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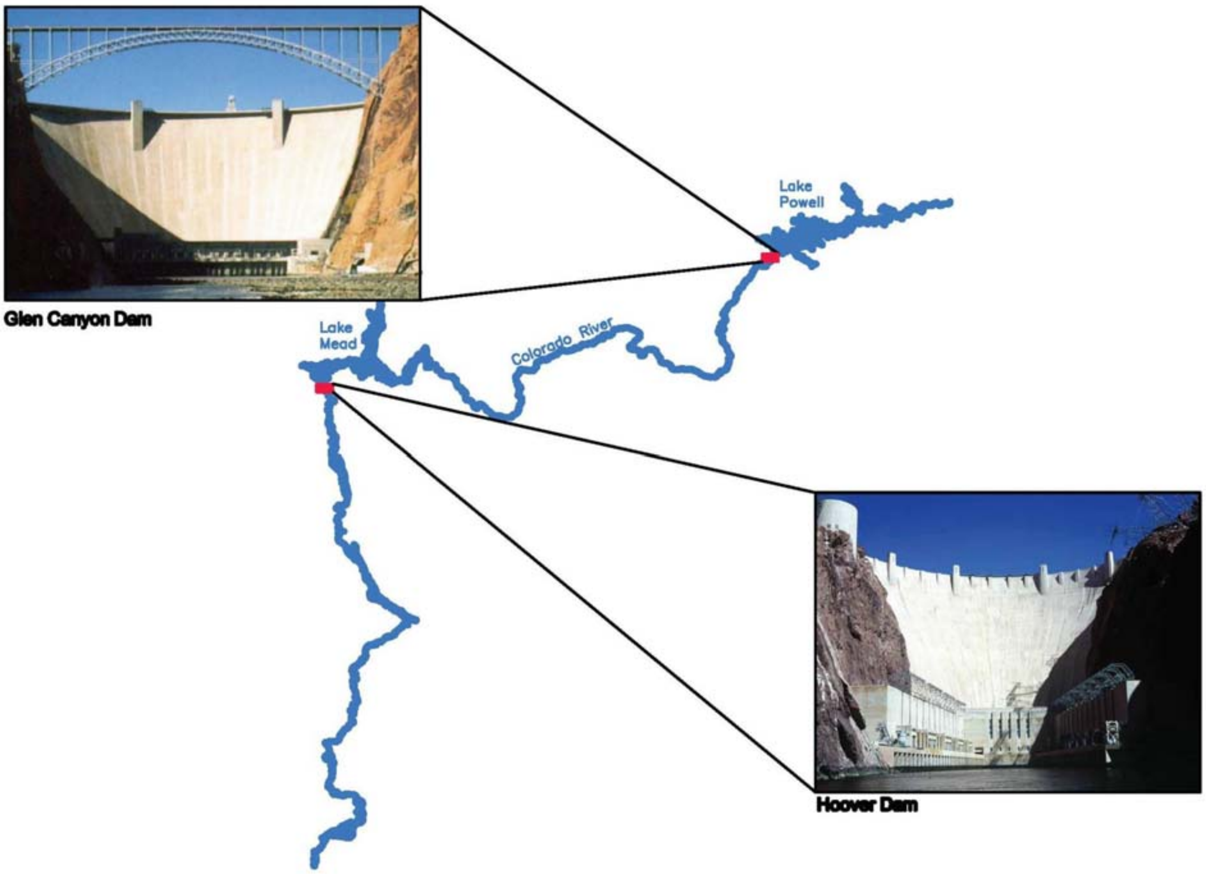
Environmental Impact Statement



Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead

Volume I

U.S. Department of the Interior
Bureau of Reclamation
Upper and Lower Colorado Regions

February 2007

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Draft Environmental Impact Statement

Volume I

U.S. Department of the Interior
Bureau of Reclamation
Upper and Lower Colorado Regions
February 2007

Mission Statement

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead
Draft Environmental Impact Statement

Lead Agency:

United States Department of the Interior
Bureau of Reclamation
Upper and Lower Colorado Regions

Cooperating Agencies:

Bureau of Indian Affairs
National Park Service
Western Area Power Administration
United States Fish and Wildlife Service
United States Section of the International Boundary and Water Commission

Abstract:

The Secretary of the Department of the Interior (Department), acting through the Bureau of Reclamation, proposes adoption of specific Colorado River Lower Basin (Lower Basin) shortage guidelines and coordinated reservoir management strategies to address operations of Lake Powell and Lake Mead, particularly under drought and low reservoir conditions. This action is proposed in order to provide a greater degree of certainty to United States Colorado River water users and managers of the Colorado River Basin by providing detailed, and objective guidelines for the operations of Lake Powell and Lake Mead, thereby allowing water users in the Lower Basin to know when, and by how much, water deliveries will be reduced in drought and other low reservoir conditions. The Department proposes that these guidelines be interim in duration and extend through 2026. The environmental impact statement (EIS) process will provide an opportunity to develop the information needed to analyze and consider tradeoffs between the frequency and magnitude of shortages, and to describe potential effects on water storage in Lake Powell and Lake Mead, and on water supplies, power production, recreation, and other environmental resources.

This Draft EIS has been prepared pursuant to the National Environmental Policy Act to address the formulation and evaluation of specific interim criteria and to identify the potential environmental impacts of implementing such criteria.

For further information regarding this Draft EIS, contact:

Bureau of Reclamation
Attention: BCOO-1000
P.O. Box 61470
Boulder City, Nevada 89006-1470
Fax number: (702) 293-8156
Phone number: (702) 293-8500
E-mail: strategies@lc.usbr.gov

Comments Due:

Comments on the Draft EIS must be submitted to the above mail or E-mail address no later than Monday, April 30, 2007.

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Executive Summary

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ES.1 Background

The Secretary of the United States Department of the Interior (Secretary), acting through the Bureau of Reclamation (Reclamation), proposes to adopt specific interim guidelines for Colorado River Lower Basin (Lower Basin) shortages and coordinated operations for Lake Powell and Lake Mead, particularly under drought and low reservoir conditions.

Reclamation, as the agency that is designated to act on the Secretary's behalf with respect to operation of Glen Canyon Dam and Hoover Dam and managing the mainstream waters of the lower Colorado River pursuant to federal law, is the lead federal agency for the purposes of compliance pursuant to the National Environmental Policy Act of 1969 (NEPA) for the development and implementation of the proposed interim guidelines. Five federal agencies are cooperating for purposes of assisting with environmental analysis and preparation of the Draft EIS. The cooperating agencies are the Bureau of Indian Affairs (BIA), United States Fish and Wildlife Service (FWS), National Park Service (NPS), Western Area Power Administration (Western), and the United States Section of the International Boundary and Water Commission (USIBWC).

The Draft EIS includes six chapters as outlined below:

- Chapter 1: Purpose and Need;
- Chapter 2: Description of Alternatives;
- Chapter 3: Affected Environment;
- Chapter 4: Environmental Consequences;
- Chapter 5: Other Considerations and Cumulative Impacts; and
- Chapter 6: Consultation and Coordination.

ES.1.1 Purpose and Need for Action

During the period of 2000 through 2006, the Colorado River Basin experienced the worst drought conditions in approximately one hundred years of recorded history. During this period, storage in Colorado River reservoirs has dropped from nearly full to less than 60 percent of capacity at the end of 2006. Currently, the Department of the Interior (Department) does not have specific operational guidelines in place to define the circumstances under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead nor to address the coordinated operations of Lake Powell and Lake Mead during drought and low reservoir conditions.

The purpose of the proposed federal action is to: 1) improve Reclamation's management of the Colorado River by considering tradeoffs between frequency and magnitude of reductions of water deliveries, and considering the effects on water storage in Lake Powell and Lake Mead, and on water supply, power production, recreation, and other environmental resources; 2) provide mainstream United States users of Colorado River water, particularly those in the Lower Division states, a greater degree of predictability with respect to the amount of annual water deliveries in future years, particularly under drought and low reservoir conditions; and 3) provide additional mechanisms for the storage and delivery of water supplies in Lake Mead.

ES.1.2 Proposed Federal Action

The proposed federal action includes the adoption of specific interim guidelines for Lower Basin shortages and coordinated operations for Lake Powell and Lake Mead. These interim guidelines would remain in effect for determinations to be made through 2025 regarding water supply and reservoir operating decisions through 2026 and would provide guidance each year in development of the Annual Operating Plan for Colorado River Reservoirs (AOP). This proposed federal action considers four operational elements that collectively are designed to address the purpose and need for the proposed federal action.

The interim guidelines would be used by the Secretary to:

- Determine those circumstances under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead to the Colorado River Lower Division states (Arizona, California, and Nevada) below 7.5 million acre-feet (maf) (a ‘‘Shortage’’) pursuant to Article II(B)(3) of the United States Supreme Court in the case of *Arizona v. California*, 547 U.S. _____ (2006) (Consolidated Decree);

- Define the coordinated operation of Lake Powell and Lake Mead to provide improved operation of these two reservoirs, particularly under low reservoir conditions;

- Allow for the storage and delivery, pursuant to applicable federal law, of conserved Colorado River system and non-system water in Lake Mead to increase the flexibility of meeting water use needs from Lake Mead, particularly under drought and low reservoir conditions; and

- Determine those conditions under which the Secretary may declare the availability of surplus water for use within the Lower Division states. The proposed federal action would modify the substance of the existing Interim Surplus Guidelines (ISG), published in the Federal Register on January 25, 2001 (66 Fed. Reg. 7772), and the term of the ISG from 2016 to 2026.

ES.1.3 Geographic Scope

The geographic region that could potentially be affected by the proposed federal action begins with Lake Powell and extends downstream along the Colorado River floodplain to the Southerly International Boundary (SIB) with Mexico. In addition to the potential impacts that may occur within the river corridor, the alternatives may also affect the water supply that is available to specific Colorado River water users in the Lower Basin. The following water agency service areas are also included in the appropriate affected environment discussions:

- Arizona water users, particularly the lower priority water users located in the Central Arizona Project service area;
- The Southern Nevada Water Authority service area; and
- The Metropolitan Water District of Southern California service area.

Figure ES-1 shows the geographic scope for the Draft EIS.

ES.1.4 Alternatives

Five alternatives are considered and analyzed in the Draft EIS. The alternatives consist of a No Action Alternative and four action alternatives. The four action alternatives are: Basin States Alternative, Conservation Before Shortage Alternative, Water Supply Alternative, and Reservoir Storage Alternative. The action alternatives reflect input from Reclamation staff, the cooperating agencies, stakeholders, and other interested parties.

Reclamation received two written proposals for alternatives that met the purpose and need of the proposed federal action, one from the seven Colorado River Basin States (Basin States) and another from a consortium of environmental non-governmental organizations (NGO). These proposals were used by Reclamation to formulate two of the alternatives considered and analyzed in the Draft EIS (Basin States Alternative and Conservation Before Shortage Alternative, respectively). A third alternative (Water Supply Alternative) was developed by Reclamation and a fourth alternative (Reservoir Storage Alternative) was developed by Reclamation in coordination with the NPS and Western. The alternatives were posted on Reclamation's website (http://www.usbr.gov/lc/region/programs/strategies.html) on June 30, 2006.

Reclamation has not identified a preferred alternative in the Draft EIS. The preferred alternative will be identified following public comments on the Draft EIS and will be expressed in the Final EIS. The preferred alternative may be one of the specific alternatives described below or it may incorporate elements or variations of these alternatives.

Summary descriptions of the No Action Alternative and the four action alternatives considered in the Draft EIS are provided below and in Table ES-1.

Figure ES-1
Geographic Scope

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Table ES-1
Matrix of Alternatives

Alternatives	Shortage Guidelines to reduce deliveries from Lake Mead (elevations in feet msl)	Coordinated Reservoir Operations (Lake Mead & Lake Powell) (elevations in feet msl)	Lake Mead Storage and Delivery of Conserved System or Non-system Water	Interim Surplus Guidelines for deliveries/releases from Lake Mead
No Action	▪ Determination made through the AOP process, absent shortage guidelines ▪ Reasonably represented by a two-level shortage strategy - probabilistic protection of Lake Mead elevation 1,050 and absolute protection of Lake Mead elevation 1,000	▪ Minimum objective release of 8.23 maf from Lake Powell unless storage equalization releases are required ▪ Operation at low reservoir levels reasonably represented by a 8.23 maf release from Lake Powell down to Lake Powell dead pool	▪ No water management mechanism for storage and delivery of conserved system and/or non-system water	▪ No modification or extension of the ISG which end in 2016 ▪ After 2016, determination made through the AOP process, absent surplus guidelines; reasonably represented by the spill avoidance (referred to as the 70R Strategy)
Basin States	▪ Shortages (i.e., reduced deliveries) of 400, 500, and 600 kaf from Lake Mead at elevations 1,075, 1,050, and 1,025 respectively ▪ Initiate efforts to develop additional guidelines for shortages if Lake Mead falls below elevation 1,025 (Note: includes reconsultation with Basin States)	▪ Under high reservoir conditions, minimum objective release of 8.23 maf from Lake Powell unless storage equalization releases are required ▪ Under lower reservoir conditions, either reduce Lake Powell release or balance volumes depending upon elevations at Lake Powell and Lake Mead	▪ Storage and delivery of conserved system and/or non-system water ▪ Maximum total storage for conserved system and/or non-system water in Lake Mead of 2.1 maf ▪ System assessment of 5 percent of stored conserved system and/or non-system water	▪ Modification of ISG to eliminate Partial Domestic Surplus condition ▪ Extension of the modified guidelines through 2026
Conservation Before Shortage	▪ Shortages are implemented in any given year when necessary to keep Lake Mead above SNWA's lower intake at elevation 1,000 (absolute protection of elevation 1,000)	▪ Under high reservoir conditions, minimum objective release of 8.23 maf from Lake Powell unless storage equalization releases are required ▪ Under lower reservoir conditions, either reduce Lake Powell release or balance volumes depending upon elevation at Lake Powell and Lake Mead	▪ Prior to shortage, conservation of different volumes of water tied to Lake Mead elevation ▪ Storage and delivery of conserved system and/or non-system water ▪ Water for environmental uses ▪ Maximum total storage of conserved system and/or non-system water greater than 4.2 maf ▪ System assessment of 5 percent of stored conserved system and/or non-system water	▪ Modification of ISG to eliminate Partial Domestic Surplus condition ▪ Extension of the modified guidelines through 2026
Water Supply	▪ Release full annual entitlement amounts until Lake Mead is drawn down to dead pool (elevation 895)	▪ Minimum objective release of 8.23 maf from Lake Powell unless storage equalization releases are required ▪ Balancing if Lake Powell is below elevation 3,575 or Lake Mead is below elevation 1,075	▪ No water management mechanism for storage and delivery of conserved system and/or non-system water	▪ Extension of the existing ISG through 2026
Reservoir Storage	▪ Shortages (i.e. reduced deliveries) of 600, 800, 1,000, and 1,200 kaf from Lake Mead at elevations 1,100, 1,075, 1,050, and 1,025 respectively	▪ Minimum objective release of 8.23 maf from Lake Powell if Lake Powell is above elevation 3,595 unless storage equalization releases are required ▪ 7.8 maf release from Lake Powell between Lake Powell elevations of 3,560 and 3,595 ▪ Balancing below Lake Powell elevation of 3,560	▪ Storage and delivery of conserved system and/or non-system water ▪ Maximum total storage of conserved system and/or non-system water of 3.05 maf ▪ System assessment of 10 percent of stored conserved system and/or non-system water	▪ Permissive provisions of existing ISG terminate in 2007, and during period from 2008 to 2026, surplus determinations are limited to Quantified and Flood Control conditions

ES.1.4.1 No Action Alternative

The No Action Alternative provides a baseline for comparison of each of the action alternatives. The No Action Alternative represents a projection of future conditions that could occur during the life of the proposed federal action without an action alternative being implemented.

Pursuant to the Long-Range Operating Criteria (LROC), the Secretary makes a number of determinations at the beginning of each operating year through the development and execution of the AOP, including the water supply available to users in the Lower Basin and the annual release from Lake Powell. However, the LROC currently does not include specific guidelines for such determinations. Furthermore, there is no actual operating experience under very low reservoir conditions, i.e., there has never been a shortage determination in the Lower Basin. Therefore, in the absence of specific guidelines, the outcome of the annual determination in any particular year in the future cannot be precisely known. However, a reasonable representation of future conditions under the No Action Alternative is needed for comparison to each action alternative. The modeling assumptions used for this representation are consistent with assumptions used in previous environmental compliance documents for the ISG, the Colorado River Water Delivery Agreement, and the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). However, the assumptions used in the No Action Alternative are not intended to limit or predetermine these decisions in any future AOP determination.

ES.1.4.2 Basin States Alternative

The Basin States Alternative was developed by the Basin States and proposes a coordinated operation of Lake Powell and Lake Mead that would minimize shortages in the Lower Basin and avoid risk of curtailments of Colorado River water use in the Upper Basin. This alternative includes shortages to conserve reservoir storage; coordinated operations of Lakes Powell and Mead determined by specified reservoir conditions; a mechanism for the storage and delivery of conserved system and non-system water in Lake Mead; and a modification and extension of the ISG through 2026.

ES.1.4.3 Conservation Before Shortage Alternative

The Conservation Before Shortage Alternative was developed by a consortium of NGOs. The Conservation Before Shortage Alternative includes voluntary, compensated reductions (shortages) in water use to minimize involuntary shortages in the Lower Basin and avoid risk of curtailments of Colorado River water use in the Upper Basin. This alternative includes voluntary shortages prior to involuntary shortages; coordinated operations of Lakes Powell and Mead determined by specified reservoir conditions; an expanded mechanism for the storage and delivery of conserved system and non-system water in Lake Mead, including water for environmental uses; and a modification and extension of the ISG through 2026.

ES.1.4.4 Water Supply Alternative

The Water Supply Alternative maximizes water deliveries at the expense of retaining water in storage in the reservoirs for future use. This alternative would reduce water deliveries only when insufficient water to meet entitlements is available in Lake Mead. When reservoir conditions are relatively low, Lakes Powell and Mead would share water ("balance contents"). This alternative does not include a mechanism for the storage and delivery of conserved system and non-system water in Lake Mead. The existing ISG would be extended through 2026.

ES.1.4.5 Reservoir Storage Alternative

The Reservoir Storage Alternative was developed in coordination with the cooperating agencies and other stakeholders, primarily Western and the NPS. This alternative would keep more water in storage in Lake Powell and Lake Mead by reducing water deliveries and by increasing shortages to benefit power and recreational interests. This alternative includes larger, more frequent shortages that serve to conserve reservoir storage; coordinated operations of Lakes Powell and Mead determined by specified reservoir conditions (more water would be held in Lake Powell than under the Basin States Alternative); and an expanded mechanism for the storage and delivery of conserved system and non-system water in Lake Mead. The existing ISG would be terminated after 2007.

ES.2 Summary of Potential Environmental Effects

ES.2.1 Methodology

Hydrologic modeling of the Colorado River system was conducted to determine the potential hydrologic effects of the alternatives. The modeling provides projections of potential future Colorado River system conditions (i.e., reservoir elevations, reservoir releases, river flows) for comparison of those conditions under the No Action Alternative to conditions under each action alternative. Due to the uncertainty with regard to future inflows into the system, multiple simulations were performed in order to quantify the uncertainties of future conditions and as such, the modeling results are typically expressed in probabilistic terms.

The hydrologic modeling also provides the basis for the analysis of the potential effects of each alternative on other environmental resources such as recreation, biology, and electrical power. The potential effects to specific resources are identified and analyzed for each action alternative and are compared to the potential effects to that resource under the No Action Alternative. These comparisons are typically expressed in terms of the relative differences in probabilities between the No Action Alternative and the action alternatives.

ES.2.2 Hydrologic Resources

ES.2.2.1 Reservoir Storage

Lake Powell. Under the No Action Alternative and the action alternatives, the elevations of Lake Powell are projected to fluctuate between full and lower levels during the period of analysis (2008 through 2060). At the 90th percentile Lake Powell end-of-July elevations values, the action alternatives and the No Action Alternative are projected to be similar over the period of analysis.

At the 50th percentile Lake Powell end-of-July elevation values, the action alternatives and the No Action Alternative are projected to be similar during the period of 2008 through 2015. During the period of 2016 through 2026, the Reservoir Storage Alternative generally provides the highest elevations of the alternatives and is approximately five feet higher than the No Action Alternative in 2026. The Water Supply Alternative generally provides the lowest elevations of the alternatives and is approximately 28 feet lower than the No Action Alternative in 2026. The 50th percentile elevation values of the Basin States and Conservation Before Shortage alternatives are similar to each other and are approximately ten feet lower than the No Action Alternative in 2026. The 50th percentile elevation values of all of the alternatives converge by 2040.

At the 10th percentile Lake Powell end-of-July elevation values, distinct differences between the action alternatives and the No Action Alternative become apparent after 2010. During the period of 2010 through 2026, the Reservoir Storage Alternative provides higher elevations than any of the alternatives and is approximately ten feet higher than the No Action Alternative in 2026. The Water Supply Alternative provides the lowest 10th percentile elevation values of the alternatives and is approximately 52 feet lower than the No Action Alternative in 2026. The 10th percentile elevation values of the Basin States and Conservation Before Shortage alternatives are similar, are higher than those under the No Action Alternative through 2017, and then are lower than those under the No Action Alternative from 2019 through 2026. The 10th percentile elevation values of the Basin States and Conservation Before Shortage alternatives are approximately seven feet lower than the No Action Alternative in 2026. The 10th percentile Lake Powell end-of-July elevation values of all of the alternatives converge by 2040.

Lake Mead. Under the No Action Alternative and the action alternatives, the elevation of Lake Mead is projected to fluctuate between full and lower levels during the period of analysis (2008 through 2060). At the 90th percentile Lake Mead end-of-December elevation values, the Basin States, Conservation Before Shortage, and Water Supply alternatives and the No Action Alternative are projected to be similar over the period of analysis. The 90th percentile Lake Mead end-of-December elevation values under the Reservoir Storage Alternative are generally slightly higher than the other alternatives during the period from 2010 through 2032 and are approximately seven feet higher than the No Action Alternative in 2026.

At the 50th percentile Lake Mead end-of-December elevation values, the Reservoir Storage Alternative provides higher elevations than any of the alternatives during the period of 2009 through 2049 and is approximately 26 feet higher than the No Action Alternative in 2026. The Water Supply Alternative provides the lowest 50th percentile elevation values of the alternatives and is approximately 15.7 feet lower than the No Action Alternative in 2026. The 50th percentile elevation values of the Basin States and Conservation Before Shortage alternatives are similar to each other, are higher than those under the No Action Alternative through 2024, and then are lower than those under the No Action Alternative from 2025 through 2032. The 50th percentile Lake Mead end-of-December elevation values of the Basin States and Conservation Before Shortage alternatives are approximately 11 feet lower than the No Action Alternative in 2026. The 50th percentile Lake Mead end-of-December elevation values of all of the alternatives converge by 2050.

At the 10th percentile Lake Mead end-of-December elevation values, the Reservoir Storage Alternative provides higher elevations than any of the alternatives and is approximately 47 feet higher than the No Action Alternative in 2026. At the 10th percentile elevations the Water Supply, Basin States, and Conservation Before Shortage alternatives fluctuate above and below the No Action Alternative. The 10th percentile elevation value for the Water Supply Alternative is approximately one foot higher than the No Action Alternative in 2026. The 10th percentile elevation value of the Basin States and Conservation Before Shortage alternatives are approximately 15 feet and 12 feet higher than the No Action Alternative in 2026, respectively. The 10th percentile Lake Mead end-of-December elevation values under all of the alternatives, with the exception of those under the Reservoir Storage Alternative, converge by about 2038. The 10th percentile Lake Mead end-of-December elevation values of the Reservoir Storage Alternative converge with the other alternatives by about 2057.

Lake Mohave and Lake Havasu. Lake Mohave and Lake Havasu are operated on rule curves and have target end-of-month elevations. This manner of operation for the two reservoirs will continue in the future and would apply to operations under the No Action Alternative and the action alternatives. Therefore, future Lake Mohave and Lake Havasu water levels would not be affected by the proposed federal action.

ES.2.2.2 Reservoir Releases

Glen Canyon Dam releases less than the annual minimum objective release of 8.23 maf is projected to occur less than one percent of the time under the No Action Alternative, approximately four percent of the time under the Basin States, Conservation Before Shortage, and Water Supply alternatives, and approximately six percent of the time under the Reservoir Storage Alternative.

Glen Canyon Dam releases greater than the annual minimum objective release of 8.23 maf is projected to occur approximately 35 percent of the time under the No Action Alternative, approximately 42 percent of the time under the Basin States, Conservation Before Shortage, and Water Supply alternatives, and approximately 37 percent of the time under the Reservoir Storage Alternative.

Glen Canyon Dam releases greater than 9.0 maf generally correspond to years that either equalization or spill avoidance releases are made from Lake Powell. Glen Canyon Dam releases greater than 9.0 maf are projected to occur 30 percent of the time under the No Action Alternative, 36 percent of the time under the Basin States and Conservation Before Shortage alternatives, 37 percent of the time under the Water Supply Alternative, and 31 percent of the time under the Reservoir Storage Alternative.

More water is held in storage in Lake Mead under the Reservoir Storage Alternative and therefore the releases from Hoover Dam are projected to be lower under this alternative during the interim period of 2008 through 2026, as compared to the No Action Alternative. Conversely, the Hoover Dam releases under the Water Supply Alternative are projected to be greater than those under the No Action Alternative because less water is held in storage under this alternative. Hoover Dam releases under the Basin States and Conservation Before Shortage alternatives are projected to be slightly less than those under the No Action Alternative. The alternative with the greatest effect on Hoover Dam releases due to shortage-related delivery reductions is the Reservoir Storage Alternative.

The releases from Davis Dam and Parker Dam generally reflect the same pattern of releases under the different action alternatives as those from Hoover Dam. The differences in the release volumes are mostly attributed to the depletions that occur upstream of each respective dam.

ES.2.2.3 Groundwater

Differences in Colorado River flows below Hoover Dam are similar between the action alternatives and the No Action Alternative and are relatively minor. Corresponding effects on groundwater will also be relatively minor.

ES.2.3 Water Deliveries

All of the action alternatives generally improve water supply conditions during the interim period relative to the No Action Alternative, improve the probability that normal deliveries will be met, and reduce the probability that Shortage condition deliveries will occur. The differences between the action alternatives and the No Action Alternative, in terms of the probability of occurrence for Normal conditions water supply deliveries, diminish after 2027 and converge by about 2038.

The Water Supply Alternative provides the same probability of Surplus condition deliveries as the No Action Alternative (between about 30 to 40 percent) between 2008 and 2016 and this alternative consistently provides the highest probability of Surplus condition deliveries during the interim period. The Reservoir Storage Alternative provides the lowest probabilities (between about 10 to 20 percent) during the interim period. The surplus provisions under the Basin States and Conservation Before Shortage alternatives are similar and the probability of Surplus conditions between 2010 through 2016 is slightly less than under the No Action Alternative. After 2026 the probability for all alternatives converges and ranges between 10 and 20 percent.

During most of the interim period, the probability of involuntary and voluntary shortage is less under all of the action alternatives compared to the No Action Alternative. The probability of occurrence of shortages under the Water Supply Alternative is generally less than under the No Action Alternative and other action alternatives during the interim period. However, after 2026, the Water Supply Alternative has the highest probability of occurrence. Average shortages that occur under the Water Supply Alternative are significantly less than those observed under the No Action Alternative during the interim period.

The probability of occurrence of shortages under the Reservoir Storage Alternative is slightly higher than under the No Action Alternative between 2008 and 2013. However, after 2013 and through about 2037, shortages under the Reservoir Storage Alternative occur less frequently as compared to the No Action Alternative. In terms of magnitude, the average shortage volumes that are observed during the interim period are highest under the Reservoir Storage Alternative.

Shortages also occur less frequently under the Basin States and Conservation Before Shortage alternatives during the interim period as compared to the No Action Alternative and are similar after 2026. The probability values of the Basin States Alternative and Conservation Before Shortage Alternative differ by a maximum of about five percent with those of the Conservation Before Shortage Alternative being generally slightly lower than those under the Basin States Alternative. The probability of an involuntary and voluntary shortage under the No Action Alternative in 2026 is 47 percent. In contrast, in 2026, the probability of an involuntary and voluntary shortage under the Basin States, Conservation Before Shortage, Water Supply, and Reservoir Storage alternatives is 35 percent, 33 percent, nine percent, and 37 percent, respectively. In terms of magnitude, the average involuntary and voluntary shortages that are observed under the Basin States and Conservation Before Shortage alternatives are similar to each other and both are less than those observed under the No Action Alternative during the interim period. After 2026, the average shortage volumes are similar.

The mechanism to deliver and store conserved system and non-system water in Lake Mead assumed as part of the Basin States, Conservation Before Shortage and Reservoir Storage alternatives has the effect of decreasing the occurrence of shortages. The greatest reduction during the interim period occurs under the Reservoir Storage Alternative.

ES.2.4 Water Quality

The future average annual salinity levels under the different action alternatives are not expected to exceed the numeric criteria for salinity at Hoover Dam, Parker Dam and Imperial Dam, established by the Colorado River Salinity Control Forum.

The temperature range for Glen Canyon Dam releases under the Water Supply Alternative could potentially be warmer due to lower Lake Powell reservoir elevations. The Reservoir Storage Alternative generally results in cooler temperatures for Glen Canyon Dam releases. The temperature of Glen Canyon Dam releases under the Basin States and Conservation Before Shortage alternatives are similar to those under the No Action Alternative.

Hydrologic and water quality modeling for Lake Mead for the Boulder Islands North Alternative (preferred alternative) published in the System Conveyance and Operations Program Final EIS (October 2006) shows that drawing the Lake Mead water level down to an elevation of 1,000 feet msl would not have a significant effect on water quality in Lake Mead. The probability that Lake Mead will be drawn down below 1,000 feet msl over the interim period is negligible for the No Action, the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives. Under the Water Supply Alternative there is up to a 4 percent chance that Lake Mead would drop below 1,000 feet msl over the interim period.

The projected elevations and corresponding changes in dilution capacity in Lake Mead are not expected to result in metals concentrations of concern. It is not anticipated that any of the action alternatives would result in a significantly increased concentration of perchlorate.

ES.2.5 Air Quality

As reservoir elevation decreases and shoreline is exposed, the potential for increased fugitive dust increases. The potential exposed shoreline acreage for the Basin States Alternative and the Conservation Before Shortage Alternative are similar to the No Action Alternative at both Lake Powell and Lake Mead. The Water Supply Alternative is projected to have the greatest increase in exposed shoreline acreage compared to the No Action Alternative at Lake Powell, but is projected to be similar to the No Action Alternative at Lake Mead. The Reservoir Storage Alternative is projected to result in less exposed shoreline acreage compared to the No Action Alternative for both Lake Powell and Lake Mead.

An increase in fugitive dust as a result of increased exposed shoreline would be limited at Lake Powell because the increased exposure of acreage would be comprised largely of sandstone. All of the action alternatives have the potential to decrease exposed acreage of shoreline at Lake Mead compared to the No Action Alternative.

ES.2.6 Visual Resources

The probability of water being visible under or near Rainbow Bridge is 59 percent under the No Action Alternative and ranged from a low of 40 percent under the Water Supply Alternative to 62 percent under the Reservoir Storage Alternative. Under the No Action Alternative there is a four percent probability of exposing Cathedral in the Desert. For the action alternatives there is a range from 17 percent probability of exposing Cathedral in the Desert to one percent under the Water Supply Alternative and Reservoir Storage Alternative, respectively. There would be no effect on attraction features at Lake Mead.

The visibility of calcium carbonate rings along the perimeter of Lake Powell and Lake Mead varies depending on reservoir water levels. At Lake Powell, the maximum height is projected to be 160 feet under the No Action Alternative and ranged from 195 feet under the Water Supply Alternative to 150 feet under the Basin States and Conservation Before Shortage alternatives. At Lake Mead, the maximum height is projected to be 209 feet under the No Action Alternative. The maximum height under the action alternatives is expected to be similar to that under the No Action Alternative. For both reservoirs, the presence of the calcium carbonate ring is more of an aesthetics effect than the height at any given reservoir elevation. Therefore, while there may be some numeric differences in the projected height of the rings, the overall difference in visual impact among the alternatives is not significant.

At both Lake Powell and Lake Mead, sediment deltas will continue to build up over time and be visible under all alternatives. The differences among alternatives are negligible for both Lake Powell and Lake Mead.

ES.2.7 Biological Resources

ES.2.7.1 Vegetation and Wildlife

Changes in reservoir storage and river flows may affect vegetation and wildlife resources by altering their habitats. These potential changes in habitat at Lake Powell and Lake Mead and the reaches of the Colorado River between Glen Canyon Dam and Lake Mead and downstream of Lake Mead were analyzed. The analysis concluded that none of the action alternatives would result in a substantial impact to vegetation or wildlife habitat located at the reservoirs or along the river.

At Lake Powell and Lake Mead, the Water Supply Alternative may result in a minor adverse effect on obligate phreatophytes and marsh habitat as a result of lower lake levels. Conversely, the Reservoir Storage Alternative may benefit these same resources because lake levels may be higher.

Between Parker Dam and Imperial Dam, the Conservation Before Shortage, Basin States, and Reservoir Storage alternatives may have minor adverse effects to obligate phreatophytes and marsh habitat because of lower flows.

No changes in habitat are expected to occur on the reaches from Hoover Dam to Davis Dam, Lake Havasu to Parker Dam, and Imperial Dam to Morelos Dam because the range of river stage (water levels) under all of the alternatives is expected to be similar to historical conditions. Between Davis Dam and Lake Havasu and Parker Dam to Imperial Dam, the Reservoir Storage Alternative may adversely affect habitat because of a potential slight decrease in the median river stage, as compared to the No Action Alternatives.

From the Northerly International Boundary with Mexico (NIB) to the SIB, moderate beneficial impacts to the habitat is expected under the Conservation Before Shortage and Reservoir Storage alternatives, due to increased probability of flows below Morelos Dam[1].

ES.2.7.2 Special Status Species

In addition to the assessment of effects on general vegetation and wildlife, the analysis also considered potential effects on special status fish, bird, and plant species. These effects were evaluated for species occurring at Lake Powell and Lake Mead and the reaches of the Colorado River between Glen Canyon Dam and Lake Mead, and downstream of Lake Mead. For the reaches of the Colorado River from Hoover Dam to Davis Dam, Lake Havasu to Parker Dam, and Imperial Dam to Morelos Diversion Dam, there would be no effects on special status fish, bird, or plant species because no changes in the range of river stage would occur. Effects on special status plant species at Lake Mead were considered minor because all habitats below full pool elevation are subject to periodic inundation and exposure.

[1] These flows were modeled as part of the storage and delivery mechanism under the Conservation Before Shortage and Reservoir Storage alternatives. These modeling assumptions were utilized in the Draft EIS in order to analyze the potential impacts to environmental resources of the storage and delivery mechanism, particularly with regard to reservoir elevations and river flow impacts. The use of these modeling assumptions does not represent any determination by Reclamation as to whether, or how, these releases could be made under current administration of the Colorado River.

Fish. At Lake Powell, special status fish species may benefit under the Conservation Before Shortage, Basin States, and Water Supply alternatives as a result of lower lake levels, thereby extending riverine habitat. At Lake Mead, the Reservoir Storage Alternative may result in minor adverse effects on special status fish species as a result of higher lake levels that may reduce riverine habitat. Conversely, the Water Supply Alternative may result in beneficial effects on special status fish species because lower lake levels may increase riverine habitat.

Between Glen Canyon Dam and Lake Mead, the Reservoir Storage and Water Supply alternatives would result in a wider range of flow and water temperature fluctuations. The wider range of temperatures may both benefit and adversely affect special status fish species and amphibians. From Davis Dam to Lake Havasu and Parker Dam to Imperial Dam special status fish species may be adversely affected under the Reservoir Storage Alternative because lower flows would result in a reduction of spawning and rearing habitat. Conversely, increased flows under the Water Supply Alternative may benefit special status fish species.

Birds. At Lake Mead, the Water Supply Alternative may result in lower elevations and minor adverse effects on habitat for special status bird species. Conversely, higher elevations under the Reservoir Storage Alternative may benefit habitat for special status bird species. Between Davis Dam and Lake Havasu, and between Parker Dam and Imperial Dam, lower flows occurring under the Reservoir Storage Alternative may have a minor adverse effect on habitats used by special status bird species. Conversely, higher flows occurring under the Water Supply Alternative may have minor beneficial effect on special status bird species.

From the NIB to the SIB, moderate beneficial impacts to habitat used by special status bird species is expected under the Conservation Before Shortage and Reservoir Storage alternatives, due to increased probability of flows below Morelos Diversion Dam. [2]

ES.2.8 Cultural Resources

For Lake Powell, under the Water Supply Alternative at the 10th percentile water elevation, there are at least 222 unexcavated sites subject to effect because of increased probability of exposure due to lower lake levels, as compared to about 193 sites under the other alternatives. Consultation is underway regarding eligibility and effect.

[2] These flows were modeled as part of the storage and delivery mechanism under the Conservation Before Shortage and Reservoir Storage alternatives. These modeling assumptions were utilized in the Draft EIS in order to analyze the potential impacts to environmental resources of the storage and delivery mechanism, particularly with regard to reservoir elevations and river flow impacts. The use of these modeling assumptions does not represent any determination by Reclamation as to whether, or how, these releases could be made under current administration of the Colorado River.

For the reach from Glen Canyon Dam to Lake Mead, the alternatives would have no substantial effect on cultural resources. In addition, a variety of programs are underway to protect these resources.

For Lake Mead, there are at least 32 cultural resource sites located below the 1,080 feet msl elevation that have not been exposed since the reservoir was initially filled. The Lake Mead water level is expected to fall below this elevation under all of the alternatives. However, the probability of exposing sites below this elevation vary by alternative, with the Reservoir Storage Alternative having the lowest probability (up to 23 percent over the interim period) and the Water Supply Alternative having the highest probability (up to 51 percent over the interim period).

For the reaches below Lake Mead, no adverse effects are anticipated from any of the alternatives; consultation regarding eligibility and effect will be undertaken.

For Indian sacred sites and other issues of Tribal concern, none of the alternatives are expected to restrict access or result in loss of physical integrity to sacred sites. Consultations with Indian tribes are ongoing with respect to these issues and other issues and concerns.

ES.2.9 Indian Trust Assets

After evaluating each resource, it is concluded that Tribal trust resources identified in the study area would not be adversely affected by any of the anticipated environmental impacts stemming from the proposed federal action.

ES.2.10 Electrical Power Resources

The Water Supply Alternative would have the greatest negative effect on total Colorado River system hydropower generation (approximately -1.5 percent) as compared to the No Action Alternative because of reduced reservoir levels. Conversely, the Reservoir Storage Alternative would result in an increase in total electrical power production as compared to the No Action Alternative (approximately three percent). The Basin States and Conservation Before Shortage alternatives are similar to the No Action Alternative.

With respect to other electrical power resource issues, the Water Supply Alternative has a higher potential for total loss of generation at the Glen Canyon Powerplant and the Hoover Powerplant than the other action alternatives and the No Action Alternative.

ES.2.11 Recreation

ES.2.11.1 Shoreline Facilities

The Reservoir Storage Alternative would result in higher reservoir water levels and a lower probability of closure of shoreline facilities than the other action alternatives and the No Action Alternative. Conversely, the Water Supply Alternative would result in the highest probability of such closures. The Basin States and Conservation Before Shortage alternatives are similar to the No Action Alternative.

At Lake Mead, all of the alternatives have similar probabilities of facility closures except for the Reservoir Storage Alternative, which has a slightly to moderately lower probability. The probability of closure of the Pearce Bay launch under the No Action Alternative and the Basin States, Conservation Before Shortage, and Water Supply alternatives range from about 76 percent to 78 percent. The probability of this occurrence under the Reservoir Storage Alternative is approximately 68 percent.

ES.2.11.2 Boating and Navigation

The Reservoir Storage Alternative is projected to result in higher reservoir water levels and a lower probability of boating restrictions or prohibitions around Castle Rock and Gregory Butte as compared to the other action alternatives and the No Action Alternative. Conversely, the Water Supply Alternative is projected to result in the highest probability of such occurrences. The Basin States and Conservation Before Shortage alternatives are similar to the No Action Alternative.

At Lake Mead, all of the alternatives have similar probabilities of exposing navigational hazards due to lower reservoir water level conditions except for the Reservoir Storage Alternative, which has a slightly to moderately lower probability. The probability of closure of Castle Rock and Gregory Butte under the No Action Alternative is 29 percent in 2026. In contrast, the probability of closure of these areas under the Basin States, Conservation Before Shortage, Water Supply, and Reservoir Storage alternatives is 36 percent, 36 percent, 47 percent, and 21 percent, respectively. The probability of navigational hazards being exposed under the No Action Alternative and the Basin States, Conservation Before Shortage, and Water Supply alternatives range from about 73 percent to 77 percent in 2026. The probability of this occurrence under the Reservoir Storage Alternative is approximately 65 percent.

For whitewater boating through the Grand Canyon, the existing required minimum boating releases will be maintained and will be similar to existing and the No Action Alternative conditions under all alternatives.

ES.2.11.3 Sport Fish Populations

Sport fish populations would not be adversely affected at Lake Powell under any of the alternatives as compared to the No Action Alternative.

High water temperatures or low dissolved oxygen could affect rainbow trout in the Lees Ferry reach. The Water Supply Alternative shows the greatest potential to provide warmer river flow temperatures in this reach, while the Reservoir Storage Alternative shows less warming potential than the No Action Alternative and the other action alternatives.

ES.2.12 Transportation

For the Lake Powell ferry, the Basin States and Conservation Before Shortage Alternatives would have minor effects on ferry service; the Water Supply Alternative would result in moderate adverse effects; and the Reservoir Storage Alternative would have beneficial effects. The probability varies from year to year, but there is up to a 17 percent probability that the ferry may become inoperable under the Water Supply Alternative for some period of time. Conversely, the ferry could potentially remain operable more of the time under the Reservoir Storage Alternative.

For the Colorado River ferry service below Davis Dam, only under the Reservoir Storage Alternative are there measurable effects and these would be minor. The other action alternatives show no difference from the No Action Alternative.

The Lake Havasu ferry service would be unaffected by any alternative.

ES.2.13 Socioeconomics and Land Use

ES.2.13.1 Employment, Income, and Tax Revenue

None of the action alternatives are expected to result in a greater change in employment, income or tax revenue attributable to changes in agricultural production due to involuntary shortages when compared to conditions under the No Action Alternative. The estimated change in employment, income, and tax revenues would be less under each of the action alternatives compared to the No Action Alternative. Among the action alternatives, the Reservoir Storage and Basin States alternatives would result in the greatest loss in employment, income, and tax revenues. None of the changes in employment and income are considered substantial when compared to total employment and income generated within the study area.

ES.2.13.2 Municipal and Industrial Water Uses

Adverse effects on employment and income in Arizona and Nevada during shortages would be minimized through implementation of local and state water supply management plans and drought response plans that are currently in place. No adverse effects are expected in California because of the low probability of shortages of sufficient magnitude to affect California and the availability of alternative water supplies within California.

ES.2.13.3 Recreation Economics

The assessment of changes in recreation-related spending at Lake Powell and Lake Mead suggest that expenditures are expected to decrease under the Basin States, Conservation Before Shortage, and Water Supply alternatives and are expected to increase under the Reservoir Storage Alternative when compared to conditions under the No Action Alternative. The greatest reduction in spending is expected to occur under the Water Supply Alternative because this alternative would result in the greatest change in reservoir storage among the alternatives.

Because river flows would remain within normal ranges, there would be no resulting changes in river-related economic activity.

ES.2.13.4 Environmental Justice

After evaluating each resource, it is concluded that the environmental justice communities identified in the study area would not be disproportionately affected by any of the anticipated environmental impacts stemming from the proposed federal action.

ES.3 Cumulative Impacts

The proposed federal action would not result in any significant cumulative impacts.

ES-2
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.3	Hydrologic Resources					
	Probability of Glen Canyon annual release volumes ≥ 7.5 maf, 2009 to 2060	100%	96.3%	96.3%	97.4%	100%
	Probability of Glen Canyon annual release volumes ≥ 8.23 maf, 2009 to 2060	99.7%	96.3%	96.3%	96.3%	94.0%
	Lake Powell March elevation, probability of elevations ≤ 3,490 feet msl, 2026	1.0%	0%	0%	8.0%	0%
	Lake Mead December elevation, probability of elevations ≤ 1,050 feet msl, 2026	26.0%	20.0%	20.0%	21.0%	4.0%
	Hoover Dam annual release, 2026 50th percentile values	9.1 maf	9.2 maf	9.1 maf	9.4 maf	8.7 maf
4.4	Water Deliveries					
	Probability of involuntary Shortage, 2026	47%	35%	8%	9%	37%
	Probability of voluntary and involuntary Shortage, 2026	47%	35%	33%	9%	37%
	Probability of Normal deliveries	35%	26%	29%	52%	47%
	Probability of Surplus	17%	38%	37%	39%	16%
4.5	Water Quality					
	Temperature at Little Colorado River, July 2026, 50th percentile	10 to 14 °C	10 to 15°C	10 to 15°C	10 to 15°C	10 to 13°C
	Lake Mead release temperature, July 2026, 50th percentile	13 to 18°C	13 to 18°C	13 to 18°C	13 to 18°C	12 to 16°C
	Salinity below Parker Dam, 2026	624 mg/L	628 mg/L	629 mg/L	637 mg/L	619 mg/L
	Salinity at Imperial Dam, 2026	744 mg/L	751 mg/L	756 mg/L	764 mg/L	740 mg/L
4.6	Air Quality					
	Lake Powell 2026, 10th percentile lake elevation, exposed shoreline	17,000 acres	17,000 acres	17,000 acres	21,000 acres	14,000 acres
	Lake Mead 2026, 10th percentile lake elevation, exposed shoreline	87,000 acres	84,000 acres	85,000 acres	86,000 acres	72,000 acres

Table ES-2
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.7	Visual Resources					
	Lake Powell maximum height of calcium carbonate ring, 10th percentile lake elevation , 2026	160 feet	150 feet	150 feet	195 feet	160 feet
	Lake Mead maximum height of calcium carbonate ring, 10th percentile lake elevation, 2026	209 feet	209 feet	209 feet	210 feet	208 feet
4.8	Biological Resources[1]					
	Effects on Vegetation and Wildlife					
	Lakes Powell and Mead	-	None	None	Minor negative	Minor positive
	Glen Canyon Dam to Lake Mead	-	Minor negative	Minor negative	Minor negative	Minor negative
	Hoover Dam to NIB	-	None to minor negative	None to minor negative	Minor positive to none	Minor negative
	NIB to SIB	-	None	Moderate positive	None	Moderate positive
	Effects on Special Status Species					
	Glen Canyon Dam to Lake Mead humpback chub	-	None	None	Minor positive	Minor negative
	Parker Dam to Imperial Dam Yuma clapper rail	-	None	None	Minor positive	Minor negative
	NIB to SIB Southwestern willow flycatcher	-	None	Moderate positive	None	Moderate positive
4.9	Cultural Resources					
	Number of Lake Powell sites potentially exposed, 10th percentile lake elevation	193 sites	190 sites	190 sites	222 sites	193 sites
	Probability of exposing 32 Lake Mead sites, elevation ≤ 1,080 feet msl, 2026	43%	44%	44%	48%	22%
4.10	Indian Trust Assets[1]					
	Water rights affected	-	None	None	None	None
	Trust land affected	-	None	None	None	None

Table ES-2
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.11	Electrical Power Resources					
	Glen Canyon Powerplant					
	Average annual generation and percent change from No Action Alternative value	4,265,749 MWh	(0.25)%	(0.21)%	(2.2)%	0.63%
	Average monthly capacity and percent change from No Action Alternative value	603 MW	0.57%	0.60%	(1.9)%	1.6%
	Average total economic value and percent change from No Action Alternative value	$6,808,948,737	(0.07)%	(0.04)%	(2.05)%	0.92%
	Hoover Powerplant					
	Average annual generation and percent change from No Action Alternative value	3,156,820 MWh	0.46%	0.59%	(1.5)%	8.7%
	Average monthly capacity and percent change from No Action Alternative value	1,201 MW	1.1%	1.3%	(1.9)%	11.3%
	Average total economic value and percent change from No Action Alternative value	$7,350,904,219	1.03%	1.22%	(1.20)%	10.1%
	Davis and Parker Powerplants					
	Average annual generation and percent change from No Action Alternative value	1,618,736 MWh	(0.58)%	(0.69)%	0.1%	(1.1)%
	Average monthly capacity and percent change from No Action Alternative value	331 MW	0%	0%	0%	0%
	Average total economic and percent change from No Action Alternative value	$2,242,612,717	(0.55)%	(0.73)%	0.28%	(1.6)%
	Headgate Rock Powerplant					
	Average annual generation and percent change from No Action Alternative value	77,386 MWh	(1.2)%	(1.6)%	(0.29)%	(1.8)%
	Average monthly capacity and percent change from No Action Alternative value	not applicable	not applicable	not applicable	not applicable	not applicable
	Average total economic value and percent change from No Action Alternative value	$102,892,840	(1.3)%	(1.9)%	(0.19)%	(2.5)%

Table ES-2
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.12	Recreation					
	Lake Powell					
	Probability of closure, Wahweap and lower Bullfrog launch ramps, 2026	6%	8%	8%	20%	2%
	Probability of navigation closures, Castle Rock, Gregory Butte, 2026	29%	36%	36%	47%	21%
	Effects on sport fish	-	None	None	None	None
	Lake Mead					
	Probability of closure, Pearce Bay launch ramp, 2026	76%	76%	77%	78%	68%
	Probability of closure, Echo Bay launch ramp, 2026	26%	20%	22%	21%	4%
	Probability of navigation difficulties, upper Lake Mead, 2026	74%	73%	73%	77%	65%
4.13	Transportation[1]					
	Probability of Lake Powell ferry closure, end of September 2026	4%	6%	6%	17%	1%
	Effects on Colorado River ferry	-	None	None	Slight increase	Slight decrease
	Effects on Lake Havasu ferry service	-	None	None	None	None

Table ES-2
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.14	Socioeconomics and Land Use[1]					
	Agricultural production and effects on employment, income, and tax revenues in Arizona, 2026	46%	35%	7%	9%	37%
	Agricultural production and effects on employment, income, and tax revenues in Arizona, 2060	79%	63%	65%	80%	67%
	Agricultural production and resulting effects on employment, income, and tax revenues in California and Nevada	-	None	None	None	None
	Recreation spending at Lake Powell	-	Same	Same	Decrease	Increase
	Recreation spending at Lake Mead (LMNRA)	-	Same	Same	Same	Increase
	Change in river recreation economic activity					
	Lake Powell to Lake Mead	-	None	None	None	None
	Downstream of Lake Mead	-	None	None	None	None
	Change in economic activity in Municipal & Industrial sector					
	Arizona	-	None	None	None	None
	Nevada	-	None	None	None	None
	California	-	None	None	None	None
4.15	Environmental Justice	-	None	None	None	None

Chapter One

Purpose and Need

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1.1 Introduction

During the period from 2000 to 2006, the Colorado River has experienced the worst drought conditions in approximately one hundred years of recorded history. During this period, storage in Colorado River reservoirs has dropped from nearly full to less than 60 percent of capacity at the end of 2006. Currently, the Department of the Interior (Department) does not have specific operational guidelines in place to address the operation of Lake Mead and Lake Powell during drought and low reservoir conditions.

Accordingly, the Secretary of the Department of the Interior (Secretary), acting through the Bureau of Reclamation (Reclamation), proposes adoption of specific Colorado River Lower Basin (Lower Basin) shortage guidelines and coordinated reservoir management strategies to address operations of Lake Powell and Lake Mead, particularly under drought and low reservoir conditions. This action is proposed in order to provide a greater degree of certainty to United States Colorado River water users and managers of the Colorado River Basin by providing detailed, and objective guidelines for the operations of Lake Powell and Lake Mead, thereby allowing water users in the Lower Basin to know when, and by how much, water deliveries will be reduced in drought and other low reservoir conditions. The environmental impact statement (EIS) process will provide an opportunity to develop the information needed to analyze and consider tradeoffs between the frequency and magnitude of shortages, and to describe potential effects on water storage in Lake Powell and Lake Mead, and on water supplies, power production, recreation, and other environmental resources.

The Secretary proposes that these guidelines be interim in duration and extend through 2026. Adoption of these new guidelines, along with modification of existing operational guidelines for a consistent interim period through 2026, will provide the opportunity to gain valuable operating experience for the management of Lake Powell and Lake Mead under modified operations and improve the basis for making additional future operational decisions, whether during the interim period or thereafter.

The Secretary intends to consider, adopt and implement the proposed federal action[1] consistent with applicable federal law and judicial decisions, and, further, in a manner that will not require any additional statutory authorization. In addition, the proposed federal action would be implemented consistent with the Colorado River Compact of 1922, the Consolidated Decree entered by the United States Supreme Court in the case of *Arizona v. California*, 547 U.S. ___ (2006) (Consolidated Decree), and other provisions of applicable federal law (Section 1.7). The proposed federal action will be implemented through the adoption of interim guidelines that would be used each year by the Department in implementing the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968 (Long-Range Operating Criteria or LROC) through issuance of the Annual Operating Plan for Colorado River Reservoirs (AOP).

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[1] The phrase "proposed federal action" is used herein to refer to the action that the Secretary may take to meet the purpose and need. A range of alternatives are considered in this document; the preferred alternative will be identified following public comments on the Draft EIS and will be expressed in the Final EIS.

This Draft Environmental Impact Statement (Draft EIS) has been prepared pursuant to the National Environmental Policy Act of 1969 (NEPA), as amended, and the Council on Environmental Quality's (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 C.F.R. pt. 1500 through 1508). This Draft EIS has been prepared to address the formulation and evaluation of the proposed federal action and to identify the potential environmental effects of implementing the proposed federal action.

This Draft EIS identifies the potential relevant environmental issues associated with, and analyzes the environmental consequences of alternatives for implementing the proposed federal action. The alternatives addressed in this Draft EIS are those Reclamation has determined would meet the purpose and need for the proposed federal action and represent a broad range of reasonable alternatives.

1.2 Proposed Federal Action

The proposed federal action includes the adoption of specific interim guidelines for Lower Basin shortages and coordinated operations of Lake Powell and Lake Mead. These interim guidelines would remain in effect for determinations to be made through 2025 regarding water supply and reservoir operating decisions through 2026 and would provide guidance each year in development of the AOP. This proposed federal action considers four operational elements that collectively are designed to address the purpose and need for the proposed federal action; these elements are addressed in each of the alternatives described in Chapter 2.

The interim guidelines would be used by the Secretary to:

1) Determine those circumstances under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead to the Colorado River Lower Division states (Arizona, California, and Nevada) (Section 1.7) below 7.5 million acre-feet (maf) (a ‘‘Shortage’’) pursuant to Article II(B)(3) of the Consolidated Decree;

2) Define the coordinated operation of Lake Powell and Lake Mead to provide improved operation of these two reservoirs, particularly under low reservoir conditions;

3) Allow for the storage and delivery, pursuant to applicable federal law, of conserved Colorado River system and non-system water in Lake Mead to increase the flexibility of meeting water use needs from Lake Mead, particularly under drought and low reservoir conditions; and

4) Determine those conditions under which the Secretary may declare the availability of surplus water for use within the Lower Division states. The proposed federal action would modify the substance of the existing Interim Surplus Guidelines (ISG), published in the *Federal Register* on January 25, 2001 (66 Fed. Reg. 7772), and the term of the ISG from 2016 to 2026.

1.3 Purpose of and Need for Action

The purpose of the proposed federal action is to: 1) improve Reclamation's management of the Colorado River by considering the tradeoffs between the frequency and magnitude of reductions of water deliveries, and considering the effects on water storage in Lake Powell and Lake Mead, water supply, power production, recreation, and other environmental resources; 2) provide mainstream United States users of Colorado River water, particularly those in the Lower Division states, a greater degree of predictability with respect to the amount of annual water deliveries in future years, particularly under drought and low reservoir conditions; and, 3) provide additional mechanisms for the storage and delivery of water supplies in Lake Mead.

The proposed federal action is needed for the following reasons:

- The Colorado River is of unique and strategic importance in the southwestern United States for water supply, hydropower production, flood control, recreation, fish and wildlife habitat, and other benefits. In addition, the United States has a delivery obligation to the United Mexican States (Mexico) for certain waters of the Colorado River pursuant to the 1944 Treaty between the United States and Mexico Relating to the Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande (1944 Treaty);

- The seven-year period from 2000 through 2006 was the driest seven-year period in the 100-year historical record; this drought in the Colorado River Basin has reduced Colorado River system storage, while demands for Colorado River water supplies have continued to increase. From October 1, 1999 through September 30, 2006, storage in Colorado River reservoirs fell from 55.7 maf (approximately 97 percent of capacity) to 33.4 maf (approximately 56.4 percent of capacity), and was as low as 29.7 maf (approximately 52 percent of capacity) in 2004. This drought was the first sustained drought experienced in the Colorado River Basin at a time when all major storage facilities were in place, and when use by the Lower Division states met or exceeded the annual "normal" apportionment of 7.5 maf pursuant to Article II(B)(1) of the Consolidated Decree (Section 1.7). These conditions, among other factors, led the Department to conclude that additional management guidelines are necessary and desirable for the efficient management of the major mainstream Colorado River reservoirs;

- In the future, low reservoir conditions may not be limited to drought periods because of anticipated future demands on Colorado River water supplies. Future Colorado River water demands are projected to increase the frequency and magnitude of drought and low reservoir conditions on the Colorado River;

- As a result of actual operating experience and through reviews of the LROC and preparation of AOPs, particularly during recent drought years, the Secretary has determined a need for more specific guidelines, consistent with the Consolidated Decree and other applicable provisions of federal law to assist in the Secretary's determination of annual water supply conditions in the Lower Basin under low reservoir conditions. The increased level of predictability is needed by water managers and the entities that receive Colorado River water to better plan for and manage available water supplies, and to better integrate the use of Colorado River water with other water supplies that they rely on;

- To date, storage of water and flows in the Colorado River has been sufficient so that it has not been necessary to reduce Lake Mead annual releases below 7.5 maf; that is, the Secretary has never reduced deliveries by declaring a "shortage" on the lower Colorado River. Without operational guidelines in place, water users who rely on the Colorado River in the Lower Division states are not currently able to identify particular reservoir conditions under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead to the Lower Division states below 7.5 maf. Nor are these water users able to identify the frequency or magnitude of any potential future annual reductions in their water deliveries;

- After public consultation meetings held in the summer of 2005, the Secretary has also determined the desirability of developing additional operational guidelines that will provide for releases greater than or less than 8.23 maf from Lake Powell; and

- To further enhance this coordinated reservoir approach, the Secretary has also determined a need for guidelines that provide water users in the Lower Division states the opportunity to conserve, store, and take delivery of water in and from Lake Mead for the purposes of enhancing existing water supplies, particularly under low reservoir conditions. The Secretary has determined the need to modify and extend the ISG to coincide with the duration of the proposed new guidelines. This will provide an integrated approach for reservoir management and more predictability for future Lower Division water supplies.

1.4 Lead and Cooperating Agencies

The Secretary is responsible for the operation of Glen Canyon Dam and Hoover Dam pursuant to applicable federal law. The Secretary is also vested with the responsibility of managing the mainstream waters of the lower Colorado River pursuant to federal law. This responsibility is carried out consistent with the Law of the River.[2] Reclamation, as the agency that is designated to act on the Secretary's behalf with respect to these matters, is the lead federal agency for the purposes of NEPA compliance for the development and implementation of the proposed interim guidelines.

[2] The treaties, compacts, decrees, statutes, regulations, contracts and other legal documents and agreements applicable to the allocation, appropriation, development, exportation and management of the waters of the Colorado River Basin are often referred to as the "Law of the River" (Table 1.7-1). There is no single, universally agreed upon definition of the "Law of the River," but it is useful as a shorthand reference to describe this longstanding and complex body of legal agreements governing the Colorado River.

Five federal agencies are cooperating for purposes of assisting with environmental analysis and preparation of this Draft EIS. These cooperating agencies are the Bureau of Indian Affairs (BIA), the United States Fish and Wildlife Service (FWS), the National Park Service (NPS), Western Area Power Administration (Western), and the United States Section of the International Boundary and Water Commission (USIBWC).

The BIA has responsibility for the administration and management of lands held in trust by the United States for American Indians (Indian) and Indian tribes located within the Colorado River Basin (a list of these Indian tribes is provided in Chapter 6). Developing forestlands, leasing assets on these lands, directing agricultural programs, protecting water and land rights, developing and maintaining infrastructure and economic development are all part of the BIA's responsibility.

The FWS is involved in the conservation, protection and enhancement of fish, wildlife and plants and their habitats for the continuing benefit of the American people. FWS manages four National Wildlife Refuges along the Colorado River Basin. Among its many other key functions, the FWS administers and implements federal wildlife laws, protects endangered species, manages migratory birds, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, and assists foreign governments with international conservation efforts. It also oversees the federal aid program that distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state fish and wildlife agencies.

The NPS administers areas of national significance along the Colorado River, including Glen Canyon National Recreation Area (GCNRA), Grand Canyon National Park, and Lake Mead National Recreation Area (LMNRA). The NPS administers visitor use (including recreation), cultural and natural resources in these areas from offices at Page, Arizona, Grand Canyon National Park, Arizona, and Boulder City, Nevada, respectively. The NPS also grants and administers concessions for the operation of marinas and other recreation facilities at Lake Powell and Lake Mead, as well as concessions operations along the Colorado River between Glen Canyon Dam and Lake Mead.

Western markets and distributes hydroelectric power and related services within a 15-state region of the central and western United States and it is one of four power marketing administrations within the Department of Energy. Its role is to market and transmit electricity from multi-use water projects. Western markets and transmits power generated from the various hydropower plants located within the Colorado River Basin and operated by Reclamation. Western customers include municipalities, cooperatives, public utility and irrigation districts, federal and state agencies, investor-owned utilities (only one of which purchases firm power from Western), and Indian tribes located throughout the Colorado River Basin who, in turn, provide retail electric service to millions of consumers within the seven Colorado River Basin States (Section 1.7).

The USIBWC is the United States component of a bi-national organization responsible for administration of the provisions of the 1944 Treaty, which includes the Colorado River waters allotted to Mexico, protection of lands along the Colorado River from floods by levee and floodway construction projects, resolution of international boundary water sanitation and other water quality problems, and preservation of Colorado River as the international boundary. The International Boundary and Water Commission (IBWC) consist of the United States Section and the Mexican Section, which have their headquarters in the adjoining cities of El Paso, Texas and Ciudad Juarez, Chihuahua, respectively.

1.5 Scope of the EIS

In a May 2, 2005 letter to the Governors of the Basin States, issued to complete the 2005 AOP mid-year review, the Secretary directed Reclamation to develop additional strategies for improving coordinated management of the reservoirs of the Colorado River system. Pursuant to that direction, Reclamation conducted a public consultation workshop on May 26, 2005, in Henderson, Nevada; issued a *Federal Register* notice soliciting public comments on June 15, 2005; and conducted public meetings on July 26 and July 28, 2005, in Henderson, Nevada, and Salt Lake City, Utah, respectively. Reclamation received a broad range of public comments and suggestions from these discussions. Based in part on the comments received from the public, Reclamation determined that the appropriate level of NEPA documentation for the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions would be in the form of an EIS.

Consequently, on September 30, 2005, Reclamation published a Notice of Intent (NOI) (70 Fed. Reg. 57322) to prepare an EIS. The NOI described the proposed federal action as having two major elements: 1) adoption of specific Lower Basin shortage guidelines; and 2) developing coordinated reservoir management strategies to address operations of Lake Powell and Lake Mead under low reservoir conditions. The NOI also initiated a public process for determining the scope of specific shortage guidelines and coordinated reservoir management strategies and the issues and alternatives to be considered and analyzed in the preparation of the EIS.

Reclamation conducted public scoping meetings on November 1, 2, 3, and 8, 2005, in Salt Lake City, Utah; Denver, Colorado; Phoenix, Arizona; and Henderson, Nevada, respectively. Reclamation also consulted with representatives from the Basin States, Indian tribes, non-governmental organizations (NGO), and other interested parties. Reclamation provided a 62-day comment period consistent with the Public Notice issued on September 30, 2005. The public comment period ended on November 30, 2005.

On March 31, 2006, Reclamation published a Scoping Summary Report on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead and issued a Notice of Availability (NOA) (71 Fed. Reg. 16341). The report summarized the comments received and the issues raised through the scoping process and provided an assessment of the proposed scope of the environmental analysis to be included in the EIS.

A total of 1,153 written comment letters were received during the scoping process. The comment letters were submitted by a wide range of interested parties that included federal, state, and local agencies; Indian tribes; businesses; special interest groups; and individuals.

1.5.1 Affected Region and Interests

The geographic region that would be affected by the proposed federal action begins with Lake Powell and extends downstream along the Colorado River floodplain to the Southerly International Boundary (SIB) with Mexico. This proposed federal action would also potentially affect interests of organizations and individuals, whose geographic distribution extends beyond the Colorado River floodplain into water districts in the Lower Basin states (Section 1.7).

1.5.2 Relevant Issues

The results of the scoping process resulted in Reclamation considering the issues listed in Table 1.5-1. Those issues considered to be potentially significant are addressed in this Draft EIS. Those that were not considered potentially significant are not analyzed in this Draft EIS.

Table 1.5-1
Relevant Issues

Resource	Potentially Significant	Issue Areas
Physical		
Geology and soils	No	No potential for effect
Climate	No	No potential for effect
Minerals	No	No potential for effect
Visual	Yes	Calcium carbonate ring in reservoirs, attraction features, sediment deltas
Unique characteristics	Yes	Wilderness, wild and scenic rivers, park units
Water resources	Yes	Hydrology, water deliveries, groundwater, operations, water quality
Air quality	Yes	Fugitive dust and exposure of reservoir shoreline
Noise	No	No potential for effect
Biological Resource		
Aquatic resources	Yes	Foodbase, fish
Vegetation	Yes	Riparian, wetlands, weeds
Wildlife	Yes	Amphibians, reptiles, raptors, mammals, waterfowl
Special-status species	Yes	Threatened and endangered species, state and tribal sensitive
Socioeconomic		
Environmental justice	Yes	Disproportionate effects on minority and low income populations
Land use	Yes	Relationship to local and state planning documents; agriculture, fallowing, prime farmland
Cultural resources	Yes	Historic properties
Indian Trust Assets	Yes	Water delivery, trust lands
Energy and hydropower	Yes	Economic analysis and capacity
Population and housing	No	No potential for effect
Recreation	Yes	Marinas, boating, fishing, camping
Transportation, traffic	Yes	Ferries in Lake Powell, Lake Mohave
Water rights	No	No potential for effect

1.6 Summary of Contents of this Draft EIS

Following is a brief description of the topics presented in the two volumes that comprise this Draft EIS.

Volume I of this Draft EIS (this volume) describes the proposed federal action, the alternatives considered, and the analysis of their potential effects on Colorado River operation and associated resources, and environmental commitments associated with the alternatives. The contents of the chapters in this volume are as follows:

- **Chapter 1, Purpose and Need,** includes the following: identification of the purpose of and need for the Lower Basin shortage guidelines and coordinated reservoir management strategies of Lake Powell and Lake Mead being considered in the proposed federal action; background information concerning the apportionment of Colorado River water and the physical facilities associated with the Colorado River Basin; and, discussion of the institutional framework within which the Colorado River Basin is managed. Chapter 1 also discusses previous and ongoing actions that have a relationship to the proposed federal action.

- **Chapter 2, Description of Alternatives,** describes the process of formulating alternatives and presents a range of reservoir operation strategies and guidelines considered under each alternative. A summary table of potential environmental consequences of these alternatives is provided at the end of Chapter 2.

- **Chapter 3, Affected Environment,** describes the affected environment for the proposed federal action.

- **Chapter 4, Environmental Consequences,** presents evaluations of potential impacts that could result from implementation of the alternatives under consideration. The discussion also addresses environmental consequences, i.e., potential effects of the alternatives that could occur as compared to baseline projections.

- **Chapter 5, Other Considerations and Cumulative Impacts,** discusses cumulative impacts, the relationship between short-term uses and long-term productivity, and irreversible and irretrievable commitments of resources affected by the reservoir operation strategies and guidelines under consideration.

- **Chapter 6, Consultation and Coordination,** describes the public involvement process, including public notices, scoping meetings, and hearings. This chapter also describes the coordination with federal and state agencies, Indian tribes, and Mexico (through the IBWC) during the preparation of this document and any permitting or approvals that may be necessary for implementation of the proposed federal action.

In addition to the above, Volume I includes a list of acronyms used throughout this document, a glossary of commonly used terms, a list of references cited in the Draft EIS, a list of persons contributing to the preparation of the Draft EIS, a distribution list of agencies, organizations and persons receiving copies of the document, and an index.

Volume II contains appendices which are comprised of documents and other supporting material that provide detailed historical background and/or technical information concerning the proposed federal action.

1.7 Water Supply Management and Allocation

This section summarizes the water supply available in the Colorado River Basin from natural runoff, its distribution under the Law of the River, and the reservoirs and diversion facilities through which the water supply is administered from mainstream Colorado River reservoirs and associated facilities.

1.7.1 Colorado River System Water Supply

The Colorado River Basin is located in the southwestern United States, as shown on Figure 1.7-1, and occupies an area of approximately 250,000 square miles. The Colorado River is approximately 1,400 miles in length and originates along the Continental Divide in Rocky Mountain National Park in Colorado. Elevations in the Colorado River Basin range from sea level to over 14,000 feet mean sea level (msl) in the mountainous headwaters.

Climate varies significantly throughout the Colorado River Basin. Most of the Colorado River Basin is arid and semi-arid, and generally receives less than 10 inches of precipitation per year. In contrast, many of the mountainous areas that rim the northern portion of the Colorado River Basin receive, on average, over 40 inches of precipitation per year.

Most of the total annual flow in the Colorado River Basin is a result of natural runoff from mountain snowmelt. Because of this, natural flow is very high in the late spring and early summer, diminishing rapidly by mid-summer. While flows in late summer through autumn sometimes increase following rain events, natural flow in the late summer through winter is generally low. Major tributaries to the Colorado River include the Green, San Juan, Yampa, Gunnison and Gila Rivers.

The annual flow of the Colorado River and its tributaries varies considerably from year to year. The natural flow at the Lees Ferry Gaging Station in Arizona (Figure 1.7-2) located 15.9 river miles (RMs) below Glen Canyon Dam, has varied annually from 5 maf to 23 maf. Natural flow represents an estimate of flows that would exist without human intervention.

The average annual natural flow at Lees Ferry Gaging Station is approximately 15.1 maf. In the Lower Basin, the average annual natural flow from the Little Colorado, Virgin, and Bill Williams Rivers is approximately 1.4 maf.

