irrigated along the mainstem Colorado River between the Virgin River and the International Boundary was 367,000 acres, most of this being in the Imperial Valley (LaRue, 1916). The 53,000 acres along the mainstem Colorado between Cottonwood Basin and the U.S./Mexico boundary resulted in a substantial loss of riparian habitat.

1920	Tamarisk appears along the mainstem of the Colorado River (Ohmart et al., 1988). This species is adapted to the changed riverine ecosystem and displaces native riparian species throughout the lower Colorado River. (Important wildlife habitats, including the cottonwood-willow gallery forests, have all but disappeared from the Colorado River and have been replaced by the less desirable Tamarisk [Anderson and Ohmart, 1984b]).
1922	Colorado River Compact signed; water allocated between the upper (Colorado, Wyoming, New Mexico, Utah) and lower (California, Nevada, Arizona) basins.
1927	Irrigated acreage along the mainstem of the lower Colorado River increased from 53,000 in 1913 to 95,000 in 1927 (Wilbur and Ely, 1948). Results in further decreases in riparian habitat.
1935	Boulder Dam (now Hoover Dam) completed; Lake Mead covers 300 square miles and stores 31 maf of water, enough to irrigate 650,000 acres in California and Arizona and 400,000 acres in Mexico. Hydrography of river changed; devastating floods eliminated. FWS stocks largemouth bass, bluegill sunfish, green sunfish and black crappie into Lake Mead; stock rainbow trout into river below Lake Mead (Jonez and Sumner 1954).
1938	Parker Dam completed; Lake Havasu behind dam covers 39 square miles and stores 600,000 acre-feet of water. MWD diversions into the Colorado River Aqueduct initiated. Imperial Dam completed; additional water diverted for irrigating southeast California and southwest Arizona. Pilot Knob Wasteway completed, allowing water diverted from behind Imperial Dam on the California side to be returned to the river.
1938-1939	Although largemouth bass and bluegills already present in the system, the State of California plants additional stocks to increase the spread of the species (Dill, 1944).
1939	Gila Gravity Main Canal completed, replacing the North Gila Canal (from behind Laguna Dam) and delivering irrigation water from behind Imperial Dam to irrigate 105,000 acres in Arizona's Gila Valley.
1940	All-American Canal completed, replacing Alamo Canal and delivering irrigation water from behind Imperial Dam to Imperial Valley in California; 461,642 acres currently irrigated.
1941	Havasu National Wildlife Refuge established near Needles, California. Imperial National Wildlife Refuge established near Martinez Lake, Arizona. Siphon Drop completed, delivering irrigation water from All-American Canal to the Yuma Valley in Arizona; replaces Yuma Main Canal (sealed in 1948) originating behind Laguna Dam.
1944	Headgate Rock Dam completed; irrigation water diverted to the CRIT Reservation near Parker, Arizona; water diverted to enable irrigation of 107,588 acres.
1948	Coachella Canal completed; water from All-American Canal conveyed to Coachella Valley in California; 58,579 acres currently irrigated. Red shiners introduced to Colorado River as baitfish.
1950	Morelos Dam completed; irrigation water delivered by Mexico to the Mexicali Valley. Davis Dam closes and first water storage for Lake Mohave begins in January 1950. Powerplant still under construction.

1952	Yuma division stabilized from Laguna Dam to SIB; 17.6 miles of levees constructed, 17.4 miles dredged, 264,000 cubic yards of riprap placed, 41 miles of access roads constructed.
1953	Davis Dam and powerplant completed, providing regulation of water to be delivered to Mexico and regulating flows from Hoover Dam; Lake Mohave behind dam capable of storing 1.8 maf of water. Threadfin shad introduced into Lake Mead. By 1956, threadfin shad had spread throughout the lower Colorado River (Minckley 1973). Mohave Division from Davis Dam to Topock, Arizona, channelized and stabilized; 31 miles of channel dredged, 288,082 cubic yards of riprap placed, and 47 miles of levees built.
1954	Laguna Dam no longer used for diversion (Imperial Dam used instead).
1956	Topock Settling Basin completed, providing control of river sediment near Needles, California; 4,400,000 cubic yards of material excavated.
1957	Palo Verde Diversion Dam completed; irrigation water diverted to the Palo Verde Valley near Blythe, California; 112,000 acres currently irrigated.
1959	Striped bass introduced by the State of California into Colorado River near Blythe. (Introduced into Lake Havasu in 1960 and into Lake Mead in 1969). Became top fish predator in the Colorado River system.
1962	Flathead catfish introduced into river by State of Arizona.
1963-1967	Tilapia introduced into Colorado River by California and Arizona.
1964	Cibola National Wildlife Refuge established near Blythe, California.
1965	Laguna Settling Basin completed, providing control of river sediment north of Yuma, Arizona; 3,120,000 cubic yards of material excavated. Irrigated acreage estimated at 293,000 acres along the mainstem of the lower Colorado River (Lower Colorado Region State-Federal Interagency Group for the Pacific Southwest Interagency Committee 1971).
1966	Senator Wash Dam and Reservoir completed north of Yuma, reservoir covers 470 acres and holds 13,836 acre-feet of water. Topock Marsh inlet and outlet structures completed providing 4,000 acres of marsh habitat at Havasu National Wildlife Refuge.
1967	Palo Verde Oxbow inlet and outlet structures completed near Blythe, California, to provide wildlife habitat.
1968	River channel stabilized from Palo Verde Dam to Taylor Ferry; 19.5 miles. Banklines armored in Parker Division, Section I; 11 miles stabilized.
1969	Training structures south of Laughlin, Nevada, completed, reducing bankline erosion.
1970	Mittry Lake inlet structure completed south of Imperial Dam, to provide wildlife habitat. Cibola Division stabilized from Taylor Ferry to Adobe Ruin; 16 miles dredged.
1974	Cibola Lake inlet and outlet structures completed at Cibola National Wildlife Refuge, to improve wildlife habitat.
1983	Reservoirs on the entire lower river spilled for the first time due to extremely high precipitation from an El Niño weather event.

1985	Inlet structure to CAP aqueduct behind Parker Dam completed; water diverted to supply Phoenix and Tucson, Arizona; 0.5 maf currently diverted.
1992	Powerplant added to Headgate Rock Dam; maximum generating capacity is 19.5 megawatts (MW).
1993	Hoover Dam powerplant upgraded from 1340 MW to 2074 MW output.
1995	Parker Division, Section II stabilized.

2. Present

a. Riparian Communities

Although the historic riparian communities along the lower Colorado River were dynamic, human-induced change since the beginning of the century has resulted in an ecosystem having significantly different physical and biological characteristics. Such changes have taken place as a result of the introduction of exotic plants (such as saltcedar), the construction of dams, river channel modification, the clearing of native vegetation for agriculture and fuel, fires, increasing soil salinity, the cessation of seasonal flooding, and lowered water tables. Figure 6 illustrates an example of the change in vegetation communities from 1879 to 1977.

The system currently used to classify vegetation along the lower Colorado River is based on plant community and structural type (Anderson and Ohmart, 1984). Six structural types have been described (I to VI) and refer to the proportion of foliage present in each of three vertical layers. For example, a plant community with structural type VI has most of its foliage in the lowermost layer, less foliage in the mid-height layer, and little or no foliage in the upper canopy. A structural type I community has well-developed foliage in all three layers, with the upper canopy dominating. Figure 7 and Table 7 illustrate the relationship between the six structural types and the foliage density at various heights. Community and structural types correlate with wildlife habitat quality, especially for birds; generally type VI provides the poorest habitat and type I the best.

Reclamation has mapped the distribution and acreage of the different riparian plant communities along the lower Colorado River since 1976 (Anderson and Ohmart, 1976; Anderson and Ohmart, 1984, Younker and Anderson, 1986; USBR, 1996; CH2MHill, 1999). The most recent compilation was conducted by CH2MHill using 1997 aerial photography (CH2MHill, 1999).

Direct comparison of acreage delineated during each study may not always be applicable. For instance, although the 1994 aerial photography covered the entire river from Davis Dam to the United States-Mexico border, the entire width of the floodplain was not flown in all places so that coverage is

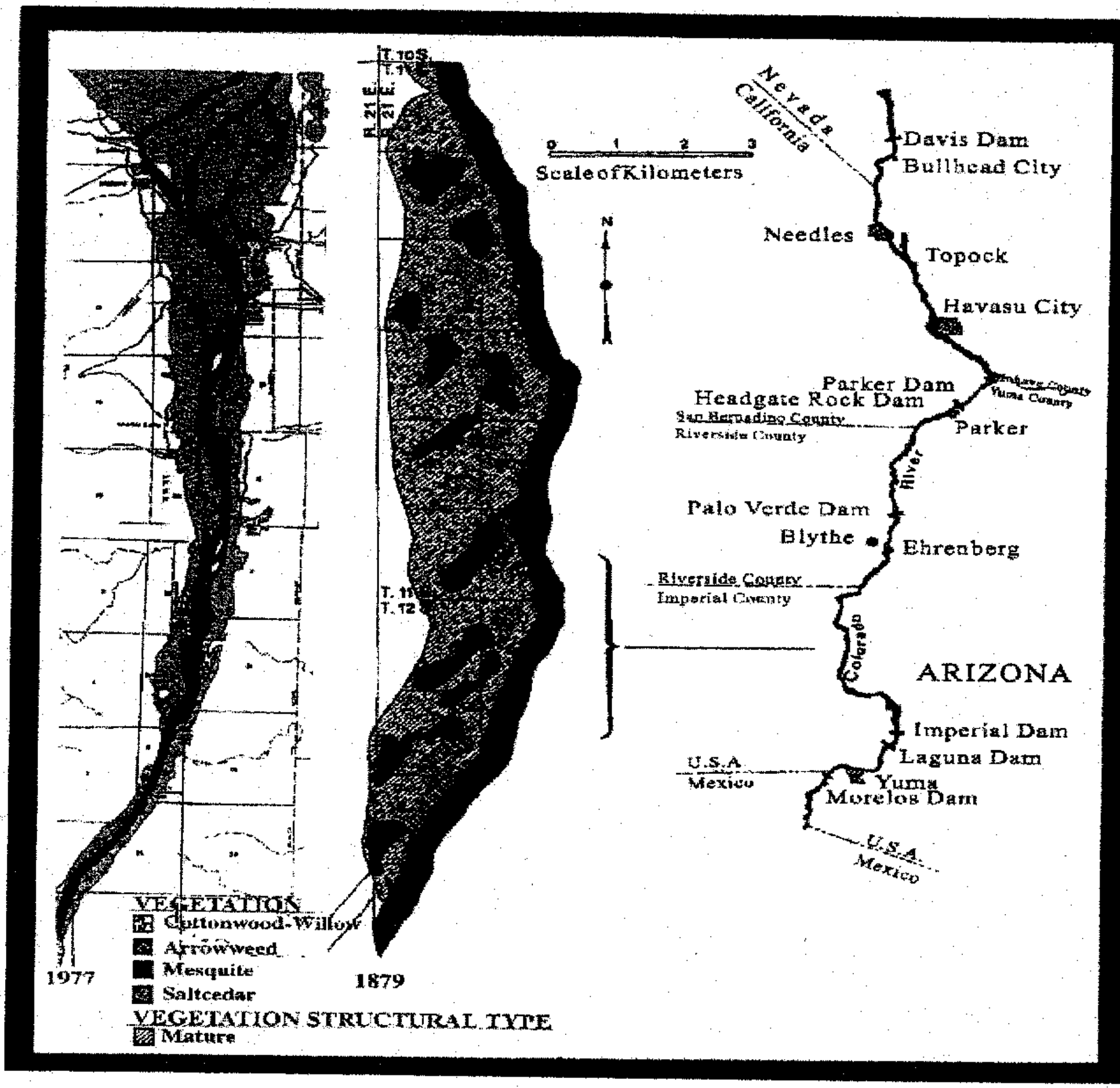

Figure 6. 1879 - 1977 comparison of vegetation communities along same stretch of lower Colorado River near Blythe, California (1879 Reconstruction; Ohmart et. al., 1977)

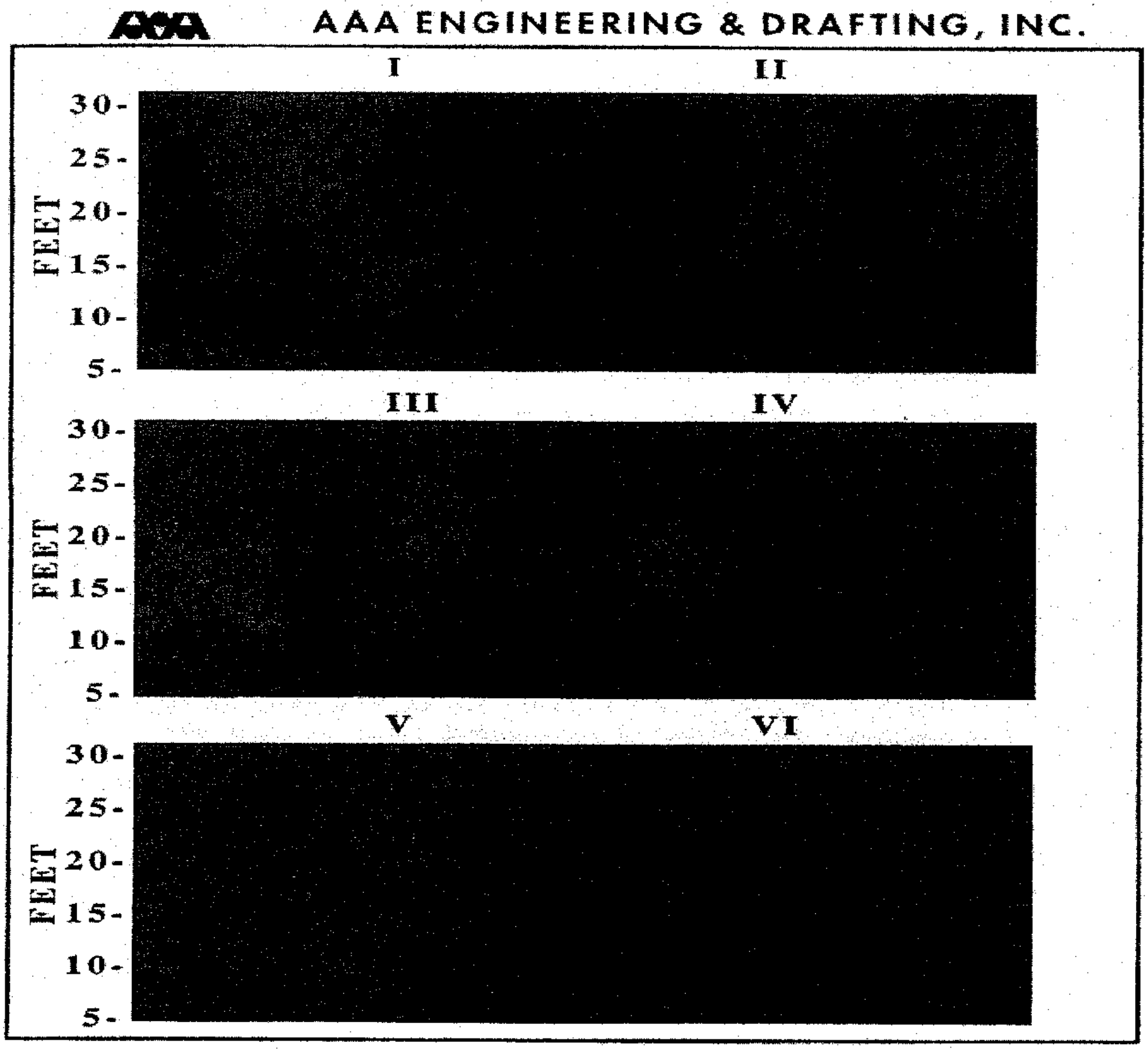

Figure 7. Examples of vertical configurations for the vegetation structural types (from the 1984 Anderson/Ohmart report).

Table 7. Description of Vegetation Structural Types.

Type I	Mature stand with distinctive overstory greater than 15 feet in height, intermediate class from 2-15 feet tall, and understory from 0-2 feet tall.
Type II	Overstory is greater than 15 feet tall and constitutes greater than 50% of the trees with little or no intermediate class present.
Type III	Largest proportion of trees are between 10-20 feet in height with few trees above 20 feet or below 5 feet in height.
Type IV	Few trees above 15 feet present. 50% of the vegetation is 5-15 feet tall with the other 50% between 1-2 feet in height.
Type V	60-70% of the vegetation present is between 0-2 feet tall, with the remainder in the 5-15 foot class.
Type VI	75-100% of the vegetation from 0-2 feet in height.

approximately 80 percent of the previous efforts (John Carlson and David Salas, USBR, pers. comm.). This discrepancy is especially important for community and structural types prevalent at the extreme outer portions of the floodplain. Interpreter bias and differences in minimum mapping unit size also led to potential discrepancies between mapping efforts.

Numerous disturbances have altered the plant community composition along the lower Colorado River since 1976. Two major flood events have occurred since these surveys began. First, high flows were recorded along the mainstem of the Colorado River from 1983 to 1987. Next, the Gila River flooded in 1993. Both flood events, as well as numerous small-scale disturbances such as wildfires, clearings, channel modifications, and restoration projects have changed species composition along the lower Colorado River. The change in community and structure types are documented in Table 8.

As of 1997, the lower Colorado River floodplain supported approximately 109,018 acres of riparian, marsh, and desert vegetation between the United States-Mexico border and Davis Dam. This includes 55,437 acres of saltcedar; 5,044 acres of cottonwood-willow; 3,258 acres of honey mesquite; 8,966 acres of screwbean mesquite; 18,065 acres of saltcedar and honey mesquite association; 4,145 acres of arrowweed; 798 acres of quailbush; 11,842 acres of marsh vegetation; and 1,463 acres of creosote scrub (CH2MHill, 1999).

The most abundant community/structural types observed in 1997 (CH2MHill,1999) were, by far, saltcedar type IV (33,175 acres) and saltcedar type V (14,528 acres). Saltcedar-honey mesquite type IV consisted of 10,470 acres, saltcedar-screwbean mesquite type IV consisted of 6,280 acres, saltcedar type VI consisted of 6,479 acres, and arrowweed type VI consisted of 4,145 acres. A complete description of the 1997 community and structural type acreages found along the lower river (per River Division) is shown in Table 9.

The 1997 aerial photography identifies a change in the acreage and structure of certain riparian plant communities (CH2MHill, 1999). Data indicate a trend in several plant communities since 1976. Saltcedar has steadily increased in abundance since vegetation type mapping began in 1976, with a total of 55,000 acres being classified as monotypic saltcedar and an additional 27,000 acres classified as mixed saltcedar-mesquite types in 1997. Monotypic honey mesquite acreage trends show a steady decrease to 3,258 acres in 1997. Screwbean mesquite acreage has also shown a decline since the 1983 Colorado River flood event.

Cottonwood-willow community types, along the lower Colorado River below Davis Dam, declined over 28% after the 1983 Colorado River flood event. The 1994 survey indicated that this trend was continuing, with only 3,398 acres being typed as cottonwood-willow during this effort. However, the 1997 survey typed over 5,000 acres of cottonwood-willow, a loss of only 700 acres from 1986. Some of the increase in cottonwood-willow acreage may be attributable to the 1993 Gila River flood event as the

Table 8. Acreage Delineated for Each Vegetation Community Type During Aerial Surveys Conducted Since 1976.

Community Type	1976	1981	1986	1994[1]	1997
SC I	106	330	310	290	366
SC II	188	101	9	87	40
SC III	334	425	11	267	849
SC IV	25,090	22,510	22,381	24,092	33,175
SC V	6,867	10,438	17,560	13,096	14,528
SC VI	2,876	5,057	4,766	7,011	6,479
SC TOTAL	35,461	38861	45,037	44,843	55,437
CW I	383	0	0	68	430
CW II	94	163	225	151	64
CW III	464	592	502	1,833	2,774
CW IV	4,396	4,581	1,733	938	1,129
CW V	2,417	1,700	2,867	152	376
CW VI	534	939	427	266	271
CW TOTAL	8,288	7,975	5,754	3,398	5,044
HM III	1,814	1,228	1,089	41	402
HM IV	10,430	9,051	8,889	149	2,309
HM V	3,963	2,156	1,583	193	483
HM VI	0	35	20	24	64
HM TOTAL	16,207	12,470	11,581	407	3,258
SM I	0	0	0	3	10
SM II	272	99	0	15	0
SM III	1,858	768	360	508	672
SM IV	13,734	12,067	7,825	8,771	6,280
SM V	4,561	5,238	7,067	3,679	1,386
SM VI	358	3,208	240	1,565	618
SM TOTAL	20,783	21,380	15,492	14,541	8,966
SH III	175	204	28	67	546
SH IV	5,268	7,149	5,966	1,115	10,470
SH V	2,503	2,735	1,879	1,027	6,128
SH VI	0	130	7	131	921

Community Type	1976	1981	1986	1994[1]	1997
SH TOTAL	7,946	10,218	7,880	2,340	10,065
AW TOTAL	3,944	4,253	7,478	5,197	4,145
ATX TOTAL		597	1,231	714	798
CR TOTAL			426	749	1,463
MA 1		3,975	5,657	4,216	4,248
MA 2		1,382	729	533	651
MA 3		1,241	1,857	1,913	2,892
MA 4		573	369	2,523	2,078
MA 5		1,093	443	314	823
MA 6		636	1,757	592	639
MA 7		1,255	1,757	931	511
MA TOTAL	5,834	10,155	12,549	11,022	11,842
TOTAL	98,463	105,909	107,428	83,211	109,018

[1]1994 aerial survey did not cover the entire floodplain

Table 9. 1997 Acreages of Lower Colorado River floodplain vegetation community types per river maintenance division.

	MOHAVE	TOPOCK GORGE	HAVASU	PARKER	PALO VERDE	CIBOLA	IMPERIAL	LAGUNA	YUMA	LIMITROPHE	Total
SC-I	284	0	7	0	0	14	15	32	6	3	361
SC-II	0	1	2	1	0	0	0	0	35	0	38
SC-III	31	22	38	35	341	196	65	39	65	15	849
SC-IV	6,815	135	1,067	3,997	6,792	7,377	2,514	2,071	605	1,104	32,478
SC-V	3,449	10	522	4,180	1,459	992	622	491	575	1,682	13,982
SC-VI	583	0	157	2,565	469	369	137	681	236	979	6,176
CW-I	0	7	19	4	39	67	32	163	58	40	430
CW-II	12	0	18	8	14	2	0	7	1	0	63
CW-III	551	55	343	32	193	465	227	445	328	91	2,731
CW-IV	54	7	0	184	105	18	132	292	269	69	1,129
CW-V	29	0	18	13	0	2	12	63	143	83	364
CW-VI	0	0	72	3	0	16	0	79	37	37	245
HM-III	5	0	2	328	54	0	12	0	1	0	402
HM-IV	1	0	32	1,699	299	241	15	5	3	0	2,296
HM-V	0	0	58	275	16	53	0	0	0	0	402
HM-VI	0	0	0	64	0	0	0	0	0	0	64
SM-I	0	0	10	0	0	0	0	0	0	0	10
SM-III	32	0	0	331	0	3	22	0	48	0	436
SM-IV	556	19	545	1,677	849	640	118	644	75	0	5,122
SM-V	108	0	76	408	187	71	13	15	0	0	878
SM-VI	55	0	184	7	18	0	21	0	0	0	285
SH-III	35	31	3	24	51	41	9	10	13	0	218
SH-IV	309	103	381	5,583	1,887	993	269	116	0	0	9,641
SH-V	602	4	176	2,596	1,416	407	57	47	0	0	5,305
SH-VI	0	0	62	398	102	4	0	1	0	0	566
AW	193	2	325	2,178	192	70	433	280	171	5	3,849
ATX	0	0	115	328	64	0	36	87	120	29	780
MA-1	1,335	490	325	58	139	841	667	288	0	6	4,150
MA-2	64	135	21	37	27	242	90	6	5	0	627
MA-3	108	31	225	311	49	678	1,046	312	68	3	2,830
MA-4	594	377	85	258	94	396	204	21	19	0	2,048
MA-5	358	112	14	17	23	30	248	9	0	0	810
MA-6	99	0	13	16	0	158	160	93	93	7	639
MA-7	45	9	11	81	9	15	13	98	38	132	450
CR	24	352	8	6	0	213	311	517	29	0	1,460
Total	21,355	4,924	22,405	32,509	17,415	18,565	10,168	8,110	3,554	4,365	143,370

Table 9. 1997 Acreages of Lower Colorado River Floodplain Vegetation Community Types Per River Maintenance Division.

1994 aerial photography may have been flown too soon after the flood event to adequately show the amount of cottonwood-willow regenerated. Another possible explanation is the ambiguity associated with this method of vegetation classification, especially when typing cottonwood-willow communities. To be classified as a cottonwood-willow type under the present system, cottonwoods or willows need only comprise 10% or more of the total number of trees present within the stand.

One trend does appear within the cottonwood-willow communities since the 1983 Colorado River flood, however. There has been a steady increase in the number of acres classified as CW I and CW III below Davis Dam. This trend signifies the maturity of stands regenerated during the 1983 Colorado River and 1993 Gila River flood events. It is interesting to note that CW II has never appeared in any significant amount in any of the surveys conducted as the shade-intolerant cottonwood and willow rarely grows to maturity as a dense overstory without gaps being created which enables other species, especially saltcedar, to become established within the stand.

Prior to 1997, aerial survey efforts were restricted to the portion of the Colorado River floodplain that stretched from Davis Dam to the southerly international boundary with Mexico. However, increased emphasis has been placed on the riparian habitats associated with Lake Mead. Following the Colorado River flood of 1983-87, an extended dry hydrologic cycle occurred which exposed sediments at the Lake Mead delta, Virgin River delta, Muddy River delta, and the lower Grand Canyon. Exposure of saturated soils coincided with natural seedfall producing large tracts of riparian habitat, especially in the lower Grand Canyon and Lake Mead delta, near Pierce Ferry, Arizona (Figure 8). An estimated 1,400 acres of cottonwood-willow habitat became established at the Lake Mead delta at this time (USBR, 1996). By 1995, lake levels had increased enough to inundate the majority of the Lake Mead delta resulting in the loss of this habitat by 1999. A similar scenario occurred at the Virgin River and Muddy River deltas, albeit at a much smaller scale. It is estimated that approximately 20 acres of occupied southwestern willow flycatcher breeding habitat was lost at the Virgin River delta due to rising lake levels (McKernan and Braden, 1999).

Since Grinnell's 1910 survey of the lower Colorado River, numerous additional surveys and investigations concerning the biotic attributes of the lower river system have been conducted. Probably one of the most recent and comprehensive terrestrial descriptions can be found in the Reclamation-funded *Wildlife Use and Densities Report of Birds and Mammals in the Lower Colorado River Valley* (Anderson and Ohmart, 1977). This report describes the average densities and diversities of birds and mammals as associated with the 26 vegetative community and structural types mentioned above. The information given in this report was obtained from data collected over a 4-year period, and involved continuous year-round surveys in each of the habitat types from Davis Dam to the Mexican border, near Yuma, Arizona. Over 250 species of birds and approximately 15 species of mammals were observed during this survey. Generally, the survey showed the highest bird and mammal densities and diversities in cottonwood-willow with mesquite, mesquite-saltcedar (mix) and saltcedar communities, respectively lower. Structural types I and II had the greatest species richness while the least diverse structure types V and VI had the lowest richness. More recent studies indicate that the 1977 survey underestimated the use of saltcedar communities, especially by neo-tropical migrant birds (Lynn and Averill, 1996; McKernan and Braden, 1999).

b. Marsh

Present-day marshes along the lower Colorado River are of two kinds. The first kind includes backwater marshes, which are defined as marsh areas adjacent to the river and which are either directly connected to the river or are connected by seepage. The second kind, which is more extensive, includes those marshes formed by impoundments such as the marshes in Mittry Lake, Imperial Reservoir, Lake Havasu, Topock Marsh, and other similar impounded areas.

The construction of river control features, such as training structures, along the lower Colorado River has resulted in the formation of more permanent and expansive backwater marshes. There are over 400 backwater marshes along the lower Colorado River today from Davis Dam to Laguna Dam. Some of these marshes were created and are maintained specifically for mitigation for channel improvement projects. Reclamation actively pursues maintenance and restoration of backwater marshes not tied to mitigation on a cost shared basis. These backwater marsh habitats are subject to successional factors as

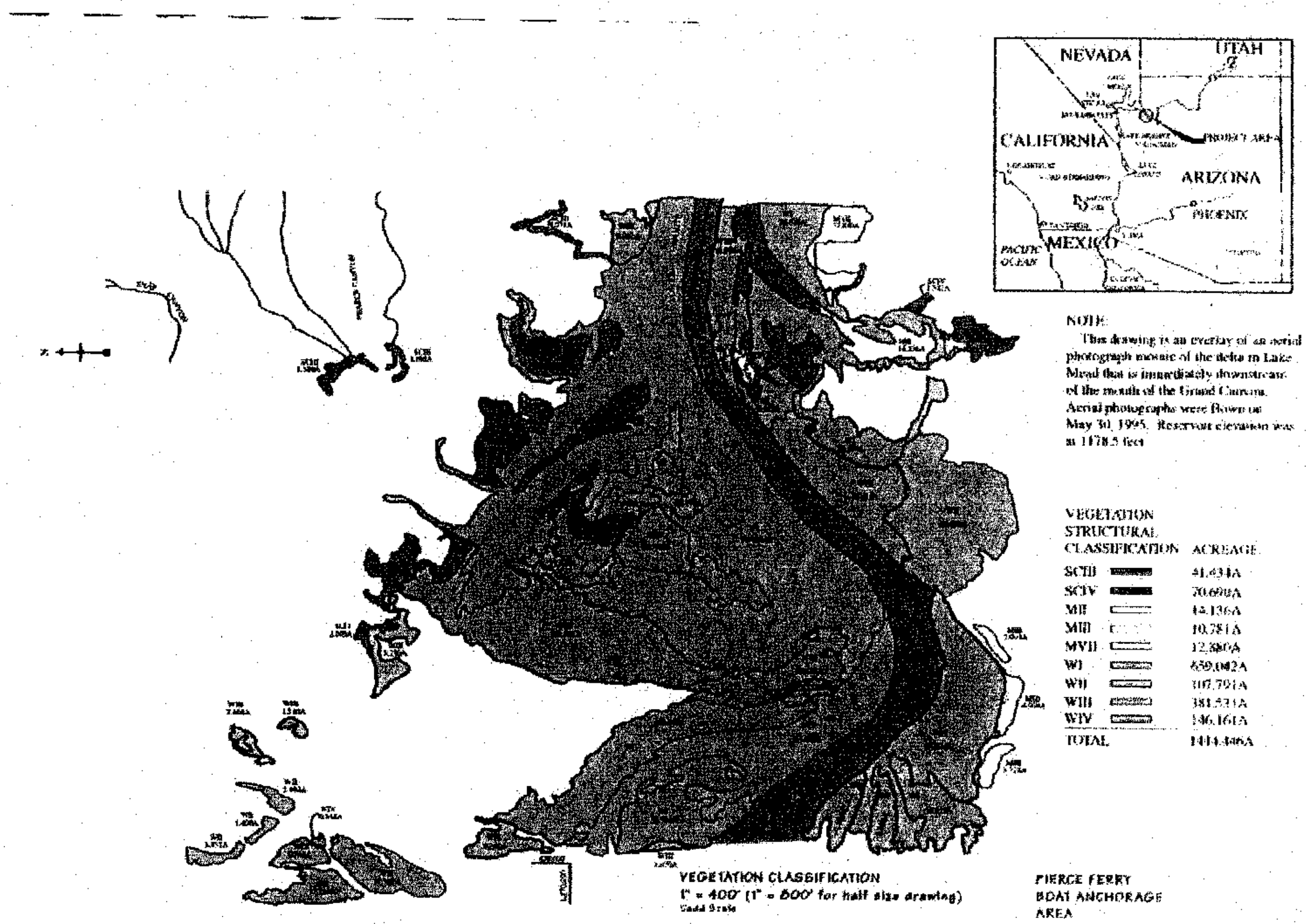

Figure 8. 1995 Colorado River Delta at Lake Mead Vegetation Classification.

were the historic marshes along the river. Under normal operating conditions, this succession is greatly slowed because current river conditions and operating criteria result in less scouring and associated sediment movement. Bankline stabilization has reduced erosion and associated sediment accrual to the river. When exceptional conditions are encountered, such as the high flow releases which occurred in 1983-1985, channel scouring occurs with associated sediment deposition in those backwater areas. These exceptional conditions would be expected to promote accelerated succession to upland conditions which are dominated by saltcedar (Tamarix sp.).

The majority of the banklines of the flowing river have been stabilized. This does not allow for natural marsh formation resulting from the river channel moving laterally, which would occur during high flows. Additionally, current river operating criteria reduce the opportunity for high flows (floods) which would also reduce natural marsh formation during those type of flows. A portion of the backwater marshes, which exist along the river today, are isolated from the main river channel, reducing the opportunity for flushing flows through them. However, it was observed during the high flows experienced on the river during 1983 through 1985, the isolated backwater marshes did not fill in with deposited sediment. Impacts which occurred to those isolated backwater marshes were a result of the main river channel scouring and the resulting drop in water table. In any case the marsh communities formed, as a result of the impoundments and training structures, are much greater in extent and permanence than those which occurred historically. As stated above, some of these marshes are specifically maintained for fish and wildlife purposes.

Vegetation mapping completed in 1997 shows the lower Colorado River floodplain supporting over 11,000 acres of marsh habitat. Of this amount, 4,248 acres were classified as Type 1, which meets the criteria of being nearly 100 percent cattail/bulrush with small amounts of common cane and open water.

Reclamation funded a 1986 report describing the development of a fish and wildlife classification system for backwaters found along the lower Colorado River from Davis Dam to Laguna Dam (Holden et al., 1986). The 2½ year study effort resulted in over 400 backwater areas being identified and classified. The backwaters were characterized by State, distance from the SIB, river division, how formed (natural or man-made), quality of associated riparian vegetation, how accessible, size, how connected to the river, shape, permanence and actual acreage of open water.

After classifying the backwaters, seasonal field studies were then undertaken to sample fish and wildlife distribution, abundance, and preferences. Eighteen individual backwaters were sampled. These efforts included sampling water quality, zooplankton, benthic macro invertebrates, and fish in nine fishery study backwaters. Wildlife studies on the 18 backwaters also included morning bird censuses, night spotlighting, small mammal trapping, and aerial waterfowl surveys. Over 100 avian species, 25 mammal species and 15 fish species were observed, quantified, and associated with classified backwaters.

This report and mapping effort was updated in 2000 with some modifications to meet present data needs (USBR, unpub. data). The backwaters for this update were defined as open water with the associated emergent vegetation (primarily cattail/bulrush). The report results still show over 400 backwaters existing on the lower Colorado River between Davis Dam and Laguna Dam. The open water areas show 7,911 acres, an increase of slightly over 1,300 acres since 1986. This differential may be due to improved sampling techniques, however. The emergent vegetation associated with the open water of the backwaters was also mapped. The total emergent vegetation acreage was slightly over 9,200 acres.

c. Aquatic

The present aquatic ecosystem of the lower Colorado River is tremendously different than found historically. Changes began in the late 1800s. The human populations of the Colorado River Basin States grew rapidly during the mid-to-late 1800s as people immigrated from the eastern United States and from other countries. The Colorado River basin, with its endemic fish community isolated for thousands of years, was invaded and swamped with new species in a very short period of time. The growing human population also set out to tame and harness the Colorado River, building flood control dams, storage reservoirs, and agricultural diversions. A chronology of the introduction of non-native fishes and dam building, are described above in the history and in the *Description and Assessment of Operations, Maintenance, and Sensitive Species of the Lower Colorado River, Biological Assessment*

(USBR, 1996).

Today, the lower Colorado River downstream of Grand Canyon is a tremendously diverse aquatic ecosystem with over 240,000 surface-acres of open water (Table 10). There are over 27 fish species occupying habitats ranging from deep, clear reservoirs to turbid, flowing river, to warm shallow marshes. While the system on an overall basis is diverse, meaning one reach of river does not look like the next, individual reaches do not change much from season to season. The annual changes in the system are missing. Historically the river environment was extreme. The river annually went from hot to cold, and from raging flood to gentle tranquility. Today, reservoirs are clear and deep all year long. For example, over two-thirds the volume of Lake Mead remains at 55 degrees 12 months of the year, resulting in a constant, cool discharge at Hoover Dam. Even in the lower reaches of the Colorado River between Blythe, California, and Yuma, Arizona, where the river is turbid and shifting sand beds still occupy the river bottom, annual fluctuations in discharge and sediment load are almost immeasurable when put on a scale with the historical ranges of these parameters. Even the daily water level changes, which occur below almost every dam, are constant and rhythmic. Unlike conditions described by Grinnell (1914), whereby rapid changes in water levels trapped fish in shallow pools and side channels (to the benefit of herons), stranding of fishes under the current operational release patterns are extremely rare and virtually non-existent.

Table 10. Surface acreage of open water along the lower Colorado River from Pierce Ferry to the U.S./Mexico International Boundary by river maintenance division (Water Classification).

DIVISION	FLOWING RIVER (acres)	RESERVOIR (acres)	BACKWATER (acres)	TOTAL (acres)
Lakes Mead & Mohave	0	191,500	20	191,520
Mohave	3,554	0	3,767	7,321
Topock Gorge	1,183	0	239	1,422
Havasu	515	20,510	740	21,765
Parker	3,748	0	1,364	5,112
Palo Verde	2,350	0	160	2,510
Cibola	1,971	0	505	2,476
Imperial	3,154	560	2,608	6,322
Laguna	436	25	585	1,046
Yuma	1,782	0	82	1,864
Limitrophe	0	0	146	146
TOTALS	18,693	212,595	10,216	241,504

The native fishes were adapted to the system of extremes. They spawned early, before the peak runoff, and their developing young moved into off-channel areas along with the rising flood waters to feed and grow. Migrations up or downstream were possible due to their body forms, and their long life allowed them to persist when reproductive failure occurred for successive years due to drought or other calamities. While top carnivores where included in the community, species such as the razorback sucker hid during the day and grew quickly to sizes less vulnerable to predation. The introduced fishes such as carp and catfish quickly invaded the off-channel habitats as witnessed by Grinnell (1914) who found them abundant in backwaters along with bonytail and razorback sucker. As discussed by Dill (1944), the physical extremes of the river system prior to dam construction must have been equally hard on native and nonnative fishes alike, and although these exotic fishes were present, their numbers were not great.

Dill (1944) reported that the populations of native fishes had declined prior to 1930. He proposed that native fishes were at a low point in their respective populations just prior to the period of dam building and that nonnative fish populations rapidly expanded with the taming of the river and prevented the rebuilding of native stocks. In his own words:

"...it seems probable that the native fish populations have undergone alternate periods of rise and fall. But each period of destruction was followed by a period during which the population could rehabilitate itself.... Because of the unfavorable water conditions around the early thirties it seems possible that the population of native fishes sank to one of its low points and that the coincidental advent of clear water following Boulder Dam brought about a heavy production of bass and other alien fishes which preyed upon the already reduced natives."

Dill (1944) argued that the native fishes had a high biotic potential which had allowed them to bounce back from previous catastrophes and had it not been for the presence of exotic fishes, they would have done so.

Minckley (1979) similarly argues that dam construction alone was not sufficient to destroy the native fish communities of the lower Colorado River:

"Destruction of the native fauna of the lower Colorado River has been attributed to physical modifications of the environment, such as channelization and construction of dams.... Considering the great age of the Colorado River, and correspondingly great ages of at least some of the genera of fishes inhabiting it..., sufficient time has been available for them to have experienced far more change than has recently been effected by man.

Excluding special cases..., almost all declines in native fish populations are directly attributable to predation by small adults or juveniles of introduced kinds upon early life-history stages of indigenous forms. Shoreline and backwater habitats once exclusively available to non-piscivorous juveniles of suckers and minnows now are inhabited by mosquitofish and young centrachids, and cropping by those animals destroys the native fauna."

Clearly, destruction of the native fauna was not a onetime event. It took some time, and in the case of razorback sucker and possibly bonytail, it is still going on today. In Lakes Mead, Mohave, and Havasu native fish expanded their populations along with the expanding aquatic habitat as the water bodies filled. Jonez and Sumner (1954) described the spawning of both bonytail and razorback sucker in Lake Mohave and of razorback sucker in Lake Mead. LaRivers (1962) details spawning of razorback sucker in Lake Havasu in 1950.

One of the few observations made of large numbers of juvenile razorback sucker this century was made in Lake Mohave in 1950, and it serves here to demonstrate how these fish populated new reservoirs during initial filling. In describing the habitat used by razorback sucker, Sigler and Miller (1963) state the following:

"This large sucker is an inhabitant of large rivers and has adjusted well to the impoundments of the lower Colorado River Basin.... The young occur in shallows at the river or reservoir margins where individuals approximately an inch long travel in schools numbering thousands. Over 6,000 specimens were taken in two hauls of a minnow seine at the margin of the Colorado River in Nevada on June 15, 1950. Here the temperature was 71-76 degrees F, whereas the adjacent river was only 58 degrees."

Davis Dam closed and began storage in January 1950. According to statements by Minckley et al. (1991), the above cited capture of juvenile razorback sucker occurred at Cottonwood Landing, which is approximately 21 miles upstream of Davis Dam. The quoted information suggests that the reservoir had backed up to that point, because the differences stated in water temperature between the riverine and ponded areas is similar to what is found today at the inflow of the Colorado River to the lake some 20 more miles upstream.

It seems apparent that as the new water bodies filled, native and nonnative fish were initially successful in recruiting young into adulthood. As time went on, the nonnative populations were able to prey on the eggs and young of native fishes and recruitment into adulthood all but ceased for the native fishes. Adults continued to survive until they succumbed to natural causes, which in the case of razorback sucker took upwards of 50 years.

Further data supporting the hypothesis that the native fishes were initially successful in recruitment were presented by McCarthy and Minckley (1987). They analyzed otoliths of seventy Lake Mohave adult razorback suckers killed between 1981 and 1983. Roughly 88 percent hatched prior to or coincident with construction and filling of Lake Mohave (1942-1954).

Ongoing work in the upper Colorado River basin, regarding the role of flooded bottom lands in the ecology of razorback suckers, provides just as striking information on how quickly the nonnative fishes can overshadow such recruitment. In attempts to increase natural recruitment of native fishes, FWS personnel flooded a bottom land parcel with water from the Green River, near Vernal, Utah, during the spring of 1995. At the end of the summer, they drained the wetland and found 28 young razorback suckers. These were the first young razorback suckers of this size observed in that age group since 1965. However, they only represented a very small portion of the fish in the wetland. Of the 11 tons of fish measured, 95 percent were non-natives. Carp dominated the catch by weight, and fathead minnows (Pimephales promelas) were numerically the most abundant fish species (FWS, 1995).

In the lower Colorado River of today, physical and chemical conditions do not favor the nonnative fishes over the native fishes, except for possibly lack of turbidity. Adequate water quality exists in the form of water volume, water temperature, dissolved oxygen, pH, specific conductance, hardness, etc. for reproduction, nursery, rearing/growth, and resting for native and nonnative fishes. Spawning habitat in the form of clean hard substrates are excessively abundant in both lentic and lotic reaches (relative to pre-Hoover Dam period). Primary production is adequate to sustain tons of fish production. Chlorophyl levels range from 1.0 to 5.0 mg/l (Paulson and Baker, 1984), which is remarkably normal for fresh waters in the temperate zone world wide (Taylor et al., 1980). Zooplankton levels in mainstem reservoirs are on the order of 10 to 50 individual organisms per liter, a level typically found in temperate lakes across North America. Benthic invertebrates in riverine reaches are probably one or two orders of magnitude greater than that which occurred in the main channel Colorado River prior to Hoover Dam. Macrophytes abound in many reaches of the lower river, adding to the already high autotrophic production. So why do the native fish not survive?

The main problem is the sheer number of new species, all with reproductive potentials as great or greater than the native fishes. Taking the three most common native fish, (historically) razorback sucker has roughly 100,000 eggs per female, Colorado squawfish produce about 100,000 eggs per female, and bonytail produce roughly 50,000 eggs per female (Hammond, pers. comm.). One of each species would yield 250,000 eggs per spawning season. Female carp average 500,000 eggs (Carlander, 1969), striped bass in the lower Colorado River have over 500,000 eggs (Edwards, 1974), one channel catfish produces 10,000 eggs (Carlander, 1969), largemouth bass average 40,000 (Carlander, 1977), one bluegill sunfish yield 25,000 eggs (Carlander, 1977), one green sunfish produces 25,000 eggs (Carlander, 1977), black crappie average 50,000 eggs (Carlander, 1977), and even one four inch threadfin shad yields 10,000 eggs per year (Carlander, 1969). One of each would total over one million for one year. Multiply these numbers by the factor of differential survival (e.g. catfish and sunfish guard their young in nests while the three native fish are broadcast spawners) and the picture becomes clearer. The nonnative fish quickly out produce the native fish. And while not all of these immature fish survive, the greatest number of each species present are the young fish (young of year and yearlings) which are the primary predators on young native fishes.

Marsh and Pacey (1998) conducted an extensive literature search on the habitat and resource use of the native and non-native fish in the lower Colorado River. They concluded the native and non-native fishes in the river over lap broadly in their physical habitat and resource use. They stated:

> "No attribute of physical habitat or resource use can be identified that markedly or marginally favors one group of fishes over another, and we cannot envision habitat manipulations or features that could be made to accomplish such a goal. Rather, the evidence supports an hypothesis that presence of non-native fishes alone precludes successful life-cycle completion by components of the native fauna. This array of non-native fishes now present has feeding, behavioral, and reproductive attributes that allow it to displace, replace, or exclude native kinds."

In Lake Mohave, Jonez and Sumner (1954) observed razorback sucker and bonytail (separate observations) spawning in large groups and the adults did not protect their eggs and larvae. In each observation, carp were observed feeding on the eggs, and young bass and/or sunfish were observed with the larvae.

Juvenile native fishes also succumb to predation. Marsh and Brooks (1989) report on the stocking of juvenile razorback suckers into the Gila River in Arizona between 1984 and 1986. They released 35,475 fish in three separate stockings. They concluded that channel catfish and flathead catfish within the first 40 kilometers of river downstream from the release sites were able to remove the entire population of planted fish.

One possible explanation for this high incidence of catfish predation was provided by the NFWG on Lake Mohave. Its work showed the juvenile razorback sucker to be nocturnal in habit, seeking protective cover during daylight hours. These observations suggest that juvenile suckers attempted to hide in the same cavities occupied by catfish, inadvertently seeking out the predator (USBR file data).

In summary, the aquatic ecosystem that exists in the lower Colorado River today, and forms the aquatic baseline for this BA, is highly modified and is physically, chemically, and biologically different than that which existed historically. Native fishes are mostly extirpated or in danger of becoming so. Physical modifications by dam construction and reservoir formation have homogenized the river system, effectively removing the "extremes" to which only the native fishes were adapted. Without such extremes the native fishes have no advantage over nonnative fishes and both groups are able to express their reproductive potential in regard to the release of gametes. Differential mortality on native fishes due to predation on early life stages by nonnative fishes sufficiently suppresses the recruitment of native fish to the adult life stage and in a matter of only a few generations, extirpation is achieved. The primary limiting factor for recruitment of native fishes in the lower Colorado River basin today is nonnative fish predation on young life stages. This has been conclusively proven by the myriad of studies and experiments in which native fishes have been successfully reared in habitats from which nonnative fishes have been removed and excluded.

Recognizing this fact, a number of current conservation and recovery actions are being taken in the lower Colorado River basin by Reclamation and other agencies to raise native fish in protected, predator-free environments until they are big enough to avoid most predators occurring in the lower Colorado River. Similarly, fishery biologists in the upper Colorado River basin now recognize the problems caused by the invasion of nonnative fishes made possible because of dams and diversions and other developments along the Green and Colorado Rivers and their tributaries and are developing strategic plans to control nonnative fishes. Recent actions in the upper basin also include offsite rearing of native fishes and stocking of juveniles back into the river system.

B. Previous and On-Going Section 7 Consultations

A complete list of previous Section 7 Consultations is contained in the *Description and Assessment of Operations, Maintenance, and Sensitive Species of the Lower Colorado River, Biological Assessment* (USBR, 1996). Reclamation completed that consultation and is in the process of implementing the Reasonable and Prudent Alternatives and Measures contained in the Biological Opinion (USFWS, 1997).

An on-going Section 7 Consultation involves development of the Lower Colorado River Multi-Species Conservation Program (MSCP). The LCR MSCP is proposed to serve as a coordinated, comprehensive conservation approach for the lower Colorado River basin for a period of 50 years.

The purpose of the LCR MSCP is to: 1) conserve habitat and work toward the recovery of threatened and endangered species and to reduce the likelihood of additional species listings under the Endangered Species Act; 2) accommodate current water diversions and power production and optimize opportunities for future water and power development; and 3) provide the basis for Federal ESA and California ESA compliance via incidental take authorizations resulting from the implementation of the first two purposes.

The program is a partnership of Federal agencies; State and local agencies in Arizona, California, and Nevada; Native American tribes; and other non-Federal participants responding to the need to balance the legal use of lower Colorado River water resources and the conservation of threatened and endangered species and their habitats in compliance with the ESA.

The program area covers the mainstem of the lower Colorado River from Separation Canyon in the Grand Canyon to the SIB with Mexico, and includes the100-year flood plain and reservoirs to full-pool elevations. Potential conservation measures will focus on the lower Colorado River from Lake Mead to the international boundary, but the partnership may consider cooperative conservation efforts developed by the Grand Canyon management effort.

A single environmental compliance document will be prepared to fulfill requirements of the National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA), Federal Endangered Species Act (ESA), and California ESA for the LCR MSCP. This document will have the working title of LCR MSCP Environmental Impact Statement/Environmental Impact Report/Biological Assessment (EIS/EIR/BA). The Bureau of Reclamation (Reclamation) and the U.S. Fish and Wildlife Service (Service) are the joint Federal lead agencies under NEPA, and the Metropolitan Water District of Southern California (Metropolitan) is the designated CEQA lead agency for the EIR.

The EIS/EIR/BA will contain the following elements:

1. Proposed Action and Habitat Conservation Plan for an ESA Section 10 permit application
2. Alternatives
3. No Action Alternative
4. Reclamation's Biological Assessment for ongoing and future actions within its legal authority.

The EIS/EIR/BA will provide a basis for a number of actions. It will document the basis for effecting ESA compliance for Federal actions through section 7 consultation and for non-Federal actions through incidental take authorization approval under a section 10 permit. The environmental documentation will also provide a basis for the issuance of a biological opinion to Reclamation and other participating Federal agencies. Finally, the environmental documentation will provide the basis for complying with the California ESA and the Natural Communities Conservation Planning Act.

C. Indirect and Cumulative Actions

1. Indirect Effects

Any indirect effects from implementation of the ISC or the SIAs will be covered under either project specific or area specific HCPs and/or Section 7 analysis.

a. Interim Surplus Criteria: No indirect effects to listed species or their habitat are expected to occur in any of the Lower Division States because of implementation of ISC. Any indirect effects of surplus criteria in Nevada will be covered under the Clark County Multi-Species Habitat Conservation Plan (HCP). This plan provides for incidental take because of growth that might result within the HCP area. Any indirect effects that may occur because of surplus water flowing into central Arizona under ISC have previously been addressed and covered under more than 40 specific consultations for the Central Arizona

Project (CAP). The CAP provides for movement and use of some of Arizona's Colorado River water including that derived from surplus through the CAP.

No indirect effects are expected in California because of implementation of the ISC. For many years, the Colorado River Aqueduct (CRA) has transported its full capacity of about 1.3 maf of water diverted from Lake Havasu to the southern coastal plain area of California. The ultimate result of implementing ISC and the actions under the SIAs discussed below will be a decrease in reliance and use by California on Colorado River water above its basic apportionment of 4.4 maf. When fully implemented this will result in as much as 800 kaf/year of Colorado River water being left in the mainstem system for other uses. The effect of ISC for California will be to provide greater predictability about the availability of surplus through 2015 on a year to year basis. The only real change will be that in years surplus is available to California, it may make up a greater share of the 1.3 maf of Colorado River water in the aqueduct. Because of this there will be no change from historic deliveries of Colorado River water into the southern coastal plain area of California and no growth inducement. Several HCP's are currently being developed in the San Diego County area.

b. Secretarial Implementation Agreements: The implementation of the SIA(s) would allow for a change in point of delivery for up to 400 kaf of Colorado River Water from Imperial Dam up stream to Parker Dam. The availability of this water would result from conservation activities associated with the lining of portions of the All-American (AAC) and Coachella Canals (CC) and from on-farm or delivery system conservation actions in the Imperial Irrigation District (IID) service area associated with the IID/SDCWA Project. The conserved water would be transferred through Metropolitan Water District's (MWD) Colorado River Aqueduct for subsequent use in the coastal plain area of Southern California.

Any indirect effects of the SIAs in California are being evaluated and addressed as effects of project specific evaluations and preparation of HCPs. The IID is preparing a HCP that will address potential effects of the IID/SDCWA Conservation & Transfer Project to endangered species within the IID and the Salton Sea area. The primary effects under evaluation relate to potential effects on listed and other sensitive species because of changes in water quantity and/or quality in agricultural drains and in flows into the Salton Sea. The IID HCP will include conservation measures for incidental take for any of these effects. Any indirect effects associated with movement of water into the Southern California area including the LA basin and San Diego County will also be covered through HCPs in place or being developed in those areas.

Potential effects to endangered species from the lining of the AAC and CC have or are being addressed under project specific ESA compliance for the lining activities. The AAC environmental compliance was completed in 1994 through filing of a FEIS and ROD. This information was reviewed for adequacy in 1999 including evaluation for the southwestern willow flycatcher. No effects were identified during this review. The CC lining DEIS will be filed in September 2000 and will include an evaluation of potential effects to listed species in the project area.

Reclamation's analysis indicates that the water transfers resulting from the canal linings and conservation activities on IID would not result in any growth inducement in the Coastal Plain area of Southern California because no additional Colorado River water will be transported through the CRA because of these actions. Historically, the CRA has transported approximately 1.3 maf of Colorado River water each year into southern California. Implementation of these actions will not change this. The only change is in the source from which the Colorado River water is derived. Historically, the water in the CRA has consisted of some combination of MWD's basic apportionment, water from a conservation agreement with IID, any unused higher priority agricultural water within California, unused apportionment from the States of Arizona or Nevada and surplus water. Under the transfer and lining actions the CRA will continue to transport the same amount of Colorado River water each year, with a greater proportion of that water likely coming from conservation and lining each year that the actions are implemented.

The environmental baseline also includes State, local, and other human activities that are contemporaneous with the consultation in process, while cumulative actions involve future State or private activities, not involving Federal activities, that are reasonably certain to occur in the action area. The various categories of these non-Federal activities are summarized below. A detailed accounting of lower Colorado River water diversions, returns, and consumptive use is provided in the "Calendar Year 1999 Compilation of Records in Accordance with Article V of the Decree of the Supreme Court of the United States in *Arizona v. California* Dated March 9, 1964" (USBR file data, 1999). It is anticipated that these contemporaneous non-Federal actions will continue in the future, and the potential effects of such actions are referenced for each ESA-protected species in Section VI. Additionally, these cumulative actions will be addressed in the MSCP process.

Many non-Federal activities listed, dealing with the direct use of mainstem water and resulting from the diversion of water from the mainstem, have affected or may affect the natural resources of the lower Colorado River and its extended environs. These can be classified as impacts occurring 1) on the mainstem river or its reservoirs, 2) on the river's floodplain, or 3) away from the river and its floodplain primarily due to the long-distance conveyance and use of Colorado River water.

The following is a list of activities that affect or may affect the resources of the lower Colorado River and its extended environs.

<u>Affecting the mainstem river and its reservoirs</u>

- diversion of state entitlement waters

- potential decrease in water quality by:
  - municipal effluent discharge
  - storm water runoff
  - agricultural drainage
  - recreational waste
  - other non-point discharges

- trash accumulation

- increased recreational use:
  - fishing
  - hunting
  - boating
  - swimming

<u>Affecting the river's adjacent floodplain</u>

- agricultural development:
  - land conversion
  - pesticide applications
  - soil erosion/minimum tillage
  - cropping patterns that benefit certain species
  - land fallowing

- municipal and industrial development:
  - land conversion
  - air pollution (dust, automotive and industrial emissions)
  - natural area management

- trash accumulation:
  - solid waste disposal (landfills)

- increased wildfire frequency
  - reduced native riparian habitat/saltcedar expansion

- increased recreational use:
  - hunting
  - camping
  - hiking
  - off-road vehicles

Affecting areas away from the lower Colorado River and its floodplain

- agricultural development:
  - land conversion
  - pesticide applications
  - water pollution (of ground or surface waters)
  - soil erosion/minimum tillage
  - land fallowing
  - air pollution (dust and smoke from burning field residues)
  - cropping patterns benefitting some species
  - water conservation and reuse

- municipal and industrial development:
  - land conversion
  - air pollution (automotive and industrial emissions)
  - water pollution (of ground or surface waters)
  - solid waste disposal (landfills)
  - water conservation and reuse

- increased recreation:
  - resource impacts (off-road vehicles, trampling)
  - management plans
  - developed recreational sites

VI. IMPACTS OF PROPOSED ACTIONS ON HABITAT AND SPECIAL STATUS SPECIES

The lower Colorado River is a dynamic system, and changes to the system as a result of human intervention over the next few decades are going to occur. Measuring the magnitude of these impacts in reference to an ever-changing baseline presents a challenge. In the present case, while a change in point of diversion of 400 kaf may not be significant, it is but a small part of a much larger identified change in point of diversion of 1.574 maf. This figure is based on projected water uses submitted to Reclamation by the Lower Basin States. This figure is the total change in point of diversion which is being analyzed under the Multi Species Conservation Program currently being developed. Therefore, impacts of smaller amounts of diversions are calculated proportional to the 1.574 maf for the following reasons:

Future changes in point of diversion may occur in increments from as little as 25 kaf initially to much larger figures. The question is, how do we apportion the impacts associated with each change in point of diversion? This is important not only ecologically, but practically, as project beneficiaries are responsible for offsetting measures for the impact. It could be argued, for instance, a change in point of diversion of 25 kaf annually is hardly measurable with insignificant environmental impacts; and indeed, it's doubtful one could place a staff gauge in the river and record the physical change in water surface elevation. However, once the change in point of diversion is made, the baseline changes accordingly. The argument could then be made for the next 25 kaf (no measurable impact) and so on. Eventually, however, the sum total of these changes in point of diversion will result in measurable ecological changes, even though individually each change is insignificant.

A. Impacts on riparian/terrestrial habitat

There are several proposed actions analyzed within this BA. Direct effects for special status species and critical habitat are discussed in section VI. Indirect and cumulative effects for the entire proposed action are discussed in section IV.C

1. Interim Surplus Criteria

Impacts on the riparian ecosystem along the lower Colorado River associated with the proposed ISC will vary for each reach of the river. The proposed ISC is discussed, in detail, in the ISC DEIS dated July 2000.

Lower Grand Canyon and Lake Mead

The ISC DEIS utilizes a hydrologic model to predict possible future hydrologic conditions within the project area (USBR, 2000) for the No Action (Baseline) and Action Alternatives. Since the future conditions are most sensitive to the inflows into the system, the model is run 85 times, each with a different inflow assumption based on historical data. The resulting set of possible outcomes (called "traces") is then statistically analyzed. These analyses consist primarily of ranking the outcomes in each future year and computing percentiles from the rankings.

Figure 9 shows the 90th, 50th (median), and 10th percentile lines for Lake Mead elevations for No Action and California Alternatives for the years 2001 through 2050. It should be noted that none of these lines are the result of any particular assumed inflow (or outcome), but rather are a statistical compilation of the set of possible outcomes. Therefore, they can be used to show general trends over the next few decades.

At the 50th percentile, under the No Action Alternative, Lake Mead is predicted to decline from approximately 1,205 feet in December 2000 to approximately 1,171 feet in December 2015. This decline is due to the relatively high reservoir levels seen in December, 1999 (the

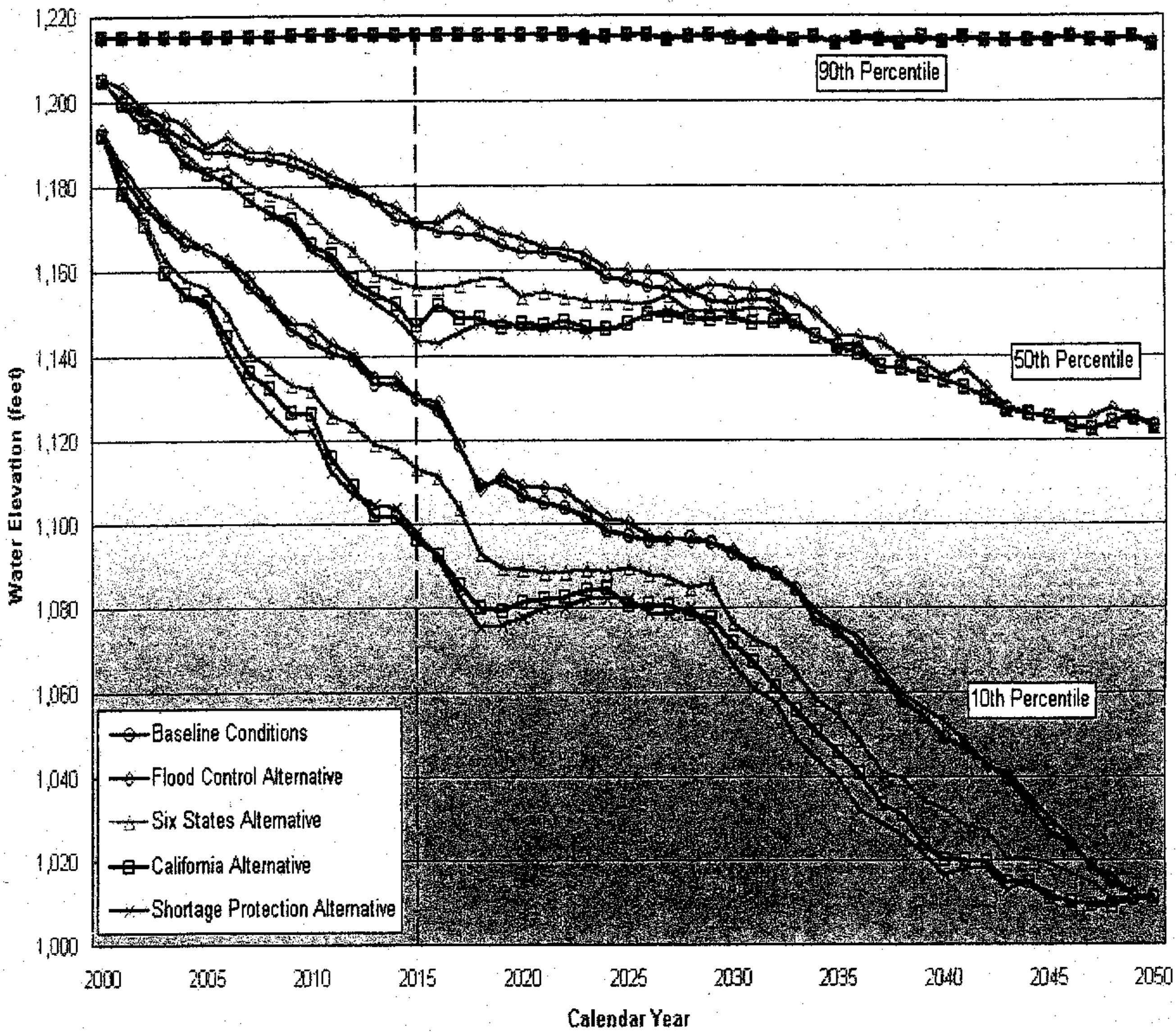

Figure 9. Lake Mead End-of-Year Water Elevations Comparison of Surplus Alternatives and Baseline Conditions 90th, 50th, and 10th Percentile Values.

initial conditions input to the model) and the increasing Upper Basin depletions, which tend to lower Lake Powell and reduce releases to the Lower Basin in excess of the minimum objective release (8.23 maf).

The alternative from the Colorado River ISC DEIS analyzed in this BA is the California Alternative (USBR, 2000). Under the California Alternative, Lake Mead levels are predicted to decline from approximately 1,205 feet in December 2000 to approximately 1,147 feet by December 2015 at the 50th percentile. This represents a reduction in Lake Mead elevation of approximately 24 feet from the No Action Alternative at the 50th percentile. By 2033, there are no predicted differences in Lake Mead elevation between the California Alternative at the 50th percentile.

To further understand the potential effects of the proposed ISC, 90th percentile and 10th percentile scenarios were also analyzed. At the 90th percentile Lake Mead stayed at its full pool elevation through the year 2050 for both the No Action Alternative and the California Alternative because the 90th percentile represents high inflow into a full system. At the 10th percentile the No Action Alternative predicted lake levels to decline to approximately 1,130 feet by 2015 and to 1,011 feet by 2050. The California Alternative predicted lake levels to decline to approximately 1,096 feet by 2015 and to 1,010 feet by 2050 at the 10th percentile (USBR, 2000).

Three major factors may influence the potential impacts of the implementation of an ISC. According to the hydrologic modeling, Lake Mead water surface elevation is projected to fluctuate between full level and progressively lower levels. Neither the timing of water level variations between the highs and the lows, nor the length of time the water level would remain high or low can be predicted. These events would depend on the future variation in basin runoff conditions. However, the timing of the decline, as it relates to the exposed sediment, will influence the future riparian habitat composition. The amount of decline may influence the establishment of riparian habitat. Also, the potential for re-filling Lake Mead must be considered.

The first factor is the timing of lake level declines. From January 1978 until June 1990, Lake Mead elevations were above 1,182 feet on a continuous basis. In June, 1990, Lake Mead elevation declined to approximately 1,182 feet and stayed below that elevation until the end of 1992. The initial decline to 1,182 feet in June, 1990, and 1,179 feet in July, 1990, coincided with seedfall for Goodding willow. Approximately 1,400 acres of predominantly Goodding willow became established at the Lake Mead delta, near Pierce Ferry, Arizona, as sediments became exposed during this time period. Willow stands also became established along the lower Grand Canyon, below Separation Rapids to the Lake Mead delta, and at the mouths of the Virgin and Muddy Rivers. In contrast, Lake Mead elevations were rarely above 1,182 feet prior to 1978, with an eleven month period from May, 1962, until March, 1963, representing the longest period that Lake Mead elevation stayed above that mark, inundating the delta area. Drought conditions in the 1950s, compounded by the filling of Lake Powell in the 1960s, produced a scenario where Lake Mead elevations exposed the delta area for periods as long as ten years. During the years when Lake Mead elevations were high enough to inundate the delta, these high lake levels almost always occurred during June and July. The Lake Mead delta only became exposed before or after cottonwood-willow seedfall. Thus, saltcedar, which seeds from early spring to late fall, became the predominant community type in the Lake Mead delta area (USBR, unpub. data).

As Lake Mead elevation declines, sediments become exposed. A second factor that may influence the type of plant community that will become established is the depth to groundwater or river surface elevation from these exposed sediments. Current lake bottom elevations are not known and may, in fact, be slightly higher than the 1,182 foot elevation seen in 1990 due to the Glen Canyon experimental beach/habitat-building flow conducted during the spring of 1996 and normal sedimentation since then. As the lake level declines and the present day lake bottom becomes exposed, the river elevation as it downcuts through the newly exposed delta will help determine whether cottonwoods or willows can survive, even if they become established. If the river surface elevation is 8-10 feet below the surface of the exposed soil, cottonwoods and willows would begin to incur mortality, thus, opening gaps for saltcedar and other species to become established.

The hydrologic modeling predicts that Lake Mead elevations are projected to fluctuate between full level and progressively lower levels during the 50-year period of analysis (2001 to 2050) under the California and No Action Alternatives. However, as wet hydrologic cycles occur in the future, Lake Mead will fill. If this event occurs after the establishment of riparian habitat due to declining lake levels, the newly established habitat would become inundated as occurred in the 1990s.

It is difficult to determine exactly how many acres of riparian habitat may be formed due to declining Lake Mead elevations. The majority of the Lake Mead shoreline does not have the soil necessary to regenerate riparian habitat. Riparian habitat created by declining lake levels would most likely occur in four areas: Lake Mead delta, Virgin River delta, Muddy River delta, and the portion of the Grand Canyon influenced by Lake Mead.

At the 50th percentile, Lake Mead elevations are predicted to decline by 34 feet under the No Action Alternative by 2015. The proposed ISC would decrease lake levels by an additional 24 feet by year 2015. This decrease in elevation is within the historic fluctuations of Lake Mead. Implementing the California Alternative ISC is unlikely to have a negative effect on river surface elevation within the delta areas around Lake Mead and may, in fact, increase the amount of exposed soil for the establishment of riparian habitat.

Hoover Dam to Parker Dam

River flows between Hoover Dam and Parker Dam are comprised mainly of flow releases from Hoover Dam and Davis Dam. Inflows from the Bill Williams River and other intermittent tributaries are infrequent and usually concentrated into short time periods due to their reliance on localized precipitation. Tributary inflows comprise less than 1 percent of the total annual flow in this reach of the river.

Seasonal, monthly, and daily releases from Hoover Dam reflect the demands of Colorado River water users with diversions located downstream of Hoover Dam, power production and storage management in Lakes Mohave and Havasu. The scheduling and subsequent release of water through Davis and Parker Dams affect daily fluctuations in river flows, depths, and water surface elevations downstream of these structures. The water surface elevation fluctuates most noticeably in the river reaches closest to the dams. Those fluctuations become more and more attenuated as the distance downstream increases. The modeling performed for the DEIS yields only mean monthly flow data. Therefore, the daily attenuation of flows in the downstream reaches were not evaluated for the DEIS or this BA.

Implementation of the California Alternative ISC may produce slightly higher mean monthly flows within this stretch of the Colorado River during the 15 year ISC period as a result of more frequent or larger surplus deliveries. At the 50th percentile, the California Alternative is predicted to increase mean monthly releases from Hoover Dam by an average of 370 cfs over the No Action Alternative, considered the baseline or 75R. At the 90th percentile, the increase in mean monthly flows average 655 cfs, while at the 10th percentile, the California Alternative is predicted to average 24 cfs less than the No Action Alternative (USBR, 2000). Beyond the 15 year interim period, there is little difference between flows predicted for the No Action Alternative conditions and those predicted under the California Alternative. This is expected as the California Alternative reverts to No Action Alternative in 2016.

Mean monthly releases from Hoover Dam differ between seasons due mainly to irrigation demands. On the Colorado River downstream of Havasu National Wildlife Refuge, the 50th (median) percentile, mean monthly flows for years 2001 to 2015 average around 9,000 cfs in the winter, 16,000 cfs in the spring, 15,000 cfs in the summer, and 10,000 cfs in the fall under both the No Action Alternative and California Alternative. During the winter season, the probability of flood releases is approximately 25% under No Action Alternative conditions. The probability declines to approximately 22% under the California Alternative. Probability of flood releases during the spring and summer are less than 2% under No Action Alternative conditions or the California Alternative (USBR, 2000).

The effects of implementing the California Alternative surplus guideline on riparian habitat between Hoover Dam and Parker Dam are negligible. Differences expected in mean monthly flows between the No Action Alternative conditions and the California Alternative are slight. The proposed surplus guideline may have a slightly positive effect on the riparian plant community within this reach of the river by providing increased flows and a corresponding increase in the groundwater table.

Parker Dam to Imperial Dam

Changes predicted by the hydrologic model in mean monthly flow between Parker Dam and Imperial Dam are influenced by the SIAs discussed in Section 1.B. The hydrologic model assumed that the SIAs were not in effect under No Action Alternative conditions while the SIAs were in effect when analyzing the ISC. Changes in mean monthly flow in this reach that may be due to the ISC are compounded by the SIAs.

One can assume that the change in normal mean monthly flows below Parker Dam due to ISC would be negligible as surplus waters are primarily diverted above Parker Dam. However, the implementation of ISC could have a slight effect on decreasing the probability of flood control releases and potential overbank flooding below Parker Dam.

The probability of flood control releases under the No Action Alternative are expected to decline from approximately 38% in 2005 to 27% in 2015. The frequency is predicted to continue to decline to approximately 18% by 2050. The decrease in probability of flood control releases is due mainly to Upper Basin development. Under the California Alternative, the probability of flood control releases are predicted to decline from 38% in 2005 to 22% in 2015, a difference of 5% in frequency from the No Action Alternative. The frequency is predicted to continue to decline to approximately 18% by 2050, the same as under the No Action Alternative (USBR, 2000).

Flood control releases do not necessarily produce the overbank flows needed for regeneration of riparian habitat. Amount, timing, and duration of potential flood events all are important elements in determining the effects of overbank flows on regeneration of riparian habitats. The best available data on the effects of overbank flooding on the lower Colorado River, since the completion of the Glen Canyon Dam in 1964, are from the 1983-87 flood event.

In January, 1983, Reclamation began flood control releases from Hoover Dam. The January 1983 average release was measured at 19,130 cfs. In early February, 1983, flood control releases were stopped. However, in April, 1983, the releases were started again, averaging 17,810 cfs in April. Releases continued to rise, peaking at 50,800 cfs on July 23, 1983. Releases continued to exceed 19,000 cfs until the spring of 1987.

The 1983-87 event impacted riparian vegetation along the Colorado River between Davis Dam and the SIB (See Table 8). Although the total amount of cottonwood-willow habitat actually decreased from 7,975 acres in 1981 to 5,754 acres in 1986, the majority of the acres lost were in the CW IV type. In the younger CW V and CW VI types, however, the amount increased slightly from 2,639 acres to 3,294 acres. Loss of older stands and an increase in recruitment is the pattern seen on the Bill Williams River when flood events occur, and is how historic flood events on the lower Colorado River would likely have affected vegetation as well. Since 1986, there has been an increase in CW III acres as the younger stands have matured. Saltcedar also increased in total acreage after the 1983-87 event, especially in the SC V type.

The 1983-87 flood event had impacts on the geomorphology of the lower Colorado River. It is estimated that the river bottom degraded at least three feet in the vicinity of the Topock Marsh inlet ditch (Bill Martin, USBR, pers. comm.). In many areas within the reach between Parker Dam and Imperial Dam, flows in excess of 50,000 cfs would be required to produce overbank flooding, without drastic manipulation of the river or adjacent floodplain. The channel bottom of the river below Davis and Parker Dams has degraded over time, but the 1983 flood event increased the degradation much more rapidly (USBR, unpub.data).