Figure 1.7-1
The Colorado River Basin

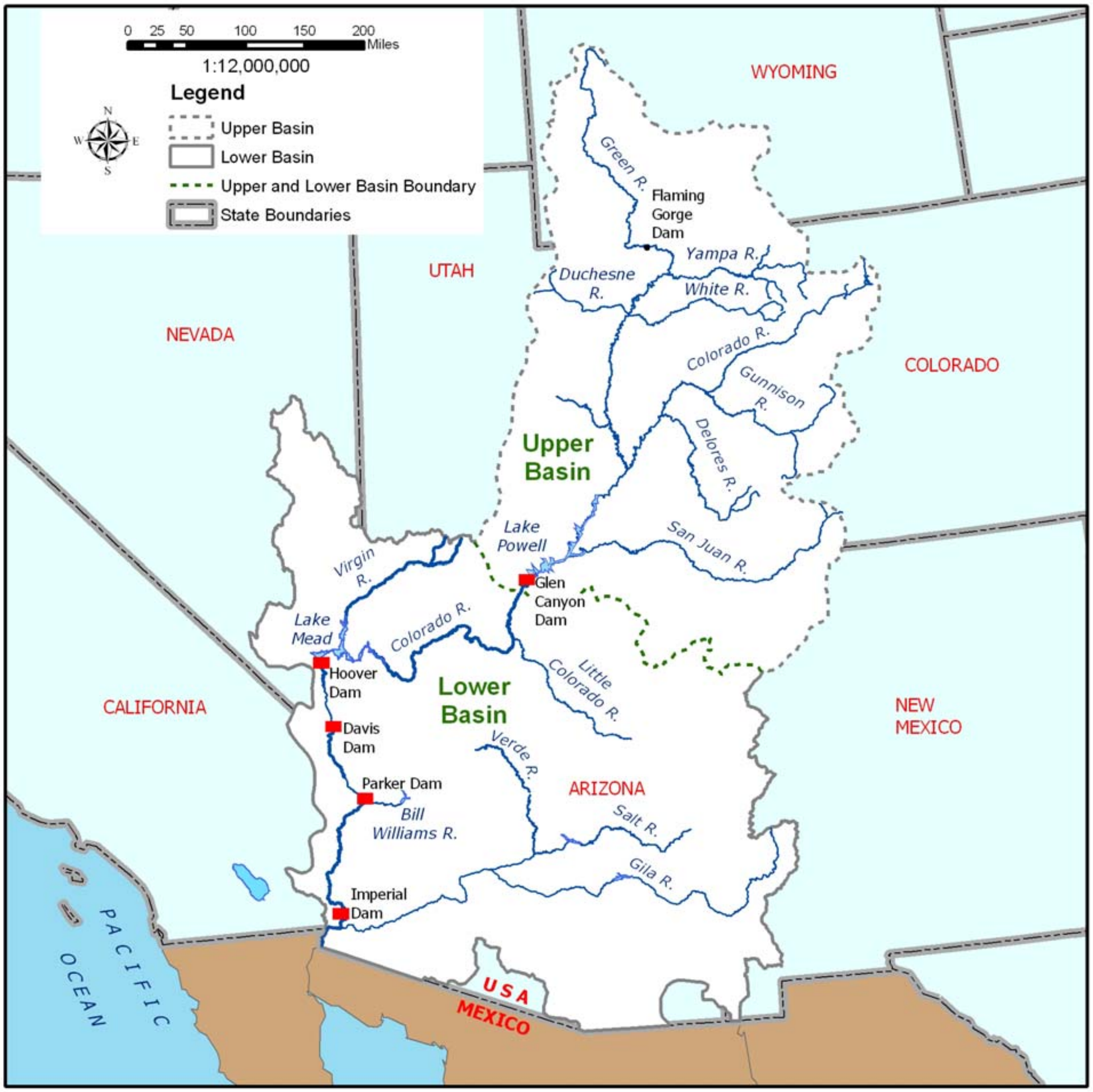

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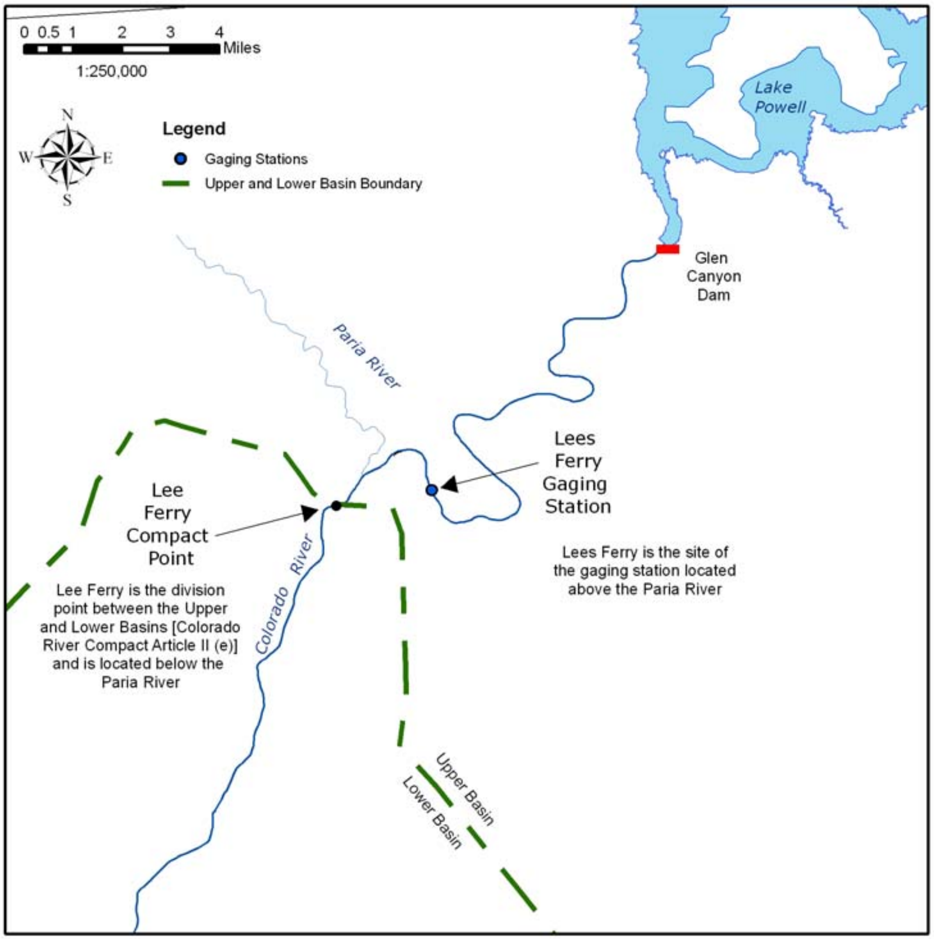
Figure 1.7-2
Lees Ferry Gaging Station



1.7.2 Apportionment of Water Supply

This section summarizes the Colorado River apportionments of the Basin States and the allotment to Mexico pursuant to the Law of the River, past and current diversions, and consumptive use and projected future depletions. The apportionments of the Basin States are generally presented in terms of consumptive use, which consists of diversions minus return flows.

1.7.2.1 The Law of the River

The Secretary is vested with the responsibility to manage the mainstream waters of the Lower Basin pursuant to applicable federal law. The responsibility is carried out consistent with a body of documents referred to as the Law of the River. The Law of the River comprises numerous operating criteria, regulations, and administrative decisions included in federal and state statutes, interstate compacts, court decisions and decrees, an international treaty, and contracts with the Secretary.

Particularly notable among these documents are:

1) The Colorado River Compact of 1922 (Compact), which apportioned beneficial consumptive use of water between the Upper Basin and Lower Basin;

2) The Boulder Canyon Project Act of 1928 (BCPA), which authorized construction of Hoover Dam and the All-American Canal (AAC), required that water users in the Lower Basin have a contract with the Secretary, and established the responsibilities of the Secretary to direct, manage and coordinate the operation of Colorado River dams and related works in the Lower Basin;

3) The California Seven Party Water Agreement of 1931, which, through regulations adopted by the Secretary, established the relative priorities of rights among major users of Colorado River water in California;

4) The 1944 Treaty (and subsequent minutes of the IBWC) related to the quantity and quality of Colorado River water delivered to Mexico;

5) The Upper Colorado River Basin Compact of 1948, which apportioned the Upper Basin water supply among the Upper Basin states;

6) The Colorado River Storage Project Act of 1956 (CRSPA), which authorized a comprehensive water development plan for the Upper Basin that included the construction of Glen Canyon Dam and other facilities;

7) The 1963 United States Supreme Court Decision in *Arizona v. California* which confirmed that the apportionment of the Lower Basin tributaries was reserved for the exclusive use of the states in which the tributaries are located; confirmed the Lower Basin mainstream apportionments of 4.4 maf for use in California, 2.8 maf for use in Arizona and 0.3 maf for use in Nevada; provided water for Indian reservations and other federal reservations in California, Arizona and Nevada; and confirmed the significant role of the Secretary in managing the mainstream Colorado River within the Lower Basin;

8) The 1964 United States Supreme Court Decree in *Arizona v. California* which implemented the Court's 1963 decision; the Decree was supplemented over time after its adoption and the Supreme Court entered a Consolidated Decree in 2006 which incorporates all applicable provisions of the earlier-issued Decrees;

9) The Colorado River Basin Project Act of 1968 (CRBPA), which authorized construction of a number of water development projects including the Central Arizona Project (CAP) and required the Secretary to develop the LROC and issue an AOP for mainstream reservoirs;

10) The Colorado River Basin Salinity Control Act of 1974, which authorized a number of salinity control projects and provided a framework to improve and meet salinity standards for the Colorado River in the United States and Mexico; and

11) The Grand Canyon Protection Act of 1992, which addressed the protection of resources in Grand Canyon National Park and in GCNRA, consistent with applicable federal law.

Documents which are generally considered as part of the Law of the River include, but are not limited to, those listed in Table 1.7-1. Among other provisions of applicable federal law, NEPA and the Endangered Species Act of 1973 (ESA), as amended, provide a statutory overlay on certain actions taken by the Secretary. For example, as noted in Section 1.1, preparation of this Draft EIS has been undertaken pursuant to NEPA.

Table 1.7-1
Selected Documents Included in the "Law of the River"

- The River and Harbor Act of March 3, 1899
- The Reclamation Act of June 17, 1902
- Reclamation of Indian Lands in Yuma, Colorado River and Pyramid Lake Indian Reservations Act of April 21, 1904
- Yuma Project authorized by the Secretary of the Interior on May 10, 1904, pursuant to Section 4 of the Reclamation Act of June 17, 1902
- Warren Act of February 21, 1910
- Protection of Property Along the Colorado River Act of June 25, 1910
- Patents and Water-Right Certificates Acts of August 9, 1912 and August 26, 1912
- Yuma Auxiliary Project Act of January 25, 1917
- Availability of Money for Yuma Auxiliary Project Act of February 11, 1918
- Sale of Water for Miscellaneous Purposes Act of February 25, 1920
- Federal Power Act of June 10, 1920
- The Colorado River Compact of November 24, 1922
- The Colorado River Front Work and Levee System Acts of March 3, 1925 and January 21,1927-June 28, 1946
- The Boulder Canyon Project Act of December 21, 1928
- The California Limitation Act of March 4, 1929
- The California Seven Party Agreement of August 18, 1931
- The Parker and Grand Coulee Dams Authorization of August 30, 1935
- The Parker Dam Power Project Appropriation Act of May 2, 1939
- The Reclamation Project Act of August 4, 1939
- The Boulder Canyon Project Adjustment Act of July 19, 1940
- The Flood Control Act of December 22, 1944
- Treaty between the United States and Mexico Relating to the Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande of February 3, 1944
- The Colorado River Storage Project Act of April 11, 1956
- Water Supply Act of July 3, 1958
- Boulder City Act of September 2, 1958
- Report of the Special Master, Simon H. Rifkind, *Arizona v. California*, et. al., December 5, 1960
- The Consolidated Decree entered by the United States Supreme Court in the case of *Arizona v. California*, 547 U.S. __ (2006) (Consolidated Decree)
- International Flood Control Measures, Lower Colorado River Act of August 10, 1964
- Southern Nevada (Robert B. Griffith) Water Project Act of October 22, 1965
- The Colorado River Basin Project Act of September 30, 1968
- Criteria for the Coordinated Long Range Operation of Colorado River Reservoirs, June 8, 1970
- Supplemental Irrigation Facilities, Yuma Division Act of September 25, 1970
- 43 C.F.R. pt. 417 Lower Basin Water Conservation Measures, September 7, 1972
- Minute 218, March 22, 1965; Minute 241, July 14, 1972, (replaced 218); and Minute 242, August 30, 1973, (replaced 241) of the IBWC
- The Colorado River Basin Salinity Control Act of June 24, 1974
- Hoover Power Plant Act of August 17, 1984
- The Numerous Colorado River Water Delivery and Project Repayment Contracts with the States of Arizona and Nevada, cities, water districts and individuals
- Hoover and Parker-Davis Power Marketing Contracts
- Reclamation States Emergency Drought Relief Act of 1991
- Grand Canyon Protection Act of October 30, 1992
- Operation of Glen Canyon Dam, Record of Decision (1996)
- Interim Surplus Guidelines Record of Decision, January 17, 2001 (66 Fed. Reg. 7772).

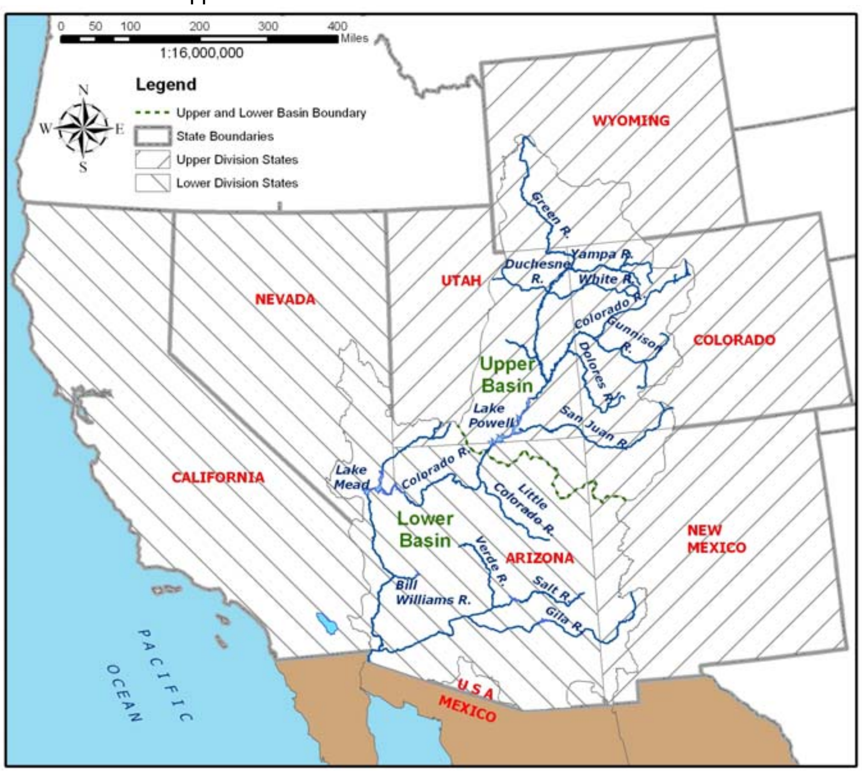
Table 1.7-1
Selected Documents Included in the "Law of the River"

▪ Gila Project Act of July 30, 1947 ▪ The Upper Colorado River Basin Compact of October 11, 1948 ▪ Consolidated Parker Dam Power Project and Davis Dam Project Act of May 28, 1954 ▪ Palo Verde Diversion Dam Act of August 31, 1954 ▪ Change Boundaries, Yuma Auxiliary Project Act of February 15, 1956	▪ Interim 602(a) Storage Guideline, May 19, 2004 (69 Fed. Reg. 28945) ▪ Colorado River Water Delivery Agreement of October 10, 2003 (69 Fed. Reg. 12202)

1.7.2.2 Apportionment Provisions

The initial apportionment of water from the Colorado River was determined as part of the Compact, which divided the Colorado River system into two sub-basins, the Upper Basin and the Lower Basin (Figure 1.7-1). The Upper Basin includes those parts of the states of Colorado, Utah, Wyoming, Arizona and New Mexico within and from which waters drain naturally into the Colorado River above Lee Ferry, Arizona. The Lower Basin includes those parts of the states of Arizona, California, Nevada, New Mexico and Utah within and from which waters naturally drain into the Colorado River system below Lee Ferry Compact Point. The Compact also divided the seven Basin States into the Upper Division and the Lower Division states (Figure 1.7-3). The Upper Division states are Wyoming, Utah, Colorado and New Mexico. The Lower Division states are Arizona, California, and Nevada.

Figure 1.7-3
Upper and Lower Division States of the Colorado River



The Compact apportioned to the Lower Basin states and the Upper Basin states, in perpetuity, the exclusive beneficial consumptive use of 7.5 maf of water per year (mafy). In addition to this apportionment, Article III(b) of the Compact gives the Lower Basin states the right to increase their beneficial consumptive use by 1.0 mafy. The Compact also stipulates in Article III(d) that the Upper Division states will not cause the flow of the river at Lee Ferry Compact Point to be depleted below an aggregate of 75 maf for any period of 10 consecutive years.

The Compact, in Article VII, states that nothing in the Compact shall be construed as affecting the obligations of the United States to Indian tribes. While the rights of most Indian tribes to Colorado River water were subsequently adjudicated, some Tribal rights remain unadjudicated. To the extent that Indian tribes consumptively use water from the Colorado River, such uses are charged against the apportionment of the relevant Colorado River Basin state.

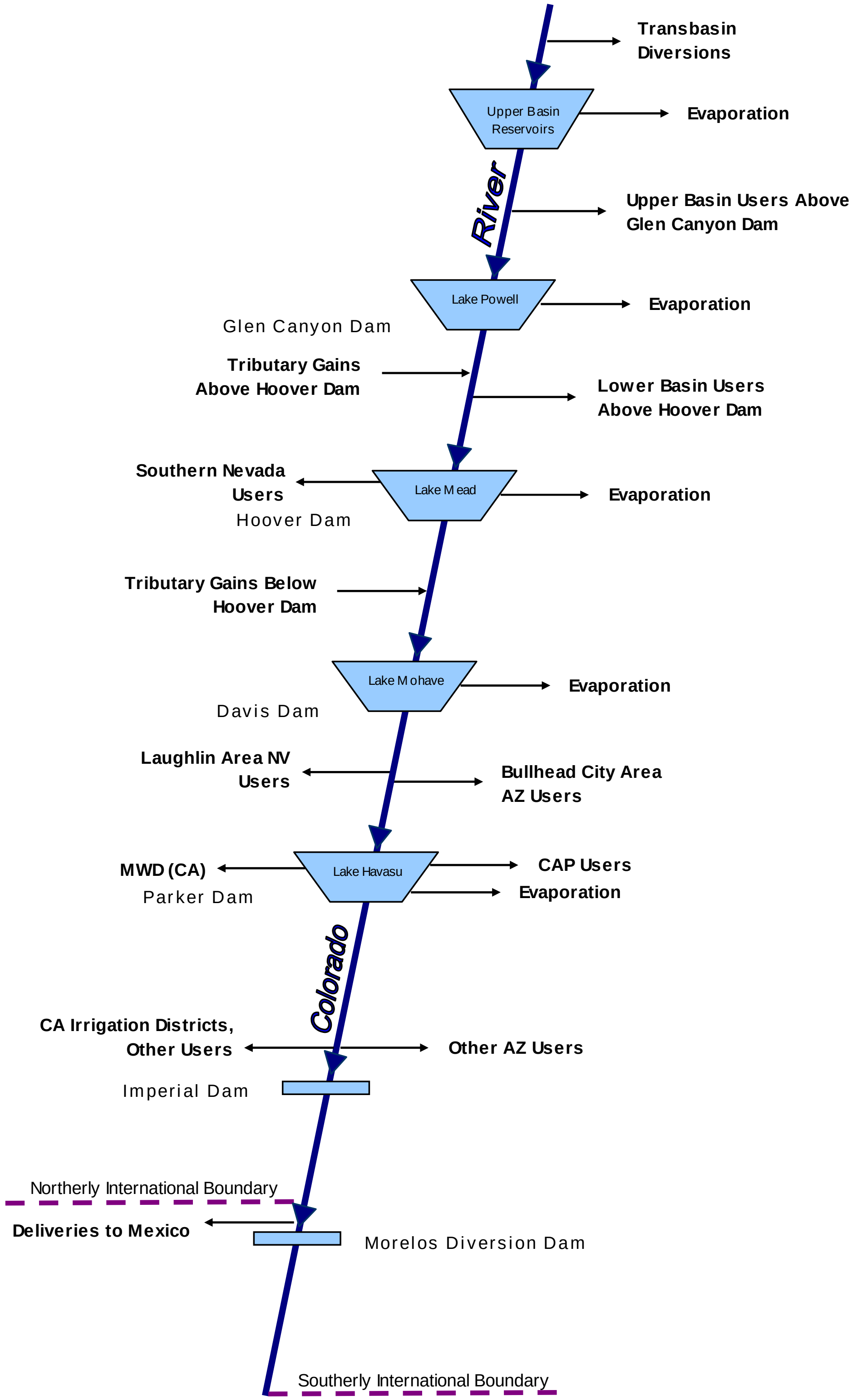
Upper Division State Apportionments. Upper Division state apportionments were established by the Upper Colorado River Basin Compact of 1948. These apportionments allocate the Upper Basin states consumptive use after deduction of up to 50,000 acre-feet per year (afy) for Arizona as follows: Wyoming, 14.00 percent; Utah, 23.00 percent; Colorado, 51.75 percent; and New Mexico, 11.25 percent. The Upper Basin state apportionments have not yet been fully developed.

Lower Division State Apportionments. Lower Division state apportionments were established by Congress in the BCPA. These apportionments are: California, 4.4 maf; Arizona, 2.8 maf; and Nevada, 0.3 maf, totaling 7.5 maf, subject to annual increases or reductions pursuant to Secretarial determinations of Shortage or Surplus conditions.

Figure 1.7-4 presents a schematic of the operation of the Colorado River, primarily in the Lower Basin. The Consolidated Decree confirms the apportionments to the Lower Division states established by the BCPA and guides the Secretary's operation of facilities, including Hoover Dam, on the lower Colorado River. If water apportioned for use in a Lower Division state is not consumed by that state in any year, the Secretary may release the unused water for use in another Lower Division state. Consumptive use by a Lower Division state includes delivered water that is stored off-stream for future use by that state or another state.

All mainstream Colorado River waters apportioned to the Lower Basin, except for a few thousand acre-feet (af) apportioned for use in Arizona, have been fully allocated to specific entities and, except for certain federal establishments, placed under permanent water delivery contracts with the Secretary for irrigation or domestic use. These entities include irrigation districts, water districts, municipalities, Indian tribes, public institutions, private water companies, and individuals. Federal establishments with federal reserved rights established pursuant to Article II(D) of the Consolidated Decree are not required to have a contract with the Secretary, but the water allocated to a federal establishment is included within the apportionment of the Lower Division state in which the federal establishment is located; e.g., Fort Mojave Indian Reservation in California and the Havasu National Wildlife Refuge in Arizona.

Figure 1.7-4
Colorado River Reservoirs and Diversions



The highest priority lower Colorado River water rights are present perfected rights (PPRs), which the Consolidated Decree defines as those perfected rights existing on June 25, 1929, the effective date of the BCPA. The Consolidated Decree also recognizes federal Indian reserved rights for the quantity of water necessary to irrigate all the practicably irrigable acreage (lands considered suitable for irrigation) on five Indian reservations along the lower Colorado River. The Consolidated Decree defines the rights of Indian and other federal reservations to be federal establishment PPRs. PPRs are important because in any year in which less than 7.5 maf of Colorado River water is available for consumptive use in the Lower Division states, PPRs will be satisfied first, in the order of their priority without regard to state lines.

Waters available to a Lower Division state within its apportionment, but having a priority date later than June 25, 1929, have been allocated by the Secretary through execution of water delivery contracts to water users within that state as required by Section 5 of the BCPA.

Allocation of Colorado River water to Mexico is governed by the 1944 Treaty. Article 10(a) of the 1944 Treaty states:

> "(a) A guaranteed annual quantity of 1,500,000 acre-feet (1,850,234,000 cubic meters) to be delivered in accordance with the provisions of Article 15 of this Treaty"

Further, Article 10(b) of the 1944 Treaty provides:

> "(b) Any other quantities arriving at the Mexican points of diversion, with the understanding that in any year in which, as determined by the United States Section, there exists a surplus of waters of the Colorado River in excess of the amount necessary to supply uses in the United States and the guaranteed quantity of 1,500,000 acre-feet (1,850,234,000 cubic meters) annually to Mexico, the United States undertakes to deliver to Mexico, in the manner set out in Article 15 of this Treaty, additional waters of the Colorado River system to provide a total quantity not to exceed 1,700,000 acre-feet (2,096,931,000 cubic meters) a year. Mexico shall acquire no right beyond that provided by this subparagraph by the use of the waters of the Colorado River system, for any purpose whatsoever, in excess of 1,500,000 acre-feet (1,850,234,000 cubic meters) annually.

Additionally, Article 10 of the 1944 Treaty provides:

> "In the event of extraordinary drought or serious accident to the irrigation system in the United States, thereby making it difficult for the United States to deliver the guaranteed quantity of 1,500,000 acre-feet (1,850,234,000 cubic meters) a year, the water allotted to Mexico under subparagraph (a) of this Article will be reduced in the same proportion as consumptive uses in the United States are reduced."

The proposed federal action is for the purpose of adopting additional operational guidelines to improve the Department's annual management and operation of key Colorado River reservoirs for an interim period through 2026. However, in order to assess the potential effects of the proposed federal action in this Draft EIS, certain modeling assumptions (discussed in Chapter 2) are used that display projected water deliveries to Mexico. Reclamation's modeling assumptions are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico.

The United States will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Treaty with Mexico through the IBWC in consultation with the Department of State.

1.7.3 System Reservoirs and Diversion Facilities

The Colorado River system contains numerous reservoirs that provide an aggregate of approximately 60 maf of storage (or roughly the same amount of four years of average flow of the Colorado River). Of these reservoirs, Lake Powell and Lake Mead provide approximately 85 percent of this storage. Lake Powell provides 24.3 maf of this storage.

The Lower Basin dams and reservoirs include Hoover Dam, Davis Dam and Parker Dam (Figure 1.7-5). Hoover Dam created Lake Mead and can store up to 26.2 maf. Davis Dam was constructed by Reclamation to re-regulate Hoover Dam's releases and to aid in the annual delivery of 1.5 maf to Mexico. Davis Dam created Lake Mohave and provides 1.8 maf of storage. Parker Dam forms Lake Havasu (0.65 maf of storage) from which water is pumped by both Metropolitan Water District of Southern California (MWD) and the CAP. Parker Dam re-regulates releases from Davis Dam and from the United States Army Corps of Engineers' (USACE) Alamo Dam on the Bill Williams River, and in turn releases water for downstream use in the United States and Mexico. Other Lower Basin mainstream reservoirs, shown on Figure 1.7-5, are operated primarily for the purpose of river flow regulation to facilitate diversion of water to Arizona, California and Mexico. Diversion facilities of the Lower Division states typically serve multiple entities.

There are several points of diversion in Arizona. Arizona can use up to 50,000 afy of water under its Upper Basin apportionment. In the Lower Basin, the largest diversion for Arizona is the CAP pumping plant on Lake Havasu below the confluence of the Bill Williams River. Irrigation water for the Fort Mojave Indian Reservation, near Needles, California, is pumped from wells. Irrigation water for the Colorado River Indian Reservation near Parker, Arizona, is diverted at Headgate Rock Dam, which was constructed for that purpose. A river pumping plant in the Cibola area provides water to irrigate lands adjacent to the river. The last major diversion for Arizona occurs at Imperial Dam, where water is diverted into the Gila Gravity Main Canal for irrigation for the Gila and Wellton-Mohawk projects and into the AAC for subsequent release into the Yuma Main Canal for the Yuma Project and the City of Yuma.

California receives most of its Colorado River water at three diversion points: MWD's pumping plant on Lake Havasu; the Palo Verde Irrigation and Drainage District's diversion at the Palo Verde Diversion Dam near Blythe, California; and the AAC diversion at Imperial Dam (Figure 1.7-5).

In Nevada, the state's consumptive use apportionment of Colorado River water is used almost exclusively for municipal and industrial (M&I) purposes. About 90 percent of this water is diverted from Lake Mead at a point approximately five miles northwest of Hoover Dam at Saddle Island by the Southern Nevada Water Authority (SNWA) facilities. The remainder of Nevada's diversion occurs below Davis Dam in the Laughlin, Nevada area and on the Fort Mojave Indian Reservation.

1.7.4 Flood Control Operation

Under the BCPA, flood control is specified as the project purpose having first priority for the operation of Hoover Dam. Subsequently, Section 7 of the Flood Control Act of 1944 established that the Secretary of War (now the U.S. Army Corps of Engineers [USACE]) will prescribe regulations for flood control for projects authorized wholly or partially for such purposes.

The Los Angeles District of the USACE published the current flood control regulations in its Water Control Manual for Flood Control, Hoover Dam and Lake Mead, Colorado River, Nevada and Arizona (Water Control Manual) dated December 1982. The Field Working Agreement between the USACE and Reclamation for the flood control operation of Hoover Dam and Lake Mead, as prescribed by the Water Control Manual, was signed on February 8, 1984. The flood control plan is the result of a coordinated effort between the USACE and Reclamation; however, the USACE is responsible for providing the flood control regulations and has authority for final approval. The Secretary is responsible for operating Hoover Dam in accordance with these regulations. Deviation from the flood control operating criteria must be authorized by the USACE.

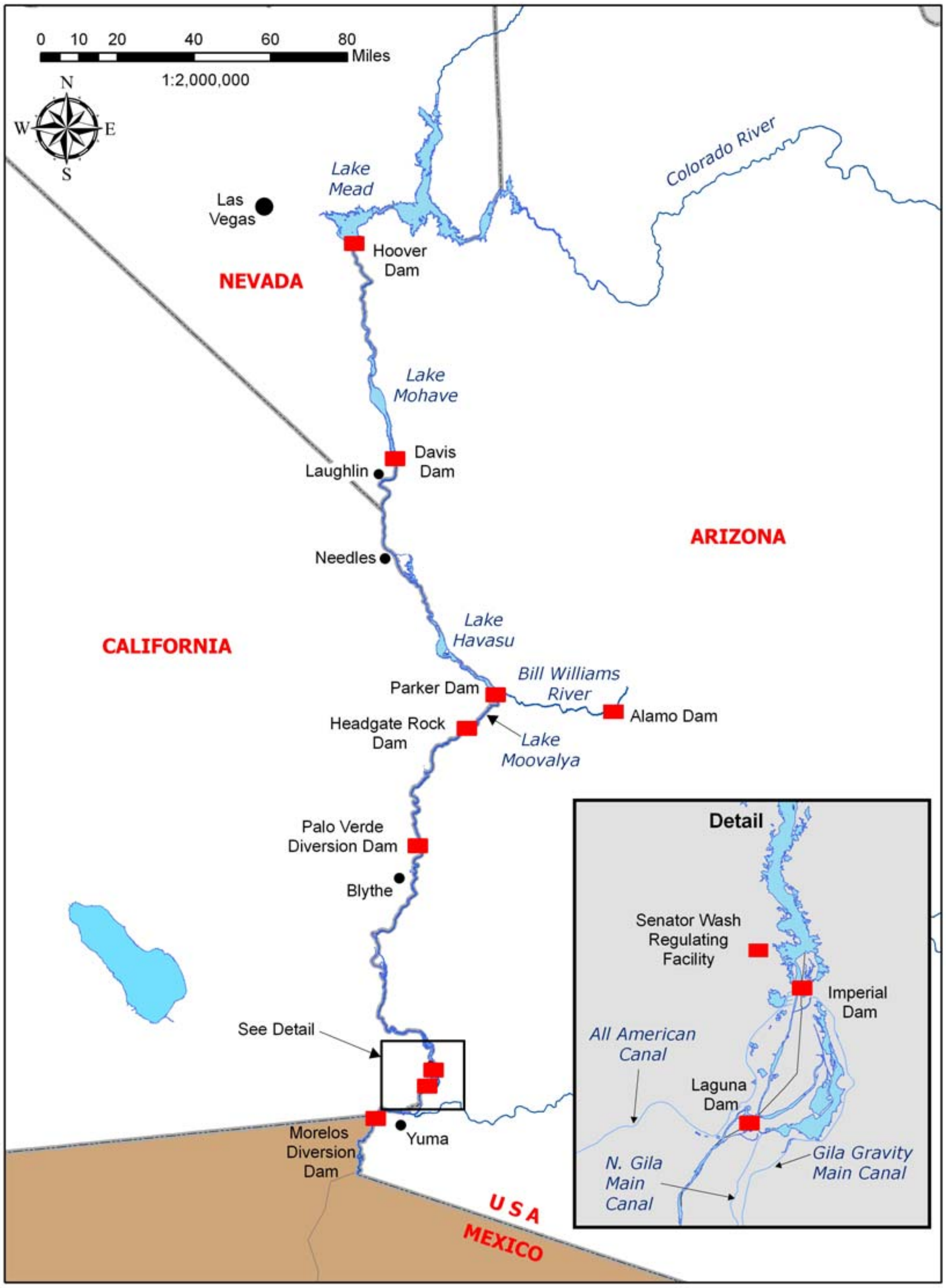
1.7.5 Hydropower Generation

Reclamation is authorized by legislation to produce electric power at Glen Canyon Dam, Hoover Dam, Davis Dam, Parker Dam, and other smaller facilities. While Reclamation is the federal agency authorized to produce power at the major Colorado River system dams, Western is the federal agency authorized to market and deliver this power. Western enters into electric service contracts on behalf of the United States with public and private utility systems for distribution of hydroelectric power produced at Reclamation facilities in excess of project demand.

1.7.6 Annual Operating Plan and Long Range Operating Criteria

The CRBPA required the Secretary to adopt operating criteria for the Colorado River by January 1, 1970. The LROC, adopted in 1970 address operation of the Colorado River reservoirs in compliance with requirements set forth in the Compact, the CRSPA, the BCPA, the 1944 Treaty and other applicable federal laws. Section 602 of the CRBPA, as amended, provides that the LROC can only be modified after correspondence with the governors of the Basin States and appropriate consultation with such state representatives as each governor may designate. The LROC call for formal reviews at least every five years. The reviews are conducted as a public involvement process and are attended by representatives of federal agencies, the seven Basin States, Indian tribes, the general public including representatives of the academic and scientific communities, environmental organizations, the recreation industry, and contractors for the purchase of federal power produced at federal hydropower plants in the Colorado River basin.

Figure 1.7-5
Lower Basin Dams and Reservoirs



Under the applicable provisions of the CRBPA, the Secretary makes annual determinations in the AOP regarding the availability of Colorado River water for deliveries to the Lower Division states. A requirement to equalize storage between Lake Powell and Lake Mead when there is sufficient storage in the Upper Basin is also included in the LROC, as required by the CRBPA. Equalization releases are made if: 1) the end of the water year storage forecast for Lake Powell is greater than that of Lake Mead; and 2) the storage forecast for the end of the water year in the Upper Basin reservoirs is greater than the quantity of storage required by Section 602(a) of the CRBPA (602(a) storage) for that same date.

The 602(a) storage quantity is the storage in the Upper Basin necessary to assure Lower Basin delivery obligations without impairing consumptive use requirements in the Upper Basin. The LROC offers factors to be considered to determine 602(a) storage, but does not present a set formula. The factors to be considered include the historic stream flows, the most critical period of record, probability of available waters, and estimated future depletions in the Upper Basin.

In 2004, Reclamation adopted an interim 602(a) storage guideline, in effect through 2016, which establishes that Lake Powell's elevation must be above 3,630 feet msl (which corresponds to storage of approximately 14.85 maf) for equalization releases to occur (Reclamation 2004b). In the event that the elevation of Lake Powell is below the 602(a) storage guideline, and equalization is not required, the LROC provide that "the objective shall be to maintain a minimum release of water from Lake Powell of 8.23 million acre-feet for that year."

In the AOP, the Secretary is required to determine when Normal, Surplus, or Shortage conditions occur in the lower Colorado River, based on various factors including storage and hydrologic conditions in the Colorado River Basin.

1.7.6.1 Normal Water Supply Condition Determinations

Normal conditions exist when the Secretary determines that sufficient mainstream water is available to satisfy 7.5 maf of annual consumptive use in the Lower Division states. If a state will not use all of its apportioned water for the year, the Secretary may allow other states of the Lower Division to use the unused apportionment, provided that the use is authorized by a water delivery contract with the Secretary.

1.7.6.2 Surplus Water Supply Condition Determinations

Surplus conditions exist when the Secretary determines that sufficient mainstream water is available for release to satisfy consumptive use in the Lower Division states in excess of 7.5 maf annually. This excess consumptive use is surplus and is distributed for use in Arizona, California, and Nevada pursuant to the terms and conditions provided in the ISG, adopted in 2001. The current provisions of the ISG are scheduled to terminate in 2016.

In general terms, the ISG link the availability of surplus water to the elevation of Lake Mead. When Lake Mead is full and Reclamation is making flood control releases, surplus supplies are unlimited. As Lake Mead's elevation drops, surplus water amounts are reduced, and ultimately eliminated. Surplus availability is also linked to continued progress by California to take actions to reduce its historic reliance on water in excess of its 4.4 mafy apportionment.

If a state does not use all of its apportioned water for the year, the Secretary may allow other states of the Lower Division to use the unused apportionment, provided that the use is authorized by a water delivery contract with the Secretary.

1.7.6.3 Shortage Water Supply Condition Determinations

Shortage conditions exist when the Secretary determines that insufficient mainstream water is available to satisfy 7.5 maf of annual consumptive use in the Lower Division states. To date, the Secretary has never made such a determination. When making a shortage determination, the Secretary must consult with various parties as set forth in the Consolidated Decree and consider all relevant factors as specified in the LROC, including 1944 Treaty obligations, the priorities set forth in the Consolidated Decree, and the reasonable consumptive use requirements of mainstream water users in the Lower Division states.

Pursuant to the Consolidated Decree, the Secretary is required to first provide for the satisfaction of the PPRs in the order of their priorities without regard to state lines. Pursuant to the CRBPA, water contract holders in Arizona with contracts dated September 30, 1968 (when the CAP was authorized) or later, have a lower priority than California's 4.4 maf apportionment. Beyond these two requirements, the Department does not have detailed guidelines in place that define the circumstances under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead, i.e., when water supplies would be reduced, by how much, or who would experience specified reductions.

In the absence of specific shortage criteria, a shortage determination would most likely be made on an annual basis through the AOP process. This is a process by which the interests of the different stakeholders are addressed through consultation. Water users who rely on the Colorado River in the Lower Division states are not currently able to identify particular reservoir conditions under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead, nor are these water users able to identify the frequency or magnitude of any potential future annual reductions in their water deliveries.

1.8 Related Actions

The alternatives considered in this Draft EIS address operation and storage of water in Lake Powell and Lake Mead. While there are many actions related to the operation of the Colorado River with respect to the proposed federal action analyzed in this Draft EIS, Reclamation has identified five primary documents that are related to, or would assist the reader in understanding the issues analyzed in this process:

- Operation of Glen Canyon Dam - Final EIS (1995) and Record of Decision (ROD) (1996);
- Off-stream Storage of Colorado River Water and Development and Release of Intentionally Created Unused Apportionment in the Lower Division States– 43 C.F.R. pt. 414 (1999);
- Interim Surplus Criteria - Final EIS (2000) and ROD - Colorado River Interim Surplus Guidelines (2001);
- Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions - Final EIS (2002) and ROD - Colorado River Water Delivery Agreement (2003); and
- Lower Colorado River Multi-Species Conservation Program (LCR MSCP) - Final Programmatic EIS/Environmental Impact Report and ROD - Lower Colorado River Multi-Species Conservation Plan (2005).

Chapter 5 of this Draft EIS provides an extensive review of these and other related actions that may have a cumulative impact on the resources affected by the alternatives presented herein.

The efforts documented in the references listed above are summarized below.

1.8.1 Operation of Glen Canyon Dam - Final EIS and ROD

The 1995 Operation of Glen Canyon Dam Final EIS was prepared in response to the 1992 Grand Canyon Protection Act, and analyzed alternative operation scenarios that met statutory responsibilities for protecting downstream resources and achieving other authorized purposes. The 1996 Glen Canyon Dam ROD describes detailed criteria and operating plans for dam operations and includes other management actions to accomplish this objective; among these are the Glen Canyon Dam Adaptive Management Program (AMP) of scientific monitoring and experimentation, beach/habitat-building flows (BHBF), and further study of temperature control.

The AMP provides a process for assessing the effects of Glen Canyon Dam operations on downstream resources and project benefits. The results of that assessment are used to develop recommendations for modifying Glen Canyon Dam operations and other resource management actions. This is accomplished through the Adaptive Management Work Group (AMWG), a federal advisory committee. The AMWG consists of stakeholders that include federal and state agencies, representatives of the seven Basin States, Indian tribes, hydroelectric power customers, environmental and conservation organizations, and recreational and other interest groups.

The BHBF releases are scheduled high releases of short duration that are in excess of power plant capacity in accordance with hydrologic triggering criteria. These BHBFs are designed to rebuild high elevation sandbars, deposit nutrients, restore backwater channels, and provide some of the dynamics of a natural system. The first test of a BHBF was conducted in spring of 1996, and a subsequent test of a BHBF was conducted in November 2004.

Evaluating the feasibility of increasing the temperature of water released from Glen Canyon Dam was a common element in the Glen Canyon Dam EIS and one of the elements of the reasonable and prudent alternative in the Biological Opinion (BO) of that document. In 1999, Reclamation issued an environmental assessment regarding potential modification of Glen Canyon Dam to construct a selective withdrawal structure, and has subsequently continued to investigate various structural designs. Reclamation has initiated a NEPA process that, among other elements, will consider construction of a selective withdrawal structure as part of a long-term experimental plan.

1.8.2 Off-stream Storage of Colorado River Water and Development and Release of Intentionally Created Unused Apportionment in the Lower Division States

In 1999, the Department adopted a rule to facilitate off-stream storage of Colorado River water and development and release of “Intentionally Created Unused Apportionment” (ICUA) for the Lower Division states. Reclamation prepared an Environmental Assessment (EA) to assess the environmental impacts of the rule, and a Finding of No Significant Impact (FONSI) was issued on October 1, 1999. The final rule was published in the Federal Register on November 1, 1999 and is codified at 43 C.F.R. pt. 414.

This rule establishes a procedural framework within the Lower Basin states for an authorized entity in one state to enter into storage agreements with authorized entities in another state for the off-stream storage (and future recovery) of Colorado River water. Under the agreements, the storing state will use water it stores under an interstate agreement and, in return, at a future date, decrease its consumptive use of Colorado River water, thereby developing the ICUA that the Secretary will release for consumptive use in the consuming state. Under this rule, two Storage and Interstate Release Agreements (SIRA) have been executed to date.

1.8.3 Interim Surplus Criteria - Final EIS and ROD - Colorado River Interim Surplus Guidelines

On January 17, 2001, the Secretary, through a ROD, adopted specific ISG that identify the conditions under which the Secretary will authorize the release of water from Lake Mead, for use in the Lower Basin, in excess of 7.5 maf. As adopted, the term of the ISG is through 2016. The ISG are applied by the Secretary each year through the AOP.

The ISG provide mainstream users of Colorado River water, particularly those in California, a greater degree of predictability with respect to the likely existence, or lack thereof, of a surplus determination in a given year for the interim period (i.e., through 2016). Prior to adoption of the ISG, availability of surplus was limited to periods when Lake Mead was nearly full and expected to make additional releases to avoid future spills. Conversely, under the ISG, surplus water is made available at lower Lake Mead elevations, provided that California has taken actions to reduce its historic reliance on water in excess of its 4.4 mafy apportionment. Surplus determinations under the AOP are further discussed in Section 1.7 of this Draft EIS.

The ISG, as adopted in the 2001 ROD, provide for certain benchmarks for reduction of California's agricultural use of Colorado River water and other actions; as long as the benchmarks are met, the more permissive determinations of surplus under the ISG are permitted. In the event that the benchmarks are not met, surplus determinations revert to a more conservative water management approach (i.e., surplus water is only made available when reservoirs are nearly full).

1.8.4 Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions - Final EIS and ROD - Colorado River Water Delivery Agreement

California's Colorado River Water Use Plan (CA Plan) calls for conservation measures to be put in place that will reduce California's dependency on Colorado River water in excess of the state's 4.4 maf apportionment. The Colorado River Water Delivery Agreement, signed by the Secretary on October 10, 2003, provides for implementation of major components of the CA Plan and incorporates contractual agreements that facilitate California's reduction of its use of Colorado River water.

The Colorado River Water Delivery Agreement is the Secretary's agreement to make those Colorado River water deliveries specified in the agreements with the relevant California entities. These agreements provide for the conservation and transfer of about 400 kaf of water annually among the Imperial Irrigation District, Coachella Valley Water District, MWD, and San Diego County Water Authority.

1.8.5 Lower Colorado River Multi-Species Conservation Program (LCR MSCP) - Final Programmatic EIS/EIR and ROD - Lower Colorado River Multi-Species Conservation Plan

The LCR MSCP is a 50-year cooperative effort between federal and non-federal entities, approved by the Secretary in April 2005, that:

- ♦ Conserves habitat and works towards the recovery of threatened and endangered species, as well as reducing the likelihood of additional species being listed;
- ♦ Accommodates present water diversions and power production and optimizing opportunities for future water and power development, to the extent consistent with the law; and
- ♦ Provides the basis for incidental take authorizations.

The LCR MSCP provides ESA compliance for specific covered federal actions and non-federal activities under ESA Sections 7 and 10. The LCR MSCP provides ESA coverage for non-federal actions that are related to the use and management of the lower Colorado River.

In addition to the covered activities of the non-federal LCR MSCP entities, specific present and potential future actions of six federal agencies on the lower Colorado River are also included in the LCR MSCP. Those federal agencies are Reclamation, BIA, NPS, Bureau of Land Management (BLM), Western, and the FWS. These federal agencies and non-federal entities are collectively referred to as the LCR MSCP participants. The covered actions and activities for the LCR MSCP participants occur along the lower Colorado River in Imperial, Riverside, and San Bernardino counties, California; La Paz, Mohave, and Yuma counties, Arizona; and Clark County, Nevada. The duration of the Section 10 permit and the associated formal ESA Section 7 consultation for the federal agencies is 50 years (2005 to 2055).

Among the many federal covered actions identified in the LCR MSCP is the implementation of shortages in the Lower Basin (which is among the elements of the proposed federal action analyzed in this Draft EIS). To the extent that the shortage strategy adopted by the Department is within the coverage provided by the LCR MSCP, it is anticipated that adoption of that element of the proposed federal action would not require further ESA compliance.

The Conservation Plan was designed to fully mitigate adverse effects to species included within the LCR MSCP resulting from federal covered actions and non-federal covered activities and to meet the ESA Section 10 standard to minimize and mitigate the impacts of the covered activities on covered species to the maximum extent practicable. While the LCR MSCP is geared toward special status species, it is important to understand that all species that use the habitats impacted by LCR MSCP-covered activities benefit from the conservation actions currently being carried out under the LCR MSCP, and are therefore fully mitigated for within the limits of the LCR MSCP analysis.

Chapter Two

Description of Alternatives

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2.1 Development of Alternatives

Based on the information and comments received during the scoping process, the proposed federal action has been designed to reflect, among others, three important considerations:

1) **Encouraging Conservation of Water:** Many comments submitted to Reclamation focused on the importance of encouraging and utilizing water conservation as an important tool to better manage limited water supplies and therefore minimize the likelihood and severity of potential future shortages. Water conservation could occur through a number of approaches such as fallowing of land, canal lining, financial incentives to maximize conservation, dry-year options, and associated storage and recovery methodologies and procedures to address conservation actions by particular parties.

2) **Consideration of Reservoir Operations at all Operational Levels:** Many comments submitted to Reclamation urged Reclamation to consider and analyze management and operational guidelines for the full range of operational levels at Lake Powell and Lake Mead. It was suggested that this approach is integral to the prudent development of new low-reservoir operational guidelines, as the approach and management of these reservoirs at higher elevations has a direct impact on available storage, thereby affecting the likelihood and severity of potential future shortages.

3) **Term of Operational Guidelines:** Many comments urged Reclamation to consider interim, rather than permanent, additional operational guidelines. In this manner, Reclamation would have the ability to use actual operating experience for a period of years, thereby facilitating a better understanding of the operational effects of the new guidelines. Modifications could then be made, if necessary, based on this operating experience.

As a result of the analyses of the comments and input received by Reclamation, the following four operational elements of the proposed federal action were developed;

1) **Shortage Guidelines:** Adoption of guidelines that would identify those circumstances under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead to the Lower Division states below 7.5 maf, pursuant to the Consolidated Decree.

   The primary purpose of this element is the orderly rationing of water supplies during drought and low-reservoir conditions. While Lake Powell and Lake Mead have large storage capacities, water supply demands are increasing and careful management of existing water supplies will help ensure sufficient supplies are available to meet these demands. The proposed shortage guidelines in the alternatives range from aggressive shortages to no reduction of water supplies until the reservoirs are empty. Most of the alternatives have discrete stepped levels of shortage associated with specific Lake Mead reservoir elevations.

2) **Coordinated Reservoir Operations:** Adoption of guidelines for the coordinated operation of Lake Powell and Lake Mead to provide improved operation of these two reservoirs, particularly under low-reservoir conditions.

Lake Powell and Lake Mead operations are currently coordinated only under high reservoir elevations through storage equalization. The action alternatives consider various options designed to better utilize existing reservoir storage throughout the full range of reservoir operations to enhance both water supply and other benefits of the reservoir system for both basins.

3) **Storage and Delivery of Conserved Water:** Adoption of guidelines for the storage and delivery of conserved Colorado River system and non-system water in Lake Mead, pursuant to applicable federal law, to increase the flexibility of meeting water use needs from Lake Mead, particularly under drought and low-reservoir conditions.

One way to increase water deliveries during drought is through the augmentation and conservation of existing water supplies. The alternatives consider options for the creation of a system of storage credits in Lake Mead whereby system and non-system water may be conserved and stored in Lake Mead, with various limits on the maximum size, storage and delivery of the credit water. The alternatives range from an operational scenario that considers no new mechanism (status quo) to a maximum Lake Mead storage credit volume of 4.2 maf.

Reclamation will establish guidelines for administration of this mechanism as part of this public NEPA process. The guidelines will set forth Reclamation requirements for verification of the conservation action and water accounting procedures. Although the guidelines for this element are interim and will expire in 2026, some of the conservation projects established under the guidelines could be permanent in duration.

4) **Interim Surplus Guidelines (ISG):** Adoption of guidelines that would identify the conditions under which the Secretary may declare the availability of surplus water for use within the Lower Division states. The proposed federal action would modify the substance of the existing ISG and extend the term of the ISG from 2016 to 2026.

The ISG are due to expire in 2016. The alternatives range from termination of the permissive provisions of the existing ISG in 2007 to extension of the current provisions of the ISG through 2026. This element of the proposed federal action helps establish an operational strategy for the full range of reservoir operations through 2026.

The alternatives considered and analyzed in this Draft EIS include some formulation of each of these four operational elements.

Reclamation has developed four action alternatives for analysis in this EIS. These alternatives reflect input from Reclamation staff, the cooperating agencies, stakeholders, and other interested parties. Reclamation received two written proposals for alternatives that met the purpose and need of the proposed federal action, one from the Basin States and another from a consortium of environmental organizations. These proposals were used by Reclamation to formulate two of the alternatives considered and analyzed in this Draft EIS. A third alternative (Water Supply Alternative) was developed by Reclamation and a fourth alternative (Reservoir Storage Alternative) was developed in coordination with the NPS and Western. The alternatives were posted on Reclamation's website (http://www.usbr.gov/lc/region/programs/strategies.html) on June 30, 2006.

Reclamation has not identified a preferred alternative in this Draft EIS. The preferred alternative will be identified following public comments on the Draft EIS and will be expressed in the Final EIS. The preferred alternative may be one of the specific alternatives described below or it may incorporate elements or variations of these alternatives.

2.2 No Action Alternative

The No Action Alternative provides a baseline against which action alternatives can be compared. The No Action Alternative represents a projection of current conditions to the most reasonable future responses or conditions that could occur during the life of the proposed federal action without any action alternative being implemented.

Pursuant to the LROC, the Secretary makes a number of determinations at the beginning of each operating year through the development and execution of the AOP, including the water supply available to users in the Lower Basin and the annual release from Lake Powell. The LROC do not include specific guidelines for such determinations. Furthermore, there is no actual operating experience under very low reservoir conditions, e.g., there has never been a shortage determination in the Lower Basin. Therefore, in the absence of specific guidelines, the outcome of the annual determination in any particular year in the future cannot be precisely known. However, a reasonable representation of future conditions under the No Action Alternative is needed for comparison to each action alternative. The modeling assumptions used for this representation are consistent with assumptions used in previous environmental compliance documents for the ISG, the Colorado River Water Delivery Agreement, and the LCR MSCP (Section 1.8). However, the assumptions used in the No Action Alternative are not intended to limit or predetermine the action decision in any future AOP determination.

The formulation of the four elements for the No Action Alternative follows.

2.2.1 Shortage Guidelines

Each year, the Secretary makes a determination as to whether the consumptive use requirements of mainstream users in the Lower Division states will be met under a Normal, Surplus, or Shortage condition, in accordance with the Consolidated Decree and the LROC. The LROC specify that the Secretary will consider all relevant factors in making a shortage determination and list some of the factors to be considered. However, there is no specific guidance as to exactly when, how, or to whom reductions in deliveries would be made. Therefore, it is impossible to know exactly how the Secretary might make a shortage determination in the future. Furthermore, conditions in the Colorado River Basin have been such that there has not been a need to declare a Shortage condition and there is no actual operating experience with regard to shortage determinations.

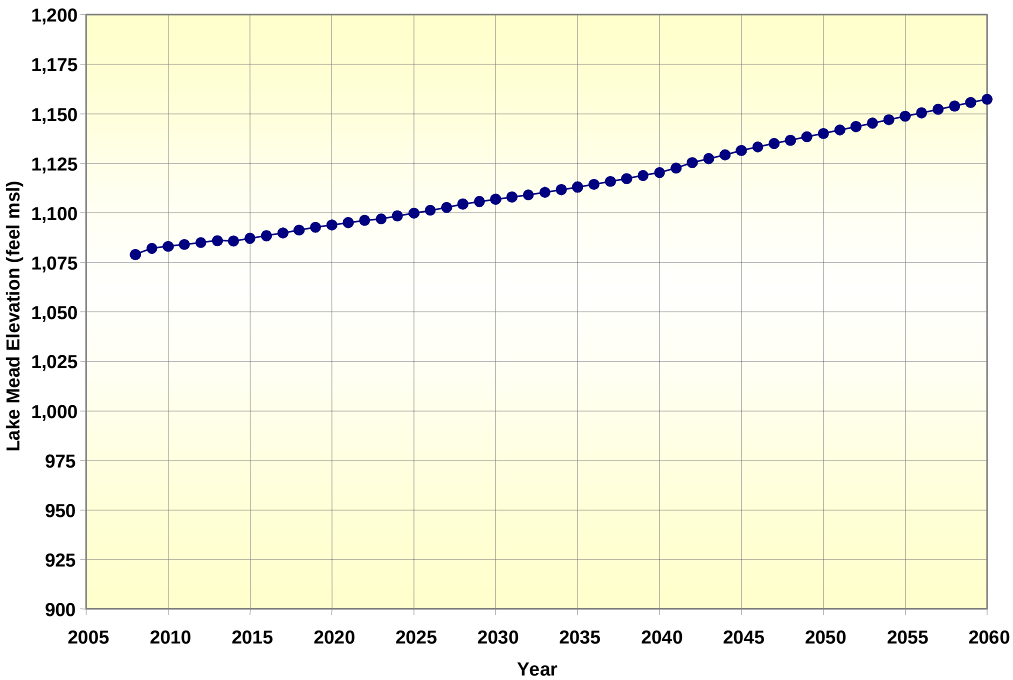
To obtain a reasonable representation of future conditions under no action (while not representing official policy of the Department with regard to future determinations), the following assumptions were made;

- As used in modeling assumptions for previous environmental compliance documents, shortage trigger elevations (Figure 2.2-1) were used to prevent Lake Mead's water level from declining below elevation 1,050 feet msl with approximately an 80 percent probability (known as a "Level 1 Shortage", Appendix A). In a given year, a shortage (or reduction in deliveries) that ranges from approximately 350 to 500 kaf would be imposed when the projected January 1 Lake Mead elevation is below the trigger elevation for that year; and

- If Lake Mead's elevation were to continue to decline, additional reductions would be imposed to keep Lake Mead above 1,000 feet msl. This approach essentially provides absolute protection of SNWA's lower intake (elevation 1,000 feet msl) at Lake Mead and would reduce deliveries to water users (including SNWA) by amounts required to maintain the Lake Mead water level at or above 1,000 feet msl.

In accordance with the Consolidated Decree, the CRBPA, and other key provisions of the Law of the River, the Secretary has the authority to declare and allocate shortages to the Lower Division states. Although some guidance exists with regard to how shortages would be allocated (e.g., PPR deliveries must be met without regard to state lines, California does not incur shortages until Arizona post-1968 contracts are reduced completely), there are no specific guidelines in place to further inform the Secretary's decision with respect to how shortages might be shared by the water users in Arizona, California and Nevada. In addition, the determination of deliveries to Mexico is not a part of the proposed federal action. Any such determination would be made in accordance with the 1944 Treaty (Section 1.7).

Figure 2.2-1
Level 1 Shortage Trigger Elevations Under No Action Alternative



Nevertheless, modeling assumptions with respect to the distribution of shortages for the Lower Division states and Mexico are necessary in order to analyze potential impacts to hydrologic and other environmental resources. These modeling assumptions were applied to the No Action Alternative as well as the action alternatives, i.e., the modeling assumptions with regard to the distribution of shortages are identical in all alternatives.

It was assumed that shortages would be allocated to each Lower Division state and Mexico based on percentages of the total shortage being applied. The modeling assumptions for distribution of shortages used in this Draft EIS are presented in Table 2.2-1. More detailed descriptions of these modeling assumptions are provided in Appendix A.

Table 2.2-1
Modeling Assumptions for Distribution of Shortages[1]

Entity	Percentage of Total Shortage, Stage 1	Percentage of Additional Shortage, Stage 2[2]
Arizona	80.00	15 to 20
California	0.00	60 to 65
Nevada	3.33	3.33
Mexico	16.67	16.67
Total	100.00	100.00

1. *These modeling assumptions do not reflect policy decisions and are not intended to constitute an interpretation or application of the 1944 Treaty. They have been developed for comparison of the alternatives.*
2. *Shortage amounts presented in the Stage 2 column are incremental over the amount of shortages that would have already been allocated*

under Stage 1.

Shortages are first imposed under Stage 1 and would be applied to the most junior users within Arizona (those with post-1968 water rights, i.e., 4th and 5th priority rights within Arizona) and Nevada (primarily the SNWA). Stage 1 shortages continue until the deliveries to the post-1968 water rights holders in Arizona (including the CAP) are reduced to zero. The maximum amount of Stage 1 shortages during the period of analysis is dependent on the scheduled depletions for the post-1968 water rights holders and decreases over time from approximately 1.8 maf in 2008 to 1.7 maf in 2060.

After deliveries to the 4th and 5th priority rights within Arizona are reduced to zero, additional reductions are applied to Arizona, California, and Nevada. These shortages, referred to as Stage 2 shortages, continue to the maximum necessary to keep Lake Mead elevation above 1,000 feet msl.

2.2.2 Coordinated Reservoir Operations

The No Action Alternative assumes Lake Powell's operation would follow the current operating criteria as specified by the LROC and as implemented through the AOP process. The three possible factors affecting the annual releases from Lake Powell are: 1) minimum objective release; 2) storage equalization; and 3) spill avoidance.

Pursuant to the LROC, the objective under current operational conditions is to maintain a minimum release of water from Lake Powell of 8.23 maf for the water year. Under the No Action Alternative, a minimum release of 8.23 maf is assumed to be made each water year unless storage equalization or spill avoidance determinations are in effect.

Annual releases from Lake Powell greater than the minimum objective release occur when Upper Basin storage is greater than the storage required by 602(a) storage, and the storage in Lake Powell is forecast to be greater than the storage in Lake Mead by the end of that water year. Under these conditions, additional releases are made from Lake Powell to equalize the storage in Lake Mead with the storage in Lake Powell by the end of the water year.

The 602(a) storage requirement specifies the amount of storage in Upper Basin reservoirs necessary to assure deliveries to the Lower Basin in compliance with the Compact without impairment to the annual consumptive use in the Upper Basin. If the 602(a) storage requirement is not met, equalization does not occur. The LROC specifies that all relevant factors including historic stream flows, the most critical period of record, the probabilities of water supply, and estimated future depletions be considered when determining the 602(a) storage amount.

In 2004, an Interim 602(a) Storage Guideline was adopted that specifies that through 2016, the 602(a) storage requirement shall utilize a storage amount of not less than 14.85 maf which corresponds to 3,630 feet msl for Lake Powell. Under the No Action Alternative, the determination of 602(a) storage is consistent with the storage criterion and the provisions of the Interim 602(a) Storage Guideline. The algorithm used to calculate the 602(a) storage requirement is presented in Appendix A.

Annual release volumes from Lake Powell greater than the minimum objective of 8.23 maf may also be made to avoid anticipated spills. An objective in the operation of Glen Canyon Dam is to attempt to safely fill Lake Powell each summer. When carryover storage from the previous year in combination with forecasted inflow is projected to exceed Lake Powell's storage capacity, Reclamation schedules the release of the volumes of water needed to avoid spills. Subject to actual inflows, Lake Powell is operated to reach storage of about 23.8 maf in July (0.5 maf from full pool). In years when Lake Powell fills or nearly fills during the summer, additional releases in the late summer and early winter are made to draw the reservoir level down, so that there is at least 2.4 maf of vacant space in Lake Powell on September 30 for flood protection. Under the No Action Alternative, it is assumed that spill avoidance releases are made when necessary.

2.2.3 Storage and Delivery of Conserved Water

There is currently no mechanism in place for the storage and delivery of conserved system and non-system waters in Lake Mead; therefore, the No Action Alternative assumes that none will exist during the interim period.

2.2.4 Interim Surplus Guidelines

The ISG specify ranges of Lake Mead elevations and operational conditions that are used to determine the availability of surplus water for each year during their effective term. The elevation ranges are coupled with specific uses of surplus water so that if Lake Mead's elevation declines, the amount of surplus water is reduced. The different surplus conditions are described below:

2.2.4.1 Flood Control Surplus

If flood control releases are anticipated to be required given the current inflow forecast, the Secretary declares Flood Control Surplus conditions for that year. The estimated annual amount of surplus water available for pumping and release from Lake Mead (in addition to the 7.5 maf normal apportionment) varies over time (2002 to 2016) and ranges between 1.20 to 1.58 mafy. Under current practice, Mexico is allowed to schedule up to an additional 200 thousand acre-feet (kaf) pursuant to the 1944 Treaty during flood control years when water supplies exceed those required for use in the United States.

2.2.4.2 Quantified Surplus (70R Strategy)

If flood control releases are anticipated to be required assuming the 70^{th} percentile inflow (the inflow value from the historical record that has not been exceeded more than 30 percent of the time), the Secretary declares Quantified Surplus conditions for that year. The estimated annual amount of surplus water available for pumping and release from Lake Mead (in addition to the 7.5 maf normal apportionment) varies over time (2002 to 2016) and ranges between 1.02 to 1.45 mafy.

2.2.4.3 Full Domestic Surplus (Lake Mead at or above Elevation 1,145 feet msl)

If the projected January 1 Lake Mead elevation is at or above 1,145 feet msl but below the elevation calculated by the 70R Strategy, the Secretary declares a Full Domestic Surplus condition for that year. The projected annual amounts of surplus water available for pumping and release from Lake Mead (in addition to the 7.5 maf normal apportionment) vary over time (2002 to 2016) and range between 340 to 535 thousand acre-feet per year (kafy).

2.2.4.4 Partial Domestic Surplus (Lake Mead at or above Elevation 1,125 feet msl)

If the projected January 1 Lake Mead elevation is at or above 1,125 feet msl and below 1,145 feet msl, the Secretary declares Partial Domestic Surplus conditions for that year. The estimated annual amounts of surplus water available for pumping and release from Lake Mead (in addition to the 7.5 maf normal apportionment) vary over time (2002 to 2016) and range between 90 to 375 kafy.

2.2.4.5 Normal and Shortage Conditions (Lake Mead below Elevation 1,125 feet msl)

If the projected January 1 Lake Mead elevation is at or below 1,125 feet msl, the Secretary declares Normal conditions or Shortage conditions for that year.

Under the No Action Alternative, surplus determinations through 2016 would be as described above. After 2016, it is assumed that surplus determinations would only be based on the more conservative Quantified Surplus (70R Strategy) and Flood Control Surplus conditions. Further details of these modeling assumptions to represent the ISG are presented in Appendix A.

2.3 Basin States Alternative

The Basin States Alternative proposes a coordinated operation of Lake Powell and Lake Mead that would minimize shortages in the Lower Basin and avoid risk of curtailments of use in the Upper Basin. This alternative also provides a mechanism for promoting water conservation in the Lower Basin. The formulation of the four elements for the Basin States Alternative follows.

2.3.1 Shortage Guidelines

The Basin States Alternative provides discrete stepped levels of shortage associated with specific Lake Mead elevations as presented below. This alternative provides criteria for shortages of up to a maximum of 600 kaf at Lake Mead elevation of 1,025 feet msl and suggests that consultations between the Basin States and Reclamation would be undertaken to define additional shortages below that elevation. The possible outcomes of such a consultation process are unknown; therefore, for modeling purposes it was assumed that shortages of 600 kaf would continue to be applied at Lake Mead elevations below 1,025 feet msl. The stepped shortages modeled under the Basin States Alternative are as follows:

- When Lake Mead is projected to be below elevation 1,075 feet msl and at or above 1,050 feet msl on January 1, a shortage of 400 kaf shall be declared for that year;

- When Lake Mead is projected to be below elevation 1,050 feet msl and at or above 1,025 feet msl on January 1, a shortage of 500 kaf shall be declared for that year;

- When Lake Mead is projected to be below elevation 1,025 feet msl on January 1, a shortage of 600 kaf shall be declared for that year; and

- When Lake Mead elevation approaches the top of the dead pool (895 feet msl), the deliveries from Lake Mead are reduced to the amount of water available.

2.3.2 Coordinated Reservoir Operations

Under the Basin States Alternative, the annual Lake Powell release is based on a volume of water in storage or corresponding elevation in Lake Powell and Lake Mead as described below.

2.3.2.1 Equalization

The Basin States Alternative provides an elevation schedule (Table 2.3-1) that would be used in determining when equalization releases would be made.

Table 2.3-1
Basin States Alternative
Lake Powell Equalization Elevations

Year	Reservoir Elevation (feet msl)
2008	3,636
2009	3,639
2010	3,642
2011	3,643
2012	3,645
2013	3,646
2014	3,648
2015	3,649
2016	3,651
2017	3,652
2018	3,654
2019	3,655
2020	3,657
2021	3,659
2022	3,660
2023	3,662
2024	3,663
2025	3,664
2026	3,666

When Lake Powell is at or above these specified elevations and when the volume of Lake Powell is projected to be greater than the volume of Lake Mead at the end of the water year, Lake Powell would release greater than 8.23 mafy to equalize its volume with Lake Mead. Otherwise, 8.23 maf is released from Lake Powell.

2.3.2.2 Upper Elevation Balancing

When Lake Powell is below the elevations stated in Table 2.3-1 and is projected to be at or above 3,575 feet msl at the end of the water year, a release in the amount of 8.23 maf from Lake Powell would be made if the projected elevation of Lake Mead is at or above 1,075 feet msl at the end of the water year. If the projected end of water year elevation of Lake Mead is below 1,075 feet msl, the volumes of Lake Mead and Lake Powell would be balanced if possible, within the constraint that the release from Lake Powell would not be more than 9.0 maf and no less than 7.0 maf.

2.3.2.3 Mid-Elevation Releases

When Lake Powell elevation is projected to be below 3,575 feet msl and at or above 3,525 feet msl at the end of the water year, a release in the amount of 7.48 maf would be made if the projected end of water year elevation of Lake Mead is at or above 1,025 feet msl. If the projected end of water year elevation of Lake Mead is below 1,025 feet msl, a release of 8.23 maf from Lake Powell would be made.

2.3.2.4 Lower Elevation Balancing

When the projected end of water year elevation of Lake Powell is below 3,525 feet msl, Lake Mead and Lake Powell would be balanced if possible, within the constraint that the release from Lake Powell would not be more than 9.5 maf and no less than 7.0 maf.

2.3.3 Storage and Delivery of Conserved Water

The Basin States Alternative includes the adoption of a mechanism to encourage and account for augmentation and conservation of water supplies, e.g., fallowing of land, canal lining and other system efficiency improvements, and introduction of non-system water in the Lower Basin. The mechanism, referred to as Intentionally Created Surplus (ICS), provides for creating and delivering the credit water.

In addition to increasing the flexibility of meeting water use needs from Lake Mead, the ICS mechanism would benefit the system through Lake Mead storage credits. At the time the ICS credits are created, five percent of the ICS credits would be dedicated to the system on a one-time basis. Additionally, ICS credits stored in Lake Mead longer than one year would be subject to annual evaporation losses of three percent per year. If flood control releases occur, ICS credits would be reduced on a pro-rata basis among all holders of ICS credits until no credits remain, i.e., ICS credit water would be released first.

The maximum amount of ICS credits that can be created during any year, the maximum cumulative amount of ICS credits that can be available at any one time, and the maximum amount of ICS credits that may be recovered by each Basin State in any one year under this alternative are presented in Table 2.3-2.

Table 2.3-2
Basin States Alternative
Volume Limitations of Storage and Delivery Mechanism

Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Total	625	2,100	1,000

2.3.4 Interim Surplus Guidelines

The Basin States Alternative includes both a modification and an extension of the ISG. The ISG would be extended through 2026 and be modified by eliminating the Partial Domestic Surplus condition, beginning in 2008, and limiting the amount of water available under the Full Domestic Surplus condition during the period 2017 through 2026.[1] The elimination of the Partial Domestic Surplus condition reduces the amount of surplus water that could be made available and leaves more water in storage to reduce the severity of future shortages.

2.4 Conservation Before Shortage Alternative

The Conservation Before Shortage Alternative was developed by a coalition of NGOs, including Defenders of Wildlife, Environmental Defense, National Wildlife Federation, Pacific Institute, Sierra Club, Sonoran Institute, The Nature Conservancy, and the Rivers Foundation of the Americas. The Conservation Before Shortage Alternative includes voluntary, compensated reductions in water use to minimize involuntary shortages in the Lower Basin and avoid risk of curtailments of use in the Upper Basin. This alternative also provides a mechanism for promoting water conservation in the Lower Basin by expanding the ICS mechanism. The formulation of the four elements for the Conservation Before Shortage Alternative follows.

2.4.1 Shortage Guidelines

Although the Conservation Before Shortage Alternative does not include stepped, involuntary shortages, it does include voluntary conservation levels similar to the Basin States Alternative shortage levels described in Section 2.3. These voluntary conservation levels are described below.

[1] During 2017 through 2026, the distribution of Domestic Surplus water would be limited as follows: 1) for use by MWD, 250 kafy in addition to the amount of California's basic apportionment available to MWD; 2) for use by SNWA, 100 kafy in addition to the amount of Nevada's basic apportionment available to SNWA; and 3) for use in Arizona, 100 kafy in addition to the amount of Arizona's basic apportionment available to Arizona contractors.

This alternative provides a shortage strategy that would absolutely protect Lake Mead elevation of 1,000 feet msl whereby water deliveries would be reduced by the amount required to maintain Lake Mead elevations at or above 1,000 feet msl.

2.4.2 Coordinated Reservoir Operations

The Conservation Before Shortage Alternative assumes the same coordinated reservoir operations as the Basin States Alternative described in Section 2.3.

2.4.3 Storage and Delivery of Conserved Water

The conservation triggers proposed under this alternative are as follows:

- ♦ When Lake Mead is projected to be below elevation 1,075 feet msl and at or above 1,050 feet msl on January 1, the Secretary will seek the conservation of 400 kaf of water;
- ♦ When Lake Mead is projected to be below elevation 1,050 feet msl and at or above 1,025 feet msl on January 1, the Secretary will seek the conservation of 500 kaf of water; and
- ♦ When Lake Mead is projected to be below 1,025 feet msl on January 1, the Secretary will seek the conservation of 600 kaf of water.

The ICS credits would be generated by activities similar to those described in the Basin States Alternative (Section 2.3). In addition, participation in the ICS program would be expanded to include other entities as shown in Table 2.4-1.

The maximum amount of ICS credits that can be created during any year, the maximum cumulative amount of ICS credits that can be available at any one time, and the maximum amount of ICS credits that may be recovered by each entity in any one year under this alternative are presented in Table 2.4-1.

Table 2.4-1
Conservation Before Shortage Alternative
Volume Limitations of Storage and Delivery Mechanism

Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Unassigned	825	2,100	600
Total	1,450	4,200	1,600

2.4.4 Interim Surplus Guidelines

The Conservation Before Shortage Alternative assumes the same modifications to and extension of the term of the ISG as described under the Basin States Alternative (Section 2.3).

2.4.5 Funding Mechanisms

There are two other aspects of the Conservation Before Shortage Proposal that are unique to the Conservation Before Shortage Proposal: a proposed funding mechanism for the voluntary conservation program and a recommendation that a portion of the conserved water be used to benefit the environment. The details of the modeling assumptions used to simulate the storage and delivery of conserved water, including water for environmental purposes, are presented in Appendix M.

The proposal described potential funding sources that include a Federal government contribution for the cost of all conservation agreements up to the volume of the bypass flow that the Secretary has not otherwise replaced in the year that a conservation trigger becomes effective and responsibility for half of the cost of any additional agreements required to generate the proposed voluntary, conserved water. A second component of the funding mechanism would be a “Power Pool Protection Fund” which proposes that a percentage of the funding for the proposed voluntary conservation program be derived from a conditional surcharge on power rates under existing or renewed contracts for hydropower produced at Hoover Dam, depending upon the storage in Lake Mead. A third component of the funding mechanism would be “Temporary Cost Recovery/Delivery Surcharges”, requiring that the cost of some portion of the conservation agreements, including those with Colorado River users in Mexico, be funded through a conservation surcharge imposed on a per-acre-foot basis on water deliveries to all Lower Basin contractors.

The viability of Conservation Before Shortage program funding proposal is not known at this time. The Department currently does not have the authority to implement all facets of this proposal and additional legislation would be necessary to gain such authority.