The probability of mean daily flows equal to or greater than 19,500 cfs being released at Parker Dam are 13.9% under No Action Alternative conditions and 13.0% under the California Alternative between 2001 and 2015. The probabilities increase slightly after the interim period ends in 2015 to 19.7% for the No Action Alternative and 17.9% for the California Alternative (USBR, 2000). Flows greater than this magnitude would begin to cause property damage in the Parker Strip area just south of Parker Dam. The 1983-87 event caused over $5.8 million in damage during 1983 alone. The 1984 Flood Control Benefits Report estimated that over $177 million in damage would have occurred along the lower Colorado River between 1983 and 1984 if flood control structures were not in place during this flood event (USBR file data, 1984).

2. Secretarial Implementation Agreement

Six actions are covered in the Secretarial Implementation Agreement (SIA). The major purpose of these actions is to establish a framework for the Secretary of the Interior to release Colorado River water to satisfy annual water supply needs within the annual apportionment of Colorado River water available for use in California. Implementation of the SIA will result in a change in point of diversion from Imperial Dam to Parker Dam of up to 400 kaf per year.

Concurrent with this BA, a separate biological assessment is being prepared for the Lower Colorado River Multi-Species Conservation Program (MSCP). The six actions covered under the SIA and the additional projects covered under the MSCP total 1.574 maf change in point of diversion. It must be noted, however, that this total figure may change in the future as the MSCP process evolves. If impacts to the affected habitat change as a result, this BA will be amended.

The effects on annual median flows at twenty points along the lower Colorado River between Parker Dam and Imperial Dam are shown in Appendix A, Table A-1. Changes to annual median flow due to the change in the point of diversion of the total 1.57 maf flows are projected to reduce river elevations by a minimum of 0.08 feet to a maximum of 1.55 feet at various points along this reach of the river.

The relationship between river surface elevation and groundwater elevation is dependent on several factors. Declines in groundwater elevation are roughly equal to river surface elevation declines in reaches where surface river water is not diverted for irrigation. Tributary inflows and water consumption by riparian vegetation are assumed to remain constant. In areas where surface water is diverted for irrigation, subsurface return flows raise the water table at the point of application. The groundwater table gradually declines as the water moves from the irrigated field towards the river or any other drain. Changes in irrigation practices and/or crops and cropping patterns will change the relationship between river surface elevation and groundwater elevation.

Flow in the Colorado River below Parker Dam can fluctuate significantly on a seasonal, daily, and hourly basis. These variations are the result of water orders (irrigation, municipal and industrial), power demands, and other routine operations (USBR, 1996). The change in point of diversion of 1.574 maf will affect maximum and minimum hourly flows differently, depending on the season. The tables in Appendix A show changes in river surface elevation for minimum and maximum hourly flows on a seasonal basis. However, for this analysis, only the annual median flows are examined. Frequency of fluctuation may affect the relationship between the groundwater elevation and the river surface elevation. Other factors, such as soil porosity and distance from the river, may affect the amount of time required for groundwater levels to correspond to changes in river surface elevations.

Riparian vegetation is sustained by groundwater and/or subsurface return flows from agriculture. For many habitat types, a reduction in groundwater elevation of 1.55 feet or less, due to a reduction in annual median flows, will have little or no impact on the continued survival of the vegetation itself. However, changes to the overall habitat quality and microclimate within stands of riparian vegetation may be affected. Survival of saltcedar, mesquite, arrowweed, and quailbush will not be affected by this change in groundwater elevation. Table 11 lists the acreage, by habitat type, between Parker Dam and Imperial Dam that may be found within the portion of the floodplain influenced by a change in groundwater elevation.

Table 11. Habitat Types Within the Area of Affect by Acreage.

Habitat Type	Acreage
Atriplex spp.	447
Arrowweed	2,660
Cottonwood-Willow	1,495
Honey Mesquite	3,056
Saltcedar	30,895
Saltcedar-Honey Mesquite	13,895
Saltcedar-Screwbean Mesquite	4,993

Cottonwoods, willows, and marsh types are most susceptible to changes in groundwater elevation. Changes in maximum hourly flows throughout the growing season have the potential to affect existing cottonwood-willow stands in areas where the change in river elevation is immediately reflected in a change in groundwater elevation, such as cottonwood-willow stands that border backwaters that are connected to the river. For areas not directly associated with backwaters connected to the river or areas very close to the mainstem river channel, the changes in maximum and minimum hourly flows will probably be muted. In these areas, changes in annual median flows were used to estimate the effects of groundwater depletion due to a change in point of diversion.

Cottonwood and willow are susceptible to changes in groundwater elevation depending on many factors including root development, structure type, existing depth to groundwater, and availability of alternate water sources, such as irrigation return flows. Recently established stands (types V and VI) are most susceptible to changes in water table elevations. Only 46 acres were classified in 1997 as CW V or CW VI within this stretch of the river (see Table 9). All of the CW VI stands and several of the CW V stands were new revegetation projects conducted by the Colorado River Indian Tribes (CRIT), Bureau of Reclamation, or State of California. Several of the CW V stands were naturally occurring within marsh types at

Imperial National Wildlife Refuge near Picacho and Imperial Dam.

Optimum depth to groundwater for cottonwood-willow stand maintenance is 4 feet or less. However, cottonwood-willow stands can survive up to 9 feet above groundwater (Pinkney, 1992; Zimmerman 1969 *in* Stromberg, 1993; USBR, unpub. data). If flow reductions reduce groundwater elevations to a point greater than 9 feet below existing cottonwood-willow stands, it is expected to cause mortality and potentially, a change in species composition. The condition or quality of cottonwood and willow habitat may be affected in varying degrees and at differing rates by changes in groundwater elevation. These impacts would depend on many factors including how fast the drop occurs, time of year, and existing root development, among others and precise impacts are difficult, if not impossible, to predict.

Habitat utilized by Willow Flycatchers can vary from site to site based on vegetational species composition, elevation, patchiness, humidity, temperature, and other factors. The dense structure of the vegetation and the presence of either standing water, moist soil, or water adjacent to the site are two characteristics that are generally consistent throughout the bird's range (McKernan, 1998; Sogge et al., 1997). A sufficient drop in groundwater level could have the effect of drying up soils at the surface and lowering surface water levels, thus affecting the suitability of the habitat for willow flycatchers.

Estimate of Potential Willow Flycatcher Habitat

Approximately 1,570 acres of cottonwood-willow and 32,141 acres of saltcedar of all structural types were determined to exist through 1997 vegetation mapping between Parker Dam and Imperial Dam (see Table 9). However, southwestern willow flycatchers are found in stands of dense vegetation with a component between 8 and 25 feet in height (USFWS, 1997; Sogge, 1997; McKernan, 1998). For riparian habitat, this corresponds to cottonwood-willow structural types I, II, III and IV and saltcedar structural types III and IV (Table 12).

The total area of cottonwood and willow types I, II, III, and IV, and saltcedar types III and IV is 21, 218 acres. The acreage known to be occupied southwestern willow flycatcher breeding habitat within this reach is approximately 1,500 acres. The remaining 19,718 acres of cottonwood/willow and saltcedar, between Parker and Imperial Dams is not presently suitable willow flycatcher habitat. Although it is comprised of the desired vegetational structure and composition, it is not suitable because it lacks other necessary features (R. McKernan, Pers. Comm.). Although this habitat is considered unsuitable at this time, it could be improved with appropriate management in the future.

The proposed action will have little effect on the 19,718 acres of habitat not presently suitable as willow flycatcher breeding habitat. The majority of this habitat is comprised of saltcedar types that are perched far enough above the groundwater table that surface water or saturated soils are not found within these stands (R. McKernan, per.comm.). A drop of 1.55 feet or less in the groundwater table will not affect the species composition within these stands. Although saltcedar stands are highly susceptible to disturbance, especially by wildfire, natural regeneration by native cottonwoods and willows has already been precluded due to the lack of scouring flood events. Saltcedar readily re-sprouts after a fire so saltcedar dominated stands will remain saltcedar. Any effects will be limited to cottonwood-willow stands that are not currently occupied habitat or in stands where cottonwood and/or willow compromise a small (<10%) component of a mixed saltcedar-native stand. The latter case represents stands that would not be classified as cottonwood-willow under the current vegetation classification system but may have a minor native plant component (Anderson and Ohmart, 1984). These stands would tend towards monotypic saltcedar after disturbance by fire.

Table 12. Acreage of *Potential Southwestern Willow Flycatcher Habitat Within the Proposed Action Area.

Habitat Type	Acreage for 1.57 MAF	Acreage for 400 KAF
Cottonwood/Willow I	112.6	28.7
Cottonwood/Willow II	27.8	7.1
Cottonwood/Willow III	875.4	223
Cottonwood/Willow IV	359.9	91.7
Total Cottonwood/Willow	**1375.7**	**350.5**
Saltcedar III	592.4	150.9
Saltcedar IV	19250.3	4904.5
Total Saltcedar	**19842.7**	**5055.4**
Total Potential Habitat	**21218.4**	**5405.9**

*Potential in this case is defined as suitable according to vegetation structure only.

Estimate of Occupied Willow Flycatcher Habitat

Occupied willow flycatcher habitat is defined as "a contiguous area with consistent physical and biotic characteristics where territorial males or pairs of flycatchers have been documented during previous breeding seasons (generally after June 15) at least once in the last few years, assuming the habitat has not been degraded or otherwise altered in the interim. If a portion of contiguous habitat is or was used, the entire contiguous area is considered occupied" (Cordery, pers. comm.). Since 1996, data from willow flycatcher surveys (McKernan, 1996, 1997, 1998, 1999) on all occupied habitat on the lower Colorado River has been stored in a GIS database by Reclamation.

Topographical maps and USBR GIS data were used to determine the acreage of occupied habitat within the area affected by a groundwater or surface water drop due to a change in point of diversion of 1.574 maf. In addition, hydrological data (Table 13) is available for sites between Parker Dam and Imperial Dam known to be occupied by willow flycatchers (McKernan, 1999). This data was collected during willow flycatcher breeding season; i.e. between May 15 and August 15, by taking soil samples from 30 locations within each site at 0 to 3cm depths every two weeks.

The acres of occupied habitat between Parker and Imperial Dams that will be affected by the 1.574 maf change in point of diversion totals 1,506 acres. Only one site has standing water present deep enough not to be affected by a groundwater drop between 0.08 feet and 1.55 feet, and it has been excluded from the analysis. The total acreage for all occupied willow flycatcher sites characterized by saturated soils and/or depth of standing water less than or equal to 1.55 feet is 1,460. Again, a proportional analysis brings this total to 372 acres.

The 5,404 acres of potential and 372 acres of occupied willow flycatcher habitat will not die, as even the maximum drop in elevation due to the change in point of diversion of the total 1.574 maf only decreases the median river elevation, and thus the groundwater, by 1.55 feet, and will not occur instantaneously regardless. As explained above, established cottonwood, willow and saltcedar can withstand a 1.55 foot drop in groundwater, as their roots extend below it (Fenner et al., 1984; Jackson et al., 1990; Segelquist, 1993). Even newly established cottonwood and willow can withstand a drop in groundwater as long as it does not occur faster than the roots can grow (Jackson et al., 1990). However gradual the drop in groundwater is, trees with roots in the groundwater below 1.55 feet would not incur mortality. However, there are possible impacts to the habitat due to changes in groundwater levels that are more subtle and there is a need to further study these changes.

The drop in groundwater due to a change in point of diversion would not be instantaneous, therefore, vegetational and microclimatic changes within the sites would be gradual and difficult to predict. Studies are underway to determine the general ecological processes which make habitat preferable to species. Some of these processes include establishment of new riparian vegetation, groundcover, species composition, prey selection and abundance.

Yellow-billed Cuckoos, are likely to be listed as endangered in the near future. The effects to the habitat this species is known to utilize overlaps the effects to willow flycatcher habitat in some areas on the lower Colorado River (McKernan, 1999) and is subject to the same impacts to the habitat previously discussed. Although less data are available for specific areas and acreage utilized by cuckoos between Parker and Imperial Dam than is available for willow flycatchers, the above general effects apply to both species.

Table 13. Site Hydrology at Southwestern Willow Flycatcher Survey Sites, 1996 –1999

SITE NAME (Acres)	% SITE WITH SURFACE WATER	AVERAGE DEPTH OF SURFACE WATER	DISTANCE FROM SURFACE WATER	% OF SITE WITH SATURATED SOIL** (excluding area with surface water)
	1996/1997/1998/1999	1996/1997/1998/1999	1996/1997/1998/1999	1996/1997/1998/1999
Big Hole Slough- Blythe (46.2 ac)*	na/na/60/50	na/na/1m/1m	na/na /20m/30m	na / na / 50 / 50
Ehrenberg (21.5 ac)	30/50/20/10	2cm/2cm/5cm/1cm	5m /5m / 5m / 5m	50/ 100 / 80 / 50
Headgate Rock (48 ac)	10/10/10/20	5cm/5cm/10cm/10cm	30m/30m/30m/30m	30 / 50 / 20 / 20
Imperial NWR (39.3 ac)	50/ 30/ 10/ 20	1cm/1cm/1cm/1cm	60m/60m/60m/60m	25/25/25/25
Lower Walker Lake (334 ac)	30/ 30/ 30/ 30	30cm/20cm/20cm/5cm	10m/10m/10m/10m	100/100/100/100
Cibola Lake (61 ac)	70/ 70/ 50/ 50	10cm/20cm/20cm/5cm	5m/5m/5m/5m	25/25/25/25
Adobe Lake (185.6)	10/ 10/10/ 10	5cm/5cm/10cm/10cm	10m/10m/10m/10m	50/50/50/50
Paradise Valley (104.4)	20/ 20/ 30/ 30	1cm/1cm/1cm/1cm	25m/25m/25m/25m	100/100/100/100
The Alley (244 ac)	70/ 70/ 50/ 50	30cm/20cm/20cm/5cm	5m/5m/5m/5m	100/100/100/100
Camp Store (44.1 ac)	50/ 50/ 30/ 30	5cm/5cm/10cm/10cm	10m/10m/10m/10m	100/100/100/100
Draper Lake (248 ac)	20/20/30/30	30cm/20cm/20cm/5cm	25m/25m/25m/25m	100/100/100/100
Ferguson Lake (130.6 ac)	70/70/50/50	5cm/10cm/10cm/10cm	5m/5m/5m/5m	100/100/100/100

* Site Deleted from analysis, water depth > 1.55'
** Saturated soil criteria is based on rankings of substrate samples taken within the SWWF survey area.
Observers sample multiple areas (n=30) of each surveyed site at 0 to 3cm soil depth every two weeks between 15 May and 15 August.

B. Impacts on aquatic and backwater habitat

1. Interim Surplus Criteria

The primary lake habitats identified for potential effect due to surplus criteria include Lake Powell and Lake Mead. Other reservoirs downstream of Lake Mead (Lake Mohave and Lake Havasu) are expected to be largely unaffected by the proposed ISC because operation of the project typically keeps lake levels at specified target elevations to facilitate power generation and water deliveries.

Native Colorado River fishes have not fared well in reservoir environment dominated by non-native predators. While some native species may spawn within the reservoir and others have young that drift into the lakes, predation is believed to eliminate young native fish from the reservoirs and precludes their survival and recruitment. Non-native species, however, have become well-established.

There are no specific threshold lake levels that are definitive for evaluation of potential impacts to lake habitat in Lake Powell or Lake Mead. Modeling results indicate a trend toward decreasing pool elevations with varying degrees of probability over time under baseline conditions and for each of the alternatives.

Modeling results indicate increased probabilities for Lake Powell and Lake Mead surface elevation declines over the 50-year period of analysis under baseline conditions and the ISC. These modeling projections indicate future habitat conditions at Lake Powell and Lake Mead will continue to be subjected to varying inflows and fluctuating lake elevations primarily based on hydrologic conditions present in the watershed and water diversions in the Upper Basin. Historically, these conditions have resulted in lake habitat that is favorable to nonnative species and unfavorable to native species. Projections of increased potential for future reservoir surface declines.in both Lake Powell and Lake Mead are similar when comparing baseline conditions to each of the alternatives and are not likely to result in substantial changes to lake habitat.

Effects of the ISC on riverine habitat are expected to be minimal. The major effects may occur on the reach of the Colorado River between Glen Canyon Dam and Lake Mead. However, expected changes, if any, would be covered within the range of operations covered by the Adaptive Management Plan for the Grand Canyon. Implementation of the ISC may produce slightly higher mean monthly flows within the Grand Canyon during the 15 year interim surplus period as a result of more frequent equalizations.

2. Secretarial Implementation Agreements

Impacts on the aquatic and backwater habitat are the result of a change in point of diversion of 400 kaf from Imperial Dam to Parker Dam. The area has over 4,000 acres of backwater habitat plus over 10,000 acres of riverine habitat. Months selected for impact analysis were April, August and December. These months were selected as April represents the highest flows in the system, and backwater areas are important for nursery areas for larval fish. April also represents new growth and dormancy break for cattail and is within the Yuma clapper rail breeding season. Backwaters in August are necessary for juvenile fish cover, and December represents the lowest water elevations throughout the year.

Table 14 shows the impacts expected for 200, 300, and 400 kaf change in point of diversion. In summary, April shows the greatest impact with a reduction of 24 acres of open water associated with backwaters, 38 acres of emergent vegetation associated with backwaters, and 47 acres of open water associated with river channel. August and December show a lesser reduction.

Table 14. Open Water and Emergent Vegetation Reductions*

April Acreage Reduction				
Acre Feet (1000s)	Backwater Open Water	Backwater Emergent	River Channel Open Water	Total Open Water
200	12	19	24	36
300	18	29	35	53
400	24	38	47	71
August Acreage Reduction				
Acre Feet (1000s)	Backwater Open Water		River Channel Open Water	Total Open Water
200	5		7	12
300	7		11	18
400	10		14	24
December Acreage Reduction				
Acre Feet (1000s)	Backwater Open Water		River Channel Open Water	Total Open Water
200	4		6	10
300	6		9	15
400	8		12	20

* Proportional to 1.574 maf reduction

Marsh species which may be affected by the acreage reduction of backwaters include the Yuma Clapper Rail and the California Black Rail. Yuma Clapper Rail and California Black Rail are found in the type of habitat provided by the backwaters along the lower Colorado River. A reduction in this habitat would be expected to affect these species.

Razorback sucker and bonytail chub likewise may be affected by the reduction in open water in the river and backwaters. The river reach below Parker Dam is designated critical habitat for the razorback sucker. While there would be some modification of the habitat, it would not be expected to be adversely affected to any great degree. As stated before, that impact would be from a slight lowering of water levels in the mainstem. While bonytail chub do not presently inhabit the reach of the river below Parker Dam, they may likely be introduced in the future. Bonytail occur in Lake Havasu immediately upstream. Bonytail are one of the four big river fishes which are the subject of intensive recovery efforts. Both of these fish species require spawning gravels in the river, and the reduction in depth from reduced flows would be expected to affect those species.

VII. SPECIES DESCRIPTIONS

A. Terrestrial

Southwestern Willow Flycatcher (*Empidonax traillii extimus*)
Federally Endangered

Description and Life Requisites

Willow flycatchers are found throughout North America and are further divided taxonomically into four subspecies, *E.t. brewseri, E.t. adastus, E. t. traillii,* and *E.t. extimus.* The latter, *E.t. extimus*, the southwestern willow flycatcher, breeds on the Lower Colorado River and its tributaries (McKernan, 1997, McKernan and Braden, 1998 & 1999). In January 1992, The U. S. Fish and Wildlife Service (FWS) was petitioned to list the southwestern willow flycatcher, *Empidonax traillii extimus* as an endangered species. In July 1993, the species was proposed as endangered with critical habitat (58FR39495). On February 27, 1995, FWS listed the southwestern willow flycatcher as an endangered species (60FR10694). There is no recovery plans in place as of this writing and the designated critical habitat does not include the lower Colorado River (60FR10694).

As a member of the genus *Empidonax,* willow flycatchers are known for the difficulty in identifying individuals to species in the field (Phillips et al., 1964; Peterson, 1990; Sogge et al., 1997). The southwestern willow flycatcher is a small bird, approximately 5.75 inches in length, with a grayish-green back and wings, whitish throat, light grey-olive breast, and pale yellowish body. Two white wing bars are visible. The upper mandible is dark, the lower light. The most distinguishable taxonomic characteristic of the southwestern willow flycatcher is the absent or faintly visible eye ring. The southwestern willow flycatcher can only be positively differentiated in the field from other species of its genus by its distinctive "fitz-bew" song.

Southwestern willow flycatchers nest in riparian habitat characterized by dense stands of intermediate sized shrubs or trees. Most southwestern willow flycatcher nests are located in the fork of a shrub or tree from 4 to 25 feet above the ground (Unitt, 1987; Sogge, 1997). The nest site almost always contains or is adjacent to water or saturated soil (Phillips et al., 1964; Muiznieks et al., 1994, McKernan and Braden, 1998). The southwestern willow flycatcher is an insectivore, foraging within and above dense riparian habitat, catching insects in the air or gleaning them from the surrounding foliage. It also forages along water edges, backwaters, and sandbars adjacent to nest sites. Details on specific prey items can be found in Drost et al. (1998). On the lower Colorado River, southwestern willow flycatchers begin arriving on breeding territories in early-May and continue to be present until August, with some records into early September (McKernan and Braden, 1998). Recent studies have documented nest building as early as May 1 (McKernan, 1997) and fledging dates as late as September 9 (McKernan and Braden, 1998).

A long-distance migrant, the southwestern willow flycatcher winters in Mexico from Nayarit and southwestern Oaxaca south to Panama and possibly extreme northwestern Columbia and migrates widely through the southern U.S., occurring as a regular migrant south to the limits of the wintering range (Peterson, 1990; Sogge, 1997, AOU, 1998). Recent field studies in Costa Rica by Koronkiewicz and Whitfield (1999) and studies of museum specimens by Phil Unitt (1999) collaborate previous information on the species' range. One specimen of willow flycatcher captured in Costa Rica during the winter of 1999 was banded at the Ash Meadows National Wildlife Refuge (NWR) in southern Nevada in July 1998 (Koronkiewicz and Whitfield, 1999). The Ash Meadows NWR is within the identified breeding range of this southwestern subspecies and thus the capture in Costa Rica is the most recent confirmed wintering site of *E.t. extimus*. Breeding range for the species as a whole extends as far south as northern Sonora, and northern Baja California (AOU, 1998) and north into Canada. Breeding range for the southwestern subspecies of the willow flycatcher, *E. t. extimus*, extends from extreme southern Utah and Nevada, through Arizona, New Mexico, and southern California, but records from west Texas and extreme northern Baja California and Sonora, Mexico remain lacking to date (Unitt, 1987). The species has been documented at El Doctor wetlands, Colorado River delta, Sonora, Mexico June 7 and 8, 1999 (Huerta, University of Arizona, pers. comm.). This sighting confirms the area is used for migration, but does not confirm breeding. The presence of the subspecies after June 15 is required to confirm breeding (Sogge et al., 1997; Braden and McKernan, 1998).

The majority of southwestern willow flycatchers found during the past five years of surveys on the lower Colorado River have been found in saltcedar, *Tamarix ramosissima*, or a mixture of saltcedar and native cottonwood and willow, especially Gooddings willow, *Salix gooddingii*, coyote willow, *S. exigua* and Fremont cottonwood, *Populus fremontii*. Based on available information at the time of this writing, aside from the presence of water and dense structure of vegetation, no clear distinctions can be made based on perennial species composition, as to what constitutes appropriate southwestern willow flycatcher habitat. Due to the difficulty in determining the presence of this species in dense habitat, its presence should not be ruled out until surveys have been conducted if habitat meeting the general description given above is present.

Distribution and Abundance

Historically, the southwestern willow flycatcher was widely distributed and fairly common throughout its range, especially in southern California and Arizona (Unitt, 1987; Schlorff, 1990). Nest and egg collections by Herbert Brown suggest that the southwestern willow flycatcher was a common breeder along the lower Colorado River near Yuma in 1902 (Unitt, 1987).

Grinnell (1914) also believed that the southwestern willow flycatcher bred along the lower Colorado River due to the similarities in habitat between the lower Colorado River and other known breeding sites. He noted the abundance and possible breeding behavior of southwestern willow flycatchers observed in the willow association. However, the date of his expedition corresponds more to the migration season of the southwestern willow flycatcher, with only a small overlap with the beginning of the breeding season.

In 1993, FWS estimated that only 230 to 500 nesting pairs existed throughout its entire range (58FR39495). However, since extensive surveying has been implemented, this number has increased, especially on the lower Colorado River where the species was thought to have been extirpated (Hunter et al., 1987; Rosenberg et al., 1991; McKernan and Braden, 1999). Sixty four nesting attempts were documented on the lower Colorado River from southern Nevada to Needles, California in 1998 (McKernan and Braden, 1999).

Several factors have caused the decline in southwestern willow flycatcher populations. Extensive areas of suitable riparian habitat have been lost due to river regulation and channelization, agricultural and urban development, mining, road construction, and overgrazing (Phillips et al., 1964; Johnson and Haight, 1984; Unitt, 1987; Rosenberg et al., 1991; Sogge et al., 1997). The total acreage of riparian vegetation has changed little in the last 25 years (see Table 8 and CH2MHill, 1999), although there is less native vegetation and more non-native present (Rosenberg, 1991). A description of historical southwestern willow flycatcher habitat can be found in Long term restoration program for the historical Southwestern Willow Flycatcher (*Empidonax trailii extimus*) habitat along the Lower Colorado River, (USBR, 1999).

Effects Analysis

At Lake Mead, declining Lake elevations may increase riparian habitat for willow flycatchers, although the habitat may be ephemeral due to possible high inflows in the future that could inundate the area. Differences in impacts to willow flycatcher habitat between the No Action Alternative and the California Alternative for the ISC between Hoover Dam and

Imperial Dam are negligible. The probability of flood control releases from Parker Dam greater than or equal to 19,500 cfs are 13.9% under the No Action Alternative and 13.0% under the California Alternative between 2001 and 2015. The probabilities increase slightly after the interim period ends in 2015 to 19.7% for the No Action Alternative and 17.9% for the California Alternative (USBR, 2000).

On the lower Colorado River, willow flycatchers utilize dense stands of vegetation adjacent to standing water or moist soil. A change in point of diversion of 400 kaf under the SIAs may affect willow flycatcher habitat by lowering river and groundwater elevations. For a more complete description of effects to willow flycatcher habitat see Section V.A.2.

Bald Eagle (Haliaeetus leucocephalus)
Federally Threatened

Description and Life Requisites

The bald eagle is a large, powerful brown raptor with a white head and tail. Bald eagles do not reach full adult plumage until they are 4 to 6 years of age. Immature birds younger than 4 years old are primarily brown with some white mottling. The bald eagle is the only member of the sea eagle family regularly occurring on the North American continent.

A bird of aquatic ecosystems, it frequents estuaries, large lakes, reservoirs, major rivers, and some seacoast habitats. In winter, bald eagles often congregate at specific wintering sites that are generally close to open water and that offer good perch trees and night roosts (59FR35584, 1994). They prey mainly on fish but also eat birds, mammals and carrion fish.

Distribution and Abundance

The bald eagle historically ranged throughout North America except extreme northern Alaska and Canada and central and southern Mexico. Bald eagles nest on both coasts from Florida to Baja California, in the south, and from Labrador to the western Aleutian Islands, Alaska, in the north. World population estimates range as high as 80,000 bald eagles (Stalmaster, 1987), with up to 20,000 eagles wintering in the contiguous United States (Gerrard, 1983).

In 1978, in response to lowering population and reproductive success, FWS listed the bald eagle throughout the lower 48 states as endangered except in Michigan, Minnesota, Wisconsin, Washington, and Oregon, where it was designated as threatened (43FR6233, February 14, 1978). In the 18 years since it was listed, the bald eagle population has clearly increased in number and expanded its range. This improvement is a direct result of the banning of DDT and other persistent organochlorines, habitat protection, and from other recovery efforts (60FR36001, July 12, 1995). On August 11, 1995, FWS reclassified the bald eagle from endangered to threatened in the lower 48 states. This reclassification also included the southwestern population (including Arizona) which was determined not to be reproductively isolated as previously believed (60FR133, pg 3600, August 12, 1995).

Little was known about the bald eagle in Arizona (and the project area) prior to 1972 when the FWS began monitoring the population (Rubink and Podborny, 1976). For many years, the unique desert nesting birds of Arizona were thought to be reproductively isolated. In 1982, a recovery plan was developed specifically for the southwestern bald eagle. The geographic boundaries of this population as defined by the recovery plan includes Arizona, New Mexico, portions of Texas and Oklahoma west of the 100th meridian, and southeast California within 10 miles of the Colorado River or its reservoirs.

In 1987-1990, Biosystems Analysis, Inc., investigated the ecology of Arizona's nesting population of bald eagles. The study was funded by Reclamation for the purpose of determining what factors limit the Arizona eagles, and particularly whether the reservoirs and regulated flows produced by construction and operation of water projects have been harmful or beneficial. Hunt et al. (1992) was an extremely comprehensive look into the biology and ecology of this raptor which will likely be used and cited by resource managers and researchers for decades to come.

Most of those who studied bald eagles previously in Arizona believed that reservoirs were relatively unimportant as foraging habitat. Rubink and Podborny (1976) speculated that, "Large reservoirs may be unsuitable as foraging habitat. Several reasons are possible: inadequate perches and shallow water areas, the absence of fish near the surface, turbidity of the water or human disturbance by boating." However, Hunt et al. (1992) concluded that bald eagles on the Salt and Verde River systems of Arizona often perched and foraged at reservoirs. Not only did nesting eagles frequently perch at reservoirs, they foraged on them extensively. Of 841 forage attempts recorded at the 7 studied territories by Hunt et al (1992), 435 (51.7%) occurred on rivers and 406 (48.3%) on reservoirs. Overall, reservoirs, dams, or regulated river reaches did not appear to have a negative effect on bald eagle reproduction. In habitats altered by dam construction, 134 young fledged from 12 sites in 122 occupied nest years for a mean of 1.1 young per year. In "natural" habitats, the eagles produced 93 young at 9 sites in 92 nest-years, for a mean of 1.0 young. The difference in productivity between altered and unaltered habitat was not significant (Hunt et al., 1992).

On reservoirs, most observed eagles foraged for fish in deep water and most were taken as carrion or as they floated moribund on the surface. Hunt et al. (1992) documented eagles foraging on a number of non-native species on reservoirs including carp, black crappie, yellow bass, largemouth bass, and catfish. Two factors which appear to strongly increase habitat quality included "reservoirs supporting warm water fisheries" and "reservoir inflow areas" (Hunt et al., 1992).

Busch (1988) commented that "Although potential cliff nest sites appear to be abundant in Arizona and New Mexico, the bald eagle's proclivity toward tree nests throughout its range may indicate that cliff nests are only marginally suitable." Hunt et al. (1992), however, found that bald eagles nested on cliffs and in trees. Of the 11 known nests within the 28 breeding areas known at the time of the study, 36 were on cliffs, 17 on pinnacles, 46 in trees, 11 in snags, and 1 was built on an artificial nesting platform. Of the 11 cumulative years of data on active nests, Biosystems, Inc. also found that at breeding areas where both cliff and nest trees were available, eagles selected cliff nests 73 percent of the time and tree nests 27 percent. More significantly, Hunt et al. (1992) found no significant difference in the nesting success between cliff nests (65% successful) and tree nests (57% successful).

No data exists to indicate that the lower Colorado River was a significant breeding area for bald eagles. Historical records of breeding are rare. In 1975 a nest was built in a cottonwood tree on Havasu National Wildlife Refuge (Hunt et al., 1992). No eggs were laid in 3 years of monitoring, and the breeding area was not included as a known breeding area by Hunt et al. (1992) or Driscoll (1994). The site was checked by the AGFD in 1994 and 1995. While the Havasu tree nest still exists, no eagles were observed in either year (Greg Beatty, AGFD, pers. comm.). An unverified report of a cliff nest 15 miles upstream of Davis Dam also exists (Hunt et al., 1992). On April 18, 1996, a large eagle-sized cliff nest was found at Gene Wash Reservoir in California approximately 1 mile west of Parker Dam. Sightings of bald eagles at Gene Wash and the Copper Basin Reservoir to the west strongly suggest that this is a new bald eagle breeding area (AGFD letter, May 15, 1996).

Two nesting pairs inhabit the Bill Williams River near Alamo Dam, and it is possible the dispersing young or wide-ranging foraging adults may be seen during spring and summer along the Colorado River. At least some of the wintering birds are known to be from the Arizona breeding population. In 1988, a radio-tracked fledgling from the Verde River, Arizona, was followed to British Columbia and then reappeared at Martinez Lake in December of the same year (Rosenberg et al., 1991).

Current river operations and maintenance may preclude the establishment of newly regenerated cottonwood/willow stands that could provide future nesting and perching substrate for eagles. However, as documented in Hunt et al. (1992) and by the potential Gene

Wash Reservoir nesting territory, bald eagles can successfully nest on other substrates (cliffs, pinnacles).

Still, Reclamation's ongoing native riparian plant restoration program has the potential to increase available tree nesting and perching habitat along the river. No evidence exists to suggest that the food resources available in the reservoirs and river are limiting nesting within the project area.

Human disturbance is a cumulative effect associated with recreational use of shorelines and waterways that has the potential to degrade bald eagle habitat. However, steps to reduce such human-induced disturbances are underway by all levels of government and numerous private conservation organizations nationwide.

The Arizona Nest Watch Program, established in 1978, has been a positive force in preserving bald eagles in Arizona. It is well known that the presence and activities of the nest watchers has resulted in a substantial increase in breeding success (Hunt et al., 1992). Efforts to coordinate inter-agency programs to monitor, protect, and educate the public on the bald eagle are actively overseen by the Southwest Bald Eagle Management Committee. Federal agencies often implement closures around bald eagle nests to manage human disturbance, and the committee provides recommendations on closure programs when requested.

Effects Analysis

The proposed action is not likely to adversely affect the food resources, foraging opportunities, or the nesting habitat of the bald eagle within the project area. Wintering birds are expected to continue using the river and most likely will congregate where food resources are plentiful and excessive disturbance from recreation can be avoided. Reclamation, and most likely other Federal and State resource management agencies, will continue to coordinate with the Southwestern Bald Eagle Management Committee and the Arizona Bald Eagle Nestwatch Program to ensure that nesting territories are protected to the greatest extent possible. The diversion of river flows and the ISC over the next 15 years will not affect the bald eagle.

Desert Tortoise (Gopherus agassizii) (Mojave population)
Federally Threatened

Description and Life Requisites

The desert tortoise occupies a variety of habitats throughout its range. In the Sonoran Desert of Arizona, the tortoise typically occurs in the palo verde-cacti-mixed scrub series (Barrett and Johnson, 1990). Range-wide, desert tortoises are typically found at elevations of 6,000 to 3,500 feet. In Arizona, they have been found as low as 500 feet (Mohave Valley, Mohave County) and as high as 5,200 feet (east slope of the Santa Catalina Mountains, Pima County). Sonoran tortoise shelter sites (dens, pallets, etc.) most often occur on rocky bajadas and slopes or in washes that dissect the desert scrub and include cavities in sides of washes, crevices beneath rocks and depressions under shrubs. Sonoran tortoises often use more than one den (Holm, 1989; Barrett and Johnson, 1990) and re-use previously occupied dens. They appear to avoid the deep, fine soiled valley situations favored by western Mojave tortoises. Nest sites are nearly always associated with soil at the mouth of shelter sites.

The Mojave population of desert tortoise occurs primarily on flats and bajadas with soils ranging from sand to sandy-gravel, characterized by scattered shrubs and abundant inter-space for growth of herbaceous plants. They occur in creosote bush, alkali sink, and tree yucca habitats in valleys, on alluvial fans, and in low rolling hills at elevations ranging from sea level to 4,000 feet. They appear to prefer bajadas and desert washes where soils range from sandy-loam to light gravel-clay which are optimal for burrow construction. Shelter sites often occur on lower bajadas and basins in burrows dug in soil, cavities in sides of washes and depressions under shrubs. Important food items of the Sonoran tortoise are similar to those of the Mojave tortoise and include various species of forbs, grasses, succulents, and shrubs.

In general, downward trends in desert tortoise numbers and habitats result from urban development, long-term livestock grazing, mining, off-highway vehicle use, and collecting. Mortimore and Schneider (1983) suggested a Nevada die-off in the early 1980s was due in part to drought conditions and that habitat had been adversely impacted by long-term grazing intensities. D'Antonio and Vitouseki (1992) indicate that the increasing incidence and severity of fires combined with changes in vegetative community types, primarily towards exotic ephemerals, have adversely effected desert tortoises. Habitat fragmentation is another major contributor to population declines (Berry, 1992). Populations have been fragmented and isolated by urban development, highway construction, and development within powerline corridors.

The most serious problem facing the Mojave population of the desert tortoise is the "cumulative effects of human and disease-related mortality accompanied by habitat destruction, degradation, and fragmentation" (FWS, 1994a).

Human contact includes a number of threats. Among the most common are collection for food, pets, commercial trade, and medicinal uses, as well as being struck and killed by on-and-off road vehicles. Still another is by gunshot. Berry (1990) found that between 1981-1987, 40 percent of the tortoises found dead on a study plot in Freemont Valley, California, had been killed by gunshot or by off-road vehicles (FWS, 1994a).

Predation is another factor. Hatchlings and juveniles are preyed upon by several native species of reptiles, birds, and mammals, as well as by domestic and feral dogs. Predation by ravens is intense, as their population has grown over the last few decades due to increased food supplies provided by human development. Berry (1990) believes that predation pressure by ravens in some portions of the Mojave is so great that recruitment of juveniles into the adult population has been halted.