2.5 Water Supply Alternative

The Water Supply Alternative is intended to maximize water deliveries at the expense of retaining water in storage in the reservoirs for future use. This alternative would implement shortages only when insufficient water to meet entitlements is available in Lake Mead. The formulation of the four elements for the Water Supply Alternative follows.

2.5.1 Shortage Guidelines

Under the Water Supply Alternative, shortages would not be imposed until Lake Mead nears elevation 895 feet msl (top of the dead pool). Near that elevation, releases would be limited to the amount of water available. However, when Lake Mead elevation drops below 1,000 feet msl SNWA would be unable to take water through its lower intake.

2.5.2 Coordinated Reservoir Operations

When Lake Powell elevation is projected to be above 3,575 feet msl at the end of the water year, the operation of Lake Powell is the same as the No Action Alternative unless Lake Mead elevation is below 1075 feet msl. When Lake Powell elevation is projected to be below 3,575 feet msl at the end of the water year or Lake Mead elevation is projected to be below 1,075 feet msl at the end of the water year, the volumes of Lake Powell and Lake Mead would be balanced if possible, within the constraint that the release from Lake Powell would not be more than 9.5 maf and no less than 7.0 maf.

2.5.3 Storage and Delivery of Conserved Water

The Water Supply Alternative does not include a mechanism for the storage and delivery of conserved system and non-system water in Lake Mead.

2.5.4 Interim Surplus Guidelines

Under this alternative, the existing ISG would be extended through 2026.

2.6 Reservoir Storage Alternative

The Reservoir Storage Alternative was developed in coordination with the cooperating agencies and other stakeholders, primarily Western and the NPS. This alternative would keep more water in storage in Lake Powell and Lake Mead by reducing water deliveries and increasing shortages to benefit power and recreational interests. This alternative also provides a mechanism for promoting water conservation in the Lower Basin. The formulation of the four elements for the Reservoir Storage Alternative follows.

2.6.1 Shortage Guidelines

The Reservoir Storage Alternative is similar to the Basin States Alternative in that it provides discrete stepped levels of shortage associated with specific Lake Mead reservoir elevations (Section 2.3). However, shortages in this alternative begin at a higher Lake Mead elevation and the stepped shortages are larger so that more water would be retained in storage and higher Lake Powell and Lake Mead elevations would be maintained. The Reservoir Storage Alternative does not contain provisions that would protect the Lake Mead elevation of 1,000 feet msl.

The stepped shortages under this alternative are as follows:

- ♦ When Lake Mead is projected to be below elevation 1,100 feet msl and at or above 1,075 feet msl on January 1, a shortage of 600 kaf would be imposed for that year;
- ♦ When Lake Mead is projected to be below elevation 1,075 feet msl and at or above 1,050 feet msl on January 1, a shortage of 800 kaf would be imposed for that year;
- ♦ When Lake Mead is projected to be below elevation 1,050 feet msl and at or above 1,025 feet msl on January 1, a shortage of 1,000 kaf would be imposed for that year; and

- ♦ When Lake Mead is projected to be below 1,025 feet msl on January 1, a shortage of 1,200 kaf would be imposed for that year.

2.6.2 Coordinated Reservoir Operations

When Lake Powell elevation is projected to be above 3,595 feet msl at the end of the water year, the operation of Lake Powell would be the same as under the No Action Alternative. Elevations at Lake Powell that trigger releases that are less than the minimum objective release of 8.23 maf are tied to critical recreation elevations at Lake Powell as follows:

- ♦ When Lake Powell elevation is projected to be below 3,595 feet msl and above 3,560 feet msl at the end of the water year, a release in the amount of 7.80 maf from Lake Powell would be made; and
- ♦ When Lake Powell elevation is projected to be below 3,560 feet msl at the end of the water year, the volumes of Lake Powell and Lake Mead would be balanced if possible, within the constraint that the release from Lake Powell would not be more than 9.5 maf and no less than 7.8 maf.

2.6.3 Storage and Delivery of Conserved Water

Under the Reservoir Storage Alternative, storage credits would be generated by activities similar to those described under the Basin States Alternative (Section 2.3). Participation in the storage mechanism would include the entities as shown in Table 2.6-1.

The maximum amount of ICS credits that can be created during any year, the maximum cumulative amount of ICS credits that can be available at any one time, and the maximum amount of ICS credits that may be recovered by each entity in any one year under this alternative are presented in Table 2.6-1.

Table 2.6-1
Reservoir Storage Alternative
Volume Limitations of Storage and Delivery Mechanism

Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Unassigned	475	950	950
Total	1,100	3,050	1,950

2.6.4 Interim Surplus Guidelines

Under the Reservoir Storage Alternative, the permissive provisions of the existing ISG are terminated in 2007 and surplus determinations revert to the Quantified Surplus and Flood Control Surplus conditions during the period beginning in 2008 and ending in 2026.

2.7 Summary Comparison of Alternatives

A summary comparison of the alternatives identified and analyzed is provided in Table 2.7-1 through Table 2.7-3 for Lake Powell and Lake Mead.

Table 2.7-1
Matrix of Alternatives

Alternatives	Shortage Guidelines to reduce deliveries from Lake Mead (elevations in feet msl)	Coordinated Reservoir Operations (Lake Mead & Lake Powell) (elevations in feet msl)	Lake Mead Storage and Delivery of Conserved System or Non-system Water	Interim Surplus Guidelines for deliveries/releases from Lake Mead
No Action	▪ Determination made through the AOP process, absent shortage guidelines ▪ Reasonably represented by a two-level shortage strategy - probabilistic protection of Lake Mead elevation 1,050 and absolute protection of Lake Mead elevation 1,000	▪ Minimum objective release of 8.23 maf from Lake Powell unless storage equalization releases are required ▪ Operation at low reservoir levels reasonably represented by a 8.23 maf release from Lake Powell down to Lake Powell dead pool	▪ No water management mechanism for storage and delivery of conserved system and/or non-system water	▪ No modification or extension of the ISG which end in 2016 ▪ After 2016, determination made through the AOP process, absent surplus guidelines; reasonably represented by the spill avoidance (referred to as the 70R Strategy)
Basin States	▪ Shortages (i.e., reduced deliveries) of 400, 500, and 600 kaf from Lake Mead at elevations 1,075, 1,050, and 1,025 respectively ▪ Initiate efforts to develop additional guidelines for shortages if Lake Mead falls below elevation 1,025 (Note: includes reconsultation with Basin States)	▪ Under high reservoir conditions, minimum objective release of 8.23 maf from Lake Powell unless storage equalization releases are required ▪ Under lower reservoir conditions, either reduce Lake Powell release or balance volumes depending upon elevations at Lake Powell and Lake Mead	▪ Storage and delivery of conserved system and/or non-system water ▪ Maximum total storage for conserved system and/or non-system water in Lake Mead of 2.1 maf ▪ System assessment of 5 percent of stored conserved system and/or non-system water	▪ Modification of ISG to eliminate Partial Domestic Surplus condition ▪ Extension of the modified guidelines through 2026
Conservation Before Shortage	▪ Shortages are implemented in any given year when necessary to keep Lake Mead above SNWA's lower intake at elevation 1,000 (absolute protection of elevation 1,000)	▪ Under high reservoir conditions, minimum objective release of 8.23 maf from Lake Powell unless storage equalization releases are required ▪ Under lower reservoir conditions, either reduce Lake Powell release or balance volumes depending upon elevation at Lake Powell and Lake Mead	▪ Prior to shortage, conservation of different volumes of water tied to Lake Mead elevation ▪ Storage and delivery of conserved system and/or non-system water ▪ Water for environmental uses ▪ Maximum total storage of conserved system and/or non-system water greater than 4.2 maf ▪ System assessment of 5 percent of stored conserved system and/or non-system water	▪ Modification of ISG to eliminate Partial Domestic Surplus condition ▪ Extension of the modified guidelines through 2026
Water Supply	▪ Release full annual entitlement amounts until Lake Mead is drawn down to dead pool (elevation 895)	▪ Minimum objective release of 8.23 maf from Lake Powell unless storage equalization releases are required ▪ Balancing if Lake Powell is below elevation 3,575 or Lake Mead is below elevation 1,075	▪ No water management mechanism for storage and delivery of conserved system and/or non-system water	▪ Extension of the existing ISG through 2026
Reservoir Storage	▪ Shortages (i.e. reduced deliveries) of 600, 800, 1,000, and 1,200 kaf from Lake Mead at elevations 1,100, 1,075, 1,050, and 1,025 respectively	▪ Minimum objective release of 8.23 maf from Lake Powell if Lake Powell is above elevation 3,595 unless storage equalization releases are required ▪ 7.8 maf release from Lake Powell between Lake Powell elevations of 3,560 and 3,595 ▪ Balancing below Lake Powell elevation of 3,560	▪ Storage and delivery of conserved system and/or non-system water ▪ Maximum total storage of conserved system and/or non-system water of 3.05 maf ▪ System assessment of 10 percent of stored conserved system and/or non-system water	▪ Permissive provisions of existing ISG terminate in 2007, and during period from 2008 to 2026, surplus determinations are limited to Quantified and Flood Control conditions

Table 2.7-2
Comparison of Alternatives – Lake Powell

Lake Powell Elevation (feet msl)	No Action Alternative	Basin States Alternative	Conservation Before Shortage Alternative	Water Supply Alternative	Reservoir Storage Alternative	Lake Powell Storage (maf)
3,700	Equalize or Release 8.23 maf	Equalize or Release 8.23 maf	Equalize or Release 8.23 maf	Equalize or Release 8.23 maf	Equalize or Release 8.23 maf	24.3
Equalization	**602(a)**	**Upper Equalization Line**	**Upper Equalization Line**	**602(a)**	**602(a)**	Equalization
	Release 8.23 maf	Release 8.23 maf; if Lake Mead < 1,075 feet msl, balance contents with a min/max release of 7.0 and 9.0 maf	Release 8.23 maf; if Lake Mead < 1,075 feet msl, balance contents with a min/max release of 7.0 and 9.0 maf	Release 8.23 maf; if Lake Mead < 1,075 feet msl, balance contents with a min/max release of 7.0 and 9.5 maf	Release 8.23 maf	
3,595					Release 7.8 maf	11.3
3,575		Release 7.48 maf; if Lake Mead < 1,025 feet msl, release 8.23 maf	Release 7.48 maf; if Lake Mead < 1,025 feet msl, release 8.23 maf	Balance contents with a min/max release of 7.0 and 9.5 maf		9.5
3,560					Balance contents with a min/max release of 7.8 and 9.5 maf	8.3
3,525		Balance contents with a min/max release of 7.0 and 9.5 maf	Balance contents with a min/max release of 7.0 and 9.5 maf			5.9
3,490						4.0
3,370						0

1

Table 2.7-3
Comparison of Alternatives – Lake Mead

Lake Mead Elevation (feet msl)	No Action Alternative	Basin States Alternative	Conservation Before Shortage Alternative	Water Supply Alternative	Reservoir Storage Alternative	Lake Mead Storage (maf)
1,220	Flood Control Surplus	Flood Control Surplus	Flood Control Surplus	Flood Control Surplus	Flood Control Surplus	25.9
1,200	Full Domestic Surplus (through 2016)	Full Domestic Surplus	Full Domestic Surplus	Full Domestic Surplus	Normal Operations	22.9
1,145	Partial Domestic Surplus (through 2016)	Normal Operations	Normal Operations	Partial Domestic Surplus		15.9
1,125	Normal Operations			Normal Operations		13.9
1,100	Shortage 80 Percent Protection of elevation 1,050 feet msl				Shortage 600 kaf	11.5
1,075		Shortage 400 kaf	Voluntary Conservation		Shortage 800 kaf	9.4
1,050		Shortage 500 kaf			Shortage 1,000 kaf	7.5
1,025		Shortage 600 kaf and Reconsultation			Shortage 1,200 kaf	5.8
1,000	Shortage Absolute Protection of elevation 1,000 feet msl		Shortage Absolute Protection of elevation 1,000 feet msl			4.3
895						0

2.8 Summary of Potential Effects

Table 2.8-1 presents a summary of the potential effects of the alternatives. Chapter 4 contains detailed descriptions of these effects.

Table 2.8-1
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.3	Hydrologic Resources					
	Probability of Glen Canyon annual release volumes ≥ 7.5 maf, 2009 to 2060	100%	96.3%	96.3%	97.4%	100%
	Probability of Glen Canyon annual release volumes ≥ 8.23 maf, 2009 to 2060	99.7%	96.3%	96.3%	96.3%	94.0%
	Lake Powell March elevation, probability of elevations ≤ 3,490 feet msl, 2026	1.0%	0%	0%	8.0%	0%
	Lake Mead December elevation, probability of elevations ≤ 1,050 feet msl, 2026	26.0%	20.0%	20.0%	21.0%	4.0%
	Hoover Dam annual release, 2026 50th percentile values	9.1 maf	9.2 maf	9.1 maf	9.4 maf	8.7 maf
4.4	Water Deliveries					
	Probability of involuntary Shortage, 2026	47%	35%	8%	9%	37%
	Probability of voluntary and involuntary Shortage, 2026	47%	35%	33%	9%	37%
	Probability of Normal deliveries	35%	26%	29%	52%	47%
	Probability of Surplus	17%	38%	37%	39%	16%
4.5	Water Quality					
	Temperature at Little Colorado River, July 2026, 50th percentile	10 to 14 °C	10 to 15°C	10 to 15°C	10 to 15°C	10 to 13°C
	Lake Mead release temperature, July 2026, 50th percentile	13 to 18°C	13 to 18°C	13 to 18°C	13 to 18°C	12 to 16°C
	Salinity below Parker Dam, 2026	624 mg/L	628 mg/L	629 mg/L	637 mg/L	619 mg/L
	Salinity at Imperial Dam, 2026	744 mg/L	751 mg/L	756 mg/L	764 mg/L	740 mg/L
4.6	Air Quality					
	Lake Powell 2026, 10th percentile lake elevation, exposed shoreline	17,000 acres	17,000 acres	17,000 acres	21,000 acres	14,000 acres
	Lake Mead 2026, 10th percentile lake elevation, exposed shoreline	87,000 acres	84,000 acres	85,000 acres	86,000 acres	72,000 acres

Table 2.8-1
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.7	Visual Resources					
	Lake Powell maximum height of calcium carbonate ring, 10th percentile lake elevation , 2026	160 feet	150 feet	150 feet	195 feet	160 feet
	Lake Mead maximum height of calcium carbonate ring, 10th percentile lake elevation, 2026	209 feet	209 feet	209 feet	210 feet	208 feet
4.8	Biological Resources[1]					
	Effects on Vegetation and Wildlife					
	Lakes Powell and Mead	-	None	None	Minor negative	Minor positive
	Glen Canyon Dam to Lake Mead	-	Minor negative	Minor negative	Minor negative	Minor negative
	Hoover Dam to NIB	-	None to minor negative	None to minor negative	Minor positive to none	Minor negative
	NIB to SIB	-	None	Moderate positive	None	Moderate positive
	Effects on Special Status Species					
	Glen Canyon Dam to Lake Mead humpback chub	-	None	None	Minor positive	Minor negative
	Parker Dam to Imperial Dam Yuma clapper rail	-	None	None	Minor positive	Minor negative
	NIB to SIB Southwestern willow flycatcher	-	None	Moderate positive	None	Moderate positive
4.9	Cultural Resources					
	Number of Lake Powell sites potentially exposed, 10th percentile lake elevation	193 sites	190 sites	190 sites	222 sites	193 sites
	Probability of exposing 32 Lake Mead sites, elevation ≤ 1,080 feet msl, 2026	43%	44%	44%	48%	22%
4.10	Indian Trust Assets[1]					
	Water rights affected	-	None	None	None	None
	Trust land affected	-	None	None	None	None

Table 2.8-1
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.11	Electrical Power Resources					
	Glen Canyon Powerplant					
	Average annual generation and percent change from No Action Alternative value	4,265,749 MWh	(0.25)%	(0.21)%	(2.2)%	0.63%
	Average monthly capacity and percent change from No Action Alternative value	603 MW	0.57%	0.60%	(1.9)%	1.6%
	Average total economic value and percent change from No Action Alternative value	$6,808,948,737	(0.07)%	(0.04)%	(2.05)%	0.92%
	Hoover Powerplant					
	Average annual generation and percent change from No Action Alternative value	3,156,820 MWh	0.46%	0.59%	(1.5)%	8.7%
	Average monthly capacity and percent change from No Action Alternative value	1,201 MW	1.1%	1.3%	(1.9)%	11.3%
	Average total economic value and percent change from No Action Alternative value	$7,350,904,219	1.03%	1.22%	(1.20)%	10.1%
	Davis and Parker Powerplants					
	Average annual generation and percent change from No Action Alternative value	1,618,736 MWh	(0.58)%	(0.69)%	0.1%	(1.1)%
	Average monthly capacity and percent change from No Action Alternative value	331 MW	0%	0%	0%	0%
	Average total economic and percent change from No Action Alternative value	$2,242,612,717	(0.55)%	(0.73)%	0.28%	(1.6)%
	Headgate Rock Powerplant					
	Average annual generation and percent change from No Action Alternative value	77,386 MWh	(1.2)%	(1.6)%	(0.29)%	(1.8)%
	Average monthly capacity and percent change from No Action Alternative value	not applicable	not applicable	not applicable	not applicable	not applicable
	Average total economic value and percent change from No Action Alternative value	$102,892,840	(1.3)%	(1.9)%	(0.19)%	(2.5)%

Table 2.8-1
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.12	Recreation					
	Lake Powell					
	Probability of closure, Wahweap and lower Bullfrog launch ramps, 2026	6%	8%	8%	20%	2%
	Probability of navigation closures, Castle Rock, Gregory Butte, 2026	29%	36%	36%	47%	21%
	Effects on sport fish	-	None	None	None	None
	Lake Mead					
	Probability of closure, Pearce Bay launch ramp, 2026	76%	76%	77%	78%	68%
	Probability of closure, Echo Bay launch ramp, 2026	26%	20%	22%	21%	4%
	Probability of navigation difficulties, upper Lake Mead, 2026	74%	73%	73%	77%	65%
4.13	Transportation[1]					
	Probability of Lake Powell ferry closure, end of September 2026	4%	6%	6%	17%	1%
	Effects on Colorado River ferry	-	None	None	Slight increase	Slight decrease
	Effects on Lake Havasu ferry service	-	None	None	None	None

Table 2.8-1
Summary of Potential Effects of the Alternatives

Draft EIS Section	Consequences by Resource, Year and Value	Alternatives				
		No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
4.14	Socioeconomics and Land Use[1]					
	Agricultural production and effects on employment, income, and tax revenues in Arizona, 2026	46%	35%	7%	9%	37%
	Agricultural production and effects on employment, income, and tax revenues in Arizona, 2060	79%	63%	65%	80%	67%
	Agricultural production and resulting effects on employment, income, and tax revenues in California and Nevada	-	None	None	None	None
	Recreation spending at Lake Powell	-	Same	Same	Decrease	Increase
	Recreation spending at Lake Mead (LMNRA)	-	Same	Same	Same	Increase
	Change in river recreation economic activity					
	Lake Powell to Lake Mead	-	None	None	None	None
	Downstream of Lake Mead	-	None	None	None	None
	Change in economic activity in Municipal & Industrial sector					
	Arizona	-	None	None	None	None
	Nevada	-	None	None	None	None
	California	-	None	None	None	None
4.15	Environmental Justice	-	None	None	None	None

Note: (1) "None" after a hyphen under the No Action Alternative column means no difference between that alternative and the No Action Alternative.

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Chapter Three

Affected Environment

3.1 Introduction

Chapter 3 describes environmental resources (i.e., hydrologic, biologic, and socioeconomic) of the Colorado River Basin that could be affected by the proposed federal action described in Chapter 1and Chapter 2. The extent to which each specific resource may be impacted is discussed in Chapter 4.

Section 3.2 presents a general discussion of the geographic scope within which potential effects of the alternatives are analyzed and describes each of the Colorado River reaches and affected water service areas. Subsequent sections in this chapter describe specific resources that may be potentially affected, such as water deliveries, recreation and biologic resources. Each resource section contains a discussion of one or more specific issues identified for consideration through scoping, public review and comment, and internal review (Chapter 1, Table 1.5-1).

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3.2 Geographic Scope

The proposed federal action considers modified operations of Lake Powell and Lake Mead over a wide range of reservoir elevations as addressed by the four operational elements discussed in Section 1.2: shortage conditions; coordinated operation of Lake Powell and Lake Mead; storage and delivery of Colorado River system and non-system water; and the modified ISG. Such operational changes may affect reservoir storage levels of, and releases from, Lake Powell and Lake Mead, which in turn may subsequently affect river flows, available water supplies, and other resources.

This section describes the geographic scope of specific issues and potential effects associated with changes in the operations of Lake Powell and Lake Mead, as discussed and analyzed under the alternatives considered in this Draft EIS (Chapter 2). Reservoirs located upstream of Lake Powell and operated independently of Lake Powell would not be affected by changes in the operations of Lake Powell and Lake Mead, but the releases from reservoirs located downstream of Lake Mead could be affected by these changes. As such, the upstream limit of the potentially affected environment for the purposes of this Draft EIS is the full pool elevation of Lake Powell, and the downstream limit is the SIB (Figure 3.2-1).

In addition to the potential impacts that may occur within the river corridor, the alternatives may also affect the water supply that is available to specific Colorado River water users in the Lower Basin due to the shortage guidelines element. The following water agency service areas are included in the affected environment discussions:

- Arizona water users, particularly the lower priority water users located in the CAP service area;
- The SNWA service area; and
- The MWD service area.

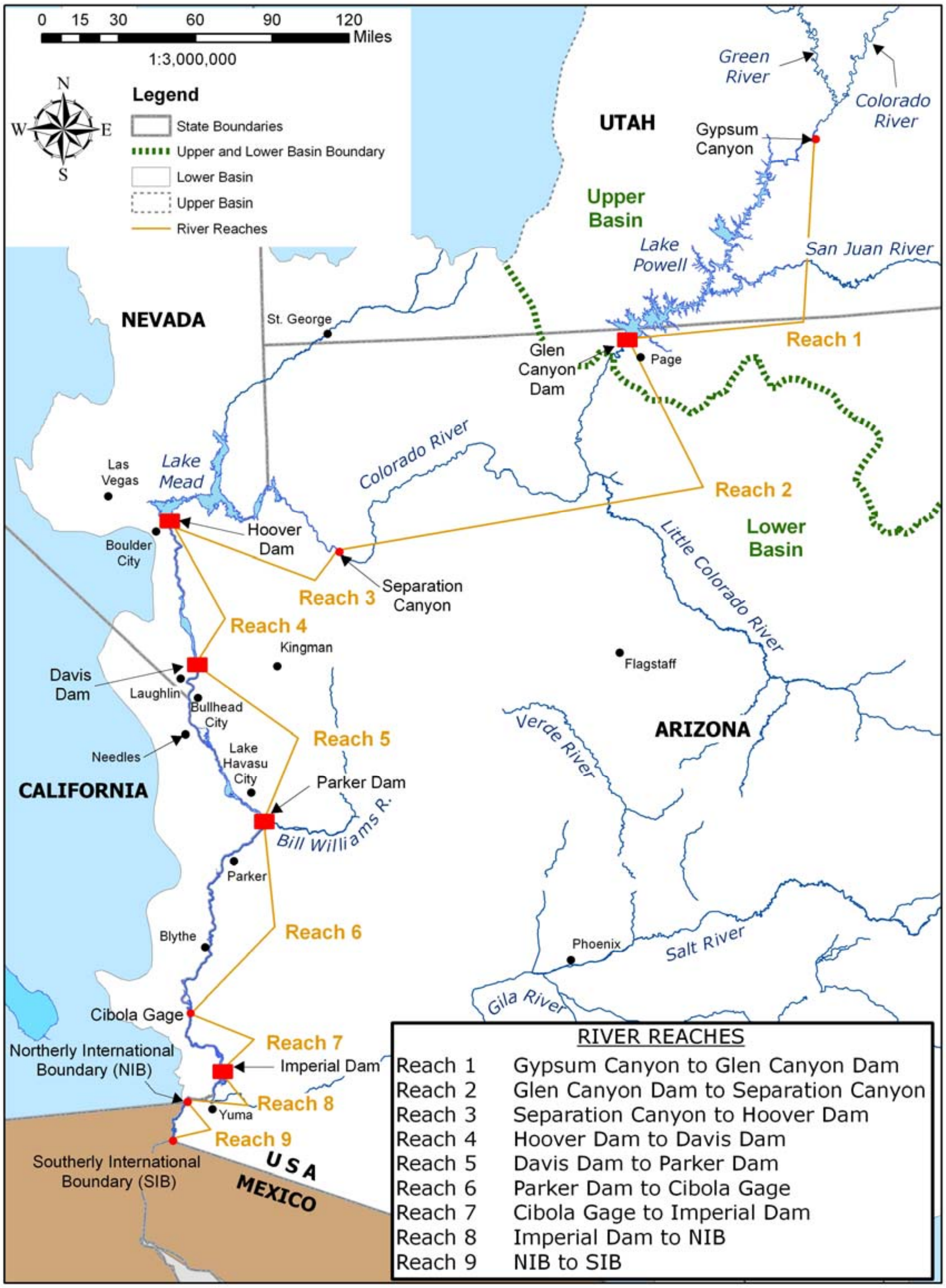
3.2.1 Definition of Colorado River Reaches

The section of the Colorado River extending from Lake Powell to the SIB consists of river reaches, two large reservoirs (Lake Powell and Lake Mead) and two smaller reservoirs downstream of Lake Mead (Lake Mohave and Lake Havasu, Figure 3.2-2). The Colorado River and adjacent areas (e.g., backwaters and marshes) comprise heterogeneous geographic and hydrologic regimes, which differ in their resource composition and resource management administration.

Figure 3.2-1
Geographic Scope

1

Figure 3.2-2
Colorado River Reaches



For the ease of discussion with respect to affected areas and potential effects, the Colorado River has been divided into the following reaches (Table 3.2-1).

Table 3.2-1
Colorado River Reaches and Reach Limits

Reach	Reach Limits
Lake Powell and Glen Canyon Dam	Gypsum Canyon to Glen Canyon Dam (RM 712.9)
Glen Canyon Dam to Lake Mead	Glen Canyon Dam to Separation Canyon (RM 450.6) [2], *including Grand Canyon National Park*
Lake Mead and Hoover Dam[1]	Separation Canyon (RM 450.6) to Hoover Dam (RM 342.2), *including Lake Mead*
Hoover Dam to Davis Dam[1]	Hoover Dam (RM 342.2) to Davis Dam (RM 276), *including Lake Mohave*
Davis Dam to Parker Dam[1]	Davis Dam (RM 276) to Parker Dam (RM 192.3), *including Lake Havasu*
Parker Dam to Cibola Gage (Adobe Ruin) [1]	Parker Dam (RM 192.3) to Adobe Ruin and Reclamation's Cibola Gage
Cibola Gage to Imperial Dam[1]	Reclamation's Cibola Gage (RM 87.3) to Imperial Dam (RM 49.2)
Imperial Dam to Northerly International Boundary (NIB) [1]	Imperial Dam (RM 49.2) to the NIB (RM 23.1)
NIB to SIB[1]	NIB (RM 23.1) to SIB (RM 0.0)

1 These reaches are identical to those described in the LCR MSCP.

2 For purposes of this Draft EIS, river miles are numbered along the length of the Colorado River channel south to north starting with RM 0.0 at the SIB with Mexico. Dam locations, other features and reach limits are identified and noted at their respective river miles.

These reaches and their associated issues are discussed briefly below and in more detail in Section 3.3, Hydrologic Resources. Each of the resource discussions is generally organized by river reaches and in some instances the river reaches are combined to better focus the discussion of issues.

3.2.1.1 Lake Powell and Glen Canyon Dam

Lake Powell is the second largest reservoir on the Colorado River and has a total storage capacity of 24.32 maf. It is formed by waters of the Colorado River impounded by Glen Canyon Dam. The reservoir is narrow, over 180 miles in length, and has a shoreline that is over 1,900 miles long. Lake Powell primarily provides water storage for use in meeting the delivery requirements to the Lower Basin consistent with the Law of the River. At the full pool elevation of Lake Powell, this reach includes approximately 25 miles of Cataract Canyon, 50 miles of the San Juan River and approximately 170 miles of Glen Canyon.

Lake Powell is located within the GCNRA which is administered by the NPS. Reclamation retains authority and discretion for the operation of Glen Canyon Dam and Lake Powell. The Navajo Indian Reservation also borders a segment of this river reach. The City of Page, Arizona is also located within this reach and diverts water from Lake Powell.

3.2.1.2 Glen Canyon Dam to Lake Mead

This reach of the Colorado River extends from Glen Canyon Dam to the upper limits of Lake Mead. It is comprised of a narrow river corridor through the last 15 miles of Glen Canyon, Marble Canyon, and the Grand Canyon. These canyons are in the GCNRA and Grand Canyon National Park which are administered by the NPS. The Navajo Indian Reservation and Hualapai Indian Reservation also border segments of this river reach.

3.2.1.3 Lake Mead and Hoover Dam

Lake Mead, formed by Hoover Dam, is the largest reservoir on the Colorado River and has a total storage capacity of 27.38 maf. The reservoir is approximately 115 miles in length and has a shoreline that is over 550 miles long. The reservoir provides water storage to regulate the water supply and meet the delivery requirements of the Lower Division states and Mexico. The reservoir is located within the LMNRA which is administered by the NPS. Reclamation retains authority and discretion for the operation of Hoover Dam and Lake Mead.

3.2.1.4 Hoover Dam to SIB

The Colorado River from Hoover Dam to the SIB is contained within the shallow Colorado River Valley in which Lake Mohave, Lake Havasu and other smaller diversion reservoirs are located. Under the BCPA and the Consolidated Decree (Chapter 1), releases from Hoover Dam are generally made to meet the downstream water delivery requirements for Arizona, California, Nevada and Mexico. The northern segment of this river reach, which includes Lake Mohave, lies within the LMNRA, which is administered by the NPS. The lower reach is bordered by a combination of federal, Tribal and private land. Lake Havasu State Park and Picacho State Recreation Area are administered by the state of Arizona. Refuges managed by the FWS include Havasu National Wildlife Refuge (NWR), Bill Williams River NWR, Cibola NWR, and Imperial NWR. Indian reservations which are located along this river reach include the Fort Mojave, Chemehuevi, Colorado River Indian, Fort Yuma Indian, and Cocopah Indian reservations. The 23.7 mile long reach that extends between the NIB to the SIB also forms part of the international boundary with Mexico.

The individual reaches included between Hoover Dam and the SIB are:

- **Hoover Dam to Davis Dam.** This reach extends from Hoover Dam to Davis Dam and includes Lake Mohave up to its full-pool elevation. The approximately 67-mile length of this reach generally comprises Lake Mohave. The reach is bound for most of its length by the steep walls of Pyramid Canyon, El Dorado Canyon, and Black Canyon. Lake Mohave is relatively narrow, not more than four miles across at its widest point. A major feature located within this reach is the Willow Beach National Fish Hatchery which is located on the Colorado River approximately five miles downstream of Hoover Dam. The Willow Beach National Fish Hatchery is managed by the FWS and is used as a hatchery and for rearing razorback suckers and bonytail chub which are used for stocking nearby Lake Mohave and Lake Mead.

- **Davis Dam to Parker Dam.** This reach extends from Davis Dam to Parker Dam and includes Lake Havasu up to its full-pool elevation. Parker Dam is located approximately 155 miles downstream from Hoover Dam. The upper 39 miles of this reach comprises an open river reach. Lake Havasu, formed by Parker Dam, comprises the lower 45 miles of this reach and can store approximately 0.648 maf of water. At its maximum elevation of 450.5 feet msl, Lake Havasu has a surface area of approximately 20,390 acres.

  Several communities are located adjacent to this reach and include the cities of Laughlin, Needles, Bullhead City, and Lake Havasu City. The Fort Mojave and Chemehuevi Indian Reservations are also located within this reach. Other important features located within this reach include Topock Marsh and the Havasu NWR, both managed by the FWS. Topock Marsh is located on the Arizona side of the Colorado River midway between Davis Dam and Parker Dam and it is almost entirely within the Havasu NWR. Topock Marsh was created by backwaters resulting from the construction of Parker Dam. The Bill Williams River, a major tributary to the Colorado River, discharges to this reach at a point located just upstream of Parker Dam.

  Lake Havasu provides a forebay and desilting basin from which water is pumped into the Colorado River Aqueduct (California) and the CAP Aqueduct System (Arizona). The pumping plant that pumps water into the Colorado River Aqueduct is located on the west side of the river and operated by the MWD. The pumping plant that pumps water into the CAP Aqueduct is located on the east side of the river and is operated by the Central Arizona Water Conservation District (CAWCD).

- **Parker Dam to Cibola Gage.** This reach is approximately 105 miles long and extends from Parker Dam to Adobe Ruin and Reclamation’s Cibola Gage located at RM 87.3. The reach is generally channelized with the greater portion bound by levees. Several features located downstream of Parker Dam are also used to manage the flows in the river and make deliveries to the Colorado River water users that divert water downstream of Parker Dam. This includes the Palo Verde Diversion Dam and Headgate Rock Dam. Lake Moovalya, the reservoir impounded by Headgate Rock Dam, is located between Parker Dam and Headgate Rock Dam. Several communities are located adjacent to this reach and include the cities of Parker, Arizona and Blythe, California. The Colorado River Indian Reservation is also located within this reach, as is the Cibola NWR.

- **Cibola Gage to Imperial Dam.** This reach is approximately 38 miles long and extends from the Cibola Gage to Imperial Dam. The major features located within this reach include Senator Wash Dam, Martinez Lake, Imperial NWR, and Imperial Dam. Senator Wash Dam and Regulating Reservoir are located approximately two miles upstream of Imperial Dam on the California side of the Colorado River. This is an off-stream water storage reservoir that is used by Reclamation to facilitate water scheduling and to help in balancing the river flows and supply with demands. The Imperial Dam and the impoundment that it forms upstream of the dam is to raise the water surface of the river flows by approximately 25 feet to provide controlled gravity flow of water into the AAC and the Gila Gravity Main Canal. The AAC system diverts water from the California side of Imperial Dam and serves Imperial Irrigation District (IID), Coachella Valley Water District (CVWD), the Yuma Project in Arizona and California, and the City of Yuma. The Gila Gravity Main Canal system diverts water from the Arizona side of Imperial Dam and serves the north and south Gila Valley, Yuma Mesa, and Wellton-Mohawk area. Imperial Dam is also used to regulate deliveries to Mexico. The AAC Desilting Works, which is located adjacent to the AAC diversion structure, is used to remove most of the sediment carried by the Colorado River prior to the water entering the AAC. The Imperial NWR is located mostly on the Arizona side of the Colorado River. Martinez Lake is a small water cove formed by the impoundment and backwater are located above Imperial Dam.

- **Imperial Dam to NIB.** This reach extends from Imperial Dam to the NIB between the United States and Mexico. The entire extent of the channel within this reach is bound by a system of levees. Several features located downstream of Imperial Dam are also used to manage river flows and make deliveries to the Colorado River water users that divert water downstream of Imperial Dam. These features include Laguna Dam, Laguna Desilting Basin, Morelos Diversion Dam, California Wasteway, and Pilot Knob Wasteway. Other features include water conveyance system components (levees, bypass channels, wasteways, etc.), access roads, farmlands, and vegetation. Mittry Lake is also located on the Arizona side of the Colorado River. The Gila River, a major tributary of the Colorado River, also discharges to the river at a point located approximately nine miles downstream from Laguna Dam.

- Laguna Dam is located on the Colorado River some five miles downstream of Imperial Dam. The original purpose of this dam was to divert Colorado River water to the Yuma Project area. Laguna Dam now serves as a regulating structure for Colorado River water, for regulating sluicing flows from Imperial Dam, and for downstream toe protection for Imperial Dam. The reservoir created by Laguna Dam is commonly referred to as Laguna Reservoir.

Mittry Lake is located on the east side of the Colorado River between Laguna Dam and Imperial Dam. The Mittry Lake Wildlife Area generally surrounds and includes Mittry Lake and includes approximately 600 acres of water surface and 2,400 acres of marsh or upland. Numerous serpentine waterways connect to the main lake body. The Mittry Lake Wildlife Area is jointly managed by the BLM, Reclamation, and the Arizona Game and Fish Department.

The California Wasteway of the Yuma Main Canal is located approximately four miles downstream from the mouth of the Gila River. This wasteway returns to the river the water which is used to fulfill the 1944 Treaty obligation to Mexico. The Rockwood Heading, an old intake structure on the Alamo Canal, is located approximately two miles upstream from Morelos Diversion Dam. It is no longer used for an intake structure but it is used as a point of return for the Pilot Knob Powerplant and Wasteway from the AAC. Under normal operating procedures, a portion of the water scheduled to be delivered to Mexico is diverted at Imperial Dam, conveyed via the AAC, and then returned to the Colorado River through this wasteway.

- **NIB to SIB.** This reach extends from the NIB to the SIB and it is 23.7 miles long. This section of the Colorado River, referred to as the limitrophe section, serves as the international boundary between the United States and Mexico, and has levees on both sides.

  Located approximately 1.1 miles downstream of the NIB is Morelos Diversion Dam. This dam functions as a diversion control structure for the Alamo Canal, which conveys water to Mexico. The Morelos Diversion Dam and the limitrophe section the Colorado River channel, including the floodplain, are designed to convey a maximum flow of 140,000 cfs. Other major features located within this reach include water conveyance system components (levee, bypass channel, wasteways, etc.) and access roads.

3.2.2 Colorado River Water User Service Areas

In addition to the mainstream river reaches, certain service areas of Colorado River water users may be affected as a result of water management programs associated with the proposed federal action. These potential effects correspond to the following agency service areas.

3.2.2.1 Arizona Water Users, Central Arizona Project Service Area

The largest Arizona diversion of water is the CAP, which delivers water to contractors in the central part of the state. CAP's diversion is located at Lake Havasu. The CAWCD administers the CAP water diversions. The CAP has more than 80 customers that generally fall within three classifications of CAP users: municipal (e.g., cities such as Phoenix, Mesa, and Scottsdale), agricultural (irrigation districts such as the Maricopa-Stanfield Irrigation District), and Indian communities (12 tribes with Colorado River water allocations within Arizona). Table 3.2-2 provides a listing of the CAP users and Figure 3.2-3 presents the general service area of the CAP.

Figure 3.2-3
CAP Service Area

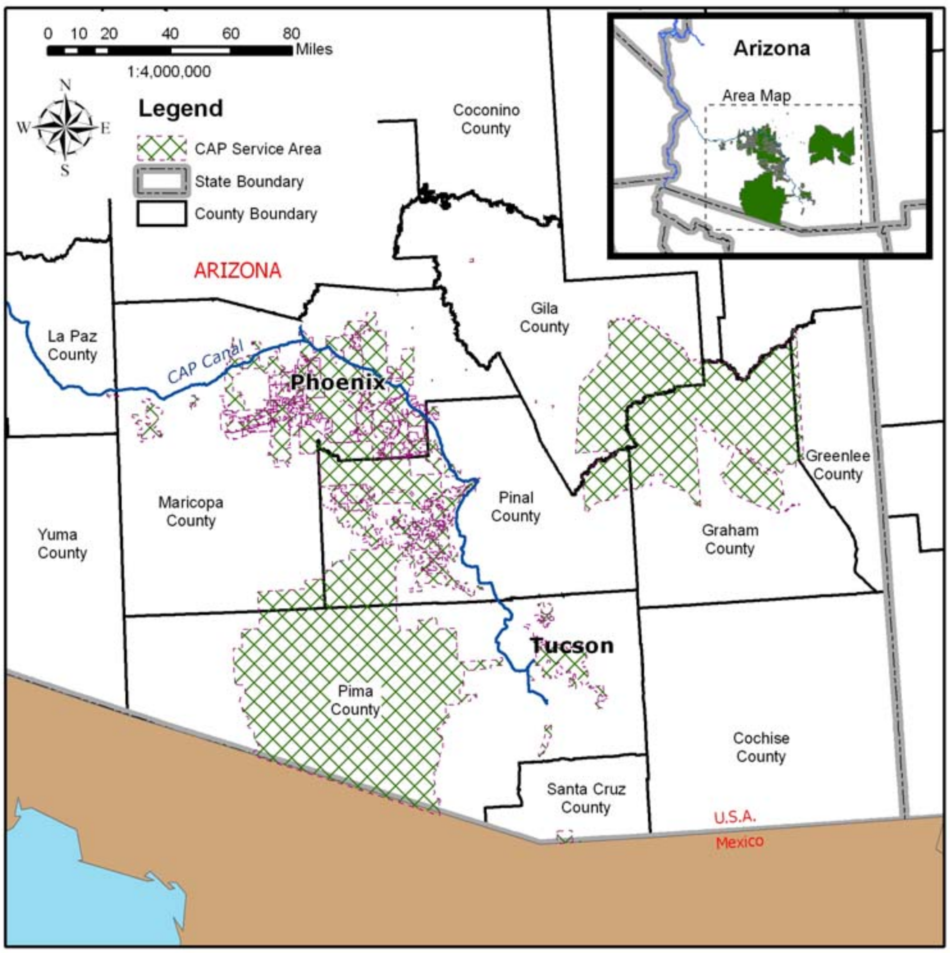


Table 3.2-2
CAP Water Users

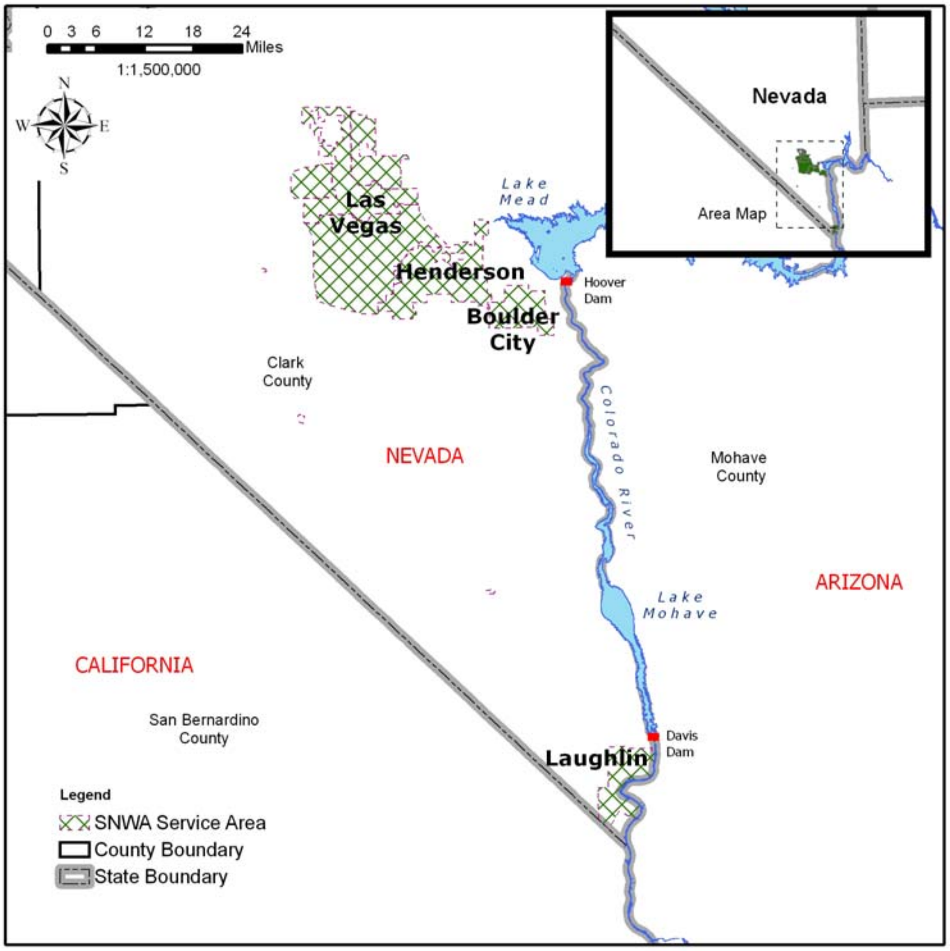
Ak-Chin Indian Community	Eloy	Salt River
Apache Junction (AZ Water Co)	Florence	San Carlos (Phelps Dodge/Globe)
ASARCO (Ray Mine)	Flowing Wells ID	San Carlos Apache
Avondale	Fort McDowell	San Tan ID
Avra Coop	Gila River	Scottsdale
AZ State Land Dept.	Gilbert	Spanish Trail Water Co
AZ-American (Agua Fria)	Glendale	Superior
AZ-American (Paradise Valley)	Goodyear	Surprise
AZ-American (Sun City West)	Green Valley DWID	Tempe
AZ-American (Sun City)	H2O Water Co	Tohono O'odham Chui Chu District
Berneil Water Co (Cave Creek)	Marana	Tohono O'odham San Xavier District
Buckeye	Maricopa County Parks & Rec	Tohono O'odham Schuk Toak District
CAGRD	MDWID	Tonto Apache
Carefree Water Co	Mesa	Tonto Hills Utility Co
Casa Grande (AZ Water Co)	Oro Valley	Tucson
Cave Creek Water Co	Pasqua Yaqui	Unallocated HVID
Chandler Heights Citrus ID	Peoria	Vail Water Co
Chandler	Phelps Dodge Miami	Valley Utilities Water Co
Chaparral City Water Co	Phoenix Memorial Park	Water Util. Comm. Fac. Dist. (AJ)
Circle City Water Co	Phoenix	Water Util. Greater Buckeye
Comm. Water Co (Green Valley)	Pine Water Co	Water Util. Greater Tonopah
Coolidge (AZ Water Co)	Queen Creek Water Co	White Tank Sys. (AZ Water Co.)
El Mirage	Rio Verde Utilities	Yavapai Apache (Camp Verde)
		Yavapai Prescott

AZ Arizona
ID Irrigation District

3.2.2.2 Southern Nevada Water Authority Service Area

Most of the Colorado River water use in Nevada occurs in the southern portion of Nevada, primarily within the Las Vegas Valley and the Laughlin area approximately 60 miles south. The largest diversion is associated with the Las Vegas Valley water users who pump water from Lake Mead at Saddle Island (on the west shore of the lake's Boulder Basin) through facilities of SNWA. The SNWA member agencies include: Big Bend Water District, Boulder City, Clark County Water Reclamation District, Henderson, Las Vegas, Las Vegas Valley Water District, and North Las Vegas (Figure 3.2-4).

Figure 3.2-4
SNWA Service Area

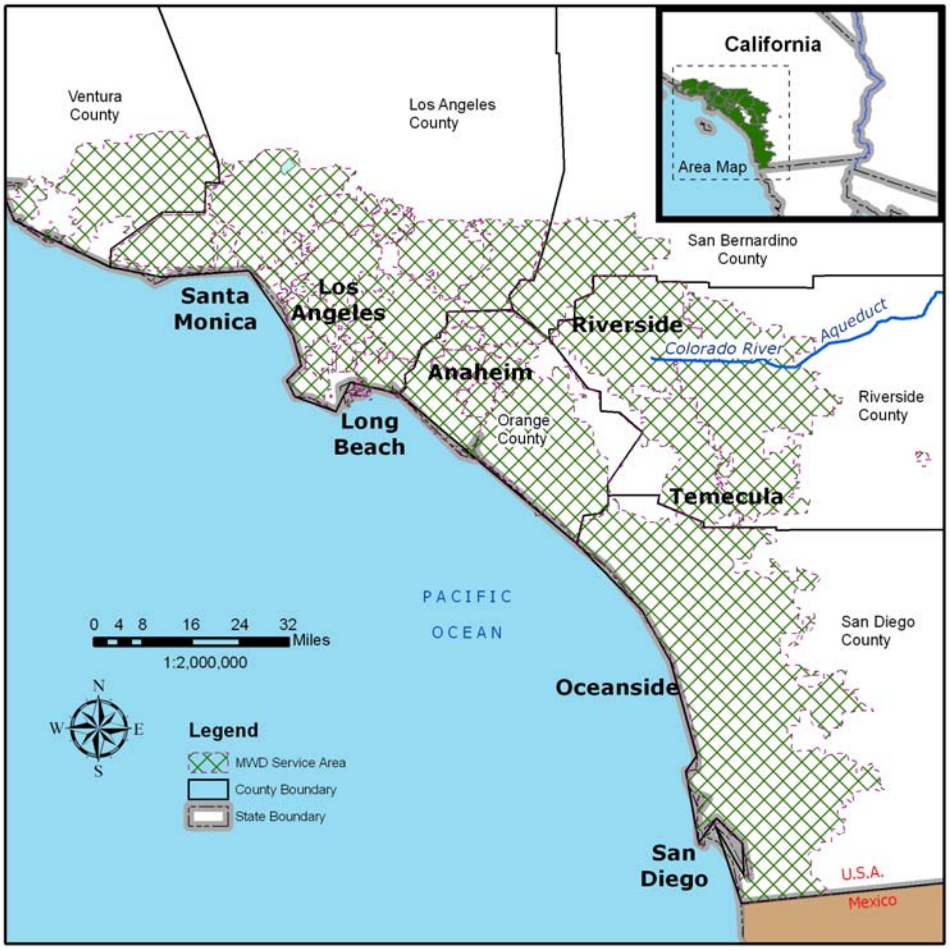


3.2.2.3 Metropolitan Water District of Southern California Service Area

MWD is a wholesale water agency that develops, stores, and distributes water to its member agencies. MWD owns and operates the Colorado River Aqueduct, which it uses to convey water from the Colorado River to its service area. MWD's Colorado River Aqueduct diversion is located at Lake Havasu.

MWD's service area covers the Southern California coastal plain. The total area served is nearly 5,200 square miles, and it includes portions of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties. MWD is currently composed of 26 member agencies, including 14 cities, 11 municipal water districts, and one county water authority. Figure 3.2-5 shows the member agencies of MWD and the cities and communities served by those member agencies.

Figure 3.2-5
MWD Service Area



3.3 Hydrologic Resources

Hydrologic resources within the study area that could potentially be affected by implementation of the proposed federal action include:

- reservoir storage, reservoir releases, and corresponding changes in Colorado River flows downstream of the reservoirs; and
- groundwater located within the Colorado River corridor and/or off-stream.

This section presents an overview of the hydrology of the Colorado River Basin, followed by descriptions of potentially affected hydrologic resources by river reach, from Lake Powell to the SIB.

A detailed description of the system facilities and current operations is provided in Appendix B. Water supply and water quality resources are discussed in Section 3.4 and Section 3.5, respectively.

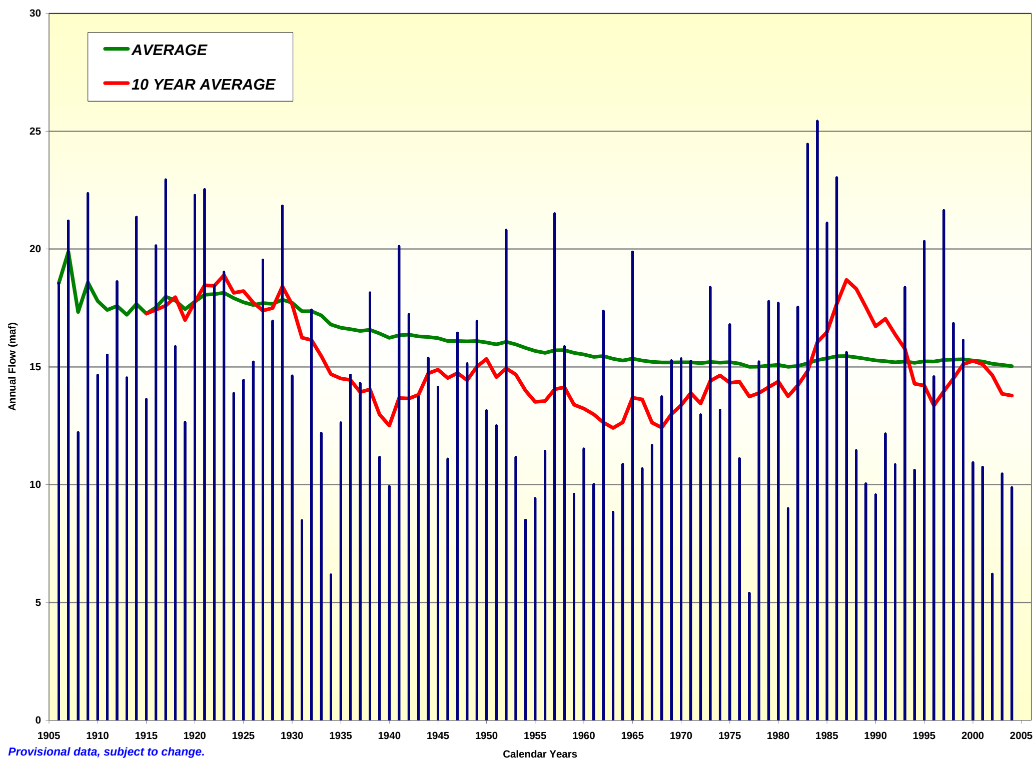
3.3.1 Hydrologic Overview

Inflows into Lake Powell originate from the mainstream of the Colorado River, the Green River, and the San Juan River. Although most of the Colorado River Basin is comprised of desert or semi-arid rangelands, which generally receive less than 10 inches of precipitation per year, many of the mountainous areas that rim the Upper Basin receive, on average, over 40 inches of precipitation per year. Most of the total annual flow in the Colorado River Basin is the result of runoff from mountain snowmelt. As such, river flows are typically very high in the late spring and early summer and diminish rapidly by mid-summer. While flows in late summer through autumn sometimes increase following rain events, flow in the late summer through winter is generally low.

Due to variability in climatic conditions, natural flow in the system is highly variable from year to year. Natural flow is an estimate of the flow that would exist at a specific point in a natural setting, without upstream storage, alteration or depletion by humans. About 92 percent of the total natural flow in the lower Colorado River originates in only 15 percent of the watershed — in the mountains of Colorado, Utah, Wyoming and New Mexico. While the average annual natural flow from 1906 through 2004 at Lees Ferry Gaging Station in Arizona is calculated as approximately 15.024 maf, annual flows have ranged between 5.399 maf and 25.432 maf.

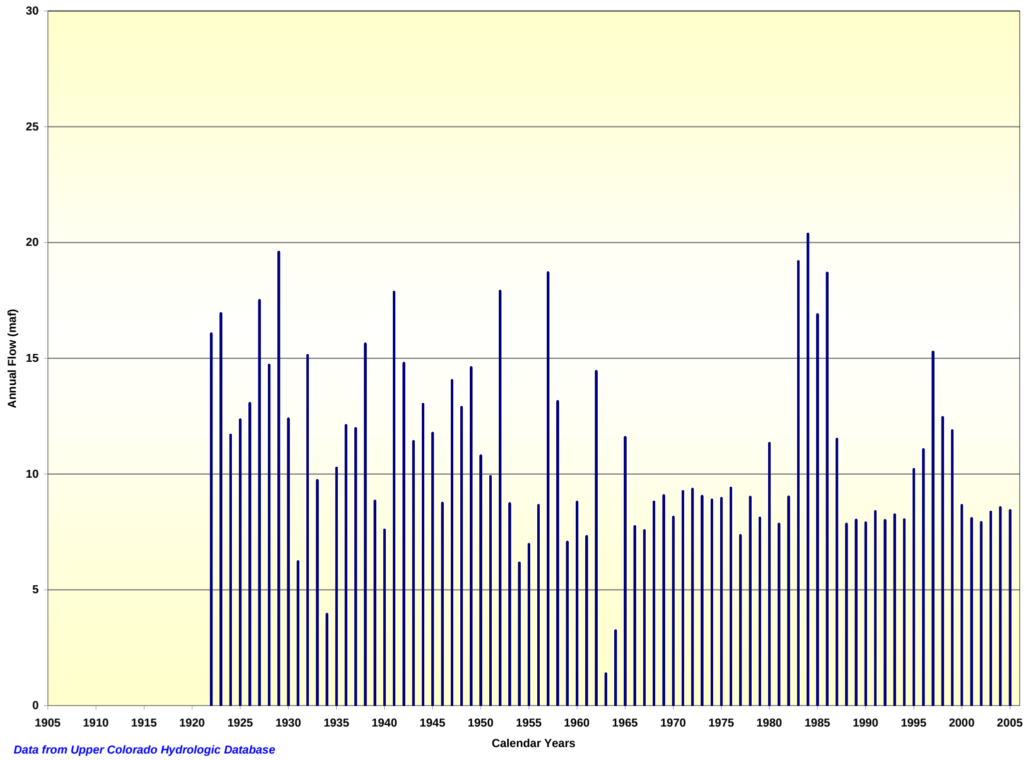
The natural flow calculated at Lees Ferry Gaging Station from 1906 through 2004 is shown in Figure 3.3-1. By comparison, the observed flows recorded at Lees Ferry Gaging Station for the period 1922 through 2005 are shown in Figure 3.3-2. The natural flow has been calculated from the observed flow by correcting for upstream reservoir changes in storage and release, losses including evaporation, as well as depletions due to agriculture and domestic uses (Reclamation 2005). The natural flow record at the Lees Ferry Gaging Station has also been extended from 1922 back to 1906 by using other observed records (Lee / Salas 2006).

Figure 3.3-1
Natural Flow of the Colorado River at Lees Ferry Gaging Station, Arizona
1906 through 2004



The natural flow calculated at Lees Ferry Gaging Station from 1906 through 2004 is shown in Figure 3.3-1. By comparison, the observed flows recorded at Lees Ferry Gaging Station for the period 1922 through 2005 are shown in Figure 3.3-2. The natural flow has been calculated from the observed flow by correcting for upstream reservoir changes in storage and release, losses including evaporation, as well as depletions due to agriculture and domestic uses (Reclamation 2005). The natural flow record at the Lees Ferry Gaging Station has also been extended from 1922 back to 1906 by using other observed records (Lee / Salas 2006).

Figure 3.3-2
Historic Annual Flow of the Colorado River at Lees Ferry Gaging Station, Arizona
1922 through 2005



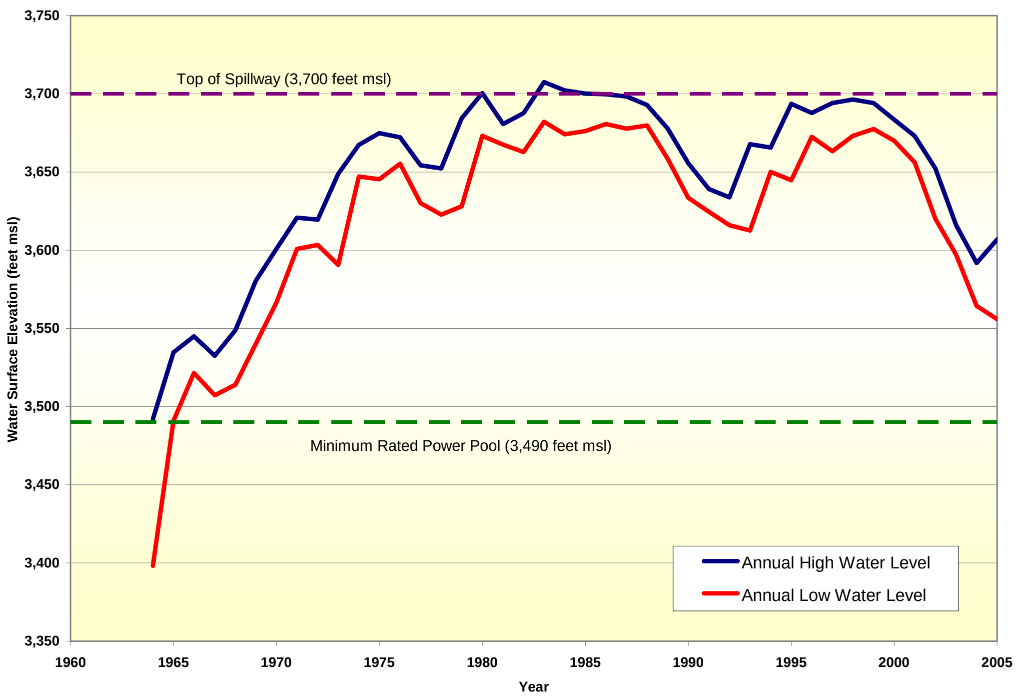
3.3.2 Lake Powell and Glen Canyon Dam

Lake Powell is the reservoir impounded by Glen Canyon Dam. Glen Canyon Dam and Lake Powell are operated consistent with the Colorado River Project Storage Act, the authoring legislation, which states that the purpose of the project is "to initiate the comprehensive development of the water resources of the Upper Colorado River Basin, for the purposes, among others, of regulating the flow of the Colorado River, storing water for beneficial consumptive use, making it possible for the States of the Upper Basin to utilize, consistently with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact and the Upper Colorado River Basin Compact, respectively, providing for the reclamation of arid and semiarid land, for the control of floods, and for the generation of hydroelectric power, as an incident of the foregoing purposes, to construct, operate, and maintain… "Additionally, some water deliveries are made directly from Lake Powell (e.g., for the city of Page, Arizona and for the Navajo Generating Station's cooling water).

The operating range of Lake Powell is between elevations 3,490 and 3,700 feet msl. Elevation 3,490 feet msl corresponds to minimum power pool. Releases from Glen Canyon Dam can be made below elevation 3,490 feet msl down to elevation 3,370 feet msl through the river bypass tubes. Elevation 3,700 feet msl corresponds to the top of the spillway radial gates, with the crest of each spillway at elevation 3,648 feet msl. The crest of Glen Canyon Dam itself is at elevation 3,715 feet msl.

Lake Powell began filling in 1962 and reached a high elevation of 3,708.34 feet msl in 1983. The elevation of the reservoir has ranged from an elevation of approximately 3,400 feet msl in 1964 to the 1983 maximum high elevation of 3,708.34 feet msl, as shown in Figure 3.3-3. The fluctuations in Lake Powell elevations are primarily the result of the highly variable hydrologic inflows into the Upper Basin as discussed in Section 1.7.

Figure 3.3-3
Historic Annual Lake Powell Water Levels
(Annual Highs and Lows)



Under the proposed federal action, future elevations of Lake Powell are expected to be within the range of historic water levels. However, the amount of time that the reservoir may be at any given elevation in the future may be affected by the proposed federal action. These potential effects are analyzed and discussed in Section 4.3.

Releases from Glen Canyon Dam are scheduled on an annual, monthly and hourly basis. The annual volume of water released from Glen Canyon Dam is made according to the provisions of the LROC that includes a minimum objective release of 8.23 maf, storage equalization between Lake Powell and Lake Mead under prescribed conditions, and the avoidance of spills. Annual releases from Lake Powell greater than the minimum objective release occur if Upper Basin storage is greater than the storage required by Section 602(a) of the CRBPA, if storage in Lake Powell is greater than the storage in Lake Mead, and to avoid anticipated spills (Appendix A).

Monthly release decisions are generally made to meet intermediate targets needed to systematically achieve the annual operating requirements, comply with the coordinated operation requirements of the CRBPA, and provide other authorized project benefits. The actual volume of water released from Lake Powell each month depends on the forecast inflow, storage targets, and annual release requirements described above. Demand for energy is also considered and accommodated within the constraints described above.

Glen Canyon Dam is operated consistent with the 1996 Glen Canyon Dam ROD (62 C.F.R. pt. 9447) developed as directed under the Grand Canyon Protection Act of 1992. The 1996 Glen Canyon Dam ROD describes criteria to ensure Glen Canyon Dam is operated in a manner consistent with the Grand Canyon Protection Act of 1992. The daily and hourly release constraints of Glen Canyon Dam are as shown in Table 3.3-1.

Table 3.3-1
Glen Canyon Dam Release Constraints

Parameter	Release Volume (cfs)	Conditions
Maximum Flow[1]	25,000	
Minimum Flow	5,000	Nighttime
	8,000	7:00 a.m. to 7:00 p.m.
Ramp Rates		
Ascending	4,000	Per hour
Descending	1,500	Per hour
Daily Fluctuations[2]	5,000 to 8,000	

1 May be exceeded for emergency and during extreme hydrological conditions.

2 Daily fluctuation limit is 5,000 cubic feet per second (cfs) for months with release volumes less than 0.6 maf; 6,000 cfs for monthly release volumes of 0.6 maf to 0.8 maf; and 8,000 cfs for monthly volumes over 0.8 maf.

Future daily and hourly releases are expected to continue to be made according to the parameters of the 1996 Glen Canyon Dam ROD and will not be affected by the proposed federal action. However, the annual minimum release as well as the monthly distribution of releases may be affected; these potential effects are analyzed and discussed in Section 4.3.

In addition to the daily and hourly release constraints discussed previously, the 1996 Glen Canyon Dam ROD implemented an Adaptive Management Program that provides a process for assessing the effects of Glen Canyon Dam operations on downstream resources, and by using the results to develop recommendations to the Secretary with regard to Glen Canyon Dam operations and other resource management actions. These recommendations have included releases for sediment conservation (i.e., BHBF), modification of powerplant fluctuations, non-native fish removal, and native fish translocation. Recommendations are developed by the AMWG, a federal advisory committee. Long-term monitoring and research activities provide a continuous record of resource conditions for use in evaluating the effectiveness of any subsequent actions.

3.3.3 Glen Canyon Dam to Lake Mead

The segment of the Colorado River between Glen Canyon Dam and Lake Mead is a narrow river corridor through Marble Canyon, Glen Canyon, and Grand Canyon. The flows in this river reach are primarily from the controlled releases from Glen Canyon Dam (Lake Powell) with contributions from the tributaries between Glen Canyon Dam and Lake Mead. Releases from Glen Canyon Dam are managed as discussed in the previous section.

The Paria River and the Little Colorado River are the major tributaries that discharge to the Colorado River within this reach. The Paria River is a perennial stream and provides the principal drainage for the Painted Desert. The Little Colorado River is also a perennial stream and it drains the rugged and arid region southeast of the Colorado River.

Inflows from these two tributaries are variable and on average provide less than three percent of the total flow in this reach. For the 99-year period from 1906 through 2004, the annual inflow from the Little Colorado River ranged from 17 kaf to 643 kaf and averaged 179 kafy. During this same period, the annual inflow from the Paria River ranged from 9 kaf to 48 kaf and averaged 20 kafy. By contrast, the annual release from Glen Canyon Dam from 1996 to 2005 ranged from 7,795 kaf to 15,289 kaf and averaged 9,975 kafy.

The daily and hourly releases from Glen Canyon Dam and therefore the daily and hourly flows in this reach will not be affected by the proposed federal action. However, the monthly and annual flows in this reach may be affected; these potential effects are analyzed and discussed in Section 4.3.

Groundwater in hydraulic connection with the Colorado River in the Grand Canyon is limited to sandbars. Due to the incised nature of this river corridor, there are no anticipated groundwater related issues that need to be considered.

3.3.4 Lake Mead and Hoover Dam

Lake Mead is the reservoir impounded by Hoover Dam and in accordance with the BCPA, is operated to meet the following priorities:

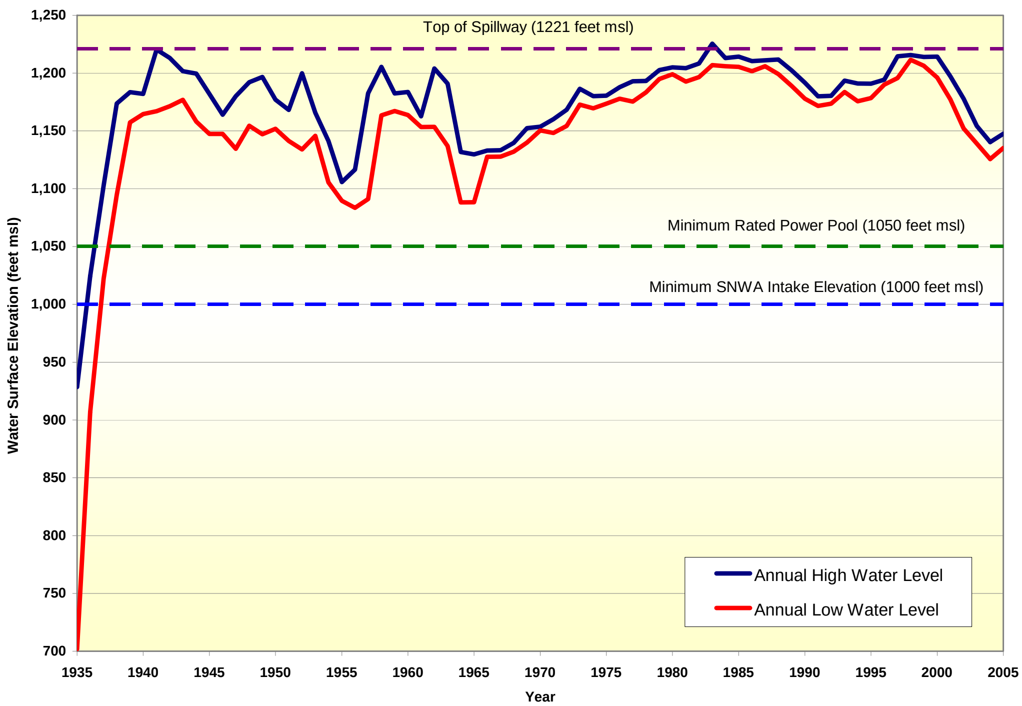
1) to provide river regulation, improvement of navigation, and flood control;

2) to provide water to meet irrigation and domestic uses, including the satisfaction of present perfected water rights; and

3) to generate hydropower.

The typical operating range of Lake Mead is between elevations 1,219.6 and 1,050 feet msl. Elevation 1,050 feet msl corresponds to the minimum power pool. Releases through the turbines can be made from Hoover Dam below elevation 1,050 feet msl down to 895 feet msl through the intake towers, although the turbines currently in place would require modification or replacement to consistently generate hydropower below elevation 1,050 feet msl. The crest of the spillways is at elevation 1,205.4 feet msl and the top of the raised spillway gates is at elevation 1,221.0 feet msl. The storage space above elevation 1,219.6 feet msl is reserved exclusively for flood control purposes. Since its initial filling in the late 1930s, the Lake Mead elevations have fluctuated from a high of 1,225.8 feet msl in July 1983 to a low of 1,083.2 feet msl in April 1956, as illustrated in Figure 3.3-4.

Figure 3.3-4
Historic Annual Lake Mead Elevations
(Annual Highs and Lows)



Future Lake Mead elevations may be affected by the proposed federal action. These potential effects are analyzed and discussed in Section 4.3.

Lake Mead's annual release is determined either by strict flood control regulations or to meet the water use apportionments to the Lower Division states and allotment to Mexico.

The USACE is responsible for developing the flood control operation plan for Hoover Dam and Lake Mead (33 C.F.R. pt. 208.11) and the Secretary is responsible for operating Hoover Dam in accordance with these regulations. The current regulations were implemented under the Field Working Agreement[1] which set forth criteria to meet system space requirements in the fall (August through December) and to determine reservoir releases during the spring runoff season (January through July). During all months of the year, the top 1.5 maf of space (the space above elevation 1,219.6 feet msl) is reserved exclusively for flood control purposes. Lake Mead is considered to be under flood control operations when the regulations determine that releases need to be made in excess of those necessary to meet water use demands in order to make available this flood control space.

Water use demands are determined by the apportionments to each Lower Division state and Mexico. For the Lower Division states, the Secretary determines the water supply condition for each year (Surplus, Normal, or Shortage), as specified by the Consolidated Decree and the LROC. Under Normal conditions, water is delivered to meet a total of 7.5 maf of use by the Lower Division states. Under Surplus conditions, additional water can be made available for consumptive use in the Lower Division states. Adopted in 2001 and extending through 2016, the ISG provide additional guidance on the amount and use of surplus water depending upon Lake Mead's elevation and other factors. Under Shortage conditions, an amount of water less than 7.5 maf would be made available for use by the Lower Division states. However, as noted in Section 1.3 there are currently no guidelines with regard to when and by how much water supplies would be reduced.

In addition to the releases to meet the Lower Division states' consumptive use, releases are made from Hoover Dam to meet Mexico's water schedule. In accordance with the 1944 Treaty, Mexico can schedule a total delivery of 1.5 maf each year and under current practice, up to an additional 200 kaf during flood control years when and the water supply exceeds the needs of Colorado River water users in the United States.

During non-flood control operations, the end-of-month Lake Mead elevations are driven by water needs pumped from and delivered below Hoover Dam and releases from Glen Canyon Dam, and tributary inflows. Lake Mead end-of-month target elevations are not fixed as are the end-of-month target elevations for Lake Mohave and Lake Havasu. Normally, Lake Mead elevations decline with increasing irrigation deliveries through June and July and then rise slightly by November and December.

[1] Field Working Agreement between the Department of the Interior, Bureau of Reclamation and USACE for Flood Control Operation of Hoover Dam and Lake Mead, Colorado River, Nevada-Arizona, February 8, 1984.

Hoover Dam releases are managed on an hourly basis to maximize the value of generated power by providing peaking during high-demand periods. The monthly release is determined based on water demands and is converted to a monthly energy target. The Hoover Dam powerplant is run on a real-time basis to meet fluctuating energy and capacity demands while meeting the end-of-month energy target. This results in fluctuating hourly flows below Hoover Dam that can typically vary from 1,000 cfs to 49,000 cfs. However, these flows are regulated by Lake Mohave immediately downstream. For the 10-year period from 1996 to 2005, annual releases from Hoover Dam have ranged from 8.275 maf to 12.776 maf and averaged 10.380 mafy.

Hourly and daily releases from Hoover Dam will not be affected by this proposed federal action. However, the proposed federal action may alter the annual release as well as the monthly distribution of those releases. These potential effects are analyzed and discussed in Section 4.3.

3.3.5 Hoover Dam to Davis Dam

The 67-mile reach from Hoover Dam to Davis Dam is dominated by Lake Mohave, the reservoir formed by Davis Dam. The upper part of this reach is bounded by the steep walls of Pyramid Canyon, El Dorado Canyon, and Black Canyon. Lake Mohave is relatively narrow, not more than four miles across at its widest point. At the high reservoir elevations (635 feet msl), the backwater from Lake Mohave affects the river stage (known as the tailbay) just downstream of Hoover Dam. Although there are some minor side washes in this river reach, the flows in this reach are comprised almost entirely of releases from Hoover Dam.

The hourly and daily operation of Hoover Dam will not be affected by the proposed federal action. As such, the hourly and daily flows through this river reach will also not be affected.

Although the annual and monthly releases from Hoover Dam may be affected by the proposed federal action, Lake Mohave will continue to be operated to meet monthly target elevations as explained in Appendix B. Lake Mohave generally reaches its maximum elevation in the spring and its minimum elevation in the fall. Reclamation generally lowers the lake level in the fall to provide flood control storage space for runoff that results from large hurricane-type storms coming up-river from Baja California, Mexico. The minimum elevation of Lake Mohave under future conditions will continue to be about 630 feet msl. The maximum target elevation will continue to be 646.5 feet msl. Therefore, the proposed federal action will not change the range of elevations that have been historically observed in Lake Mohave. Combined with the extent of this reach occupied by Lake Mohave, these potential changes in Hoover Dam monthly and annual releases will have no effect on this reach.

The upper section of this reach is the narrow Black Canyon immediately below Hoover Dam. Groundwater connected to the river in this bedrock canyon is limited to a few small sandbars. The rest of this reach is dominated by Lake Mohave. As noted above, the proposed federal action will have no effect on the operation of Lake Mohave or the elevations in this reservoir. Therefore, there are no anticipated effects of the proposed federal action to these groundwater basins.

3.3.6 Davis Dam to Parker Dam

This reach is approximately 84 miles long and it is bounded downstream by Parker Dam which forms Lake Havasu. Lake Havasu provides a forebay and desilting basin from which water is pumped into aqueducts for delivery to the MWD and CAP service areas. Above Lake Havasu, there are some minor tributaries. However, the flows in the reach are comprised almost entirely of releases from Davis Dam.

The largest tributary in this reach is the Bill Williams River, which flows directly into Lake Havasu. Inflows from the Bill Williams River are regulated by USACE operations of Alamo Dam upstream and are typically small (on the order of 50 cfs). Larger flows from the Bill Williams River are concentrated over short periods of time and are due to flood control operations at Alamo Dam. For the 99-year period from 1906 to 2004, the annual inflow to the Colorado River mainstream from the Bill Williams River ranged from 1.3 kaf to 702 kaf and averaged 98 kafy. By contrast, during the 10-year period from 1996 to 2005, the annual releases from Davis Dam ranged from 8.000 kaf to 12.587 kaf, and averaged approximately 10.092 kafy.

Releases from Davis Dam are scheduled on a daily and hourly basis, primarily to meet downstream water needs, although the hourly release pattern is typically shaped to meet demand for power. Releases can range from a maximum of 28,000 cfs to a minimum of about 1,000 cfs, the minimum flow needed to run one turbine at about one-half capacity. Such low flows are usually associated with downstream flooding, construction, search and rescue, or other emergency conditions.

The ranges of hourly releases from Davis Dam and the corresponding ranges of flows in this river reach will not be affected by this proposed federal action. However, the shape and duration of hourly flows and the corresponding daily, monthly, and annual flows may be affected; these potential effects are analyzed and discussed in Section 4.3.

Although releases from Davis Dam may be affected by the proposed federal action, Lake Havasu will continue to be operated to meet monthly target elevations as explained in Appendix B.

Lake Havasu generally reaches its maximum elevation in the spring and its minimum elevation in the winter. Similar to Lake Mohave, Reclamation generally lowers the lake level during the winter months to provide flood control storage space for runoff that results from large storms coming up-river from Baja California, Mexico. The minimum elevation of Lake Havasu under future conditions will continue to be about 445.8 feet msl. Reclamation attempts to accommodate this minimum target elevation when other higher priority uses are not compromised. The maximum target elevation will continue to be 450.5 feet msl. Therefore, the proposed federal action will not affect the range of historically observed Lake Havasu elevations.

The Davis Dam to Parker Dam reach of the Colorado River flows through two separate groundwater basins. The bedrock Topock Narrows separates the Mohave Valley to the north of the narrows from the Chemehuevi Valley to the south. On the Arizona side, the valley south of Topock Narrows is called the Lake Havasu basin.

The aquifer in Mohave Valley is mostly alluvial fill deposited by both the river and the washes draining to the river from the mountains bounding the valley, and may be affected by the proposed federal action. The potential effects due to the potential change in river flows are in this segment of this river reach are analyzed and discussed in Section 4.3.

The portion of the river reach that is located within the Chemehuevi Valley and the Lake Havasu basin is dominated by Lake Havasu. As noted above, the proposed federal action will have no effect on the operation of Lake Havasu or the elevations in this reservoir. Therefore, there are no anticipated effects of the proposed federal action to the groundwater basins underlying the Chemehuevi Valley and the Lake Havasu basin.

3.3.7 Parker Dam to Cibola Gage

This reach is approximately 105 miles long and it is bounded by Reclamation's Cibola Gage at RM 87.3 downstream. Although there are some minor drainages, flows in this reach are almost entirely comprised of releases from Parker Dam to meet water delivery requirements in the United States and Mexico.

Similar to Davis Dam, releases from Parker Dam are scheduled on daily and hourly basis, primarily to meet downstream water needs, although the hourly release pattern is typically shaped to meet demand for power. Releases can range from a maximum of 16,800 cfs to a minimum of about 1,000 cfs, the minimum flow needed to run one turbine at about one-half capacity. Such low flows are usually associated with downstream flooding, construction, search and rescue, or other emergency conditions. For the 10-year period from 1996 to 2005, annual releases from Parker Dam have ranged from 6.185 maf to 10.344 maf and averaged 7.578 mafy.

The ranges of hourly releases from Parker Dam and the corresponding ranges of flows in this river reach will not be affected by this proposed federal action. However, the shape and duration of hourly flows and the corresponding daily, monthly, and annual flows may be affected; these potential effects are analyzed and discussed in Section 4.3.

Impoundments associated with the two major diversion dams located in this reach (Headgate Rock Dam, diverting water for use by the Colorado River Indian tribes, and Palo Verde Diversion Dam, diverting water for use by the Palo Verde Irrigation District) are operated at nearly constant levels in order to facilitate the diversion of water. These facilities will continue to be operated in this same manner and therefore, the elevations of these impoundments will not be affected by the proposed federal action. However, releases from the diversion dams may be affected; these potential effects are analyzed discussed and analyzed in Section 4.3.

The Colorado River from Parker Dam to Cibola Gage flows through one very large groundwater basin but it is typically referred to by separate valley names (Parker Valley, Cibola Valley, and Palo Verde Valley). The aquifer underlying these valleys is mostly alluvial fill deposited by the river and secondarily by the washes draining to the river from the mountains bounding the valleys. The potential effects due to the potential change in river flows are analyzed and discussed in Section 4.3.

3.3.8 Cibola Gage to Imperial Dam

This reach is approximately 38 miles long and it is bounded by Imperial Dam downstream. Although there are some minor drainages, flows in this reach are almost entirely comprised of the water released from Parker Dam reduced by upstream depletions, including diversions of water for the Colorado River Indian tribes and the Palo Verde Irrigation District.

The ranges of hourly releases from Parker Dam and the corresponding ranges of flows in this river reach will not be affected by this proposed federal action. However, the shape and duration of hourly flows and the corresponding daily, monthly, and annual flows may be affected; these potential effects are analyzed and discussed in Section 4.3.

The impoundment associated with Imperial Dam is operated at a nearly constant level in order to facilitate the diversion of water. The AAC diverts water from the California side of Imperial Dam and serves IID, CVWD, the Yuma Project in Arizona and California, the City of Yuma, and Mexico. The Gila Gravity Main Canal system diverts water from the Arizona side of Imperial Dam and serves the north and south Gila Valley, Yuma Mesa, and Wellton-Mohawk area. This facility will continue to be operated in this same manner and therefore, the elevations of this impoundment will not be affected by the proposed federal action.

Senator Wash, an off-stream reservoir just upstream of Imperial Dam is used to store and release mainstream water to meet demands at Imperial Dam. It will continue to be operated in the same manner to manage water deliveries and will not be affected by the proposed federal action.

The Colorado River from the Cibola Gage to Imperial Dam flows through a relatively narrow alluvial fill valley. There is no irrigated agriculture along this reach and there are many backwaters, especially in the southern half of the reach. The potential effects due to the potential change in river flows are analyzed and discussed in Section 4.3.

3.3.9 Imperial Dam to NIB

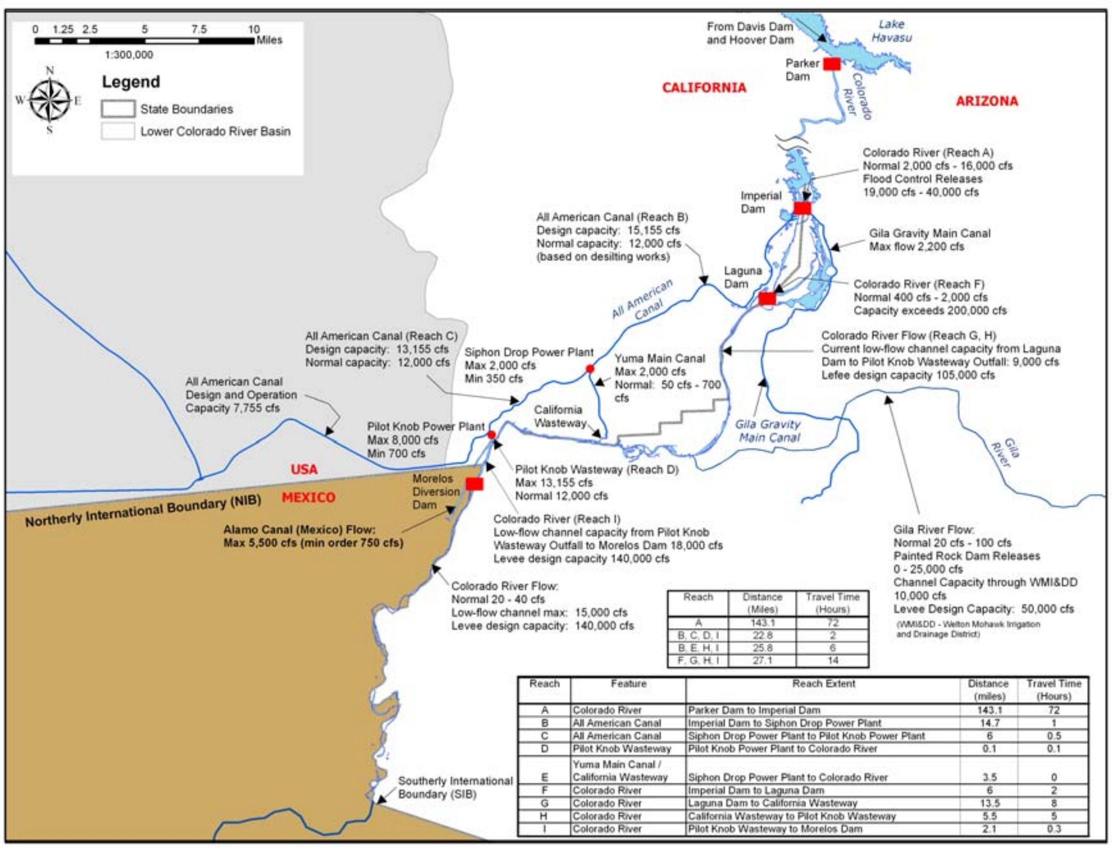
This reach is approximately 26 miles long and is bounded by the NIB downstream. Excluding inflows from the confluence of the Gila River, flows in this reach are comprised primarily of water that has leaked or been released from Imperial Dam and return flows from water diverted at Imperial Dam.

The flows in the upper portion of this reach (just below Imperial Dam) typically range from about 250 cfs to 350 cfs and are comprised principally of return flows from the AAC desilting basins, gate leakage from the California sluiceway gates at Imperial Dam, and occasional small releases to meet Mexico’s scheduled water deliveries at the NIB. In addition, water may be released to remove sediment accumulated from the desilting basins in the sluiceway channel (known as “sluicing flows”). These flows occur two to three times per month, may range from 8,000 cfs to 12,000 cfs, and the duration may be up to 20 minutes. Laguna Dam, just downstream of Imperial Dam, is used to capture these sluicing flows for subsequent delivery downstream. These operations and the flows in the upper portion of the reach will not be affected by the proposed federal action.

The drainage return flows originate from the irrigated lands located in the Yuma area and are nearly constant throughout the year and from year to year. These drainage return flows comprise both gravity and pumped drainage flows and are not expected to be affected by the proposed federal action.

Most of Mexico's scheduled delivery at the NIB is diverted at Imperial Dam into the AAC and returned to the river through the Pilot Knob and Siphon Drop Powerplants and their respective wasteway channels, 2.1 miles and 7.6 miles upstream of the NIB, respectively. Mexico diverts that water at Morelos Diversion Dam which it owns, operates, and maintains. Figure 3.3-5 show how water deliveries to Mexico pursuant to the 1944 Treaty are routed from Imperial Dam to the NIB, as well as the source and routing of other flows that occur between Imperial Dam and the NIB. The proposed federal action will not alter the operation of these diversions and wasteways.

Figure 3.3-5
Water Routing from Imperial Dam to NIB
Deliveries to Mexico Pursuant to the 1944 Treaty



Reach	Distance (Miles)	Travel Time (Hours)
A	143.1	72
B, C, D, I	22.8	2
B, E, H, I	25.8	6
F, G, H, I	27.1	14

Reach	Feature	Reach Extent	Distance (miles)	Travel Time (Hours)
A	Colorado River	Parker Dam to Imperial Dam	143.1	72
B	All American Canal	Imperial Dam to Siphon Drop Power Plant	14.7	1
C	All American Canal	Siphon Drop Power Plant to Pilot Knob Power Plant	6	0.5
D	Pilot Knob Wasteway	Pilot Knob Power Plant to Colorado River	0.1	0.1
E	Yuma Main Canal / California Wasteway	Siphon Drop Power Plant to Colorado River	3.5	0
F	Colorado River	Imperial Dam to Laguna Dam	6	2
G	Colorado River	Laguna Dam to California Wasteway	13.5	8
H	Colorado River	California Wasteway to Pilot Knob Wasteway	5.5	5
I	Colorado River	Pilot Knob Wasteway to Morelos Dam	2.1	0.3

The Gila River is highly regulated and although inflows from the Gila River to the mainstream of the Colorado River have averaged approximately 250 kafy over the past 75 years, these inflows occur very sporadically and they are of very high magnitudes. These inflows are not expected to be affected by the proposed federal action.

Groundwater basins proximal to the Colorado River within this reach include portions of the Yuma Valley and the South Gila Valley. With the exception of the Yuma Valley, these basins are generally small in size and are bounded by zones of non-water-bearing rock. As noted above, the method used to route water from Imperial Dam to the NIB bypasses most of the river channel and the proposed federal action will not affect these operations. Therefore, the portions of the groundwater basins adjacent to this reach are not anticipated to be affected by the proposed federal action.

3.3.10 NIB to SIB

Mexico diverts the majority of its Colorado River water supply at Morelos Diversion Dam, and only limited flows occur in the river reach that extends between Morelos Diversion Dam and SIB. These flows may occur as a result of:

1) seepage from Morelos Diversion Dam;

2) water in excess of Mexico’s scheduled delivery (e.g. flood flows, cancelled orders in the United States) not diverted by Mexico and released from Morelos Diversion Dam;

3) irrigation return flows from Mexico and the United States; and

4) groundwater accumulation from both the United States and Mexico.

Water released from Parker Dam, under orders from irrigation districts in Imperial Valley, Coachella Valley, and the lower Colorado River Valley, normally takes up to three days to reach its point of diversion. Occasionally, unforeseen events such as localized precipitation force the irrigation districts to cancel these water delivery orders after the water has been released at Parker Dam. Usually, the water is diverted at Morelos Diversion Dam for use in Mexico. However, some of this water may flow past Morelos Diversion Dam. The proposed federal action will not affect water that flows past the NIB as a result of canceled water orders.

Morelos Diversion Dam forms an impoundment that facilitates Mexico’s diversion of water from the Colorado River. The elevation of this impoundment is maintained at a nearly constant level in order to facilitate the diversion of water by Mexico. It is anticipated that Mexico will continue to operate Morelos Diversion Dam and this impoundment in this same manner, and therefore, elevations of this impoundment will not be affected by the proposed federal action. Accordingly, the rate of seepage that occurs at Morelos Diversion Dam will not be affected by the proposed federal action.

Gila River flood events reaching the mainstream of the Colorado River are rare. Only once has flow been recorded over 4,000 cfs at the Dome Gaging Station, Arizona, since 1941. In 1993, up to 27,500 cfs flowed past the Dome Gaging Station as a result of the 1993 Gila River flood (USGS 1999). The 1993 flood created much of the habitat presently found along the Colorado River below its confluence with the Gila River (Glenn 2000). The proposed federal action will not affect water that flows past the NIB as a result of Gila River flood events.

Excess flows to Mexico are almost entirely due to flood control releases originating at Hoover Dam. These flood control releases are dictated by the flood control criteria established for Lake Mead and Hoover Dam and are largely dependent upon hydrologic conditions. The proposed federal action may affect the frequency and magnitude of flood control operations that originate at Hoover Dam due to potential changes in reservoir storage that occurs under the different action alternatives. These potential effects are analyzed and discussed in Section 4.3.

The Colorado River from the NIB to the SIB flows through the large and deep Colorado River delta groundwater basin. The upper portion of this reach is a gaining reach, which means that groundwater enters the channel and provides a portion of the river flow. This occurs because the high groundwater level in the adjacent lands has a sloping gradient that intercepts the channel. The proposed federal action is not expected to affect this gaining reach because the high groundwater levels occur due to application of water on the adjacent irrigated lands, a condition that will remain unchanged.

The lower part of this reach is a losing reach which means that a portion of the flows from the river channel provides recharge to the groundwater basin. However, the proposed federal action will not affect the flows that normally occur in this lower part of this river reach and that contribute to groundwater recharge. Therefore, the portions of the groundwater basins adjacent to this reach are not anticipated to be affected by the proposed federal action.

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3.4 Water Deliveries

Colorado River water is delivered to entities in the seven Basin States and Mexico, consistent with a body of documents often referred to as the Law of the River, as discussed in Section 1.7. Water is diverted from the river at various points and used for irrigation and domestic purposes. A portion of the diverted water may be returned to the river for subsequent use downstream and is referred to as return flow. The net amount of water used (termed consumptive use or depletion) is equal to the diversion less the return flow.

This section describes the water deliveries within the study area that could potentially be affected by implementation of the proposed federal action, including shortage determinations, the storage and delivery of conserved water in Lake Mead, and modification and/or extension of the ISG.

3.4.1 Apportionments to the Upper Division States

As described in Section 1.7, the Compact apportioned 7.5 maf of water per year for consumptive use in the Upper Basin and stipulated that the flow in the river at the Lee Ferry Compact Point not be depleted below 75 maf for any consecutive 10-year period. The Upper Colorado River Basin Compact of 1948 allocated the Upper Basin apportionment among the four Upper Division states. The apportionments are based on percentages of the total quantity of consumptive use available each year within the Upper Basin remaining after deduction of the use, not to exceed 50,000 afy made in the State of Arizona. These apportionment percentages are provided in Table 3.4-1.

Table 3.4-1
Upper Division States Apportionment

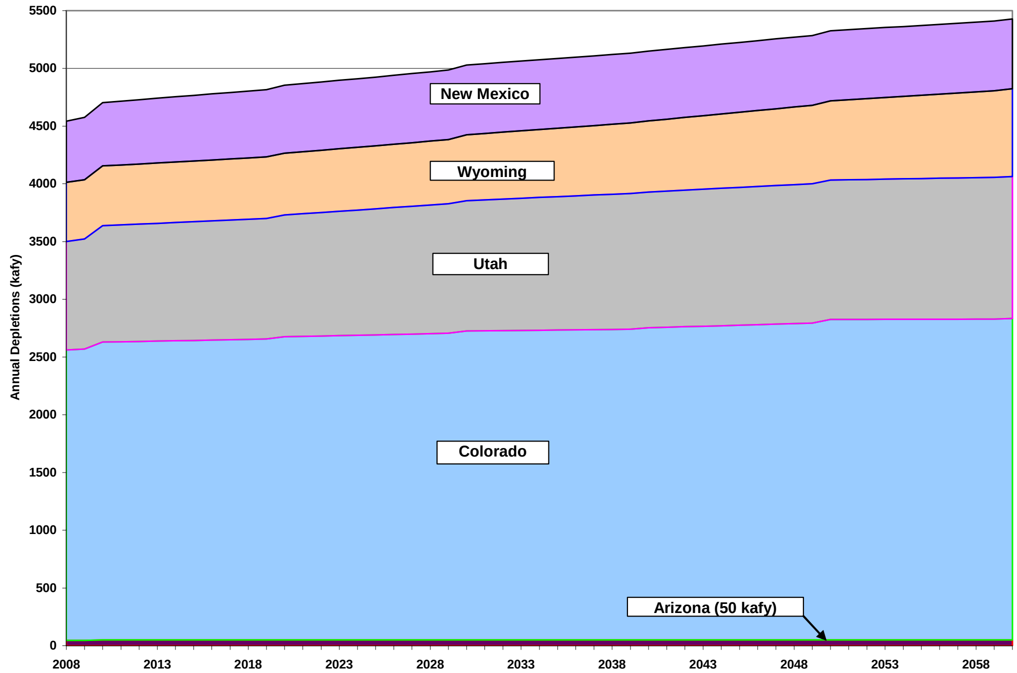
State	Annual Apportionment (%)
Colorado	51.75
New Mexico	11.25
Utah	23.00
Wyoming	14.00

The Upper Colorado River Basin Compact of 1948 also established the Upper Colorado River Commission (Commission). The Commission is an interstate administrative agency, that among other duties, makes findings with regard to the annual quantities of Colorado River water that are available for use and are used by each Upper Basin state, and the annual quantity of water delivered at Lee Ferry. Reclamation operates the mainstream reservoirs to meet the project purposes including the delivery of water downstream. Each Upper Division state regulates and controls the use of Colorado River water within its boundaries.

The depletion schedules for the Upper Basin states were developed by the Commission and submitted to Reclamation in December 1999. These depletions were subsequently updated by Reclamation in coordination with the Commission to include updated Indian tribe depletions (Appendix C).

Figure 3.4-1 shows that the total scheduled depletion of the Upper Division states increases from approximately 4.5 maf in 2008 to approximately 5.4 maf by 2060. These schedules do not include the evaporation losses that occur within the Upper Basin, estimated to average approximately 574,000 afy.

Figure 3.4-1
Upper Basin Scheduled Depletions
Years 2008 to 2060



The proposed federal action would not affect the apportionments to the Upper Division states nor their ability to use those apportionments.

3.4.2 Apportionments to the Lower Division States and Water Entitlements within Each State

The apportionments to the Lower Division states which were established by the BCPA and confirmed by the Consolidated Decree are provided in Table 3.4-2.

Table 3.4-2
Lower Division States Apportionment

State	Annual Apportionment (maf)
Arizona	2.8
California	4.4
Nevada	0.3
Total	7.5

The apportionments to the Lower Division states would not be affected by the proposed federal action.

3.4.2.1 Water Delivery Entitlements to Entities in the Lower Division States

With the exception of approximately 10,000 af in the state of Arizona, all of the water apportioned to each Lower Division state by the BCPA is allocated to specific entities within each state. These allocations, known as entitlements, are established in accordance with the BCPA and the Consolidated Decree.

Section 5 of the BCPA authorizes the Secretary to operate as the contracting authority for the delivery of water from the lower Colorado River and requires any user of Colorado River water in the Lower Basin to have a water delivery contract with Reclamation. This requirement, which was confirmed by the Consolidated Decree, applies to all diversions made from the river except for federal establishments and PPRs.

For Colorado River water users in the Lower Division states, an entitlement to use Colorado River water can exist in one of three forms: (i) a Consolidated Court decreed right, (ii) a Section 5 water delivery contract with the Secretary of the Interior, or (iii) a Secretarial Reservation.

A “decreed right” is a right to use water defined by the Consolidated Decree. The right, which must have existed prior to June 15, 1929 (the effective date of the BCPA), is also referred to as a PPR. The Consolidated Decree lists and quantifies these PPRs. A summary of the total volumes of water apportioned to the PPRs in each of the Lower Division states is provided in Table 3.4-3. These entitlements are summarized based on the diversion and consumptive-use entitlements. The return flow credits used to compute consumptive use have been estimated from historical data.

Table 3.4-3
Volumes of Water Apportioned to PPRs in the Lower Division States

State	Estimated Diversion Entitlement (afy)	Estimated Consumptive-use Entitlement (afy)
Arizona	1,078,398	618,172
California	3,019,573	2,723,325
Nevada	13,034	8,898
Total Lower Division States	4,111,005	3,350,395

A Section 5 water delivery contract is a written agreement between the United States, through the Secretary or his/her duly authorized representative, and another person or entity. All Colorado River water delivery contracts in the Lower Basin are for permanent service, as provided in the BCPA. The form and content of these contracts have evolved since 1929 to reflect advancements in flow measurement, water scheduling, and water accounting technology. Water delivery contracts describe the entitlement in terms of an annual diversion right, an annual consumptive use right, or in some cases both.

A “Secretarial Reservation” is an entitlement established by the Secretary. Secretarial Reservations have been used to reserve Colorado River water for use at federal facilities or lands. Secretarial Reservations have been exercised for Colorado River water use at the Cibola NWR, for use on BLM lands, and for uses at Hoover Dam and Davis Dam.

The proposed federal action will not affect the entitlements to Colorado River water for water users in the Lower Division states. However, water deliveries to each state and to users within each state may potentially be affected and are analyzed and discussed in Section 4.4.

3.4.3 Lower Division States Water Supply Determination

In accordance with the Consolidated Decree and Article III of the LROC, the Secretary determines yearly the water supply condition for the Lower Division states. The conditions are as follows:

- Normal condition: when sufficient mainstream water is available to satisfy 7.5 maf of consumptive use in the Lower Division states;
- Surplus condition: when sufficient mainstream water is available to satisfy in excess of 7.5 maf of consumptive use in the Lower Division states; and
- Shortage condition: when insufficient mainstream water is available to satisfy 7.5 maf of consumptive use in the Lower Division states.

Under a Surplus condition, the Consolidated Decree apportioned 46 percent of the surplus in excess of 7.5 maf for use in Arizona, 50 percent for use in California, and 4 percent for use in Nevada. The ISG established further guidelines for the Secretary’s decision with regard to when a surplus would be declared and the volumes and type of use (e.g., agriculture and domestic use) of that surplus water, including the recognition of any agreements between the states that might modify how the surplus waters would be divided amongst the states (known as “forbearance” agreements).

Under a Shortage condition, the Consolidated Decree directs the Secretary to first satisfy all PPR’s in order of their priority dates without regard to state lines, and then to apportion any remaining shortage amount consistent with the BCPA and other applicable federal statutes. The CRBPA states that satisfaction of all PPRs and California’s 4.4 maf apportionment would have priority over CAP and other post-1968 water delivery contracts. It also states that Nevada shall not be required to bear shortages in any proportion greater than would have been imposed in the absence of the CRBPA. The proposed federal action will provide guidance to the Secretary’s annual determination of the water supply condition for the Lower Division states, and are analyzed and discussed in Section 4.4.

3.4.4 Depletion Schedules for Lower Division States (Normal and Surplus)

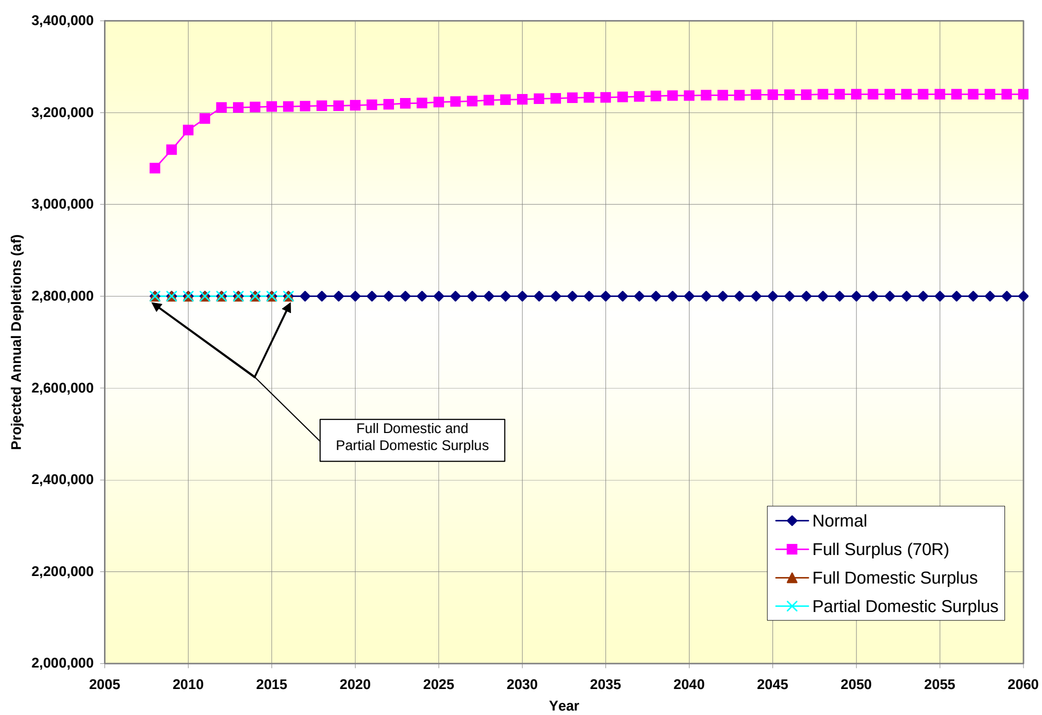
The following sections describe the projected depletions of the three Lower Division states, Arizona, California, and Nevada, for Normal and Surplus conditions, under the No Action Alternative. Surplus schedules for each action alternative are presented in Appendix D.

3.4.4.1 State of Arizona

Arizona's normal year depletion schedule is shown on Figure 3.4-2. The normal year depletions are projected to be 2.8 maf throughout the period of analysis (i.e., 2008 to 2060). The CAP is the largest single Arizona diverter and its (consumptive use) are projected to be approximately 1.382 maf in 2008 and gradually decrease to 1.271 maf by 2060. Concurrently, the demands of Arizona's non-CAP users increase towards their full apportionment, making up the balance of Arizona's normal 2.8 maf apportionment.

The state's projected Full Surplus depletions increase from 3.08 maf in 2008 to approximately 3.24 maf in 2060. The projected CAP Surplus condition demand rises steadily from 1.715 maf to approximately 1.835 maf in 2012. Thereafter, the CAP Surplus condition depletion schedule remains at approximately 1.835 maf.

Figure 3.4-2
Arizona's Projected Colorado River Water Depletion Schedules Under No Action Alternative

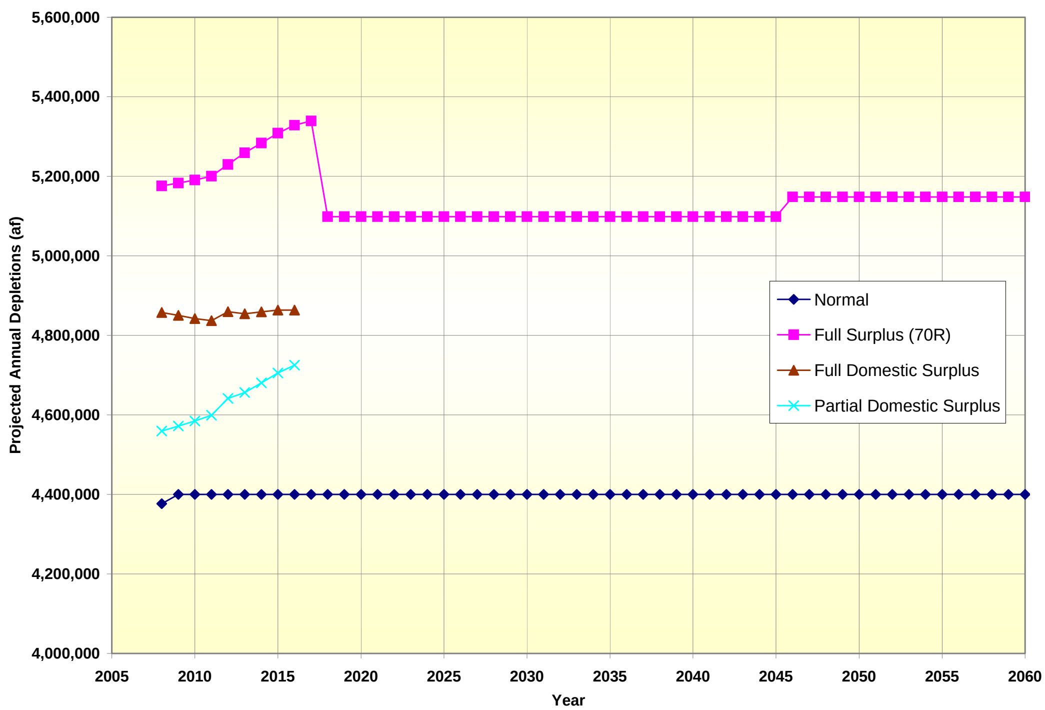


3.4.4.2 State of California

California's normal year depletion schedule is shown on Figure 3.4-3. The normal year depletions are projected to be 4.4 mafy throughout the period of analysis (i.e., 2008 to 2060). The exception to this is the first year (2008) wherein the depletion schedule reflects a delivery reduction of 23,315 af which coincides with scheduled repayment of inadvertent overruns by IID (14,763 af) and CVWD (8,552 af). As such, California's scheduled depletion for 2008 is 4.377 maf.

The surplus schedules for California consider its continued need for surplus water, when available, in order to implement the conjunctive use programs (e.g., groundwater banking) that will assist California in reducing its projected Colorado River depletion to its normal apportionment of 4.4 mafy. California's surplus schedule considers the potential availability of more surplus water during the effective period of the ISG, which are scheduled to expire in 2016. Figure 3.4-3 shows the surplus depletion schedules under the Full Surplus, Full Domestic Surplus, and Partial Domestic Surplus conditions during the ISG period and the surplus depletion schedule for the post-2016 period.

Figure 3.4-3
California's Projected Colorado River Water Depletion Schedules Under No Action Alternative

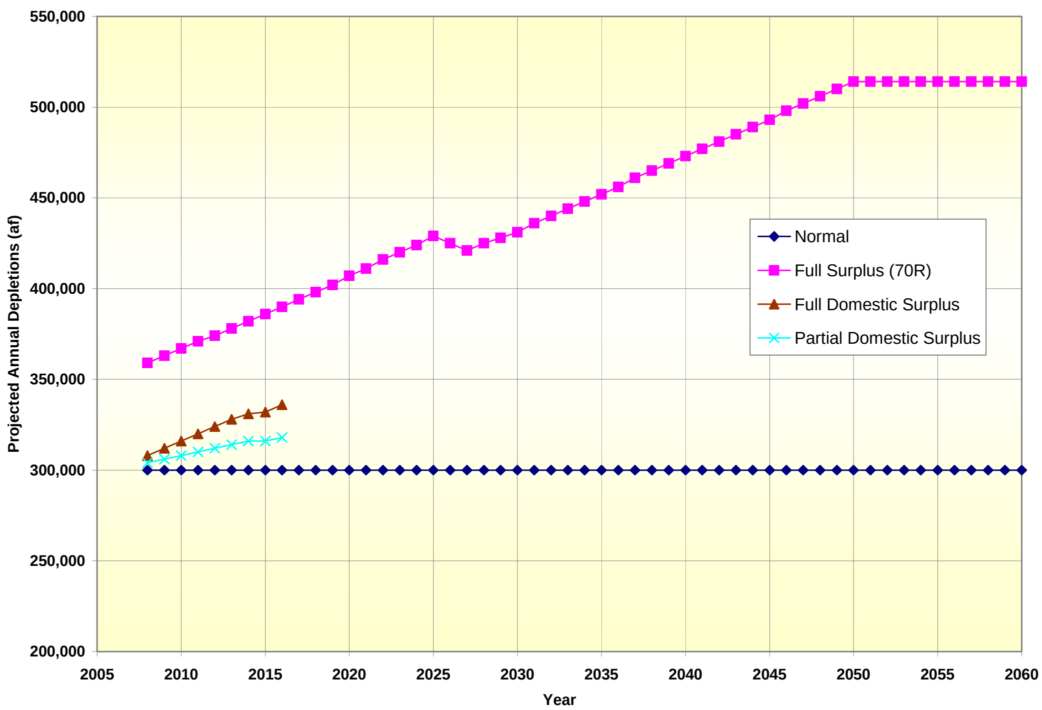


3.4.4.3 State of Nevada

Nevada's normal year depletion schedule is shown on Figure 3.4-4. The normal year depletions are projected to be 300 kaf throughout the period of analysis (i.e., 2008 to 2060). The SNWA is the largest single Nevada diverter and its normal year depletions are projected to be approximately 271 kaf for the period 2008 through 2025, increases to 279 kaf in 2026, increases to 287 kaf in 2027 and remains at that level through 2060.

Figure 3.4-4 also shows Nevada's surplus depletion schedule under the Full Surplus, Full Domestic Surplus, and Partial Domestic Surplus conditions during the ISG period and the surplus depletion schedule for the post-2016 period. Nevada's Full Surplus condition depletion schedule projects that Full Surplus depletion in 2008 is approximately 330 kaf in year 2008 and increases to approximately 501 kaf in 2060.

Figure 3.4-4
Nevada's Projected Colorado River Water Depletion Schedules Under No Action Alternative



3.4.5 Mexico's Allotment

As discussed earlier in Section 1.7, Mexico has an allotment to Colorado River water under the 1944 Treaty that states the following:

> "Of the waters of the Colorado River, from any and all sources, there are allotted to Mexico:
>
> (a) A guaranteed annual quantity of 1,500,000 acre-feet (1,850,234,000 cubic meters) to be delivered in accordance with the provisions of Article 15 of this Treaty.

> (b) Any other quantities arriving at the Mexican points of diversion, with the understanding that in any year in which, as determined by the United States Section, there exists a surplus of waters of the Colorado River in excess of the amount necessary to supply uses in the United States and the guaranteed quantity of 1,500,000 acre-feet (1,850,234,000 cubic meters) annually to Mexico, the United States undertakes to deliver to Mexico, in the manner set out in Article 15 of this Treaty, additional waters of the Colorado River system to provide a total quantity not to exceed 1,700,000 acre-feet (2,096,931,000 cubic meters) a year. Mexico shall acquire no right beyond that provided by this subparagraph by the use of the waters of the Colorado River system, for any purpose whatsoever, in excess of 1,500,000 acre-feet (1,850,234,000 cubic meters) annually.
>
> In the event of extraordinary drought or serious accident to the irrigation system in the United States, thereby making it difficult for the United States to deliver the guaranteed quantity of 1,500,000 acre-feet (1,850,234,000 cubic meters) a year, the water allotted to Mexico under subparagraph (a) of this Article will be reduced in the same proportion as consumptive uses in the United States are reduced."

Additionally, Minute 242 provides, in part, that the United States will deliver to Mexico approximately 1,360,000 af annually upstream of Morelos Diversion Dam and approximately 140,000 af annually on the land boundary at San Luis and in the limitrophe section of the Colorado River downstream from Morelos Diversion Dam. It should be noted that while a portion of Mexico's 1.5 maf annual allotment is actually delivered below Morelos Diversion Dam, the entire delivery to Mexico was modeled at Morelos Diversion Dam. This basic assumption, while different than actual practice, served to simplify and facilitate the analysis of water deliveries to Mexico under the No Action Alternative and the action alternatives.

Allocation of Colorado River water to Mexico is governed by the 1944 Treaty. The proposed federal action will improve the Department's annual management and operation of key Colorado River reservoirs. However, in order to assess the potential effects of the proposed federal action in this Draft EIS, certain modeling assumptions (discussed in Chapter 2) are used that display projected water deliveries to Mexico. Reclamation's modeling assumptions are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding reductions in deliveries to Mexico. The United States will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Treaty with Mexico through the IBWC in consultation with the Department of State.

3.4.6 Distribution of Shortages To and Within the Lower Division States

The assumptions with respect to the distribution of shortages between the three Lower Division states are discussed in Section 4.2. The following sections describe how the shortages would be distributed within Arizona, California, and Nevada.

3.4.6.1 Distribution of Shortages Within Arizona

Of Arizona's 2.8 maf apportionment, the largest use is the CAP which has historically diverted up to 1.7 mafy from Lake Havasu for delivery to water users in the central part of the state. Other noteworthy diversions are those of the Colorado River Indian Reservation at Headgate Rock Dam and the Gila and Yuma Projects at Imperial Dam. Other diversions serve irrigated areas and communities along the Colorado River corridor, including lands of the Fort Mojave Reservation, water used by federal agencies in Arizona, the cities of Bullhead, Lake Havasu and Parker, the Mohave Valley Irrigation and Drainage District, and the Cibola Valley Irrigation and Drainage District. A portion of the water from the river corridor is also diverted by wells located along the river.

Arizona established the Arizona Water Banking Authority (AWBA) in 1996 to store unused apportionment from Arizona and other states in groundwater basins in Arizona for future use. These banked water supplies help ensure an adequate water supply to CAP M&I water users in times of shortages or disruptions of the CAP system, in meeting water management plan objectives of the Arizona state groundwater code, and in Indian water rights claims settlements.

Within Arizona, a priority system for the delivery of Colorado River water to water users within the state has been included in the water delivery contracts executed after 1992. Prior to 1992, the contracts defined priorities as existing in three time bands: entitlements existing before June 25, 1929, entitlements existing between June 26, 1929 and September 30,1968, and entitlements existing after September 30, 1968. For water delivery contracts in Arizona executed after 1992, Reclamation assigned a numerical rating to these priorities (priorities 1 through 4) and also defined priorities for unused apportionment (priority 5) and surplus water (priority 6) (Table 3.4-4).

Table 3.4-4
Arizona Priority System for Mainstream Colorado River

Priority	Rights to be Satisfied
First	Present Perfected Rights (PPRs) established prior to June 25, 1929
Second	Federal reservations and perfected rights established or effective prior to September 30, 1968
Third	Entitlements pursuant to contracts executed on or before September 30, 1968
Fourth	(1) Entitlements pursuant to contracts, Secretarial reservations, and other arrangements between the United States and water users established subsequent to September 30, 1968 (2) Contract for CAP
Fifth	Any unused Arizona entitlement
Sixth	Entitlements to surplus water

All Arizona water users in each priority are listed in Appendix E.

Under a Shortage condition, any use of water occurring under contracts for unused entitlement would be the first eliminated. In the absence of shortage-sharing agreements, any remaining reduction in Arizona would most likely be shared proportionately among the CAP and the non-CAP holders with fourth priority entitlements. More severe shortages would result in holders of higher priority entitlements having to incur reductions in their water use.

Arizona's framework for responding to shortages is presented in the Arizona Drought Preparedness Plan and the Operational Drought Plan that was released in October 2004. Elements of this framework are discussed in Section 4.14.

3.4.6.2 Distribution of Shortages Within California

Of California's 4.4 maf apportionment, the largest use is the IID which diverts approximately 3.0 mafy from Imperial Dam for delivery and use primarily for irrigated agriculture in the Imperial Valley. Other major water users include the Palo Verde Irrigation District (PVID), the CVWD, the Chemehuevi Reservation, the Fort Yuma Indian Reservation, the Colorado River Indian Reservation, the Fort Mojave Reservation, and the MWD. Other diversions serve irrigated areas and communities along the river corridor. A portion of the water from the river corridor is also diverted by wells located along the river.

Within California, a priority system for the delivery of mainstream Colorado River water to users within the state was established by Secretarial regulations that incorporated provisions of the California Seven-Party Agreement of 1931, and is shown in Table 3.4-5.

Table 3.4-5
California's Seven-Party Agreement for Mainstream Colorado River

Priority	Rights to be Satisfied
First	PVID for beneficial use upon 104,500 acres
Second	Reclamation's Yuma Project for beneficial use upon 25,000 acres
Third[1]	(a) Imperial Irrigation District and Coachella Valley Water District (b) Palo Verde Irrigation District for use on 16,000 acres on the Lower Palo Verde Mesa
Fourth[2]	MWD and/or City of Los Angeles and/or others on the coastal plain of Southern California for 550,000 afy
Fifth	(a) MWD and/or City of Los Angeles and/or others on the coastal plain of Southern California for 550,000 afy (b) City and/or County of San Diego for 112,000 afy
Sixth[3]	(a) IID and CVWD (b) PVID for use on Lower Palo Verde Mesa
Seventh	All remaining water available within California for agricultural use

1 The total beneficial use of Priorities 1, 2, and 3 shall not exceed 3.85 mafy

2 The sum of priorities 1 through 4 totals 4.4 mafy.

3 The sum of priority six is 300 kafy

The Consolidated Decree, however, also identified a number of PPRs in California as listed in Appendix E. Although some of the California PPRs were included in the Seven-Party Agreement, the recently implemented "California 4.4 Plan" addressed how the rights of other PPRs would be met relative to the priority scheme set forth in the Seven-

Party Agreement during the applicable term of the agreements embodied in the "California 4.4 Plan."

Due to the provision in the CRBPA that CAP and other fourth priority rights in Arizona are junior to 4.4 maf of water use in California, reductions to California water users would occur only during severe shortages. If that were to occur, MWD would most likely incur the shortage owing to its lower priority within the 4.4 maf apportionment.

MWD's short-term and long-term strategies for managing and building its portfolio of water supplies are presented in its 2006 Integrated Water Resources Plan. Elements of this plan are discussed in Section 4.14.

3.4.6.3 Distribution of Shortages within Nevada

Of Nevada's 0.3 maf apportionment, SNWA is the single largest diverter, with consumptive use of approximately 280 kafy. Established in 1991, SNWA delivers M&I water from Lake Mead to the service areas of Las Vegas, North Las Vegas, Henderson, Boulder City and Nellis Air Force Base. Water is pumped from two intakes at elevations 1,050 feet msl and 1,000 feet msl.

Existing water delivery contracts that authorize the use of Colorado River water by entities within Nevada are listed below in Table 3.4-6. This priority scheme was developed and implemented in 1992 when Reclamation contracted with the SNWA for the balance of Nevada's apportionment.

Table 3.4-6
Nevada's Priority System for Mainstream Colorado River

Priority	Rights to be Satisfied
First	Fort Mojave Indian Reservation (12,534 afy) Lake Mead National Recreation Area (Diversion = 500 afy or CU= 300 afy)
Second	Lake Mead National Recreation Area (1,500 afy, estimated)
Third	Boulder City (5,876 afy)
Fourth	City of Henderson (15,878 afy) Basic Management, Inc. (8,608 afy)
Fifth	Lakeview Co. (0 afy) Pacific Coast Building Products (PABCO) (928 afy)
Sixth	Las Vegas Valley Water District (15,407 afy)
Seventh	U.S. Air Force (Delivery from SNWA) (4,000 afy) Boy Scouts (Annexed by SNWA) (10 afy) Reclamation (300 afy) NV Dept of Fish and Game (25 afy) and NV Dept of Wildlife (25afy)
Eighth	Robert B. Griffith Water Project (304,000 afy) Big Bend (10,000 afy) SNWA (balance of state apportionment, unused and surplus)

Under a Shortage condition, Nevada would likely share in shortages due to the recent dates of the majority of its water delivery contracts. Within Nevada, reductions would most likely be borne by the lower priority use of SNWA. More severe shortages would result in holders of higher priority entitlements having to incur reductions in their water use. As noted previously, in accordance with the Consolidated Decree, the PPRs would not be affected.

SNWA and the State of Nevada's Colorado River Commission have developed a water resources management plan for Southern Nevada to manage and develop water supplies to meet the current and future water demands of the region. This plan is summarized in SNWA's 2006 Water Resource Plan. Elements of this plan are discussed in Section 4.4.

3.5 Water Quality

This section describes the existing water quality constituents that could potentially be affected by the alternatives. These water quality constituents of concern include:

- salinity;
- temperature;
- sediment;
- nutrients and algae;
- dissolved oxygen;
- metals; and
- perchlorate.

While other water quality-related issues and parameters were also considered, they were determined unlikely to be affected by the alternatives and are therefore not discussed here.

3.5.1 Salinity

Increased salinity levels are a primary water quality concern in the Colorado River because of its effects on agricultural, municipal and industrial users. With increased salinity levels, agricultural water users may suffer economic damage due to reduced crop yields, added labor costs for irrigation management, and added drainage requirements. Urban or municipal users must replace plumbing and appliances more often, or spend increased money on water softeners or bottled water. Industrial users and water and wastewater treatment facilities incur reductions in the useful life of infrastructure (Colorado River Basin Salinity Control Forum 2002). Water treatment plants face increased costs when salinity is elevated, and results in disinfection byproducts that exceed drinking water standards.

Salinity occurs naturally in the Colorado River Basin due to the erosion of saline sediments and rocks; however, human activities such as agriculture, irrigation, and energy production may increase the rate of natural salt movement to the system (Colorado River Basin Salinity Control Forum 2002; USEPA 1971). Consumptive use of system water also reduces the dilution capacity of the watershed, increasing the salinity concentrations.

In 1972, the United States Environmental Protection Agency (USEPA) suggested the development of water quality criteria for salinity in the Colorado River following passage of the Clean Water Act (CWA). In 1973, the seven Basin States formed the Colorado River Basin Salinity Control Forum (Forum) to develop salinity criteria and an implementation plan to provide compliance while allowing the Basin States to continue to develop their Compact-allocated water. The Forum specifies flow-weighted average annual salinity criteria for three locations on the lower Colorado River (Table 3.5-1). The criteria, first established in 1975, are reviewed every three years; the latest review was completed in 2005.

Table 3.5-1
Numeric Salinity Standards for the Colorado River

Station	Flow-weighted average annual salinity (mg/L)[1]
Below Hoover Dam (to Parker Dam)	723
Below Parker Dam (to Imperial Dam)	747
At Imperial Dam	879

(Colorado River Basin Salinity Control Forum, 2005)

1 mg/L – milligram per liter

Salinity below Glen Canyon Dam has varied between 390 to 660 mg/L. Historic salinity concentrations and flows, and the criteria specified by the Forum by location for the lower reaches of the Colorado River below Hoover Dam are illustrated in Figures 3.5-1 through 3.5-3. As shown, increases in salinity typically correspond to decreases in flow. Diluting effects of record high flows during the 1980s resulted in lower salinity levels. Conversely, low flows from 1988 to 1992 and 2000 to 2004 caused relatively higher salinity levels. While the salinity concentrations vary from year to year, concentrations have not exceeded the criteria, even during the recent drought. Although salinity at Hoover Dam has approached the criteria of 723 mg/L on several days during the current drought, the salinity criteria would not be violated unless the annual average salinity exceeds the salinity criteria.

Figure 3.5-1
Historic Salinity Concentrations and Flows below Hoover Dam from 1941 to 2005

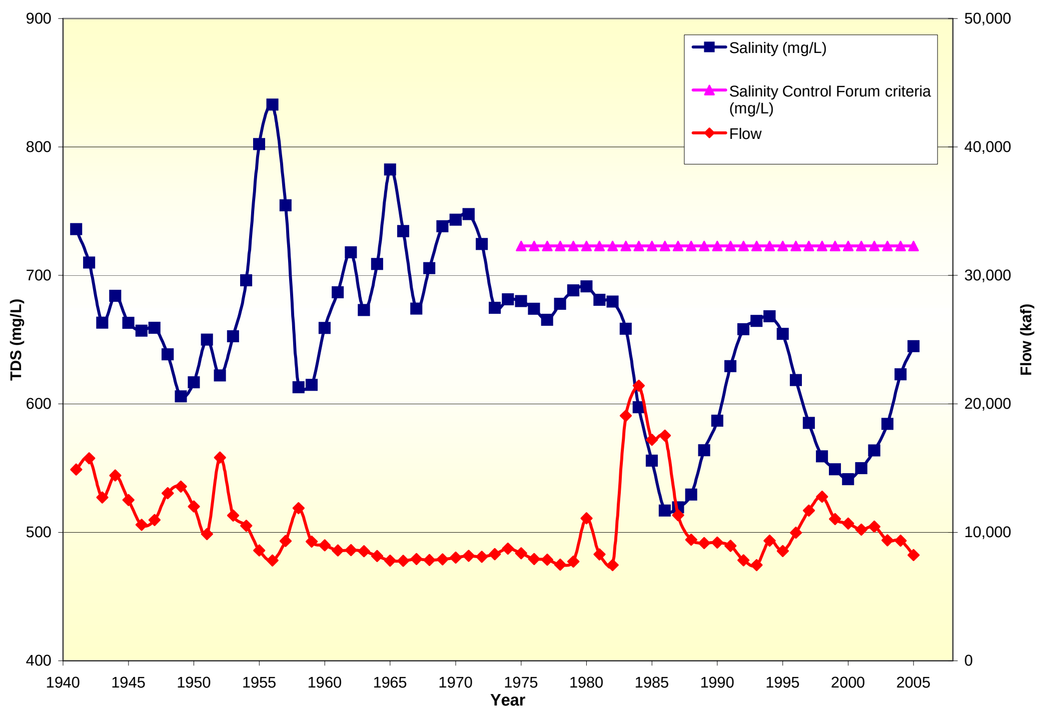


Figure 3.5-2
Historic Salinity Concentrations and Flows below Parker Dam from 1941 to 2005

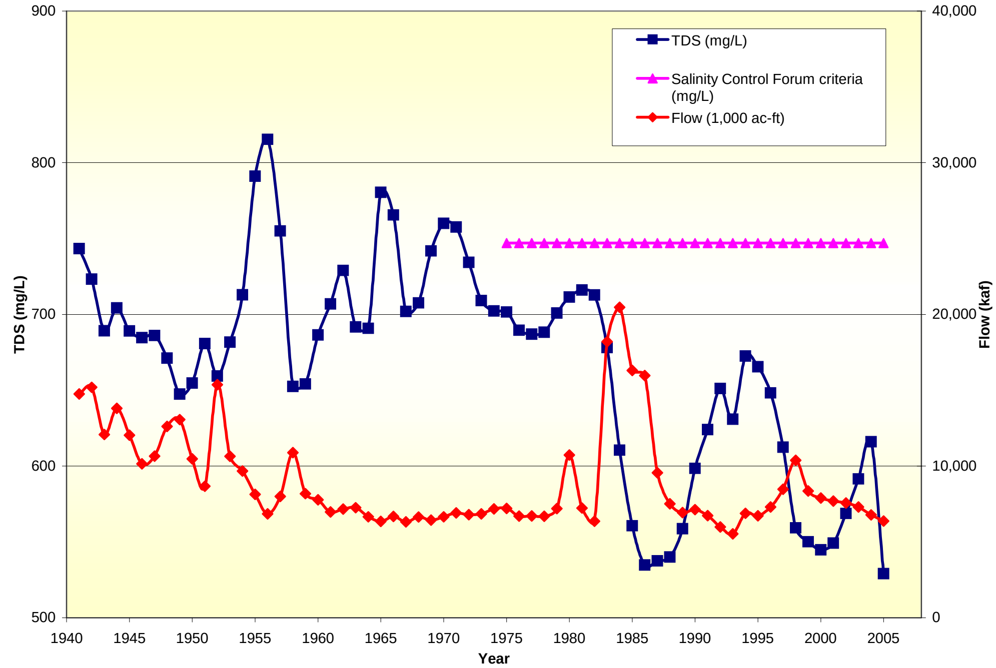
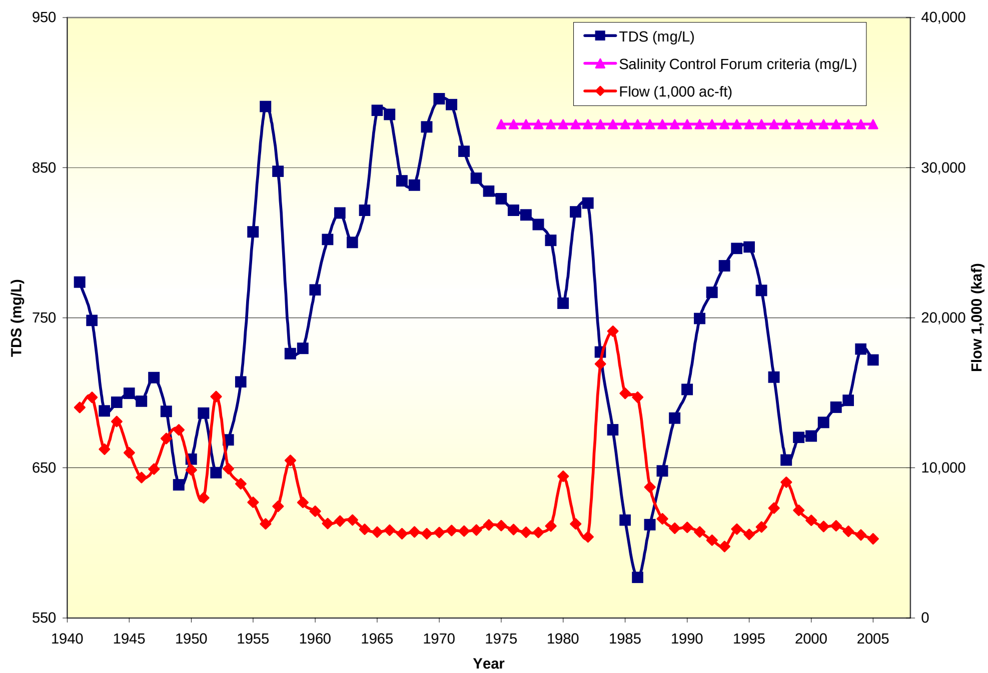


Figure 3.5-3
Historic Salinity Concentrations and Flows at Imperial Dam from 1941 to 2005



To address Mexico's concerns with regard to salinity, Minute 242 (Section 3.4) was developed in 1973 pursuant to the 1944 Treaty. Minute 242 limits the differential in annual salinity between Imperial Dam and the NIB to 115 parts per millimeter (ppm) ± 30 ppm. In addition, the Colorado River Basin Salinity Control Act of 1974 was authorized to implement desalting and salinity control projects to improve river water quality. Salinity control projects that have been implemented include projects to control irrigation seepage and reduce transport of groundwater salt loads to the Colorado River.

3.5.2 Temperature

Impounding water in reservoirs affects the water temperatures of dam releases due to stratification. The surface layer (epilimnion) of Lake Powell and Lake Mead warms as a result of inflows, ambient air temperature, and solar radiation. For example, during the summer, both Lake Powell and Lake Mead epilimnions reach temperatures as high as 30° degrees Celsius(C) or 86° degrees Fahrenheit (F) (LaBounty and Horn 1997). Lake Mead's deeper layer (hypolimnion) remains around 12° C (54° F) year-round and Lake Powell's ranges from 6 to 9° C (43-48° F) (LaBounty and Horn 1997), resulting in cold dam release temperatures.

Water temperatures downstream of Lake Powell are influenced by Lake Powell elevations and release volumes. Figure 3.5-4 illustrates that Lake Powell release temperatures have varied from 7 to 11° C (46 to 52° F) until 2002. Between 1999 and 2005, Lake Powell elevations have dropped more than 140 feet as a result of a basin-wide drought. While winter release temperatures remained cold, Lake Powell release temperatures increased to 16° C (61° F) in the summer of 2005. The drop in Lake Powell elevation has resulted in the warmer epilimnion being closer to the penstock withdrawal zone and the warmer water being released downstream. Release temperatures from Glen Canyon Dam during 2004 and 2005 were the highest since August 1971 when the reservoir was filling.

As water travels between Glen Canyon Dam and Lake Mead, water temperatures in the Colorado River can increase by 7° C (14.4° F). The amount of warming is affected by season and release volume, with highest warming rates occurring in mid-summer and at low release volumes (Vernieu et. al. 2005). Generally, during late fall and winter, as air temperatures decrease, water released from Glen Canyon Dam cools as it moves downstream towards Lake Mead. Figure 3.5-5 illustrates that historic water release temperatures at Lake Mead have typically been approximately 13°C (58°F).

3.5.3 Sediment

After Glen Canyon Dam and Hoover Dam were constructed, the reservoirs retained the vast majority of the inflowing sediment. Following dam closure, large sediment deltas formed near the inflow areas. When the reservoirs are drawn down during droughts, the Colorado River must cut a new channel through these sediments into the reservoirs. Generally the greater the reservoir drawdown, the greater the sediment delta headcut and the finer the sediment exposed. The resuspended sediments have a significant oxygen demand and also temporarily release nutrients which can result in greater algal growth.

Figure 3.5-4
Historic Elevation and Dam Release Temperatures at Lake Powell

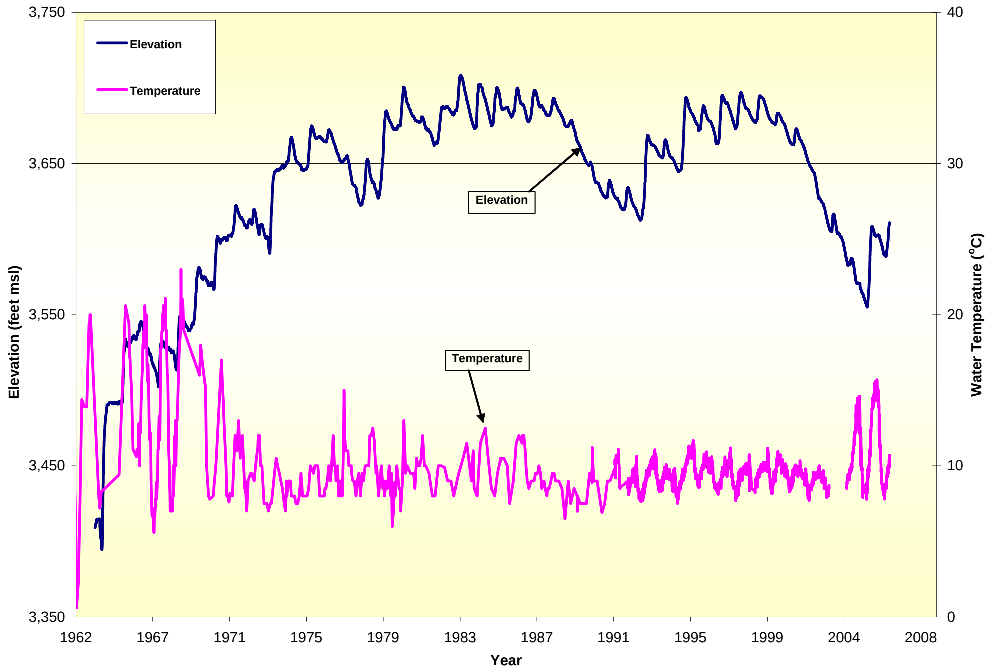
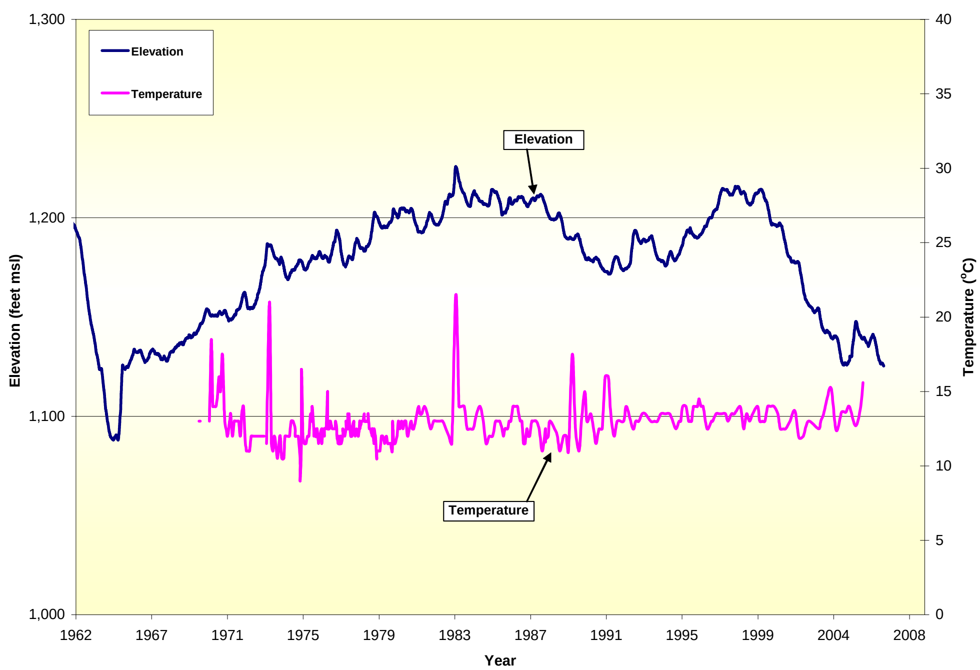


Figure 3.5-5
Historic Elevation and Dam Release Temperatures at Lake Mead



Riverine sediment transport is an important concern in the Glen Canyon Dam to Lake Mead reach due to recreation and biological resource impacts, and is addressed in the AMP. Beach sediment volumes have declined since closure of Glen Canyon Dam eliminated annual replenishment by sediment-laden spring runoff. Recent efforts by the AMP have focused on making BHBF releases from Glen Canyon Dam timed with downstream tributary inputs from the Paria and Little Colorado rivers.

Downstream of Hoover Dam the only significant sediment inputs are produced by large, infrequent events on the Bill Williams River and the Gila River, affecting the reaches from Parker to Imperial Dam and from Imperial Dam to the NIB. On-going Reclamation dredging operations remove this sediment at and upstream of Imperial Dam as well as upstream of Morelos Diversion Dam to improve diversion capability and to efficiently convey water to downstream users (Figure 3.3-5). These operations will continue and therefore the action alternatives would have no significant impact.

3.5.4 Nutrients and Algae

Nutrients are a group of chemical elements and compounds such as carbon, nitrogen, and phosphorus. When nutrient concentrations rise above certain thresholds or levels (usually measured in mg/L) they impair water quality. Nitrogen and phosphorous are nutrients of concern because they foster algal growth. Excess algal growth can affect drinking water treatment operations and can contribute to taste and odor problems and potentially toxic disinfection by-product (DBP) formation. Noxious and toxic blue-green algae blooms may also be a concern.

Large, long reservoirs like Lake Powell are very efficient at retaining nutrients (nitrogen and phosphorus) through biological processes and settling. Paulson and Baker (1983) found phosphorus to be the limiting nutrient for primary biological activity in both reservoirs. More than 95 percent of the phosphorous reaching Lake Powell is in particulate form or associated with suspended sediment particles, and a large percentage of the particulate phosphorous load settles out of the water column in the upstream portion of the reservoir. Therefore, primary biological activity is phosphorous-limited by the time the water reaches Glen Canyon Dam. A similar storage effect is repeated in Lake Mead. This settling process can be reversed when the reservoirs are drawn down and deltaic sediments are re-suspended by the inflows. Nutrient concentrations remain elevated in the hypolimnion where the lack of light limits primary biological activity. Consequently, hypolimnetic releases from Glen Canyon Dam are relatively nutrient rich whereas periods of epilimnetic releases may cause a reduction in the amount of nutrients available to the downstream ecosystem.

Tributary inflows (Paria River and Little Colorado River) are important sources of phosphorus in the Colorado River between Glen Canyon Dam and Lake Mead (Maddux et. al. 1987). However, most phosphorus arrives in particulate form adsorbed to fine sediment. This fine sediment causes high turbidity and restricts primary biological activity due to limited light penetration.

Lake Mead receives nutrient loads primarily from Las Vegas Wash and the Colorado River. A Total Maxium Daily Load (TMDL) has been developed by the Nevada Division of Environmental Protection (NDEP) and USEPA to reduce ammonia and phosphorous concentrations in Las Vegas Wash. Boulder Basin, the receiving body of Las Vegas Wash, has the highest nutrient concentrations in the Lake Mead system (Paulson and Baker 1981; Prentki and Paulson 1983). Except for the algae growth in Boulder Basin of Lake Mead, substantial algae growth along the rest of the system is not common.

3.5.5 Dissolved Oxygen

Dissolved oxygen concentrations in the reservoirs are affected by variations in inflow volume and temperature, seasonal reservoir circulation, and biological production and decomposition. In years of high inflows when the reservoir elevations are low, tributary inputs cut through deltaic sediments, resuspending organic matter and nutrients that contribute to both chemical and biological oxygen demand as the inflow water passes down the reservoir water column. The resulting plumes of low oxygen water cause the release of oxygen-poor water. When deltaic sediments and organic matter are not resuspended, oxygen demand is lower and dissolved oxygen concentrations remain higher. Downstream of dams, turbulence, exposure to the atmosphere, and primary productivity reaerate the water.

To date, low dissolved oxygen has only been an issue in Lake Powell and at Glen Canyon Dam. The dissolved oxygen concentration reaches saturation downstream of Glen Canyon Dam before the confluence with the Little Colorado River (Gloss et. al. 2005)) after passing through several major rapids.

In Lake Mead, dissolved oxygen concentrations decrease in Boulder Basin as a result of nutrient contributions from Las Vegas Wash and algae growth. However, dissolved oxygen has not been documented to have dropped below acceptable minimum levels. Further, dissolved oxygen has not been documented as an issue in downstream reaches.

3.5.6 Metals

Metals of concern in the study area are selenium, chromium, and mercury. Selenium is an essential trace element, but can be bioconcentrated in a complex aquatic food chain to potentially hazardous levels to wildlife. A chronic standard to protect wildlife has been adopted by the Lower Basin states of 2 micrograms per liter (µg/L). This is a higher standard than the USEPA criteria for selenium. The drinking water standard for selenium is 50 µg/L, therefore selenium is not a human health concern from drinking water.

Selenium present in marine sedimentary rocks dissolves in runoff and groundwater flows to the Colorado River and its tributaries. Concentrations along the Colorado River in the Lower Basin indicate that the selenium loads to the Colorado River are from the Upper Basin and Lower Basin tributaries only (U.S. Department of the Interior and The Metropolitan Water District of Southern California 2004). The Colorado River from Hoover Dam to Lake Mohave inlet and from Parashant Canyon to Diamond Creek, and reaches of the Gila River, Las Vegas Wash, and the Virgin River have all been designated as impaired waterbodies due to selenium. To date, TMDLs have not been drafted or approved for selenium in these waterbodies.

The Forum established a selenium sub-committee in 2004 (U.S. Department of the Interior 2005). The long term average selenium concentration is 2.4 µg/L below Glen Canyon Dam, greater than the Lower Basin states selenium standard of 2 µg/L (Department of the Interior 2005).

The USEPA's drinking water standard for the soluble hexavalent form of chromium, (Cr(VI)) is 100 parts per billion (ppb); at this concentration, it is considered dangerous to human and environmental health. The Cr(VI) is impacting groundwater in two known locations in the lower Colorado River Basin, at the Pacific Gas & Electric (PG&E) Compressor Station near Needles, California, and at the former McCulloch manufacturing plant in Lake Havasu City, Arizona. The plume of contaminated groundwater from the PG&E facility has concentrations of Cr(VI) as high as 700 ppb and has traveled several hundred feet from its source to within 60 feet of the Colorado River. Investigation and mitigation efforts are ongoing and under direction of the California Environmental Protection Agency Department of Toxic Substances Control (DTSC).

The Cr(VI) plume in Lake Havasu City has been delineated and it is being monitored by the current land owner. Concentrations have been detected as high as 240,000 ppb Cr(VI) and the plume is approximately 3,800 feet from the Colorado River.

Mercury is naturally occurring in the Colorado River Basin and has been mobilized as a result of historic mining activities. Mercury can be toxic to both humans and wildlife and has been shown to bioaccumulate and biomagnify up the food chain. High levels of methylmercury have been detected in fish tissue at Alamo Lake in the Bill Williams Watershed, a tributary to Lake Havasu. Mercury is present in the discharge from Alamo Lake and may also be entering the Colorado River from the Little Colorado River and between Lake Mead and Lake Havasu. Mercury is highly regulated with the Safe Drinking Water Act maximum contaminant level of 2.0 ppb.