Disease has been noted as a factor since 1990. An upper respiratory tract disease has been discovered and is currently a major cause of mortality in the western Mojave Desert population. Predisposing factors, such as habitat degradation, poor nutrition, and drought, have only served to compound the problem (FWS, 1994a).

Habitat destruction, degradation, and fragmentation are yet some other threats. Over the last 150 years, there have been substantial decreases in perennial grasses and native annuals and an increase in exotics, which serve as fire hazards. Perennial shrubs and grasses used for cover and food have been diminished and have been replaced by inedible exotic ephemerals. Also, as the habitat becomes increasingly fragmented, desert tortoises are forced to forage over larger areas and are thus exposed to greater dangers. Finally, grazing by domesticated animals damages the soil, reduces water filtration, promotes erosion, and invites invasion by exotic vegetation (FWS, 1994a).

Distribution and Abundance

The desert tortoise has a rather extensive range in the Mojave and Sonoran Deserts of the United States and Mexico. Tortoise populations occurring in the Mojave and Sonoran deserts are for the most part isolated from each other by the Colorado River.

Sonoran Population:

Arizona's Sonoran population of the desert tortoise occurs discontinuously south and east of the Colorado River, from Lake Mead National Recreational Area through the southwest, westcentral and southcentral parts of the State. The precise range limits are generally not well known, and there are frequent occurrence information gaps within the known or suspected limits. The distribution map prepared by Johnson et al. (1990) (Figure 10), represents known areas of Sonoran tortoise occurrence within Arizona. Within this estimated 68,228 acres of occupied habitat, actual occurrence depends on local habitat parameters and other factors affecting tortoise populations. Available data indicate the range of the desert tortoise has not been reduced in Arizona in recent times (Barrett and Johnson, 1990).

Mojave Population:

The Mojave desert tortoise population, including both the western and eastern subpopulations, occurs (generally) in eastern California, southern Nevada, and the Beaver Dam Slope and the Virgin River Basin of southwestern Utah and extreme northwestern Arizona. These areas include portions of both the Mojave and Sonoran deserts. Within the Mojave region, the Mojave Desert is represented in parts of Inyo, Kern, Los Angeles, San Bernardino, and Riverside Counties in California; the northwestern part of Mohave County in Arizona; Clark County, and the southern parts of Esmeralda, Nye, and Lincoln Counties in Nevada; and part of Washington County, Utah. The Colorado Desert, a division of the Sonoran desert, is located south of the Mojave Desert and includes Imperial County and parts of San Bernardino and Riverside Counties, California.

Effect Analysis

Potential effects to desert tortoises from activities associated with the proposed action are not expected to occur since tortoises are not expected to occupy areas in close proximity to the river channel. Furthermore, no river maintenance activities such as bankline stabilization, levee maintenance, or dredging activities are anticipated in areas along the lower river where desert tortoises are known or expected to occur. All existing bankline and levee roads are either immediately adjacent to the river and/or within previously disturbed agricultural and/or urban areas and, hence, not within suitable tortoise habitat. The diversion of river flows and the ISC over the next 15 years will not affect the desert tortoise.

Yellow-billed Cuckoo (*Coccyzus americanus*)
Federally Proposed Endangered, State Endangered-California, State Protected-Nevada

Description and Life Requisites

Cuckoos are riparian obligates, found along the lower Colorado River in mature riparian forests characterized by a canopy and mid-story of cottonwood, willow and saltcedar, with little ground cover (Haltermann, 1998). Within the area of interest, cuckoos occur during the breeding season from interior California and the lower parts of the Grand Canyon, and Virgin River Delta in southern Nevada (McKernan and Braden, 1999) south to Southern Arizona, Baja California,, Chihuahua, Choahuila, Nuevo Leon, and Tamaulipas and have been recorded breeding as far south as Yucatan. The species winters in the southern United States, and from northern South America to Northern Argentina (AOU, 1998; Hughes, 1999). Cuckoos are largely insectivorous, with cicadas, (*Diceroprocta apache*) comprising 44.6% of their diet on the Bill Williams River National Wildlife Refuge (Halterman, 1998). The Bill Williams River is a tributary of the lower Colorado River near Parker, AZ. The lower 10 miles of this tributary is designated as the Bill Williams River National Wildlife Refuge, comprised of a large expanse of native cottonwood and willow habitat, interspersed with saltcedar. This area is believed to contain the largest cuckoo population in the lower Colorado River Valley. In February 1998, the western subspecies of the yellow-billed cuckoo, *C. a. occidentalis*, was petitioned for listing under the Endangered Species Act. The U.S. Fish and Wildlife Service made a preliminary determination that the petition presented substantial scientific or commercial information to indicate that the listing of the species may be warranted (FWS, 2000). A final determination on status listing is not yet available. Surveys for this species were conducted throughout Arizona in 1998 and 1999 (Carman and Magill, 2000), and have been conducted on the Bill Williams River NWR, beginning in 1993 (Halterman, 1994). In 2000, surveys have been expanded into southern Nevada and also include the Bill Williams River and Alamo Lake in Arizona.

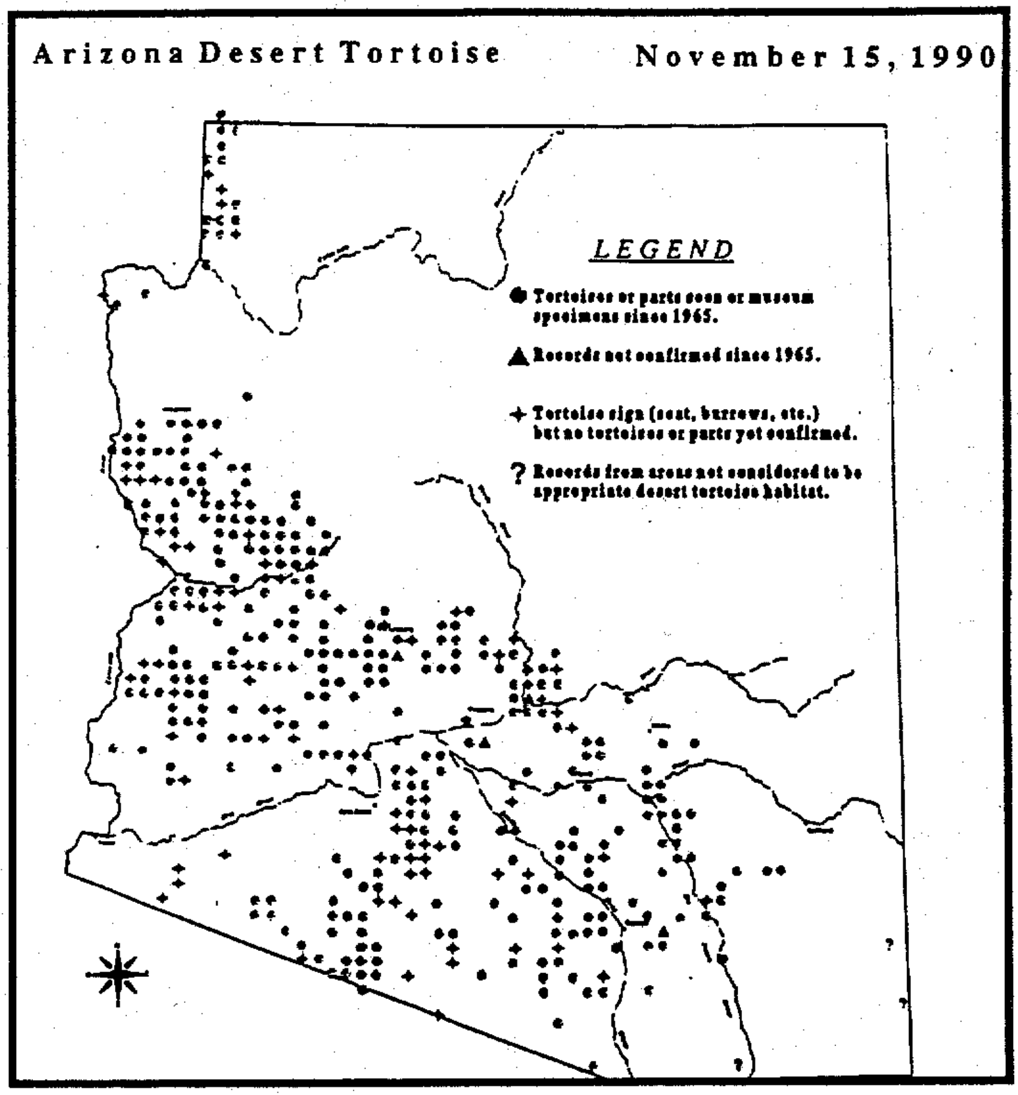

Figure 10. Known Sonoran Tortoise Sites

Distribution and Abundance

As seen in Table 15 below, the numbers of cuckoos detected have fluctuated widely since surveying began in 1993 on the Bill Williams River. In 1997, on the Kern River in California, numbers of cuckoos detected declined in a similar manner as that seen on the Bill Williams River during the same time period, 1994-1997. On the Kern River, cuckoos detected declined from 14 pairs in 1996 to 6 pairs in 1997 (Halterman, 1998); on the Bill Williams, cuckoos detected declined from 26 pairs to 12 pairs. In 1990, numbers detected were back up on the Bill Williams, but down again in 1999. In other areas of the lower Colorado River, Cuckoos have been detected as far south as Gadsden and Imperial National Wildlife Refuge (Carman and Magill, 2000; McKernan and Braden, 1999).

Table 15. Cuckoos detected from 1993-2000

Survey Results BWRNWR	1993	1994	1997	1998	1999
Pairs Detected	22	26	12	20	6
Single Birds Detected	11	14	11	11	8
Nests Found	6	5	3	4	2
Date First Pair Encountered	25 Jun	27 Jun	20 Jun	18 Jun	5 Jun

Without complete and standardized surveys, it can only be speculated that the birds are present across the border in the Colorado River Delta in Mexico. The range of this species includes the Colorado River Delta (AOU, 1998).

Effects Analysis

Yellow-billed Cuckoos utilize mature riparian habitat with some mid- and under-story present. Flood control releases are the only condition under which riparian habitats are established on the lower Colorado River, and a high ground water table is needed to maintain this habitat. At Lake Mead, declining elevations may increase riparian habitat for Yellow-billed Cuckoos, although the habitat may be ephemeral due to possible high inflows in the future that could inundate the area. Differences in impacts to Yellow-billed Cuckoo habitat between the No Action Alternative and the California Alternative for the ISC below Hoover Dam are negligible.

Yellow-billed cuckoo habitat consisting of mature cottonwood and willow trees is dependent on groundwater. A change in point of diversion of 400 kaf under the SIAs may affect Yellow-billed Cuckoo habitat by lowering river and groundwater elevations.

B. Marsh

Brown Pelican (Pelecanus occidentalis)
Federally Endangered

Description and Life Requisites

Easily recognized by its large pouch, a fully grown brown pelican can have a wingspan of 7 feet. Although they usually inhabit coastal waters, the birds sometimes forage as far as 100 miles offshore. In California, brown pelicans feed mainly on northern anchovy, Pacific sardine, and Pacific mackerel (Thelander and Crabtree, 1994).

Brown pelicans were added to the Federal endangered species list in 1970. In the late 1960s, biologists discovered that pesticide-caused eggshell thinning had decimated brown pelican populations including those in southern California. Populations have rebounded since the banning of DDT, and the question of whether to reclassify the pelican is currently a contested issue.

Distribution and Abundance

The majority of California's brown pelicans nest south of the border, mostly on islands along the Pacific coast of Baja California, Mexico, and in the Gulf (between 50,000 and 75,000 pairs) (Thelander and Crabtree, 1994).

Along the lower Colorado River, the brown pelican is a rare but annual post-breeding wanderer from Mexico in late summer and early fall. It is most frequently seen around Imperial Dam, but individuals have occurred north to Davis Dam and even to Lake Mead. Virtually all records are of lone immature birds, undoubtedly dispersing from breeding colonies in the Gulf or perhaps via the Salton Sea (Rosenberg et al, 1991). Along the river, they prefer large open-water areas near dams.

Effect Analysis

This species will not be affected as the proposed action will not change the character of aquatic habitat potentially utilized by this species. Any change in the status of this species (e.g., breeding) would initiate a reexamination of potential operational effects.

Yuma Clapper Rail (Rallus longirostris yumanensis)
Federally Endangered

Description and Life Requisites

Yuma clapper rails are found in emergent wetland vegetation such as dense or moderately dense stands of cattails (Typha latifolia and T. domingensis) and bulrush (Scirpus californicus) (Eddleman, 1989; Todd, 1986). They can also occur, in lesser numbers, in sparse cattail-bulrush stands or in dense reed (Phragmites australis) stands (Rosenberg et al., 1991). The most productive clapper rail areas consist of a mosaic of uneven-aged marsh vegetation interspersed with open water of variable depths (Conway et al., 1993). Annual fluctuation in water depth and residual marsh vegetation are important factors in determining habitat use by Yuma clapper rails (Eddleman, 1989).

Yuma clapper rails may begin exhibiting courtship and pairing behavior as early as February. Nest building and incubation can begin by mid-March, with the majority of nests being initiated between late April and late May (Eddleman, 1989; Conway et al., 1993). The rails build their nests on dry hummocks, on or under dead emergent vegetation and at the bases of cattail or bulrush. Sometimes they weave nests in the forks of small shrubs that lie just above moist soil or above water that is up to about 2 feet deep. The incubation period is 20-23 days (Ehrlich et al., 1988; Kaufman, 1996) so the majority of clapper rail chicks should be fledged by August. Yuma clapper rails nest in a variety of different micro habitats within the emergent wetland vegetation type, with the only common denominator being a stable substrate. Nests can be found in shallow water near shore or in the interior of marshes over deep water (Eddleman, 1989). Nests usually do not have a canopy overhead as surrounding marsh vegetation provides protective cover.

Crayfish (Procambarus clarki) are the preferred prey of Yuma clapper rails. Crayfish comprise as much as 95 percent of the diet of some Yuma clapper rail populations (Ohmart and Tomlinson, 1977). Availability of crayfish may be a limiting factor in clapper rail populations and is believed to be a factor in the migratory habits of the rail (Rosenberg et al., 1991). Eddleman (1989), however, has found that crayfish populations in some areas remain high enough to support clapper rails all year and that seasonal movement of clapper rails can not be correlated to crayfish availability.

One issue of concern with the Yuma clapper rail is selenium. Eddleman (1989) reported selenium levels in Yuma clapper rails and eggs and in crayfish used as food were well within levels that will cause reproductive effects in mallards. Rusk (1991) reported a mean of 2.24 ppm dry weight selenium in crayfish samples from six lower Colorado River backwaters from Havasu National Wildlife Refuge, near Needles, CA to Mittry Lake, near Yuma, AZ. Over the past decade, there has been an apparent two-to five fold increase in selenium concentrations in crayfish, the primary prey species for the Yuma Clapper Rail (King et al., 2000). Elevated concentrations of selenium (4.21- 15.5 ppm dry weight) were present in 95 percent of the samples collected from known food items of rails. Crayfish from the Cienega de Santa Clara in Mexico contained 4.21 ppm selenium, a level lower than those in the U. S., but still above the concern threshold. Recommendations from this latest report on the subject conclude that if selenium concentrations continue to rise, invertebrate and fish eating birds could experience selenium induced reproductive failure and subsequent population declines (King et al., 2000).

Yuma clapper rail may be impacted by man-caused disturbance in their preferred habitat. In recent years the use of boats and personal watercraft has increased along the lower Colorado River. This has led to speculation that the disturbance caused by water activities such as those may have a negative impact on species of marsh dwelling birds.

Distribution and Abundance

This subspecies is found along the Colorado River from Needles, California, to the Gulf, at the Salton Sea and other localities in the Imperial Valley, California, along the Gila River from Yuma to at least Tacna, Arizona, and several areas in central Arizona, including Picacho Reservoir (Todd, 1986; Rosenberg et al., 1991). In 1985, Anderson and Ohmart (1985) estimated a population size of 750 birds along the Colorado River north of the international boundary. FWS (1983) estimated a total of 1,700 to 2,000 individuals throughout the range of the subspecies. Based on the most recent call count surveys (Table 16), the population of Yuma clapper rail in the United States appears to be holding steady (FWS, Phoenix, Arizona, unpublished data). Due to the variation in surveying over time, these estimates can only be considered the minimum number of birds present (Eddleman, 1989; Todd, 1986). The range of the Yuma clapper rail has expanded in the past 25 years and continues to do so (Ohmart and Smith, 1973; Monson and Phillips, 1981; Rosenberg et al., 1991; SNWA, 1998; McKernan and Braden, 1999,), so there is a strong possibility that population size may increase. Yuma clapper rails are known to expand into desired habitat when it becomes available. This is evidenced by the colonization of the CFG Finne-Ramer habitat management unit in Southern California. This unit was modified to provide marsh habitat specifically for Yuma clapper rail and a substantial resident population exists there. There is also recent documentation of the species in Las Vegas Wash, Virgin River and the lower Grand Canyon (SNWA, 1998; McKernan and Braden, 1999).

A substantial population of Yuma clapper rail exists in Colorado River Delta in Mexico. Eddleman (1989) estimated a total of 450 to 970 Yuma clapper rails were present there in 1987. The birds were located in the Cienega, Sonora, Mexico (200-400 birds), along a dike road on the delta proper (35-140 birds), and at the confluence of the Rio Hardy and Colorado River (200-400 birds). Piest and Campoy (1998) detected a total of 240 birds responding to taped calls in the Cienega. From these data, they estimate a total population of approximately 5000 rails in the cattail habitat in the Cienega. Hinojosa-Huerta et al. (2000) estimated approximately 6,300 rails in 1999.

Crayfish were introduced into the lower Colorado River about 1934. This food source and the development of marsh areas resulting from river control such as dams and river management helped to expand the breeding range of the Yuma clapper rail. The original range of the Yuma clapper rail was primarily the Colorado River delta. The southernmost confirmed occurrence of Yuma clapper rail in Mexico was three birds collected at Mazaltan, Sinaloa; Estero Mescales, Nayarit; and inland at Laguna San Felipe, Puebla (Banks and Tomlinson, 1974).

Yuma clapper rail were thought to be a migratory species, the majority of them migrating

Table 16. Yuma Clapper Rail Survey Data 1990-1999

Location	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mohave Division	0	0	0	0	0	0	0	0	0	0
Havasu NWR										
Topock Marsh	59	52	66	30	14	NC	33	32	48	NC
Topock Gorge	111	98	122	97	NC	NC	20	36	37	45
Havasu Division	6	3	3	8	6	NC	4	0	1	9
B.Williams NWR	6	15	16	18	10	7	15	14	NC	11
Parker Division	0	9	9	2	4	NC	0	0	NC	5
Palo Verde Div.	4	0	4	NC	0	NC	0	0	NC	2
Cibola Division	11	14	21	27	28	NC	NC	NC	NC	NC
Cibola NWR	52	39	29	34	109	NC	NC	41	61	89
Imperial Division	64	69	91	107	72	86	117	104	1	10
Imperial NWR	38	24	NC	127	113	50	43	31	59	51
Laguna Division										
S. Imperial Dam	NC	NC	7	16	32	NC	NC	29	3	NC
West Pond	NC	3	2	1	7	17	13	NC	NC	16
Mittry Lake	21	18	16	16	27	NC	NC	18	NC	NC
Teal Alley	44	50	38	20	18	38	53	35	34	40
YPG Slough	43	70	68	65	38	31	36	37	28	31
Yuma Division	17	14	10	4	0	3	11	1	NC	6
Limitrophe Div.	2	7	27	13	3	4	17	6	NC	0
Yuma Vy. Drains	NC	11	11	14	5	NC	NC	NC	NC	NC
Lower Gila River										
N. Gila Valley	NC	NC	7	3	NC	NC	NC	0	0	NC
Welton-Mohawk	11	NC	13	10	6	5	9	7	0	1
Dendora Valley	NC	NC	4	4	5	NC	NC	NC	NC	NC
Citrus Valley	NC	NC	4	0	0	0	NC	NC	NC	NC
Buckeye-Arling.	11	52	45	39	48	26	32	20	7	15
Salt-Verde Conf.	NC	0	0	0	0	NC	0	NC	NC	NC
Picacho Reservoir	0	0	2	7	2	5	1	2	2	0
Imperial Wildlife Area: Wister Unit	90	259	331	302	309	307	239	211	185	191
Salton Sea NWR	16	13	40	96	102	80	83	63	61	67
Salton Sea Area										
Barnacle Beach	NC	9	6	16	2	20	33	24	20	13
Salt Creek	0	4	NC	NC	NC	0	0	0	0	0
Holtville Drains	0	NC	NC	NC	NC	12	10	5	6	5
Bard Valley	4	4	NC	NC	NC	NC	NC	NC	NC	NC
C. de Santa Clara									240	6300
TOTALS	610	837	1012	1076	969	691	769	716	553*	607*

* Rails in Cienega de Santa Clara not included in total for year (US birds only)
1999 Cienega figure is population estimate for all Cienega and Lower Colorado River habitats in Mexico
NC = No survey conducted
Figures represent number of birds
(USFWS, Ecological Services Office, Phoenix, Arizona)

south into Mexico during the winter, with only a small population resident in the United States during the winter. Eddleman (1989) concluded the Yuma clapper rail was not as migratory as once thought and estimated approximately 70 percent remained in or near their home range during the winter.

A Recovery Plan was implemented in 1983 for the Yuma clapper rail. The criteria for downlisting of the species states there must be a stable breeding population of 700-1000 individuals for a period of 10 years. Other goals to be met include:

- Clarifying the breeding and wintering status in Mexico.
- Obtaining an agreement with Mexico for management and preservation of the species.
- Development of management plans for Federal and State controlled areas where the rails are known to breed.
- Written agreements are made with Federal and State agencies to protect sufficient wintering and breeding habitat to support the proposed population numbers.

As of 1999, not all of the above recovery actions had been met, and FWS recommended the Yuma clapper rail remain classified as endangered. In 1999 the Yuma Clapper Rail Recovery Team recommended the existing recovery criteria be examined and brought up to date.

Effect Analysis

The ISC would result in slightly reduced probability of flood flow releases below Hoover Dam. The Cienega de Santa Clara, where the largest population of Yuma clapper rail exist in the Colorado River Delta is sustained by irrigation return flows originating in the U.S. The Cienega is not directly connected to the Colorado River channel. Yuma clapper rail adjacent to the Colorado River from Imperial Dam to Parker Dam may be affected by the reduction in backwater acreage resulting from a change in point of diversion of 400 kaf.

California Black Rail (*Laterallus jamaicensis coturniculus*)
Federal Species of Concern, State Threatened - California

Description and Life Requisites

Black Rails are most often found in shallow salt marshes, but also utilize freshwater marshes, wet meadow-like areas and riparian habitat along rivers. Both males and females of this species exhibit slate black plumage with narrow, white barring on the back and flanks and a chestnut nape with a very short tail and a small black bill. Juveniles look much the same as adults, but their eyes are brown or olive rather than red like those of adults. Full grown birds measure about 5 to 6 inches in length.

The life history and status of the California black rail are poorly known (Wilbur, 1974; Todd, 1977; Evens et al., 1991), due to its secretive nature and tendency to inhabit densely vegetated marshes. The preferred habitat of the California black rail is characterized by minimum water fluctuations that provide moist surfaces or very shallow water, gently sloping shorelines, and dense stands of marsh vegetation (Repking and Ohmart, 1977). California black rails are most often found in areas where cattails (Typha sp.) and California bulrush (*Scirpus californicus*) are the predominant plant species (Rosenberg et al., 1991). While California black rails are more commonly associated with cattail and bulrush, habitat structure as described above was more effective than plant composition in predicting California black rail use of habitat. Water depth appeared to be a limiting factor, as the California black rails prefer shallow water (Flores and Eddleman, 1995). The breeding season along the lower Colorado River extends from April through July (Flores and Eddleman, 1995). California black rails eat mainly aquatic insects and some seeds (Ehrlich, 1988; Rosenberg et al., 1991; Kaufmann, 1996).

Distribution and Abundance

This subspecies of California black rail occurs along the California coast from Tomales Bay in Marin County, south to San Diego and extreme northern Baja California and Veracruz. It also occurs in interior California around the Salton Sea and along the Colorado River from Imperial National Wildlife Refuge south to the international boundary (Peterson, 1990; Rosenberg et al., 1991; AOU, 1998). The species has also been recorded as recently as 1997 at the Bill Williams River National Wildlife Refuge and at Havasu National Wildlife Refuge. Historically, the California black rail primarily occurred along the California coastline. In the mid-1970s, an estimate of between 100 and 200 individuals was given for the area between Imperial National Wildlife Refuge and Mittry Lake, Arizona (Repking and Ohmart, 1977). No quantitative data are yet available on the current populations of the California black rail along the lower Colorado River or in the Colorado River Delta area, although the species is present in both areas. Surveys are currently underway on the Lower Colorado River between Havasu National Wildlife Refuge and Yuma, Arizona. Various agencies including BLM and FWS survey California black rail concurrently during surveys for the Yuma clapper rail.

Effect Analysis

The effect analysis for the California black rail are the same as for the Yuma clapper rail. The ISC would result in slightly reduced probability of flood flow releases below Hoover Dam. California black rail adjacent to the Colorado River from Imperial Dam to Parker Dam may be affected by the reduction in backwater acreage resulting from a change in point of diversion of 400 kaf.

C. Aquatic

Razorback Sucker (Xyrauchen texanus)
Federally Endangered

Description and Life Requisites

The razorback sucker is a large fish, reaching over 2 feet in length and 8 pounds in weight. Sexual dimorphism is present, with males being smaller, slimmer, and having larger fins than females. During the breeding season males have nuptial tubercles covering posterior fins and portions of the body. Females tend to be larger, heavier-bodied and have fins that are somewhat smaller in proportion to their body size (Minckley, 1973).

During the non-reproductive season adults may be found widely dispersed throughout lakes and in riverine sections. Radiotelemetry work in both the upper and lower basins show wide ranges in movement. However, some individuals were relatively sedentary and over the course of a year strayed no more than a few miles from their original point of capture (Minckley et al., 1991).

Reproduction in the lower basin has been studied in Lakes Mead and Mohave. Spawning in Lake Mohave typically begins in January or February, while in Lake Mead it begins slightly later (Jonez and Sumner, 1954). Spawning typically runs 30-90 days, at water temperatures ranging from 55° to 70° F. In reservoirs, spawning aggregations can contain up to several hundred fish. Spawning areas tend to be wave-washed, gravelly shorelines and shoals. Fish spawn in water from 3 to 20 feet in depth with the majority of fish in the 5-10 foot range. Razorback suckers apparently spawn continuously throughout the spawning season, with females releasing only a portion of their gametes at each event. Spawning occurs both day and night on Lake Mohave (USBR, file data). There is considerable fidelity based on recapture data, and fish often show up on the same spawning site year after year (Minckley et al., 1991). Recent sonic tracking data on Lake Mohave showed some fish visiting three or four spawning sites in a single season (Gordon Mueller, pers. comm.).

The following observations on Lake Mead by Jonez and Sumner (1954) clearly describe the spawning act:

"The period of spawning activity of suckers in Lake Mead was between the 1st of March and 15th of April.... The areas of spawning activity seemed widespread about gravel shores.... A number of male suckers were seen to converge upon a ripe female. They completely surrounded her, then closed in upon her sides. At the proper time a convulsive movement spontaneously erupted throughout the formation. This movement resembled the effects of a mild electric shock, and was a series of rapid successive sidewards undulations. The duration of these convulsions usually was approximately 2 minutes. During this time the spawning act, extrusion of eggs and milt, was consummated. The unit then normally moved away in a less confining formation. No attempt was made to guard the nest site. In a number of instances the same female was observed to consummate this action several times during an hour or so. This was accomplished with the same and/or other male suckers in attendance."

Eggs hatch in 5 to 10 days depending on water temperature. Optimal hatching success is around 68°F; hatching does not occur at extremes of cold or hot (50° or 86°F) (Marsh and Minckley, 1985). Larvae swim up within several days and begin feeding on plankton. As the terminal mouth migrates to a sub-terminal position, larvae begin to feed on benthos as well. Growth is variable. Within a single cohort some individuals may attain 14 inches in length in their first year while others may not reach 7 inches. Males generally reach maturity in their second year, and females mature at 3 years of age. However, sexual maturity has been noted for males at 10 months of age for fish raised in backwaters of Lake Mohave by the NFWG (USBR, file data).

Larval stages of razorback suckers are positively phototactic and readily come to bright lights suspended over spawning sites at night. Fish up to ¾ of an inch have been captured by this technique. Older juveniles (generally over 1 inch) switch from being positively phototactic to being negatively phototactic, or nocturnal. Juvenile razorback suckers in lakeside rearing ponds hide during the day in dense aquatic vegetation and under brush and debris and in rock cavities (USBR, file data). It is not known at exactly what age/stage/size the nocturnal behavior ends. Adults are found throughout the river/reservoir system during non-spawning periods and are observed during daytime hours all year long. Intuitively then, the nocturnal behavior must end by the fish's first spawn because spawning behavior occurs both day and night during the spawning period.

These observations on nocturnal behavior, as well as the documented rapid growth in predator-free rearing ponds, suggest that razorback sucker used two strategies to avoid predation by historical predators such as the Colorado squawfish. They hid during the day, and they grew quickly.

Distribution and Abundance

The razorback sucker was formerly the most widespread and abundant of the big-river fishes in the Colorado River. It ranged from Wyoming to northwestern Mexico and occurred in most of the major tributaries (Minckley et al., 1991). Early explorers report the fish as extremely abundant (Gilbert and Scofield, 1898). In central Arizona it was abundant enough to be commercially harvested for human and animal food and for fertilizer in the late 1800s. Similar abundances have been noted for the upper basin (Bestgen, 1990). Today the species occupies only a small portion of its historical range, and most occupied areas have very low numbers of fish. The razorback sucker was listed as an endangered species in October 1991 (FR Vol.56 No. 205, 1991).

Distribution along the lower Colorado River is briefly summarized as follows. In Lake Mead the fish were abundant for many years after the reservoir filled but greatly declined during the 1960s and 1970s. The current population in Lake Mead is estimated to be less than 300 fish. Of interest is a small number of juvenile adults have been captured since 1997, indicating some successful recruitment is taking place. Larval razorback sucker were captured at the upper end of Lake Mead in the Spring of 2000 (Holden, pers. Comm). An occasional fish is captured in the upper reaches of the Overton Arm near the Moapa and Virgin River inflows (Sjoberg, 1995). There are two populations of razorback sucker in Lake Mead, one in Las Vegas Bay and the other at Echo Bay. Currently a study is underway to determine population size and movements of these fish. As part of this study, an attempt is being made to determine why there is a small number of fish able to recruit to the population thus enabling some small number of razorback sucker to persist in Lake Mead.

Lake Mohave has the largest single population, currently estimated to contain less than 12,000 razorbacks. Of those, 75 percent are wild adults and 25 percent are repatriated juveniles (Pacey and Marsh, 1999). This population was estimated to be 60,000 fish as recently as 1987 (Marsh, 1994). The rapid decline for the Lake Mohave population was predicted by McCarthy and Minckley (1987). They aged a large sample of adult fish taken from Lake Mohave. Of the fish they aged, the youngest was 24 years with the oldest 44. Eighty-eight percent of the fish they aged hatched prior to or around the time Lake Mohave was constructed and filled. They reported that in other reservoirs in the Colorado River basin, razorback suckers had drastically declined around 40 years after closure of the dam and filling of the reservoir. They predicted that a similar event would occur on Lake Mohave by the turn of the century. In an effort to replace this aging population before it underwent complete collapse, an interagency team of biologists began rearing fish in protected lakeside ponds in 1992. Between 1992 and the present, this group, NFWG, has reared and released over 38,000 juvenile razorback suckers in Lake Mohave .

For the entire reach of the Colorado River downstream of Lake Mohave, including associated backwaters and side channel habitats (except Senator Wash Reservoir), confirmed records exist for capture of only 42 adult razorback suckers between 1962 and 1988 (Marsh and Minckley, 1989). Numerous reintroductions of larvae, juvenile and adult razorback suckers have taken place during this same period. Observations on adults and reintroductions are discussed below for each reach of the lower Colorado River.

Immediately below Davis Dam, a few adult fish are seen (and sometimes captured) almost every year, but no estimate of the population size can be made (Burrell, pers. comm.). Between Davis Dam and Lake Havasu observations of razorback suckers are extremely rare. CFG conducted a fishery survey of 15 backwaters between Davis Dam and Lake Havasu in 1976 and captured 3 adult razorback suckers (Marshall, 1976). These areas were surveyed by CFG and Reclamation personnel in 1983, and no razorback suckers were captured or observed. CFG stocked approximately 400,000 larval razorback suckers into this reach of the river during 1985 (Ulmer, 1987). In 1999 12 razorback suckers were captured between Davis Dam and Lake Havasu. These 12, plus 8 more were radio tagged and released as part of an ongoing study.

In Lake Havasu, observations on adults are again, extremely rare, with only 16 adults captured or observed since 1962. Open water sampling for fish eggs and larvae as part of a striped bass study by CFG resulted in the capture of 37 larval razorback suckers in 1985-86 (Marsh and Papoulias, 1989). Flow data for Lake Havasu suggest that the larvae hatched out either within the upper end of Lake Havasu or in the Colorado River inflow area to the lake. Two larval and three adult razorback suckers were entrained into and captured within the CAP canal between 1987 and 1989 (Mueller, 1989a). An interagency native fish rearing and stocking program has been initiated on Lake Havasu as part of an ongoing Lake Havasu Fishery Improvement Project. Patterned after the NFWG's program on Lake Mohave, the project has reared and/or stocked over 18,000 razorback suckers into Lake Havasu since 1992. Enough fingerling razorback suckers are being reared at present to meet the goal of reintroducing 25,000 juveniles.

Below Lake Havasu, adult razorback suckers are again, very rare. Dill (1944) reported the largest single capture of adults within the lower river since closure of Hoover Dam, when he captured 13 fish below Headgate Rock Dam in 1942. Larval razorback suckers have been stocked by CFG in 1986 into backwater areas connected to the main channel below Headgate

Rock Dam. Two larval razorback suckers were captured during a fish passage study at Headgate Rock Dam in 1988 (USBR, file data). Thirty eight juvenile razorback suckers were captured in 1987 in the CRIT canal system, which diverts Colorado River water at Headgate Rock Dam. These fish were most likely a result of fish stocked in 1986. Three adult fish were captured in 1988 in the same canal and aged by ASU as 3, 4, and 7 years old. They did not coincide with any stocking and were concluded to have been naturally produced within the system (Marsh and Minckley, 1989). Four adults were captured in 1993 (Marsh, pers. comm.).

Over 250,000 juvenile razorback suckers were stocked into the river and into backwater areas between Headgate Rock Dam and Imperial Dam by CFG in 1987-88 (Langhorst, 1988; Langhorst, 1989), and nearly 500,000 larval razorback suckers were stocked into the river and backwaters (Ulmer, 1987). Razorback suckers are being reared in the old river channel impoundment known as "High Levee Pond" on Cibola National Wildlife Refuge downstream of Blythe, California. Over 100 fish have been reared to ten or more inches in length and released into the river during 1996 (C.O. Minckley, pers. comm.).

Since 1999, five thousand juvenile razorback suckers have been released to the Colorado River below Parker Dam. There are an additional 12,000 razorback suckers being reared for release in later years. These are a portion of a 50,000 razorback sucker reintroduction requirement Reclamation is implementing as a result of the Biological Opinion on the routine operations and maintenance on the lower Colorado River.

Razorback suckers were reported at Senator Wash Reservoir, a pump-back storage facility, during the 1970s. Exactly when these fish accessed the reservoir, and at what size, is not known. The reservoir was filled in 1966, but the earliest record of a razorback sucker in Senator Wash Reservoir was seven adults captured in a gill net in 1973. The population in the reservoir was estimated to be about 55 adults. No fish from this population were aged. Fish did annually spawn and produced larvae, but there was never any indication of recruitment into the adult population (Ulmer and Anderson, 1985). Attempts to locate these fish in 1988 and 1989 were unsuccessful, and it is believed this small population had died off (Paul Marsh, pers. comm.) Adult razorback suckers from Niland State Fish Hatchery ponds were transferred to Senator Wash Reservoir in 1990 after the hatchery was closed. CFG netted these fish during monitoring activities in the of spring 1996, capturing 100 of these fish, all of which were in excellent condition (CFG, file data.). Razorback suckers are occasionally captured or observed in the All-American and Coachella Canals, laterals and sumps during outages for maintenance.

The pattern of decline for the razorback sucker in lower basin reservoirs has been as follows. Upon initial impoundment, razorback suckers expand their population into the newly flooded reservoir basin. Over the next 30 or so years fish are observed spawning along gravel shorelines in late winter and early spring. Fishery managers believe there is recruitment to adulthood because of the abundance of fish, despite the lack of observations of juvenile fish. However, recruitment to the adult life stage does not occur due to predation from nonnative fishes, and the population gets older and eventually collapses as fish die of old age and natural causes.

This scenario was played out in Lake Roosevelt and Saguaro Lake on the Salt River and in Lakes Mead and Havasu on the Colorado River. In all cases, 40 to 50 years after dam completion, the reservoir populations completed a boom-and-bust cycle and were left with small remnant populations. This scenario is being played out today at Lake Mohave.

No single introduced species is responsible for the lack of recruitment. On Lake Mohave for example, razorback suckers spawn from January through April, which is the earliest of all the fish species in the reservoir. Adult razorback suckers are passive and provide no protection of the fertilized eggs. Upon release of gametes, the adults swim away and carp can be observed moving to the site of the released eggs. Carp have been captured and sacrificed at the site, showing their stomachs to contain gravel and fish eggs (file data, USBR). Those eggs that survive and incubate to hatching yield prolarvae that only have pectoral fins and are relatively poor swimmers. The preceding year's crop of young sunfish, only a few centimeters long themselves, can be observed feeding on the emerging larvae.

After observing spawning razorback suckers on Lake Mohave in 1954, Jonez and Sumner (1954) make the following report:

> "Very small fish (about ¾ of an inch long, threadlike, and translucent) which appeared to have been humpback suckers, were observed in the areas where the above described spawning took place. It is doubtful whether very many of those tiny humpback suckers survived because they were mingling with predaceous small bass and sunfish."

Juvenile suckers that survive past the larval stage take on a nocturnal behavior pattern, hiding during the day in weeds, brush, and rock crevices and caverns. Unlike historical times, they now must share these hiding places with nonnative, nocturnal predators, such as channel catfish. During dawn and dusk, when young fish emerge from their hideouts, they are preyed upon by ambush predators such as largemouth bass. Occasionally, some fish do survive and individuals are still caught in some of these impoundments. Regardless of what percentage of fish do make it to adult life-stage, the numbers have not been sufficient to sustain the populations.

Today, razorback suckers are only infrequently encountered in the Colorado River below Lake Mohave, and nothing is really known of the current population status although it is thought to be extremely low, consisting of releases to the river either for research purposes in the Imperial Division or as a result of recent releases below Parker Dam mentioned earlier.

As stated in Minckley et al. (1991):

> "The only substantial numbers of juveniles resulting from natural spawning in the 1980s were caught from irrigation canals and ponds downriver from Parker Dam."

Why and how this occurs is not known for sure; however, one hypothesis is that the off-season shut down, and periodic drawdowns for maintenance actions on the irrigation systems, provides windows of opportunity wherein the nonnative fishes are reduced or eliminated long enough for a few native fish to grow large enough to avoid most predators. As a side note, this may be the mechanism which is allowing for limited recruitment in Lake Mead. Aging studies are being conducted on the razorbacks currently encountered, and these ages will be compared to times when Lake Mead has had considerable drawdown.

Numerous attempts to stock razorback suckers in the lower river have met with limited success. Langhorst (1988, 1989) reports on several stockings in the lower Colorado River, all of which have met with almost no success. Several million larvae have been introduced with no noted survival. Larger fish raised in some backwaters appeared to do better, but predation rates remain high. Similarly, of the tens of thousands of young razorback suckers stocked into the Gila River the overwhelming majority were lost due to predation by catfish (Marsh and Brooks, 1989).

Minckley et al. (1991) concluded that lack of recruitment to adulthood was the primary limiting factor for razorback suckers today, and that predation by nonnative fishes was the single most likely factor precluding recruitment of razorback suckers in nature. The authors stated:

> "The strongest evidence that predation is the major factor in loss of larval razorback suckers is simply that larvae persist and grow, to maturity if given adequate time in habitats from which predators are excluded."

Marsh and Pacey (1998) conducted an extensive literature search on the habitat and resource use of the native and non-native fish in the lower Colorado River. They concluded the native and non-native fishes in the river overlap broadly in their physical habitat and resource use. They stated:

> "No attribute of physical habitat or resource use can be identified that markedly or marginally favors one group of fishes over another, and we cannot envision habitat manipulations or features that could be made to accomplish such a goal. Rather, the evidence supports an hypothesis that presence of non-native fishes alone precludes successful life-cycle completion by components of the native fauna. This array of non-native fishes now present has feeding, behavioral, and reproductive attributes that allow it to displace, replace, or exclude native kinds."

Effect Analysis

Much of the lower Colorado River plus Lake Powell must be considered as occupied habitat for some life-stage of the razorback sucker, both wild and reintroduced fish. Therefore, it would not be remarkable to encounter a larval or adult fish anywhere in the mainstream river between Lake Powell and Yuma, Arizona. Because of the significant differences in their makeup, reservoirs and river reaches are each considered separately.

1) Mainstem Reservoirs:

Lake Mead has been occupied by razorback suckers since its formation. As the reservoir filled, razorback suckers must have initially been successful in recruiting fish to the adult life stage because the populations did initially expand. Lake Powell did not produce a large population after its filling. This may have been due to a scarcity of razorback sucker in the new reservoir either because the habitat was limiting to begin with, or razorback sucker in the area of the new reservoir were already on the decline due to the presence of non-native fish. The spawning process described earlier continues today on Lake Mohave. Biologists have captured over 100,000 razorback sucker larvae from the reservoir, indicating that both spawning and incubation of eggs has been successful over the wide range of reservoir operations during that period. However, despite these hundreds of thousands of spawning acts and production of hundreds of thousands of larvae, the reservoir population has not been able to replenish itself, and over 50 percent of the adult population has died of old age during the last 10 years. In Lake Mead, only remnant populations exist and without help; extirpation is only a matter of time.

In the future, adult populations of repatriated fish will be present in Lakes Mohave and Havasu as well as the lower river below Parker Dam. No decision has been made on augmenting the Lake Mead population. These populations, and designated critical habitat would continue to be protected under ESA. Efforts are currently being made to supplement adult breeding populations of razorback suckers by stocking lakes with young reared in predator free ponds. Operations at Lake Mohave are conducted in an effort to conserve and protect razorback sucker by controlling the amount of lake fluctuation during the spawning season. Spawning success has been limited by predation of eggs and larvae by non-native fish.

2) Riverine Reaches:

Limited observations of adult razorback suckers have been made in the river reach between Davis Dam and Lake Havasu, and between Parker Dam and Imperial Dam. Indirect evidence of spawning is provided in the periodic capture of young fish in canal systems and at structures which divert water from these reaches. Daily water level changes in these reaches expose gravel bars during the known spawning season for razorback sucker. A reduction of 0.05 (½ in.) to 0.66 feet (8 in.) in the river elevation resulting from a 400 kaf change in point of diversion will slightly increase the amount of exposed gravel bars. While the probability of this increase affecting incubating eggs of razorback sucker is remote, the possibility does exist, especially in light of recent repatriation of the species through various interagency rearing and stocking programs. Therefore, it must be concluded that the reduction of flows in the river reaches from Parker Dam to Imperial Dam may affect razorback sucker spawning potential.

Reasons for the statement that this possibility is remote are as follows. Historically, these reaches were mostly shifting sand bottom, which would be poor quality spawning habitat. Today, most of the entire reach has large areas of clean gravels available for spawning, and most of these are not exposed during daily flow changes. Adult razorback suckers spawn over an extended period and spawn both day and night (file data, USBR). Water level changes happen everyday in these reaches, and it is highly unlikely that these fish would be unaware that the river is moving up and down. The rate of change is greatest near the dams, and spawning gravels are available along most of the river's course, especially where desert washes enter the river and provide debris fans.

Finally, if such an effect would occur, it would be inconsequential to the continued existence of these fish. The primary limiting factor for these populations is nonnative fish predation, and the annual production of even tens of thousands of eggs and larvae have not been sufficient to stem the predation losses in Lakes Mead and Mohave. Similarly, the stocking of tens of thousands of larvae and small juveniles into these reaches of river over the last decade have not resulted in increased abundance of the species.

A decrease of 24 acres (0.6%) of open water out of a total of 4,012 acres in backwaters would also occur as a result of the change in point of diversion of 400 kaf. Razorback suckers use backwaters in the Imperial Division in varying degrees. Also associated with the change in river surface elevation would be a decrease of 71 acres (0.5%) of open water out of a total of 10,305 acres of open water associated with the main river channel.

Effect Summary:

Through ongoing conservation measures described for the razorback sucker described previously, and those proposed as part of the project, the status and survival of this species in Lakes Mohave, Havasu and other reaches of the river will be substantially improved. The goal of this conservation effort is to have 50,000 new adults in Lake Mohave and 25,000 new adults in Lake Havasu by the Year 2003; Reclamation is committed to fund and assist in providing at least half of these numbers. It is anticipated the Lake Mohave goal will be reached by 2002. With such success, the baseline status of the species will be dramatically improved and the potential jeopardy status diminished. The completion of these efforts, along with the Lake Mohave program, will provide for maintenance of the genetic variability of the razorback sucker for at least one more generation. Imminent extinction will be avoided and survival and recovery opportunities provided.

In summary, the effect analysis for razorback sucker concludes that implementing ISC and the change in point of diversion of 400 kaf from Imperial Dam to Parker Dam as a result of the SIAs may affect razorback sucker.

Bonytail (Gila elegans)
Federally Endangered

Description and Life Requisites

In appearance bonytail are gray to gray-green on the dorsal, with silvery sides fading to a white ventral surface. The fish is elongated and somewhat laterally compressed with a narrow caudal peduncle. A smooth predorsal hump is present in the adult form. Breeding males can be distinguished by reddish marks on the paired fins and the presence of tubercles anterior on the body (Vanicek, 1967). Adults are from 11 to 13 inches in length, although larger individuals (up to 24 inches) are occasionally taken. Positive field identification between bonytail and other forms of Gila is quite difficult and often considered tentative. Further, the name bonytail was assigned in general to the genus Gila by many researchers; thus, its population status in historic times is far from certain in areas where a mix of Gila species occurs. However, this problem is associated more with upper Colorado River basin populations.

As a result of the rarity of this species, the biology of the bonytail is not well understood. Spawning of bonytail has not been observed in riverine habitats, but based on the appearance of ripe fish in the upper basin, spawning appears to occur during late June and early July. Spawning in the lower basin occurs from late spring to early summer (Wagner, 1954). In Lake Mohave, schools of bonytail were observed over gravel reefs (Jonez and Sumner, 1954) and along clean sandy bottoms. Bonytail have spawned in earthen ponds in captivity, including rearing ponds around Lake Mohave (USBR, file data) and on the La Paz County golf course near Parker, Arizona (C.O. Minckley, pers. comm.). Bonytail produce an average of about 50,000 eggs/per fish (Hammond, pers. comm.). Hatching success is greatest in water temperatures from 59° to 68°F (Marsh, 1985). In the Green River, Vanicek and Kramer (1969) estimated fish to reach approximately 2 inches during their first year of life, 4 inches by the end of the second season, and approximately 6 inches by the end of the third season. Growth rates from young bonytail stocked into backwaters of Lake Mohave indicate substantially higher growth rates are possible depending on habitat conditions. During 1995, 4-inch fish were stocked into lakeside ponds in March and grew to over 12 inches by November (USBR, file data). Fish appear to feed primarily on zooplankton and insects.

Distribution and Abundance

The bonytail once ranged throughout the mainstem Colorado River and principal tributaries (Minckley, 1973). They were still abundant in Lake Mead after the completion of Hoover Dam (Moffett, 1943), however, by 1950 they were considered rare (Jonez and Sumner, 1954). By the time concern was raised for this fish, it had disappeared from much of its range. Consequently, the species was listed as endangered by FWS in April 1980. The most recent recovery plan for the bonytail summarizes the fish's distribution as:

> "The bonytail chub is very rare. In the Colorado River Basin, few individuals have been found in the last decade, and recruitment is apparently nonexistent or extremely low." (FWS, 1990)

Presently, bonytail are believed to be extirpated in the Colorado River from Glen Canyon Dam to Hoover Dam (McCall, 1979). Small populations may still exist in the upper basin, but as mentioned earlier, there is much confusion in fish identification due to the similarity in physical appearances with some of the roundtail chubs. Like the razorback, the largest remaining population of bonytail in the entire Colorado River basin resides in Lake Mohave. Unlike the razorback, however, population data from Lake Mohave are incomplete because too few fish have been captured to allow for a credible population estimate to be made.

Whether or not wild fish remain in Lake Mohave is not known, and most likely it cannot be determined. There were at least nine augmentation stockings of bonytail into Lake Mohave between 1981 and 1991 (USBR, file data). These stockings total over 150,000 fish and have ranged in size from less than 1 inch (fry) to 4-inch juveniles. These fish all originated at Dexter National Fish Hatchery, New Mexico, and were descendants of bonytail adults captured from Lake Mohave. (One group of 1,162 fish came from CFG's Niland Fish Hatchery, where they were being reared, but had originated as fry from Dexter National Fish Hatchery.) Only a small percentage of these fish was ever tagged or in some way marked. As part of the NFWG effort on Lake Mohave fingerling bonytail from Dexter National Fish Hatchery have been stocked into predator-free rearing ponds around the lake and later stocked into the reservoir after reaching 10-12 inches in length. All of these later fish have been PIT-tagged. A few of these fish have been recaptured (USBR, file data).

Fish were occasionally taken from Lake Havasu prior to 1970, but no up-to-date information or recent captures exist other than recaptures of fish released by the HAVFISH program during the past 2 years. The historical population has most likely been extirpated. Efforts are being undertaken to reintroduce bonytail back to Lake Havasu from lakeside coves using young obtained from Dexter National Fish Hatchery.

Like the razorback sucker, the primary limiting factor for bonytail appears to be non-native fish predation of the early life stages (egg to subadult). This conclusion is based on the fact that when reintroduced at a large size, the fish survive in the reservoir, and when stocked into predator-free environments the young fish grow to adulthood.

How and when the predation occurs is not certain, but Jonez and Sumner wrote the following report after observing spawning bonytail in Lake Mohave in May 1954:

> "In May 1954, with the aid of shallow-water diving gear, a large population of bonytail was observed spawning on a gravelly shelf about ten miles below Eldorado Fish Camp. It was estimated that there were about 500 bonytails spawning in the quarter-mile of gravel. It appeared that each female had three to five male escorts. Neither males nor females dug nests, and the eggs were broadcast on the gravel shelf. No effort was made to protect the eggs by covering them with gravel or by guarding them. However, the eggs adhered to the rocks, and that gave them some protection.... Large schools of adult carp were intermingling with the spawning bonytail. No young bonytails were observed in the spawning area, and it is presumed that the carp ate most of the eggs."

As mentioned earlier, juvenile razorback suckers tend to hide during the day in areas that are now occupied by predators, and when they emerge from these hiding areas, they fall prey to ambush predators such as largemouth bass. It is not known whether bonytail juveniles are nocturnal and subject to the same predation pressures. Bonytail juveniles placed in a large backwater pond connected to Lake Mohave by a barrier net (Davis Cove) were readily eaten by largemouth bass, an ambush predator that normally feeds during dawn and dusk when fish would be immerging and emerging from cover (USBR, file data).

<u>Effects Analysis</u>

Bonytail are presently found in Lakes Mohave and Havasu. Implementation of the ISC or change in point of diversion of 400,000 kaf between Imperial Dam and Parker Dam will not affect the operation of those lakes. Efforts are underway to re-introduce bonytail to the lower Colorado River below Parker Dam. The expected reduction in surface water elevation may affect the habitat for this potential recovery action.

1. Critical Habitat Description - Razorback Sucker and Bonytail

Critical habitat for the razorback sucker and bonytail was designated in March 1994. The critical habitat for the razorback sucker includes Lakes Mead and Mohave and the river reach between them. It also includes the Colorado River and its 100-year floodplain from Parker Dam to Imperial Dam including Imperial reservoir (Figure 11).

Critical habitat for bonytail includes the Colorado River from Hoover Dam to Davis Dam, including Lake Mohave. It also includes the Colorado River from the northern boundary of Havasu National Wildlife Refuge to Parker Dam, including Lake Havasu (Figure 11).

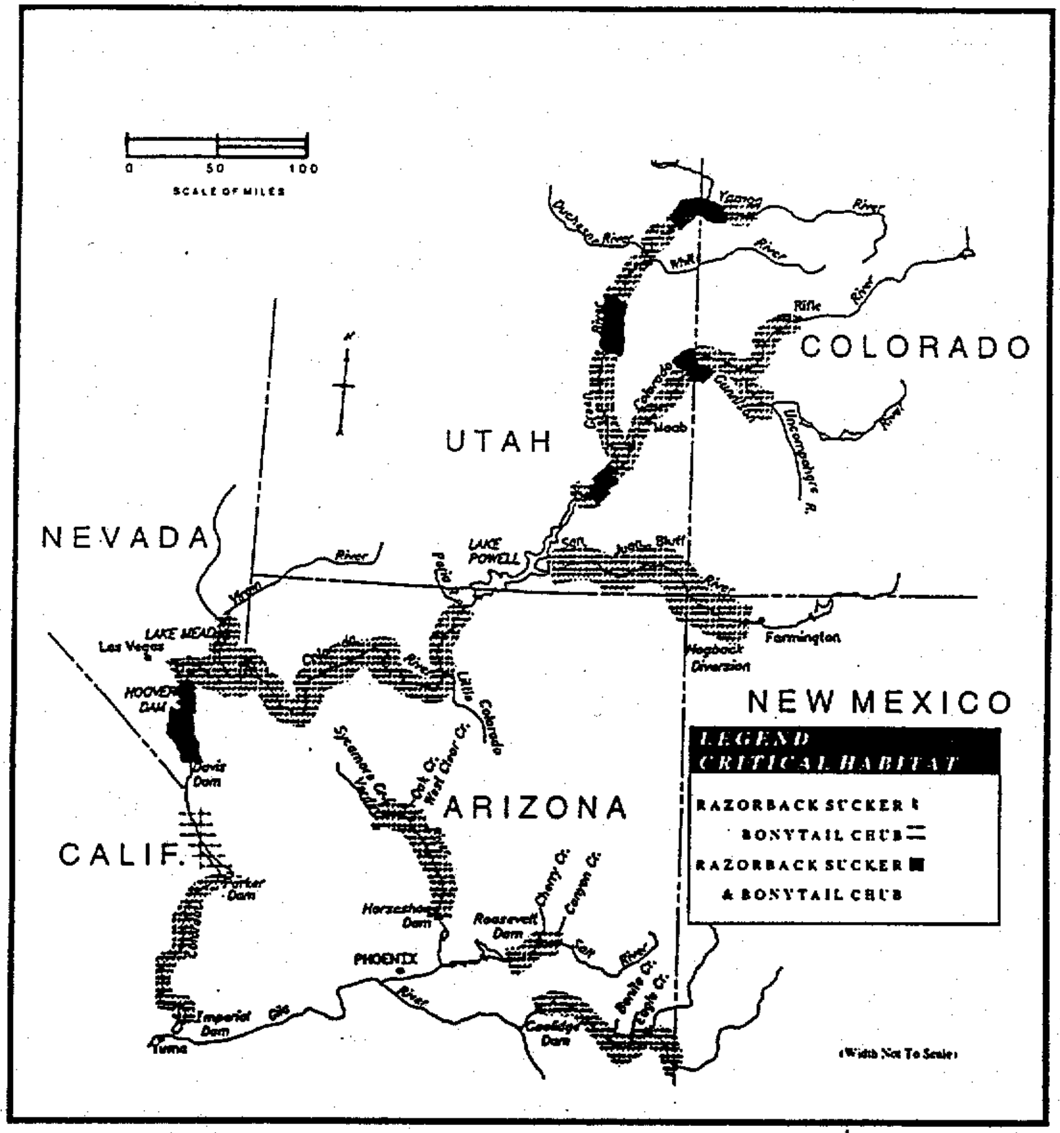

Figure 11. Location of Critical Habitat for Bonytail Chub and Razorback Sucker.

Critical habitat is a regulatory term used to describe requirements for certain species survival. It encompasses physical and biological features essential for survival and recovery of listed species. Within the context of this document, the components of critical habitat will be addressed jointly for each species. There are some differences in species requirements, but the system itself functions as a whole, so it should be addressed as a whole. For the endangered big-river fishes, critical habitat encompasses three major areas of consideration as follows :

Water - A quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, contaminants, nutrients, turbidity etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life-stage of each species.

Physical Habitat - Areas of the Colorado River system that are inhabited or potentially habitable for use in spawning, nursery, feeding and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats.

Biological Environment - Food supply, predation, and competition are important elements of the biological environment. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation, although considered a normal component of this environment, may be out of balance due to introduced fish species in some areas.

Each aspect of a critical habitat may, in and of itself, explain some changes in the population status of the big-river fishes, but the interactions between, and cumulative effects of, the combined elements are also of important concern.

Effects Analysis

Native fishes historically lived under more severe extremes of conditions than are currently found. The most visible changes that have occurred along the lower Colorado River have been those associated with the construction of facilities.

Water:

Implementing the SIA or Surplus Criteria will not destroy or adversely modify the quality of water, a constituent element needed for the critical habitat of these fishes.

Water temperature is known to impact the ability of fish to spawn. However, this effect in the lower basin impacts only a localized area and does not account for why the species has declined across its entire range (Minckley et al., 1991). Hoover Dam, for example, releases cold, hypolimnetic water, which may impair the ability of some stage of the life-cycle to survive, but Mueller (1989b) documented spawning and presence of larvae in this reach of the river. There have been numerous accounts of razorback suckers and bonytail spawning downstream in Lake Mohave where water temperatures approach 80° F, yet the population still does not recruit.

Historically, water quality exhibited wide ranges for common physico-chemical parameters deemed important for fish (e.g. temperature, dissolved oxygen, pH, salinity). Water quality in reservoirs is more stable than it was historically due to the buffering capacity of large masses of water. Reservoir temperatures are relatively stable on a daily basis. Oxygen levels are within tolerable ranges, as are a host of other basic limnological characteristics such as pH and conductivity.

Mainstem dams desilt the water. Reduced turbidity downstream of dams is a factor related to initial construction, and it's impact is conjectural: less suspended sediment means less physical stress to fish, but clear water may accelerate predation. Lower turbidity means greater light penetration and more primary production, and removal of fines means cleaner spawning gravels and more attachment sites for benthic and sessile animals (secondary production).

Increasing salinity has been a major water quality concern on the lower river. Much of the increase in salt load is a result of agricultural drainage. Diversions result in less water in the river channel to dilute saline return flows. Increases in salinity along the mainstem Colorado River have not yet attained a level that would impact native fishes. The proposed changes in point of diversion would not be expected to cause a salinity increase significant enough to impact native fishes.

The potential exists for the concentration of other chemicals and toxic compounds besides salt. Selenium and several pesticides have been identified, but there are no data yet that demonstrate levels are high enough in the lower river to affect reproduction of native fishes. A discussion of selenium in the lower Colorado River can be found in Appendix G.

As far as actual quantity of water, consistent low or high flows really do not differ from each other, because in either case the habitat stabilizes around the flow. Average seasonal patterns of water release, although not nearly of historical magnitude, follow the same general pattern, with the highest flows occurring in the spring and early summer. Potential adverse effects may occur due to the slightly lower minimum daily flows expected from changing points of diversion from Imperial Dam to Parker Dam.

Physical Habitat:

Historically, the stream bed through most of the lower Colorado River was shifting sand. Initial blockage of sediment by dam building caused armoring of the stream bed. The increases in potential spawning sites for native fishes has never been quantified, but intuitively they are very great. For example, there is about 44 miles of river channel between Headgate Rock Dam near Parker, Arizona, and Palo Verde Diversion Dam near Blythe, California. Historically this 44-mile reach was predominately shifting sand substrate. Placement of Headgate Rock Dam in 1941 caused channel cutting and armoring over this entire reach. Placement of Palo Verde Diversion Dam in 1957 caused some backing up of the river reach above it, and fine materials again were deposited. Today, coarse materials (gravels, cobbles, boulders) now comprise over 50 percent of the stream bed substrate for the first 32 miles below Headgate Rock Dam (Minckley, 1979).

Routine operation causes fluctuations in the river which may expose gravel bars and desiccate incubating eggs. Slightly lower minimum daily flows may expose more gravel bars than are currently exposed. This may adversely modify critical habitat for these fishes.

Changes in water levels drain backwater habitats, making these habitats unavailable for use by fishes. Slightly lower minimum daily flows may result in more shallow backwaters. Artificial measures have been used to physically recreate backwaters in several reaches of the river. Some of these are potentially useful to fish, while many are separated from the river and require manual introduction and removal. On some backwater habitats left open to the river, maintenance dredging assures these habitats maintain enough water to be viable over the full range of water fluctuations.

Short-term fluctuations in reservoir can destroy eggs of native fishes by exposing them to wave action or desiccation. In the three mainstem Colorado River reservoirs, it is unlikely Reclamation will lower the water level more than 2 feet in any 10-day period, thus preventing such an impact from occurring during the spawning period.

Desert pupfish (Cyprinodon macularius)
Federally Endangered

Description and Life Requisites

The desert pupfish is a small killifish with a smoothly rounded body shape. Adults generally range from 2-3 inches in length. Males are smaller than females and during spawning the males are blue on the head and sides and have yellow edged fins. Most adults have narrow, dark, vertical bars on their sides. The species was described in 1853 from specimens collected in San Pedro River, Arizona. There are two recognized species and possibly a third form (yet to be described). The species, Cyprinodon macularius, occurs in both the Salton Sea area of southern California and the Colorado River delta area in Mexico and is the species of concern, herein. The other species is C. eremus and is endemic to Quitobaquito Spring, Arizona.

The desert pupfish was listed as an endangered species on March 31, 1986. Critical habitat for the species was designated at the time of listing and included the Quitobaquito Spring which is in Organ Pipe Cactus National Monument, and San Felipe Creek along with its two tributaries Carrizo Wash and Fish Creek Wash in southern California. All of the former and parts of the latter were in Federal ownership at the time of listing. Reclamation purchased the remaining private holdings along San Felipe Creek and its tributary washes and turned them over to CFG in 1991. All of the designated critical habitat is now under State or Federal ownership.

Desert pupfish are adapted to harsh desert environments and are extremely hardy. They routinely occupy water of too poor quality for other fishes, most notably too warm and too salty. They can tolerate temperatures in excess of 110° F; oxygen levels as low as 0.1 ppm; and salinity nearly twice that of sea water (over 70 parts per thousand [ppt]). In addition to their absolute tolerance of these parameters, they are able to adjust and tolerate rapid, extreme changes to these same parameters (Marsh and Sada, 1993). Pupfish have a short life span, usually only 2 years, but they mature rapidly and can reproduce as many as three times during the year.

Desert pupfish inhabit desert springs, small streams, creeks, marshes and margins of larger bodies of water. The fish usually inhabit very shallow water, often too shallow for other fishes. Present distribution of the subspecies C. macularius includes natural populations in at least 12 locations in the United States and Mexico, as well as over 20 transplanted populations.

Distribution and Abundance

Desert pupfish do not inhabit the project area. One of the natural populations in Mexico is in the Cienega de Santa Clara, a 100,000 acre bowl on the Colorado River Delta 60 miles south of the U.S./Mexico border. The area is about 90 percent unvegetated salt flats with a number of small marsh complexes along the eastern edge of the bowl where it abuts an escarpment. The area is disconnected from both the Colorado River and the Gulf (Sea of Cortez), however extreme high tides result in the lower half of the bowl becoming inundated to a level of one foot or less of salt water from the gulf. The marsh areas on the east side are small and are spring fed. The largest marsh complex is on the northeast side where two agricultural drains provide relatively fresh water inflows. The desert pupfish occur in a number of these marsh complexes.

Reclamation biologists discovered this population of desert pupfish in 1974 during preproject investigations for a feature of the Colorado River Basin Salinity Control Project. At that time, the Cienega was being fed by agricultural return flows from the Riito Drain in Mexico which provided about 35 cfs flow. The project feature being investigated was construction of a bypass canal for drain water from WMIDD.

Desert pupfish were found in the marsh along with mosquitofish, sailfin mollies, carp and red shiners. The bypass canal was completed in 1978 and provided a steady flow of over 150 cfs to the marsh. Based upon aerial surveys, the added inflow caused the marsh to grow from an estimated 300 acres of vegetated area in 1974 to roughly 10,000 acres in 1985. Recent aerial surveys show that while the inflows have continued, the marsh has not continued to grow in size. Desert pupfish continue to exist in the marsh. The fish tend to inhabit the shallow edges of the marsh in vegetated areas. Desert pupfish from the Cienega were transported to Dexter National Fish Hatchery during May 1983, and many of the transplanted populations in the United States are of this subspecies and stem from this initial transplant.

Effects Analysis

Desert pupfish will not be affected by the ISC.

D. Summary of Effects Analysis

Conservation measures will offset adverse effects associated with the proposed action. Approximately 124 acres of riparian restoration will have beneficial effects to the enhancement of southwestern willow flycatcher habitat. Creation and restoration of 62 acres of backwater are intended to offset the projected reduction of backwater habitat. Introduction of 20,000 razorback suckers into the system are expected to help offset impacts to the species as a result of water surface reduction. Continuation of Lake Mead razorback sucker study will help contribute to the understanding of why a population persists and may lead to techniques for establishing self-sustaining populations elsewhere. Life history studies to add to the very limited knowledge on bonytail will help contribute to the successful re-establishment of populations. Conservation measures will be accomplished in such a manner and timed as to minimize effects to breeding and maximize beneficial use.

The potential effects of the implementation of the ISC and SIA's on species under consideration are summarized in Table 17.

Table 17. Summary of Effect Analyses

Common Name	Scientific Name	Status[1]	Effect Analysis		
			Species		Critical Habitat
			No Effect	May Affect	May Adversely Modify
TERRESTRIAL					
Southwestern willow flycatcher	*Empidonax traillii extimus*	E		X	
Bald eagle	*Haliaeetus leucocephalus*	T	X		
Desert tortoise (Mohave population)	*Gopherus agassizii*	T	X		
Yellow-billed cuckoo	*Coccyzus americanus*	S		X	
MARSH					
Brown pelican	*Pelecanus occidentalis*	E	X		
Yuma clapper rail	*Rallus longirostris yumanensis*	E		X	
California black rail	*Laterallus jamaicensis cotorniculus*	S		X	
AQUATIC					
Razorback sucker	*Xyrauchen texanus*	E		X	X
Bonytail	*Gila elegans*	E		X	
Desert pupfish	*Cyprinodon macularius*	E	X		

[1]E=Endangered, T=Threatened, PT=Proposed Threatened, S=Sensitive

APPENDIX A.
Tables Showing Flows at Selected Sites Along the Lower Colorado River

Introduction

Effects on river flows due to change in point of diversions were determined for several points on the river between Parker Dam and Imperial Dam. This reach of the river will be affected because of anticipated reduction in diversions to Imperial Valley at Imperial Dam. The reduced diversions at Imperial Dam and corresponding Parker Dam releases will be transferred to California by increased diversions from Lake Havasu. Annual river flows above Lake Havasu and below Imperial Dam will not be affected by this transfer.

The annual reduction in releases from Parker Dam due to the Secretarial Implementation Agreement as shown on Table 3 is anticipated to be about 400 kaf by 2011 and should remain at that amount there after. For the past 10 years, annual releases from Parker Dam in non-flood years has varied between 5.5 maf in 1993 to 7.3 maf in 1996 due to crop infestation, Gila River flows, fallowing, and climatic conditions. The following tables use 1996 as the baseline condition, and reductions are made from 1996 monthly releases from Parker Dam. Monthly water diversion, returns, and losses along this river reach were also based on this same year.

Several different reductions in releases were examined. The greatest annual reduction, 1.574 maf, assumed agricultural uses below Parker Dam would be cut back to allow full M&I uses for year 2060 during extreme shortage conditions. This 1.574 maf is within the natural variation in releases from Parker Dam in non-flood years for the last 10 years. Diversions to Imperial Valley have varied about 0.6 maf during the last 10 years.

Reductions in the 1996 monthly releases were distributed according to Imperial Irrigation Districts monthly 1996 diversions so that changes in Parker Dam releases were greater in the summer than in the winter. For the monthly amount transferred, Parker Dam's 1996 monthly release was reduced accordingly. This average monthly release rate was assumed to be the typical daily release rate for that month. This daily release was then distributed hourly to give the typical hourly release rate pattern for that daily release amount. The hourly releases could then be routed downstream to give the attenuated flow patterns at the downstream sites of interest.

The downstream routing of hourly releases were calibrated with observed flows at downstream flow gages using the Muskingum method with adjustments for diversions, returns, and losses. The downstream flow gages were Colorado River at Waterwheel (ww), at Taylor Ferry (tf), at Cibola (cib), and at Imperial Dam (imp). Figure A-1 shows an example of the hourly releases from Parker Dam and the depleted and attenuated routed flows to these downstream flow gage sites.

Points of interest are located by river mileage above the Southerly International Boundary. The river miles for selected points of interest are:

River Mile	Location Name
192.2	Parker Dam
177.7	Headgate Rock Diversion Dam
152.0	Waterwheel Gage
133.8	Palo Verde Diversion Dam
106.6	Taylor Ferry Gage
87.3	Cibola Gage
49.2	Imperial Dam

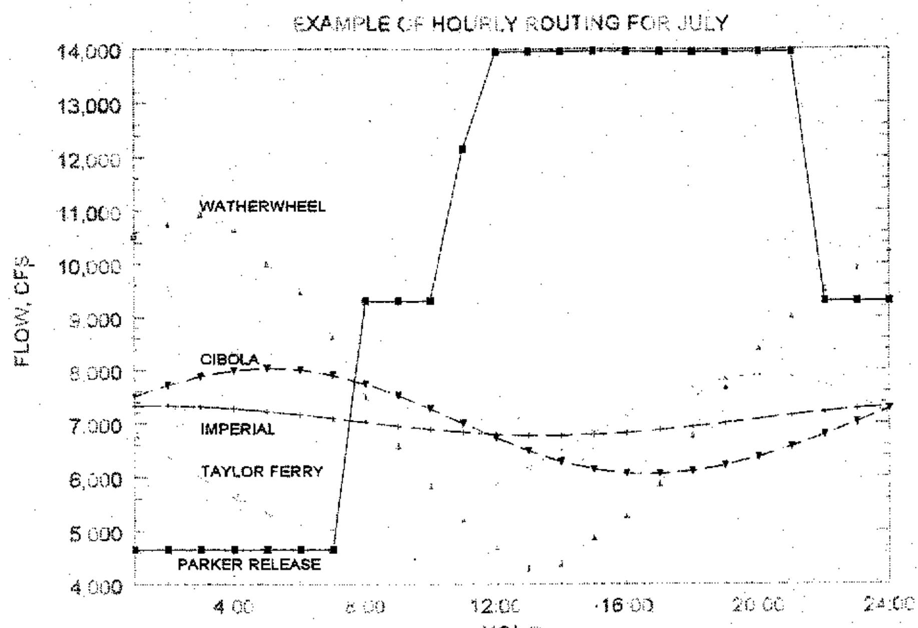

Figure A-1

Tables 1-7 show the river mileage at selected points of interest. At the top of each table, the designations ww, tf, cib, and imp indicate the point where the routed flows were determined. These sites were close enough to the actual river mile of interest to accurately reflect the flow rates at the nearby sites.

Each table shows the average daily flow in cubic feet per second at Parker Dam (Parker Dam Avg Flow) for the baseline and the reduced flow due to transfers. Table 1 shows the daily average flow for the year routed to the points of interest, and Tables 2-7 show the hourly minimum or maximum flow at the downstream points of interest for selected months in cubic feet per second.

For each of the routed flows, river elevations were computed at each river cross-section of interest. The elevation versus flow ratings were developed from the steady flow and elevation data presented in Appendix A4 of the Review Draft Multi-Species Conservation Program report (MSCP, 2000). The river elevations for steady flow for the draft report were computed using the step-back water surface computations of the Corps of Engineers HEC-RAS computer program with cross-sectional survey data located about every mile. Figure A-2 shows an example of the hourly routed and depleted flows converted to elevation using the elevation versus flow rating for 2 example sites.

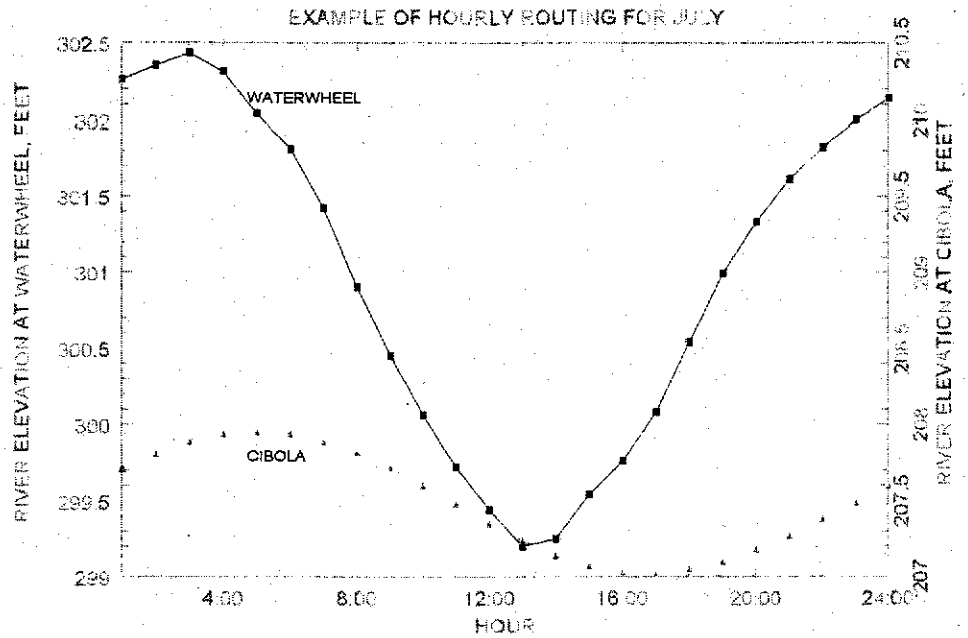

Figure A-2

The dates of the cross-sectional surveys used in the draft MSCP report are as follows:

Mile 176.3 to 139.9 surveyed 1996-1997
Mile 138.9 to 134.1 surveyed 1987
Mile 133.5 to 87.9 surveyed 1985
Mile 86.9 to 49.4 surveyed 1991

Of special note are river elevation changes at river mile 135.8 and river mile 50.8. These 2 sites are located in the reservoirs of Palo Verde Dam and Imperial Dam respectively and show little change in elevation with change in flow.