3.5.7 Perchlorate

Perchlorate in the form of ammonium perchlorate is a concern when found in drinking water because of its potential adverse effect on human thyroid function. No final USEPA standards for perchlorate have been developed. Perchlorate contamination in water supplies in the lower Colorado River was traced to Lake Mead and Las Vegas Wash from a groundwater plume from the Kerr McGee Chemical Company in Henderson, Nevada. Containment, control and mitigation activities are ongoing to reduce perchlorate concentrations in Lake Mead and downstream.

3.6 Air Quality

The only air quality issue related to the proposed federal action would be fugitive emissions (dust) generated from shorelines exposed by changes in the Lake Powell and Lake Mead elevations.

3.6.1 Federal Air Quality Requirements

The Clean Air Act as amended (42 USC 7401 *et seq.*) established Prevention of Significant Deterioration (PSD) provisions for use in protecting the nation's air quality and visibility. The PSD provisions apply to new or modified major stationary sources and are designed to keep an attainment area in continued compliance with the National Ambient Air Quality Standards (NAAQS). Major stationary sources are industrial-type facilities and include power plants and manufacturing facilities that emit over 100 tons per year of a regulated pollutant. The USEPA promulgated NAAQS for six criteria pollutants to protect public health and welfare. One of the national air quality standards addresses particulate matter (PM), or dust.

No major stationary sources are being proposed for construction or modification by the proposed federal action; therefore the statutory provisions are not applicable. However, the standards do provide thresholds from which to evaluate potential effects to ambient air quality.

The PSD standards are most stringent in Class I Areas and are progressively less stringent in the Class II and Class III Areas (Table 3.6-1). Lake Powell and Lake Mead are designated as Class II Areas while the Grand Canyon National Park is a Class I Area. .

Table 3.6-1
Clean Air Act Prevention of Significant Deterioration Designations

Designation	Definition
Class I Area	Visibility is protected more stringently than under the national ambient air quality standards; includes national parks, wilderness areas, monuments, and other areas of special national and cultural significance.
Class II Area	Moderate change is allowed but stringent air quality constraints are nevertheless desired.
Class III Area	Substantial industrial or other growth is allowed and increases in concentrations up to the national standards would be considered insignificant.

The allowable PM concentrations increase over the baseline concentrations for the Class I, II and III Area designations are provided in Table 3.6-2.

Table 3.6-2
Clean Air Act Allowable Particulate Matter Concentration Increases over the Baseline Concentrations

Pollutant	Averaging Times	Class I Area [1,2]	Class II Area [1,2]	Class III Area [1,2]
Particulate Matter	Annual Geometric Mean	5	19	37
	24-Hour Maximum	10	37	75

1 Unit of measure for standards is in micrograms per cubic meters of air (µg/m3)

2 Maximum allowable increases over baseline concentrations

3.6.2 State and Local Air Quality Requirements

In September 2006, USEPA established new PM10 (dust particles less than 10 $\mu g/m^3$) and PM2.5 (dust particles less than 2.5 $\mu g/m^3$) standards for future implementation. Additionally, each state must develop an implementation plan describing how it will attain and maintain the NAAQS. Some states have developed more stringent ambient air quality standards for PM10 and PM2.5, as listed in Table 3.6-3. California has a more stringent PM standard than the national standard. Arizona, Nevada, and Utah have adopted PM standards to meet the NAAQS (CalEPA 2006; Clark County AQEM 2006; MDAQMD 2006; Utah 2006; UDEQ 2006). These state standards were adopted prior to the new 2006 NAAQS.

Table 3.6-3
National and State Ambient Air Quality Standards for Particulate Matter

Jurisdiction	PM 10 ($\mu g/m^3$)	PM 2.5 ($\mu g/m^3$)	Averaging Times
2006 NAAQS	150	35	24-hours
	None [1]	15	Annual Arithmetic Mean
Arizona	150	65	24-hours
	50	15	Annual Arithmetic Mean
California	50	65	24-hours
	20	12	Annual Arithmetic Mean
Nevada	150	65	24-hours
	50	15	Annual Arithmetic Mean
Utah	150	65	24-hours
	50	15	Annual Arithmetic Mean

1 Revoked in 2006 due to a lack of evidence linking health problems (effective December 17, 2006).

Eight state and local air quality agencies are responsible for attaining the state and federal standards within the study area, as listed in Table 3.6-4.

Table 3.6-4
State and Local Air Pollution Control Agencies Having Jurisdiction within the Lake Powell and Lake Mead Areas

Agency	Location	Colorado River Reaches
Arizona Department of Environmental Quality	Arizona	Lake Powell and Glen Canyon Dam Glen Canyon Dam to Lake Mead
Utah Department of Environmental Quality, Division of Air Quality	Utah	Lake Powell and Glen Canyon Dam
Clark County Air and Environmental Management	Nevada	Lake Mead and Hoover Dam Hoover Dam to Davis Dam

3.6.3 Ambient Air Quality by River Reach

A description of the PSD classification and the air quality standards within the reaches provides a means of characterizing the standards applied to the affected environment. Reaches meeting regulatory standards are classified as attaining a pollutant standard. The attainment status provides a qualitative characterization of a reach as compliant with the standards; attainment characterizes the specific pollutant as not a significant concern within the reach. Consequently, characterizing the PM attainment status in the reaches provides a qualitative assessment of the significance of fugitive emissions within the reach. The Glen Canyon to Lake Mead reach is included because particulate matter generated at the Lake Mead delta may be dispersed into this reach.

3.6.3.1 Lake Powell and Glen Canyon Dam

The Lake Powell and Glen Canyon Dam reach is a PSD Class II Area. North central Arizona and southern Utah, including Lake Powell, is in attainment of the PM10 and PM2.5 standards (USEPA 2006a; 2006b). This attainment status corresponds with windrose information for both areas (i.e., relatively low average wind speeds implying low wind-blown fugitive emissions on average) and the relatively low levels of fugitive emissions generated from human activities.

3.6.3.2 Glen Canyon to Lake Mead

This reach is located in northern portions of Mohave County and Coconino County and encompasses the Grand Canyon National Park. Consistent with the federal air quality designations for national parks, the Grand Canyon National Park is designated as a PSD Class I Area. Mohave County and Coconino County, including the Glen Canyon Dam to Lake Mead reach, is in attainment of the PM10 and PM2.5 standards (EPA 2006a). Within the Grand Canyon National Park, wind velocities with the greatest potential for particulate transport from the Lake Mead delta occur during the April and May windy season.

3.6.3.3 Lake Mead and Hoover Dam

Lake Mead is located in the LMNRA on the Nevada and Arizona boundary in Clark County and Mohave County, respectively, and is a PSD Class II Area. The Lake Mead and Hoover Dam reach is in attainment (criteria air pollutant meets the corresponding NAAQS) of the PM10 and PM2.5 standards (EPA 2006a; 2006c). While some urban areas (including Las Vegas, North Las Vegas, and Henderson) within Clark County are in non-attainment of the NAAQS for PM10, the remaining county, including Lake Mead, is in attainment of the standard. That portion of Mohave County, Arizona adjacent to Lake Mead is also in attainment of the PM10 standard (Reclamation 2000).

3.7 Visual Resources

This section discusses the visual resources within the study area that may be affected by the proposed federal action. Topics include:

- Attraction features;
- Extent (height) of visible calcium carbonate ring; and
- Exposure of sediment deltas at reservoir in-flow areas.

3.7.1 Lake Powell and Glen Canyon Dam Reach

3.7.1.1 Attraction Features

The general visual/scenic resources of the Glen Canyon/Lake Powell area are dominated by the presence of Navajo Sandstone and desert varnish. Resources include sweeping vistas of red rock towers, buttes, and mesa framed by Lake Powell. One geologic attraction feature within this Reach is Rainbow Bridge. It is contained within the Rainbow Bridge National Monument that was established in 1910. At that time, it was accessible only by the rugged Wetherill Trail from Navajo Mountain. Today, it is estimated that more than 82,000 visitors see this attraction on an annual basis. Current low water conditions have reduced visitation to the monument by about half. The Lake Powell elevations change the view of Rainbow Bridge. At a Lake Powell elevation of 3,700 feet msl, visitors see the bridge with water in Bridge Canyon. At lower elevations, the view is one of Navajo Sandstone, with the water in Bridge Canyon further away.

Another geologic attraction is Cathedral in the Desert. This feature was inundated by the waters of Lake Powell as the reservoir filled. This geologic feature is now only exposed at low Lake Powell elevations; it is completely visible and accessible at elevations below 3,550 feet msl.

Glen Canyon Dam is also an attraction feature. The American Society of Civil Engineers considers it one of the finest examples of concrete thin arch dams in the United States.

3.7.1.2 Calcium Carbonate Ring

Lake Powell has deposits of calcium carbonate surrounding the reservoir that become visible as the reservoir is drawn down. At lower reservoir elevations the colorful sandstone canyon walls show a white band of calcium carbonate deposit between the full reservoir elevation and the lower reservoir elevation, which change the visual contrast of rock and water.

3.7.1.3 Sediment Deltas

Sediment deltas appear as expansive, deep and eroding mud flats, cut by river channels. Sediment exposed for more than a few months is soon colonized by tamarisk. Sediment that is carried by the Colorado River and the San Juan River are deposited near the inflow areas of Lake Powell, forming downstream-progressing deltas. These sediment deltas may be considered a visual detraction. Ferrari (2006) and Mussetter (not dated) indicate the sediment elevation at Hite Marina is about 100 feet above the original riverbed.

3.7.2 Glen Canyon Dam to Lake Mead

River trips down the Colorado River through Marble Canyon and the Grand Canyon are renowned for their visual character. The proposed federal action will not have any visual effects on this reach.

3.7.3 Lake Mead and Hoover Dam

3.7.3.1 Attraction Features

Hoover Dam is a major destination and a national landmark. In 1955 it was selected as one of the seven engineering wonders in the United States by the American Society of Civil Engineers. The dam is located in a narrow, steep-walled canyon. Only a small portion of Lake Mead within Black Canyon can be viewed from Hoover Dam and the adjacent visitor facilities.

3.7.3.2 Calcium Carbonate Ring

Lake Mead also has deposits of calcium carbonate surrounding the reservoir that become visible as the reservoir is drawn down. At lower reservoir elevations the steep rock slopes, canyon walls, and islands show a white band of calcium carbonate deposit between the full reservoir elevation and the lower reservoir elevation, that changes the visual contrast of rock and water. The ring is primarily noticeable to travelers on US Highway 93 between Boulder City, Nevada and Hoover Dam, and to boaters and hikers. The main view shed affected is the 56 square mile Boulder Basin.

3.7.3.3 Sediment Deltas

Sediment deltas have built up at the confluence of the Virgin River and Muddy River at the upper Overton Arm and at Upper Lake Mead (Iceberg Canyon, Pearce Basin, and Lower Granite Gorge). Sediment deltas are visible primarily to water-based recreationists, though they can also be viewed by visitors of the Lake Mead National Recreation Area (NRA) at Overton Beach and Pearce Ferry.

3.8 Biological Resources

This section describes the existing conditions related to biological resources within the study area that could be affected by implementation of the proposed federal action, including vegetation, wildlife and special status species associated with the Colorado River, its mainstream reservoirs, and historic floodplain.

Water deliveries are made to the service areas of the CAP, SNWA and MWD through a series of pumps, pipelines, diversions, and lined canals. Accordingly, the vegetation and wildlife habitat potential of this infrastructure is essentially absent. Therefore, no impacts to biological resources within these facilities are expected, and they are not analyzed in this Draft EIS. Furthermore, Reclamation does not have the authority to decide how these agencies will operate under a Shortage condition. For example, Reclamation does not control, and cannot anticipate which specific agricultural acreages may be planted or fallowed as a result of changes in water deliveries under the alternatives, nor are individual farm operator's response to various water delivery conditions predictable over the long-term given access to alternative sources of water, economic conditions, and other factors. While this EIS has identified the potential for fallowing agricultural lands, it cannot identify specific acreages which would be fallowed as a result of the proposed federal action. Therefore, it would be speculative to attempt to identify potential biological effects within the broader limits of the service areas, and thus these effects are not analyzed in this Draft EIS.

Reclamation is involved with numerous ongoing activities aimed at reducing the impact its operations have on biological resources, particularly on endangered species. For example, Reclamation is implementing the Glen Canyon Dam Adaptive Management Program, aimed at protecting and improving the environment downstream of Glen Canyon Dam, and the LCR MSCP, aimed at enhancing habitat for several endangered species and providing comprehensive mitigation to offset impacts from a range of conditions below Hoover Dam.

3.8.1 Vegetation

Plant communities in the study area can be broadly categorized as riparian. The riparian vegetation along the Colorado River is among the most important wildlife habitat in the region. Riparian habitats, or vegetated areas along streams and rivers, in the Western United States typically support a disproportionately large number of wildlife species.

Much of the information in this section comes from the Final Environmental Impact Statement on the Colorado River Interim Surplus Criteria (USBR 2000) and various LCR MSCP documents (LCR MSCP 2005).

3.8.1.1 Lake Powell and Glen Canyon Dam

Riparian vegetation around Lake Powell is extremely restricted because of the desert terrain that extends directly to the water's edge, and the continuously fluctuating lake levels. Tamarisk or salt cedar (*Tamarix ramosissima*), a nonnative invasive shrub along the Lake Powell shoreline is still becoming established and has not yet formed stable communities. These communities may attain some level of importance as insect and wildlife (particularly bird) habitat in the future, and provide habitat for fish during high lake levels when the plants are inundated.

Fluctuations in lake levels may result in standing water in the side canyons of Lake Powell where riparian vegetation has become established. Dominant plants found in these canyons include Fremont cottonwood (*Populus fremontii*), tamarisk (*Tamarix ramosissima*), and cattail (*Typha sp.*). The GCNRA has many springs, seeps that are common in alcoves along Glen Canyon walls, and waterpockets located in canyons and uplands. These areas are recognized for their significance as wetland habitats and as unique ecosystems within the desert. These seeps support hanging gardens which are a specialized vegetation community (Welsh et. al. 1987:7). The water sources that support hanging gardens originate from natural springs and seeps within the Navajo Sandstone formation and are independent of Lake Powell. This plant community will not be affected by the proposed federal action and as such it is not considered further in this EIS.

3.8.1.2 Glen Canyon Dam to Lake Mead

There is a change in the composition of the riparian community in this reach from Intermountian flora to that of the southern Basin and Range. Total area associated with the riparian community measures at least 10 square miles (6,400 acres).

Today, tamarisk (*Tamarix ramosissima*), arrowweed (*Pluchea sericea*), black willow or Gooding willow (*Salix goodingii*), coyote willow (*Salix exigua*), and Emory seepwillow (*Baccharis emeroyi*) are the primary phreatophytes in the riparian zone (taxonomy is after Welsh et. al. 1987). Those species that are more adapted to dry conditions may also be found further upslope on the terraces. Terrace dominants including four-wing saltbush (*Atriplex canescens*), arrowweed (*Pluchea sericea*), rubber rabbitbrush (*Chrysothamnus nauseosus*), and netleaf hackberry (*Celtis reticulata*), may also be located closer to the riverbank.

Marshes composed of emergent aquatics such as common cattail (*Typha domingensis*), broad-leaved cattail (*Typha latifolia*), and bulrushes (*Scirpus spp.*) have become established in return-current channels (backwaters), channel margins, and mouths of tributary streams from Glen Canyon Dam downstream to Lake Mead. Stands of emergent marsh vegetation in the riparian zone tend to be dominated by a few species, depending on soil texture and drainage. A cattail (*Typha domingensis*) and common reed (*Phragmities australis*) association grows on fine-grained silty loams while a horseweed (*Conyza canadensis*), knotweed (*Polygonum aviculare*), and Bermuda grass (*Cynodon dactylon*) association grows on loamy sands.

Since 1995, there has been a modest increase in woody vegetation and an increase in marsh communities under modified Glen Canyon Dam operations (Gloss et. al. 2005). However, the increase in woody vegetation is partially due to expansion of the non-native tamarisk and arrowweed into the riparian zone. The United States Geological Survey (USGS) has indicated that there has been a decrease in wet marsh and an increase in dry marsh (Gloss et. al. 2005).

3.8.1.3 Lake Mead to SIB

The highest concentration of vegetated habitat associated with Lake Mead is found in the Lake Mead and Virgin River deltas. Fluctuating water levels limit the shoreline vegetation. Riparian vegetation that does develop within the range of lake level fluctuation is temporary as fluctuating lake levels either dewater or inundate these areas through time. Linear riparian woodlands may be present along the shoreline of the Lake Mead delta following high water flows, and associated sediment deposition and exposure. The sediment deposition and the associated growth of riparian vegetation at the Lake Mead delta has occurred for decades. As lake levels decline, vegetation in the Lake Mead and Virgin River deltas begins to establish on clay/silt deposits. The dynamic nature of fluctuating lake levels and deposition of sediment in the Lake Mead delta is expressed as a change in plant species composition and relative abundance over time. An increase in sediment deposition in the deltas followed by lower lake levels allows establishment of native riparian habitat if the lowering of the lake is timed to match native seed dispersal.

Vegetation for this reach is categorized using the methodology outlined in the LCR MSCP. Detailed descriptions of the vegetation resources can be found in the LCR MSCP documents. A summary of the vegetation cover types and their characteristics found from Lake Mead to the SIB is provided below in Table 3.8-1.

Table 3.8-1
Summary of Vegetation Cover Types from Lake Mead to the SIB

Vegetation Cover Type	Characteristics
Woody Riparian	
Cottonwood-willow (6 structural types)	Gooding willow and cottonwood at least 10% of total trees
Saltcedar (6 structural types)	Saltcedar species constituting 80-90% of total trees
Honey Mesquite (4 structural types)	Honey mesquite constituting 90-100% of trees
Saltcedar-honey mesquite (4 structural types)	Honey mesquite at least 10% of total trees (usually <40%)
Saltcedar-screwbean mesquite (5 structural types)	Screwbean mesquite at least 20% of total trees
Arrowweed	Arrowweed at least 90-100% of total vegetation
Atriplex	Saltbush species constituting 90-100% of total vegetation
Marsh (7 compositional types)	Cattail/bulrush; little common reed, trees and grasses, and open water
Aquatic	
River	Mainstream plus tributaries and natural/artificial channels
Reservoir	"Lakes" formed by dams with variable water levels
Backwater	Open water plus marsh, temporary to permanent
Desert Scrub	Adjacent to riparian and aquatic land cover types
Agriculture	Active or fallow, adjacent to riparian and aquatic land cover types
Developed	Buildings, roads, campgrounds, landscaped areas

Table 3.8-2 provides a summary of the vegetation cover type acreage by river sub-reach that was determined to be present for the LCR MSCP analysis. A detailed breakdown of the sub-categories of cover types, is provided in Table 4-8 of the LCR MSCP Biological Assessment (BA).

Table 3.8-2
Summary of Vegetation Cover Types from Lake Mead to the NIB (acres)[a]

Type	Lake Mead and Hoover Dam	Hoover Dam to Davis Dam	Davis Dam to Park Dam	Park Dam to Cibola Gage	Cibola Gage to Imperial Dam	Imperial Dam to NIB
Cottonwood-willow	1,721	1	1,541	889	616	1,325
Saltcedar	2,254	838	13,647	26,923	5,581	6,257
Honey Mesquite	0	4	627	6,443	175	5
Saltcedar-Honey Mesquite	58	359	3,463	13,398	778	234
Saltcedar-Screwbean Mesquite	0	32	5,058	4,654	579	786
Marsh	137	22	4,358	2,091	3,762	1,414
Atriplex	0	0	19	582	0	177
Arrow weed	0	0	496	6,541	48	1,069
Desert Scrub	353	31	7,676	11,710	397	3,151
Agriculture	0	0	19,166	169,664	260	36,799
Undetermined Riparian	0	0	6,634	6,268	0	2,337

[a] From LCR MSCP BA Table 4-8

For reference, further description of the LCR MSCP vegetation types present in this reach are provided below. The vegetation is classified according to the Anderson and Ohmart system, which is further described in the LCR MSCP documents (LCR MSCP 2005).

3.8.1.4 NIB to SIB

Riparian communities comprise approximately 6,974 acres of the land cover present below Morelos Diversion Dam; 3,638 acres of which is in the United States. Approximately 77 percent of these communities are dominated by non-native saltcedar. The types of riparian communities present in this reach are described above in Table 3.8-1. Table 3.8-3 below summarizes the extent of riparian communities in the United States below Morelos Diversion Dam.

Table 3.8-3
Summary of Vegetation Cover Types in the United States from NIB to SIB[a]

Type	Acreage
Arrow weed	33
Atriplex	38
Cottonwood-Willow-I	14
Cottonwood-Willow-II	38
Cottonwood-Willow-III	212

Table 3.8-3
Summary of Vegetation Cover Types in the United States from NIB to SIB[a]

Type	Acreage
Cottonwood-Willow-IV	165
Cottonwood-Willow-V	27
Subtotal	*527*
Marsh	50
Saltcedar	2,996
Saltcedar-screwbean mesquite	65
TOTAL	3,638

[a] *Reclamation, July-September 2005 surveys.*

The Borderlands Task Force consisting of the BLM, the Border Patrol, the USACE, FWS, Reclamation, and the Cocopah Indian Tribe is planning a vegetation clearing project along this reach aimed at improving security along this section of the United States and Mexico border. BLM is the lead federal agency responsible for compliance on this proposed effort.

3.8.2 Wildlife

The Colorado River and its associated riparian vegetation provide important habitat for a variety of wildlife. Table 3.8-4 lists the native and non-native fish species that occur in the study area. The study area extends from the northern tip of Lake Powell in Utah south to the SIB (RM 0.0).

Table 3.8-4
Native and Non-Native Fish Species Present in the Study Area by Reach

Species	Reach	Native/ Non-native
Black bullhead *(Ictalurus melas)*	All	Non-native
Black crappie *(Pomoxis nigromaculatus)*	All	Non-native
Bluegill *(Lepomis macrochirus)*	All	Non-native
*Bluehead sucker *(Catastomus discobolus)*	Glen Canyon Dam to Hoover Dam	Native
*Bonytail *(Gila elegans)*	Lake Powell (rare), Hoover Dam to Imperial Dam	Native
Carp *(Cyprinus carpio)*	All	Non-native
Channel catfish*(Ictalurus punctatus)*	All	Non-native
*Colorado pikeminnow *(Ptychocheilus lucius)*	Lake Powell to Glen Canyon Dam (rare)	Native
Fathead minnow *(Pimephales promelas)*	All	Non-native
*Flannelmouth sucker *(Catostomus latipinnis)*	Lake Powell, Separation Canyon, Lake Mead, immediately below Davis Dam	Native
Flathead catfish *(Pylodictis olivaris)*	Davis Dam to NIB	Non-native
Green sunfish *(Lepomis cyanellus)*	Lake Powell to Glen Canyon Dam,Lake Mead to SIB	Non-native
*Humpback chub *(Gila cypha)*	Lake Powell (rare) Glen Canyon Dam to Separation Canyon	Native
Largemouth bass *(Micropterus salmoides)*	Lake Powell to NIB	Non-native
Mosquitofish *(Gambusia affinis)*	Glen Canyon Dam to SIB	Non-native

Table 3.8-4
Native and Non-Native Fish Species Present in the Study Area by Reach

Species	Reach	Native/ Non-native
Plains killifish *(Fundulus zebrinus)*	Glen Canyon Dam to Hoover Dam	Non-native
Rainbow trout *(Oncorhynchus mykiss)*	Glen Canyon Dam to Below Davis Dam	Non-native
*Razorback sucker *(Xyrauchen texanus)*	Lake Powell to Imperial Dam (rare above Lake Mead)	Native
Red shiner *(Notropis lutrensis)*	All	Non-native
Shortfin mollies *(Poecilia mexicana)*	Lake Mead, Laguna Dam to SIB	Non-native
Smallmouth bass *(Micropterus dolomieui)*	Lake Powell, Separation Canyon (rare), Lake Mead to Imperial Dam	Non-native
Striped bass *(Morone saxatilis)*	Lake Powell to NIB	Non-native
Threadfin shad *(Dorosoma petenense)*	Lake Powell to SIB	Non-native
Tilapia *(Oreochromis aureus)*	Lake Mead to SIB	Non-native
Walleye *(Stizostedion vitreum)*	Lake Powell to Glen Canyon Dam	Non-native
Redear Sunfish *(Lepomis Microlophus)*	Davis Dam to NIB	Non-Native
Warmouth *(Chaenobryttus gulosus)*	Parker Dam to NIB	Non-Native
Sailfin Molly *(Poecillia latipinna)*	Palo Verde Diversion Dam to SIB	Non-native
Striped Mullet *(Mugil cephalus)*	Laguna Dam to SIB	Native
Goldfish *(Carassius auratus)*	Lake Mead to SIB	Non-native
Yellow bullhead *(Ameiurus natalis)*	Lake Powell to SIB	Non-native

Distribution Information from: CDFG 2000; Colorado Division of Wildlife no date; Fuller 2006; Mexico Game and Fish 2004; NatureServe 2006; Pima County no date; Ptacek et al 2005; Rees et al 2005a; Rees et al 2005b; FWSa no date; FWSb no date; FWSc no date; Valdez 2006.

**Note: These fish species are discussed further below under Special Status Species.*

3.8.2.1 Lake Powell and Glen Canyon Dam

Fifteen fish species reside in Lake Powell and include 14 non-native fish species and one native fish species (flannelmouth sucker).

Common fish species in Lake Powell include walleye, bluegill, green sunfish, carp and channel catfish. Species that occur in the reservoir, but that are mainly associated with tributaries and inflow, include fathead minnow, mosquitofish, red shiner and plains killifish (NPS 1996). Mueller and Horn (1999) reported large numbers of fish in the reservoir upstream of the dam, but Budy et. al. (2005) found large seasonal variances in fish abundances with low numbers of striped bass, threadfin shad and gizzard shad present at Wahweap Bay in May and July.

Non-native fish species became established by intentional and unintentional introductions. Lake Powell was stocked with non-native sport and forage fish and movement of stocked non-native fish into the lake has also taken place. Largemouth bass and crappie populations were stocked initially and proliferated to provide the bulk of the sport fisheries. Both species have declined in recent years due to lack of habitat structure for young fish. Filling, fluctuation, and aging of the reservoir resulted in changing habitat that eliminated most of the vegetation and favored many species. The habitat change led to the introduction of smallmouth bass and striped bass, presently the two dominant predator species in the reservoir, with striped bass being the most dominant. Threadfin shad were introduced to provide an additional forage base and quickly became the predominant prey species (NPS 1996).

The sport fishery in Lake Powell is primarily based on striped bass. Other sport fish found in Lake Powell include largemouth bass, catfish and trout. Threadfin shad in Lake Powell exist in the northernmost portion of their range, and are the primary food source for striped bass.

At least six species of amphibians are currently known to live in Glen Canyon National Recreation Area. The Canyon tree frog (*Hyla arenicolor*) is common along the shores of Lake Powell (Spence 1996). All other herpetofauna, including the declining northern leopard frog (*Rana pipiens*), are associated with side canyons off Lake Powell and are therefore outside the area of influence of the proposed federal action.

Common waterfowl of the Lake Powell area include American widgeon (*Anas americana*), northern pintail (*Anas acuta*), bufflehead (*Bucephala albeola*) common goldeneye (*Bucephala clangula*), common merganser (*Mergus merganser*), green-winged teal (*Anas crecca*), lesser scaup (*Aythya affini*), eared grebe (*Podiceps nigricollis*), and mallard (*Anas platyrhynchos*). The majority of these are winter residents or spring and fall migrants. Most shorebirds are summer residents. Common shorebird species include western sandpiper (*Calidris mauri*), least sandpiper (*Calidris minutilla*), American avocet (*Recurvirostra americana*), long-billed dowitcher (*Limnodromus scolopaceus*), snowy egret (*Egretta thula*), and great blue heron (*Ardrea herodias*). Ring-billed gulls (*Larus delarwarensis*) are common year-round residents.

Larger mammals inhabiting the study area include beavers, desert bighorn sheep, mule deer, coyotes, mountain lions, and bobcats (U.S. Department of Interior, 2004b). Mountain lions and bobcats are rare. Smaller mammals include ringtail and western spotted skunks and six bat species (Carothers and Brown 1991).Two skunk species are some of the most common to the area.

3.8.2.2 Glen Canyon Dam to Lake Mead

A total of 18 non-native fish species have been reported between Glen Canyon Dam and Lake Mead during the period of 1957 through 2006 (Lauretta and Johnstone 2005; Lauretta and Seratto 2006; Trammell and Valdez 2003; Valdez and Ryel 1995). Non-native fish infrequently occurring in this reach include the golden shiner, redside shiner, striped bass, and threadfin shad.

The Glen Canyon Dam to Lake Mead reach supports six native fish species which include small numbers of the three non-ESA listed species: flannelmouth sucker, bluehead sucker, and speckled dace. The flannelmouth sucker spawns in the Colorado River (McIvor and Thieme 2000; Thieme 1998), although the water generally is too cold for survival of eggs and larvae. Populations of bluehead and flannelmouth suckers are protected under a multi-state cooperative agreement between Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming (Utah Department of Natural Resources 2004). Their populations appear to have remained relatively stable under the MLFF operating policy of Glen Canyon Dam.

The primary sport fish in the Colorado River between Glen Canyon Dam and Lake Mead inflow is rainbow trout. Natural reproduction of rainbow trout in the Grand Canyon is dependent on cool water temperatures, access to tributaries for spawning and continued availability of suitable mainstream habitat. These variables are directly related to patterns of flow releases from Lake Powell. McKinney and Speas (2001) conducted a study analyzing 658 rainbow trout around Lees Ferry to determine the predominant food sources. It was found that *Gammarus*, chironomids, and *Cladophora* constituted about 90 percent of the food by volume.

Humpback chub have also been reported to rely on *Gammarus* and chironomids, but also rely on larval simuliids, which become more common downstream of the Paria River (Gloss et. al. 2005). *Cladophora, Oscillatoria spp* and terrestrial organic matter serve as key energy sources for aquatic invertebrates between Glen Canyon Dam and Lake Mead. *Cladophora and Oscillatoria* are also consumed by fish (Gloss et. al. 2005).

Over 27 species of herpetofauna have been documented in the riparian zone of the Grand Canyon. Within this reach, herpetofauna densities are generally highest in the new high water zone of riparian vegetation that has developed since emplacement of Glen Canyon Dam. The old high water zone is situated higher in elevation, a result of pre-dam flooding. However, Carpenter (2006) found that, other than the resident frog species, all herpetofuana observed in the canyon utilized all three hydrologic zones - shoreline, the new high water zone and the old high water zone. Toads and tree lizards used the shoreline proportionally more than any of the other species and were observed more in the new, than in the old high water zone.

The most common lizards in the riparian zone are the side-blotched lizard (*Uta stansburiana*), the Western whiptail (*Cnemidophorus tigris*), the desert spiny lizard (*Sceloporus magister*), and the tree lizard (*Urosaurus ornatus*). The collared lizard (*Crotaphylus insularis*) and the chuckwalla (*Sauromalus obesus*) are less common in the riparian zone than in the old high water zone. Warren and Schwalbe (1986) reported lizard densities during June averaged 858 per hectare in the riparian zone versus 300 per hectare in the old high water zone. Kearsley et. al. (2006) suggested that the high density of lizards in the riparian zone may be attributed to increased abundance of food resources (insects) and to some degree to organic debris left on popular camping beaches.

Snakes are common in the higher and drier elevations of the riparian zone and in the more xeric terraces and hillsides. Eight snake species have been documented within the riparian zone; the most common of these are the Grand Canyon rattlesnake (*Crotalus viridis abyssus*), the southwestern speckled rattlesnake (*C. mitchellii pyrrhus*) and the desert striped whipsnake (*Masticophis taeniatus*).

Listed as a species of special concern in Arizona, the northern leopard frog is declining throughout its range. Recent surveys have found healthy populations of the Woodhouse's toad (*Bufo woodhousii*), the red-spotted toad, (*B. punctatus*), the canyon treefrog, and the tiger salamander (*Ambystoma tigrinum*) (Gloss et. al. 2005).Northern leopard frog populations have declined substantially (Drost 2004).

The canyon tree frog is confined mostly to relatively steep side canyons while the two toad species are generally found in the active riparian zone in spring and fall but appear to favor the shore zone in summer (Kearsley et. al. 2003). For riverside dwellers, egg deposition and larval development generally occurs in the backwaters or along the shallow waters at the boundary of the aquatic and riparian ecosystems.

Listed as a species of special concern in Arizona, the northern leopard frog is declining throughout its range. Leopard frogs have disappeared from 70 percent of the known sites above and below Glen Canyon Dam and there appear to be declines among some of the remaining populations (Gloss et. al. 2005). The only known remaining population below Glen Canyon Dam is located between Glen Canyon Dam and the Paria River in a series of off-channel pools. Inundation at this site occurs at approximately 21,000 cfs. This population has experienced wide year-to-year fluctuations in numbers, but recent survey efforts indicate a sharp decline in population size with only two adult individuals found in 2004 (Drost 2004).

In 2004, a previously unknown small population of a second leopard frog species was found in Surprise Canyon. Although genetic studies are still in progress, the frogs appear to be an ever rarer species, the lowland leopard frog (*Rana yavapaiensis*). This small population is located well up the canyon and outside the influence of flows in the Colorado River (Drost 2005).

More than 30 bird species have been recorded breeding in the riparian zone along the Colorado River in Grand Canyon. Most nest and forage for insects within the riparian zone and the adjacent upland area. Of the 15 most common riparian breeding bird species, 10 are neotropical migrants that breed in the study area but winter primarily south of the United States-Mexico border. The rest of the breeding birds that use the canyon are year-round residents or short-distance migrants that primarily winter in the region or in nearby southern Arizona (Brown et. al. 1987).

Eleven of these nesting bird species are referred to as obligate riparian birds due to their complete dependence on the riparian zone. Obligate riparian birds nesting within the riparian zone include the neotropical migrants Lucy's warbler (*Vermivora luciae*) and Bell's vireo (*Vireo bellii*), two species identified as "high priority" under regional Partners-in-Flight bird plans and area state bird plans, Common yellowthroat (*Geothlypis trichas*), yellow warbler (*Dendroica petechia*), yellow-breasted chat (*Icteria virens*), black-chinned hummingbirds (*Archilochus alexandri*), the endangered Southwestern willow flycatcher (*Empidonax trailii extimus*), and Bewick's wren (*Thryomanes bewickii*), a sometimes permanent resident of Grand Canyon. Black Phoebe (*Sayornis* *nigricans*) is a common permanent resident of the canyon having a close association with water.

The riparian breeding bird community appears little changed since the riparian plant community stabilized in the 1970s and bird studies were initiated in the 1980s. Exceptions are Bell's vireo and song sparrow (*Melospiza melodia*), which appear to have expanded their breeding ranges, and Bullock's oriole (*Icterus bullockii*) and yellow warbler which have increased in number. The blue-gray gnatcatcher (*Polioptila caerulea*) has shown a steady decline in numbers (Brown et. al. 1987; Spence 2004; Yard and Blake 2004).

Winter songbirds include ruby-crowned kinglet, white-crowned sparrow, dark-eyed junco, and song sparrow (Spence 2004). Spence (2004) found that winter species diversity increased below RM 205.

The aquatic bird community is almost exclusively made up of winter residents. Thirty-four species of wintering waterfowl along with loons, cormorants, grebes, herons, rails, and sandpipers utilize the Colorado River corridor. Increases in abundance and species richness have been attributed to the increased river clarity and productivity associated with the presence of Glen Canyon Dam (Spence 2004; Stevens et. al. 1997a). The majority of waterfowl tends to concentrate above the Little Colorado River due to the greater primary productivity that benefits dabbling ducks and greater clarity for diving, piscivorous ducks. Common waterfowl species include American coot (*Fulica americana*), American widgeon, bufflehead, common goldeneye, common merganser, gadwall (*Anas strepera*), green-winged teal, lesser scaup (*Aythya affinis*), mallard, and ring-necked duck (*Aythya collaris*). Shorebirds other than great blue heron and spotted sandpiper (*Actitis macularia*) are rare in the action area. These species are fairly common winter and summer residents along the river.

The American peregrine falcon (*Falco peregrinus*) are uncommon year-round residents in the action area. In recent years, as many as twelve active eyries have been found in the canyon. Nest sites are usually associated with water. In the Grand Canyon, common prey items in summer include white-throated swift (*Aeronautes saxatalis*), swallows, other song birds, and bats (Brown 1991), many of which feed on invertebrate species (especially Diptera) that emerge out of the Colorado River (Stevens et. al. 1997b). In winter, a common prey item is waterfowl.

The common bird species found in this reach (Gloss et. al. 2005) are summarized in Table 3.8-5 and Table 3.8-6.

Table 3.8-5
The Fifteen Generally Most Common Terrestrial Breeding Bird Species Found in Riparian Habitats Along the Colorado River in Grand Canyon

Common Name	Scientific Name
Ash-throated flycatcher	*Myiarchus cinerascens*
Bell's vireo	*Vireo bellii*
Bewick's wren	*Thryomanes bewickii*
Black-chinned hummingbird	*Archilochus alexandri*
Blue grosbeak	*Passerina caerulea*
Blue-gray gnatcatcher	*Polioptila caerulea*
Bullock's oriole	*Icterus bullockii*
Common yellowthroat	*Geothlypis trichas*
House finch	*Carpodacus mexicanus*
Lesser goldfinch	*Carduelis psaltria*
Lucy's warbler	*Vermivora luciae*
Mourning dove	*Zenaida macroura*
Song sparrow	*Melospiza melodia*
Yellow warbler	*Dendroica petechia*
Yellow-breasted chat	*Icteria virens*

Table 3.8-6
The Ten Generally Most Common Overwintering Aquatic Bird Species Encountered During Surveys Along the Colorado River below Glen Canyon Dam

Common Name	Scientific Name
American coot	*Fulica Americana*
American wigeon	*Anas Americana*
Bufflehead	*Bucephala albeola*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Gadwall	*Anas strepera*
Green-winged teal	*Anas crecca*
Lesser scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Ring-necked duck	*Aythya collaris*

Within the GCNRA and Grand Canyon National Park, 64 and 34 species of mammals, respectively, have been found (Carothers and Aitchison 1976; Warren and Schwable 1986; Frey 2003). Of these mammals only three can be considered obligate aquatic mammals - beaver (*Castor canadensis*), muskrat (*Ondatra canadensis*), and river otter

(*Lutra canadensis*). Despite occasional reported sightings of river otters in the Grand Canyon, river otters are classified as extirpated and muskrats are considered extremely rare.

An increase in the population size and distribution of beavers in Glen Canyon and Grand Canyon has occurred since the construction of Glen Canyon Dam, likely due to the increase in riparian vegetation and relatively stable flows. Beavers cut willows, cottonwoods, and shrubs for food and can significantly affect the riparian vegetation. Bats in the Grand Canyon typically roost in desert uplands, but forage on abundant insects along Lake Powell, the Colorado River and its tributaries. The deer mouse (*Peromyscus maniculatus*) is restricted to the riparian zone. Larger mammals included coyotes (*Canis latrans*), bighorn sheep, mule deer (*Odocoileus rafinesque*), mountain lions (*Puma concolor*), and bobcats (*Lynx rufus*). Mountain lions and bobcats are rarely seen (Gloss et. al. 2005).

3.8.2.3 Lake Mead and Hoover Dam

The sport fishery in Lake Mead is primarily for striped bass and largemouth bass. Other sport fish found in the lakes include catfish and hatchery reared rainbow trout (USBR 2000).

Native fishes in this reach include the razorback sucker, and the flannelmouth sucker. Non-native fishes inhabiting this reach include red shiner (*Cyprinella lutrensis*), common carp (*Cyprinus carpio*), and mosquitofish, among others (USBR 1982a).

A large number of non-native fish species are present, predominantly downstream of the Warm Springs area and continuing into Lake Mead (FWS 1995). Non-native species that co-occur with native fishes in spring-fed pools include shortfin mollies (*Poecilia mexicana*), mosquitofish, and tilapia (*Oreochromis aureus*) (Scoppettone et. al. 1998).

The herpetofauna and their habitat use of upper Lake Mead is an extension of the more common species and habitat use described above for the Glen Canyon Dam to Lake Mead reach. The two relict leopard frog (*Rana onca*) populations within LMNRA are associated with isolated springs and are outside the area of influence of the proposed federal action. The spiny soft-shelled turtle (*Trionyx spiniferus*) has also been introduced and it is present in Lake Mead (Allan and Roden 1978).

Avifuana for upper Lake Mead is similar to that discussed for the previous river reaches. Songbird species are similar to those of the canyons upstream with greater diversity than in Glen Canyon and Grand Canyon. Waterfowl species are similar to those described above for Lake Powell. Waterfowl use is highest in winter months.

Mammalian use of this reach is similar to that discussed for the previous reaches.

3.8.2.4 Hoover Dam to NIB

This section of the lower Colorado River supports several hundred species of wildlife (birds, mammals, fish, reptiles, and amphibians), including both resident species and migratory visitors, that use the land cover types described above. Common mammals include mule deer (*Odocoileus hemionus*), burro (*Equus asinus*) (a non-native mammal), coyote (*Canis latrans*), bobcat (*Felis rufus*), Audubon cottontail (*Sylvilagus audubonii*), several species of rodents and bats, striped skunk (*Mephitis mephitis*), and raccoon (*Procyon lotor*) (Anderson and Ohmart 1984b). Reptiles and amphibians are represented by several species of lizards, snakes, toads, and frogs, many of which are native to the area. Most of these use upland and riparian areas, but the amphibians require water for reproduction. The spiny soft-shelled turtle (*Trionyx spiniferus*) has also been introduced in Lake Mohave (Allan and Roden 1978). A variety of aquatic invertebrates inhabit the reservoirs and river. Fourteen species of zooplankton have been reported in Lake Mead and Lake Mohave as well as mollusks, crustaceans, aquatic and terrestrial insects, and a freshwater jellyfish (Allan and Roden 1978).

The Colorado River corridor provides important habitat for migratory birds, both neotropical songbirds and waterfowl and other wetland dependent species, as well as habitat for resident species. These migratory species include such songbirds as humming birds, cuckoos, flycatchers, vireos, warblers, tanagers, orioles, buntings, waterfowl and wetland birds such as geese, ducks, cranes, rail, killdeer and other plovers, stilts, avocets, yellowlegs, dowitchers, and sandpipers.Woody riparian vegetation and wetlands provide habitat for a variety of raptors that include sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperii*), northern harrier (*Circus cyaneus*), red-tailed hawk (*Buteo jamaicensis*), rough-legged hawk (*Buteo lagopus johannis*), common black hawk (*Buteogallus anthracinus*), Harris' hawk (*Parabuteo unicinctus*), bald eagle (*Haliaeetus luecocephalus*), golden eagle (*Aquila chrysaetos*), white-tailed kite (*Elanus leucurus*), American kestrel (*Falco sparverius*), peregrine falcon (*Falco peregrinus*), and osprey (Pandion haliaetus). Other common birds include egrets, herons, and woodpeckers. Backwaters and reservoirs provide resting and foraging habitat for waterfowl and shorebirds.

3.8.2.5 NIB to SIB

This reach, known as the Limitrophe Reach, is inhabited by warm water fish and wildlife species similar to those found upstream. As identified in Table 3.8-4, sixteen species of fish, primarily non-native, may be found in this reach."

3.8.3 Special Status Species

Special status species are species that are listed, or those that are proposed for listing as threatened or endangered under the ESA that may be present in the study area, and include species of special concern to states and other entities responsible for management of resources within the study area. This includes special status species and their habitat from Lake Powell to the SIB that may be affected by the proposed federal action. Special status species not associated with the Colorado River, or which otherwise are not likely to be affected, are not described in this EIS.

Reclamation is consulting with the FWS to meet its responsibilities under Section 7 of the ESA on the potential effects of the proposed federal action to ESA-listed species. A considerable amount of information pertinent to this analysis is available from various recent documents prepared by Reclamation and the FWS under NEPA and/or the ESA. These documents were relied upon for much of the information for this section.

Reclamation prepared a biological assessment (BA) on the ISG and Secretarial Implementation Agreement (SIA), which analyzed the potential effects on special status species, including ESA-listed species which may occur in the study area from the full pool elevation of Lake Powell to the SIB (Reclamation 2000).

More recently, Reclamation completed consultation under ESA for various current and projected federal and non-federal activities covered by the LCR MSCP. The purpose of the LCR MSCP was to provide for conservation of several federally listed species and many non-listed species, while allowing the federal and non-federal MSCP partners to continue their ongoing and future operations below Lake Mead. The geographic scope of the LCR MSCP includes the full pool elevation of Lake Mead and the floodplain downstream to the SIB. Among the activities covered by the consultation were future water delivery reductions under shortage conditions.

Reclamation is consulting with the FWS to meet its responsibilities under Section 7 of the ESA on the potential effects beyond the LCR MSCP coverage, of the proposed federal action to federally listed species. This includes: 1) Lake Powell to Lake Mead (outside LCR MSCP coverage); and 2) Incremental effects beyond LCR MSCP coverage, if any, from Lake Mead to the SIB.

Table 3.8-7 lists those special status species potentially affected by the proposed federal action. Further description of special status species is available in several existing documents including the LCR MSCP (2004, 2005) and Colorado River Interim Surplus Guidelines Final EIS (USBR 2000).

Table 3.8-7
Special Status Species Potentially Affected by the Proposed Federal Action

Common Name	Scientific Name	Listing Status	Location		
			Lake Powell	GCS to Lake Mead	Lake Mead to SIB
Fish					
Colorado pikeminnow	Ptychocheilus lucius	FE CH CA E UT SP AZ SC	X		
Flannelmouth sucker	Catostomus latipinnis	AZ SC BLM S UT CS	X	X	X
Humpback chub	Gila cypha	FE CH UT State Protected AZ SC	X	X	

Table 3.8-7
Special Status Species Potentially Affected by the Proposed Federal Action

Common Name	Scientific Name	Listing Status	Location		
			Lake Powell	GCS to Lake Mead	Lake Mead to SIB
Bonytail	Gila elegans	FE CH AZ SC CA E	X		X
Razorback sucker	Xyrauchen texanus	FE CH CA E UT SP AZ SC	X	X	X
Bluehead sucker	Catostomus discobolus	FC AZ SC UT CS		X	X
Birds					
California Condor	Gymnogyps californianus	FE EX AZ SC CA E	X	X	
Bald eagle	Haliaeetus leucocephalus	FT - PDL AZ SC CA E NV SP	X	X	X
Osprey	Pandion haliaetus	AZ SC CA SC	X	X	X
Belted kingfisher	Ceryle alcyon	AZ SC NV SP	X	X	X
American peregrine falcon	Falco peregrinus	FSC AZ SC CA E (fully protected) NV E	X	X	X
Southwestern willow flycatcher	Empidonax traillii extimus	FE CH AZ SC CA E NV SP		X	X
Clark's grebe	Aechmophorus clarkia	AZ SC	X	X	X
Snowy egret	Egretta thula	AZ SC		X	X
Yuma clapper rail	Rallus longirositris yumaniensis	FE AZ SC CA T			X

Table 3.8-7
Special Status Species Potentially Affected by the Proposed Federal Action

Common Name	Scientific Name	Listing Status	Location		
			Lake Powell	GCS to Lake Mead	Lake Mead to SIB
Western yellow-billed cuckoo	Coccyzus americanus	FC AZ SC CA E NV SP		X	X
California black rail	Laterallus jamaicensis coturniculus	FSC AZ SC CA T			X
Elf owl	Micrathene whitneyi	CA E			X
Gilded flicker	Colaptes chrysoides	CA E			X
Gila woodpecker	Melanerpes uropygialis	CA E			X
Vermillion flycatcher	Pyrocephalus rubinus	CA SC			X
Arizona Bell's vireo	Vireo bellii arizonae	CA E			X
Sonoran yellow warbler	Dendroica petechia sonorana	CA SC			X
Summer tanager	Piranga rubra	CA SC			X
American white pelican	Pelecanus erythrorhynchos	CA SC NV SP UT SC			X
Double-crested cormorant	Phalacrocorax auritus	CA SC			X
Western least bittern	Ixobrychus exilis hesperis	FSC CA SC			X
American bittern	Botaurus lentiginosus	AZ SC			X
Great egret	Ardea alba	AZ SC			X
Black-crowned night-heron	Nycticorax nycticorax	CA SC			X
White-faced ibis	Plegadis chihi	FSC CA SC NV SP			X
Black tern	Chlidonias niger	CA SC			X
Greater sandhill crane	Grus canadensis tabida	CA T			X
Long-eared owl	Asio otus	CA SC NV SP			X
Brown-crested flycatcher	Myiarchis tyrannulus	CA SC			X
Crissal thrasher	Toxostoma crissale	CA SC			X
Lucy's warbler	Vermivora luciae	CA SC			X
Yellow-breasted chat	Icteria virens	CA SC			X
Yellow-headed blackbird	Xanthocephalus xanthocephalus	CA SC			X
Northern cardinal	Cardinalis cardinalis	CA SC			X

Table 3.8-7
Special Status Species Potentially Affected by the Proposed Federal Action

Common Name	Scientific Name	Listing Status	Location		
			Lake Powell	GCS to Lake Mead	Lake Mead to SIB
Northern harrier	Circus cyaneus	CA SC NV SP			X
Cooper's hawk	Accipiter cooperii	CA SC NV SP			X
American kestrel	Falco sparverius	NV SP			X
Mammals					
Townsend's big-eared bat	Corynorhinus townsendii	UT SC BLM S CA SC	X	X	X
Pale Townsend's Big-Eared Bat	Corynorhinus townsendii pallescens	FSC AZ SC	X	X	X
Spotted Bat	Euderma maculatum	FSC CA SC AZ SC UT SC	X	X	X
Allen's Big-eared Bat	Idionycteris (=Plecotus) phyllotis	UT SC BLM S	X	X	X
Western Red Bat	Lasiurus blossevillii	AZ SC	X	X	X
Yuma myotis	Myotis yumanensis	FSC BLM S	X	X	X
Western Yellow Bat	Lasiurus xanthinus	AZ SC			X
Colorado River Cotton Rat	Sigmodon arizonae plenus	FSC CSC			X
Yuma Hispid Cotton Rat	Sigmodon hispidus eremicus	FSC CA SC			X
Occult little brown bat	Myotis lucifugus occultus	FSC CA SC AZ SC			
Cave Myotis	Myotis velifer	FSC CA SC			X
Greater Western Mastiff Bat	Eumops perotis californicus	FSC CA SC		X	X
Small-footed myotis	Myotis ciliolabrum	BLM S		X	X
Amphibians					
Colorado River Toad	Bufo alvarius	CA SC			X

Table 3.8-7
Special Status Species Potentially Affected by the Proposed Federal Action

Common Name	Scientific Name	Listing Status	Location		
			Lake Powell	GCS to Lake Mead	Lake Mead to SIB
Relict Leopard Frog	Rana onca	FC NV SP AZ SC CA SC			X
Lowland leopard frog	Rana yavapaiensis	FSC AZ SC CA SC		X	X
Northern leopard frog	Rana pipens	AZ SC CA SC	X	X	
Plants					
Grand Canyon evening primrose	Camissonia specuicola	FSC		X	
Sticky buckwheat	Eriogonum viscidulum	FSC			X
Geyer's milkvetch	Astragalus geyeri var triquetrus	NV CE			X
Las Vegas Bear Poppy	Arctomecon californica	NV CE			X
Invertebrates					
Kanab ambersnail	Oxyloma haydeni kanabensis	FE AZ SC		X	
MacNeill's sooty-winged skipper	Hesperopsis gracielae	FSC BLM S		X	X
Niobrara ambersnail	Oxyloma haydeni haydeni	BLM S		X	

Listing Status Legend

FT – Federally threatened under Endangered Species Act (ESA)

FT PDL – Federally threatened under ESA, proposed for de-listing

FE – Federally endangered under ESA

FE CH – Federally endangered under ESA with designated Critical Habitat (CH)

FE EX – Federally endangered under ESA, experimental population

FC – Federal candidate for listing under ESA

FSC – Federal Species of Concern (non-ESA)

BLM S – Bureau of Land Management Sensitive

NV E – Nevada Endangered

NV CE – Nevada Critically Endangered

NV SP – Nevada State Protected

AZ SC – Arizona Wildlife of Special Concern

CA T – California Threatened

CA E – California Endangered

CA SC – California Species of Special Concern

UT CS – Utah special management under Conservation Agreement to preclude the need for Federal listing

UT SC – Utah Species of Concern

UT SP – Utah State Protected

3.9 Cultural Resources

This section describes the cultural resources that may be affected by the proposed federal action. The cultural resources include historic and prehistoric buildings, structures, sites, and objects, including Indian sacred sites and traditional cultural properties. Historic properties are the subset of cultural resources that are either listed or determined eligible for listing on the National Register of Historic Places (NRHP). Eligibility to the NRHP is determined by the ability of a property to convey its significance or importance in American history, prehistory, culture, or engineering, and by its integrity, essentially its preservation (36 C.F.R. pt. 60.4).

Section 106 of the National Historic Preservation Act of 1966 (NHPA) as amended, and its implementing regulations (36 C.F.R. pt. 800) require federal agencies to take into account the effects of their actions (undertakings) on historic properties and to allow the Advisory Council on Historic Preservation (ACHP) an opportunity to comment. Exec. Order No. 13007 requires consultation with Indian tribes regarding Indian sacred sites. Executive Memorandum from the White House of April 29, 1994 requires government-to-government consultation on other issues of Tribal concern. These concerns may also involve cultural resources. Reclamation has initiated consultation with concerned Indian tribes, State Historic Preservation Officers (SHPO), Tribal Historic Preservation Officers (THPO), and other interested parties regarding cultural resources.

3.9.1 Undertaking Determination

Reclamation has determined that the proposed federal action is an undertaking subject to compliance with Section 106 of the NHPA. This is because it adds a new element to the existing program of on-going operations of the Colorado River that could lead to changes in the manner in which Lake Powell and Lake Mead have been operated historically. Specifically, the alternatives address operation of these two reservoirs at low elevations that might result in the emergence of cultural resources that have been submerged since the creation of the reservoirs. A reduction in the amount of water to be delivered downstream of Lake Mead could result in lower river levels, which could lead to changes in stream dynamics and patterns of deposition and erosion that could potentially affect cultural resources.

3.9.2 Definition of the Area of Potential Effects and Identification Efforts

The area of potential effects (APE) of an undertaking is defined at 36 C.F.R. pt. 800.16(d) as "the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist." This section goes on to state that "the APE is influenced by the scale of the undertaking and may be different for different kinds of effects caused by the undertaking." Reclamation defines the APE to be the reaches of the Colorado River from Lake Powell downstream to Imperial Dam. In the reach from Davis Dam to Imperial Dam, the APE is further defined as the Colorado River channel from bank to bank, and the lateral extent of backwaters, lakes, and marshes directly connected to it.

Reclamation has compiled all available information about previously documented cultural resources in the APE. This information will form the basis of consultation with the SHPO and THPO, as required by 36 C.F.R. pt. 800.

3.9.3 Lake Powell and Glen Canyon Dam

The NPS database indicates that 518 historic properties were recorded within the full reservoir pool of Lake Powell (elevation 3,700 feet msl) during the Upper Colorado River Basin Archaeological Salvage Project (more commonly referred to as the Glen Canyon Project [Jennings 1966]) between 1956 and 1963. All were inundated by 1980 when Lake Powell reached full pool elevation. The Glen Canyon Project was completed prior to the enactment of the NHPA; hence none of the sites were evaluated for eligibility to the NRHP. Of the 518 sites, 61 were excavated and 10 tested for significance under the Historic Sites Act of 1935. This left 447 sites for which documentation was the only form of mitigation.

It is not known whether any of the inundated sites would retain integrity should they be exposed through the lowering of Lake Powell elevation. Inundation studies conducted by the NPS and the USACE (Dunn 1996; Lenihan et. al. 1981; Ware 1989) concluded that cultural resources located within the deep-water zone of reservoirs are least susceptible to impacts of inundation and reservoir operations, while cultural resources within the operational zones of reservoirs are subject to adverse impacts from wave action and the alternating effects of wetting and drying related to fluctuating pool levels. Cultural resources immediately above the full pool elevation have generally been disturbed and damaged by recreation and visitation.

Indian sacred sites and other resources of Tribal concern have been documented in this reach.

3.9.4 Glen Canyon Dam to Lake Mead

The first 15 miles of this reach is within the GCNRA. The remainder of the reach is within the Grand Canyon National Park, the Navajo Indian Reservation and the Hualapai Indian Reservation. An intensive archaeological survey of this reach was conducted during 1991 and 1992 by NPS and the Department of Anthropology, Northern Arizona University (NAU) through funding provided by Reclamation. In all, 475 sites were recorded, 336 of which were potentially subject to impacts from dam operations. Of the 336 sites, 313 were determined NRHP-eligible, 14 not eligible, and nine were recommended for testing (Fairley et. al. 1994). A programmatic agreement was developed to address the possible impacts to cultural resources resultant from the operation of Glen Canyon Dam (USDI 1994). Currently, Reclamation in conjunction with the NPS, Navajo Nation Archaeological Department (NNAD), Utah State University (USU), the Zuni Cultural Resource Enterprise (ZCRE), and Museum of Northern Arizona is developing a treatment plan for mitigation of adverse effects to 160 historic properties. Additional long term monitoring and resource protection is afforded by the Grand Canyon Protection Act of 1992.

The Navajo Nation, Pueblo of Zuni, Hopi Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians, and Paiute Indian Tribe of Utah have been actively monitoring Grand Canyon natural resources, as well as resources of traditional religious and cultural significance. These tribes are currently developing culturally specific long-term monitoring protocols. In addition, the Pueblo of Zuni has completed a NRHP eligibility nomination for selected historic properties or traditional cultural properties (TCP) as defined by National Register Bulletin 38. The Navajo Nation, Hopi Tribe, and Hualapai Tribe are currently developing TCP nominations. Indian sacred sites and other resources of Tribal concern have been documented in this reach.

3.9.5 Lake Mead and Hoover Dam

Most of the prehistoric cultural resources in this reach were documented by Harrington and the Civilian Conservation Corps in the 1920s and 1930s (Harrington 1925a, b, 1926, 1927; Harrington et. al. 1930), while those of historic and architectural value are compiled in WESTEC Inc. (1980). Property types include: mines, ferry and steamboat landings, roads, ranches, farms, buildings, and town sites (Kaolin, St. Thomas, Rioville, and Callville). Notable ethnographic resources include a Southern Paiute farm observed by Jedediah Smith in 1827, a village site, and the Salt Song Trail, the general location of which is shown in the map that serves as the frontispiece to Laird’s work on the Chemehuevi (Laird 1976). Two resources are listed on the NRHP: Lost City/Pueblo Grande de Nevada, and Hoover Dam. Hoover Dam is further distinguished by its status as a National Historic Landmark. Most of these resources have been submerged since 1937 when Lake Mead rose above elevation 1,083 feet msl to an elevation of 1,102 feet msl.

Since its initial filling in the late 1930s, Lake Mead elevations have fluctuated from a high of 1,226 feet msl in 1983 to a low of 1,083 feet msl in 1956. Based on the results of the National Reservoir Inundation Study (Lenihan et. al. 1981; Ware 1989) it is anticipated that most cultural resources located within the historical operational zone of Lake Mead (between the 1,225-foot msl and 1,083-foot msl elevation contours) have lost integrity as a result of repeated, periodic exposure at the margin of the reservoir where they would have been subject to mechanical erosion by wave action. Although some sites in the historical operational zone such as St. Thomas (Wyskup 2006) may continue to retain integrity, the National Reservoir Inundation Study and other reservoir specific studies (Labadie 2001) indicate only cultural resources submerged at depth since initial inundation are likely to retain integrity. Recent sidescan sonar and high-resolution seismic-reflection studies performed at Lake Mead (Harper et. al. 2005; Twichell et. al. 1999, 2003) appear to confirm this finding and suggest that cultural resources submerged in Lake Mead since it reached historic operational levels in 1937 could retain sufficient integrity for listing on the NRHP.

Though some 156 resources appear in agency records, documentary sources, and inventory reports, this analysis concentrates on 108 sites previously identified in agency and repository records. Of these 108 sites it is likely that as many as 73 sites within the operational zone of Lake Mead (that area between elevations 1,226 feet msl and 1,083 feet msl) are likely to have been completely destroyed or damaged to the point where they would not qualify for listing on the NRHP. The remaining 35 sites below elevation 1,083 feet msl may retain sufficient integrity to qualify for listing. Examples of submerged resources in excellent condition are the B-29 bomber that went down in Lake Mead in the 1950s, and features associated with the aggregate classification plant used during the construction of Hoover Dam (Harper et. al. 2005).

Previously undocumented cultural resources in the operational zone of Lake Mead will likely have been impacted to varying degrees and some will probably retain sufficient integrity to qualify for listing on the NRHP. However, as noted above, the excellent condition of the B-29 bomber and the features associated with the aggregate classification plant located in the Boulder Basin suggest there is a good chance previously undocumented cultural resources that have been submerged since 1937, below elevation 1,083 feet msl, could retain sufficient integrity to be considered for listing. Examples of the kinds of cultural resources that are likely to retain some information potential include historic sites with structural remains and archaeological sites with subsurface deposits and features. Information from sidescan sonar studies conducted in the Boulder Basin and other areas of Lake Mead indicate deposition of sediment has been greatest in the area of the delta, and along the old channels of the Colorado River and Virgin River, and the major washes that feed into them. Undocumented cultural resources in these areas are likely buried beneath considerable thickness of sediment or, as is the case with St. Thomas, cultural resources may be covered by a mantle of silt several to tens of inches thick (Wyskup 2006).

3.9.6 Lake Mohave and Davis Dam

Most of the prehistoric cultural resources in this reach were documented by Baldwin (1943, 1948). WESTEC Inc. (1980) reported on historic and architectural resources. Though 196 previously recorded prehistoric and historic period cultural resources are known or suspected to be located in or immediately adjacent to the Lake Mohave and Davis Dam reach, many of the resources documented by Baldwin prior to the construction of Davis Dam (Baldwin 1943, 1948) are features, rather than sites. When Baldwin's clusters are treated as single sites, the total number of sites suspected to be located in and immediately adjacent to the Lake Mohave and Davis Dam reach is reduced to 89.

Types of historic sites include mines, ranches, buildings and structures, ferry and steamboat landings, roads, trails, campsites, and a railroad (the Quartette Mining Company line). One traditional cultural property of importance to several tribes that is listed on the NRHP is located in this reach. Prehistoric property types documented in this reach include pit houses, rock art, rock shelters, lithic and ceramic scatters, rock circles, rock alignments, and rock piles.

With respect to the probable condition of documented and undocumented sites submerged in Lake Mohave, it can be anticipated that the portions of resources located between the 647-foot msl elevation contour and the 628-foot msl elevation contour will have lost integrity as a result of wave action. The results of a recent sidescan sonar and seismic-reflection study (Foster et. al. 2004) suggest portions of sites located below the 628-foot msl elevation contour may retain sufficient integrity to qualify them for consideration for listing on the NRHP.

3.9.7 Davis Dam to Parker Dam

The environment in which cultural resources exist is different in fluvial and lacustrine systems. For this reason, the highly channelized river reach from Davis Dam to Upper Lake Havasu is treated separately from that of Lake Havasu and Parker Dam.

3.9.7.1 Davis Dam to Upper Lake Havasu

The 39-mile reach of the Colorado River from Davis Dam to Upper Lake Havasu is one of its most highly modified and controlled stretches. Within this part of the reach, the Colorado River levels will likely fall rather than rise from a decrease in water deliveries when shortages are declared. For this reason, the APE for this reach is the Colorado River channel from bank to bank, and the lateral extent of backwaters, lakes, and marshy areas directly connected to it.

Information contained in WESTEC Inc. (1980) indicates that at least 22 historic period cultural resources may be present in or located in the immediate vicinity of Davis Dam to Upper Lake Havasu. Property types located in this reach include river crossings, ferry and steamboat landings, town sites or camps, buildings, structures, trails, roads, and highways, railroads, bridges, and the suspected location of the Rose-Brown massacre. This information also indicates that a number of these resources had already been significantly impacted by the 1970s by residential and commercial development, historic flood events, or destroyed during the 1950's when portions of this stretch was confined within levees, channelized, and stabilized with rip-rap. The Arch Bridge/1916 Colorado River Highway Bridge, a part of a multiple property listing on the NRHP, is in this reach. Prehistoric sites include caves and rockshelters, lithic and ceramic scatters, rock alignments, and petroglyphs.

3.9.7.2 Lake Havasu and Parker Dam

This part of the APE includes Lake Havasu from RM 237 downstream to Parker Dam. Information in WESTEC, Inc. (1980) and other sources provide a brief description of eight cultural resources submerged beneath Lake Havasu. These are primarily river landings associated with mills, and commercial and residential structures established to support several local mines active from 1860 to the turn of the century. Historic records indicate that several historic-period Chemehuevi Indian villages were located along both sides of the Colorado River at the upper end of the Chemehuevi Valley. An additional 20 cultural resources appear in repository records as being located at the margin of Lake Havasu or on small islands or peninsulas extending into the reservoir. Prehistoric types include lithic and ceramic scatters, rock alignments, trails, bedrock mortars, petroglyphs, and intaglios. Due to limited information currently available, it is not possible to know the condition of the submerged resources or how much post-impoundment sedimentation has occurred.

Any cultural resources located within the current operational zone of the reservoir (between elevations 450.5 feet msl and 445.8 feet msl), or within the historic operational zone between elevations 451 feet msl and 444 feet msl, will likely have been impacted. Sites located in these zones will likely not be considered as eligible properties. However, it is possible based on results of recent findings in Lake Mead and Lake Mohave that cultural resources consistently submerged beneath Lake Havasu since its creation may retain sufficient integrity to be eligible for the NRHP.

3.9.7.3 Parker Dam to Imperial Dam

This reach extends from Parker Dam to Imperial Dam and covers the 143 miles of river channel (from bank to bank) and the lateral extent of backwaters, lakes, and marshy areas having a direct connection to the river.

Minimal cultural resources inventorying has been conducted in this portion of the APE. Possible cultural resources within and the limits of the APE are described in the Implementation Agreement FEIS (Reclamation 2002). The information provided in this document suggests that numerous historic resources may be present in and around this reach. Twelve sites have been recorded proximate to the boundary of the APE. These consist of a segment of a railway where it crosses the Colorado River, a ceramic scatter, heat altered rock, intaglios, historic mining/milling features, bedrock mortar depressions, a natural cavern used as a jail for the historic gold milling community of Picacho, a lithic scatter, a trail segment, mining cairns, rock art, and cleared circles. Only one of the twelve sites, a prehistoric habitation site, is listed on the National Register and is near the edge of the APE. Only three recorded sites are known to exist within the APE. These are Parker Dam, Imperial Dam, and a portion of the "Old Parker Road" alignment. Parker Dam is a contributing element to the Parker Dam Historic District, which is eligible for listing on the National Register. Imperial Dam is potentially eligible for individual listing on the National Register and is a contributing element to the All-American Canal system.

Though cultural inventories of areas within the historic floodplain of this river reach are extremely limited, it appears that historic site distribution along the river corridor is more random then on the uplands bordering the historic floodplain. Also, prior to construction of Hoover Dam in the 1930s, river flows were extremely dynamic, its course meandering and altering across the floodplain. Trench evaluations reveal that sediments within the floodplain have been laid down under high-energy fluvial conditions, under which it is extremely unlikely to expect in situ cultural remains.

3.9.7.4 Imperial Dam to SIB

There is little to no data relative to the existence of historic properties within the river channel for the river reach that extends from Imperial Dam to the SIB. Nevertheless, any known or as yet undiscovered cultural resources within this reach of the River will not be affected by the No Action Alternative or action alternatives because the current river operations will continue into the future. This is also applies to sites listed on the National Register of Historic Places. One of these sites is the Ocean to Ocean Bridge, constructed in 1915 for Highway 80 in Yuma, Arizona which is the first highway bridge to be constructed across the Colorado River. Another site is Yuma Crossing and associated sites, which has been designated as a National Historic Landmark. The landmark boundaries straddle the River from the St. Thomas Yuma Indian Mission on the north and the Quartermaster Depot and Yuma Territorial Prison on the south.

3.10 Indian Trust Assets

3.10.1 Introduction

Indian Trust Assets (ITAs) are "…'legal interests' in 'assets' held in 'trust' by the federal government for federally recognized Indian tribes or individual Indians" (USBR 1994). The United States, as trustee, is responsible for protecting rights reserved by, or granted to, Indian tribes or individual Indians by treaties, statutes, executive and secretarial orders, and other federal actions. The Department's policy is that when a proposed federal action appears likely to adversely affect an ITA, the action agency should seek ways to minimize or avoid the adverse effect; if adverse effects cannot be avoided, then the action agency should provide appropriate mitigation or compensation. While most ITAs are located on reservation lands, they can also be located off-reservation. Examples of ITAs include, but are not limited to, water rights, land, minerals, and rights to hunt and fish.

Reclamation consulted with potentially affected tribes whose reservations are located along the mainstream Colorado River from Lake Powell to the SIB, as well as with those tribes who have a water service contract (Chapter 6) to identify ITAs and to assess potential effects of the proposed federal action on these ITAs. Reclamation has determined that no tribes or reservations located upstream of Lake Powell will be affected by the proposed federal action.

The trust assets that might potentially be impacted as a result of implementing the proposed federal action are described and discussed below. Impacts to the ITAs are discussed and analyzed in Chapter 4, and cumulative effects are discussed in Chapter 5.

3.10.2 Water Rights and Trust Lands

For this analysis, the Indian water rights and land assets considered include:

- federally reserved Indian rights to Colorado River water including rights established pursuant to *Arizona v. California;*
- Colorado River water Tribal delivery contracts where such contracts are part of a congressionally approved water rights settlement; and
- Indian reservations.

Indian trust lands are areas for which the United States holds title in trust for the benefit of the tribe (Tribal trust land) or for an individual Indian (individual trust land). Trust lands may be located on or off a reservation. While Indian reservations are not technically synonymous with trust lands, the exterior boundaries of Indian reservations are used to define the trust assets for purposes of this NEPA analysis. The BIA and United States Census Bureau identified and provided the data on size and location of reservations analyzed here.

3.10.2.1 Indian Trust Assets Determined under Arizona v. California: Fort Mojave, Chemehuevi, Colorado River Indian, Fort Yuma, and Cocopah Indian Reservations

The March 9, 1964 Arizona v. California Decree and several supplemental decrees (consolidated in 2006 into the Consolidated Decree) quantified the Indian reserved water rights of the Fort Mojave, Chemehuevi, Colorado River Indian, Fort Yuma, and Cocopah Indian reservations. The amounts of water (diversion entitlements), priority dates for this water, net acres, and the states where the water rights are perfected for these Indian reservations are listed in Table 3.10-1, and discussed below.

Table 3.10-1
Colorado River Mainstream Diversion Entitlement (Water Rights) in Favor of Indian Reservations

Reservation	State	Diversion Entitlement (Water Right) (afy)[1]	Net Acres1	Present Perfected Right Number[1]	Priority Within State	Priority Date[1]
FORT MOJAVE RESERVATION	Arizona	27,969	4.327	3	1	Sept.18,1890
		75,566	11,691			Feb 2, 1911
	California	16,720	2,587	25	1	Sept. 18, 1890
	Nevada	12,534	1,939	81	1	Sept. 18, 1890
Total	--	132,789	--	--	--	
CHEMEHUEVI RESERVATION	California	11,340	1,900	22	1	Feb. 2, 1907
Total	--	11,340	--	--	--	
COLORADO RIVER INDIAN RESERVATION	Arizona	358,400	53,768	2	1	Mar. 3, 1865
		252,016	37,808			Nov. 22, 1873
		51,986	7,799			Nov. 16, 1874
	California	10,745	1,612	24	1	Nov. 22, 1873
		40,241	6,037			Nov. 16, 1874
		5,860	879			May 15, 1876
Total	--	719,248	--	--	--	
FORT YUMA INDIAN RESERVATION	Arizona	6,350	952	3a	1	Jan. 9, 1884
	California	71,616	10,742	23	1	Jan. 9, 1884
Total	--	77,966	--	--	--	
COCOPAH INDIAN RESERVATION	Arizona	1,140	190	8	1	1915
		7,681	1,206	1		Sept. 27, 1917
		2,026	318	--	4	June 24, 1974
Total	--	10,847	--	--	--	
Arizona Total	--	783,134	--	--	--	
California Total	--	156,522	--	--	--	
Nevada Total	--	12,534	--	--	--	

1 *Source: Consolidated Decree of March 27, 2006. The quantity of water in each instance is measured by (i) diversions or (ii) consumptive use required for irrigation of the respective acreage and for satisfaction of related uses, whichever of (i) or (ii) is less.*

Fort Mojave Reservation (Fort Mojave Indian Tribe of Arizona, California and Nevada). The Fort Mojave Reservation is located in the lower Colorado River basin where Nevada, Arizona, and California meet. The Fort Mojave Reservation possesses present perfected federal reserved water rights from the Colorado River in all three of these states that contain reservation land pursuant to the Consolidated Decree.