Table A-1 Annual Median Flows at Selected Locations along the Lower Colorado River

Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
			ww	ww	ww	ww	ww	ww	tf	tf	tf
Baseline	10083	Flow:	8474	8474	8474	8474	8474	8474	7796	7796	7796
		Elev:	334.12	327.66	316.12	298.96	295.52	283.83	248.26	241.93	239.50
200K AF Reduction	9808	Flow:	8199	8199	8199	8199	8199	8199	7521	7521	7521
		Elev:	333.98	327.51	315.98	298.81	295.41	283.81	248.12	241.75	239.33
Change	-275	dElev:	-0.14	-0.15	-0.14	-0.14	-0.11	-0.02	-0.14	-0.18	-0.17
300K AF Reduction	9669	Flow:	8060	8060	8060	8060	8060	8060	7382	7382	7382
		Elev:	333.91	327.44	315.91	298.74	295.35	283.80	248.05	241.65	239.24
Change	-414	dElev:	-0.21	-0.22	-0.22	-0.22	-0.17	-0.03	-0.21	-0.28	-0.26
400K AF Reduction	9531	Flow:	7922	7922	7922	7922	7922	7922	7244	7244	7244
		Elev:	333.84	327.36	315.83	298.67	295.29	283.80	247.98	241.56	239.15
Change	-552	dElev:	-0.28	-0.30	-0.29	-0.29	-0.22	-0.04	-0.28	-0.37	-0.34
500K AF Reduction	9393	Flow:	7784	7784	7784	7784	7784	7784	7106	7106	7106
		Elev:	333.77	327.28	315.76	298.59	295.24	283.79	247.91	241.46	239.07
Change	-690	dElev:	-0.35	-0.38	-0.36	-0.36	-0.28	-0.04	-0.35	-0.47	-0.43
675K AF Reduction	9152	Flow:	7543	7543	7543	7543	7543	7543	6865	6865	6865
		Elev:	333.64	327.15	315.63	298.46	295.13	283.77	247.78	241.29	238.91
Change	-932	dElev:	-0.47	-0.51	-0.50	-0.50	-0.38	-0.06	-0.48	-0.63	-0.59
948K AF Reduction	8775	Flow:	7166	7166	7166	7166	7166	7166	6488	6488	6488
		Elev:	333.45	326.94	315.42	298.25	294.97	283.75	247.58	241.02	238.66
Change	-1308	dElev:	-0.67	-0.72	-0.70	-0.71	-0.55	-0.08	-0.68	-0.90	-0.84
1,553K AF Reduction	7940	Flow:	6331	6331	6331	6331	6331	6331	5653	5653	5653
		Elev:	333.00	326.45	314.94	297.75	294.59	283.70	247.11	240.40	238.07
Change	-2143	dElev:	-1.12	-1.21	-1.18	-1.20	-0.93	-0.13	-1.15	-1.53	-1.43
1,574K AF Reduction	7911	Flow:	6302	6302	6302	6302	6302	6302	5624	5624	5624
		Elev:	332.98	326.43	314.92	297.74	294.57	283.70	247.09	240.38	238.05
Change	-2172	dElev:	-1.14	-1.23	-1.20	-1.22	-0.95	-0.13	-1.17	-1.55	-1.45

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tf	tf	tf	cib	cib	cib	cib	cib	imp	imp	imp
109.1	103.1	96.7	86.1	80.4	72.2	70.3	66.1	56	53.6	50.8
7796	7796	7796	8860	8860	8860	8860	8860	8856	8856	8856
230.96	224.50	215.98	207.15	202.15	194.28	193.24	189.20	183.93	180.97	179.70
7521	7521	7521	8585	8585	8585	8585	8585	8581	8581	8581
230.79	224.36	215.81	207.01	202.03	194.16	193.12	189.08	183.83	180.91	179.69
-0.17	-0.15	-0.17	-0.13	-0.11	-0.12	-0.12	-0.13	-0.11	-0.06	-0.01
7382	7382	7382	8446	8446	8446	8446	8446	8443	8443	8443
230.71	224.28	215.72	206.94	201.97	194.10	193.05	189.01	183.77	180.88	179.68
-0.26	-0.22	-0.26	-0.20	-0.17	-0.19	-0.19	-0.19	-0.16	-0.10	-0.02
7244	7244	7244	8308	8308	8308	8308	8308	8305	8305	8305
230.62	224.21	215.63	206.87	201.92	194.03	192.99	188.95	183.72	180.85	179.68
-0.35	-0.30	-0.35	-0.27	-0.23	-0.25	-0.25	-0.26	-0.21	-0.13	-0.02
7106	7106	7106	8170	8170	8170	8170	8170	8167	8167	8167
230.53	224.13	215.55	206.80	201.86	193.97	192.92	188.88	183.67	180.81	179.67
-0.43	-0.37	-0.44	-0.34	-0.29	-0.31	-0.32	-0.32	-0.27	-0.16	-0.03
6865	6865	6865	7929	7929	7929	7929	7929	7926	7926	7926
230.37	224.00	215.39	206.68	201.75	193.86	192.81	188.77	183.57	180.76	179.66
-0.59	-0.51	-0.59	-0.47	-0.40	-0.42	-0.43	-0.43	-0.36	-0.21	-0.04
6488	6488	6488	7552	7552	7552	7552	7552	7549	7549	7549
230.13	223.78	215.14	206.48	201.58	193.68	192.63	188.59	183.42	180.67	179.65
-0.84	-0.72	-0.84	-0.67	-0.56	-0.60	-0.61	-0.61	-0.52	-0.30	-0.05
5653	5653	5653	6718	6718	6718	6718	6718	6715	6715	6715
229.55	223.30	214.57	206.01	201.20	193.27	192.22	188.18	183.07	180.49	179.62
-1.42	-1.21	-1.41	-1.14	-0.95	-1.01	-1.02	-1.02	-0.87	-0.49	-0.08
5624	5624	5624	6689	6689	6689	6689	6689	6686	6686	6686
229.53	223.28	214.55	205.99	201.18	193.26	192.20	188.17	183.05	180.48	179.62
-1.44	-1.22	-1.43	-1.16	-0.96	-1.02	-1.04	-1.03	-0.88	-0.49	-0.08

Table A-2 Minimum Hourly Flows at Selected Locations along the Lower Colorado River in April

Location (RM)	ParkerDam Avg Flow		171.3 ww	167.6 ww	160.9 ww	149.5 ww	146.9 ww	135.8 ww	119.7 tf	116.5 tf	114.6 tf
Baseline	14234	Flow:	10437	10437	10437	10437	10437	10437	10004	10004	10004
		Elev:	335.05	328.67	317.09	299.89	296.24	283.97	249.29	243.28	240.75
200K AF Reduction	13405	Flow:	9245	9245	9245	9245	9245	9245	9360	9360	9360
		Elev:	334.49	328.07	316.51	299.34	295.82	283.88	249.00	242.91	240.40
Change	-829	dElev:	-0.56	-0.60	-0.57	-0.55	-0.43	-0.08	-0.29	-0.38	-0.34
300K AF Reduction	13219	Flow:	9185	9185	9185	9185	9185	9185	9236	9236	9236
		Elev:	334.46	328.04	316.48	299.31	295.79	283.88	248.94	242.83	240.33
Change	-1015	dElev:	-0.59	-0.63	-0.60	-0.58	-0.45	-0.09	-0.34	-0.45	-0.41
400K AF Reduction	13034	Flow:	9141	9141	9141	9141	9141	9141	9132	9132	9132
		Elev:	334.44	328.01	316.46	299.29	295.78	283.88	248.90	242.77	240.28
Change	-1200	dElev:	-0.61	-0.66	-0.63	-0.60	-0.47	-0.09	-0.39	-0.51	-0.47
500K AF Reduction	12849	Flow:	9092	9092	9092	9092	9092	9092	9019	9019	9019
		Elev:	334.42	327.99	316.44	299.27	295.76	283.87	248.84	242.70	240.21
Change	-1385	dElev:	-0.63	-0.68	-0.65	-0.63	-0.49	-0.10	-0.44	-0.58	-0.53
675K AF Reduction	12364	Flow:	8678	8678	8678	8678	8678	8678	8530	8530	8530
		Elev:	334.22	327.77	316.23	299.06	295.60	283.84	248.62	242.40	239.94
Change	-1870	dElev:	-0.83	-0.90	-0.86	-0.83	-0.64	-0.12	-0.67	-0.88	-0.81
948K AF Reduction	11608	Flow:	6565	6565	6565	6565	6565	6565	7359	7359	7359
		Elev:	333.12	326.59	315.08	297.90	294.70	283.71	248.04	241.64	239.23
Change	-2626	dElev:	-1.93	-2.08	-2.01	-2.00	-1.55	-0.26	-1.25	-1.65	-1.52
1.553K AF Reduction	9932	Flow:	4988	4988	4988	4988	4988	4988	5441	5441	5441
		Elev:	332.23	325.63	314.11	296.87	293.90	283.63	246.99	240.23	237.92
Change	-4302	dElev:	-2.82	-3.04	-2.97	-3.03	-2.34	-0.34	-2.30	-3.05	-2.83
1.574K AF Reduction	9874	Flow:	4978	4978	4978	4978	4978	4978	5395	5395	5395
		Elev:	332.22	325.62	314.11	296.86	293.89	283.62	246.96	240.20	237.88
Change	-4360	dElev:	-2.83	-3.05	-2.98	-3.03	-2.35	-0.34	-2.33	-3.09	-2.86

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tf	tf	tf	cib	cib	cib	cib	cib	imp	imp	imp
109.1	103.1	96.7	86.1	80.4	72.2	70.3	66.1	56	53.6	50.8
10004	10004	10004	10970	10970	10970	10970	10970	11547	11547	11547
232.23	225.61	217.27	208.09	202.97	195.17	194.13	190.14	184.88	181.62	179.81
9360	9360	9360	10230	10230	10230	10230	10230	10733	10733	10733
231.88	225.30	216.91	207.78	202.69	194.87	193.83	189.82	184.61	181.42	179.78
-0.35	-0.31	-0.36	-0.32	-0.28	-0.30	-0.30	-0.32	-0.27	-0.20	-0.04
9236	9236	9236	10101	10101	10101	10101	10101	10566	10566	10566
231.81	225.24	216.84	207.72	202.64	194.81	193.78	189.76	184.55	181.38	179.77
-0.42	-0.37	-0.43	-0.37	-0.33	-0.35	-0.36	-0.38	-0.33	-0.24	-0.05
9132	9132	9132	9990	9990	9990	9990	9990	10400	10400	10400
231.75	225.19	216.78	207.67	202.60	194.77	193.73	189.71	184.49	181.34	179.76
-0.48	-0.42	-0.49	-0.42	-0.37	-0.40	-0.40	-0.43	-0.39	-0.28	-0.05
9019	9019	9019	9873	9873	9873	9873	9873	10235	10235	10235
231.69	225.13	216.71	207.62	202.56	194.72	193.68	189.66	184.44	181.30	179.75
-0.54	-0.48	-0.56	-0.47	-0.42	-0.45	-0.45	-0.48	-0.45	-0.32	-0.06
8530	8530	8530	9412	9412	9412	9412	9412	9758	9758	9758
231.41	224.88	216.43	207.41	202.37	194.52	193.48	189.45	184.27	181.19	179.73
-0.83	-0.72	-0.84	-0.69	-0.60	-0.64	-0.65	-0.69	-0.62	-0.43	-0.08
7359	7359	7359	8398	8398	8398	8398	8398	8928	8928	8928
230.69	224.27	215.71	206.92	201.95	194.07	193.03	188.99	183.96	180.99	179.70
-1.54	-1.34	-1.56	-1.18	-1.02	-1.09	-1.10	-1.15	-0.92	-0.63	-0.11
5441	5441	5441	6502	6502	6502	6502	6502	7190	7190	7190
229.39	223.17	214.42	205.88	201.09	193.17	192.11	188.08	183.27	180.59	179.64
-2.84	-2.44	-2.85	-2.21	-1.88	-2.00	-2.03	-2.06	-1.61	-1.03	-0.18
5395	5395	5395	6447	6447	6447	6447	6447	7132	7132	7132
229.36	223.14	214.38	205.85	201.07	193.14	192.08	188.05	183.24	180.58	179.63
-2.87	-2.47	-2.88	-2.25	-1.90	-2.03	-2.05	-2.09	-1.64	-1.04	-0.18

Table A-3 Maximum Hourly Flows at Selected Locations along the Lower Colorado River in April

Location (RM)	ParkerDam Avg Flow		171.3 ww	167.6 ww	160.9 ww	149.5 ww	146.9 ww	135.8 ww	119.7 tf	116.5 tf	114.6 tf
Baseline	14234	Flow:	15864	15864	15864	15864	15864	15864	12353	12353	12353
		Elev:	337.29	331.09	319.33	301.95	297.83	284.42	250.24	244.54	241.89
200K AF Reduction	13405	Flow:	14504	14504	14504	14504	14504	14504	11389	11389	11389
		Elev:	336.77	330.53	318.82	301.49	297.48	284.30	249.87	244.04	241.44
Change	-829	dElev:	-0.52	-0.56	-0.51	-0.46	-0.35	-0.13	-0.38	-0.50	-0.45
300K AF Reduction	13219	Flow:	14034	14034	14034	14034	14034	14034	11110	11110	11110
		Elev:	336.58	330.33	318.63	301.32	297.35	284.26	249.75	243.89	241.30
Change	-1015	dElev:	-0.71	-0.76	-0.70	-0.62	-0.48	-0.17	-0.49	-0.64	-0.59
400K AF Reduction	13034	Flow:	13559	13559	13559	13559	13559	13559	10854	10854	10854
		Elev:	336.39	330.12	318.44	301.15	297.22	284.22	249.65	243.76	241.18
Change	-1200	dElev:	-0.90	-0.97	-0.89	-0.80	-0.62	-0.21	-0.60	-0.78	-0.71
500K AF Reduction	12849	Flow:	12888	12888	12888	12888	12888	12888	10587	10587	10587
		Elev:	336.12	329.82	318.17	300.90	297.02	284.16	249.53	243.61	241.05
Change	-1385	dElev:	-1.17	-1.26	-1.16	-1.05	-0.81	-0.26	-0.71	-0.93	-0.85
675K AF Reduction	12364	Flow:	12300	12300	12300	12300	12300	12300	10118	10118	10118
		Elev:	335.87	329.56	317.92	300.67	296.85	284.11	249.33	243.35	240.81
Change	-1870	dElev:	-1.42	-1.53	-1.41	-1.28	-0.99	-0.31	-0.91	-1.19	-1.09
948K AF Reduction	11608	Flow:	11984	11984	11984	11984	11984	11984	9779	9779	9779
		Elev:	335.74	329.41	317.78	300.55	296.75	284.09	249.19	243.15	240.63
Change	-2626	dElev:	-1.55	-1.68	-1.55	-1.40	-1.08	-0.34	-1.06	-1.39	-1.26
1.553K AF Reduction	9932	Flow:	11579	11579	11579	11579	11579	11579	8328	8328	8328
		Elev:	335.56	329.22	317.61	300.38	296.62	284.05	248.52	242.27	239.82
Change	-4302	dElev:	-1.73	-1.87	-1.73	-1.57	-1.21	-0.37	-1.72	-2.27	-2.07
1.574K AF Reduction	9874	Flow:	11530	11530	11530	11530	11530	11530	8264	8264	8264
		Elev:	335.54	329.20	317.58	300.36	296.61	284.05	248.49	242.23	239.78
Change	-4360	dElev:	-1.75	-1.89	-1.75	-1.59	-1.23	-0.37	-1.76	-2.31	-2.11

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tf	tf	tf	cib	cib	cib	cib	cib	imp	imp	imp
109.1	103.1	96.7	86.1	80.4	72.2	70.3	66.1	56	53.6	50.8
12353	12353	12353	12529	12529	12529	12529	12529	11979	11979	11979
233.42	226.66	218.49	208.71	203.52	195.77	194.73	190.80	185.02	181.73	179.84
11389	11389	11389	11686	11686	11686	11686	11686	11141	11141	11141
232.95	226.24	218.00	208.39	203.23	195.45	194.41	190.44	184.75	181.52	179.80
-0.47	-0.42	-0.48	-0.33	-0.29	-0.32	-0.32	-0.35	-0.28	-0.21	-0.04
11110	11110	11110	11438	11438	11438	11438	11438	10939	10939	10939
232.81	226.12	217.86	208.29	203.14	195.35	194.32	190.34	184.68	181.47	179.79
-0.61	-0.54	-0.63	-0.43	-0.38	-0.41	-0.41	-0.46	-0.34	-0.26	-0.05
10854	10854	10854	11194	11194	11194	11194	11194	10736	10736	10736
232.68	226.00	217.72	208.19	203.05	195.26	194.22	190.24	184.61	181.42	179.78
-0.74	-0.66	-0.76	-0.52	-0.47	-0.51	-0.51	-0.56	-0.41	-0.31	-0.06
10587	10587	10587	10946	10946	10946	10946	10946	10533	10533	10533
232.54	225.88	217.58	208.08	202.96	195.16	194.12	190.13	184.54	181.37	179.77
-0.88	-0.78	-0.90	-0.63	-0.56	-0.61	-0.61	-0.67	-0.48	-0.35	-0.07
10118	10118	10118	10453	10453	10453	10453	10453	10047	10047	10047
232.29	225.66	217.33	207.88	202.78	194.96	193.92	189.92	184.37	181.26	179.75
-1.12	-1.00	-1.16	-0.84	-0.74	-0.81	-0.81	-0.88	-0.65	-0.47	-0.09
9779	9779	9779	9997	9997	9997	9997	9997	9369	9369	9369
232.11	225.50	217.14	207.68	202.60	194.77	193.73	189.72	184.12	181.09	179.72
-1.31	-1.16	-1.35	-1.04	-0.92	-0.99	-1.00	-1.08	-0.90	-0.63	-0.12
8328	8328	8328	8476	8476	8476	8476	8476	7743	7743	7743
231.29	224.78	216.30	206.96	201.99	194.11	193.07	189.03	183.50	180.72	179.66
-2.13	-1.88	-2.18	-1.75	-1.53	-1.66	-1.67	-1.77	-1.53	-1.01	-0.18
8264	8264	8264	8413	8413	8413	8413	8413	7684	7684	7684
231.25	224.75	216.27	206.93	201.96	194.08	193.04	189.00	183.47	180.70	179.65
-2.17	-1.92	-2.22	-1.79	-1.56	-1.68	-1.69	-1.80	-1.55	-1.02	-0.18

Table A-4 Minimum Hourly Flows at Selected Locations along the Lower Colorado River in August

Location (RM)	ParkerDam Avg Flow		171.3 ww	167.6 ww	160.9 ww	149.5 ww	146.9 ww	135.8 ww	119.7 tf	116.5 tf	114.6 tf
Baseline	10818	Flow:	5412	5412	5412	5412	5412	5412	6853	6853	6853
		Elev:	332.48	325.89	314.38	297.16	294.13	283.65	247.78	241.29	238.90
200K AF Reduction	10502	Flow:	5251	5251	5251	5251	5251	5251	6490	6490	6490
		Elev:	332.38	325.79	314.28	297.05	294.04	283.64	247.58	241.03	238.66
Change	-316	dElev:	-0.09	-0.10	-0.10	-0.11	-0.09	-0.01	-0.20	-0.26	-0.24
300K AF Reduction	10344	Flow:	5204	5204	5204	5204	5204	5204	6351	6351	6351
		Elev:	332.36	325.76	314.25	297.02	294.02	283.64	247.50	240.92	238.57
Change	-474	dElev:	-0.12	-0.13	-0.13	-0.14	-0.11	-0.01	-0.27	-0.36	-0.34
400K AF Reduction	10186	Flow:	5132	5132	5132	5132	5132	5132	6204	6204	6204
		Elev:	332.32	325.72	314.21	296.97	293.98	283.63	247.42	240.82	238.46
Change	-632	dElev:	-0.16	-0.18	-0.18	-0.19	-0.15	-0.01	-0.35	-0.47	-0.44
500K AF Reduction	10028	Flow:	5038	5038	5038	5038	5038	5038	6066	6066	6066
		Elev:	332.26	325.66	314.15	296.90	293.93	283.63	247.35	240.71	238.37
Change	-790	dElev:	-0.22	-0.24	-0.24	-0.26	-0.20	-0.02	-0.43	-0.57	-0.53
675K AF Reduction	9752	Flow:	4941	4941	4941	4941	4941	4941	5841	5841	5841
		Elev:	332.20	325.60	314.08	296.83	293.87	283.62	247.22	240.54	238.21
Change	-1067	dElev:	-0.28	-0.30	-0.30	-0.33	-0.25	-0.02	-0.56	-0.74	-0.69
948K AF Reduction	9320	Flow:	4784	4784	4784	4784	4784	4784	5557	5557	5557
		Elev:	332.11	325.50	313.98	296.72	293.79	283.61	247.05	240.32	238.00
Change	-1498	dElev:	-0.37	-0.40	-0.40	-0.44	-0.34	-0.03	-0.72	-0.96	-0.90
1,553K AF Reduction	8364	Flow:	5123	5123	5123	5123	5123	5123	5352	5352	5352
		Elev:	332.31	325.71	314.20	296.96	293.97	283.63	246.93	240.16	237.85
Change	-2454	dElev:	-0.17	-0.18	-0.18	-0.20	-0.15	-0.02	-0.84	-1.12	-1.05
1,574K AF Reduction	8331	Flow:	5051	5051	5051	5051	5051	5051	5302	5302	5302
		Elev:	332.27	325.67	314.15	296.91	293.93	283.63	246.90	240.12	237.81
Change	-2487	dElev:	-0.21	-0.23	-0.23	-0.25	-0.19	-0.02	-0.87	-1.16	-1.09

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tf	tf	tf	cib	cib	cib	cib	cib	imp	imp	imp
109.1	103.1	96.7	86.1	80.4	72.2	70.3	66.1	56	53.6	50.8
6853	6853	6853	8264	8264	8264	8264	8264	8930	8930	8930
230.37	223.99	215.38	206.85	201.90	194.01	192.97	188.93	183.96	180.99	179.70
6490	6490	6490	7914	7914	7914	7914	7914	8604	8604	8604
230.13	223.79	215.14	206.67	201.74	193.85	192.80	188.76	183.84	180.92	179.69
-0.24	-0.20	-0.24	-0.18	-0.15	-0.16	-0.16	-0.16	-0.12	-0.08	-0.01
6351	6351	6351	7754	7754	7754	7754	7754	8443	8443	8443
230.03	223.71	215.05	206.59	201.67	193.78	192.73	188.69	183.77	180.88	179.68
-0.33	-0.28	-0.33	-0.27	-0.22	-0.24	-0.24	-0.24	-0.19	-0.11	-0.02
6204	6204	6204	7591	7591	7591	7591	7591	8284	8284	8284
229.93	223.62	214.95	206.50	201.60	193.70	192.65	188.61	183.71	180.84	179.68
-0.43	-0.37	-0.43	-0.35	-0.30	-0.31	-0.32	-0.32	-0.25	-0.15	-0.02
6066	6066	6066	7435	7435	7435	7435	7435	8128	8128	8128
229.84	223.54	214.85	206.41	201.53	193.63	192.57	188.53	183.65	180.81	179.67
-0.53	-0.45	-0.53	-0.44	-0.37	-0.39	-0.39	-0.39	-0.31	-0.19	-0.03
5841	5841	5841	7177	7177	7177	7177	7177	7858	7858	7858
229.68	223.41	214.70	206.27	201.41	193.50	192.45	188.41	183.54	180.74	179.66
-0.69	-0.58	-0.68	-0.58	-0.48	-0.51	-0.52	-0.52	-0.42	-0.25	-0.04
5557	5557	5557	6813	6813	6813	6813	6813	7447	7447	7447
229.48	223.24	214.50	206.06	201.24	193.32	192.27	188.23	183.37	180.65	179.64
-0.89	-0.75	-0.88	-0.79	-0.65	-0.69	-0.70	-0.70	-0.59	-0.34	-0.06
5352	5352	5352	6430	6430	6430	6430	6430	6655	6655	6655
229.33	223.11	214.35	205.84	201.06	193.13	192.07	188.04	183.04	180.47	179.62
-1.04	-0.88	-1.03	-1.01	-0.84	-0.88	-0.90	-0.89	-0.92	-0.52	-0.08
5302	5302	5302	6387	6387	6387	6387	6387	6619	6619	6619
229.29	223.08	214.32	205.81	201.04	193.11	192.05	188.02	183.02	180.47	179.62
-1.07	-0.9[illegible]	-1.06	-1.04	-0.86	-0.91	-0.92	-0.91	-0.94	-0.53	-0.08

Table A-5 Maximum Hourly Flows at Selected Locations along the Lower Colorado River in August

			ww	ww	ww	ww	ww	ww	tf	tf	tf
Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
Baseline	10818	Flow:	12101	12101	12101	12101	12101	12101	9786	9786	9786
		Elev:	335.79	329.46	317.83	300.59	296.78	284.10	249.19	243.16	240.63
200K AF Reduction	10502	Flow:	11950	11950	11950	11950	11950	11950	9481	9481	9481
		Elev:	335.72	329.39	317.77	300.53	296.74	284.08	249.05	242.98	240.47
Change	-316	dElev:	-0.06	-0.07	-0.07	-0.06	-0.05	-0.01	-0.14	-0.18	-0.16
300K AF Reduction	10344	Flow:	11896	11896	11896	11896	11896	11896	9332	9332	9332
		Elev:	335.70	329.37	317.75	300.51	296.72	284.08	248.99	242.89	240.39
Change	-474	dElev:	-0.09	-0.10	-0.09	-0.08	-0.06	-0.02	-0.20	-0.27	-0.24
400K AF Reduction	10186	Flow:	11721	11721	11721	11721	11721	11721	9159	9159	9159
		Elev:	335.62	329.29	317.67	300.44	296.67	284.07	248.91	242.79	240.29
Change	-632	dElev:	-0.16	-0.18	-0.17	-0.15	-0.12	-0.03	-0.28	-0.37	-0.34
500K AF Reduction	10028	Flow:	11685	11685	11685	11685	11685	11685	8982	8982	8982
		Elev:	335.61	329.27	317.65	300.43	296.65	284.06	248.83	242.68	240.19
Change	-790	dElev:	-0.18	-0.19	-0.18	-0.17	-0.13	-0.03	-0.36	-0.48	-0.44
675K AF Reduction	9752	Flow:	11383	11383	11383	11383	11383	11383	8649	8649	8649
		Elev:	335.47	329.13	317.52	300.30	296.56	284.04	248.67	242.47	240.00
Change	-1067	dElev:	-0.31	-0.34	-0.31	-0.29	-0.23	-0.06	-0.52	-0.68	-0.63
948K AF Reduction	9320	Flow:	10894	10894	10894	10894	10894	10894	8076	8076	8076
		Elev:	335.26	328.89	317.30	300.09	296.40	284.00	248.40	242.11	239.67
Change	-1498	dElev:	-0.53	-0.57	-0.54	-0.50	-0.39	-0.09	-0.79	-1.05	-0.96
1,553K AF Reduction	8364	Flow:	7764	7764	7764	7764	7764	7764	6378	6378	6378
		Elev:	333.76	327.27	315.75	298.58	295.23	283.79	247.52	240.94	238.58
Change	-2454	dElev:	-2.03	-2.19	-2.09	-2.01	-1.56	-0.31	-1.67	-2.21	-2.05
1,574K AF Reduction	8331	Flow:	7760	7760	7760	7760	7760	7760	6361	6361	6361
		Elev:	333.76	327.27	315.74	298.58	295.23	283.79	247.51	240.93	238.57
Change	-2487	dElev:	-2.03	-2.19	-2.09	-2.01	-1.56	-0.31	-1.68	-2.23	-2.06

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tf	tf	tf	cib	cib	cib	cib	cib	imp	imp	imp
109.1	103.1	96.7	86.1	80.4	72.2	70.3	66.1	56	53.6	50.8
9786	9786	9786	10208	10208	10208	10208	10208	9467	9467	9467
232.12	225.51	217.15	207.77	202.68	194.86	193.82	189.81	184.16	181.12	179.72
9481	9481	9481	9912	9912	9912	9912	9912	9160	9160	9160
231.95	225.36	216.98	207.64	202.57	194.74	193.70	189.68	184.05	181.05	179.71
-0.17	-0.15	-0.17	-0.13	-0.11	-0.12	-0.12	-0.13	-0.11	-0.07	-0.01
9332	9332	9332	9756	9756	9756	9756	9756	9003	9003	9003
231.86	225.29	216.89	207.57	202.51	194.67	193.63	189.61	183.99	181.01	179.70
-0.25	-0.22	-0.26	-0.20	-0.18	-0.19	-0.19	-0.20	-0.17	-0.11	-0.02
9159	9159	9159	9592	9592	9592	9592	9592	8844	8844	8844
231.77	225.20	216.79	207.49	202.44	194.60	193.56	189.54	183.93	180.97	179.70
-0.35	-0.30	-0.35	-0.28	-0.24	-0.26	-0.26	-0.27	-0.23	-0.15	-0.03
8982	8982	8982	9422	9422	9422	9422	9422	8684	8684	8684
231.67	225.11	216.69	207.41	202.38	194.53	193.49	189.46	183.87	180.93	179.69
-0.45	-0.39	-0.46	-0.35	-0.31	-0.33	-0.33	-0.35	-0.29	-0.18	-0.03
8649	8649	8649	9112	9112	9112	9112	9112	8400	8400	8400
231.48	224.95	216.50	207.27	202.25	194.39	193.35	189.32	183.76	180.87	179.68
-0.64	-0.56	-0.65	-0.50	-0.43	-0.47	-0.47	-0.49	-0.40	-0.25	-0.04
8076	8076	8076	8594	8594	8594	8594	8594	7945	7945	7945
231.14	224.65	216.15	207.02	202.04	194.16	193.12	189.08	183.58	180.76	179.66
-0.98	-0.85	-0.99	-0.75	-0.65	-0.69	-0.70	-0.73	-0.58	-0.35	-0.06
6378	6378	6378	7111	7111	7111	7111	7111	6844	6844	6844
230.05	223.72	215.07	206.23	201.38	193.47	192.42	188.38	183.12	180.52	179.62
-2.06	-1.78	-2.08	-1.53	-1.30	-1.39	-1.41	-1.43	-1.04	-0.60	-0.10
6361	6361	6361	7089	7089	7089	7089	7089	6814	6814	6814
230.04	223.71	215.06	206.22	201.37	193.46	192.40	188.37	183.11	180.51	179.62
-2.08	-1.79	-2.09	-1.55	-1.31	-1.40	-1.42	-1.44	-1.05	-0.61	-0.10

Table A-6 Minimum Hourly Flows at Selected Locations along the Lower Colorado River in December

			ww	ww	ww	ww	ww	ww	tf	tf	tf
Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
Baseline	4986	Flow:	2424	2424	2424	2424	2424	2424	3530	3530	3530
		Elev:	330.60	323.87	312.30	294.74	292.25	283.50	245.77	238.59	236.35
200K AF Reduction	4849	Flow:	2334	2334	2334	2334	2334	2334	3373	3373	3373
		Elev:	330.54	323.80	312.23	294.65	292.18	283.50	245.66	238.44	236.21
Change	-137	dElev:	-0.06	-0.07	-0.07	-0.09	-0.07	-0.00	-0.11	-0.15	-0.14
300K AF Reduction	4780	Flow:	2328	2328	2328	2328	2328	2328	3313	3313	3313
		Elev:	330.54	323.80	312.22	294.65	292.18	283.50	245.62	238.38	236.15
Change	-206	dElev:	-0.07	-0.07	-0.08	-0.09	-0.07	-0.00	-0.15	-0.21	-0.20
400K AF Reduction	4712	Flow:	2324	2324	2324	2324	2324	2324	3235	3235	3235
		Elev:	330.53	323.80	312.22	294.64	292.17	283.50	245.56	238.31	236.08
Change	-274	dElev:	-0.07	-0.07	-0.08	-0.10	-0.08	-0.00	-0.21	-0.28	-0.27
500K AF Reduction	4643	Flow:	2224	2224	2224	2224	2224	2224	3157	3157	3157
		Elev:	330.46	323.72	312.14	294.54	292.09	283.50	245.51	238.23	236.01
Change	-343	dElev:	-0.14	-0.15	-0.16	-0.20	-0.15	-0.01	-0.26	-0.36	-0.34
675K AF Reduction	4523	Flow:	2171	2171	2171	2171	2171	2171	3042	3042	3042
		Elev:	330.43	323.68	312.10	294.49	292.05	283.49	245.42	238.12	235.90
Change	-463	dElev:	-0.17	-0.19	-0.20	-0.25	-0.20	-0.01	-0.35	-0.47	-0.45
948K AF Reduction	4336	Flow:	2136	2136	2136	2136	2136	2136	2882	2882	2882
		Elev:	330.40	323.66	312.07	294.45	292.02	283.49	245.31	237.96	235.74
Change	-650	dElev:	-0.20	-0.21	-0.23	-0.29	-0.22	-0.01	-0.46	-0.63	-0.61
1,553K AF Reduction	3921	Flow:	2008	2008	2008	2008	2008	2008	2537	2537	2537
		Elev:	330.31	323.56	311.97	294.32	291.92	283.49	245.05	237.60	235.40
Change	-1065	dElev:	-0.29	-0.31	-0.33	-0.42	-0.33	-0.02	-0.72	-0.98	-0.95
1,574K AF Reduction	3906	Flow:	2007	2007	2007	2007	2007	2007	2525	2525	2525
		Elev:	330.31	323.56	311.97	294.32	291.92	283.49	245.04	237.59	235.39
Change	-1080	dElev:	-0.29	-0.31	-0.33	-0.42	-0.33	-0.02	-0.73	-1.00	-0.96

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tf	tf	tf	cib	cib	cib	cib	cib	imp	imp	imp
109.1	103.1	96.7	86.1	80.4	72.2	70.3	66.1	56	53.6	50.8
3530	3530	3530	4476	4476	4476	4476	4476	4857	4857	4857
227.89	221.93	212.96	204.54	200.03	192.07	190.98	187.03	182.21	180.08	179.57
3373	3373	3373	4329	4329	4329	4329	4329	4718	4718	4718
227.76	221.82	212.83	204.43	199.95	191.98	190.89	186.95	182.14	180.05	179.56
-0.13	-0.11	-0.13	-0.11	-0.08	-0.09	-0.09	-0.08	-0.07	-0.03	-0.00
3313	3313	3313	4255	4255	4255	4255	4255	4647	4647	4647
227.71	221.78	212.78	204.37	199.91	191.94	190.85	186.91	182.10	180.04	179.56
-0.19	-0.15	-0.18	-0.17	-0.13	-0.13	-0.13	-0.12	-0.10	-0.04	-0.01
3235	3235	3235	4182	4182	4182	4182	4182	4578	4578	4578
227.64	221.73	212.72	204.31	199.86	191.89	190.80	186.87	182.07	180.02	179.56
-0.25	-0.21	-0.24	-0.22	-0.17	-0.17	-0.18	-0.16	-0.14	-0.06	-0.01
3157	3157	3157	4108	4108	4108	4108	4108	4508	4508	4508
227.57	221.67	212.65	204.26	199.82	191.85	190.76	186.83	182.03	180.01	179.56
-0.32	-0.26	-0.31	-0.28	-0.21	-0.22	-0.22	-0.20	-0.17	-0.07	-0.01
3042	3042	3042	3988	3988	3988	3988	3988	4389	4389	4389
227.47	221.59	212.55	204.16	199.75	191.78	190.68	186.77	181.97	179.98	179.55
-0.43	-0.34	-0.41	-0.37	-0.28	-0.29	-0.30	-0.26	-0.23	-0.10	-0.01
2882	2882	2882	3808	3808	3808	3808	3808	4204	4204	4204
227.32	221.48	212.42	204.02	199.64	191.67	190.57	186.67	181.88	179.94	179.55
-0.57	-0.46	-0.54	-0.52	-0.39	-0.40	-0.41	-0.36	-0.33	-0.14	-0.02
2537	2537	2537	3435	3435	3435	3435	3435	3802	3802	3802
227.01	221.22	212.12	203.71	199.42	191.44	190.33	186.46	181.67	179.86	179.54
-0.89	-0.71	-0.84	-0.83	-0.62	-0.63	-0.65	-0.57	-0.54	-0.22	-0.03
2525	2525	2525	3421	3421	3421	3421	3421	3788	3788	3788
227.00	221.21	212.10	203.70	199.41	191.43	190.32	186.46	181.66	179.86	179.54
-0.90	-0.72	-0.85	-0.84	-0.63	-0.64	-0.66	-0.58	-0.55	-0.22	-0.03

Table A-7 Maximum Hourly Flows at Selected Locations along the Lower Colorado River in December

Location (RM)	ParkerDam Avg Flow		ww 171.3	ww 167.6	ww 160.9	ww 149.5	ww 146.9	ww 135.8	tf 119.7	tf 116.5	tf 114.6
Baseline	4986	Flow:	6116	6116	6116	6116	6116	6116	5170	5170	5170
		Elev:	332.88	326.32	314.81	297.62	294.48	283.69	246.83	240.02	237.71
200K AF Reduction	4849	Flow:	6109	6109	6109	6109	6109	6109	5061	5061	5061
		Elev:	332.87	326.32	314.81	297.62	294.48	283.69	246.76	239.93	237.63
Change	-137	dElev:	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.07	-0.09	-0.08
300K AF Reduction	4780	Flow:	6081	6081	6081	6081	6081	6081	4996	4996	4996
		Elev:	332.86	326.30	314.79	297.60	294.46	283.68	246.72	239.87	237.58
Change	-206	dElev:	-0.02	-0.02	-0.02	-0.02	-0.02	-0.00	-0.11	-0.14	-0.13
400K AF Reduction	4712	Flow:	6051	6051	6051	6051	6051	6051	4931	4931	4931
		Elev:	332.84	326.28	314.77	297.58	294.45	283.68	246.68	239.82	237.53
Change	-274	dElev:	-0.04	-0.04	-0.04	-0.04	-0.03	-0.00	-0.15	-0.20	-0.18
500K AF Reduction	4643	Flow:	6008	6008	6008	6008	6008	6008	4863	4863	4863
		Elev:	332.82	326.26	314.75	297.55	294.43	283.68	246.64	239.76	237.47
Change	-343	dElev:	-0.06	-0.07	-0.06	-0.07	-0.05	-0.01	-0.19	-0.25	-0.24
675K AF Reduction	4523	Flow:	5923	5923	5923	5923	5923	5923	4725	4725	4725
		Elev:	332.77	326.21	314.70	297.50	294.39	283.68	246.55	239.65	237.37
Change	-463	dElev:	-0.11	-0.12	-0.12	-0.12	-0.10	-0.01	-0.27	-0.37	-0.35
948K AF Reduction	4336	Flow:	5840	5840	5840	5840	5840	5840	4530	4530	4530
		Elev:	332.72	326.16	314.65	297.44	294.35	283.67	246.43	239.48	237.21
Change	-650	dElev:	-0.15	-0.17	-0.17	-0.18	-0.14	-0.02	-0.40	-0.53	-0.50
1,553K AF Reduction	3921	Flow:	5491	5491	5491	5491	5491	5491	4040	4040	4040
		Elev:	332.52	325.94	314.43	297.21	294.17	283.65	246.11	239.06	236.80
Change	-1065	dElev:	-0.35	-0.38	-0.38	-0.41	-0.31	-0.03	-0.71	-0.96	-0.91
1,574K AF Reduction	3906	Flow:	5477	5477	5477	5477	5477	5477	4021	4021	4021
		Elev:	332.52	325.93	314.42	297.20	294.16	283.65	246.10	239.04	236.78
Change	-1080	dElev:	-0.36	-0.39	-0.39	-0.42	-0.32	-0.04	-0.72	-0.98	-0.93

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tf	tf	tf	cib	cib	cib	cib	cib	imp	imp	imp
109.1	103.1	96.7	86.1	80.4	72.2	70.3	66.1	56	53.6	50.8
5170	5170	5170	5565	5565	5565	5565	5565	5163	5163	5163
229.20	223.00	214.22	205.30	200.62	192.68	191.61	187.60	182.36	180.15	179.57
5061	5061	5061	5436	5436	5436	5436	5436	5027	5027	5027
229.11	222.93	214.14	205.21	200.56	192.61	191.53	187.54	182.29	180.12	179.57
-0.08	-0.07	-0.08	-0.09	-0.07	-0.07	-0.07	-0.07	-0.07	-0.03	-0.00
4996	4996	4996	5367	5367	5367	5367	5367	4959	4959	4959
229.07	222.89	214.10	205.16	200.52	192.57	191.50	187.50	182.26	180.10	179.57
-0.13	-0.11	-0.13	-0.13	-0.10	-0.11	-0.11	-0.10	-0.10	-0.04	-0.01
4931	4931	4931	5299	5299	5299	5299	5299	4892	4892	4892
229.02	222.85	214.05	205.12	200.48	192.53	191.46	187.47	182.22	180.09	179.57
-0.18	-0.15	-0.18	-0.18	-0.14	-0.14	-0.15	-0.14	-0.13	-0.06	-0.01
4863	4863	4863	5229	5229	5229	5229	5229	4823	4823	4823
228.97	222.81	214.00	205.07	200.45	192.49	191.42	187.43	182.19	180.07	179.56
-0.23	-0.19	-0.23	-0.22	-0.18	-0.18	-0.19	-0.17	-0.17	-0.07	-0.01
4725	4725	4725	5100	5100	5100	5100	5100	4701	4701	4701
228.86	222.72	213.89	204.98	200.38	192.42	191.34	187.36	182.13	180.05	179.56
-0.34	-0.28	-0.33	-0.31	-0.25	-0.25	-0.26	-0.24	-0.23	-0.10	-0.01
4530	4530	4530	4899	4899	4899	4899	4899	4511	4511	4511
228.71	222.60	213.75	204.84	200.27	192.31	191.23	187.26	182.03	180.01	179.56
-0.49	-0.40	-0.48	-0.45	-0.35	-0.37	-0.38	-0.35	-0.32	-0.14	-0.02
4040	4040	4040	4422	4422	4422	4422	4422	4080	4080	4080
228.32	222.28	213.37	204.50	200.00	192.04	190.95	187.00	181.81	179.92	179.55
-0.88	-0.72	-0.85	-0.80	-0.62	-0.64	-0.66	-0.60	-0.54	-0.23	-0.03
4021	4021	4021	4405	4405	4405	4405	4405	4064	4064	4064
228.30	222.27	213.35	204.48	199.99	192.03	190.94	186.99	181.80	179.91	179.55
-0.89	-0.74	-0.87	-0.81	-0.63	-0.65	-0.67	-0.61	-0.55	-0.23	-0.03

APPENDIX B.
Description of the Interim Surplus Criteria Alternatives

1. **California Alternative.** The California Alternative specifies Lake Mead water surface elevations to be used for an interim period through 2015 for determining the availability of surplus water. The elevation ranges are coupled with uses of surplus water in such a way that, if Lake Mead's surface elevation declines, the permitted uses of surplus water would become more restrictive, thereby reducing deliveries of surplus water. This combination of "tiered" surplus trigger elevations would limit the use of surplus water to priority municipal and industrial (M&I) needs at lower water levels. The trigger elevations for each tier are not static, but are expressed by lines (see Figure 3). The California Alternative also provides for periodic adjustment of the triggering line elevations in response to changes in Upper Basin water demand projections to 2015, as described below. Use schedules are provided in the ISC DEIS (USBR, 2000).

The Lake Mead elevations at which surplus conditions would be determined under the California Alternative are indicated by a series of tiered, sloping lines from the present to 2015. Each tiered line would be coupled with stipulations regarding the purposes for which surplus water may be used at that tier. Each tier is defined as a trigger line that rises gradually year by year to 2015, in recognition of the gradually increasing water demand of the Upper Division States. Each tier under the California alternative would be subject to adjustment during the interim period based on changes in Upper Basin demand projections or other factors during the five-year reviews or as a result of actual operating experience.

The following sections describe the California Alternative tiers and the associated purposes for which surplus water may be used at those tiers. Notwithstanding the restrictions mentioned in the description of these tiers, when flood control releases are made, any and all beneficial uses would be met, including unlimited off stream groundwater banking and additional water for Mexico.

a. **California Alternative Tier 1.** California Alternative Tier 1 Lake Mead surplus trigger elevations range from a current elevation of 1160 feet msl to 1166 feet msl in 2015 (based on 1998 Upper Basin demand projections). Lake Mead water surface elevations at or above the Tier 1 trigger line would permit surplus water diversions by the Lower Division States.

b. **California Alternative Tier 2.** California Alternative Tier 2 Lake Mead surplus trigger elevations range from 1116 feet msl to 1125 feet msl (based on 1998 Upper Basin demand projections). Lake Mead water surface elevations at or above the Tier 2 line (and below the Tier 1 line) would permit surplus water diversions as outlined in applicable use schedules.

c. **California Alternative Tier 3.** California Alternative Tier 3 trigger elevations range from 1098 feet msl to 1102 feet msl (based on Upper Basin demand projections). Lake Mead water surface elevations at or above the Tier 3 line (and below the Tier 2 line) would permit surplus water diversions. When Lake Mead water levels are below the Tier 3 trigger elevation, surplus water would not be made available.

2. **Six States Alternative.** The Six States Alternative specifies ranges of Lake Mead water surface elevations to be used through 2015 for determining the availability of surplus water. As with the California Alternative, elevation ranges are coupled with uses of surplus water in such a way that, if Lake Mead's surface elevation were to decline, the permitted uses of surplus water would become more restrictive, thereby reducing delivery of surplus water. Unlike the California Alternative, the Six States Alternative trigger elevations for the various tiers are static over the 15 years during which the interim surplus criteria will be in effect (interim period) and are not subject to revisions based on changes in Upper Basin demand projections. However, the interim criteria will be reviewed at five-year intervals and as needed based upon actual operational experience.

Surplus determination elevations under the Six States Alternative consist of a series of tiered Lake Mead water surface elevations and each tier places stipulations on the purposes for which surplus water could be used.

a. Tier 1. The Six States Alternative Tier 1 surplus trigger elevations follow the 75R line and range from approximately 1,194 feet msl in Year 1 to 1,196 feet msl in Year 15 of the interim period. The notation 75R refers to the specific inflow where 75 percent of the historic natural runoff is less than this value (18.1 maf) for the Colorado River Basin at Lee Ferry. The minimum 75R trigger line rises from approximately 1194 feet msl to 1196 feet msl during the period through 2015 for which interim surplus conditions are being considered. The gradual rise in elevation shown by the 75R trigger line is the result of increasing water use in the Upper Basin. Water will be available to the Lower Division States when Lake Mead surface elevations are at or above the 75R line. The Six States Alternative includes a schedule of projected depletions from Year 2000 through 2050 that forecasts how much water will be available to each Lower Division State for each year from 2000 through 2050.

b. Tier 2. The Six States Alternative Tier 2 surplus trigger elevation is 1,145 feet msl. At or above this elevation, surplus water is available as outlined in The Six States Alternative Tier 2 Lake Mead surplus trigger elevation is 1145 feet msl. At or above this Tier 2 elevation (and below Tier 1), surplus water is available.

c. Tier 3. The Six States Alternative Tier 3 Lake Mead surplus trigger elevation is 1,125 feet msl. At or above this Tier 3 elevation (and below Tier 2), surplus water is made available. When Lake Mead water levels are below the Tier 3 trigger elevation, surplus water would not be available.

3. **Shortage Protection Alternative.** The Shortage Protection Alternative is based on maintaining an amount of water in Lake Mead necessary to provide the one year Lower Division normal supply of 7.5 maf, and storage necessary to provide an 80th percentile of protection against Lake Mead dropping below the shortage elevation line (rule curve).

During the interim period when surplus criteria are in effect, California's progress in achieving their intended goal of reducing dependence on surplus flows would be monitored. The continuation of the interim surplus criteria through 2015 would be contingent upon satisfactory progress.

The Shortage Protection Alternative criteria would be in effect through 2015. In 2016, the Shortage Protection Alternative criteria would terminate, and in the absence of any subsequently-specified surplus criteria, surplus determinations would be made by future Secretaries based on then relevant factors. The surplus triggers under this alternative range from an approximate Lake Mead elevation of 1,116 feet msl in Year 1 to an elevation of 1,121 feet msl in Year 15. At Lake Mead elevations above the rule curve, surplus conditions would be determined to be in effect, and all surplus schedules would be met. Below the rule curve, surplus water is not made available.

4. **Flood Control Alternative.** The Flood Control strategy involves making flood releases from Lead Mead based on the maximum forecasted inflow into Lake Mead to prevent filling the reservoir beyond its 1.5 maf minimum flood control storage space. Under the Boulder Canyon Project Act, flood control is specified as the project purpose having first priority for operation of Hoover Dam. The Corps of Engineers prescribes flood control regulations for Lake Mead after consulting and coordinating with Reclamation. Flood control operation of Lake Mead deals with two types of flooding - snowmelt and rain. Lake Mead's uppermost 1.5 maf of storage capacity, between elevations 1,219.61 and 1,229.0 feet mean sea level (msl), is allocated exclusively to control floods from rain events. Snowmelt constitutes about 70 percent of the annual runoff into the Upper Basin and 3.85 maf of storage space is needed for basin-wide snowmelt. This storage space is distributed among Lake Mead, Lake Powell, and several other Upper Basin reservoirs. In preparation for each year's snow accumulation and projected runoff, the minimum reservoir space required is increased progressively from a 1.5 maf on August 1 to 5.35 maf on January 1. Space building releases are made when needed to meet the required progression in increased flood control space from August 1 to January 1. Between January 1 and July 31, flood control releases may be required, based on the maximum forecasted inflow into Lake Mead, to prevent filling Lake Mead beyond its 1.5 maf minimum space.

APPENDIX C.
California's Colorado River Water Use Plan Principal Components

The purpose of California's Colorado River Water Use Plan (The Plan) is to provide Colorado River water users with a framework by which programs, projects and other activities will be coordinated and cooperatively implemented, allowing California to most effectively satisfy its annual water supply needs within its annual apportionment of Colorado River water. The framework specifies how California will transition and live within its annual basic apportionment of 4.4 million acre feet (maf) of Colorado River water. The included activities of The Plan are wide in scope, involving water quantification for two districts, voluntary water transfer programs, improved water conveyance efficiencies (canal lining), water storage, improved management and operations, surplus and drought water management planning, groundwater management, and Colorado River salinity control and watershed protection. The principal components and sub-components of The Plan are summarized in Table 1 (Colorado River Board of California, 2000).

Table C-1. Components of California's Colorado River Water Use Plan.

Principal Component	Sub-components
Water Transfers	• Cooperative Water Conservation Programs • Land Fallowing/Water Supply Programs • Water Purchases • Other
Increased User Supply Availability, Existing Projects	• Storage and Conjunctive Use Programs • Coordinated Project Operations • Interstate Offstream Water Bank • Unused Apportionments and Entitlements
Other Integrated Sources of User Supply	• Ground, Surface, and Imported Supplies • Additional Local Projects • Water Reuse • Groundwater and Surface Water Recovery • Dry Year Supplies
Demand Management	• Water Conservation • Water Use Best Management Practices • Water Scheduling • Peak Water Use Management
Water Supply to Others (Non-Colorado River Water Rights Users)	• San Luis Rey Indian Water Right Settlement Parties • Lower Colorado Water Supply Project Contractors
Improved River and Reservoir Management and Operations	• Interim Surplus Water and Shortage Criteria • Long-Range Surplus Water and Shortage Criteria • Reduced System Losses • Improved Coordinated Reservoir Operation • Annual Operating Plan • Five-Year Reviews of LROC
Resource Management	• Groundwater Management • Exchanges • Drought and Surplus Water Management Plans • Lower Colorado River Multi-Species Conservation Program • Salton Sea • Vegetation Management • River Augmentation
Water Quality	• Salinity Control Program • Watershed Protection
International Aspects	• Mexican Water Treaty Obligation • Minute No. 242 Compliance • Yuma Desalting Plant Operations • Emergency Supplies

Principal Component	Sub-components
Administration of Water Rights and Use	• Mainstream and Tributary Water Determinations • Section 5 Contracts • Priority System • Reasonable Beneficial Use Requirements • Proper Credit for Return Flows • Overrun Accounts and Pay Backs • Further Quantification of Water Rights and Uses • Decree Accounting • Agency Water Budgets • Interagency Water Supply and Management Agreements

APPENDIX D.
Programs, Projects and Activities as Part of California's Colorado River Water Use Plan

1. **Quantification of Priority 3.** The California Seven-Party Agreement, dated August 18, 1931 (Seven-Party Agreement), established the priority system for delivery of Colorado River water to the principal California water districts. The Seven-Party Agreement establishes seven levels of water priority among the parties to that agreement. Implementation of the Proposed SIA Action will primarily affect Priority 3 water. The six priority levels set forth in the Seven-Party Agreement are shown in Table D-1.

Table D-1. Water Priorities in the California Seven-Party Agreement of 1931

Priority Number	Agency and Description	Annual Quantity in af
1	Palo Verde Irrigation District – gross area of 104,500 acres	
2	Yuma Project (Reservation Division) –not exceeding a gross area of 25,000 acres	
3(a)	Imperial Irrigation District (IID) and lands in Imperial and Coachella Valleys to be served by All-American Canal	
3(b)	Palo Verde Irrigation District – 16,000 acres of mesa lands	Combined total
4	Metropolitan Water District, City of Los Angeles and/or others on coastal plain	3,850,000
5(a)	Metropolitan Water District, City of Los Angeles and/or others on coastal plain	550,000
5(b)	City and/or County of San Diego	550,000
6(a)	Imperial Irrigation District and lands in Imperial and Coachella Valleys to be served by All-American Canal	112,000
6(b)	Palo Verde Irrigation District – 16,000 acres of mesa lands	300,000

The Quantification Settlement Agreement places a limit in non-surplus or limited surplus years on deliveries of Colorado River water to IID and CVWD and obligates IID to undertake major conservation activities over many years. IID and CVWD will agree to place temporary delivery limits on their previously unquantified entitlements to Colorado River water during the 75 years of the Quantification Period. During the Quantification Period, the Secretary will deliver annually, after adjustments for return flows, up to 3.1 maf to IID and up to 330 thousand acre-feet (kaf) to CVWD. The Colorado River water made available by quantifying IID's and CVWD's Priority Three rights will be transferred to MWD pursuant to The Plan. In addition, the Colorado River water to be saved by the water conservation activities that IID will implement pursuant to the Plan will transfer to MWD through The Plan.

Note: The 3.1 maf available to IID pursuant to the Quantification Settlement Agreement is reduced by the 110 kaf of water from a water conservation program that was in place prior to the Quantification Settlement Agreement. IID and MWD entered into an Agreement for Implementation of Water Conservation Program and Use of Conserved Water, dated December 22, 1988 (1988 Agreement). This program resulted in the transfer of 110 kaf to MWD, IID, MWD, CVWD; and PVID entered into an Approval Agreement, dated December 19, 1989 (1989 Agreement), that transferred to CVWD 20 kaf of the water that is conserved under the 1988 Agreement. Although these transfers are already in effect, they are noted here because they are components of The Plan and must be subtracted from IID's 3.1 maf Priority 3 right.

Except as agreed in the Quantification Settlement Agreement and put into effect through legal documents entered into by the affected parties, all terms and conditions of existing water delivery contracts will remain in full force and effect through the Quantification Period. When the Quantification Period ends, the Secretary will resume delivering Colorado River water in accordance with the water delivery contracts that were in effect immediately preceding the start of the Quantification Period.

2. **IID/SDCWA Water Conservation and Transfer Project.** IID and SDCWA entered into an Agreement for Transfer of Conserved Water, dated April 29, 1998, that provides for IID to undertake water conservation activities in IID for the benefit of SDCWA. The conserved water will be transferred to SDCWA over several years. The initial transfer is projected to occur in 2004. The quantity of conserved water transferred will increase by 20 kaf each succeeding calendar year until the maximum amount of the transfer has been established, which will be no less than 130 kaf and as much as 200 kaf of conserved water.

There is an exchange agreement between San Diego and MWD that provides for the transfer of IID water to MWD at Lake Havasu, but since this is not a Federal action the exchange agreement is not part of this assessment.

3. **IID/CVWD/MWD Conservation Program.** The water conservation actions to be undertaken by IID to implement the IID/SDCWA transfer are expected to conserve up to 300 kaf. In addition to the 200 kaf to be transferred to SDCWA, 100 kaf of conserved water will be made available to CVWD in two 50 kaf increments under the quantification settlement and ancillary agreement. If CVWD elects not to accept this conserved water, it will transfer to MWD.

4. **All-American Canal Lining Project.** The lining of the All-American Canal was authorized by Title II of an Act of Congress dated January 25, 1988. This Act authorized the Secretary to construct a new lined canal or to line the previously unlined portions of the All-American Canal to reduce seepage of water. Title II authorizes the Secretary to determine the amount of water conserved by this canal lining. The Act further directs that the water so conserved is to be made available for consumptive use by California contractors within their service areas according to their priority under the Seven-Party Agreement. Reclamation prepared a Final Environmental Impact Statement/Final Environmental Impact Report for the All-American Canal Lining Project in March 1994. This EIS states that the preferred alternative for controlling seepage from the All-American Canal would reduce seepage by approximately 67.7 kaf per year.

Title I of this same Act of January 25, 1988, is known as the San Luis Rey Indian Water Rights Settlement Act. Title I authorizes a source of water to settle the reserved water rights claims of the La Jolla, Rincon, San Pasqual, Pauma, and Pala Bands of Mission Indians in San Diego County, California. The Act authorized the Secretary to arrange for development of a water supply for the benefit of the bands of not more than 16 kaf per year and authorized the Secretary to use water conserved from the works authorized by Title II of the Act of January 25, 1988 for this purpose.

The Quantification Settlement Agreement among the State of California, IID, CVWD, and MWD divided the 67.7 kaf of annual conserved water as follows: 56.2 kaf to MWD and 11.5 kaf for San Luis Rey Indian Water Rights Settlement Act purposes. This undertaking, which involves Federal canal rights-of-way and the San Luis Rey water settlement, is part of the proposed SIA (Table 1). The State of

California enacted legislation to fund the lining of the All-American Canal to help facilitate implementation of The Plan.

5. Coachella Canal Lining Project. The lining of the previously unlined portions of the Coachella Branch of the All-American Canal (Coachella Canal) was also authorized by Title II the Act of January 25, 1988. This Act authorized the Secretary to construct a new lined canal or to line the previously unlined portions of the Coachella Canal to reduce seepage of water. As with the All-American Canal, Title II authorizes the Secretary to determine the amount of conserved water and directs that the water so conserved is to be made available for consumptive use by California contractors within their service areas according to their priority under the Seven-Party Agreement. Reclamation prepared a Draft Environmental Impact Statement/Final Environmental Impact Report for the Coachella Canal Lining Project in December 1993. The preferred alternative for controlling seepage from the Coachella Canal would result in projected water savings of approximately 26 kaf per year.

As with the All-American Canal, Title I of the Act of January 25, 1988 authorizes use of some of the conserved water to settle the reserved water rights claims of the La Jolla, Rincon, San Pasqual, Pauma, and Pala Bands of Mission Indians in San Diego County, California.

The Quantification Settlement Agreement among the State of California, IID, CVWD, and MWD divided the 26 kaf of annual conserved water as follows: 21.5 kaf to MWD and 4.5 kaf for San Luis Rey Indian Water Rights Settlement Act purposes. This undertaking is part of the All-American Canal lining project authorized by Title II of the Act of January 25, 1988, involves Federal canal rights-of-way and the San Luis Rey water settlement, and is part of the proposed SIA (Table 3). The legislation enacted by the State of California to fund the lining of the All-American Canal includes funding to line the Coachella Canal.

6. MWD/CVWD Exchange. The Plan calls for an exchange by MWD of 35 kaf of (California) State Water Project water for 35 kaf of Colorado River water from CVWD. This action does not have a Federal nexus as to approval but is part of the programs, projects, and activities that make up The Plan.

Bibliography

U.S. Bureau of Reclamation. 1994. *Final Environmental Impact Statement/Final Environmental Impact Report for All-American Canal Lining Project.* U.S. Department of Interior Bureau of Reclamation, Lower Colorado River Region, Boulder City, Nevada and Imperial Irrigation District, Imperial, California. Clearinghouse Number SCH90010472.

U.S. Bureau of Reclamation. 1993. *Draft Environmental Impact Statement/Environmental Impact Report for the Coachella Canal Lining Project.* U.S. Department of the Interior Bureau of Reclamation, Lower Colorado River Region, Boulder City, Nevada.

APPENDIX E.

Description of Preliminary Hydrologic Depletion Analysis of Backwater, Aquatic, and Riparian Changes Resulting from a 1.574 Million Acre Foot (MAF) Change in Point of Diversion Between Parker and Imperial Dams on the Lower Colorado River California and Arizona, August 2000

Backwater and Aquatic Analysis

Introduction

The potential exists that, over the next 50 years, an additional 1.574 maf of water, may be diverted at Parker Dam. This will result in a reduction of flows in the river between Parker and Imperial Dams. Flows below Imperial Dam are not expected to change. This analysis is to determine the changes in the backwater and aquatic habitat resulting from this diversion.

Purpose

The purpose of this analysis is to provide an estimate of the effects of diverting up to 1.574 million acre-feet (maf) annually at Parker Dam over the next 50 years. Incremental flow data was utilized to facilitate a pro rata analysis of the effect(s) of the diversion.

Data from this analysis were used to determine the following:

1. An estimate of the range of water surface elevation and open water surface area changes (i.e. changes in width and depth) in the river resulting from the subject diversions. Estimates included adjustment for representative seasonal and daily flows.

2. Identified affected river channel sections adjacent to concentrations of backwaters, marshes, or riparian habitat.

3. Projected changes in ground water elevations in areas adjacent to the river for the purpose of estimating the effect(s) on the riparian and marsh communities.

4. Characteristics of river channels in affected reaches with respect to degree of channelization, stabilization, and natural or non-channelized river channel conditions.

5. Characteristics of backwaters adjacent or connected to affected reaches of the river with respect to morphology, gross plan outline, and bank slope characteristics.

6. Projected changes in backwater surface area and depths at representative seasonal and daily flows.

Data Sources

Data sources utilized for the analysis included, but were not limited to:

1. Hydrologic model runs and river channel cross-sections for 20 representative type-areas distributed throughout the affected river reaches (Parker, Palo Verde, Cibola, and Imperial Divisions).

Input to the hydrologic model runs includes calendar month and average daily releases from Parker Dam. The output from the hydrologic model runs includes an hourly release pattern for Parker Dam, which is routed downstream through the Water Wheel, Taylor Ferry, and Cibola gages to Imperial Dam (Carson, July 7, 2000). A subsequent hydrologic model run was also performed to determine the annual median flows for the river in the affected reaches. The purpose of this run was to facilitate calculation of the median water surface elevations and their effect on ground water levels in areas adjacent to, but not directly connected to the river. Input for this run includes average monthly releases from Parker Dam, output includes values for annual median flows in the affected reaches.

Flows routed to each side of the river are adjusted for diversions, gains, and losses, depending on the month. The routing method used is called the 'Muskingum method', which is further calibrated for historical flows at the gages specified above. Past experience using this method for calculations has indicated good correlation and reliability of values over a wide range of flows. Elevation flow ratings at the representative channel sections were also used to compute the water surface elevations (Carson, 2000).

River channel cross-sections are a composite of surveyed channel sections (bankline to bankline) and river floodway maps (profile extending out from the bankline) (Langmaid, July 10, 2000). Criteria for selection of representative river channel cross-sections for the type-areas included: correlative similarities in channel morphology and geometry, location with respect to river flow direction (upstream) and proximity to concentrations of representative backwater acreage, availability of quantitative data (i.e. depth, channel profile, etc.) at or adjacent to the foci of representative backwaters, and other relevant information.

2. Detailed surveys of 27 representative backwaters located adjacent to or connected with the affected reaches of the river. Surveys were conducted using global positioning system (GPS) technology and traditional surveying methods. Backwater survey lines generally included several cross-sections, including profiles along the longitudinal and lateral axes.

3. Other data and related reports and reference texts including current facilities maps, recent consultant river and backwaters mapping update and vegetation mapping / GIS development reports.

Data Analysis

The analysis was accomplished by the application of a variety of methods, techniques, principles, and/or rationales. The process for determining the following results included, but was not limited to:

1. *Estimates of the range of water surface elevation and open water surface area changes* - these estimates were the results of analysis of data from a combination of incremental hydrologic modeling runs and selected representative river channel cross-sections, in combination with geographic information systems (GIS) modeling and analysis.

The projected maximum (base case), average and minimum flows and water surface elevations derived from the hydrologic modeling runs were superimposed onto the river channel cross-sections for a comparison of the qualitative and quantitative changes in river channel geometry, morphology and effect(s) on associated habitat(s).

2. *Affected river channel sections adjacent to concentrations of backwaters, marshes, or riparian habitat* - these channel sections were identified according to the criteria listed (Data Sources section; item 1). Tabulated data from the recent consultant river and backwaters mapping update (GEO/Graphics, Inc.; June, 2000) were summarized and used to identify these channel sections as foci for 'clusters' or concentrations of backwaters in the affected reaches. This data was also used to quantify and/or determine relevant backwater characteristics (i.e. total acreage, emergent vegetation, open water, type of connection with the main channel, backwater status, etc.) for the analysis. The updated backwaters maps were also used to verify the existence and characteristics of the backwaters listed. The number of backwaters associated with each of the river channel sections varies, ranging from 2 - 42 backwaters/section and averaging about 14 backwaters/section.

3. *Projected changes in ground water elevations adjacent to the river to determine the effect(s) on riparian/marsh habitat* - the changes in ground water elevations adjacent to the river were determined based on the annual median flows for the affected river reaches, as determined by the hydrologic model runs for annual median flows released from Parker Dam (Data Sources section; item 1).

4. *Characteristics of river channel related to the degree of channelization, stabilization, and natural or unchannelized conditions in affected reaches* - the river channel characteristics in the affected reaches were determined by inspection and comparison of the current facilities maps (USBR, 1994-1997) and consultant river and backwaters mapping update (GEO/Graphics, Inc., 2000). This included an estimate of the current degree of channelization and/or stabilization and the presence of 'natural' or unchannelized conditions in the affected reaches.

5. *Characteristics of representative backwaters connected to or adjacent to affected reaches of the river* - the relevant characteristics of the representative backwaters were determined by extracting, filtering, and summarizing data (i.e. longitudinal and lateral profiles, slopes, depths, gross plan outlines, acreage, etc.) for analysis, reducing the data by further analysis and inspecting the results for trends, natural groups, anomalies, or other data characteristics.

Three natural groups of backwaters were identified based on shape or gross plan outline: linear, ellipsoid, and combination (features from both groups). Analysis of bank slope (angle) data revealed a trend toward convergence of average bank slope angle values in the range of 30^0 - 39^0 from horizontal. These values closely approximate those observed and documented in the literature as the angle of repose for natural, unconsolidated slopes (Longwell and others, 1969; Bates and Jackson, 1980). The lower value (30^0) was used for determining the reduction in surface area for both the backwaters and the open river.

6. *Projected changes in backwater surface area and depths at representative seasonal and daily flows* - the reduction in backwater surface area and depth values was determined using the data obtained above (item 5 of this section and Data Sources section; item 1) in combination with geographic information systems (GIS) modeling and analysis.

7. *GIS Modeling and Analysis*

General Strategy

The primary source of information for this analysis was the study entitled "Lower Colorado Backwaters Mapping, Davis Dam to Laguna Dam, June 2000." The study was performed under contract by GEO/Graphics Inc. (2000). ArcInfo, based on Fall 1997 color aerial photography, was used to depict the backwaters of the Colorado River and their characteristics.

The purpose of the analysis was to determine the reduction in surface area of backwaters and open river resulting from a 1.574 maf flow reduction in the Colorado River below Parker Dam. The overall strategy was to 1) determine the average slope of the banks of the backwaters and river and then 2) use this slope, along with the drop in water surface elevation resulting from a 1.574 maf flow reduction, in a GIS analysis to calculate the reduced surface area of the backwaters/river. In this way, a before and after acreage summary of the conditions during normal flow and reduced flow was developed, along with a graphical depiction of those conditions.

Slope of the backwaters was determined from AutoCAD drawings of 27 representative backwaters, dated April 21, 2000. The average slope for linear-shaped backwaters is 39 degrees, and for ellipsoid-shaped backwaters is 30 degrees. Thirty degrees falls within the well-documented angle of repose for natural slopes, which rarely is less than 30 degrees or more than 39 degrees.

Tables were developed listing drawdowns in water surface elevation resulting from various flow reductions for 20 different stretches of the Colorado River below Parker Dam. Data was developed for flow reductions in three different months (April, August, and December), as well as for the annual median flow.

In total, GIS analyses were performed for 6 different scenarios: Reduction in the surface area of backwaters for the months of April, August, and December, and reductions in the surface area of the Colorado River for April, August, and December.

In their backwater study, GEO/Graphics designated backwaters as being either directly connected or indirectly connected to the open water of the Colorado River. Directly-connected backwaters have open water leading directly to the river channel. Indirectly-connected backwaters are separated from the river by an upland area, and are most likely supported through sub-surface flow from the river.

The surface elevation of the directly-connected backwaters immediately rises or falls with the river. Therefore, monthly drawdown figures for the directly-connected backwaters were used in the GIS analysis. These same monthly figures were used in the analyses of reduction in surface area for the Colorado River.

Because the indirectly-connected backwaters do not rise or fall immediately with the river, the annual median drawdown figures were used in the subsequent GIS analyses for those backwaters.

Riparian Analysis

Summary

The goal of the California Colorado River Water Use Plan (The Plan) is to put into place, during the 15 year Interim Surplus Criteria, the necessary cooperative water conservation/transfers, storage and conjunctive use and other programs that allow California to meet its Colorado River water needs within its basic apportionment. The average of the annual median flows below Parker Dam for the period 1974-1998 was 7,547,000 acre-feet. Due to the Secretarial Implementation Agreements, the annual median Lower Colorado River flow between Parker and Imperial Dams will decline over a period of 50 years by 1.574 maf. The corresponding river surface elevation drop will be between 0.08 and 1.55 feet depending on location. This, in turn, will result in a drop in groundwater elevation adjacent to the river.

Losing Reaches

The river loses water through reaches with riparian vegetation and no surface diverted river water for irrigation. In these reaches, the riparian vegetation draws on the water table which in turn induces a water table gradient away from the river. The river is essentially the only source of water for the flood plain riparian vegetation because tributary groundwater inflow is extremely small. The water table elevation decline at any location in riparian vegetation dominated reaches will be the same as a decline in river surface elevation. The small average annual tributary groundwater inflow, where applicable, and water consumption by riparian vegetation are assumed to remain constant.

Gaining Reaches

The river gains water through reaches where river water is used for irrigation on the flood plain and or within the river valley. The difference between surface diverted irrigation water and subsurface return to the river is the water consumptively used by irrigated crops. Irrigation raises the water table and the groundwater moves toward the river or any other drain.

The near-river water table decline in a river reach bounded by irrigated agriculture can be influenced by a change in cropping pattern. In these reaches the river is not the only changeable contributor to water table elevation changes. Wells near the river, pumping a thousand or more gallons per minute, can cause a depression in the near river groundwater levels.

Measured "Near-River" Groundwater Levels

Water levels in the river and in "near-river" observation wells were automatically measured every three hours during the mid-1970's in the Yuma area. Loeltz and Leake (1983) reported average annual water elevations for 1974-78 for the river and the near river observation wells in U. S. Geological Survey Water-Resources Investigations Report 83-4220. The observation wells were located 100 and 400 feet from the edge of the river on each side and were aligned in sections normal to the river. The observation well sections were about one mile apart in the Yuma area and most were washed out by the 1983 high flow.

Five of the river observation well sections clearly show the influence of river elevation on near river groundwater elevation. In many cases, however, the river is not the controlling influence. The Yuma area near river groundwater level changes in response to river level change is believed to be representative of the groundwater response in the valleys below Parker Dam because the geohydrology is the same. See U.S. Geological Survey Professional Papers 486-G (Geohydrology of the Parker-Blythe-Cibola Area...) and 486-H (Geohydrology of the Yuma Area...) for a detailed description of the river aquifer from Parker to Yuma.

Typical Groundwater Response

The river induced groundwater elevation changes in the Yuma area in the mid-1970's, as reported by

Loeltz and Leake (1983), suggest that the water table drop under the nearest field irrigated with river water will be about one half the river elevation drop. The water table drop along the river will probably be the same in the Parker, Palo Verde, and Cibola river reaches because the aquifer is essentially the same. The drop in river elevation will cause the water table to drop which in turn will impact riparian vegetation.

Estimated River Elevation Drop

Table A-1 in Appendix A shows river surface elevation from Parker Dam to Imperial Dam at annual median flow, and in reductions in increments of 200,000 af to the total 1.57 maf, and the difference. The annual median flow is based on daily flows for calendar year 1996.

Estimate of Riparian Acreage Influenced by River Flow Reductions

A hand drawn contour map of river induced groundwater drop was made by using the estimated river elevation drop and assuming one half that drop under the nearest irrigated field. In a non-irrigated reach, the groundwater elevation drop is assumed to equal the river drop. The groundwater elevation decline contour map was drawn with a 0.2 foot contour interval.

An estimate of riparian acreage influenced by a reduction in river flow was made by overlaying the groundwater decline contour map on aerial photo based vegetation type maps. Occupied Willow Flycatcher acreage influenced by the groundwater decline was also determined. This data has been stored by Reclamation as a Global Information System database in ArcView format.

References

1. Bates, R.L. and Jackson, J.A.; Glossary of Geology, p. 24; American Geological Institute, 1980.

2. Carson, Rod; Hydraulic Engineer; Boulder Canyon Operations Office, Lower Colorado Regional Office, U.S. Bureau of Reclamation; personal communication; July 7, 2000.

3. CH2M Hill; 1997 Vegetation Mapping and GIS Development; prepared for: U.S. Bureau of Reclamation; February, 1999.

4. GEO/Graphics, Inc.; Lower Colorado River Backwaters Mapping - Davis Dam to Laguna Dam; submitted to: U.S. Bureau of Reclamation; June 15, 2000.