Subsequent to recent changes made to the Fort Mojave Reservation's water rights resulting from a boundary adjustment, the reservation has the right to divert up to 103,535 afy in Arizona (2004 diversion of 69,103 af)[1], up to 16,720 afy in California (in 2004 the reservation diverted 16,019 af), and up to 12,534 afy in Nevada (2004 diversion of 3,870 af).

Chemehuevi Reservation (Chemehuevi Indian Tribe of the Chemehuevi Reservation, California). The Chemehuevi Reservation is located in southern California, near Lake Havasu. The Chemehuevi Reservation holds present perfected federal reserved water rights from the mainstream Colorado River pursuant to the Consolidated Decree. The lands of the Chemehuevi Reservation are mostly on the plateau above the shoreline of Lake Havasu. Present agricultural water use is limited. The Chemehuevi Reservation has a right to divert up to 11,340 afy in California; the 2004 reported diversion was 1,444 af.

Colorado River Indian Reservation (Colorado River Indian Tribes of the Colorado River Indian Reservation, Arizona and California). The Colorado River Indian Reservation is located in Arizona and California. The Colorado River provides 90 miles of shoreline for the Colorado River Indian Reservation. The reservation economy centers around agriculture, recreation, and light industry. The Colorado River Indian Reservation was established on March 3, 1865. The Colorado River Indian Reservation's diversion right in Arizona is 662,402 afy (2004 diversion was 585,534 af) and the reservation's diversion right in California is 56,846 afy (2004 diversion was 6,231 af).

Fort Yuma Indian Reservation (Quechan Tribe of the Fort Yuma Indian Reservation, California and Arizona). The Fort Yuma Indian Reservation is located in southwestern Arizona and southern California, near Yuma, Arizona. The Consolidated Decree provided additional water rights to the Fort Yuma Indian Reservation in both Arizona and California. The Fort Yuma Indian Reservation has the right to divert up to 6,350 afy in Arizona (2004 diversion was 1,279 af) and up to 71,616 afy in California (2004 diversion was 46,259 af).

Water for the Fort Yuma Indian Reservation is diverted from the Colorado River at Imperial Dam and delivered through the Yuma Project Reservation Division - Indian Unit. The Fort Yuma Indian Reservation has other small uses at homestead sites south of Yuma, Arizona. The current water uses shown in Table 3.10-1 include only uses within the Fort Yuma Indian Reservation.

[1] 2004 diversions are provided in this section to indicate approximate use of the entitlements for each Indian tribe.

Cocopah Indian Reservation (Cocopah Tribe of Arizona). The Cocopah Indian Reservation is located in southwestern Arizona. The western boundary of the reservation is bordered by Mexico and portions of the Colorado River. The Cocopah Indian Reservation was established through Exec. Order No. 2711 on September 27, 1917, but additional acres were added to the reservation through 1974. The Cocopah Indian Reservation economy is centered on agriculture. The Cocopah Indian Reservation's present perfected federal reserved water rights provide for the diversion of up to 10,847 afy in Arizona. The 2004 reported diversion was 3,878 af.

The 1974 decreed right for the Cocopah Indian Reservation is unique because of its more recent priority date, i.e., post-1968. The 1984 Supplemental Decree in *Arizona v. California* recognized the decreed right for the Cocopah Indian Reservation dated June 24, 1974 and amended paragraph 5 of Article II (D) of the Consolidated Decree to reflect this 1974 right.

3.10.2.2 Seven Central Arizona Indian Tribes

The CAP makes Colorado River water available to Indian tribes located in central Arizona in addition to the ITA entitlements discussed above. Over the years, there have been several Secretarial decisions allocating water to 10 Indian tribes in central Arizona. All of these Indian tribes, with the exception of the Gila River Reservation, have signed a CAP water delivery contract in 1980. The Gila River Reservation, with the largest allocation of CAP water, signed its CAP water delivery contract in 1992. Each of the CAP water delivery contracts contained a provision that the Indian tribes' CAP water would be credited against their Winters right (*Winters v. United States*, 207 U.S. 564 (1908)), if and when such rights were finally determined. Over the years, water rights settlements have been implemented for seven of these 10 Indian tribes. Under these settlements, the seven Indian tribes generally have a right to lease their CAP water within Arizona; the CAP water does not have to have a history of use in order for the water to be leased. A listing of the major water rights settlement legislation for these seven Indian tribes in chronological order follows:

- Settlement of Ak-Chin Indian Community Water Rights Claims of July 28, 1978 (92 Stat. 409) and the Ak-Chin Indian Community Water Rights Settlement Act of October 19, 1984 (96 Stat. 2698)

- Southern Arizona Water Rights Settlement Act of October 12, 1982 (Title III of Public Law 97-293) and Title III of the Arizona Water Settlements Act of December 10, 2004

- Salt River Pima-Maricopa Indian Community Water Rights Settlement Act of 1988 (102 Stat. 2549)

- Fort McDowell Indian Community Water Rights Settlement Act of 1990 (104 Stat. 4469)

- San Carlos Apache Tribe Water Rights Settlement Act of 1992 (Title XXVII of the Reclamation Projects Authorization and Adjustment Act of 1992)
- Yavapai-Prescott Indian Tribe Water Rights Settlement Act of 1994 (108 Stat. 4526) (Indian tribes' CAP water permanently assigned to Scottsdale)
- Gila River Indian Community Water Rights Settlement Act (Title II of the Arizona Water Settlements Act of December 10, 2004)

Table 3.10-2 lists the CAP Tribal water entitlements for the seven Indian tribes discussed above. These entitlements and their priorities are discussed further below.

Table 3.10-2
Central Arizona Project Indian Tribal Diversion Entitlements (Water Rights)

Reservation	Diversion Entitlement (Water Right) (afy)	Land Area (square miles)[1]	Arizona Priority	CAP Priority[2]
Ak-Chin Indian Community of the Maricopa Indian Reservation	47,500	--	2 and 3	Arizona Priority (CAP 1)
	27,500	--	4	Indian Priority (CAP 2)
Ak-Chin Indian Community Total	*75,000*	*32.9*		
Tohono O'odham Nation - San Xavier District	27,000	--	4	Indian Priority (CAP 2)
	23,000	--	4	Non-Indian Agriculture (NIA) Priority (CAP 3)
Tohono O'odham Nation - San Xavier District Total	*50,000*	*111.4*		
Tohono O'odham Nation – Schuk Toak District	10,800	--	4	Indian Priority (CAP 2)
	5,200	--	4	NIA Priority (CAP 3)
Tohono O'odham Nation - Schuk Toak District Total	*16,000*	*4342.0*		
Salt River Reservation	13,300	--	4	Indian Priority (CAP 2)
Salt River Reservation Total	*13,300*	*80.0*		
Fort McDowell Reservation		--		
Contracted in 1980	4,300	--	4	Indian Priority (CAP 2)
Acquired from HVID	13,933	--	4	Indian Priority (CAP 2)
Fort McDowell Reservation Total	*18,233*	*38.6*		
San Carlos Reservation	12,700	--	4	Indian Priority (CAP 2)
M&I Reassignment	18,145	--	4	M&I Priority (CAP 2)
Ak–Chin Settlement	30,800	--	4	Indian Priority (CAP 2)
San Carlos Reservation Total	*61,645*	*2910.6*		
Gila River Reservation	191,200	--	4	Indian Priority (CAP 2)
	120,600	--	4	(NIA) Priority (CAP 3)
Gila River Reservation Total	*311,800*	*583.9*		

1 Source is www.census.gov\geo\wvw\ezstate\airpov.pdf, accessed December 10, 2006

2 CAP Priority Definitions:

CAP 1: Arizona Priority 2 and Arizona Priority 3 Water
CAP 2: M&I Priority and Indian Priority Water
CAP 3: NIA Priority Water
CAP 4: Excess Agricultural Users
CAP5: Excess Water for Bank

An understanding of the CAP priority system is necessary to discern how shortages could potentially impact the different priorities of CAP water and CAP water users, including Indian tribes. Within CAP, shortages reduce water deliveries to CAP water users in the following order: CAP 5 Bank; CAP 4 Excess Agricultural Users; CAP 3 NIA Priority Water; equally CAP 2 M&I Priority and Indian Priority Water,; and finally CAP 1 Arizona Priority 2 and Arizona Priority 3 Water. A detailed explanation of the CAP water priority rights is included in Appendix E. Modeled reductions are based on what was available to a user under its entitlement in that year based on higher priority use.

Ak-Chin Indian Community of the Maricopa (Ak-Chin) Indian Reservation. In 1912, President Taft created a reservation at Ak-Chin comprised of 21,840 acres. In 1961, the Ak-Chin Tribal Council was formally recognized under the Indian Reorganization Act of 1934. The Ak-Chin Indian Reservation is located in Pinal County 50 miles south of Phoenix. Farming (Ak-Chin Farms) is a major part of the economy of the reservation.

Ak-Chin Reservation’s water rights settlement of 1978 was the first of a series of Indian water rights settlements in central Arizona. The 1978 Settlement Act was amended in 1984. Under the 1984 water rights settlement, the Ak-Chin Indian Reservation has the right to receive up to 75,000 afy of water at the southeastern corner of the reservation. In years of shortage on the Colorado River, the United States may deliver no less than 72,000 afy. The 1984 Settlement Act further provides for payment of damages by the United States if these quantities of water are not delivered to the Ak-Chin Indian Reservation. In other years when surplus water is available, the United States may deliver up to an additional 10,000 afy of water to the Ak-Chin Indian Reservation (maximum of 85,000 afy). The Ak-Chin Indian Reservation was also provided with the right to lease some of its CAP water supplies within Arizona, and the Ak-Chin Indian Reservation has leased a portion of its water to the Del Webb Corporation. The Ak-Chin Indian Reservation’s water infrastructure is in place, and with the exception of water that the Ak-Chin Indian Reservation leased, the community is using all of its CAP water for farming purposes.

The United States acquired 50,000 afy of Colorado River water entitlement from the Yuma Mesa Division of the Gila Project to partially meet the requirement to deliver required quantities to the Ak-Chin Indian Reservation. This 50,000 afy of water has a priority date that precedes the date of enactment of the CRBPA, and therefore has a higher priority during times of shortage than other CAP water.

Tohono O’odham Nation of Arizona. The Tohono O’odham Nation sits in the heart of the Sonoran Desert, sixty miles west of Tucson, Arizona. The Tohono O’odham Nation is divided into multiple districts totaling more than 4,342 square miles. Under the Tohono O’odham Nation’s 1982 water rights settlement, as subsequently amended, the nation’s water rights are specific to two of Tohono O’odham Nation’s districts, the San Xavier District and the Schuk Toak District.

The San Xavier District has the right to receive a total of 50,000 afy of water, consisting of 27,000 afy of CAP 2 Indian Priority Water, and 23,000 afy of CAP 3 NIA Priority Water (Table 3.10-2). CAP 3 NIA Priority Water is the most vulnerable portion of the CAP water supply, and the United States is required to firm (i.e., provide a backup water supply) the delivery of this water during the next 100 years.

The Schuk Toak District has the right to receive a total of 16,000 afy of water, consisting of 10,800 afy of CAP 2 Indian Priority Water, and 5,200 afy of CAP 3 NIA Priority Water. The United States is required to firm the delivery of CAP 3 NIA Priority Water during the next 100 years as in the case with the San Xavier District.

Yet another Tohono O'odham Nation's district, the Chui-Chi District, has a CAP water delivery contract with the Secretary to receive up to 8,000 afy of CAP 2 Indian Priority Water. As this water is not presently covered by a water rights settlement, it is not considered an ITA.

Construction of the works necessary for the Tohono O'odham Nation to take delivery of its water under the 1982 Settlement Act is ongoing. The works necessary to deliver water to the Schuk Toak and San Xavier Districts have been completed. The Schuk Toak District is currently using a portion of the water provided under this settlement. The San Xavier District has initiated water deliveries and will expand these deliveries upon completion of the rehabilitation of its existing cooperative farm, which is ongoing.

Salt River Reservation (Salt River Pima-Maricopa Indian Community). The Salt River Reservation is located in Arizona, aside the boundaries of Mesa, Tempe, Scottsdale, Fountain Hills, and metropolitan Phoenix. The reservation was created in 1879. The Salt River Reservation is occupied by two tribes, the Pima and the Maricopa; and the combined enrolled population exceeds 7,000. The Salt River Reservation consists of 53,600 acres and maintains 19,000 acres as a natural preserve. Approximately 12,000 acres are under cultivation with cotton, melons, onions, broccoli, and carrots being the major crops.

Under its water rights settlement, the United States obtained the rights to 22,000 afy of Colorado River water entitlement from the Wellton-Mohawk Irrigation and Drainage District, near Yuma, Arizona. This right is senior to CAP. Pursuant to the settlement, this water was contracted by the Secretary to several Phoenix area cities and the tribe agreed to accept delivery of an equivalent amount of Salt River Project (SRP) water. The SRP water deliveries to the tribe will not be affected by the proposed federal action.

The Salt River Reservation has the right to receive up to 13,300 afy of CAP 2 Indian Priority Water. The Salt River Reservation has the right to lease its CAP water under the settlement within Arizona and has leased all of its CAP water to the City of Phoenix for a 100-year period. This water supply is considered an ITA.

Fort McDowell Reservation (Fort McDowell Yavapai Nation). The Fort McDowell Reservation is located in Maricopa County, Arizona about 23 miles northeast of Phoenix. The Verde River flows north to south through the reservation. The Fort McDowell Reservation was created by executive order in 1903 for the Yavapai, Mojave, and Apache Indian tribes. The 38.6 square-mile Fort McDowell Reservation is home to 600 community members, while another 300 members live off the reservation.

Under its water rights settlement, the Fort McDowell Reservation received a combination of water resources from both the SRP and the CAP. With respect to the Colorado River supplies, the Fort McDowell Reservation received the rights to delivery of up to 18,233 afy of water. This consisted of 4,300 afy of CAP water that the Fort McDowell Reservation had contracted for in 1980, plus an additional 13,933 afy of CAP water that the United States acquired from the Harquahala Valley Irrigation District (HVID). The acquired HVID water was converted from its CAP 3 NIA Priority Water to CAP 2 Indian Priority Water through this settlement. The Fort McDowell Reservation has leased 4,300 afy of its CAP water to the City of Phoenix for a 100-year period, and the reservation is presently not using the remaining 13,933 afy of CAP water.

San Carlos Reservation (San Carlos Apache Tribe). The San Carlos Reservation is located in southeastern Arizona. The reservation was established by executive order in 1871 and covers 2,910.6 square miles. Approximately one-third of the San Carlos Apache Tribe's land is forested or wooded. San Carlos Lake is a hub of recreational activity, especially for fishing.

Under its water rights settlement, the San Carlos Reservation has the rights to delivery of up to 61,645 afy of Colorado River water. This consists of 12,700 afy of CAP 2 Indian Priority Water, 18,145 afy of CAP 2 M&I Priority Water (previously allocated to Phelps Dodge and the town of Globe), and 30,800 afy of water made available by the Ak-Chin Indian Community Water Rights Settlement Act of 1984. Given that the San Carlos Reservation is not able to physically divert CAP water, the tribe will need to implement a water exchange to benefit from its CAP water supplies. The San Carlos Reservation has the right to lease CAP water under its 1992 settlement, and has leased up to 14,000 afy to Phelps Dodge through an exchange with the SRP. The San Carlos Reservation has also entered into a lease with the City of Scottsdale for 12,500 afy of CAP 2 M&I Priority Water.

Yavapai Reservation (Yavapai-Prescott Tribe of the Yavapai Reservation). Under its 1994 settlement, the Yavapai Reservation permanently assigned and transferred its CAP contractual right of 500 afy to the City of Scottsdale, Arizona, in return for funds to develop alternative water supplies. Since the Yavapai Reservation no longer has a right to CAP water, no trust asset is attributable to the Yavapai Reservation.

Gila River Reservation (Gila River Indian Community). The Gila River Reservation was established by executive order in 1859 for Pima and Maricopa Indians. The 583.9 square mile reservation is located in Maricopa and Pinal Counties, 35 miles south of the Phoenix metropolitan area. The Gila River Reservation is bounded by the San Tan and Sacaton

Mountains to the east, the Estrella Mountains to the west, and the South Mountains to the north. The Gila River Indian Community established Gila River Farms during the late 1960s, with approximately 16,000 acres in production. The Gila River Reservation is the homeland for two distinct tribes, the Pima and the Maricopa.

The 2004 Gila River Indian Community Water Rights Settlement Act provides the community with 311,800 afy of CAP water. The CAP supply consists of 120,600 afy of CAP 3 NIA Priority Water and 191,200 afy of CAP 2 Indian Priority Water. Under the 2004 Settlement Act, the state of Arizona is required to firm 15,000 afy of the CAP 3 NIA Priority Water so that it has a reliability equivalent to CAP 2 Indian Priority and M&I Priority Water over a 100-year period. Construction of the infrastructure to deliver CAP water to the Gila River Reservation for farming purposes is ongoing. Under the 2004 settlement, the Gila River Reservation has the right to lease its CAP water within Arizona. Approximately 40,000 afy of the Gila River Reservation's CAP water has already been leased to Phoenix area cities. In addition, the Gila River Reservation has entered into effluent exchange agreements with surrounding municipalities, Chandler and Mesa, whereby the Gila River Reservation exchanges some of its CAP water for a larger quantity of treated effluent.

3.10.3 Hydroelectric Power Generation and Distribution

Headgate Rock Dam and Powerplant is owned and operated by the BIA, which supplies energy generated at the Headgate Rock Powerplant to the Colorado River Indian Tribes of the Colorado River Indian Reservation, Arizona and California (CRIT) and other Indian tribes. Western markets any excess power produced at Headgate Rock Powerplant on the open market. Headgate Rock Dam and Powerplant is a run-of-the-river hydroplant, which means it is dependent on Colorado River flow to generate power. For this reason the Headgate Rock Dam is unable to store water in excess of the amount that can flow through its generator turbines or through CRIT's diversion facilities. Any water that is not diverted by CRIT or used by the Headgate Rock Powerplant generators is spilled downstream. Chapter 4 provides a more detailed description of hydroelectric power generation. Reclamation has determined that the water appropriated to non-CRIT entities that flows through Headgate Rock Dam and generates power is not an ITA.

3.10.4 Cultural Resources

Cultural resources located on Indian trust lands are often the property of the tribe or individual Indians beneficially owning those lands; these resources may be ITAs (Reclamation 1994). During consultation, the Hualapai Tribe identified historic and traditional cultural properties, archaeological resources and sacred sites in the Grand Canyon and on the Hualapai Reservation as Tribal trust resources that should be addressed in this EIS. None of the tribes identified cultural resources on- or off-reservation lands that should be considered ITAs for the purposes of this analysis.

3.10.5 Biological Resources

During consultation on this proposed federal action, none of the tribes identified fishing or hunting rights. The Hualapai Indian Tribe raised a concern with fish and wildlife, wildlife habitat, and culturally significant plants located throughout the Grand Canyon and on the Hualapai Reservation.

3.10.6 Other Potentially Affected Tribes Asserting Colorado River Water Rights

Reclamation has determined that no quantified water right trust assets are located within the study area upstream of Lake Mead. However, the following tribes have asserted that they have unquantified water right trust assets and other ITAs that will be affected by the proposed federal action.

3.10.6.1 Navajo Indian Reservation (Navajo Nation, Arizona, New Mexico and Utah)

The Navajo Nation is a federally recognized Indian tribe whose 12.5 million-acre reservation was initially established by treaty in 1868 and expanded by a series of executive orders in 1884, 1900, and 1930. The Navajo Nation economy is historically based on livestock herding and dry farming. Under the Winters doctrine established by the United States Supreme Court, the United States implicitly reserved water in an amount necessary to fulfill the purposes of an Indian Reservation. The existence of a federally reserved right for the Navajo Nation to mainstream Colorado River water has not been judicially determined at this time. Unquantified water rights of the Navajo Nation are considered an ITA.

During consultation on this proposed federal action, the Navajo Nation wrote Reclamation a letter (dated August 21, 2006) identifying a water budget of 76,732 afy that the Navajo Nation believes must be satisfied out of the Colorado River mainstream. The water budget of the Navajo Nation is premised on the use of 63,000 afy from the Little Colorado River which would otherwise contribute to the supply available in Lake Mead. In addition, the Navajo Nation asked Reclamation to consider the effects of the proposed federal action on 6,411 afy of CAP 3 NIA Priority Water identified for use by the Navajo Nation in the Arizona Water Settlements Act of 2004. This water is included in the 76,732 afy that the Navajo Nation believes must be satisfied out of the Colorado River mainstream. Overall, the Navajo Nation has asked the Secretary to account for the needs of the Navajo Nation as the Secretary undertakes the difficult task of developing guidelines to deal with Lake Powell and Lake Mead in time of shortage (Navajo Nation letter dated August 21, 2006).

3.10.6.2 Hualapai Indian Reservation (Hualapai Indian Tribe)

The 992,463-acre Hualapai Indian Reservation is located in northwestern Arizona. The reservation was established by executive order on January 4, 1883. Under the Winters doctrine established by the United States Supreme Court, the United States implicitly reserved water in an amount necessary to fulfill the purposes of an Indian Reservation. The existence of a federally reserved right for the Hualapai Indian Tribe to mainstream Colorado River water has not been judicially determined at this time. Unquantified water rights of the Hualapai Indian Tribe are considered an ITA.

During consultation on this proposed federal action, the Hualapai Indian Tribe has asserted in a letter (dated August 28, 2006) that it has Tribal trust resources and other Tribal assets in the Grand Canyon and on the Hualapai Indian Reservation that may be adversely affected by the proposed federal action. The Hualapai Indian Tribe's claimed resources include:

> "…tribal lands, the Tribe's senior, federal reserved water rights to the use and flows of the Colorado River, historic and traditional cultural properties, archaeological resources and sacred sites, fish and wildlife habitat, sensitive beaches, and culturally significant plants located throughout the Grand Canyon and on the Hualapai Reservation" (Hualapai Indian Tribe letter dated August 28, 2006).

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3.11 Electrical Power Resources

This section provides an overview of electrical power (i.e., hydropower) generation, power marketing, and the River Basin power funds used to manage electrical power revenues and expenditure requirements for mainstream Colorado River dams. A description of potentially affected electrical power generation facilities and energy dependent infrastructure within the study area is provided below. The electrical power resources that could potentially be affected by implementation of the proposed federal action include:

- Amount of electrical power generated,
- Available generation capacity,
- Economic value of electrical power produced,
- Electrical power related revenues and contributions to the different basin power funds and programs supported by these funds, and
- Electrical costs for entities that pump water directly from Lake Powell and Lake Mead.

3.11.1 Overview

The primary electrical power resources that could be affected by the proposed federal action include the Glen Canyon Powerplant, Hoover Powerplant, Parker/Davis Project (P-DP) generation systems, and the Headgate Rock Dam Powerplant. Reclamation operates and maintains the Glen Canyon, Hoover, and P-DP power generation facilities. Western is responsible for marketing and transmitting the power. The Headgate Rock Dam Powerplant is operated by the BIA.

3.11.1.1 Hydropower Generation

Hydropower generation is directly related to the net effective head on the generating units and the quantity of water flowing through the turbines. The net effective head is the difference between the elevation of the forebay behind a dam and in the tail water below the dam. The head influences the maximum power output capability of the power plant, measured in megawatts (MW). In general, the powerplant capability increases as a function of increasing head. However, turbine capacities or other equipment limitations, such as switches or transformer ratings, cap maximum power plant output levels.

The turbines at a powerplant are designed to produce maximum efficiency at a design head. At design head, the powerplant can produce the maximum capacity and the most energy per acre-foot of water passing through the turbine. As the net effective head on the powerplant is reduced from the design head because of reduced forebay (upstream reservoir) elevation, the power output of the turbine, the electrical capacity of the generator attached to the turbine, and the efficiency of the turbine are all reduced. This reduction continues as net effective head decreases until, below the minimum elevation for power generation, the turbines cannot be operated safely and must be bypassed for downstream water deliveries. Minimum power elevation generally occurs at a point where cavitation within the turbine causes extremely rough operation, air becomes entrained in the water, and/or vortices appear in the forebay.

Ramping is the change in the water release from the reservoir to meet the electrical load. Both scheduled and unscheduled ramping are crucial in load following, ancillary services, emergency situations, and variations in real time (what actually happens compared to what was scheduled) operations. North American Electric Reliability Council (NERC) and Western Electricity Coordinating Council (WECC) operating criteria require Western and Reclamation to meet scheduled load changes by ramping the generators up or down beginning at 10 minutes before the hour and ending at 10 minutes after the hour.

Hydropower generation can react instantaneously to the load (or power demand) - a pattern called load following. By comparison, coal- and nuclear-based resources have a relatively slow response time; consequently, they generally are not used for load following in the WECC.

As a control area operator, Western regulates the transmission system within a prescribed geographic area. Western is required to react to moment-by-moment changes in electrical demand within this area, adjusting the electrical power output of hydroelectric generators within the area in response to changes in the generation and transmission system to maintain the scheduled level of generation in accordance with prescribed NERC criteria. Automatic Generation Control (AGC) is a process whereby the control system automates the water releases in a manner that follows the power system’s actual dynamic demands on a moment-to-moment (typically a four-second-interval) basis.

Regulation depends on being able to ramp releases up or down quickly in response to system conditions. In addition, each utility is required to have sufficient generating capacity - in varying forms of readiness - to continue serving its customer load, even if the utility loses all or part of its own largest generating unit or largest capacity transmission line. This reserve capacity ensures electrical service reliability and an uninterrupted power supply.

Generating capacity that is in excess of the load on the system is called spinning reserve. Spinning reserves are used to quickly replace lost electrical generation resulting from a forced outage, such as the sudden loss of a major transmission line or generating unit. Additional off-line generating units are also used to replace generation shortages, but they cannot replace lost generation capacity as quickly as spinning reserves.

3.11.1.2 Power Marketing and Customers

Western markets the power and administers the power contracts for power generated from Reclamation-owned and operated hydropower facilities, i.e. Glen Canyon, Hoover, P-DP and the smaller generation facilities.

Marketing of electricity is based on two concepts: capacity and energy. In power marketing, capacity is the rate of delivery or demand of electricity and is measured in kilowatts (kw) or megawatts. Electricity must be available the instant consumers need it. Capacity is more important to meet consumers' instantaneous demand as they turn on lights, appliances and motors. Energy is the amount of electricity delivered over time and is measured in kilowatt-hours (kwh)or megawatt-hours. One kilowatt-hour of energy delivered over one hour requires one kilowatt of capacity. Energy is important to meeting consumers' continuing need for electricity. With the delivery of electricity, capacity and energy are both present; however, they can be marketed and billed separately. Power rates usually include individual charges for capacity and energy.

Power is marketed in terms of firm and nonfirm power. Firm power is capacity and energy that is guaranteed to be available. A sufficient portion of the generation capacity is held in reserve to enable continued delivery of firm power even if an outage occurs at a power plant. The amount of power that is held in reserve is established by various power pooling agreements and reliability criteria.

Nonfirm power is sold to power contractors that would rather purchase nonfirm energy that is less expensive than the cost of their own generation or cost of alternative sources of supply. Nonfirm energy is usually sold with the requirement that the sale can be stopped on short notice and the buyer must have the resource available to meet its own load. Rates for nonfirm energy only include a charge for the energy delivered, since the customer has the capacity to meet its loads, if necessary.

Any power surplus or deficit affects all WECC power customers since the WECC region is one large interconnected system. However, customers most affected are those that have an allocation of hydropower resources sold by Western through various contractual arrangements.

The contracts for power from Glen Canyon Dam terminate in 2025, from Hoover Dam in 2017, and from the P-DP in 2008. After these dates, the identity of the recipients of power from these resources is not known. Recognizing that contracts for power will exist in some form in the future, an analysis of the effects of the action alternatives compared with those of the No Action Alternative consider the general effects in the overall areas served by the power facilities.

The states that could be potentially affected by changes in energy production and capacity changes at Glen Canyon and Hoover power plants are Arizona, California, Nevada, Utah, Wyoming, New Mexico and Colorado. These states make up the Rocky Mountain, Arizona-New Mexico-Southern Nevada, and California-Mexico areas of the WECC. Electrical energy produced in each of these areas is derived from a variety of sources including the subject facilities. The total generation capability of the areas as of January 1, 1999, is 86,348 MW. The generation capability of each WECC area is listed in Table 3.11-1.

Table 3.11-1
Generation Capability in WECC Areas

WECC Area	Available Capacity, MW
Rocky Mountain	10,584
Arizona-New Mexico-Southern Nevada	22,272
California-Mexico	53,492

The capacity of Glen Canyon and Hoover Powerplants represents approximately 3.6 percent of the total generating capability of these three areas of WECC (WSCC 1999).

3.11.2 Lake Powell and Glen Canyon Dam

Glen Canyon Powerplant has eight generators with a maximum combined capacity of 1,320 MW when the reservoir elevation is 3,700 feet msl. The maximum combined discharge capacity of the eight turbines is approximately 31,500 cfs. Due to environmental restrictions, the maximum release is limited to 25,000 cfs except for extreme hydrologic or emergency conditions, limiting Glen Canyon power generation capacity to approximately 1,000 MW, depending on reservoir elevation. The generators require a minimum Lake Powell elevation of 3,490 feet msl to operate. At this elevation, Glen Canyon Powerplant has a maximum capacity of about 630 MW. The annual gross generation has averaged approximately 4,951,918 MWh for the last 25 years and has averaged approximately 3,453,806 MWh over the past 5 years.

Glen Canyon Powerplant is part of the Salt Lake City Area Integrated Projects (SLCA/IP), which is a group of hydroelectric facilities marketed by Western. The SLCA/IP consists of hydroelectric facilities of Colorado River Storage Project (CRSP), Rio Grande Project, and Collbran Project.

Changes to reservoir elevations or releases could affect generation at Glen Canyon Dam.

3.11.3 Lake Mead and Hoover Dam

The Hoover Powerplant is located at the toe of the dam, and extends downstream 650 feet along each canyon wall. The turbines are designed to operate at heads ranging from 420 to 590 feet. The minimum water level for efficient power generation is currently estimated to be approximately 1,050 feet msl. The final generating unit, N-8, was installed at Hoover Dam in 1961, giving the Hoover Powerplant a total of 17 commercial generating units with a rated capacity of 1,850,000 horsepower. Two station-service units, rated at 3,500 horsepower each, increased the powerplant total rated capacity to 1,344.8 MW.

Between 1982 and 1993, the 17 commercial generating units were uprated with new turbines, and new transformers and breakers were installed, raising the Hoover Powerplant's maximum capacity to 2,074 MW. The annual gross generation has averaged approximately 4,819,524 MWh for the last 25 years and has averaged approximately 4,014,655 MWh over the past 5 years.

Western markets the power to 15 customers in three states (Arizona, California, and Nevada); these are non-firm contracts. Any excess energy generated at the Hoover Powerplant is distributed to Hoover Powerplant contractors in accordance with their contracts.

Changes to reservoir elevations or releases could affect electrical power generation at Hoover Powerplant.

3.11.4 Parker/Davis Projects

The Davis Powerplant has five generators and a 256 MW maximum operating capacity. Between 1987 and 2005, the average annual net energy generated from Davis was 1,166,286 MWh.

Parker Powerplant has four generators and a 108 MW maximum operating capacity. Between 1987 and 2005, the average annual net energy generated from the Parker Powerplant was 487,649 MWh. MWD has a perpetual contract right to 50 percent of the electric power generated at Parker Powerplant. Reclamation's 50 percent share of power generated by the Parker Powerplant is part of the P-DP.

The P-DP was formed in 1954 by consolidating the Parker Dam power project and the Davis Dam power project. Western markets the power generated by the P-DP. The P-DP supplies power to five Priority Use Projects (PUP) customers and 25 firm electric service contractors. The P-DP has 283 MW of capacity under contract to PUP and to firm electric service customers. The total annual energy committed to the five PUP and 25 firm electric service customers is 1,345,801 MWh (the PUP commitment is 195,266 MWh and the firm commitment is 1,150,534 MWh). The contracted capacity and energy for the P-DP, including system losses and reserves, is based on Davis Powerplant capacity and energy and Reclamation's half of Parker Powerplant's capacity and energy. The current P-DP firm electric service commitments are in effect until September 30, 2008. Western is close to concluding the process of finalizing the contractual commitments through September 30, 2028.

Under the existing P-DP firm electric service contracts, the amounts of power per month and per season are guaranteed. This means if the power is not available, Western would purchase the additional power required to fulfill the contracts.

Power generated at the P-DP, over and above what has been guaranteed to PUP and preference customers having firm electric service contracts, is referred to as surplus energy. A portion of the surplus energy, referred to as excess energy, is offered to P-DP customers for purchase at an "at cost" rate or for "banking" of energy up to the limit of the contractor's contract rate of delivery. Any remaining surplus energy may be sold at market rates to interested parties or may be "banked" for future use.

Changes to dam releases could affect electrical power generation at the P-DP.

3.11.5 Other Small Hydropower Facilities

Headgate Rock Dam and Powerplant, which is owned and operated by the BIA and is located downstream of Parker Dam, is a run-of-the-river powerplant that generates power through three turbines with a total generator capacity of 19.5 MW. Between CY 2001 through CY 2005, the average net energy generated annually from Headgate Rock Dam power plant was 76,157 MWh. Changes to downstream water demand could affect generation at Headgate Rock Powerplant.

There are other small hydropower facilities located below Parker Dam. These facilities include Senator Wash, Siphon Drop, and Pilot Knob. In addition, there are several hydropower facilities owned by IID located at various drop structures along the All American Canal and on various other canals.

3.11.6 Basin Power Funds

3.11.6.1 Upper Colorado River Basin Fund

The Upper Colorado River Basin Fund (Basin Fund) was established under Section 5 of the CRSP Act. The CRSP Act "authorized a separate fund in the Treasury of the United States to be known as the Upper Colorado River Basin Fund for carrying out provisions of this Act other than Section 8". Money appropriated for construction of CRSP facilities and Section 8 funding is credited in the Basin Fund. Revenues derived from operation of the CRSP and participating projects are deposited in the Basin Fund. Most of the revenues come from sales of hydroelectric power and transmission services. The Basin Fund also receives revenues from M&I water service sales, rents, salinity funds from the Lower Colorado Basin (as a pass-through for the Colorado River Basin Salinity Control Program), and miscellaneous revenues collected in connection with the operation of the CRSP and participating projects.

Basin Fund revenues must first be used to repay costs associated with the operation and maintenance of the CRSP units and used to repay the United States Treasury Department the reimbursable investment costs previously spent on construction of the CRSP units and costs allocated to the irrigation investment above the irrigator's ability to pay. The Basin Fund is managed by Western. Approximately $ 175 million is needed each year to fund Reclamation and Western operation and maintenance needs. Of this amount, approximately $20 million is used to support environmental programs. Reclamation's allocation of its portion of the Basin Fund, approximately $62 million, is shown in parentheses below.

- Reclamation and Western's costs associated with the operation, maintenance, equipment replacements, and emergency expenditures for all facilities of the CRSP and participating projects, provided, that with respect to each participating project, such costs shall be paid from revenues received from each such project. (Reclamation - $42.9 million);

- Cost sharing for Colorado River Basin Salinity Control Program (Reclamation - $2 million);

- The major portion of the cost of the Glen Canyon Adaptive Management Program (Reclamation - $9 million);
- Cost sharing for Endangered Fish Recovery Implementation Program (Reclamation - $7 million);
- Water quality studies (Reclamation - $0.8 million); and
- Consumptive use studies (Reclamation - $0.3 million).

Basin Fund revenues may not be appropriated and used for construction projects. Also, they may not be used for construction, operation and maintenance of public recreational facilities or facilities to mitigate losses of and improve conditions for the propagation of fish and wildlife (Section 8 of the CRSP Act authorizes Congressional appropriations for these purposes).

Western is responsible for transmission and marketing of CRSP power, collecting payment for the power, and transfer of revenues for repayment to the United States Treasury Department. A change in the amount of available capacity or energy could potentially affect the revenue derived from the sale of energy and the contributions to the Basin Fund, or rates charged to power customers.

3.11.6.2 Lower Colorado River Basin Funds

Currently there are three funds that are used to manage revenue and expenditure requirements of Lower Colorado Region power projects for the CAP, Boulder Canyon Project (Hoover) and the P-DP. Two are legislated funds and one is an account fund. A change in the amount of available capacity or energy could potentially affect the revenue derived from the sale of energy and the contributions to these funds, or rates charged to power customers.

The Lower Colorado River Basin Development Fund (Development Fund) was established by the CRBPA. The Colorado River Dam Fund (Dam Fund) was established by the BCPA. The Parker-Davis Account was established to enable the P-DP to fund in advance capital improvements and other expenses.

Lower Colorado River Basin Development Fund. In a manner similar to the Basin Fund, the Development Fund defrays costs of operation, maintenance and replacements of all project facilities, salinity control programs, repayment of CAP construction, and, as amended by the Arizona Water Settlements Act, of certain Tribal projects. It also reimburses water users in Arizona for losses sustained as a result of diminution of the production of hydroelectric power at Coolidge Dam, Arizona, resulting from exchanges of water between users in the States of Arizona and New Mexico. The Development Fund is composed of revenue deposited from:

- Surplus power sales of the United States entitlement of the Navajo Generating Station;

- CAP surcharge revenues from the Boulder Canyon and Parker Davis projects; and
- Certain other CAP revenue receipts.

Colorado River Dam Fund. The Dam Fund is utilized to fund operation and maintenance (O&M) of Hoover Dam, payments to states, visitor services, up-rating program, replacements, investment repayment and interest expenses of the Boulder Canyon Project (BCP). The Dam Fund is composed of:

- Power revenues collected from the BCP power contractors;
- Revenues collected from the BCP Visitor Center; and
- Revenues from other BCP revenue receipts.

The BCP annual revenue requirement, base charge and rates, are determined annually to provide sufficient revenue to pay all annual costs, including interest expense and to repay investments, within the allowable period.

Parker-Davis Account. The Parker-Davis Account is utilized to advance-fund the costs of the P-DP, including operation, maintenance, and capital improvements. The funds are drawn from the customers' account into Reclamation on a monthly basis throughout the year. The advances are reconciled to the actual expenditures and the customers get credit for any remaining balance in the following period.

3.11.7 Water Supply System

3.11.7.1 Navajo Generating Station

The Navajo Generating Station (NGS) is a 2,250 MW coal-fired powerplant located on the Navajo Indian Reservation near Page, Arizona, and serves electric customers in Arizona, Nevada and California. The coal-fired powerplant is jointly owned by Reclamation, Salt River Project, Los Angeles Department of Water and Power, Arizona Public Service Company, Nevada Power Company and the Tucson Electric Power Company. The Salt River Project (SRP) operates the plant. The station supplies energy to pump water through the CAP. NGS was constructed near Lake Powell to ensure it had a dependable supply of cooling water for its three generators.

When NGS was constructed, it received an annual allotment of 34,100 af of water, and the intakes that pump water from Lake Powell to the powerplant were installed at an approximate elevation of 3,470 feet msl, or 230 feet below the lake's full pool level of 3,700 feet msl. Changes in drops in the elevation of Lake Powell could cause an increase in the cost of power for the NGS.

To ensure that cooling water will be available for the continued operation of NGS, a proposal is being advanced to modify the water intake system of NGS by installing new intake structures at an elevation below that of the current intakes. The planning for this proposal is ongoing.

3.11.7.2 City of Page Water Supply Intake

The City of Page provides municipal water to approximately 7,800 residents from Lake Powell. The intake pump station is operated by Reclamation using power produced at the Glen Canyon Powerplant. Municipal water use in the City of Page is dominated by residential use with substantial residential landscape irrigation. The average annual use of water by the City of Page in recent years has been about 2,650 afy. Under contract with Reclamation, the City of Page pays energy costs associated with pumping the water plus costs associated with operation and maintenance of the pump station by Reclamation. Annual energy usage has averaged around 3,900,000 kWh per year over the past 10 years. At the current rate of $0.03286 per kWh, the annual cost of energy for pumping the water is around $130,000 per year. Changes in CRSP power generation or drops in the elevation of Lake Powell could cause an increase in the cost of power for the City of Page's intake pump station.

3.11.7.3 SNWA Lake Mead Intake

The largest diverter of Colorado River water in Nevada is the SNWA. It diverts most of its allocation of Colorado River water from Lake Mead through the SNWA pumping plant located at Saddle Island within Lake Mead. The power-consuming features of this system are the pumping plants that are used to pump water from Lake Mead to the water treatment facility that is also owned and operated by SNWA.

The minimum required Lake Mead elevations necessary to operate the pumping units for SNWA's upper and lower intakes are 1,050 and 1,000 feet msl, respectively. Changes in the elevation of Lake Mead could cause a change in the cost of power for SNWA's intakes.

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3.12 Recreation

Key recreation resources or issues include reservoir or riverine recreational activities or facilities that might be affected by changes in reservoir level or river flow. The affected environment for recreation resources includes:

- shoreline public use;
- reservoir boating;
- river and whitewater boating; and
- sport fishing.

Information in this section was compiled after review of published and unpublished sources and through personal communications with Reclamation, NPS, and resource specialists. Key published sources of information used in the preparation of this section include:

- Lake Mead National Recreation Area, General Management Plan Amendment/EA (NPS 2005a);
- Grand Canyon National Park Final EIS, Colorado River Management Plan, Volume I (NPS 2005b);
- Glen Canyon National Recreation Area Final EIS, Personal Watercraft Rulemaking, Volume I (NPS 2003);
- Lower Colorado River Multi-Species Conservation Program, Final PEIS/EIR (Reclamation 2004);
- Colorado River Interim Surplus Criteria Final EIS (Reclamation 2000); and
- Operation of Glen Canyon Dam Final EIS (Reclamation 1995).

3.12.1 Shoreline Public Use

The following sections describe shoreline public use associated with boating facilities (marinas, boat docks, and boat launch ramps), access to points of interest, and other opportunities within each Colorado River reach. Where available, the number and type of facilities at each marina, boat dock, and boat launch ramp are included for major shoreline access points. Recreational boating in the study area is dependent on these major shoreline access points. Fluctuation in water levels is a normal aspect of reservoir operations, and facilities have been designed and operated to accommodate these fluctuations. However, changes in pool elevations or increased variations or rates in pool elevation fluctuation could result in changes in operation costs and temporary closures.

Representative threshold pool elevations and river flows were selected for the boating facilities, at or below which certain facilities may be rendered inoperable or relocation of facilities could be required to maintain their operation. These thresholds were chosen based on either information provided in studies or communications with NPS personnel.

3.12.1.1 Lake Powell and Glen Canyon Dam

Lake Powell is located entirely within the GCNRA, which receives approximately two million visitors each year (NPS 2006f). Table 3.12-1 summarizes visitation to GCNRA for the most recent six years. The data indicate a gradual decrease in the number of visitors.

Table 3.12-1
Glen Canyon National Recreation Area Recreational Visitors

Year	Recreational Visitors
2000	2,568,111
2001	2,340,031
2002	2,106,896
2003	1,876,984
2004	1,841,845
2005	1,908,726

Source: NPS, 2006f.

Table 3.12-2 summarizes the total number of visits to GNCRA by visitor segment for 2003, the most recent year for which data are available.

Table 3.12-2
Glen Canyon National Recreation Area Visits by Visitor Segment for 2003

	Local Day Trips	Non-Local Day Trips	Hotel	Camp	Total
Number of Recreational Visits	187,698	656,944	218,548	750,794	1,876,984
Percent Segment Shares in Recreational Visits	10	35	15	40	100
Party Days[1]	81,608	252,671	196,886	870,804	1,415,939

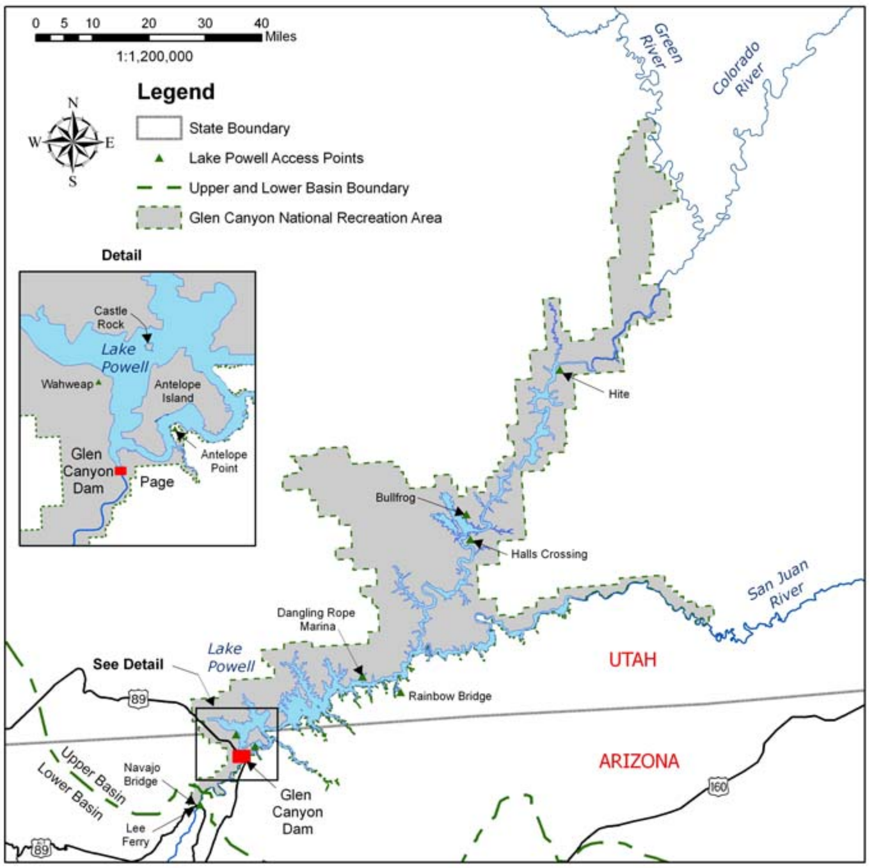
Source: NPS 2006b.

1 Party days equal the number of days each visitor party spends in the local region. Party days are estimated by converting recreation visits using estimates of the average party size, length of stay in the area, and number of park entries per trip (re-entry rate).

Lake Powell, its many side canyons, and related natural, cultural, and geologic resources are the primary recreation features of GCNRA. Recreation activities that occur at Lake Powell include swimming and sunbathing, power boating, waterskiing, fishing, off-beach activities associated with boat trips (such as hiking and exploring ruins), house boating, personal water craft use, canoeing, kayaking, sailing, wildlife viewing, photography, sightseeing, and other activities. Visitors can enjoy camping opportunities ranging from remote and undeveloped campsites to fully developed campgrounds. Visitors can also see archeologically and culturally important sites throughout the recreation area.

Boating Facilities. Recreation boating is the most important recreational activity on Lake Powell, with more than 831,000 boater days in 2001 (NPS 2003). Specific boating facilities, and reservoir elevations important to their operation, are discussed in the following sections. Figure 3.12-1 shows Lake Powell and the locations of its shoreline access points.

Figure 3.12-1
Lake Powell Shoreline Access Points



Water-based recreational facilities at Lake Powell are located at Wahweap, Dangling Rope, Halls Crossing, Bullfrog, Hite, and Antelope Point marinas. Table 3.12-3 lists critical lake elevations, identified by the NPS for Lake Powell, below which marinas, boat docks, or boat launch ramps become inoperable. Dangling Rope Marina is only accessible by boat, and it is used primarily for accessing Rainbow Bridge National Monument. There are no known reservoir elevations that would impair operation of Dangling Rope Marina.

Lake Elevation (feet msl)	Impact and Facility
3,700	Full pool
3,620	Castle Rock Cut closed; Hite Marina and Public Launch Ramp closed
3,588	Antelope Point Public Launch Ramp closed
3,580	Main Bullfrog Launch Ramp closed
3,560	Wahweap and Stateline Public Launch Ramps closed; Bullfrog Low Water Alternative Launch Ramp closed; Halls Crossing Public Launch Ramps closed
3,555	Wahweap Marina closed; Antelope Point Marina closed; Bullfrog Marina closed; Halls Crossing Marina closed

Table 3.12-3
Critical Elevations for Lake Powell by Boating Facility

Source: Henderson 2006

Access to Points of Interest. The facilities at Rainbow Bridge National Monument include courtesy docks, restrooms, a floating walkway, and a floating interpretive platform. Trails from the dock lead to viewing areas. One viewing area is used when Lake Powell is at the full-pool elevation of 3,700 feet msl, and the other is used when the reservoir is below full-pool elevation. The docks and trail system are designed to accommodate Lake Powell elevation fluctuations from 3,490 feet msl to 3,700 feet msl (NPS 1993). Boat tours to the Rainbow Bridge National Monument originate at Dangling Rope Marina.

When Lake Powell elevations fall below 3,650 feet msl, the floating walkway and interpretive platforms would be removed and stored, dock facilities would be moved to a lower elevation, dock facilities would be connected to the trail with a short walkway, and the old land trail through Bridge Canyon (submerged at full pool) would be exposed, hardened, and used for access (NPS 1990).

3.12.1.2 Glen Canyon Dam to Lake Mead

The 15.5 miles of river below Glen Canyon Dam to Lees Ferry are managed by GCNRA and are used by anglers; campers; and commercial float trip operators, kayakers, and other boaters. Fishing opportunities (with an Arizona state non-native fishing license and a trout stamp) for rainbow and brown trout also occur below this reach.

Grand Canyon National Park begins at Lees Ferry and the NPS manages most of the reach, except where it is bordered on the east by the Navajo Indian Reservation and the south by the Hualapai Indian Reservation. The Grand Canyon National Park regulates visitor use of the Colorado River in accordance with the Colorado River Management Plan (NPS 2005b).

Lees Ferry to Diamond Creek has relatively low use densities and levels of development, providing opportunities for solitude on the Colorado River and at many camps and attraction sites. This section of the river is where the majority of whitewater boating occurs. Take-outs are located at Diamond Creek and Pearce Ferry, and the reach below Diamond Creek offers different recreation opportunities than upstream as it transitions to a more populated and developed setting. The Pearce Bay take-out is closed at elevation 1,175 feet msl. Whitewater boating trips become intermingled with very high levels of general boating and recreation use in the Quartermaster Area.

Several helicopter operations transport people into the Grand Canyon and connect with motorized pontoon boats that give 20-minute tours of the immediate area. These same helicopters serve a dual service in flying out boaters who have traveled from Diamond Creek on commercial motor day trips.

Camping also occurs in the Grand Canyon National Park on undeveloped beaches along the river. The important variable is the number and quality of high-water versus low-water campsites.

The Hualapai Indian Reservation offers camping, fishing, hiking, and big game hunting. A Tribal enterprise operates a river rafting company that offers rafting trips on the section of river from Diamond Creek to Quartermaster Canyon.

Boating Facilities. There are few boating facilities in the Grand Canyon National Park, except for major launch facilities that include Lees Ferry, Phantom Ranch, Whitmore, Diamond Creek, and the Quartermaster Area. Brief descriptions of each facility are provided below.

Lees Ferry. Lees Ferry, the primary put-in at the start of a Grand Canyon river trip, has a large ramp, parking, a camping area, and an information kiosk where pre-trip logistics and information sessions are conducted.

Phantom Ranch. Phantom Ranch is a collection of cabins, a small store, an NPS ranger station, and campground. River trips are prohibited from camping at Phantom Ranch, but it is a popular exchange location.

Whitmore. The Whitmore exchange point consists of a helicopter landing pad on Hualapai Indian Reservation and a boat tie-up and camping area. The Whitmore area is used by commercial trips as an exchange point for passengers to begin or end their river trip; nearly all of those passengers arrive at or depart from the area via a helicopter flight.

Diamond Creek. The Diamond Creek take-out and launch is operated by both the NPS and the Hualapai Indian Tribe. The tribe charges fees to use Diamond Creek. The Hualapai River Runners (HRR) manage take-out and launch operations in addition to conducting guided whitewater trips that put-in at Diamond Creek, and floating trips that put-in at Quartermaster Canyon. All of these trips take out at Pearce Ferry. There is a gravel ramp area and a limited parking lot.

Quartermaster Area. There are 15 helipads, 2 docks, and other facilities in the Quartermaster Area. While all of the pads offer access for look-and-leave flights, a few pads are also used to transport HRR and pontoon trip passengers out of the canyon.

Camping. Sandbars form the camping beaches are used by river runners. Camping is possible in only a limited number of locations along the Colorado River between Glen Canyon Dam and Lake Mead because most of the shoreline is unsuitable. At a given time, however, campable area depends on the local stage (height) of the river, which is determined by the magnitude of releases and local topography.

There are three general categories for camp sizes: small (one to 12 people); medium (13 to 24 people); and large (25 or more people), that are further divided into high-water and low-water camps (Kearsley and Warren 1993). High-water camps are available at flows above 15,000 cfs, generally on terraces. Low-water camps are available only at flows below 15,000 cfs. Thirty-seven favorable sites that become available at discharges of 15,000 cfs or less were identified by Kearsley and Warren (1993). Table 3.12-4 lists the number of small, medium, and large camps, as well as the number of high- and low-water camps.

Table 3.12-4
Number of Camping Beaches by Camp Size for High- and Low-Water Camps

High- and Low-Water Camping Beaches	Small (1 to 12 people)	Medium (13 to 24 people)	Large (25 to 36 people)	Total
Camping beaches at high water (15,000 cfs or greater)	47	102	90	239
Additional camping beaches available at low water only (15,000 cfs or less)	27	10	*	37

*Source: Kearsley and Warren 1992, 1993; * not measured.*

3.12.1.3 Lake Mead and Hoover Dam

LMNRA contains 1.5 million acres and encompasses the 110-mile-long Lake Mead, 67-mile-long Lake Mohave, the surrounding desert, and the isolated Shivwits Plateau in Arizona.

The Virgin River flows into upper Lake Mead from the north. Recreational activities such as camping, boating, fishing, and hiking occur on upper Lake Mead. The Overton Wildlife Management Area provides opportunities for wildlife viewing and photography, waterfowl and upland game bird hunting, hiking, and fishing. The Overton Wildlife Management Area has an average of 5,300 annual visitor use days (Nevada Department of Wildlife 2006).

LMNRA extends along the lower Colorado River from the western border of Grand Canyon National Park (with the dividing line at the Grand Wash Cliff, RM 276.5) to Davis Dam. Primary recreational activities on the Lake Mead by percentage of users include cruising/sailing 41.4 percent, personal watercraft usage 17.5 percent, waterskiing

16.9 percent, fishing 14.2 percent, swimming 6.7 percent, and other 3.3 percent (NPS 2002). A number of campgrounds and picnic areas provide additional recreational opportunities and include Boulder Beach, Calville Bay, Echo Beach, Las Vegas Bay, and Temple Bar. The LMNRA has approximately six million visitor use days per year (NPS 2001).

Table 3.12-5 summarizes recreational visits to LMNRA for the last six years.

Table 3.12-5
Lake Mead National Recreation Area Recreational Visitors

Year	Recreational Visitors
2000	8,755,005
2001	8,465,547
2002	7,550,284
2003	7,915,581
2004	7,819,984
2005	7,692,438

Source: NPS 2006c.

Table 3.12-6 summarizes the total number of visits to LMNRA by visitor segment for 2003, the most recent year for which data are available.

Table 3.12-6
Lake Mead National Recreation Area Visits by Visitor Segment for 2003

	Local Day Trips	Non-Local Day Trips	Hotel	Camp	Total
Number of Recreational Visits	2,374,674	2,374,674	791,558	2,374,674	7,915,581
Percent Segment Shares in Recreational Visits	30	30	10	30	100
Party Days[1]	719,598	719,598	263,853	668,482	2,415,452

Source: NPS 2006d.

1 Party days equal the number of days each visitor party spends in the local region. Party days are estimated by converting recreational visits using estimates of the average party size, length of stay in the area, and number of park entries per trip (re-entry rate).

Boating Facilities. The LMNRA is considered one of the premier water-based recreation areas in the nation. Most visitors are involved in water-based recreational activities, primarily between May and September. These recreational activities are supported by marina and launch ramp facilities developed along the Lake Mead shoreline. On average, the majority of boats are personal watercraft. There may be as many as 6,000 boats on Lake Mead and Lake Mohave during a peak recreation use weekend. The Boulder Beach developed area, which is one of the most heavily visited portions of the recreation area located near the urbanized area of Las Vegas and surrounding communities, includes special use areas for sailing, scuba, and personal watercraft use.

Water-based recreational facilities at Lake Mead are located at Boulder Beach, Las Vegas Bay, Callville Bay, Echo Bay, Overton Beach, and Temple Bar marinas and Hemenway, Government Wash, South Cove, and Pearce Ferry boat ramps. Pearce Ferry is used as a take-out by Colorado River boaters. Table 3.12-7 shows critical elevations, identified by the NPS for Lake Mead, below which marinas, boat docks, or boat launch ramps become inoperable. The Pearce Bay launch ramp, a take-out point for rafts and whitewater boats, is closed at elevation 1,175 feet msl. This results in rafts and other whitewater boats having to continue downstream to South Cove, an additional 16 miles.

Table 3.12-7
Critical Elevations and Surface Area for Lake Mead by Recreational Facility

Lake Elevation (feet msl)	Impact and Facility
1,225	
1,175	Pearce Bay Launch Ramp closed
1,150	Las Vegas Bay and Government Wash Public Launch Ramps closed
1,125	Overton Beach Marina, Callville Ramp and South Cove Ramp closed
1,112	Lake Mead Marina – Relocation of "C Dock" to Hemenway
1,110	Overton Public Launch Ramps closed
1,100	Lake Mead Marina Must Relocate Out of Protected Harbor
1,080	Lake Mead Marina public launch ramp closed; Hemenway public launch ramp closed; Temple Bar Public Launch Ramp closed
1,050	Echo Bay Public Launch Ramp closed

Source: Henderson 2006

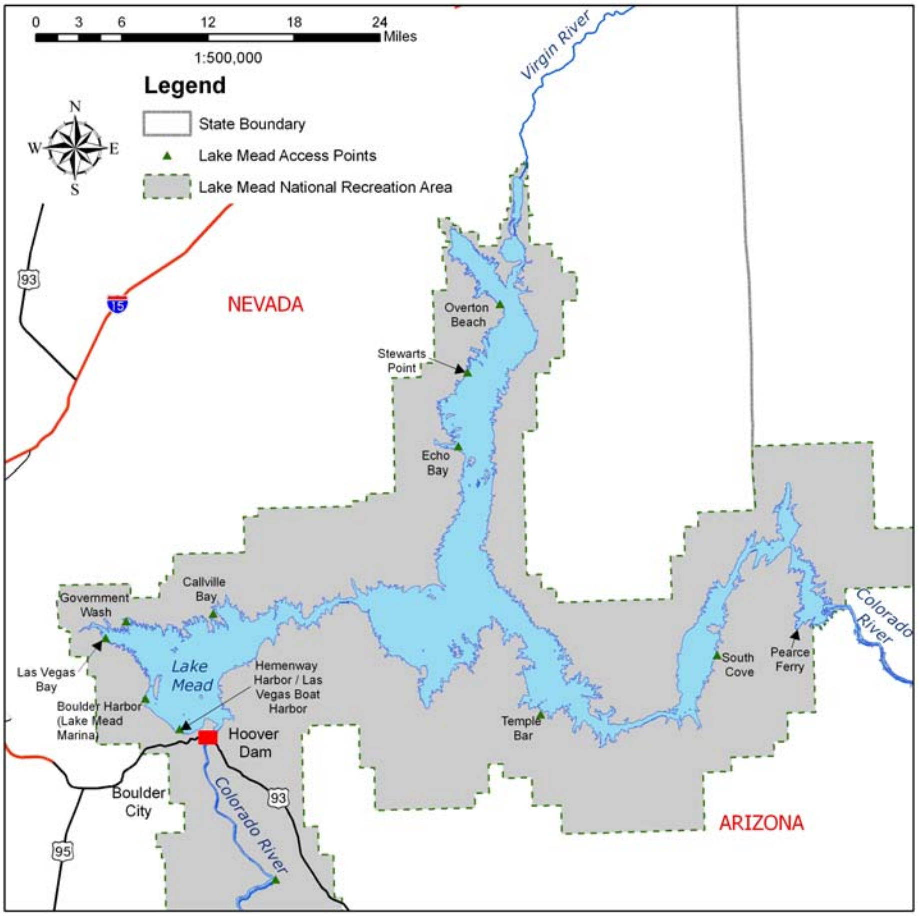
Shoreline public use facilities on Lake Mead are shown on Figure 3.12-2 and described on the following pages.

Pearce Ferry. Pearce Ferry includes a primitive public launch ramp used by Grand Canyon raft tour companies as their take-out. The ramp is located in a cove off of the river and operable when Lake Mead is at an elevation above 1,175 feet msl. Below that elevation, the cove becomes isolated from the river by a large sand bar separating the cove and graded ramp from the main flow of the Colorado River (NPS 2006e).

When Pearce Ferry is inaccessible due to low flows, boaters must continue downstream to South Cove, an additional 16 miles. This costs river runners fuel (for motorized craft), time (one to two more hours on the river), and possible safety problems (due to fatigue).

South Cove. The facilities at South Cove provide access to one of the best sand beach areas. There is one courtesy dock, public launch ramp, picnic facilities, and unpaved parking (Henderson 2000). The public launch ramp is constructed of asphalt and concrete and extends to an elevation of 1,125 feet msl. Other public facilities include a picnic area and restrooms. In addition, there is an airstrip approximately four miles from the facilities at South Cove (Henderson 2000).

Figure 3.12-2
Lake Mead Shorline Access Points



Temple Bar. Temple Bar Marina includes a public launch ramp, boat, houseboat, and personal watercraft rentals, slip rentals, and fuel. Other facilities and services include a restaurant/lounge, motel, cabin rentals, trailer village, recreational vehicle sites, dry boat storage, store, shower/laundry, boat/motor repairs, and auto/boat gas.

Overton Beach. The facilities at Overton Beach Marina include two public launch ramps. The marina is closed at elevation 1,125 feet msl and the public launch ramps are closed at 1,110 feet msl.

Additional available facilities and services at the Overton Beach Marina include covered rental slips, boat and personal watercraft rentals, small boat repair, fuel dock, and snack bar. Land based facilities include a store, shower/laundry, recreational vehicle campground, a trailer village, and dry boat storage.

Stewart's Point. Stewart's Point has an unpaved launch ramp (River Lakes Host 2006). The shoreline at Stewart's Point is a popular summertime weekend destination. The area is also a vacation cabin site area. The 2003 Lake Management Plan approved the future construction of a public boat launch at this location.

Echo Bay. The Echo Bay Marina includes boat, houseboat, and personal watercraft rentals, slip rentals, and fuel. Other facilities and services include a restaurant, motel, trailer village, recreational vehicle sites, dry boat storage, store, shower/laundry, boat/motor repairs, and auto/boat gas.

Callville Bay. The Callville Bay Marina includes rental slips; boat, houseboat, and personal watercraft rentals; and fuel. Other facilities and services include boat and motor repair, a trailer village, recreational vehicle sites, cafe/lounge, shower/laundry, auto/boat gas, dry boat storage, and a general store.

Government Wash. The facilities at Government Wash include one courtesy dock, public launch ramp, and a parking area. These facilities are closed at elevation 1,150 feet msl.

Las Vegas Bay. The facilities at Las Vegas Bay Marina include two public launch ramps, dry boat storage, and fuel service and maintenance area. The public launch ramps close at elevation 1,150 feet msl.

Las Vegas Boat Harbor. The facilities at Las Vegas Boat Harbor Marina are located next to Hemenway Harbor, and include rental slips, boat and personal watercraft rentals, floating gas dock, boat/motor repairs, store, and restaurant.

Boulder Harbor. The facilities at Boulder Harbor include two public launch ramps at Boulder Beach.

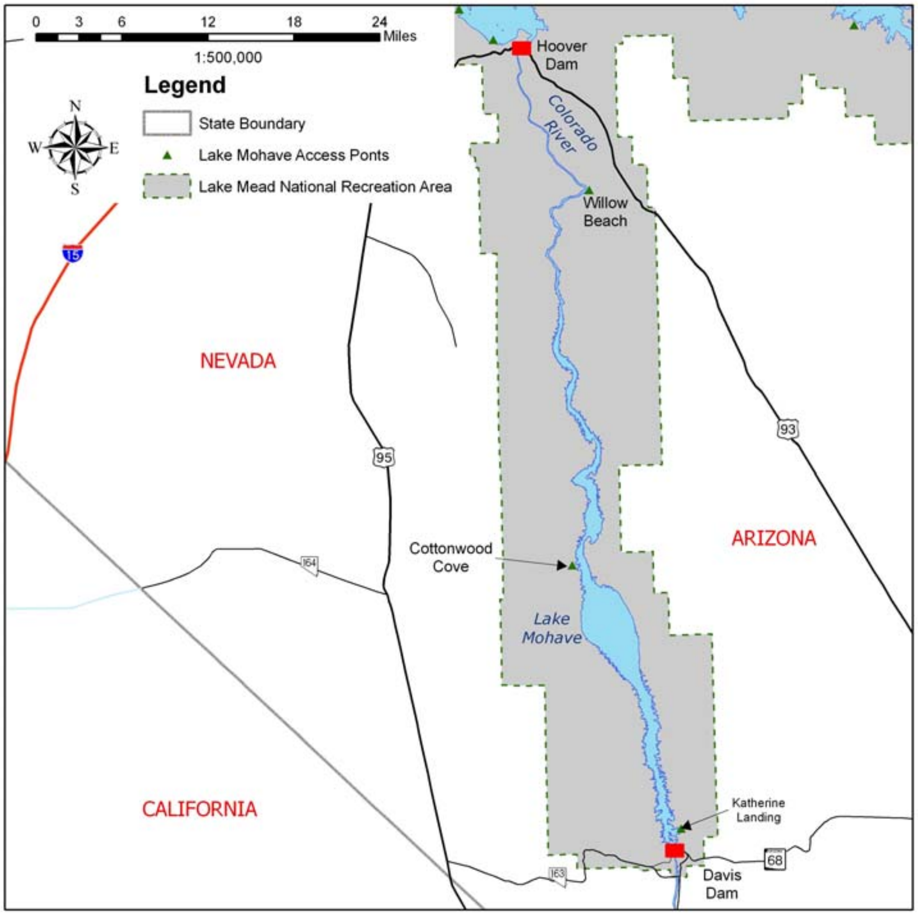
Hemenway Harbor. The facilities at Hemenway Harbor include one courtesy dock, public launch ramp, campgrounds, and a parking area. It also serves as the departure point for Lake Mead Cruises that provides sightseeing tour boat service to and from Hoover Dam, breakfast and dinner cruises, and charter boat service.

3.12.1.4 Hoover Dam to Davis Dam

Lake Mohave provides a multitude of recreational opportunities. Activities include boating, canoeing on northern parts of the lake, camping, exploring, fishing, photography, picnicking, swimming, parasailing, two locations for cliff diving, and water skiing. There are also hundreds of beaches that can only be accessed by boat.

The main shoreline access points for Lake Mohave are Katherine Landing, Cottonwood Cove, and Willow Beach (Figure 3.12-3). Facilities for public use and boat launching are located at Katherine's Landing in Arizona near Davis Dam, and at Cottonwood Cove, east of Searchlight, Nevada. Boats and jet skis can be rented at both locations. Public campgrounds are available at both locations where concessionaires provide trailer parks, restaurants, lodging, docking facilities, boat and fishing tackle equipment, and fishing licenses. Facilities for public use and boat launching are also located at Willow Beach, 31 miles upstream on the Arizona shore.

Figure 3.12-3
Lake Mohave Shoreline Access Points



3.12.1.5 Davis Dam to Parker Dam

Recreational Areas. The Davis Dam to Parker Dam reach includes several recreational areas along the Colorado River including Laughlin, Bullhead City, Davis Camp, Needles, Havasu NWR, Lake Havasu State Park, and Bill Williams River NWR. Relevant recreational areas are briefly described in the following sections.

Davis Camp. Located near Bullhead City, Davis Camp, a campground and day use area, has boat launching facilities, picnic areas, numerous campsites, and recreational vehicle hookups. Davis Camp offers many river-oriented recreational opportunities, including fishing and water sports.

Havasu National Wildlife Refuge. The Havasu NWR, managed by the FWS, covers 30 river miles (300 miles of shoreline) from Lake Havasu City, Arizona to Needles, California, and includes one of the last remaining natural stretches of the lower Colorado River, which flows through the 20-mile-long Topock Gorge (FWS 2002f). Typical activities include canoeing, fishing, boating through the scenic Topock Gorge, and hiking in the Havasu Wilderness Area. Each year, thousands of visitors explore the 4,000–acre Topock Marsh, which offers excellent canoeing, fishing, and water-bird watching. Other activities offered by the Havasu NWR include camping and hunting.

Lake Havasu State Park. Lake Havasu, formed by Parker Dam, contains a number of coves and inlets, and it is a popular spot for fishing. The waters of Lake Havasu also are used for canoeing, house boating, jet-skiing, kayaking, sailing, and speed-boating, swimming, and water-skiing. Camping and hiking also occur along the more than 400 miles of the lake's shoreline. Additional visitor opportunities include viewing the London Bridge. Lake Havasu is a popular spring break and family vacation destination.

Lake Havasu is the premier attraction area within the Davis Dam to Parker Dam reach. Visitation for Arizona's Lake Havasu and Cattail Cove State Parks is listed in Table 3.12-8.

Table 3.12-8
Visitation at Arizona's Lake Havasu and Cattail Cove State Parks

State Park	Visitation (1995-1996)	Visitation (2000-2001)	Percent Change
Lake Havasu	371,700	345,590	-7.0
Cattail Cove	96,459	106,939	10.9
Totals	468,159	451,983	-3.4

Source: Northern Arizona University 2002

Bill Williams River National Wildlife Refuge. The Bill Williams River NWR, managed by the FWS, is located along the Bill Williams River near its confluence outlet into Lake Havasu. The refuge offers a variety of recreational opportunities, including hiking and bird watching (as well as other wildlife viewing), with opportunities to view Yuma clapper rails and southwestern willow flycatchers, among other species. Hunting is permitted for dove, cottontail, quail, and desert bighorn sheep. Other activities include boating and fishing.

Boating Facilities. The Davis Dam to Parker Dam reach includes shoreline public use facilities at Laughlin, Nevada; Bullhead City, Arizona; Davis Camp, near Bullhead City; Needles, California; Havasu NWR, covering 30 river miles (300 miles of shoreline) from Lake Havasu City, Arizona to Needles, California; Lake Havasu State Park, Arizona; and Bill Williams River NWR, Arizona. Recreational activities within this reach include canoeing, fishing, houseboating, jet-skiing, kayaking, sailing, speed-boating, swimming, and water-skiing.

3.12.1.6 Parker Dam to Cibola Gage

Recreational Areas. The Parker Dam to Cibola Gage reach includes several recreational areas including Parker Strip Recreation Area, Palo Verde Diversion Dam, Blythe, and Cibola NWR. Relevant recreational areas are briefly described in the following sections.

Parker Strip Recreation Area. The Parker Strip Recreation Area includes an 11-mile road along the Colorado River. Recreational activities include boating, camping, fishing, hiking, rock hounding, swimming, and wildlife viewing.

Palo Verde Diversion Dam. There are approximately 95 miles of navigable waters between the Imperial Dam below Yuma and the Palo Verde Diversion Dam above Blythe. Activities include canoeing, fishing, hunting, power boating, and other water sports.

Cibola National Wildlife Refuge. The Cibola NWR, including Cibola Lake, managed by the FWS is located about 15 miles south of Blythe. The largest concentration of Canada geese and sandhill cranes on the lower Colorado River winter at the refuge. Visitors to the refuge engage in canoeing, fishing, hiking hunting, photography, and wildlife observation.

Boating Facilities. The Parker Dam to Cibola Gage reach includes shoreline public use facilities at Parker Strip Recreation Area, Arizona; Palo Verde Diversion Dam, Arizona; Blythe, California; and Cibola NWR, Arizona. Typical water activities within this reach include canoeing, power boating, fishing, swimming, and other water sports.

3.12.1.7 Cibola Gage to Imperial Dam

Recreational Areas. The Cibola Gage to Imperial Dam reach includes a few recreational areas including Picacho State Recreation Area (SRA), Imperial NWR, and Martinez Lake. Each recreational area is briefly described in the following sections.

Picacho State Recreation Area. Picacho SRA is a popular area for camping, desert exploring, river running, and sport fishing. It receives approximately 60,000 visitors annually (Picacho State Recreation Area 2006). The area has a group boat-in area, three individual boat-in camp areas, and large group camping areas. Bird watching and small game hunting for doves, ducks, and quail are among other recreational opportunities.

Imperial National Wildlife Refuge. Recreational opportunities at the Imperial NWR include canoeing, fishing, and hunting. The refuge is valued by boaters for its remote scenery.

Martinez Lake. Martinez Lake, which adjoins the Imperial NWR, encompasses 300 to 500 acres and it is an attraction catering to anglers, birdwatchers, boaters, fishers, hunters, nature lovers, rock hounds, sightseers, and water skiers. Martinez Lake has a large variety of birds year around that can be viewed from boats on the Colorado River as well as the many side lakes along the river.

Boating Facilities. Cibola Gage to Imperial Dam reach includes shoreline public use facilities at Picacho SRA, California; Imperial NWR, Arizona; and Martinez Lake, Arizona. Picacho SRA has a group boat-in area and three individual boat-in camp areas. Typical water activities within this reach include river running, boating, canoeing, water-skiing, and sport fishing.

3.12.1.8 Imperial Dam to NIB

Recreational Areas. The Imperial Dam to the NIB reach includes a few recreational areas along the Colorado River, including Betty's Kitchen and Mittry Lake Wildlife Area. Each recreational area is briefly described in the following sections.

Betty's Kitchen. Betty's Kitchen, a 10-acre wildlife interpretive area, provides bird watching and fishing opportunities.

Mittry Lake Wildlife Area. Mittry Lake, within the Mittry Lake Wildlife Area, covers approximately 600 acres and it is an ideal location for small game hunting and sportfishing. There is a three-lane boat launch ramp for motorized boating on the lake. The area is also popular for birdwatching and nature study.

Boating Facilities. The Imperial Dam to the NIB reach includes shoreline public use facilities such as a public fishing pier (National Recreation Trails Program 2006) at Betty's Kitchen, Arizona and a three-lane boat launch ramp for motorized boating and fishing jetties Mittry Lake Wildlife Area, Arizona (AZBLM 2006). Typical water activities within this reach include boating, swimming, and sport fishing.

3.12.1.9 NIB to SIB

The NIB to the SIB reach includes shoreline public use facilities in the City of Yuma, Arizona. Located on the edge of the historic floodplain to the east of the Colorado River, typical water activities within this reach include boating, swimming, and sport fishing.

3.12.2 Reservoir Boating

Reservoir boating is affected by fluctuating reservoir elevations, specifically causing changes in exposure to boating navigation hazards and changes in safe boating capacities. Hazards such as exposed rocks may become more evident and changes in navigation patterns may be necessary as reservoir elevations decline. At low pool elevations, special buoys or markers may be placed within reservoirs to warn boaters of navigational hazards. In addition, signs may be placed in areas that are deemed unsuitable for navigation.

3.12.2.1 Lake Powell

Safe Boating Navigation. In 1986, the GCNRA developed an "Aids to Navigation Plan" for Lake Powell that identified boating safety issues on the reservoir and low pool elevations that could affect boating (NPS 1986). The navigation system uses regulatory buoys and other marking devices to warn boat operators of hazardous conditions associated with subsurface obstructions or changes in subsurface conditions that could be hazardous for safe passage. Placement of many of these marking devices is dependent on the lake elevation.

At pool elevations below 3,680 feet msl, there are several places that remain passable, although buoys are placed for safe navigation. At elevations 3,626 feet msl and 3,620 feet msl, there are two areas on the reservoir that are closed to commercial tour boats and recreational boats, respectively, because of hazardous obstructions to navigation. One of these areas is around Castle Rock (elevation 3,620 feet msl), just east of the Wahweap Marina, and the other is around Gregory Butte, which is about midway to Dangling Rope Marina from Wahweap (Figure 3.12-1). At elevation 3,626 feet msl commercial tour boats leaving the Wahweap Marina heading up reservoir (east) must detour 8.5 miles around the southern end of Antelope Island. At elevation 3,626 feet msl, commercial tour boats must detour 4.5 miles around Padre and Gregory Buttes (NPS 1986). The added mileage and increased travel time makes the more popular half-day trips of the area infeasible for commercial tour boat operators. In addition, the added mileage may influence recreational boaters to remain in the area of Wahweap Bay, which can result in congestion (Henderson 2000).

In addition to buoys marking obstructions, the Aids to Navigation Plan also established a marked travel corridor to guide boat travel on Lake Powell. This primary travel corridor is the main channel of the Colorado River and it is marked with buoys along the entire length of the reservoir. Except for the reservoir mouth, there are no known pool elevations at which boat passage along this main travel corridor becomes restricted and affects boating.

Near Hite a delta has formed that can affect river boaters coming into Lake Powell at low-pool elevations. River boaters from the Colorado River row or motor through Lake Powell to a location where a boat transports them 20 to 25 miles (depending on the pick-up location) to the Hite Marina. At low elevations, the river boaters must travel further downstream to reach a location accessible to the transport company's boat.

Although this results in more miles to the takeout, there is usually enough current in the river to carry the boats. At lower elevations, additional rapids are exposed in Cataract Canyon (Hyde 2000), benefiting river runners; however, lower Lake Powell elevations result in the possibility of additional navigational hazards due to restricted channel widths and subsurface conditions.

As shown in Table 3.12-9, watercraft use in the Glen Canyon NRA peaks in the months of June through August.

Table 3.12-9
Estimates of Watercraft Use in Glen Canyon National Recreation Area by Month in 2001

Month	Other Watercraft		Personal Watercraft		All Watercraft	
	Boat Days	Monthly Use (percentage)	Boat Days	Monthly Use (percentage)	Boat Days	Annual Use (percentage)
January	747	96	30	4	777	<1
February	1,059	97	33	3	1,092	<1
March	8,995	97	261	3	9,256	1
April	18,686	94	1,122	6	19,808	2
May	68,444	81	15,771	19	84,215	10
June	137,675	74	47,985	26	185,660	22
July	113,984	70	48,600	30	162,584	20
August	126,628	72	49,491	28	176,119	21
September	80,045	62	49,883	38	129,928	16
October	37,658	86	6,336	14	43,994	5
November	11,946	96	445	4	12,391	2
December	5,189	99	67	1	5,256	1
Total	611,056	74	220,023	26	831,079	100

Source: NPS 2003.

Safe Boating Capacity. Recreational boating is the most frequent type of boating activity on Lake Powell, with an estimated 1.5 million boaters per year. One of the most popular activities at Lake Powell is to take houseboats and motorboats for multiple day excursions to explore the reservoir.

At full-pool elevation for Lake Powell (3,700 feet msl), its operating surface area is 160,782 acres. Using nine surface acres per boat, Lake Powell's safe boating capacity at full-pool elevation is approximately 17,865 boats at one time. As pool elevation decreases, the surface area available for boats also decreases.

3.12.2.2 Lake Mead

Safe Boating Navigation. Regulatory buoys and other marking devices are used on Lake Mead to warn boat operators of dangers, obstructions, and changes in subsurface conditions in the main channel or side channels.

The main channel of the Colorado River forms the primary travel corridor on Lake Mead and it is marked along its entire length with buoys for boating guidance. In addition, regulatory buoys are placed in areas where there may be a danger for safe passage.

Excursions from Lake Mead into the Grand Canyon are a popular activity. Boats entering the Grand Canyon usually launch at Pearce Ferry, South Cove, or Temple Bar (Figure 3.12-2). In addition to sightseeing being a popular activity, many boaters include overnight camping on these excursions.

The upper arms and inflow areas of Lake Mead may be difficult to navigate due to shifting subsurface sediments. In the main channel of the reservoir, the Grand Wash Cliffs area is the beginning of dangerous navigation conditions and no houseboats are allowed beyond this point (NPS 2005a).

Over the years, sediment has built up in the section of the reservoir between Grand Wash and Pearce Ferry. When Lake Mead elevations drop below 1,170 feet msl, the sediment is exposed as mud flats and there is no well-defined river channel. As a result, the area is too shallow for motor boats to navigate upstream and into the lower reaches of the Grand Canyon. With fluctuating flows, even smaller crafts may have a difficult time accessing the area because of the shifting channel (Reclamation 1995b). Based on this information, 1,170 feet msl is considered a threshold elevation for safe boating navigation for the upper end of Lake Mead.

While the area around Pearce Ferry is an issue for navigation at elevation 1,170 feet msl, the Pearce Bay launch ramp is inaccessible as a take-out for boaters at elevation 1,175 feet msl and boaters must paddle an additional 16 miles to South Cove (Henderson 2006).

Safe Boating Capacity. At full-pool elevation for Lake Mead, its operating surface area is 153,235 acres. Using the safe boating density of nine surface acres per boat, Lake Mead's safe boating capacity at full-pool elevation is approximately 17,000 boats. As pool elevation decreases, the safe boating capacity also decreases.

3.12.2.3 Lake Mohave and Lake Havasu

Because Lake Mohave and Lake Havasu will continue to be operated to meet monthly target elevations, reservoir boating safe navigation and capacity in these reaches will not be impacted by the proposed federal action.

3.12.3 River and Whitewater Boating

Whitewater boating is the key recreational activity in the Grand Canyon from Lees Ferry to the Diamond Creek or Pearce Ferry take-outs. Other reaches are not predominately whitewater localities and so they are not covered here.

3.12.3.1 Glen Canyon Dam to Lake Mead

Most Grand Canyon river trips begin at Lees Ferry and take-out at Diamond Creek or Pearce Ferry when Lake Mead elevations are higher than 1,175 feet msl, or at South Cove when Lake Mead elevations are below 1,175 feet msl (Figure 3.12-2). Boating is regulated by the NPS through its Colorado River Management Plan (NPS 2005b). The number of permits or boaters will not change as a result of this proposed federal action: the key issue is whether the visitor experience could change as a result of potential changes in Glen Canyon Dam releases. The total number of river users is approximately 22,800 per year. Use is expected to increase to 28,000 per year as indicated in the Grand

Canyon National Park Colorado River Management Plan. There are seasonal differences in the number of river users, with the winter season having the lowest daily and monthly uses.

Motorized boats travel up and down river from Glen Canyon Dam to Lees Ferry and in the upper end of Lake Mead. Limited camps in the latter area discourages overnight use.

3.12.3.2 Hoover Dam to SIB

Fluctuations in river flows between Hoover Dam and the SIB under each alternative are expected to be within the range of historic operations for the river and would not deviate from historic highs and lows. Between Hoover Dam and the SIB, river and whitewater boating are not expected to be adversely affected by the proposed federal action.

3.12.4 Sport Fishing

This discussion is based on the GCNRA Fish Management Plan (NPS 1996) for Lake Powell, and the Desert Lake View Newspaper, Fall/Winter 1999 for Lake Mead. In addition, creel information and angler fishing data have been obtained from state agencies in Utah, Arizona, and Nevada responsible for managing the fisheries resources at Lake Mead, Lake Powell, Lake Mohave, and on the Colorado River.

There are no specific reservoir elevation thresholds or river stages related to sport fishing identified from the literature reviewed. Catch rates for reservoir fishing are assumed to be directly related to reservoir habitat. Fishing satisfaction is assumed to be directly related to the general recreation issues of boating access to water via shoreline facilities, and boating navigation potential for hazards or reservoir detours due to low reservoir elevations. Catch rates are not expected to be affected by fluctuations in reservoir elevations.

3.12.4.1 Lake Powell and Glen Canyon Dam

Lake Powell supports a popular warm water sport fishery comprised mainly of striped and smallmouth bass. The striped bass depend on threadfin shad, a mid-water forage species, for a significant portion of their diet. The threadfin shad in Lake Powell are at the northernmost portion of their range and are sensitive to fluctuations of water temperature. Gizzard shad, which were inadvertently released recently and made their way to Lake Powell, may become an important striped bass forage fish. In addition to striped and smallmouth bass, Lake Powell supports largemouth bass, walleye, channel catfish, bluegill, and black crappie. There are two million angler hours per year in pursuit of sport fish. Due to the drought and declining visitation, angler use in 2003 was the lowest it has been since 1985 (Blommer et. al. 2004).

3.12.4.2 Glen Canyon Dam to Lake Mead

The rainbow trout in the 15.5-mile stretch below Glen Canyon Dam attract large numbers of local and international anglers. In 2003, angler use was approximately 14,000 user days. The fishery is managed as a “blue ribbon” rainbow trout fishery by the Arizona Game and Fish Department and Glen Canyon NRA. The intention of blue ribbon management is to provide a quality fishing opportunity where anglers can catch larger than average trout, at a relatively high catch rate, in a unique recreational setting. Most fishing occurs from boats, but some anglers wade in the area around Lees Ferry. Downstream of this area the native fishery is emphasized.

3.12.4.3 Lake Mead and Hoover Dam

Lake Mead has an excellent warm water sport fishery comprised of largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill. Eighty-six percent of the catch consists of striped bass. Fishing is generally better in the fall months of September, October and November. Larger fish are caught by deep water trolling in spring from March through May.

3.12.4.4 Hoover Dam to Davis Dam

Lake Mohave's fishery is similar to Lake Mead's fishery. In Lake Mohave there are largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill. Largemouth and striped bass are in deep water in the winter and move into shallow water to spawn in the spring. Fishing is open year round, but the best fishing generally occurs in September, October and November. For deep water trolling, March through May is best.

3.12.4.5 Davis Dam to Parker Dam

Striped bass is the dominant sport fish in Lake Havasu. They can be caught throughout the year, but best fishing locations change with seasons and with water temperature. The largemouth bass population supports tournaments nearly every weekend from September through May. The smallmouth bass population has experienced an increase in numbers over the past couple of years adding a needed resource for tournament anglers. Channel catfish are abundant and average two to four pounds in size. Flathead catfish grow to large sizes in the lake. Only a limited number of anglers fish specifically for catfish. Black crappie numbers are limited due to over-harvesting and lack of habitat. The lake also contains some very large bluegill and redear sunfish, many are well over a pound (Lake Havasu Fishing 2006).

3.12.4.6 Parker Dam to SIB

Fishing in Cibola NWR is limited to certain times of the year. Cibola NWR is managed to protect wintering waterfowl that use the lake. The lake is closed to fishing from Labor Day to March 15. Sport fishing in the lake includes largemouth, smallmouth, and striped bass, channel and flathead catfish, crappie, sunfish, tilapia, and common carp (FWS 2006a).

The Imperial NWR is managed as a refuge and breeding area for migratory birds and other wildlife. Fishing is limited to an area on the Colorado River (FWS 2006b).

Fishing is allowed in the mainstream Colorado River any time of the year by boat. Fluctuations in flows between Parker Dam and the SIB under the alternatives are expected to be within the historic operating range of the Colorado River.

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3.13 Transportation

Transportation refers to the movement of people and vehicles on existing road networks and on ferries that cross the Colorado River. While there are other transportation services, only the ferry service has the potential to be impacted by the proposed federal action.

3.13.1 Ferry Service

Three ferry services transport people and vehicles across the Colorado River and its reservoirs. These services are:

- Lake Powell ferry service;
- Laughlin River Taxis; and
- Lake Havasu ferry service.

3.13.1.1 Lake Powell Ferry Service

The John Atlantic Burr Ferry on Lake Powell is located 95 miles upriver from Glen Canyon Dam and connects Bullfrog and Hall Crossing marinas on Lake Powell (Figure 3.13-1). The State of Utah operates this ferry service year round. This ferry saves approximately 130 miles of driving and the cost is $39.50 plus tax for a one-way trip. If Lake Powell elevation falls below 3,550 feet msl, the ferry becomes inoperable (Aramak 2006).

3.13.1.2 Laughlin River Taxis and Tour Boats

Privately owned river taxis and tour boats operate on the Colorado River approximately 2.5 miles downstream of Davis Dam in Laughlin, Nevada (California Department of Boating and Waterways 2006) (Figure 3.13-2). The river taxis provide transportation between the casinos located along the Colorado River in Laughlin. The tour boats offer services ranging from air-conditioned cabins, open-air top decks, wedding chapels, and full service bars. The operation of these river taxis and tour boats depends upon the Colorado River elevations that result from releases of water from Davis Dam. Many operations, especially the larger tour boats with paddle wheels, require releases of two units (approximately 9,200 cfs) from Davis Dam to operate. Although some of the river taxi operations that operate smaller boats can get by with 0.5 units (approximately 2,300 cfs), most prefer at least one unit (approximately 4,600 cfs) (Fitch pers. com.).

3.13.1.3 Lake Havasu Ferry Service

The Dreamcatcher ferry transports people and vehicles between Havasu Landing Casino on the Chemehuevi Indian Reservation, California and a point near the London Bridge in Lake Havasu City, Arizona (California Department of Boating and Waterways 2006) (Figure 3.13-3). This ferry carries approximately 400,000 people per year but does not carry vehicles (Arizona State Parks 2006). This ferry is used to shuttle people to the Havasu Landing Casino located on the Chemehuevi Indian Reservation. Lake Havasu will continue to be operated to meet monthly elevation targets and therefore, the proposed federal action will not affect the operation of the Lake Havasu ferry service.

Figure 3.13-1
John Atlantic Burr Ferry Route – Lake Powell

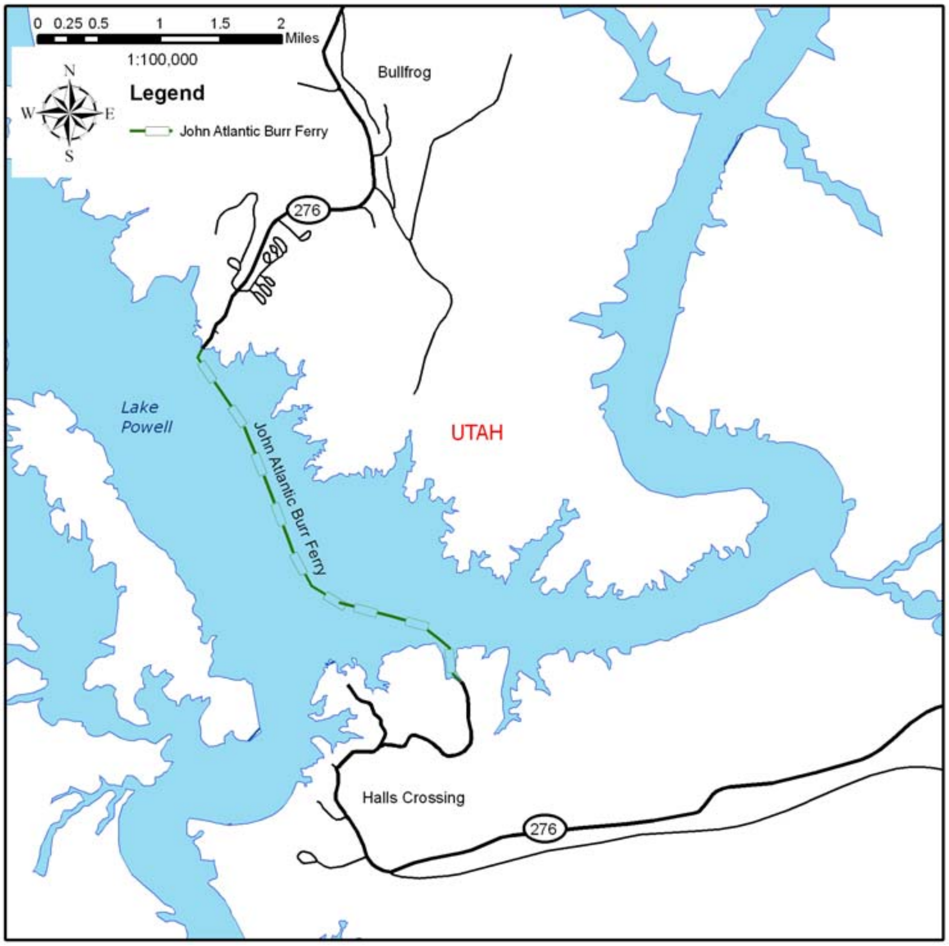

Figure 3.13-2
Laughlin River Taxi and Tour Boat Crossing

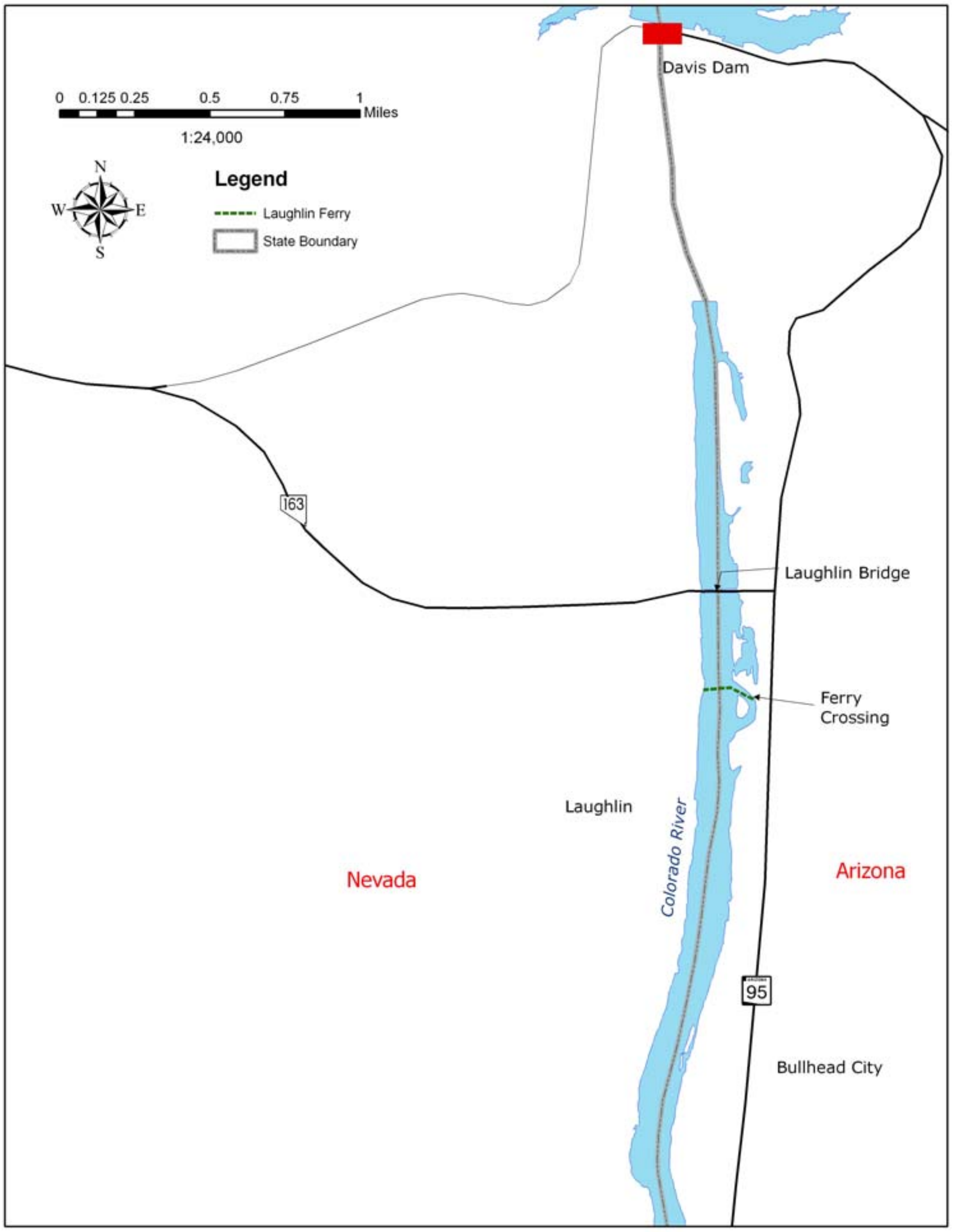

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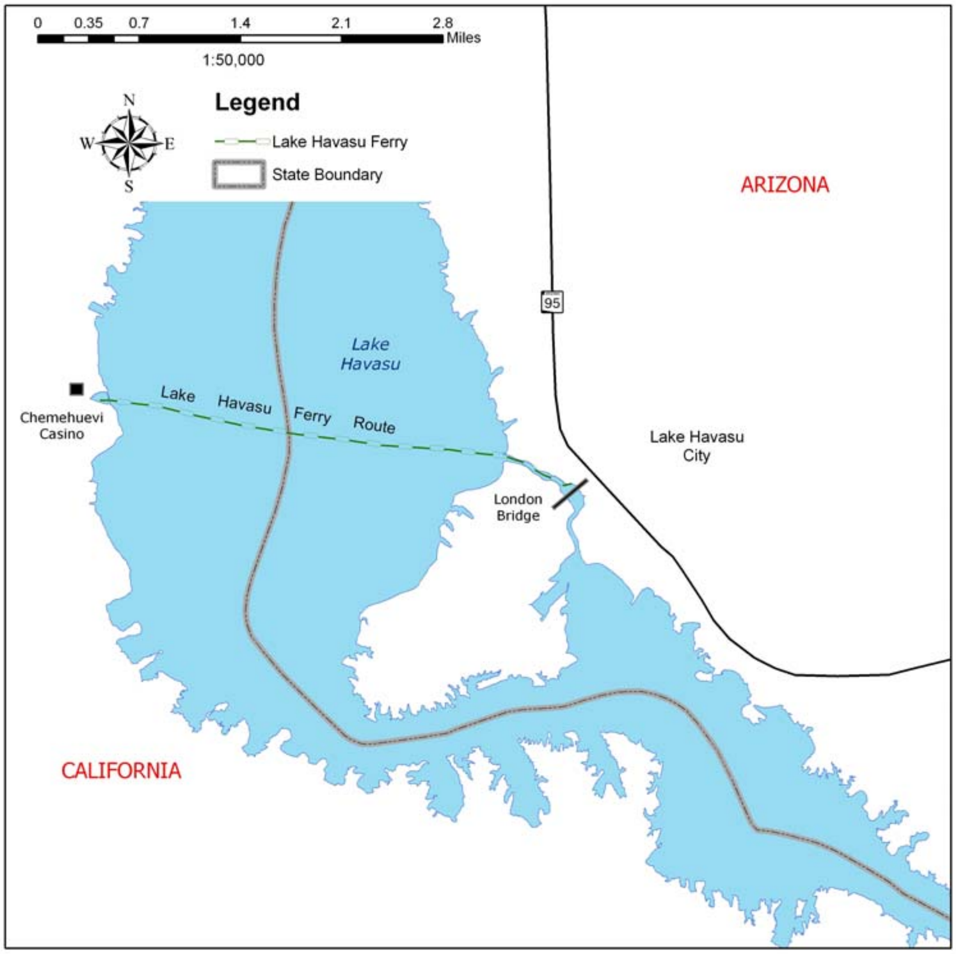
Figure 3.13-3
Lake Havasu Ferry Route



3.14 Socioeconomics and Land Uses

This section provides an overview of socioeconomic and land use conditions within the states that could be affected by implementing the proposed federal action. The potentially affected socioeconomic and land use issues addressed include changes in:

- agricultural production and resulting changes in employment, income, and tax revenues;
- municipal and industrial uses and resulting changes in economic activity; and
- reservoir-related and river-related recreation activity and resulting changes in employment and income.

No long-term permanent changes in land uses are expected to be caused by the proposed federal action because only agricultural lands would be directly affected during a shortage and these lands would be fallowed and not permanently removed from production. In addition, the proposed federal action would not change apportionment or entitlements and changes in water deliveries would be temporary in nature. The proposed federal action will not result in any effects on prime or unique farmlands pursuant to the Farmlands Protection Policy Act of 1978. Any changes in land uses are likely to be short-term and the proposed federal action would not result in or encourage the conversion of agricultural lands to other uses.

Information regarding the value of agricultural production was limited to the counties falling within the CAP service area. Specific information regarding the value of agricultural production has not been included for Nevada or California. The value of agricultural production in Nevada is small relative to the sectors that drive the state and local economy. Agricultural production in California is not expected to be adversely affected because the potentially affected areas within California are almost all urbanized. Economic activity related to recreation is included in the information provided for Lake Powell, Lake Mead, and the Colorado River downstream of Lake Mead.

3.14.1 Study Area

The study area for the socioeconomics assessment was based on the states and counties in which a shortage may occur or in which changes in reservoir storage or river flow would result in a change in recreation opportunities or use. A county-level analysis was selected because information on employment and income is typically reported at the county level. The study area consists of counties in Utah, Arizona, Nevada, and California.

The Utah study area is comprised of Garfield, Kane, and San Juan counties. Although Utah will not experience shortages under any of the alternatives, changes in storage at Lake Powell could result in changes in recreation-related expenditures made in these counties.

The Arizona study area is comprised of Coconino, La Paz, Mohave, Pima, Pinal, Yavapai, Yuma, Maricopa, and Graham counties. These counties were selected because they are either located directly adjacent to Lake Powell, Lake Mead, or the Colorado River, or they are counties in which shortages would likely occur. The counties in which measurable shortages could potentially occur, resulting in reduction in agricultural production or reduced municipal/industrial deliveries are Maricopa, Pinal, Pima, Mohave, La Paz, and Yuma.

The Nevada study area is comprised of Clark County. The study area was limited to Clark County because it is located adjacent to Lake Mead and encompasses the service area of the Southern Nevada Water Authority. Shortages in Nevada would be limited to the Southern Nevada Water Authority service area.

The California study area is comprised of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and San Diego counties. These counties were selected because they are either located directly adjacent to the lower Colorado River, or they are within the MWD service area.

3.14.2 Water Use

The potentially affected area within Arizona includes Coconino, La Paz, Mojave, Pima, Pinal, Yavapai, Yuma and Maricopa Counties. Maricopa, Pima, and Pinal Counties are served by the CAP, whereas Coconino, La Paz, Yavapai, Yuma, and Mojave Counties are adjacent to the Colorado River and/or Lake Mead.

3.14.2.1 Arizona

Agriculture. The total market value of agricultural production in Arizona was a little over $2.4 billion in 2002. The market value of agricultural production occurring within the Arizona study area accounted for nearly 90 percent of the statewide production value. In 2002, production values ranged from a low of approximately $16 million in Mohave County to a high of $802 million in Yuma County. (U.S. Department of Agriculture, National Agricultural Statistics Service 2002).

Agricultural lands receiving water for irrigation from the CAP are located generally within Pinal, Maricopa, and Pima Counties. A list of irrigation districts and Indian communities receiving water from the CAP is provided in Appendix H.

The three counties account for approximately 53 percent of statewide irrigated harvested cropland. These three counties also account for approximately 71 percent of Arizona's harvested cotton acreage, 18 percent of the State's vegetable crops and approximately 48 percent of irrigated wheat cultivation (USDA 2004). Table 3.14-1 provides a summary of lands in irrigated farms within these three counties.

Table 3.14-1
Central Arizona Irrigated Agricultural Land in 2002

Area	Total Land in Irrigated Farms (acres)	Total Land Area (acres)	Land in Irrigated Farms as a Percentage of Total Land in 3-County Area
CAP Counties	829,957	14,928,438	5.6
Western Arizona Counties	536,152	14,928,438	3.6

Source: USDA, National Agricultural Statistics Service 2004.

Agricultural resources in western Arizona are located in Mohave, La Paz, and Yuma Counties. Agricultural lands are located primarily along the Colorado River and in Yuma County along the Gila River Valley. A list of these districts is provided in Appendix H.

These three Western Arizona counties account for approximately 75 percent of the State's production of vegetable crops, 49 percent of irrigated wheat cultivation, and 38 percent of orchard lands (USDA 2004). Table 3.14-1 provides a summary of irrigated agricultural lands within these Western Arizona counties.

Municipal and Industrial Uses. Municipalities potentially affected by the proposed federal action include the cities of Phoenix, Tucson, Scottsdale, and numerous other Arizona towns and cities that rely on Colorado River water delivery through the CAP. Industrial land uses located in Arizona on the Colorado River include the major power facilities of Glen Canyon Dam and Navajo Generating Station in Coconino County and Parker Dam in La Paz County (and San Bernardino County, California).

Employment. Full and part time employment in Arizona totaled 3,047,543 jobs in 2004, an increase of approximately 477,000 jobs from 1994 levels. Employment in the private sector represented nearly 85 percent of total employment in 2004 (U.S. Department of Commerce, Bureau of Economic Analysis 2006c). In 2004, employment in the arts, entertainment, and recreation sector totaled 59,022 jobs or approximately two percent of total employment in Arizona. Farm employment totaled 23,315 in 2004 and accounted for less than one percent of total employment in the state.

Full and part time employment in Coconino, La Paz, Mojave, Pima, Pinal, Maricopa, Yavapai, and Yuma Counties totaled 2,878,279 jobs in 2004, an increase of approximately 860,500 jobs from 1994. Total employment in the eight-county study area represents more than 94 percent of total employment in Arizona. Employment in the arts, entertainment, and recreation sector to the eight counties totaled 56,581 jobs or approximately two percent of total employment in the eight counties. Employment in the agricultural sector in Maricopa, Pima, and Pinal Counties totaled 12,295 jobs in 2004 and represented less than one percent of total employment for those three counties. (U.S. Department of Commerce, Bureau of Economic Analysis, 2006c).

Income. Total personal income in Arizona totaled just over $145.5 billion in 2004. This represents a substantial increase from the 1994 level of $81.5 billion. Statewide per capita income increased from approximately $19,000 in 1994 to approximately $29,000 in 2004 (U.S. Department of Commerce, Bureau of Economic Analysis, 2006d).

In 2004, average per capita income ranged from a low of approximately $19,743 per year in La Paz County to a high of $31,757 per year in Maricopa County. The total personal income of the eight counties represents just over 94 percent of the state total (U.S. Department of Commerce, Bureau of Economic Analysis 2006d).

3.14.2.2 Nevada

The Nevada study area is comprised of Clark County, which is adjacent to the Colorado River.

Agriculture. Agricultural production in Clark County is very small compared to other farming areas in the study area. Table 3.14-2 provides a summary of agricultural land in this county. A small proportion of this land is used for cropland, most of which is irrigated. Cropland is used primarily for producing forage crops. Livestock and poultry are also produced in Clark County.

Table 3.14-2
Southern Nevada (Clark County) Agricultural Land in 2002

Total Land in Irrigated Farms (acres)	Total County Area (acres)	Land in Irrigated Farms as a Percentage of Total Land
65,206	5,062,614	1.3 percent

Source: USDA, National Agricultural Statistics Service 2002.

Municipal and Industrial Uses. Municipalities potentially affected by the proposed federal action include Boulder City, Henderson, Las Vegas, and North Las Vegas due to their reliance on Colorado River water supplied by SNWA. These municipalities support urban, commercial, and industrial land uses that could be potentially affected by the proposed federal action.

Employment. Full and part time employment in Nevada totaled 1,430,370 jobs in 2004, an increase of approximately 521,000 jobs from 1994 levels. Employment in the private sector represented nearly 89 percent of total employment in 2004 (U.S. Department of Commerce, Bureau of Economic Analysis 2006e). In 2004, employment in the arts, entertainment, and recreation sector totaled 46,137 jobs or approximately three percent of total employment in the state. Employment in the accommodations and food service sector totaled 293,157 jobs and was the largest employment sector in Nevada. This is the largest employment sector in Nevada, accounting for approximately 24 percent of total employment.

Full and part time employment in Clark County totaled 998,000 jobs in 2004, an increase of approximately 422,000 jobs from 1994. Total employment in Clark County represents almost 70 percent of total employment in Nevada. Full- and part-time employment in the Clark County government sector was lower than the Nevada average (U.S. Department of Commerce, Bureau of Economic Analysis 2006e). In 2004, employment in the arts, entertainment, and recreation sector totaled 30,391 jobs or approximately three percent of total employment in the county. Similar to statewide totals, the accommodations and food service sector was the largest employment sector in the county, totaling 235,632 jobs in 2004.

Income. Total personal income in Nevada totaled just over $78 billion in 2004. This represents a substantial increase from the 1994 level of $43 billion. Statewide per capita income increased from approximately $23,800 in 1994 to approximately $33,800 in 2004 (U.S. Department of Commerce, Bureau of Economic Analysis 2006f).

In 2004, per capita income in Clark County was $32,900, slightly lower than the state average. The total personal income of Clark County represents more than 69 percent of the state total (U.S. Department of Commerce, Bureau of Economic Analysis 2006f).

3.14.2.3 California

The California study area is comprised of Los Angeles, Orange, Riverside, San Bernardino, and San Diego Counties. These counties were identified because they are located within the service area of the MWD, which receives a portion of its water supply from the Colorado River. Although Ventura County is also in MWD's service area, it does not receive any water from the Colorado River and therefore it is not included in the study area.

Agriculture. Table 3.14-3 presents the amount of agricultural land present in each California county served by the IID, the CVWD, the MWD, and the San Diego County Water Authority (SDCWA), and the percentage of land in the counties that is in agricultural use. These counties include Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura. The categories included in Table 3.14-3 are used by the California Department of Conservation and are based on the Important Farmland maps for California. These maps are compiled from United States Department of Agriculture (USDA) Natural Resources Conservation Service soil surveys and current land use information.

Table 3.14-3
Southern California Agricultural Land in the Seven-County Study Area (2004)

Important Farmland in the Seven-County area[1] (acres)	Grazing Land in the Seven-County Area (acres)	Total Agricultural Land in the Seven-County Area[2] (acres)	Total Seven-County Area (acres)	Agricultural Land as a Percentage of Total Land in the Seven-County Area
1,443,109	1,601,689	3,044,798	27,334,413	11.1 percent

Source: California Department of Conservation (CDC) 2004 a-g.

Notes:

1. *Important Farmland includes Prime Farmland, Farmland of Statewide Importance, Unique Farmland and Farmland of Local Importance.*
2. *This category includes both Important Farmland and Grazing land.*
3. *Counties are Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura.*

Municipal and Industrial. Municipalities potentially affected by the proposed federal action include some 88 cities in Los Angeles County, 34 cities in Orange County, 24 cities in Riverside County, 31 cities in San Bernardino County, and 18 cities in San Diego County.

Employment. Full- and part-time employment in California totaled 20 million jobs in 2004, an increase of approximately 3.5 million jobs from 1994 levels. Employment in the private sector represented nearly 85 percent of total employment in 2004 (U.S. Department of Commerce, Bureau of Economic Analysis 2006g).

Full- and part-time employment in the six county study area totaled 11 million jobs in 2004, representing 55 percent of total California employment. Full and part time employment in the government sector was higher than the California average (13 percent) in four counties (Imperial: 24 percent, Riverside: 14 percent, San Diego: 18 percent, and San Bernardino: 15 percent) and lower in two counties (Los Angeles: 11 percent, and Orange: eight percent) (U.S. Department of Commerce, Bureau of Economic Analysis, 2006g).

Income. Total personal income in California totaled just over $1.2 trillion in 2004. This represents a substantial increase of $497 billion from 1994. Statewide per capita income increased from approximately $23,000 in 1994 to approximately $35,000 in 2004 (U.S. Department of Commerce, Bureau of Economic Analysis, 2006h).

In 2004, total personal income ranged from a low of approximately $3.3 billion in Imperial County to a high of $329 billion in Los Angeles County. When combined, the total personal income of the six counties represents 44 percent of the state total. Per capita income ranged from a low of approximately $22,000 in Imperial County to a high of approximately $42,000 in Orange County (U.S. Department of Commerce, Bureau of Economic Analysis 2006h).

3.14.3 Recreation

Economic benefits result when visitors spend dollars locally on recreational activities. Those benefits include increased sales, income, and jobs. Direct economic benefits occur when businesses sell goods and services to park visitors. Indirect economic benefits result from the circulation of spending throughout the local economy (NPS 2005c).

This section describes the direct and indirect economic value of recreation occurring in the GCNRA and the LMNRA. The NPS maintains a database of recreational visits and the economic impacts of those visits. That information is summarized here for Lake Powell and Lake Mead. Lake Mohave is included within the LMNRA. Consequently, the visitor spending associated with Lake Mohave is included as part of the LMNRA discussion below. A discussion of recreation-related economic activity occurring on the Colorado River below Lake Powell and Lake Mead was not included because no change in recreation activities and resulting change in economic activity is expected under the proposed federal action.

3.14.3.1 Glen Canyon National Recreation Area

GCNRA hosted 1.88 million recreational visits in 2003. (Section 4.12 provides additional information on recreation use occurring within the GCNRA.) Table 3.14-4 summarizes the direct and indirect effects of visitor spending by sector. Direct recreation-related expenditures totaled $86.09 million in 2003 resulting in 2,119 jobs and $31.76 million in personal income. As direct spending circulates through the local economy, secondary or indirect economic effects occur. This spending created an additional $14.11 million in personal income and 548 jobs.

Table 3.14-4
Glen Canyon National Recreation Area Economic Impacts of Visitor Spending by Sector for 2003

Sectors	Sales (millions)	Personal Incomes (millions)	Jobs	Value Added (millions)
Direct Effects				
Motel, Hotel, B&B, and Cabins	$16.36	$5.34	356	$8.11
Campsites	$13.21	$4.31	288	$6.55
Restaurants & Bars	$20.65	$7.03	590	$9.80
Admissions & Fees	$13.11	$4.54	387	$7.42
Retail	$14.98	$7.64	410	$11.94
Others	$7.78	$2.31	88	$3.50
Total Direct Effects	$86.09	$31.17	2,119	$47.32
Total Indirect Effects	$38.80	$14.11	548	$24.36
Total Effects	$124.88	$45.28	2,667	$71.68

Source: National Park Service 2006b.

3.14.3.2 Lake Mead National Recreation Area

LMNRA (Lake Mead and Lake Mohave) hosted 7.92 million recreational visits in 2003. Tables 3.14-5 summarize the direct and indirect effects of visitor spending by sectors. Direct recreation-related expenditures totaled $176.82 million in 2003 resulting in 5,197 jobs and $63.15 million in personal income. This direct spending created an additional 856 jobs and $18.73 million in personal income.

Table 3.14-5
Lake Mead National Recreation Area Economic Impacts of Visitor Spending by Sector for 2003

Sectors	Sales (millions)	Personal Incomes (millions)	Jobs	Value Added (millions)
Direct Effects				
Motel, Hotel, B&B, and Cabins	$27.08	$7.86	693	$11.95
Campsites	$18.59	$5.39	476	$8.20
Restaurants & Bars	$52.77	$16.62	1,648	$23.15
Admissions & Fees	$30.98	$10.65	912	$17.43
Retail	$35.57	$18.15	1,257	$28.34
Others	$11.82	$4.48	211	$6.51
Total Direct Effects	$176.82	$63.15	5,197	$95.58
Total Indirect Effects	$55.82	$18.73	856	$34.55
Total Effects	$232.64	$81.89	6,052	$130.12

Source: National Park Service 2006d.

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3.15 Environmental Justice

Environmental justice refers to the fair treatment and meaningful involvement of all people in the development, implementation and enforcement of environmental laws, regulations and policies.

- *Fair treatment* means that no group of people, including minority and low-income populations, should bear a disproportionate share of the adverse environmental impacts of government actions.
- *Meaningful involvement* means that people who would be adversely affected by the environmental impacts of government actions should have the opportunity to participate in decisions leading up to those actions and have their views considered.

Executive Order No. 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires that all federal agencies make achieving environmental justice part of their mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations. Census data were used to identify the minority and low-income populations living in counties that could potentially be affected by the alternatives.

The affected area for environmental justice is comprised of 18 counties; three in Utah (Garfield, Kane, and San Juan), eight in Arizona (Coconino, La Paz, Maricopa, Mohave, Pima, Pinal, Yavapai, and Yuma), one county in Nevada (Clark), and six counties in California (Imperial, Los Angeles, Orange, Riverside, San Bernardino, and San Diego). Ventura County in California is located within the MWD service area, but does not receive any water from the Colorado River, and therefore, it is not addressed in this section.

3.15.1 Minority, Low-Income Populations, and Indian Tribes

For purposes of this analysis, minority populations and low-income populations are defined following the CEQ's (1997) guidance as:

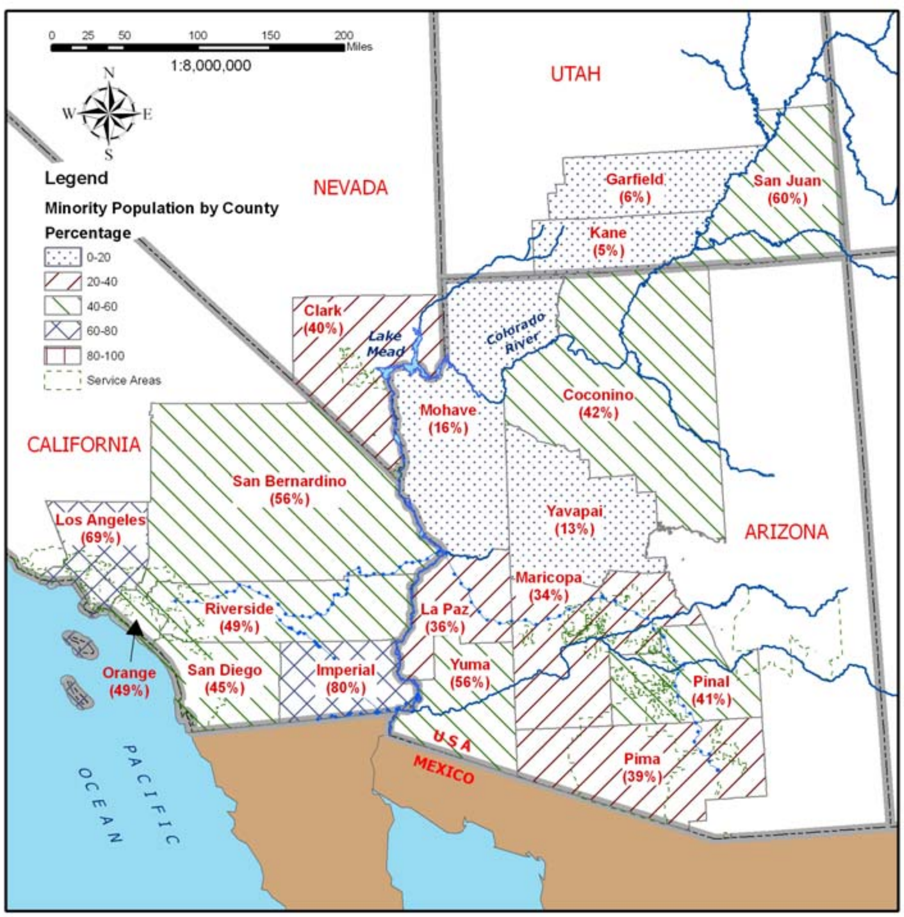
- *Minorities* – Persons of American Indian or Alaska Native; Asian or Pacific Islander; Black, not of Hispanic origin; Hispanic; or persons of two or more races (without double-counting persons of Hispanic or Latino origin who are also contained in the latter groups); and
- *Low-income populations* – As reported in the 2000 census, persons living below the poverty level, which is $18,104 for a family of four in 1999 and varies depending on family size (U.S. Census Bureau 2000b).

Identification of minority and low-income populations was based on the 2000 Census of Population and Housing, which estimates each of the separate categories contained in these definitions. Minority populations were estimated using 2000 Census data that report Hispanic or Latino populations by race, and, separately, populations not Hispanic or Latino by race

(U.S. Census Bureau 2000a). Low-income populations were estimated using the 2000 Census data that report poverty status in 1999 by age (U.S. Census Bureau 2000b). The population for whom poverty status is determined is generally slightly less than the total population because the 2000 Census data excludes certain groups from consideration.

In 2000, population of the 18-county area was 24,691,833, of whom 13,225,335 (or 53.6 percent) were minorities. Minority populations are identified where minorities of the affected area [county] exceed fifty percent of the total population. Of the 18 counties, five have a minority percentage greater than 50 percent: Yuma County, Arizona; Imperial County, Los Angeles County, and San Bernardino County, California; and San Juan County, Utah; with Imperial County the highest at 79.8 percent. In the remaining 13 counties, the minorities comprise less than 50 percent of the population and so these counties are not considered environmental justice communities (Figure 3.15-1).

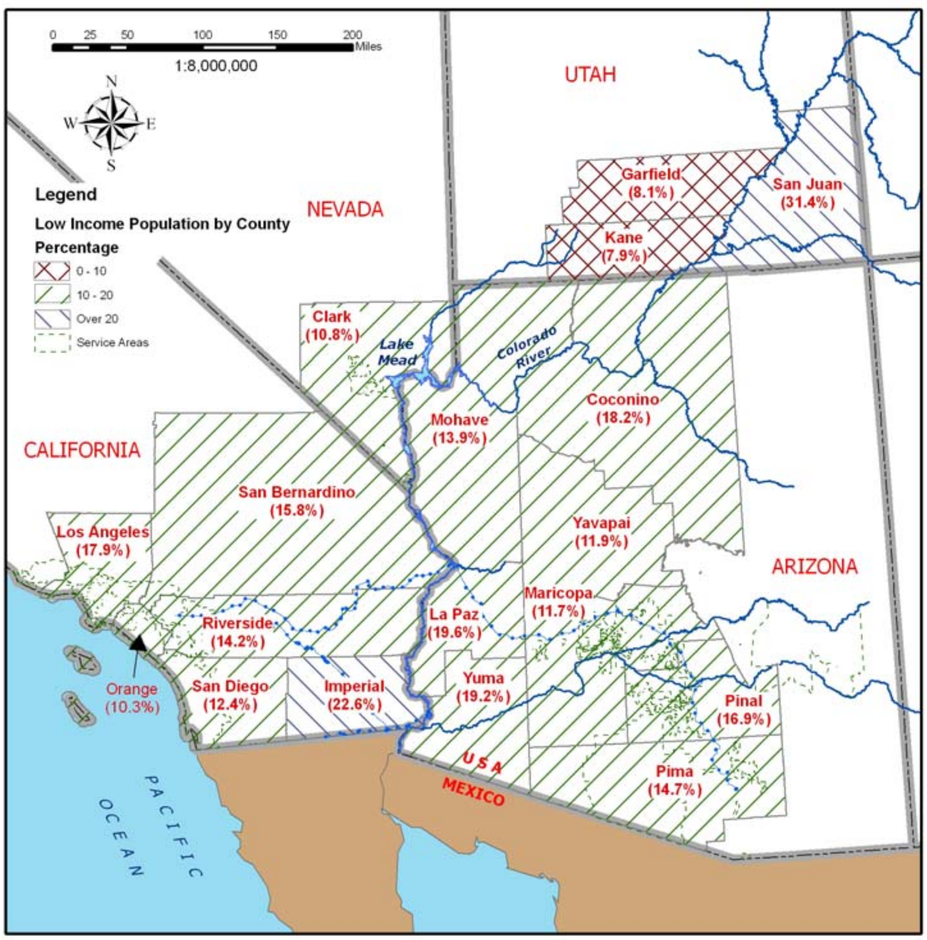
Figure 3.15-1
Minority Population by County



Indians are included within these census data. Following CEQ's 1997 guidance on environmental justice, as well as Exec. Order No. 13175 and the Presidential Memorandum on Government-to-Government Relations with Native American Tribal governments, Reclamation sought input from 42 federally-recognized tribes including those with reservations located within these counties and from tribes that might have interests in the proposed federal action. A description of the consultations undertaken for this project is included in Chapter 6 of this Draft EIS.

In 2000, some 3,559,939 persons (or 14.7 percent) in the study area were living below the poverty level. The percent poverty for the 18 counties is between 7.9 percent and 31.4 percent, with San Juan County, Utah having the highest percentage (Figure 3.15-2). For the environmental justice analysis, low income counties were defined as those above the average poverty percentage for the 18 counties (14.7 percent) in the study area (Figure 13.15-2). This added four counties in Arizona: Coconino, La Paz, Pinal, and Pima (the five minority counties were also low-income). Therefore, for purposes of this analysis, there are nine total environmental justice counties/communities.

Figure 3.15-2
Low Income Population by County



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Chapter Four

Environmental Consequences

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4.1 Introduction

Chapter 4 presents the probable consequences (impacts or effects) of each of the alternatives on the environmental resources described in Chapter 3. The potential effects of each action alternative compared to the No Action Alternative are presented for each potentially affected resource in this chapter, in the same order as described in Chapter 3.

The methodology and technical assumptions used to analyze the potential impacts to the Colorado River system (e.g., reservoir elevations, releases, and flows) is described in Section 4.2. Additional methodologies and assumptions used to analyze specific resources are described in the appropriate resource section.

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4.2 Methodology

Hydrologic modeling of the Colorado River system was conducted to determine the potential hydrologic effects of the alternatives. The modeling provided projections of potential future Colorado River system conditions (e.g., reservoir elevations, reservoir releases, river flows) for comparison of those conditions under the No Action Alternative to conditions under each action alternative. Due to the uncertainty with regard to future inflows into the system, multiple simulations were performed in order to quantify the uncertainties of future conditions and the modeling results are typically expressed in probabilistic terms.

The hydrologic modeling also provided the basis for the analysis of the potential effects of each alternative on other environmental resources such as recreation, biology, energy, etc. The potential effects to specific resource issues are identified and analyzed for each action alternative and again, compared to the potential effects to that resource issue under the No Action Alternative. These comparisons are typically expressed in terms of the incremental differences in probabilities (or projected circumstances associated with a given probability) between the No Action Alternative and the action alternatives.

This section provides an overview of the hydrologic modeling system. Further detail is also provided in Appendix A. For some resource analyses, additional modeling using other techniques was needed to analyze the potential effects to particular resource issues. In most of these cases, the output from the hydrologic modeling was used as input to these other models. The methodologies used for the additional modeling are described in each respective resource section.

4.2.1 Alternatives Modeled

As discussed in Chapter 2, five alternatives are considered in this Draft EIS: No Action, Basin States, Conservation Before Shortage, Water Supply, and Reservoir Storage. Each alternative includes specific assumptions with regard to the four operational elements of the proposed federal action: Shortage Guidelines, Coordinated Reservoir Operations, Storage and Delivery of Conserved Water, and Interim Surplus Guidelines. Additional details with respect to the modeling assumptions used to represent each alternative is presented in this section and in Appendix A.

4.2.2 Period of Analysis

This Draft EIS addresses guidelines that would be in effect for the period between 2008 to 2026 for Lower Basin reservoir operations and the coordinated operations of Lake Powell and Lake Mead. All action alternatives are assumed to revert back to the assumptions used to represent the No Action Alternative beginning in 2027. Due to the potential for hydrologic effects of the action alternatives beyond the 19-year interim period, the hydrologic modeling for all alternatives extends through 2060.

4.2.3 Model Description

Future Colorado River system conditions under the No Action Alternative and the action alternatives were simulated using the Colorado River Simulation System (CRSS). The model framework used for this process is a commercial river modeling software called RiverWare™. RiverWare™ is a generalized river basin modeling software package developed by the University of Colorado through a cooperative process with Reclamation and the Tennessee Valley Authority. CRSS was originally developed by Reclamation in the early 1970s and was implemented in RiverWare™ in 1996. River operation parameters modeled and analyzed in CRSS include the water entering the river system, storage in system reservoirs, releases from storage, river flows, and the water demands of and deliveries to water users in the Basin States and Mexico.

The water supply used as input to the model consisted of the historic record of natural flow in the river system over the 99-year period from 1906 through 2004 from 29 individual inflow points (or nodes) on the system. The future Colorado River water demands were based on demand and depletion projections prepared by the Basin States. Depletions are defined as diversions from the river less return flow credits, where applicable. The operation of the mainstream reservoirs including Lake Powell and Lake Mead is provided as a set of operating rules which describe how water is released and delivered under various hydrologic conditions. Further explanation of the model and operating rules is provided in Appendix A.

4.2.4 Computational Procedures and Future Hydrology

The model was used to simulate the future operational conditions of the Colorado River system on a monthly time-step for the period 2008 through 2060. Output data included reservoir elevations and storages, releases from the dams, hydroelectric energy generation, salinity concentration, flows at various points along the system, and diversions to and return flows from various water users. The input data for the model included monthly natural inflows, various physical process parameters (such as the evaporation rates for each reservoir), initial reservoir conditions, and the diversion and depletion schedules for entities in the Basin States and Mexico. The common and specific operating rules were also input for each alternative analyzed.

Despite the differences in the operating rules under the No Action Alternative and each action alternative, the future conditions of the Colorado River system (especially water levels at Lake Mead and Lake Powell) are most sensitive to future inflows. As discussed in Section 3.3, observations over the period of historical record (1906 through present) show that inflow into the system has been highly variable from year to year, and over decades. Although the model does not project future inflows, it can be used to analyze a range of possible future inflows and to quantify the probability of particular events (e.g., lake elevations levels being below or above certain levels).

Although several methods are available for projecting the range of possible future inflows, Reclamation utilized the existing historical record of natural flows to create a number of different hydrologic sequences using a technique for sampling from the historical record known as the Indexed Sequential Method (ISM) (USBR 1985; Ouarda et. al. 1997). These sequences were used to perform a series of simulations and the output was analyzed to quantify the uncertainty due to hydrologic variability for each variable of interest.

Each future inflow scenario was generated by “cycling” through the historical natural flow record. For example, assuming a 99-year historical record (1906 through 2004) and that the model projects 53 years into the future (2008 through 2060), the first inflow sequence would be comprised of the series of historical natural flows from 1906 through 1958; the second inflow sequence would utilize the series of historical natural flows from 1907 through 1959; the last sequence would utilize the series of historical natural flows beginning in 2004, with historical natural flows from 1906 through 1957 appended to the end to form a complete (53-year) sequence. The result of ISM is a set of 99 separate simulations (referred to as “traces”) for each alternative that is analyzed. This enables an analysis of the respective criteria over a broad range of possible future hydrologic conditions using standard statistical techniques, discussed below.

4.2.5 Post-processing and Interpretation Procedures

The physical, biological, and socioeconomic analyses in this Draft EIS required the sorting and arranging of various types of model output data into tabulations or plots of specific operational conditions or parameters at various locations on the system. This was done through the use of statistical methods and other numerical analyses.

The hydrologic model generated data on a monthly time step for over 300 points (or nodes) on the river system. Furthermore, through the use of ISM, the model generated 99 possible outcomes for each node for each month over the time period 2008 through 2060. These very large data sets generated for each alternative can be visualized as three-dimensional data “cubes” with the axes of time, space (or node) and trace (or outcome for each future hydrology). The data were aggregated to reduce the volume of data and to facilitate comparison of the alternatives. The type of aggregation varies depending upon the needs of the particular resource analysis. The post-processing techniques used for this Draft EIS fall into two basic categories: those that aggregate in time, space or both, and those that aggregate the 99 possible outcomes.

For aggregation of data in time and space, simple techniques were employed. For example, deliveries of Colorado River water to all California diversion nodes in the model were summed to produce the total delivery to the state for each calendar year. Similarly, lake elevations were chosen on an annual basis (i.e., end of December) to show long-term lake level trends as opposed to short-term fluctuations. In other analyses, since the interim criteria period is 2008 through 2026, those analyses found it important to aggregate the data over that period of time and compared the aggregation over the remaining years (2027 through 2060). The particular aggregation used is noted in the methodology section for each resource, where applicable.

Once the appropriate temporal and spatial aggregation was chosen, standard statistical techniques were used to analyze the 99 possible outcomes for a fixed time or particular temporal span. Statistics that were generated included the mean, standard deviation, and percentiles.

Percentiles were determined by simply ranking the outcomes at each time (from highest to lowest) and determining the value at the specified percentile. For example, if end-of-calendar year Lake Mead elevations are ranked for each year, the 50th percentile (median) outcome for a given year is the elevation for which half of the values are below and half are above that elevation. Similarly, the 10th percentile value is the elevation for which ten percent of the values are lower and 90 percent are higher. This statistical method is used to view the results of all hydrologic sequences in a compact manner yet maintains the variability at high, medium, and low reservoir levels that may be lost by averaging the results of all traces. Several presentations of the ranked data are then possible. For example, a graph (or table) may be produced that is used to compare the 90th percentile, 50th percentile, and 10th percentile outcomes from 2008 through 2060 for the No Action Alternative and the action alternatives. It should be noted that a statistic such as the 10th percentile is not the result of any one hydrologic trace (i.e., no historical sequence produced the 10th percentile). Such a statistic provides information with regard to the probability (e.g., a 10 percent probability) of the variable of interest being at or below the 10th percentile value in a specified year; however, the statistic cannot be used to understand the probability of remaining at that value in subsequent years.

4.2.6 Model Uncertainty

The CRSS model does not project future inflows, but rather relies on the historic record to analyze a range of possible future inflows. For this reason, projections of future reservoir elevations are probabilistic, based on the 99-year historic record. The historic record includes periods of extreme drought and periods with above average flow, allowing analysis of the proposed federal action under a wide range of future flow conditions. However, 99-year record period is a relatively short time frame, and it is possible that future flows may include periods of wet or dry conditions that are outside of all the possible sequences seen in the historical record. Use of the historic record also cannot reflect potential future climate changes.

Reclamation has several on-going research and development programs to investigate alternative methods for generating ranges of possible future inflows on the Colorado River, including stochastic hydrology methods and paleo-reconstruction methods (reconstruction of historical inflows from analysis of tree-rings). A hydrologic sensitivity analysis was performed using three distinct methods for generating future inflows and is presented in Appendix N.

Model output is also sensitive to input diversion and depletion schedules. The best available data for future diversions and depletions were input to CRSS. Actual future depletion schedules, especially when simulating system conditions far into the future (beyond about 20 years from the present) may differ.

Finally, all models are sensitive to the quality of the data available as input information. For example, water flows are based upon the data from gages which have uncertainties associated with their measurements. These uncertainties limit the accuracy of any model that uses that data, even though that is generally the best available information.

4.2.7 Modeling Assumptions Common to All Alternatives

In addition to the specific operating rules necessary to model each of the alternatives (discussed in Chapter 2, Appendix A, and in the following section), the modeling of river system operations also requires certain assumptions about various aspects of water delivery and system operations that are common to all alternatives.

Assumptions common to all alternatives:

- All simulations were performed with a start year of 2008 and a simulation length of 53 years (2008 through 2060);
- Each action alternative was assumed to be in effect for the interim period which extends from 2008 through 2026. After 2026, the operating rules for all action alternatives revert to the rules of the No Action Alternative;
- The initial conditions for the Upper Basin and Lower Basin reservoirs reflect the 2007 end-of-calendar year (EOCY) elevations as projected by the August 2006 24-Month Study. The Lake Powell and Lake Mead starting conditions (initial elevations) in the model were 3,614.80 and 1,116.53 feet msl, respectively. Initial conditions for all reservoirs are detailed in Appendix A;
- Future hydrology was generated from the 99-year (1906 through 2004) historic record of calculated natural flows at 29 separate inflow points in the Colorado River watershed using the ISM. Ninety-nine simulations were performed for each alternative;
- The current Upper Basin reservoir operating rules, with the exception of Lake Powell, are identical under all alternatives. Under the action alternatives, the operation of Lake Powell reflects the coordinated operations strategy of each respective alternative during the Interim Period;
- Future water demands for Upper Division water users are based on depletion projections prepared by the Upper Division states in coordination with the Upper Colorado River Commission and Reclamation and published in the SIA Final EIS (Volume II, Appendix G). These depletion schedules are provided in Appendix C to this Draft EIS;
- The Lake Mead flood control procedures are always in effect;
- Except during flood control, Lake Mead is operated to meet downstream demands under the water supply condition (Normal, Surplus, or Shortage condition) in effect in a particular year;
- Future water demands for Lower Division water users are based on depletion projections prepared by the Lower Division states and published in the SIA Final EIS (Volume II, Appendix G) with some exceptions. The depletion schedules under

Normal conditions for IID, CVWD, and MWD are those specified in the Colorado River Water Delivery Agreement and include accelerated Inadvertent Overrun paybacks through 2004 and any subsequent changes in payback schedules. The depletion schedules for all Arizona users were provided by the Arizona Department of Water Resources for this EIS effort. These depletion schedules are provided in Appendix D to this Draft EIS;

- ♦ If the Lake Mead elevation falls below 1,000 feet msl, the delivery to SNWA is reduced to zero. This reflects the limitations of the SNWA intakes which are used to pump water from Lake Mead;
- ♦ Lake Mohave and Lake Havasu are operated in accordance with their existing rule curves;
- ♦ Water deliveries to Mexico are pursuant to the requirements of the 1944 Treaty. This provides annual deliveries of 1.5 maf to Mexico and up to 1.7 maf during Lake Mead flood control release conditions;
- ♦ Mexico's principal diversion is at Morelos Diversion Dam where most of its Colorado River apportionment of 1.5 maf is diverted. In practice, up to 140 kafy is delivered to Mexico near the SIB. The model, however, extends to just south of the NIB to include the Morelos Diversion Dam and accounts for the entire 1944 Treaty delivery at that point;
- ♦ For 2008 and 2009, the model sets the delivery schedule to Mexico at the NIB to 1.577 mafy. The additional 77 kafy reflects the average over-deliveries to Mexico for the period 1964 through 2005 (excluding years when there were flood control releases on the Colorado mainstream or Gila River);
- ♦ Beginning in 2010, the proposed Drop 2 Reservoir is assumed to be in operation and to conserve an average of 69 kafy, reducing the average over-delivery to Mexico from 77 kafy to 8 kafy;
- ♦ The bypass of return flows from the Welton-Mohawk Irrigation and Drainage District to the Cienega de Santa Clara in Mexico is assumed to be 109 kafy (the historical average for the period 1990 through 2005) and are not counted as part of the 1944 Treaty delivery;
- ♦ Except under the Conservation Before Shortage Alternative, replacement of the bypassed water is not assumed to occur in the future. The United States recognizes that it has an obligation to replace, as appropriate, the bypass flows and the assumptions made herein, for modeling purposes; do not necessarily represent the policy that Reclamation will adopt for replacement of bypass flows. The assumptions made with respect to modeling the bypass flows are intended only to provide a thorough and comprehensive accounting of the Lower Basin water supply. The

United States is exploring options for replacement of the bypass flows, including options that would not require operation of the Yuma Desalting Plant; and

- For modeling purposes, the Yuma Desalting Plant is not assumed to operate over the modeling period.

Assumptions with regard to the reduction of deliveries to the Lower Division states and Mexico are as described below.

4.2.7.1 Shortage Sharing Assumptions

A summary of the modeling assumptions with respect to the reduction of deliveries to the Lower Division states and Mexico was provided in Section 2.2. These modeling assumptions are identical in all alternatives and are explained further in this section. Shortage-sharing assumptions within a particular state are detailed in Section 4.4 and in Appendix A.

It was assumed that shortages would be allocated to each Lower Division state and Mexico based on percentages of the total Lower Basin shortage being applied. Two sets of percentages were assumed depending upon the amount of total Lower Basin shortage to be applied. Shortages less than or equal to the magnitude that would cause Arizona 4th priority uses to be reduced to zero are termed “Stage 1” shortages. This magnitude is dependent upon the scheduled depletions for the Arizona 4th priority users (post September 30, 1968 contractors, including the CAP), which vary over the period of analysis. In a “Stage 2” shortage, additional shortages above that magnitude are applied.

In order to assess the potential effects of the alternatives, it was assumed that Mexico would share proportionately in Lower Basin shortages. Allocation of Colorado River water to Mexico is governed by the 1944 Treaty. The proposed federal action is for the purpose of adopting additional operational strategies to improve the Department’s annual management and operation of key Colorado River reservoirs for an interim period through 2026. However, in order to assess the potential effects of the proposed federal action in this Draft EIS, certain modeling assumptions are used that display projected water deliveries to Mexico. Reclamation’s modeling assumptions are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico. The United States will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Treaty with Mexico through the IBWC in consultation with the Department of State.

The shortage-sharing percentages were computed as follows:

Stage 1 Shortage Sharing Modeling Assumptions. Shortages are first imposed under Stage 1 and would be applied to the most junior users within Arizona (those with post-1968 water rights, i.e., 4th and 5th priority rights within Arizona), Nevada and Mexico. Stage 1 shortages continue until the deliveries to the post-1968 water rights holders in Arizona (including the CAP) are reduced to zero. The maximum amount of Stage 1 shortages during the period of analysis is dependent on the scheduled depletions for the post-1968 water rights holders and decreases in time (2008 through 2060) from approximately 1.8 maf to 1.7 maf.

The assumed Stage 1 shortage sharing percentages are explained in Table 4.2-1.

Table 4.2-1
Modeling Assumptions for Distribution of Stage 1 Shortages[1]

Entity	Percentage of Stage 1 Shortage	Calculation
Arizona[2]	80	▪ Computed assuming that Arizona takes the remaining amount of shortage after Nevada and Mexico take their respective shares ▪ Calculated as: 1.0 – 0.1667 – 0.0333 = 0.80 or 80.0 percent
California	0	▪ Does not receive shortage under Stage 1
Nevada	3.33	▪ Computed as a ratio of Nevada's allotment to the total allotments of the Lower Division states and Mexico ▪ Calculated as: 0.3 maf / 9.0 maf – 0.0333 or 3.33 percent
Mexico	16.67	▪ Computed as a ratio of Mexico's allotment to the total allotments of the Lower Division states and Mexico ▪ Calculated as: 1.5 maf / 9.0 maf = 0.1667 or 16.67 percent

1. *These modeling assumptions do not reflect policy decisions and are not intended to constitute an interpretation or application of the 1944 Treaty. They have been developed for comparison of the alternatives.*
2. *Within the CAP, Ak-Chin and Salt River Pima-Maricopa Indian Community tribes have pre-1968 contracts for the delivery of 72 kaf that is not reduced until a Stage 2 Shortage is applied.*

Stage 2 Shortage Sharing Modeling Assumptions. After deliveries to the 4^{th} and 5^{th} priority rights within Arizona are reduced to zero, it is assumed that any additional delivery reductions would be distributed to Arizona, California, Nevada, and Mexico. The assumed Stage 2 shortage sharing percentages are explained in Table 4.2-2. Under a Stage 2 Shortage, the total Lower Basin shortage is the sum of the computed Stage 1 and Stage 2 shortage amounts.

Table 4.2-2
Modeling Assumptions for Distribution of Stage 2 Shortages[1]

Entity	Percentage of Stage 2 Shortage	Calculation
Arizona	15-20	▪ The percentage changes as Arizona's 4^{th} priority use schedule changes and ranges between 15 and 20 percent ▪ Computed as a ratio of Arizona's allotment less the amount of shortage applied to Arizona under Stage 1, to the total allotments of the Lower Division states and Mexico less the total amount shorted to users under Stage 1 ▪ Calculated as: (2.8 – Arizona Stage 1 shortage) / (9.0 – total Stage 1 shortage)
California	60-65	▪ California shortage sharing percentage changes as Arizona's 4^{th} priority use schedule changes and ranges between 60 and 65 percent ▪ Computed assuming that California takes the remaining amount of the additional shortage ▪ Calculated as: 1.0 – 0.1667 – 0.0333 – Arizona's Stage 2 percentage expressed as a fraction

Table 4.2-2
Modeling Assumptions for Distribution of Stage 2 Shortages[1]

Entity	Percentage of Stage 2 Shortage	Calculation
Nevada	3.33	▪ Computed as a ratio of Nevada's allotment less the amount of shortage applied to Nevada under Stage 1, to the total allotments of the Lower Division states and Mexico less the amount shorted to users under Stage 1 ▪ Calculated as: (0.3 – Nevada Stage 1 shortage) / (9.0 – total Stage 1 shortage) = 0.0333 or 3.33 percent
Mexico	16.67	▪ Computed as a ratio of Mexico's allotment less the amount of shortage applied to Mexico under Stage 1, to the total allotments of the Lower Division states and Mexico less the total amount shorted to users under Stage 1 ▪ Calculated as: (1.5 – Mexico Stage 1 shortage) / (9.0 – total Stage 1 shortage) = 0.1667 or 16.67 percent

1. These modeling assumptions do not reflect policy decisions and are not intended to constitute an interpretation or application of the 1944 Treaty. They have been developed for comparison of the alternatives.

4.2.8 Modeling Assumptions Specific to Alternatives

Each alternative includes specific assumptions with regard to the four operational elements of the proposed federal action. Assumptions with regard to Shortage Guidelines, Coordinated Reservoir Operations, and the ISG were presented in Chapter 2 and are detailed in Appendix A. In this section, the assumptions with regard to the Storage and Delivery of Conserved Water element are summarized. Details of these assumptions are presented in Appendix M.

Modeling Assumptions Regarding Storage and Delivery of Conserved Water. The general concept of a storage and delivery mechanism is that water users could conserve system water or non-system water and store that water in Lake Mead to be delivered in later years, subject to specified losses.

Three alternatives assume some form of a storage and delivery mechanism (Basin States Alternative, Conservation Before Shortage Alternative, and Reservoir Storage Alternative). Each alternative specifies the maximum amount of storage credits that can be created during any year, the maximum amount of storage credits that may be recovered during any year, and the maximum cumulative amount of storage credits that can be available at any one time (Tables 2.3-2, 2.4 1, and 2.6-1). These volume limitations are recognized in the model as are other rules that specify under which water supply conditions conserved system or non-system water may be delivered or stored.

Under all three alternatives, it is assumed that specific losses would be applied to the conserved water that is stored in Lake Mead, including a one-time system assessment, and yearly evaporation losses. At the time the storage credits are created, the entity that generates the storage credits is required to dedicate a percent of the storage credits to the system, defined as a system assessment, on a one-time basis to provide a water supply benefit to the system. For the Basin States Alternative and the Conservation Before Shortage Alternative, the system assessment is assumed to be five percent. For the Reservoir Storage Alternative, the system assessment is assumed to be ten percent. Additionally, storage credits are subject to annual evaporation losses which are assumed to be three percent per year during each year the conserved water remains in storage in Lake Mead. The exception to this is during Shortage conditions, when no evaporation loss is applied.

At this time, it is unknown which entities might participate in a Lake Mead mechanism that allows the storage and delivery of conserved system and non-system water. Furthermore, the timing and magnitude of the storage and delivery of conserved water is unknown. However, modeling assumptions with respect to the entities that might participate and their respective level of participation were needed to enable the evaluation of the mechanism and its potential effects on environmental resources, particularly to reservoir storage and river flows below Lake Mead.