5. Langmaid, Dean; General Engineer; Boulder Canyon Operations Office, Lower Colorado Regional Office, U.S. Bureau of Reclamation; personal communication; July 10, 2000.

6. Loeltz, O.J. and S.A. Leake. 1983. *A Method for Estimating Ground-Water Return Flow to the Lower Colorado River in the Yuma Area, Arizona and California*, U.S. Geological Survey Water-Resources Investigations Report 83-4220.

7. Longwell, C.R.; Flint, R.F.; and Sanders, J.E.; Physical Geology, p.163-164; John Wiley & Sons, Inc.; 1969.

8. U.S. Bureau of Reclamation; Colorado River Front Work and Levee System, Arizona - California - Nevada; Colorado River from Davis Dam to Mexican Border; Drawing Nos. 423-303-2750T through 423-303-2769; 1994-1997.

9. U.S. Bureau of Reclamation; Colorado River Backwaters Maps - Parker Dam to Imperial Dam; Drawing Nos. 423-303-2918 through 423-303-2949; 1999-2000.

APPENDIX F.
Historical Total Selenium - Lower Colorado River

Selenium, an element left from shale sediment deposits in ancient seabeds along the Colorado River tributaries, serves as an agent to balance biochemical reactions in living organisms. Programs to control selenium have focused on the Colorado River's upper basin because of the large amounts of sediments from the source rock, Mancos shale.

Based on the historical selenium data, current Selenium levels in the waters of the LCR do not appear to be above the Department of Interior (DOI) level of concern which is 5.0 ug/l. Existing studies listed below on selenium have not identified or documented observable harmful effects to native flora or fauna in the LCR. To date, there are no fish Consumption Advisories for Selenium in the lower Colorado River**.

Below is a graph of recent selenium levels in the lower Colorado River from Lees Ferry to Morelos Dam. Predicting selenium levels based on anticipated reduced flows is not possible due to this report's time constraints and to the small amount of existing data from both the Colorado River as well as the agricultural drains entering the River below Parker Dam. Grab samples were taken at the PVID outfall drain during January 1999 and 2000 and contained 5 ug/l and 1.6 ug/l of selenium, respectively.

Selenium levels in isolated backwaters have different levels of selenium than connected backwaters and what are termed "pseudo-seep" backwaters. These differences and why they occur are important to the long-term management of these backwaters. Changes to groundwater or surface water elevations and amounts of flows may have effects to selenium deposition. More information is needed to assess this.

An indirect estimation of selenium levels using salinity as an indicator was attempted but no correlation between salinity levels and selenium concentrations in the River could be made.

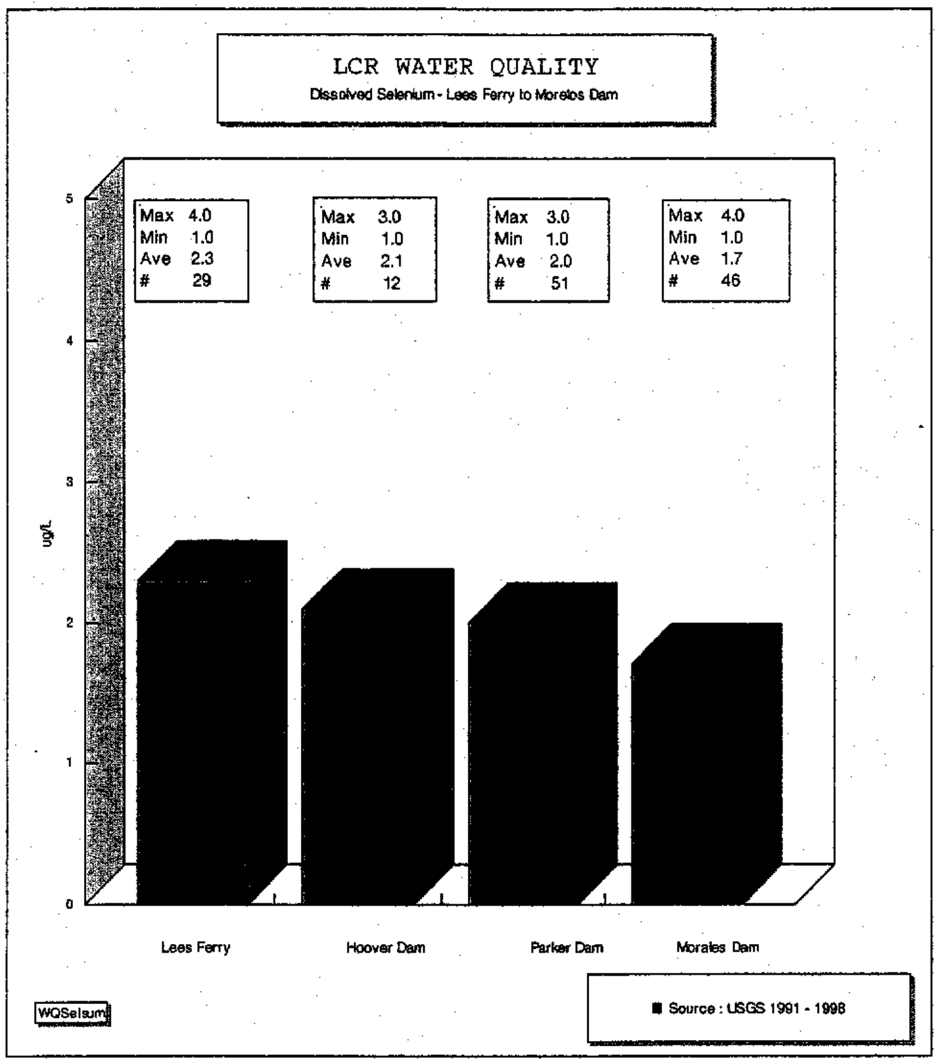
References

A USGS Water Resources Reconnaissance Investigation Report (88- 4002),1986-87, indicated similar findings (3.4 or less ug/l) for dissolved Selenium concentrations at several sites in the lower Colorado River.

DOI's Pre-reconnaissance Investigation Study, pub.cerca1992 reported similar findings (less than 3.4 ug/l) for selenium in water of the Colorado River at Pilot Knob.

USGS , IBWC Study, 1995. In the vicinity of Yuma , AZ . 18 Selenium water samples averaged 1.72* ug/l , with maximum of 8.0 and minimum value of <1.0 .

* 9 of the 18 values were reported as <1.0 .
** Kirt Ketinger, Pers. comm., AZ Game & Fish Dept.


LCR WATER QUALITY
Dissolved Selenium - Lees Ferry to Morelos Dam
Max 4.0 Min 1.0 Ave 2.3 # 29
Max 3.0 Min 1.0 Ave 2.1 # 12
Max 3.0 Min 1.0 Ave 2.0 # 51
Max 4.0 Min 1.0 Ave 1.7 # 46
ug/L
0
1
2
3
4
5
Lees Ferry
Hoover Dam
Parker Dam
Morales Dam
WQSelsum
Source : USGS 1991 - 1998

APPENDIX G.
Literature Cited

American Ornithologists' Union. 1998. Check-list of North American Birds, 7th edition. American Ornithologists' Union, Washington, D.C. 829 pp.

Anderson, B.W., and R.D. Ohmart. 1976. Vegetation type maps of the lower Colorado River from Davis Dam to the southerly International Boundary. Final Report, U.S. Bureau of Reclamation, Boulder City, Nevada.

________, B.W., and R.D. Ohmart. 1977. Wildlife Use and Densities Report of Birds and Mammals in the Lower Colorado River Valley. Annual Report. U.S. Bureau of Reclamation. Boulder City, Nevada. Contract No. 7-07-30-V0009.

________, B.W., and R.D. Ohmart. 1984. Lower Colorado River Riparian Methods of Quantifying Vegetation Communities to Prepare Type Maps. Final Report, U.S. Bureau of Reclamation, Lower Colo. Reg., Boulder City, Nevada.

________, B.W., and R.D. Ohmart. 1984. Vegetation management study for the enhancement of wildlife along the lower Colorado River. Final Report, U.S. Bureau of Reclamation Contract No. 7-07-30-V0009. 529 pp.

________, B.W., and R.D. Ohmart. 1985. Habitat use by clapper rails in the lower Colorado River Valley. Condor 87: 116-126.

Banks, R.C. and R.E. Tomlinson. 1974. Taxonomic position of certain clapper rails of southwestern United States and northwestern Mexico. Wilson Bull. 86:325-335.

Barrett, S.L., and T.B. Johnson. 1990. Status summary for the desert tortoise in the Sonoran Desert. Unpublished report to U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Berry, K.H. 1990. The status of the desert tortoise in California in 1990 as amended to include data from 1990-1992. Draft report from the Bureau of Land Management, Riverside, California to the Fish and Wildlife Service, Region 1, Portland, Oregon.

______, K.H. 1992. Relationships between tortoise population declines, levels of human use and impacts to habitats. Paper presented at the Desert Tortoise Council Symposium, Palace Station, Las Vegas, Nevada.

Bestgen, K.R. 1990. Status Review of the Razorback Sucker, Xyrauchen texanus. Final Report to USBR, Colorado State Univ. Larval Fish Lab, Fort Collins, CO. 92 pp.

Braden, G.T. and R. L. McKernan. 1998. Observations on Nest Cycles, Vocalization Rates, The Probability of Detection, and Survey Protocols for the Southwestern Willow Flycatcher (Empidonax trailii extimus). San Bernardino County Museum, Redlands, CA. March.

Busch, D.E. 1988. Bald Eagle. Pages 57-64 in Proceedings of the Southwest Raptor Management Symposium and Workshop, R.L. Glinski et al. National Wildlife Federation, Washington, D.C.

Carlander, K.D. 1969. Handbook of Freshwater Fishery Biology. Volume 1. Ames:Iowa State University Press. 752 pp.

________, K.D. 1977. Handbook of Freshwater Fishery Biology. Volume 2. Ames: Iowa State University Press. 431 pp.

Carothers, Steven W. and C.O. Minckley. 1981. A Survey of the Fishes, Aquatic Invertebrates and Aquatic Plants of the Colorado River and Selected Tributaries from Lees Ferry to Separation

Rapids. U.S. Bureau of Reclamation, Contract No. 7-07-30-X0026. 401 pp.

CH2MHill, Inc. 1999. Report: 1997 Vegetation Mapping and GIS Development. Prepared for USBR, Lower Colorado River Regional Office, Boulder City, NV

Colorado River Board of California. 2000. Draft California's Colorado River Water Use Plan. Los Angeles, CA, 156 pps.California. 2000. Key Terms for Quantification Settlement among the State of California, IID, CVWD, and MWD. California, 36 pps + 3 exhibits.

Conway, C.J., W.R. Eddleman, S.H. Anderson, and L.R. Hanebury. 1993. Seasonal changes in Yuma clapper rail vocalization rate and habitat use. Journal of Wildlife Management 57(2): 282-290.

Carman, Troy E. and R.T. Magill. 2000. Western Yellow-billed Cuckoo in Arizona:1998 and 1999 Survey Report. Nongame and Endangered Wildlife Program Technical Report 150. Arizona Game and Fish Department, Phoenix, Arizona.

D'Antonio, C.M. and P.M. Vitouseki. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Ann. Rev. Ecol. Syst. 23:63-87.

Deacon, J.E. and W.L. Minckley. 1974. Chapter VII, Desert Fishes. Pp 385-488. Desert Biology, Volume II. Ed. by G.W. Brown, Jr. Academic Press, Inc. New York and London.

DeLoach, C.J. 1989. Saltcedar, a weed of western North American riparian areas: A review of its taxonomy, biology, harmful and beneficial values, and its potential for biological control. Final Report Volume I, U.S. Bureau of Reclamation Contract No. 7-AG-30-04930. 296 pp.

Dill, W.A. 1944. The fishery of the lower Colorado River. California Fish and Game 30, 109-211.

Drost, Charles, A., M.K. Sogge, and E. Paxton. 1998. Preliminary Diet Study of the Endangered Southwestern Willow Flycatcher. Report submitted to U.S. Bureau of Reclamation, Phoenix, July 1998.

Eddleman, W.R. 1989. Biology of the Yuma clapper rail in the southwestern U.S. and northwestern Mexico. USBR, IA No. 4-AA-30-020060. 127 pp.

Edwards, G.B. 1974. Biology of the striped bass, Morone saxatilis, in the lower Colorado River (Arizona-California-Nevada). Master's Thesis. Arizona State Univ., Tempe.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The Birder's Handbook, a Field Guide to the Natural History of North American Birds. Simon and Schuster, Inc., New York, New York. 783 pp.

Evens, J.G., G.W. Page, L.S. Laymon, and R.W. Stallcup. 1991. Distribution, relative abundance and status of the California black rail in western North America. Condor 93:952-966.

Fenner, Pattie, W.W. Brady and D.R. Patton. 1984. Observations on seeds and seedlings of Fremont cottonwood. Desert Plants 6(1): 55-58

Fitch, J.E. and R.L. Brownell. 1968. Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. Jour. Fish. Res. Bd. Can. 25:2561-2574.

Flanagan, C.A. and J.R. Hendrickson. 1976. Observations on the commercial fishery and reproductive biology of totoaba, Cynoscion macdonaldi, in the northern Gulf of California. Fishery Bulletin 74:531-544.

Flores, R.E. and W.R. Eddleman. 1995. California Black Rail Use of Habitat in Southwestern Arizona. J. Wildl. Manage. 59(2):357-363.

Freeland, S.J. 1973. Marshlands of the Lower Colorado River - A historical study and analysis by the

Bureau of Reclamation. June 18, 1973: nl. Tapes J and K.

Gause, C.I. 1969. A fish threatened. Underwater Nat. 6:28-31

Gerrard, J.M. 1983. A review of the current status of bald eagles in North America. Pages 5-22 In Bird 1983.

Gilbert, C.H., and N.B. Scofield. 1898. Notes on a collection of fishes from the Colorado Basin in Arizona. Proceedings of the U.S. National Museum 20:487-499.

Grinnell, J. 1914. An account of the mammals and birds of the lower Colorado Valley, with especial reference to the distributional problems presented. Univ. Calif. Publ. Zool. 12: 51-294.

Halterman, M.D. 1998. Population Site Tenacity and habitat requirements of the yellow-billed cuckoo at the Bill Williams River, Arizona: summer 1998. Report for USDI Bureau of Reclamation, Lower Colorado River Regional Office, Boulder City, Nevada.

Halterman, M.D. 2000. Population Status of the yellow-billed cuckoo at the Bill Williams River, Arizona: summer 1999. Report for USDI Bureau of Reclamation, Lower Colorado River Regional Office, Boulder City, Nevada.

Holden, P.B., R.D. Hugle, L. Crist, S.B. Chanson, and W.J. Masslich. 1986. Development of a fish and wildlife classification system for backwaters along the lower Colorado River. Prepared for USBR by Biowest Incorporated.

Holm, P.A. 1989. Desert tortoise monitoring baseline study: Harquahala Mountains. Bureau of Land Management, Phoenix District, Arizona.

Hinojosa-Huerta, O., S. DeStefano, and W.W. Shaw. 2000. Distribution, Abundance, and Habitat Use of the Yuma Clapper Rail (Rallus longirostris yumanensis) in the Colorado River Delta, Mexico. Annual Report to the U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico.

Huerta, O.H., Y.C Guerrero, and J.J. Butron. 1999. Report of Southwestern Willow Flycatcher (Empidonax trailii extimus) in the Colorado River Delta, Mexico. Unpublished Report to U.S. Bureau of Reclamation, Phoenix Area Office, Phoenix, Arizona. University of Arizona, Environmental Research Laboratory, Dept. of Soil, Water and Environmental Science, College of Agriculture, Tucson, Arizona

Hughes, J. M. 1999. Yellow-billed cuckoo (Coccyzus americanus). *In* The Birds of North America, No. 418 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Hunt, W.G., D.E. Driscoll, E.W. Bianchi, and R.E. Jackman. 1992. Ecology of Bald Eagles in Arizona. Part F: Arizona Bald Eagle Nest Map Atlas, 1990. Report to US Bureau of reclamation, Contract 6-CS-30-04470. Biosystems Analysis, Inc. Santa Cruz, California. With 1991-1993 Update by Daniel E. Driscoll, American Eagle Research Institute, Mesa, Arizona. May 1994

Hunter, W.C., R.D. Ohmart, and B.W. Anderson. 1987. Status of breeding riparian-obligate birds in southwestern riverine systems. Western Birds 18:10-18.

Ives, J.C. 1861. Report upon the Colorado River of the West. Explored in 1857 and 1858 by Lieutenant Joseph C. Ives, Corps of Topographical Engineers, under the direction of the Office of Explorations and Surveys, A.A. Humphreys, Captain Topographical Engineers in charge. By the order of the Secretary of War, 36th Cong., 1st Sess., House Exec. Doc. No. 90, GPO. Washington, D.C. 353 pp.

Jackson, Janet J., J.T. Ball, and M.R. Rose. 1990. Assessment of the salinity threshold of eight Sonoran desert riparian trees and shrubs. Desert Research Institute, University of Nevada, Reno, Nevada.

Johnson, R.R., and L.T. Haight. 1984. Riparian problems and initiatives in the American Southwest: A regional perspective. In California Riparian Systems: Ecology, Conservation, and Productive Management, R.E. Warner and K.M. Hendrix (eds), University of California Press. pp. 404-412.

Johnson, T.B., N.M. Ladehoff, C.R. Schwalbe and B.K. Palmer. 1990. Summary of literature on the Sonoran Desert population of the desert tortoise. Unpublished report to U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico.

Jonez, A., and R.C. Sumner. 1954. Lakes Mead and Mohave investigations: A comparative study of an established reservoir as related to a newly created impoundment. Federal Aid to Fisheries Restoration Project Completion Report, F-1-R, 1-186. Nevada Game and Fish Commission, Reno, Nevada.

Kaufmann, Kenn. 1996. Lives of North American Birds. Houghton Mifflin Co.. 675 pp.

King, Kirke A., A.L. Velasco, J. Garcia-Hernandez, B.J. Zaun, J. Record, and J. Wesley. 2000. Contaminants in potential prey of the Yuma Clapper Rail: Arizona and California, USA, and Sonora and Baja. U.S. Fish and Wildlife Service, Arizona Ecological Services Field Office, Phoenix, AZ.

Koronkiewicz, Thomas J. and M. J. Whitfield. 1999. Surveys for Wintering Willow Flycatchers (Empidonax traillii) in Costa Rica and Panama. Final Report: Submitted to the Bureau of Reclamation, Phoenix, AZ, November 5, 1999.

Langhorst, D.R. 1988. A monitoring study of razorback sucker reintroduced into the lower Colorado River in 1987. Final Report, Calif. Fish and Game Contract C-1888. Blythe, CA. 76pp.

_________, D.R. 1989. A monitoring study of razorback sucker reintroduced into the lower Colorado River in 1988. Final Report, Calif. Fish and Game Contract FG-7494. Blythe, CA. 33 pp.

LaRivers, I. 1962. Fishes and Fisheries of Nevada. Carson City, Nevada State Fish and Game Commission. 782 pp.

LaRue, E.C. 1916. Colorado River and its utilization. USDI Geological Survey Water-Supply Paper No. 395. 231 pp.

Lingenfelter, R.E. 1978. Steamboats on the Colorado River, 1852-1916. University of Arizona Press. 195 pp.

Lower Colorado Region State-Federal Interagency Group for the Pacific Southwest Interagency Committee. 1971. Irrigation and drainage. In Lower Colorado region Comprehensive Framework Study, Appendix X. 70 pp.

Lynn, S. and A. Averill. 1996. Neotropical Migratory Bird Monitoring Project in the Lower Colorado River Valley. Final Report, 1994-1995. Submitted to USFWS, Bill Williams River National Wildlife Refuge, Parker, AZ.

McCall, T.C. 1979. Fisheries investigations of Lake Mead, Arizona-Nevada, from Separation Rapids to Boulder Canyon 1978-1979. Final Report for U.S. Water and Power Resources Service Contract 8-07-30-X0025. Arizona Game and Fish Department, Phoenix, Arizona.

McCarthy, M.S., and W.L. Minckley. 1987. Age estimation for razorback sucker (Pisces:Catostomidae) from Lake Mohave, Arizona-Nevada, Journal of the Arizona-Nevada Academy of Sciences 21: 87-97.

McKernan, R.L. 1997. Status, Distribution, and Habitat Affinities of the Southwestern Willow Flycatcher Along the Lower Colorado River, Year 1 – 1996., San Bernardino County Museum, Redlands, CA, November.

________, R.L. and G. Braden. 1998. Status, Distribution, and Habitat Affinities of the Southwestern Willow Flycatcher Along the Lower Colorado River, Year 2 – 1997, San Bernardino County Museum, Redlands, CA., March.

________, R.L. and G. Braden. 1999. Status, distribution, and habitat affinities of the southwestern willow flycatcher along the Lower Colorado River: Year 3 – 1998. Submitted to U.S. Bureau of Reclamation, Lower Colorado River Region, Boulder City, NV. March.

Marsh, P.C. 1994. Abundance, movements, and status of adult razorback sucker, Xyrauchen Texanus, in Lake Mohave, Arizona and Nevada. Proc. Desert Fishes Council. XXV: 35 (Abstract)

Marsh, P.C., and J.L. Brooks. 1989. Predation by ictalurid catfishes as a deterrent to re-establishment of introduced razorback suckers. The Southwestern Naturalist 34: 188-195.

_____, P.C., and D.R. Langhorst. 1988. Feeding and fate of wild larval razorback sucker. Environmental Biology of Fishes 21(1): 59-67.

_____, P.C., and W.L. Minckley. 1989. Observations on recruitment and ecology of razorback sucker: Lower Colorado River, Arizona-California-Nevada. Great Basin Naturalist 49:71-78.

_____, P.C. and D.Papoulias. 1989. Ichthyoplankton of Lake Havasu, a Colorado River impoundment, Arizona-California. Calif. Fish and Game 75(2):68-73

_____, P.C. and D.W. Sada. 1993. Desert Pupfish Recovery Plan. Fish and Wildlife Service, Albuquerque, New Mexico. 67 pp.

Marshall, C.W. 1976. Inventory of fish species and the aquatic environment of 15 backwaters of Topock Gorge Division, Colorado River. California Department of Fish and Game, Inland Fisheries. Report #76-4. Sacramento, California. 65 pp.

Miller, R.R. 1959. Origin and affinities of the freshwater fish fauna of western North America, pp. 187-222 *in* C.L. Hubbs, ed. Zoogeography. Am. Assoc. Adv. Sci. Publ. 51: 509 pp.

______, R.R. 1961. Man and the changing fish fauna of the American Southwest. In Minckley, W.L. 1973. Fishes of Arizona, AZ. Game and Fish Dept. Phoenix

Minckley, W.L. 1973. The Fishes of Arizona. Arizona Game and Fish Department. Phoenix, Arizona.

________, W.L. 1979. Aquatic Habitats and Fishes of the Lower Colorado River, Southwestern United States. Final Report for U.S. Bureau of Reclamation Contract 14-06-300-2529. Arizona State University, Tempe, Arizona.

________, W.L., and D.E. Brown. 1982. Part 6--Wetlands. Pages 223-287 *in* D.E. Brown, ed. Biotic Communities of the American Southwest--United States and Mexico. Desert Plants 4:.1-342.

________, W.L., P.C. Marsh, J.E. Brooks, J.E. Johnson, and B.L. Jensen. 1991. Management towards recovery of the razorback sucker. Pages 303-357 In W.L. Minckley and J.E. Deacon, eds. Battle Against Extinction: Native Fish Management in the American West. Univ. of AZ., Press, Tucson, Arizona.

Moffett, G.W. 1943. A preliminary report on the fishery of Lake Mead. Transactions of the North American Wildlife Conference. 8: 179-186.

Monson, G., and A. Phillips. 1981. Revised Checklist of Arizona Birds. University of Arizona Press, Tucson, Arizona. 240 pp.

Mortimore, C. and P. Schneider. 1983. Population studies of the desert tortoise in the Paiute Valley Study Plot of Southern Nevada. Nevada Department of Wildlife, Reno, Nevada.

Moyle, P.B. 1976. Inland fishes of California. Berkeley: Univ. Calif. Press.

Mueller, G. 1989. Fisheries Investigations-Central Arizona Project Canal System. Final Report 1986-1989. Boulder City, NV 114 pps.)

_______, G. 1989. Observations of spawning razorback sucker (Xyrauchen texanus) utilizing river habitat in the lower Colorado River, Arizona-Nevada. The Southwestern Naturalist 34: 147-149.

Muiznieks, B.D., T.E. Carman, S.J. Sferra, M.K. Sogge, and T.J. Tibbitts. 1994. Arizona Partners in Flight southwestern willow flycatcher survey 1993. Arizona Game and Fish Department Report, Phoenix, Arizona.

Ohmart, R.D. 1982. Past and present biotic communities of the Lower Colorado River mainstem and selected tributaries: Volume 1 Davis Dam to Mexican border. Report to Bureau of Reclamation. 238 pp.

_______, R.D., and R.W. Smith. 1973. North American clapper rail (Rallus longirostris) literature survey with special consideration being given to the past and present status of yumanensis. USBR, Contract No. 14-06-300-2409. 45 pp.

_______, R.D., and R.E. Tomlinson. 1977. Foods of western clapper rails. Wilson Bulletin 89: 332-336.

_______, R.D., W.O. Deason, and S.J. Freeland. 1975. Dynamics of marshland formation and succession along the lower Colorado River and their importance and management problems as related to wildlife in the arid Southwest. Trans. 40th N. Am. Wildl. Nat. Resources Conf. 1975:240-251.

_______, R.D., B.W., Anderson, and W.C. Hunter. 1988. The ecology of the lower Colorado River from Davis Dam to the Mexico-United States international boundary: A community profile. Biological Report 85(7.19) USFWS.

Pacey, Carol A. and Paul C. Marsh. 1998. Resource Use by Native and Non-Native Fishes of the Lower Colorado River: Literature Review, Summary, and Assessment of Relative Roles of Biotic and Abiotic Factors in Management of an Imperiled Indigenous Ichthyofauna. Final Report, agreement number 7-MT-30-R0012, Lower Colorado Region, U.S. Bureau of Reclamation, Boulder City, Nevada.

_______, C.A. and Paul C. Marsh. 1999. A Decade of Managed and Natural Population Change for Razorback Sucker in Lake Mohave, Colorado River, Arizona and Nevada. Arizona State University Department of Biology, Tempe, Arizona.

Paulson, L.J. and J.R.Baker. 1984. The limnology in reservoirs on the Colorado River. Lake Mead Limnological Research Center Technical Report No.11. Final Report to Bureau of Reclamation, contract #14-34-0001-1243. 276 pp.

Peterson, R.T. 1990. A field guide to western Birds, 3rd edition. Houghton Mifflin Company, Boston, Massachusetts. 432 pp.

Phillips, A.R., J. Marshall, and G. Monson. 1964. The birds of Arizona. University of Arizona Press, Tucson, Arizona. 212pp.

Piest, L. and J. Campoy. 1998. Report of Yuma Clapper Rail Surveys at Cienega de Santa Clara, Sonora. Unpublished Report submitted to Arizona Game and Fish Department, Yuma, Arizona.

Pinkney, F.C. 1992. Revegetation and Enhancement of Riparian Communities Along the lower Colorado River. Bureau of Reclamation, Denver, Colorado.

Repking, C.F., and R.D. Ohmart. 1977. Distribution and density of black rail populations along the lower Colorado River. Condor 79: 486-489.

Rosenberg, K.V., R.D. Ohmart, W.C. Hunter, and B.W. Anderson. 1991. Birds of the Lower Colorado River Valley. University of Arizona Press, Tucson, Arizona. 416 pp.

Rubink, D.M. and K. Podborny. 1976. The southern bald eagle in Arizona: a status report. U.S. Fish and Wildlife Service Endangered Species Report 1. Albuquerque, New Mexico. 33 pp.

Rusk, M.K. 1991. Selenium risk to Yuma clapper rails and other marsh birds of the lower Colorado River, M.S. Thesis, Univ. Arizona, Tucson. 75 pp.

Schlorff, R.W. 1990. Status review of the willow flycatcher (Empidonax traillii) in California. California Department of Fish and Game, Department Candidate Species Report 90-1. 23 pp.

Segelquist, Charles A., M.L. Scott and G. Auble. 1993. Establishment of Populus deltoides under simulated groundwater declines. Am. Midl. Nat. 130:274-285.

Sigler, W.F. and R.R. Miller. 1963. Fishes of Utah. Utah State Department of Fish and Game. 203 pp.

Sjoberg, J.C. 1995. Historic distribution and current status of the razorback sucker in Lake Mead, Nevada-Arizona. Proceedings of the Desert Fishes Council, 1994 Symposium. DFC 26:24-27.

Smith, M.T. 1972. The Colorado River: Its history in the lower Canyon area. PhD Dissertation, Brigham Young University, Provo, Utah. 511 pp.

Smith, P.M. 1975. Habitat requirements and observations on the clapper rail, Rallus longirostris yumanensis. M.S. Thesis. Arizona State Univ. Tempe, AZ. 35 pp.

Sogge, M.K., T.J. Tibbitts, and J.R. Peterson. 1997. Status and breeding ecology of the southwestern willow flycatcher in the Grand Canyon. Western Birds 28:142-157.

Stalmaster, M.V. 1987. The bald eagle. Universe Books. New York, NY. 227 pp.

SWCA, Inc. 1998. A Survey for Southwestern Willow Flycatchers along Las Vegas Wash, Clark Co. Wetlands Park, NV. Final Report to Clark Co. Dept. of Parks and Recreation, Las Vegas, NV prepared by SWCA Inc. Environmental Consultants, Salt Lake City, Utah.

Taylor, W.D., V.M. Lambou, L.R.Williams, and S.C.Hern. 1980. Trophic state of lakes and reservoirs. U.S. EPA, Environmental Monitoring and Support Laboratory, Las Vegas, NV.

Thelander C.G. and M. Crabtree. 1994. Life on the edge: a guide to California's endangered natural resources. Biosystems Books, Santa Cruz, Ca. 550 pp.

Todd, R.L. 1977. Black rail, little black rail, black crake, Farrallon rail (Laterallus jamaicensis). Pages 71-83 In G.C. Sanderson, ed. Management of Migratory Shore and Upland Game Birds in North America. Int. Assoc. Fish and Wildl. Agencies, Washington, D.C. 358 pp.

Todd, R.L. 1986. A saltwater marsh hen in Arizona: a history of the Yuma clapper rail (Rallus longirostris yumanensis). Arizona Game and Fish Dept., Fed. Aid Proj. W-95-R. Competion Rept. 290 pp.

Ulmer, L. 1987. Management plan for the razorback sucker in California. Proceedings of the Desert Fishes Council 17:183 (abstract).

Ulmer, L. and K.R.Anderson. 1985. Management plan for the razorback sucker in California. California Department of Fish and Game, Region 5, Information Bulletin #0013-10-1985, 26 pp.

Unitt, P. 1987. Empidonax traillii extimus: An endangered subspecies. Western Birds 18(3): 137-162.

U.S. Bureau of Reclamation. 1996. Description and Assessment of Operations, Maintenance, and Sensitive Species of the Lower Colorado River. Final Biological Assessment prepared for the U.S. Fish and Wildlife Service and Lower Colorado River Multi-Species Conservation Program. U.S. Department of the Interior, Bureau of Reclamation, Lower Colorado Region. 207 pp. + appendices.

______. 1999. Long term restoration program for the historical Southwestern Willow Flycatcher (Empidonax trailii extimus) habitat along the Lower Colorado River. Report by U.S. Bur. of Reclamation, Lower Colorado River Regional Office submitted to the U.S. Fish and Wildlife Service, Phoenix, Arizona. 70pp.

______. 2000. Draft Environmental Impact Statement Colorado River Interim Surplus Criteria July 2000. Lower Colorado Region, Boulder City, NV.

______ and Coachella Valley Water District. 1993. Draft Environmental Impact Statement/Environmental Impact Report Coachella Canal Lining Project December 1993. Lower Colorado Region, 223 pps.

______ and Imperial Irrigation District 1994. Draft Environmental Impact Statement/Environmental Impact Report All American Canal Lining Project March 1994. Lower Colorado Region, Boulder City, NV.

U.S. Fish and Wildlife Service. 1983. Yuma clapper rail recovery plan. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 51 pp.

______. 1990. Bonytail Chub Recovery Plan. Prepared by the Colorado River Fishes Recovery Team for U.S. Fish and Wildlife Service, Denver, CO. 35 pp.

______. 1994a. Desert tortoise (Mojave population) Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 73 pp + appendices.

______. 1994b. Draft Endangered Species Consultation Handbook - Procedures for Conducting section 7 Consultations and Conferences. Portland, Oregon. 200+ unnumbered pages.

______. 1995a. Virgin River Fishes Recovery Plan. U.S. Fish and Wildlife Service, Region 6, Denver, CO. 45 pp.

______. 1995b. "Wetlands hold promise for raising endangered fish." Recovery Program for the Endangered Fishes of the Upper Colorado, Newsletter. Winter,1995. Denver, CO.

______. 1997. Final Biological and Conference Opinion on Lower Colorado River Operations and Maintenance- Lake Mead to Southerly International Boundary, May 1997. U.S. Fish and Wildlife Service Regional Office, Albuquerque, NM.

______. 2000. Notice of 90-day finding on petition to list the yellow-billed cuckoo as endangered, with critical habitat. February 17, 2000, Federal Register 65 (33): 8104-8107. U.S. War Department. 1852. Report of the Secretary of War, communicating in compliance with a resolution of the Senate, a reconnaissance of the Gulf of California and the Colorado River by Lieutenant Derby. Government Printing Office, Washington, D.C. 28 pp.

U.S. Geological Survey. 1973. Surface water supply of the United States -- Part 9, Colorado River basin U.S. Geol. Surv. Water-Suppl. Pap. 3: 1-634

Vanicek, C.D. 1967. Ecological studies of native Green River fishes below Flaming Gorge Dam, 1964-66. Ph.D. diss., Utah State University, Logan, Utah.

_______, C.D., and R.H. Kramer. 1969. Life-history of the Colorado squawfish, Ptychocheilus lucius, and the Colorado chub, Gila robusta, in the Green River in Dinosaur National Monument, 1964-66. Transactions of the American Fisheries Society 98, 193-208.

Wagner, R.A. 1954. Basic survey of the Verde River and its on-stream impoundments. Federal Aid to Fisheries Restoration, Project Completion Report F-2-R-1,9-12. Arizona Game and Fish Department, Phoenix, Arizona.

Wilbur, S.R. 1974. The literature of the California black rail. U.S. Fish and Wildlife Serv. Spec. Sci. Rep. Wildl. 179. 17 pp.

Wilbur, R.L., and N. Ely. 1948. The Hoover Dam Documents. U.S. Government Printing Office, Washington, D.C., 80th Congress, 2nd Session, House Document No. 717. 936 pp.

Younker, G.L., and C.W. Anderson. 1986. Mapping methods and vegetation changes along the lower Colorado River between Davis Dam and the border with Mexico. Final Rept. to U.S. Bur. Rec., Lower Colo. Reg., Boulder City, NV. 21 pp., 1 appendix, 21 maps.

Zimmerman, R. L. 1969. Plant ecology of an arid basin, Tres Alamos-Redington area. U.S. Geological Survey Professional Paper 485-D:1-51 in Stomberg, J. C. 1993. Fremont cottonwood-Gooding willow riparian forests: a review of their ecology, threats and recovery potential J. Arizona-Nevada Academy of Science 26 (3): 97-110.

PERSONAL COMMUNICATIONS

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Declaration of Larry Purcell

04-08-02P02:03 RCVD

I, Larry Purcell, declare that:

1. I am a Water Resources Manager for San Diego County Water Authority, in San Diego, California. I hereby make this declaration in my official capacity on behalf of the San Diego County Water Authority.

2. I declare that the attached exhibit titled "Open Water and Emergent Vegetation Reductions" dated 10/25/00, is a true and accurate copy of the document that was delivered directly to me, by hand, by Mr. Thomas Shrader of the United States Bureau of Reclamation on October 26, 2000.

I certify under penalty of perjury under the laws of the State of California that the above statements are true.

Dated: This 8th day of April, 2002.

Larry Purcell

from Tom Shrader

Table 14. BA

per Shrader: corrections to April due to incomplete flow analysis (several days were left out when calc. average monthly flow). When revised the acres of backwater decrease from 62 to 45.

Pre-Decisional Draft Document - Not to be Released - Contents Subject to Change

OPEN WATER AND EMERGENT VEGETATION REDUCTIONS* 10/25/00

APRIL ACREAGE REDUCTION

	Backwater Open Water	Backwater Emergent	River Channel Open Water	Total Open Water
200	9	14	17	26
300	13	21	26	39
400	17	28	35	52
675	29	47	58	87
948	41	66	82	123
1553	67	107	134	201
1574	68	109	136	204

AUGUST ACREAGE REDUCTION

	Backwater Open Water	River Channel Open Water	Total Open Water
200	5	7	12
300	7	11	18
400	10	14	24
675	17	24	41
948	23	34	58
1553	38	56	95
1574	39	57	96

DECEMBER ACREAGE REDUCTION

	Backwater Open Water	River Channel Open Water	Total Open Water
200	4	6	10
300	6	9	15
400	8	12	20
675	13	21	33
948	18	29	47
1553	30	47	77
1574	30	48	78

* Porportional to 1574 maf reduction