Table 4.2-3 summarizes the modeling assumptions with regard to the entities that were assumed to participate under each alternative, the activities undertaken to generate storage credits, and the water supply conditions under which storage and delivery of storage credits could occur. Appendix M further describes these and other key modeling assumptions. The proposed federal action is for the purpose of adopting additional operational strategies to improve the Department's annual management and operation of key Colorado River reservoirs. However, in order to assess the potential effects of the proposed federal action in this Draft EIS, certain modeling assumptions are used that display projected water deliveries to Mexico. Reclamation's modeling assumptions are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico. The United States will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Treaty with Mexico through the IBWC in consultation with the Department of State [1].

Under the Conservation Before Shortage Alternative, extraordinary conservation is assumed to occur during voluntary shortage conditions but not during involuntary shortage conditions.

[1] Notwithstanding the lack of an existing mechanism to implement such modeling assumptions, Reclamation utilized these assumptions for a number of reasons, including the following: (1) a larger volume of potential storage in Lake Mead is identified and the associated impacts are thereby analyzed; (2) the maximum potential changes to river flows below Hoover Dam are identified and the associated impacts analyzed; (3) the assignment of water conservation amounts to entities in the Lower Basin states in excess of amounts currently requested by each state is avoided; and (4) a program of potential future cooperation between the United States and Mexico is identified.

Table 4.2-3
Modeling Assumptions for Storage and Delivery of Conserved System and Non-System Water

Water Supply Condition		BS, CBS & RS [1]						CBS & RS	CBS	RS
		California	Arizona	Nevada				Mexico	Federal	Federal
		Extraordinary Conservation	Extraordinary Conservation	Tributary Conservation	Groundwater	Desalinization	Drop 2 Reservoir [4]	Extraordinary Conservation	Extraordinary Conservation	Extraordinary Conservation
Flood Control Surplus	Store	No	No	No	No	No	No	No	No	No
	Deliver	No	No	No	No	No	No	No	No	No
Quantified (70R) Surplus	Store	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
	Deliver	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Full Domestic Surplus	Store	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
	Deliver	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Normal	Store	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Deliver	Yes	yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shortage (involuntary and voluntary)	Store	No	No	Yes	Yes	Yes	No	No	No [5]	Yes
	Deliver	No	No	Yes	Yes	Yes	No	No	No	Yes
System Assessment		Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Period of Activity		2006-2026	2017-2026	2009-2060	2009-2060	2020-2060	Temporary	2008-2026	2008-2026	2008-2026

Notes:

1. *BS = Basin States Alternative, CBS = Conservation Before Shortage Alternative, RS = Reservoir Storage Alternative*
2. *yes = activity assumed to occur*
3. *no = activity assumed to not occur*
4. *Beginning in 2012, Nevada is assumed to receive 40 kafy of the water conserved by the Drop 2 Reservoir during Normal and Surplus years until a total of 300 kaf has been credited to Nevada. Thereafter, water conserved by the Drop 2 Reservoir is assumed to be system water.*
5. *Under the Conservation Before Shortage Alternative, extraordinary conservation is assumed to be undertaken by the federal government during voluntary shortage conditions but not during involuntary shortage conditions*
6. *These modeling assumptions do not reflect policy decisions and are not intended to constitute an interpretation or application of the 1944 Treaty. They have been developed for comparison of the alternatives..*

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4.3 Hydrologic Resources

This section identifies the potential effects on hydrologic resources that may occur as a result of implementing the No Action Alternative and the action alternatives.

4.3.1 Methodology

The methodology used to analyze the potential impacts of the alternatives to reservoir storage, reservoir releases, and the corresponding changes in river flows downstream of the reservoirs is described in Section 4.2.

As noted in Section 4.2, the CRSS model is a monthly time-step model and output for simulated water system conditions, such as reservoir elevations or releases, can be provided on monthly and annual bases. The data and output used in the impact analysis may vary depending on the specific issue being addressed. An example of the different months considered in the analyses follows:

Lake Powell

- **March:** representative of months (or period) with seasonal low Lake Powell elevations;
- **July:** representative of months (or period) with seasonal high Lake Powell concentration of visitors; and
- **September:** month representing End-of-Water Year, used for water accounting and reporting in Upper Basin.

Lake Mead

- **July:** representative of months (or period) with seasonal low Lake Mead elevations; and
- **December:** month representing End-of-Calendar Year, used for water accounting and reporting in Lower Basin.

The specific data and output used in the different resource analyses are presented in this chapter.

4.3.1.1 Methodology Used To Estimate a Range of Daily Glen Canyon Dam Releases

The observed CRSS model output for six annual Lake Powell release volumes were used to estimate the monthly volumes that would be seen under water year release volumes that were less than, equal to, and greater than 8.23 maf. These annual release volumes consisted of 7.00, 7.48, 7.80, 8.23, 9.00, and 9.50 mafy, corresponding to the Glen Canyon Dam release volumes observed under the modeled alternatives. For each month corresponding to each one of these annual flow volumes, the average, maximum, and minimum daily flow volumes were then calculated using the allowable daily fluctuation parameters specified in the 1996 Glen Canyon ROD. It is recognized that monthly and daily flow patterns observed in the different release years could potentially deviate somewhat from the flow values and patterns calculated using this approach although they would most likely be very close to the calculated value. It is also noted that the release patterns for the 7.0 maf release are not as consistent because the monthly volumes would be affected by balancing of Lake Powell and Lake Mead storage. When balancing takes place, monthly release volumes shift as forecasted inflow shifts, resulting in more than one possible pattern for the 7.0 maf release years.

4.3.1.2 Methodology Used To Estimate the Effect on Groundwater

The annual median elevation of the water surface in the Colorado River has been used as an indicator of groundwater elevations adjacent to the Colorado River within the potentially affected river reaches. This is due to the slow movement of groundwater and the time required for the decline in the groundwater table to stabilize at a decline equal to that of the river (LCR MSCP BA, Appendix J and Appendix K). The methodology used to analyze the potential effects to groundwater followed the methodology established in the LCR MSCP analysis.

4.3.2 Lake Powell and Glen Canyon Dam

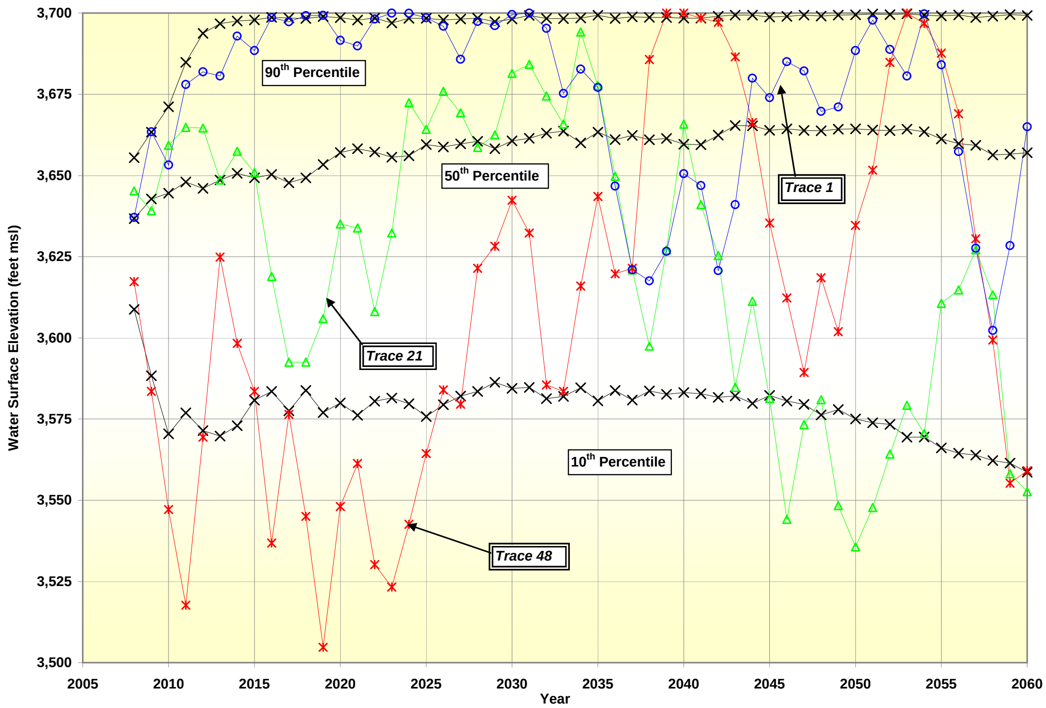
As noted in Section 3.3, future elevations of Lake Powell are expected to be within the range of historic water levels. However, each action alternative may alter the probability (when compared to the No Action Alternative) that the reservoir may be at a given elevation in the future.

Under the No Action Alternative, the elevation of Lake Powell is projected to fluctuate between full and lower levels during the period of analysis (2008 through 2060). Figure 4.3-1 illustrates the range of water levels by three lines, labeled 90^{th} percentile, 50^{th} percentile and 10^{th} percentile. The 50^{th} percentile line shows the modeled median elevation for each future year. The median elevation gradually increases from about 3,640 feet msl to about 3,660 feet msl in the year 2060. The 10^{th} percentile line shows that the elevation would gradually decline from about 3,610 feet msl to about 3,560 feet msl.

It should be noted that the Lake Powell elevations depicted in Figures 4.3-1 and 4.3-2 are for modeled lake water levels at the end of July. The Lake Powell water level generally reaches its seasonal high in July whereas the seasonal lows generally occur in March.

Three distinct traces were added to Figure 4.3-1 to illustrate what was actually simulated under the various traces and respective hydrologic sequences and to highlight that the 90^{th}, 50^{th}, and 10^{th} percentile lines do not represent actual traces, but rather the ranking of each year’s data from the 99 traces for the conditions modeled. The traces also illustrate the variability among the different traces and that the reservoir levels could temporarily decline below the 10^{th} percentile line. Trace 1 represents the hydrologic sequence that begins in year 1906. Trace 21 represents the hydrologic sequence that begins in year 1926. Trace 48 represents the hydrologic sequence that begins in year 1953.

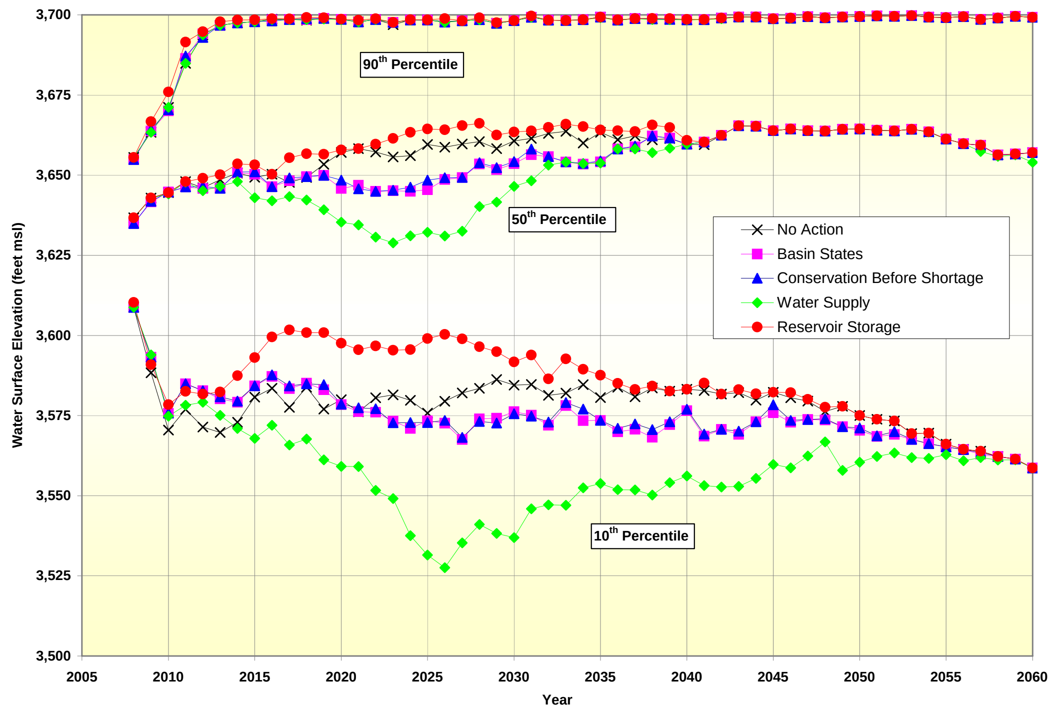
Figure 4.3-1
Lake Powell End-of-July Elevations Under the No Action Alternative
90th, 50th and 10th Percentile Values



In Figure 4.3-1, the 90th and 10th percentile lines bracket the range where 80 percent of the water levels simulated for the No Action Alternative occurred. The highs and lows shown on the three traces would likely be temporary conditions. The reservoir level would tend to fluctuate in the range through multi-year periods of above-average and below average inflows. Neither the timing of water level variations, 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.

Figure 4.3-2 presents a comparison of the 90^{t}h, 50th, and 10th percentile values obtained for the No Action Alternative to those of the action alternatives. This figure is best used for comparing the relative differences in the general lake level trends that result from the simulation of the different alternatives.

Figure 4.3-2
Lake Powell End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values



As illustrated in Figure 4.3-2, the 90th percentile results were nearly identical for all of the alternatives. For the 50th and the 10th percentile results, the Reservoir Storage Alternative had the highest Lake Powell water levels and the Water Supply Alternative had the lowest water levels. The water levels under the Basin States Alternative and the Conservation Before Shortage Alternative were similar and were generally lower than those under the No Action Alternative.

Table 4.3-1 provides a summary of the data illustrated in Figure 4.3-2, which is the 90th percentile, median (50th percentile) and 10th percentile values of the alternatives compared to those of the No Action Alternative. The values presented in this table include those for years 2026 and 2060 only. Results for the 90th percentile show that Lake Powell elevations under the action alternatives were almost the same as those under the No Action Alternative. For the 50th percentile, the water levels under the Water Supply, Basin States, and Conservation Before Shortage Alternatives were lower than those under the No Action Alternative during 2026, but were almost the same by 2060. The 10th percentile trend was very similar to the 50th percentile trend.

Table 4.3-1
Lake Powell End-of-July Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	3,697.90	3,658.75	3,579.43	3,699.27	3,656.99	3,558.63
Basin States	3,697.71	3,648.61	3,572.63	3,699.27	3,656.99	3,558.63
Conservation Before Shortage	3,697.74	3,649.20	3,573.50	3,699.27	3,656.99	3,558.63
Water Supply	3,697.64	3,631.02	3,527.55	3,699.27	3,654.00	3,558.63
Reservoir Storage	3,698.85	3,664.17	3,600.29	3,699.27	3,656.99	3,558.63

When the Lake Powell water level is at or exceeds 3,695 feet msl, the reservoir is considered to be essentially full. Figure 4.3-3 shows the frequency that future Lake Powell End-of-July elevations would exceed elevation 3,695 feet msl under the No Action Alternative and the action alternatives. This type of figure is best used to compare the likelihood that the Lake Powell elevations would be at or above the noted elevation (3,695 feet msl in this example) under an action alternative as compared to the No Action Alternative. Figure 4.3-3 illustrates that the percent of values that were above elevation 3,695 feet msl under the action alternatives were similar to the No Action Alternative throughout the period of analysis. The exception to this is the Reservoir Storage Alternative which provides slightly higher exceedence values than the No Action Alternative between years 2010 through 2033. This means that the Lake Powell elevations would generally tend to be higher under the Reservoir Storage Alternative, as compared to the No Action Alternative.

As summarized in Table 4.3-2, the exceedence values under the Basin States, Conservation Before Shortage, and Water Supply Alternatives were essentially the same as those observed under the No Action Alternative in most years. The exceedence values under the Reservoir Storage Alternative were slightly higher than those under the No Action Alternative.

Figure 4.3-3
Lake Powell End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Greater Than or Equal to Elevation 3,695 feet msl

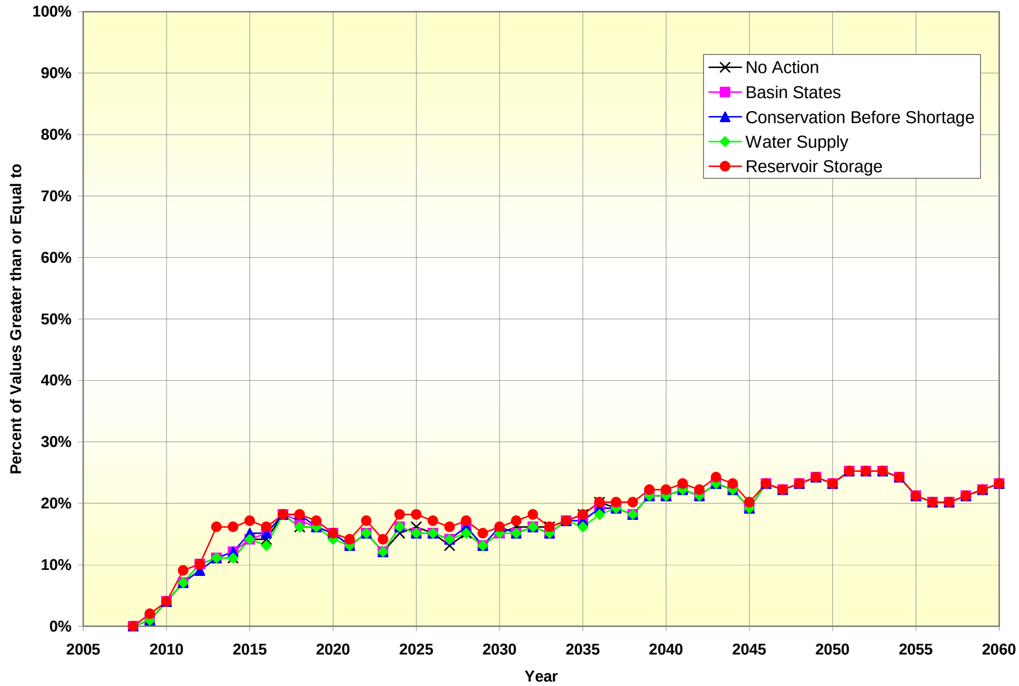


Table 4.3-2
Lake Powell End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Greater Than or Equal to Elevation 3,695 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	14%	15%	15%	21%	23%	23%
Basin States	0%	15%	15%	15%	21%	23%	23%
Conservation Before Shortage	0%	15%	15%	16%	21%	23%	23%
Water Supply	0%	13%	15%	15%	21%	23%	23%
Reservoir Storage	0%	16%	17%	16%	22%	23%	23%

The threshold for water access to Rainbow Bridge is an elevation of 3,650 feet msl. Below this threshold elevation, access to Rainbow Bridge would require hiking. As shown in Figure 4.3-4, the Reservoir Storage Alternative had the lowest frequency of occurrences below this threshold, and the Water Supply Alternative had higher frequency of occurrences below elevation 3,650 feet msl relative to the No Action Alternative.

Figure 4.3-4
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,650 feet msl

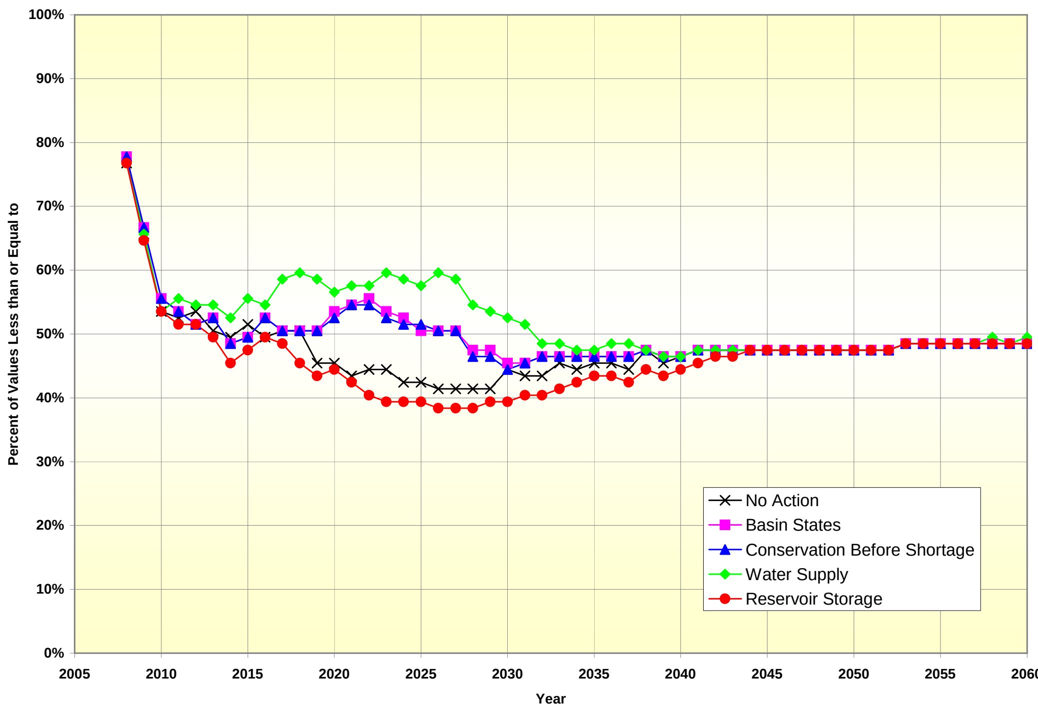


Table 4.3-3 summarizes the results shown in Figure 4.3-4 for elevation 3,650 feet msl for the No Action Alternative and the action alternatives for selected years. All alternatives were similar at the beginning and end of the modeled years, but variation did occur from about 2016 until about 2040. The water levels under the Reservoir Storage Alternative fell below elevation 3,650 feet msl less frequently than those under the No Action Alternative and the water levels under the Basin States, Conservation Before Shortage, and Water Supply alternatives fell below elevation 3,650 feet msl more frequently than those under the No Action Alternative.

Table 4.3-3
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,650 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	77%	49%	41%	44%	46%	47%	48%
Basin States	78%	53%	51%	45%	46%	47%	48%
Conservation Before Shortage	78%	53%	51%	44%	46%	47%	48%
Water Supply	77%	55%	60%	53%	46%	47%	49%
Reservoir Storage	77%	49%	38%	39%	44%	47%	48%

Figure 4.3-5 illustrates the results for elevations equal to or less than 3,626 feet msl. An elevation of 3,626 feet msl is the level at which there is a navigational detour at the Wahweap Marina and at Gregory Butte. As is shown on this figure, the Reservoir Storage Alternative had less impact on this threshold than the No Action Alternative. The elevations under the Water Supply, Basin States, and Conservation Before Shortage alternatives fell below elevation 3,626 feet msl more frequently than those under the No Action Alternative. All alternatives were similar by about 2053.

Figure 4.3-5
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,626 feet msl

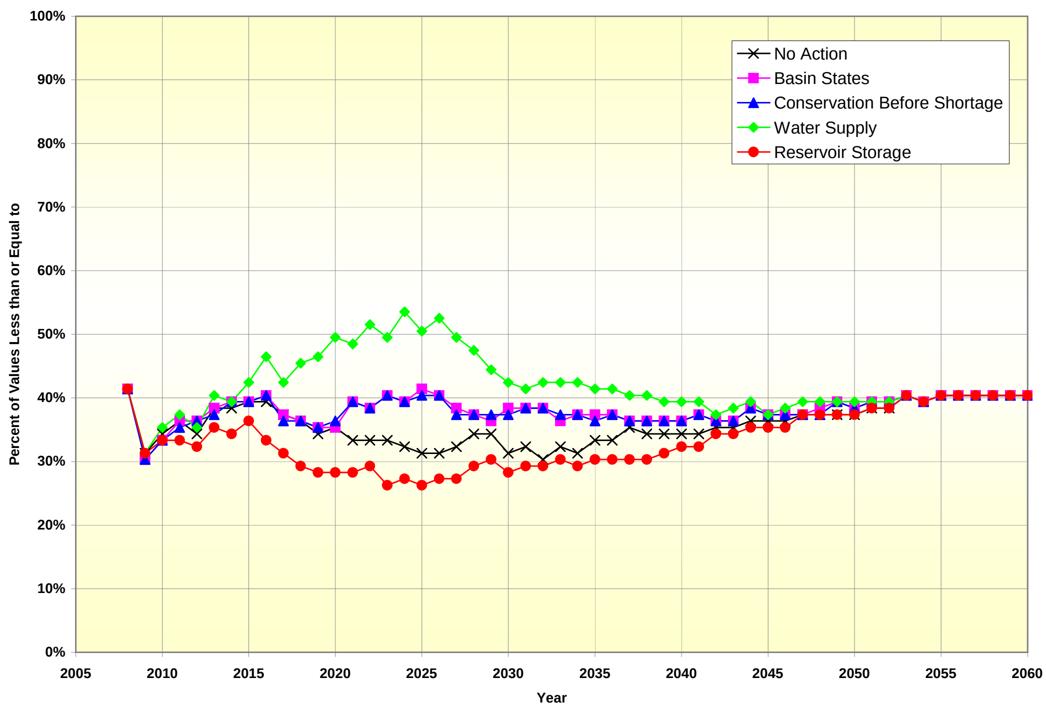


Table 4.3-4 summarizes the data illustrated in Figure 4.3-5 for elevation 3,626 feet msl. The water levels under the Reservoir Storage Alternative fell below elevation 3,626 feet msl less frequently than those under the No Action Alternative. The water levels under the Water Supply, Basin States, Conservation Before Shortage alternatives were observed to fall below elevation 3,626 feet msl more frequently than those under the No Action Alternative.

Table 4.3-4
Lake Powell End-of- September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,626 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	41%	39%	31%	31%	34%	37%	40%
Basin States	41%	40%	40%	38%	36%	38%	40%
Conservation Before Shortage	41%	40%	40%	37%	36%	38%	40%
Water Supply	41%	46%	53%	42%	39%	39%	40%
Reservoir Storage	41%	33%	27%	28%	32%	37%	40%

Figure 4.3-6 compares the percent of values less than or equal to elevation 3,620 feet msl for the No Action Alternative and the action alternatives. Elevation 3,620 feet msl is the water level at which the Hite Marina, Hite Public Ramp, and Castle Rock Cut are closed. Lake Powell elevations under the Water Supply, Basin States, and Conservation Before Shortage alternative were observed to fall below elevation 3,620 feet msl more frequently than those under the No Action Alternative. The water levels under the Reservoir Storage Alternative fell below elevation 3,620 feet msl less frequently than those under the No Action Alternative for most of the modeled years.

Table 4.3-5 shows that all of the different action alternatives varied from the No Action Alternative from about 2016 until about 2040. All of the alternatives, including the No Action Alternative, fell below elevation 3,620 feet msl about 21 to 40 percent of the time.

Figure 4.3-6
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,620 feet msl

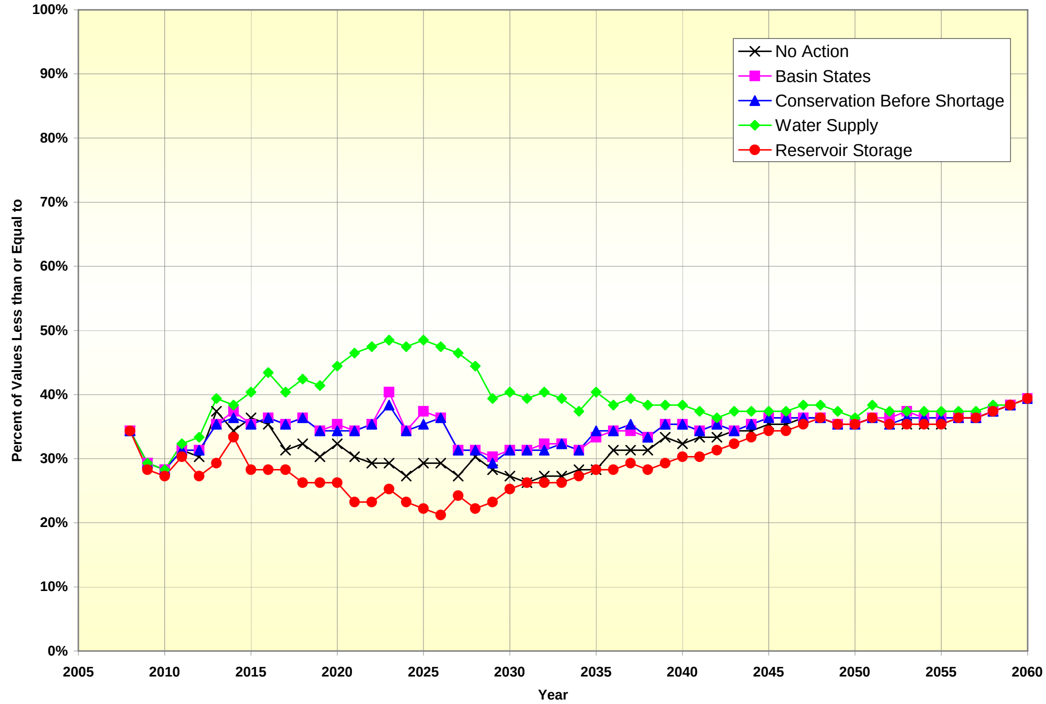


Table 4.3-5
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,620 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	34%	35%	29%	27%	32%	35%	39%
Basin States	34%	36%	36%	31%	35%	35%	39%
Conservation Before Shortage	34%	36%	36%	31%	35%	35%	39%
Water Supply	34%	43%	47%	40%	38%	36%	39%
Reservoir Storage	34%	28%	21%	25%	30%	35%	39%

Figure 4.3-7 compares the percent of values less than or equal to elevation 3,588 feet msl for the No Action Alternative and the action alternatives. When Lake Powell elevations are below 3,588 feet msl, the Antelope Point Public Launch Ramp is closed. The water levels under the Reservoir Storage Alternative were observed to fall below elevation 3,588 feet msl less frequently than those under the No Action Alternative for most of the modeled years. The water levels under the Water Supply, Basin States, and Conservation Before Shortage alternatives were observed to fall below elevation 3,588 feet msl more frequently than those under the No Action Alternative.

Figure 4.3-7
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,588 feet msl

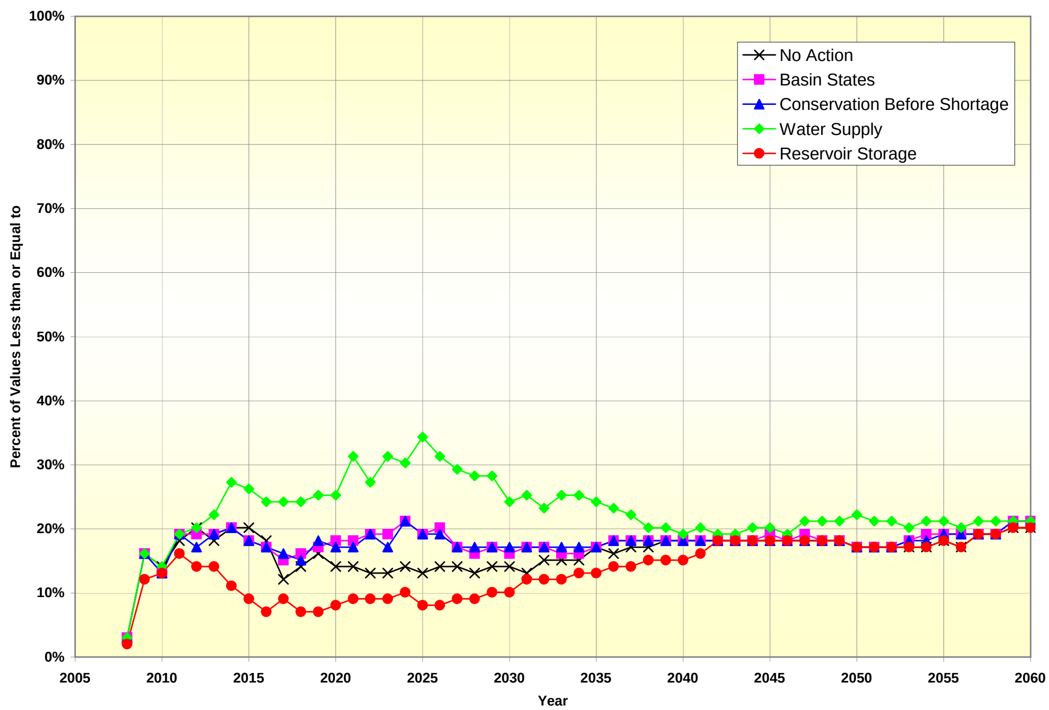


Table 4.3-6 provides a summary of the data illustrated in Figure 4.3-7 for an elevation of 3,588 feet msl. In general, elevations for all alternatives dropped below elevation 3,588 feet msl between 2 to 21 percent of the time. The exceptions are the water levels under the Water Supply Alternative which fell below elevation 3,588 feet msl between 3 to 31 percent of the time.

Table 4.3-6
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,588 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	3%	18%	14%	14%	18%	17%	20%
Basin States	3%	17%	20%	16%	18%	17%	21%
Conservation Before Shortage	3%	17%	19%	17%	18%	17%	21%
Water Supply	3%	24%	31%	24%	19%	22%	21%
Reservoir Storage	2%	7%	8%	10%	15%	17%	20%

Figure 4.3-8 compares the percent of values less than or equal to elevation 3,560 feet msl for the No Action Alternative and the action alternatives. Below an elevation of 3,560 feet msl, the Wahweap and Stateline Public Launch Ramps, the Bullfrog Low Water Alternative Launch Ramp, and the Halls Crossing Public Launch Ramps are closed. Results indicate that for all alternatives, the Lake Powell end-of-September elevations were lower than 3,560 feet msl between 0 to 12 percent of the time, with the exception of the Water Supply Alternative. The water levels under the Water Supply Alternative fell below elevation 3,560 feet msl as much as 20 percent of the time.

Table 4.3-7 provides a summary of the data illustrated in Figure 4.3-8 for elevation 3,560 feet msl. The water levels under the Water Supply Alternative fell below elevation 3,560 feet msl more frequently than those under the No Action Alternative. The water levels under the Reservoir Storage Alternative fell below elevation 3,560 feet msl less frequently than those under the No Action Alternative.

Figure 4.3-9 compares the percent of values equal to or less than elevation 3,555 feet msl for the No Action Alternative and the action alternatives. Below an elevation of 3,555 feet msl, the Wahweap, Antelope Point, Bullfrog, and Halls Crossing marinas are closed. Results indicate that for all alternatives, the Lake Powell end-of-September elevations were lower than 3,555 feet msl between 0 to 10 percent of the time. The exceptions are the water levels under the Water Supply Alternative which had elevations lower than 3,555 feet msl as much as 19 percent of the time.

Figure 4.3-8
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,560 feet msl

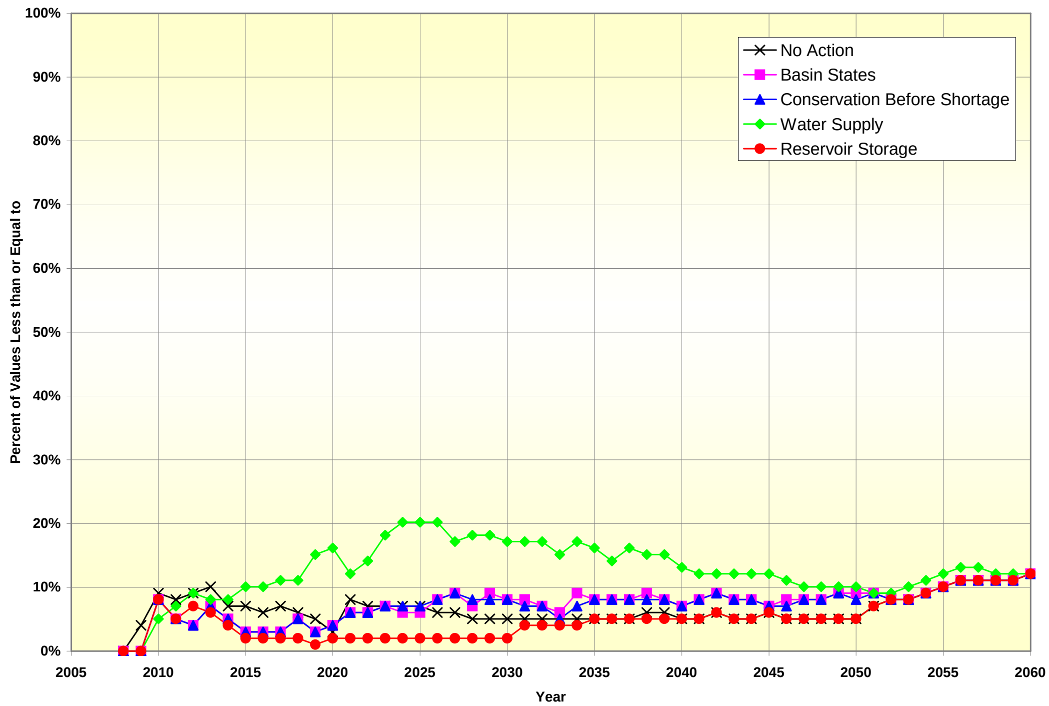


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Table 4.3-7
Lake Powell End-of- September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,560 feet msl

Alternative	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	6%	6%	5%	5%	5%	12%
Basin States	0%	3%	8%	8%	7%	9%	12%
Conservation Before Shortage	0%	3%	8%	8%	7%	8%	12%
Water Supply	0%	10%	20%	17%	13%	10%	12%
Reservoir Storage	0%	2%	2%	2%	5%	5%	12%

3

Figure 4.3-9
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,555 feet msl

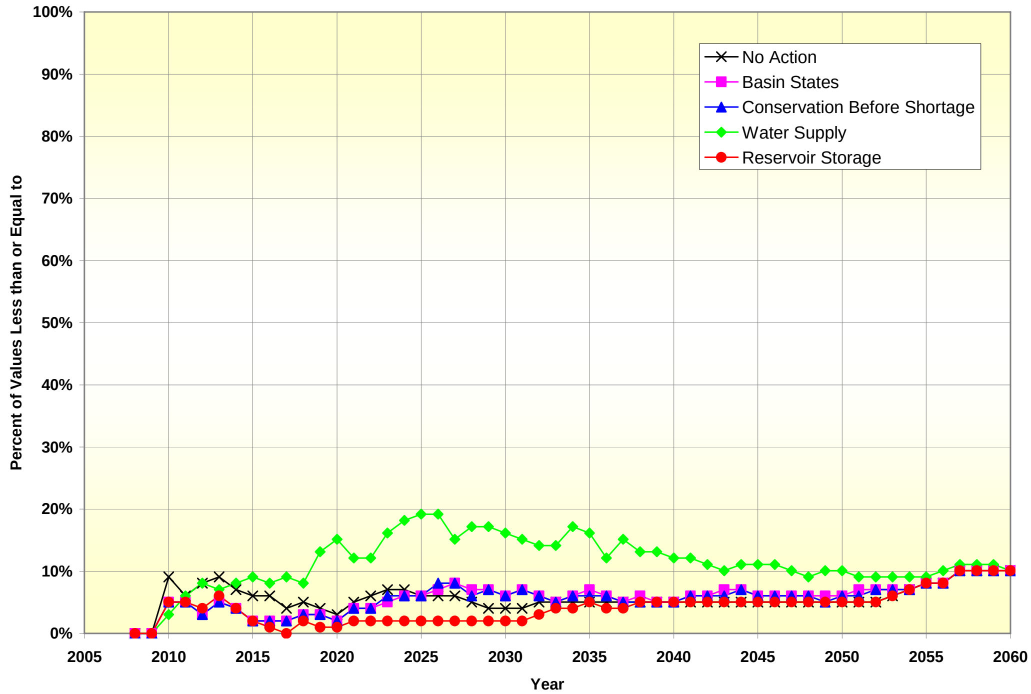


Table 4.3-8 provides a summary of the data illustrated in Figure 4.3-9 for elevation 3,555 feet msl. The water levels under the Water Supply Alternative fell below elevation 3,555 feet msl more frequently than those under the No Action Alternative. The water levels under the Reservoir Storage Alternative fell below elevation 3,555 feet msl less frequently than those under the No Action Alternative through year 2030 and thereafter, the values were similar.

Table 4.3-8
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,555 feet msl

Alternative	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	6%	6%	4%	5%	5%	10%
Basin States	0%	2%	7%	6%	5%	6%	10%
Conservation Before Shortage	0%	2%	8%	6%	5%	6%	10%
Water Supply	0%	8%	19%	16%	12%	10%	10%
Reservoir Storage	0%	1%	2%	2%	5%	5%	10%

Figure 4.3-10 compares the percent of values equal to or less than 3,550 feet msl for the No Action Alternative and the action alternatives. Below this elevation, the operation of the John Atlantic Burr Ferry may be affected. The Lake Powell end-of-September elevations under all of the alternatives were lower than 3,550 feet msl infrequently, ranging between zero to 10 percent. The exception to this was the Water Supply Alternative, which had water levels that fell below elevation 3,550 feet msl as much as 18 percent of the time. The water levels under the Reservoir Storage, Basin States, and Conservation Before Shortage Alternatives were all very similar to those under the No Action Alternative throughout the period of analysis.

Figure 4.3-10
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,550 feet msl

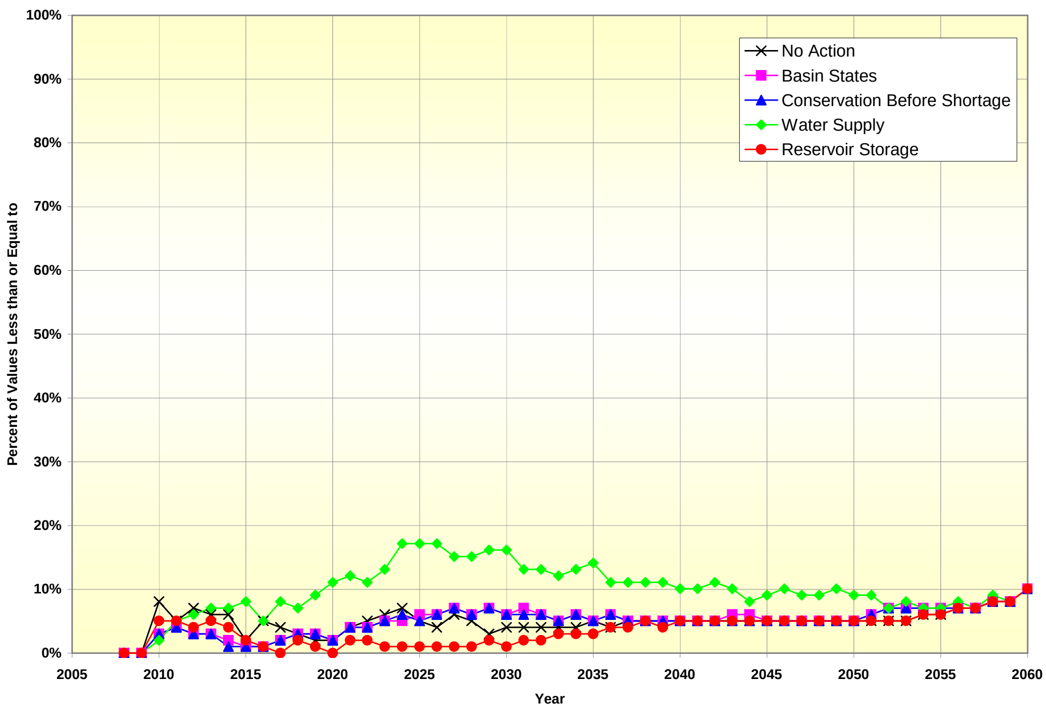


Table 4.3-9 provides a summary of the data illustrated in Figure 4.3-10 and shows that the water levels under the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives were generally within the same range as those under the No Action Alternative. The water levels under the Water Supply Alternative fell below elevation 3,550 feet msl most frequently compared to the other alternatives, as much as 17 percent of the time.

Table 4.3-9
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,550 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	5%	4%	4%	5%	5%	10%
Basin States	0%	1%	6%	6%	5%	5%	10%
Conservation Before Shortage	0%	1%	6%	6%	5%	5%	10%
Water Supply	0%	5%	17%	16%	10%	9%	10%
Reservoir Storage	0%	1%	1%	1%	5%	5%	10%

Figure 4.3-11 compares the percent of values for Lake Powell end-of-March elevations that were less than or equal to an elevation of 3,490 feet msl, the minimum power pool for Lake Powell and the Glen Canyon Powerplant, between the No Action Alternative and the action alternatives. The figure shows that the Lake Powell end-of-March elevation fell below 3,490 feet msl under the No Action, Basin States, Conservation Before Shortage, and Reservoir Storage alternatives very infrequently. The Lake Powell end-of-March elevations under the Water Supply Alternative were observed to fall below 3,490 feet msl more frequently than those under the No Action Alternative, with the differences being as high as seven percent.

Figure 4.3-11
Lake Powell End-of-March Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,490 feet msl

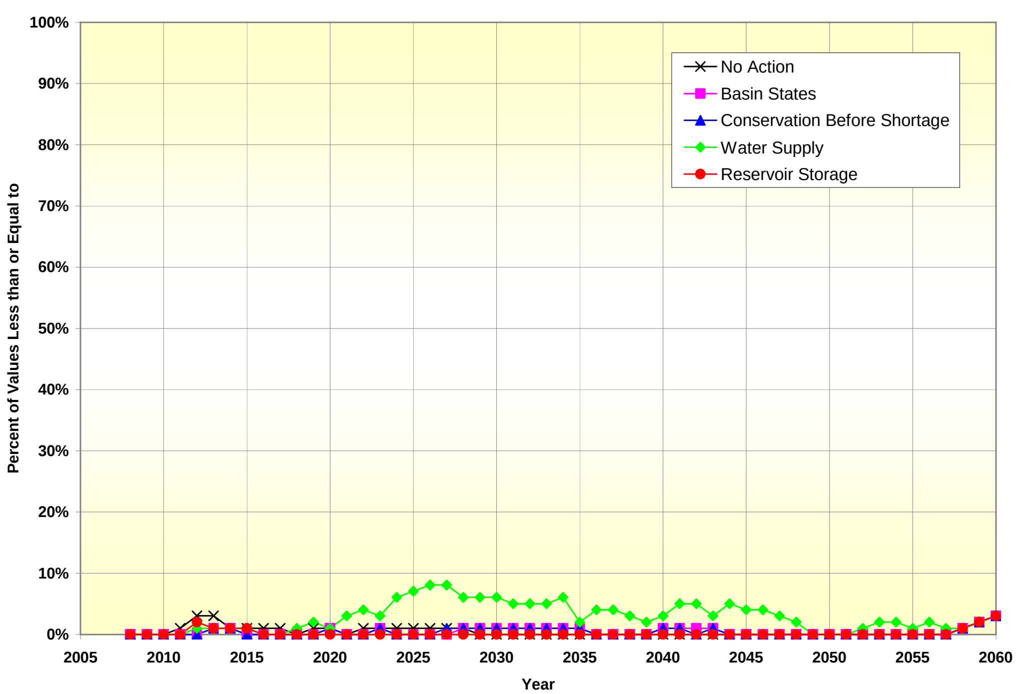


Table 4.3-10 provides a summary of the data illustrated in Figure 4.3-11 for elevation 3,490 feet msl. As show on this table, the water levels under all of the alternatives, with the exception of the Water Supply Alternative, fell below elevation 3,490 feet msl less than three percent of the time.

Table 4.3-10
Lake Powell End-of-March Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,490 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	1%	1%	0%	0%	0%	3%
Basin States	0%	0%	0%	1%	1%	0%	3%
Conservation Before Shortage	0%	0%	0%	1%	1%	0%	3%
Water Supply	0%	0%	8%	6%	3%	0%	3%
Reservoir Storage	0%	0%	0%	0%	0%	0%	3%

4.3.3 Glen Canyon Dam to Lake Mead

The river flows that occur between Glen Canyon Dam and Lake Mead result mostly from controlled releases from Glen Canyon Dam (Lake Powell). The gains from tributaries in this reach on average are less than three percent of the total inflow, are concentrated over very short periods of time, and will not be affected by the proposed federal action. As noted in Section 3.3, future annual and monthly releases may be affected by the proposed federal action. However, each alternative may alter the probability (when compared to the No Action Alternative) of the magnitude and timing of particular releases.

Table 4.3-11 provides a comparison of the relative frequency of occurrence of annual releases from Lake Powell under the No Action Alternative and the action alternatives, during the period between 2009 through 2060. The reported values are water year values. Releases greater than 9.0 maf generally correspond to years where either equalization or spill avoidance releases are made from Lake Powell. As is shown, the most frequently occurring releases for all alternatives are 8.23 maf. Releases less than the annual minimum objective release of 8.23 maf occurred less than one percent of the time under the No Action Alternative, approximately 3.7 percent under the Basin States, Conservation Before Shortage, and Water Supply alternatives, and approximately six percent under the Reservoir Storage Alternative. Releases greater than the annual minimum objective release of 8.23 maf occurred approximately 35.5 percent under the No Action Alternative, approximately 42.4 percent under the Basin States, Conservation Before Shortage, and Water Supply alternatives, and approximately 36.67 percent under the Reservoir Storage Alternative.

Table 4.3-11
Glen Canyon Dam Water Year Releases
Probability of Occurrence of Different Size Annual Releases
Comparison of Action Alternatives to No Action Alternative
Water Years 2009 through 2060

Glen Canyon Dam Release Volumes	Alternative				
	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
Greater than 9.00 mafy	29.80%	35.53%	35.53%	36.67%	30.94%
Between 8.51 to 9.00 mafy	3.44%	4.58%	4.58%	3.44%	3.44%
Between 8.24 to 8.50 mafy	2.29%	2.29%	2.29%	2.29%	2.29%
Minimum Objective Release of 8.23 mafy	64.18%	53.87%	53.87%	53.87%	57.30%
Between 7.51 to 8.22 mafy	0.27%	0.00%	0.00%	1.15%	6.00%
Between 7.0 to 7.50 mafy	0.00%	3.71%	3.71%	2.56%	0.00%
Less than 7.0 mafy	0.00%	0.00%	0.00%	0.00%	0.00%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 4.3-12 presents a comparison of the 90th, 50th, and 10th percentile values observed under the action alternatives to those under the No Action Alternative. As illustrated in Figure 4.3-12, the 90th percentile values under all of the alternatives fluctuate and range between 12.0 mafy to about 13.4 mafy, primarily due to spill avoidance releases. For the 50th percentile values, the Reservoir Storage Alternative and the No Action Alternatives are nearly identical, with consistent releases of 8.23 maf. The Basin States, Conservation Before Shortage, and Water Supply alternatives show releases greater than the minimum objective release of 8.23 maf, up to 9.5 maf, a result of balancing or equalization releases. The 10th percentile values showed that the Water Supply Alternative varied only in the initial three years, providing slightly lower releases than the No Action Alternative. The Basin States and Conservation Before Shortage alternatives also provided slightly lower annual release volumes than the No Action Alternative through the year 2016. The 10th percentile values for releases under the Reservoir Storage Alternative are not as low as those of the other action alternatives but are slightly lower than those of the No Action Alternative and extend through 2026.

Figure 4.3-12
Glen Canyon Dam Water Year Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

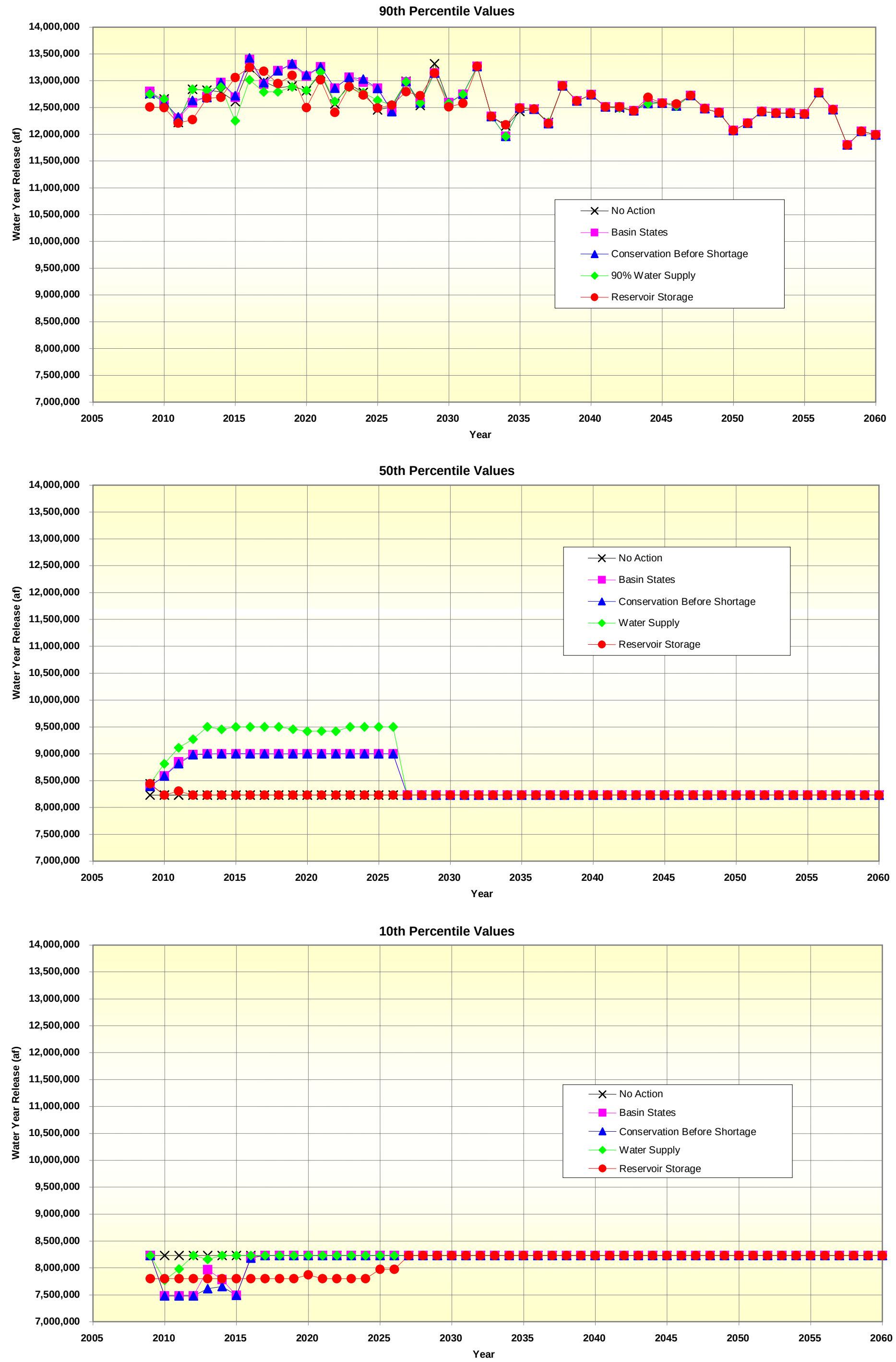
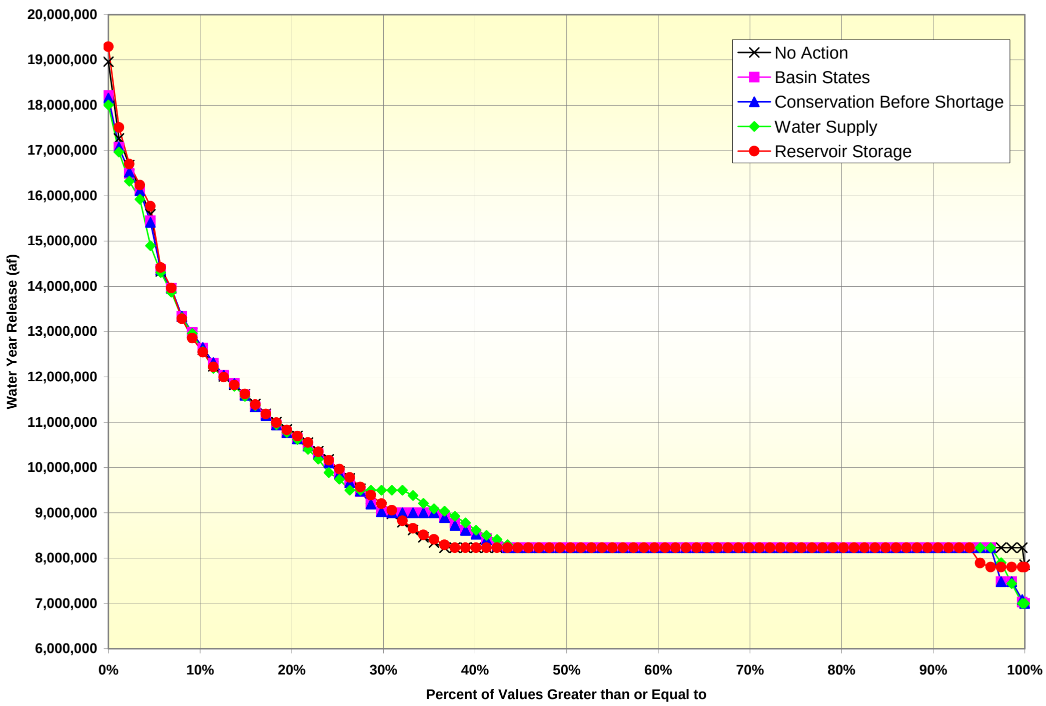


Figure 4.3-13 illustrates the cumulative distribution of the Glen Canyon Dam water year releases under the No Action Alternative and the action alternatives for the modeling period 2009 through 2060. This figure provides a means for comparing the frequency that the minimum objective release of 8.23 maf is made under the different alternatives as well as identifying the frequency and magnitude of Glen Canyon Dam releases above and below the minimum objective release of 8.23 maf. As illustrated in Figure 4.3-13, the minimum objective release of 8.23 maf in all alternatives is met or exceeded 95 percent or more of the time.

Figure 4.3-13
Glen Canyon Dam Water Year Releases
Comparison of Action Alternatives to No Action Alternative
Water Years 2009 through 2060



4.3.3.1 Effect of Glen Canyon Dam Annual Releases on Daily River Flows Below Glen Canyon Dam

As illustrated in Figure 4.3-13, the primary difference among alternatives in Glen Canyon Dam releases occurs in years when balancing of Lake Powell and Lake Mead occurs (between the 30th and 40th percentiles) and when releases are constrained at specific Lake Powell elevations (between the 95th to 100th percentiles). These circumstances occur relatively infrequently and the majority of future releases under any alternative is expected to be 8.23 maf or higher. However, in order to assess potential impacts from departures from the No Action Alternative, Tables 4.3-12 through 4.3-14 are presented to illustrate most probable daily flow characteristics for various annual releases ranging from 7.0 to 9.5 maf. These tables provide a means for comparing the average, minimum, and maximum flows that could be expected under the different Glen Canyon Dam release volumes observed in the modeling of the different alternatives.

Table 4.3-12
Average Daily Glen Canyon Dam Releases (cfs)
Corresponding to Various Annual Release Volumes

	7.0 maf	7.48 maf	7.8 maf	8.23 maf	9.0 maf	9.5 maf
Oct	9,758	7,806	9,758	9,758	9,758	9,758
Nov	10,083	8,403	10,083	10,083	10,083	10,083
Dec	13,011	9,758	9,758	13,011	13,011	13,011
Jan	10,717	13,011	13,011	13,011	13,011	13,824
Feb	9,771	10,804	10,804	10,804	11,704	11,704
Mar	7,354	9,758	9,758	9,758	10,571	10,571
Apr	7,599	8,403	10,083	10,083	10,083	10,924
May	7,354	9,758	9,758	9,758	10,571	13,011
Jun	9,119	10,083	10,083	10,924	13,444	15,125
Jul	11,767	13,011	13,011	13,824	16,263	17,077
Aug	11,767	13,011	13,011	14,637	17,077	17,890
Sep	7,599	10,083	10,083	10,588	13,444	14,285

Table 4.3-13
Minimum Hourly Glen Canyon Dam Release (cfs)
Corresponding to Various Annual Release Volumes

	7.0 maf	7.48 maf	7.8 maf	8.23 maf	9.0 maf	9.5 maf
Oct	6,458	5,006	6,458	6,458	6,458	6,458
Nov	6,783	5,603	6,783	6,783	6,783	6,783
Dec	8,711	6,458	6,458	8,711	8,711	8,711
Jan	7,417	8,711	9,711	8,711	8,711	9,524
Feb	6,971	7,504	7,504	7,504	8,404	8,404
Mar	5,000	6,458	6,458	6,458	7,271	7,271
Apr	5,000	5,603	6,783	6,783	6,783	7,624
May	5,000	6,458	6,458	6,458	7,271	8,711
Jun	6,319	6,783	6,783	7,624	9,144	10,825
Jul	8,467	8,711	8,711	9,524	11,963	12,777
Aug	8,467	8,711	8,711	10,337	12,777	13,590
Sep	5,000	6,783	6,783	7,288	9,144	9,985

Table 4.3-14
Maximum Hourly Glen Canyon Dam Release (cfs)
Corresponding to Various Annual Release Volumes

	7.0 maf	7.48 maf	7.8 maf	8.23 maf	9.0 maf	9.5 maf
Oct	12,458	10,006	12,458	12,458	12,458	12,458
Nov	12,783	10,603	12,783	12,783	12,783	12,783
Dec	16,711	12,458	12,458	16,711	16,711	16,711
Jan	13,417	16,711	15,711	16,711	16,711	17,524
Feb	11,971	13,504	13,504	13,504	14,404	14,404
Mar	10,000	12,458	12,458	12,458	13,271	13,271
Apr	10,000	10,603	12,783	12,783	12,783	13,624
May	10,000	12,458	12,458	12,458	13,271	16,711
Jun	11,319	12,783	12,783	13,624	17,144	18,825
Jul	14,467	16,711	16,711	17,524	19,963	20,777
Aug	14,467	16,711	16,711	18,337	20,777	21,590
Sep	10,000	12,783	12,783	13,288	17,144	17,985

Table 4.3-12 provides a listing of the average flow for the month that would occur under the various annual releases. Tables 4.3-13 and 4.3-14 provide listings of the minimum and maximum hourly flow from Glen Canyon Dam under the various annual releases when the parameters of the 1996 Glen Canyon Dam ROD (Section 3.3) are applied to the monthly volumes.

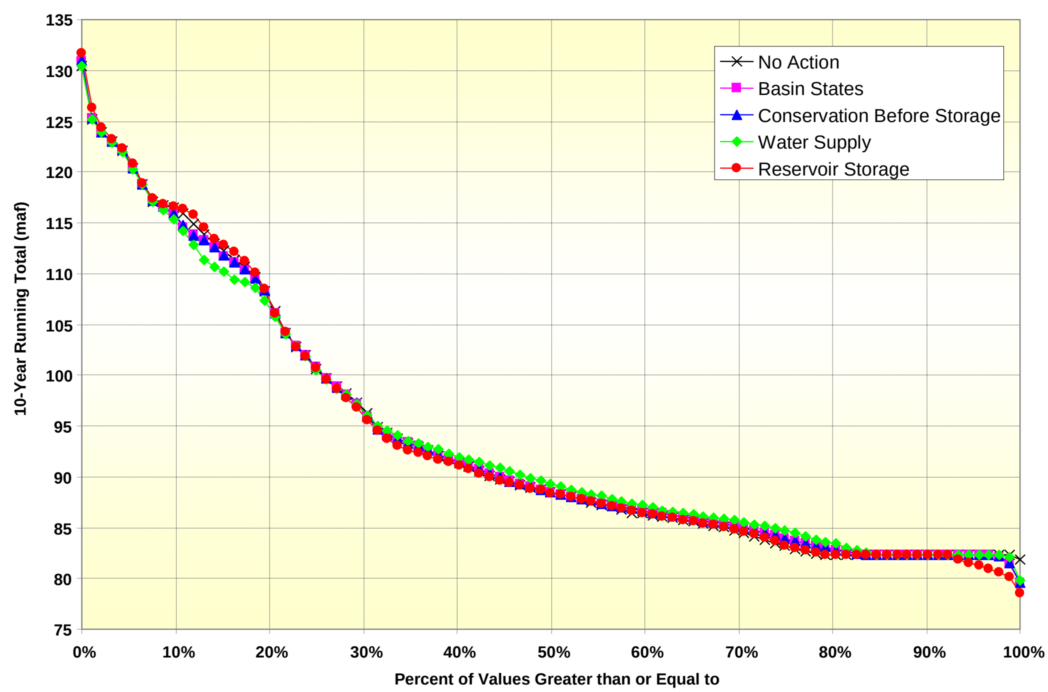
The monthly release values listed in Table 4.3-12 for the months of October, November and December in the 7.0 maf column are identical to monthly releases in 8.23 maf years. This occurs because the operation is governed by balancing releases between Lake Powell and Lake Mead in 7.0 maf years and the first inflow forecast for the upcoming year is not available until January. Beginning in January and continuing through the remainder of the water year, monthly releases from Lake Powell in 7.0 maf years are adjusted to balance volumes between Lake Powell and Lake Mead. It should also be noted that the variability in forecasts and different levels of Lake Powell and Lake Mead in 7.0 maf years result in there not being a consistent monthly pattern for these years, as opposed to the other years in the table where the monthly pattern is more predictable. The 7.0 maf pattern shown in Table 4.3-13 represents Trace 91 for water year 2014 from the Water Supply Alternative.

These hourly releases are needed in order to analyze potential downstream impacts to water quality and other resources.

4.3.3.2 10-year Running Total of Glen Canyon Dam Releases

Figure 4.3-14 compares the 10-year running totals of the Glen Canyon Dam water year releases (10-year running total) under the action alternatives to the No Action Alternative. The values used to compute the 10-year running total for the years between 2008 through 2017 included a combination of historical values (for years prior to 2006), projections from the 24-month study (for years 2006 and 2007), and output from the CRSS model (for years 2008 and later). As noted in Section 4.2, the 24-month study was used to project the starting conditions for the reservoir levels for January 1, 2008.

Figure 4.3-14
Glen Canyon Dam 10-Year Running Total of Annual Releases
Comparison of Action Alternatives to No Action Alternative
Years 2008 through 2060



The upper limit of the 10-year running total was similar under the No Action Alternative and the action alternatives and equaled approximately 131 maf. The 10-year running total under all of the alternatives, including the No Action Alternative, was always above 75 maf.

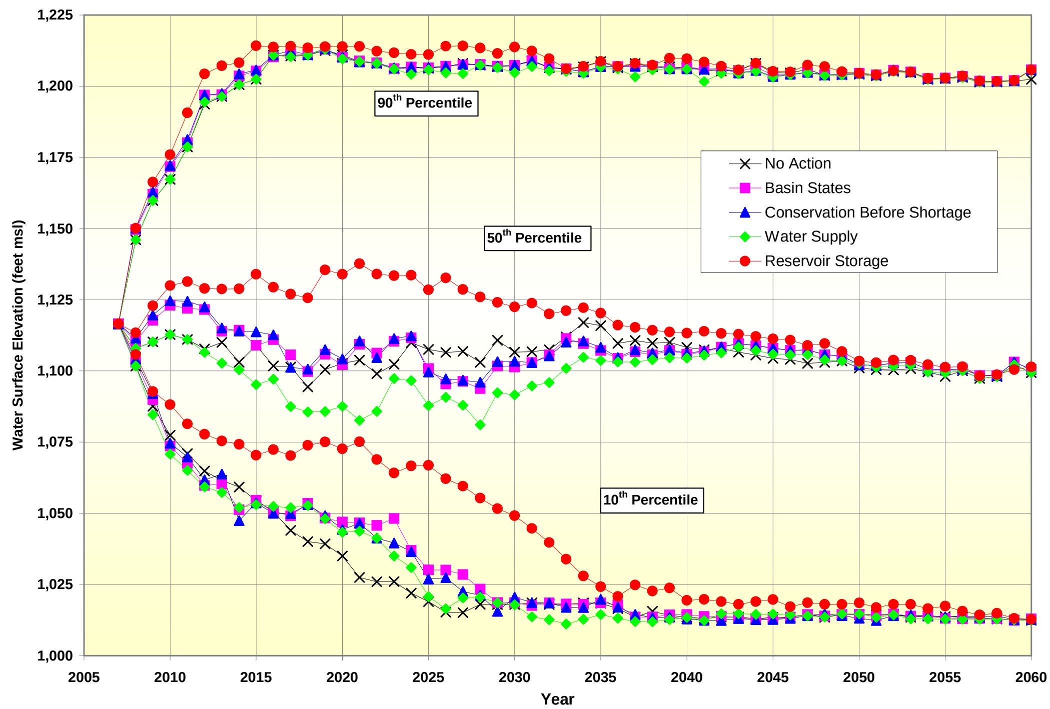
The 10-year running total under the No Action Alternative was less than 8.23 maf less than one percent of the years with a minimum value of 81.9 maf. The 10-year running total under the Basin States and Conservation Before Shortage alternatives was less than 82.3 maf in approximately two percent of the years and the minimum value was 79.6 maf. The 10-year running total under the Water Supply Alternative was less than 82.3 maf in only one percent of the years and the minimum value was 79.8 maf. The 10 year running total under the Reservoir Storage Alternative was less than 82.3 maf in approximately 6.7 percent of the years and the minimum value was 78.5 maf.

4.3.4 Lake Mead and Hoover Dam

As noted in Section 3.3, future elevations of Lake Mead are expected to be within the range of historic water levels. However, each alternative may alter the probability (when compared to the No Action Alternative) that the reservoir may be at a given elevation in the future.

Figure 4.3-15 presents a comparison of the 90th, 50th, and 10th percentile values observed for the action alternatives to those under the No Action Alternative. Under the No Action Alternative, the elevation of Lake Mead was projected to fluctuate between full (1,219.6 feet msl) and lower water during the period of analysis (2008 through 2060). The 90th percentile line increases from starting conditions to nearly full pool, about elevation 1,212 feet msl. The median water level values (50th percentile) under the No Action Alternative fluctuated between approximately 1,100 feet msl to approximately 1,120 feet msl between 2008 and 2035. The 10th percentile values show a declining trend between 2008 and 2025, from about 1,101 feet msl to about 1,018 feet msl.

Figure 4.3-15
Lake Mead End-of-December Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values



All action alternatives showed similar 90th percentile values compared to the No Action Alternative. It should be noted that the Lake Mead elevations depicted in Figure 4.3-15 represent water levels at the end of December which is when lake levels are typically at a seasonal high. Conversely, the Lake Mead water level generally reaches its annual low in July.

The Basin States and Conservation Before Shortage alternatives had slightly higher 50th percentile values than the No Action Alternative between 2008 through 2024, then dropped below those of the No Action Alternative between 2025 and about 2041, and thereafter were similar. The Water Supply Alternative had lower 50th percentile values than the No Action Alternative between 2012 through 2041, and thereafter were similar. Conversely, the Reservoir Storage Alternative had higher 50th percentile values than the No Action. During the interim period, the 10th percentile values for the Basin States, Conservation Before Shortage, and Water Supply alternatives are higher than the No Action Alternative, and the values for the Reservoir Storage Alternative are significantly higher than the No Action.

Table 4.3-15 provides a summary of the data illustrated in Figure 4.3-15 which reflects the 90th, 50th, and 10th percentile values observed under the No Action Alternative and the action alternatives. The values presented in this table include those for years 2026 and 2060 only. The 90th, 50th, and 10th percentile values under the action alternatives differ from the No Action Alternative to some extent in year 2026 and at very insignificant levels in year 2060.

Table 4.3-15
Lake Mead End-of-December Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	1,206.87	1,106.50	1,015.31	1,202.39	1,099.41	1,012.44
Basin States	1,207.05	1,095.39	1,030.07	1,205.79	1,100.55	1,012.95
Conservation Before Shortage	1,207.05	1,097.22	1,027.39	1,205.79	1,100.55	1,012.70
Water Supply	1,204.72	1,090.78	1,016.47	1,205.59	1,099.41	1,012.42
Reservoir Storage	1,214.05	1,132.64	1,062.16	1,205.80	1,101.47	1,012.75

The 90th percentile values in year 2026 vary little between the action alternatives and the No Action Alternative. The exception to this is the Reservoir Storage Alternative which is approximately seven feet higher than that of the No Action Alternative.

The 50th percentile values for the Basin States, Conservation Before Shortage, and Water Supply alternatives in year 2026 are approximately 11, 9, and 15 feet lower than that of the No Action Alternative, respectively. In contrast, the 50th percentile value for the Reservoir Storage Alternative in year 2026 is approximately 26 feet higher than that of the No Action Alternative.

The 10th percentile values for the Basin States, Conservation Before Shortage, Water Supply, and Reservoir Storage alternatives were all higher than that of No Action Alternative in year 2026 as shown on Table 4.3-15. The greatest difference observed occurs between the Reservoir Storage Alternative and No Action Alternative which is about 47 feet.

Figure 4.3-16 illustrates the results for exceedence values above an elevation of 1,200 feet msl, nearly the full pool elevation of Lake Mead. All of the action alternatives were very similar to the No Action Alternative throughout the modeled years, with exceedence values ranging between zero to 20 percent.

Figure 4.3-16
Lake Mead End-of-December Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Greater Than or Equal to Elevation 1,200 feet msl

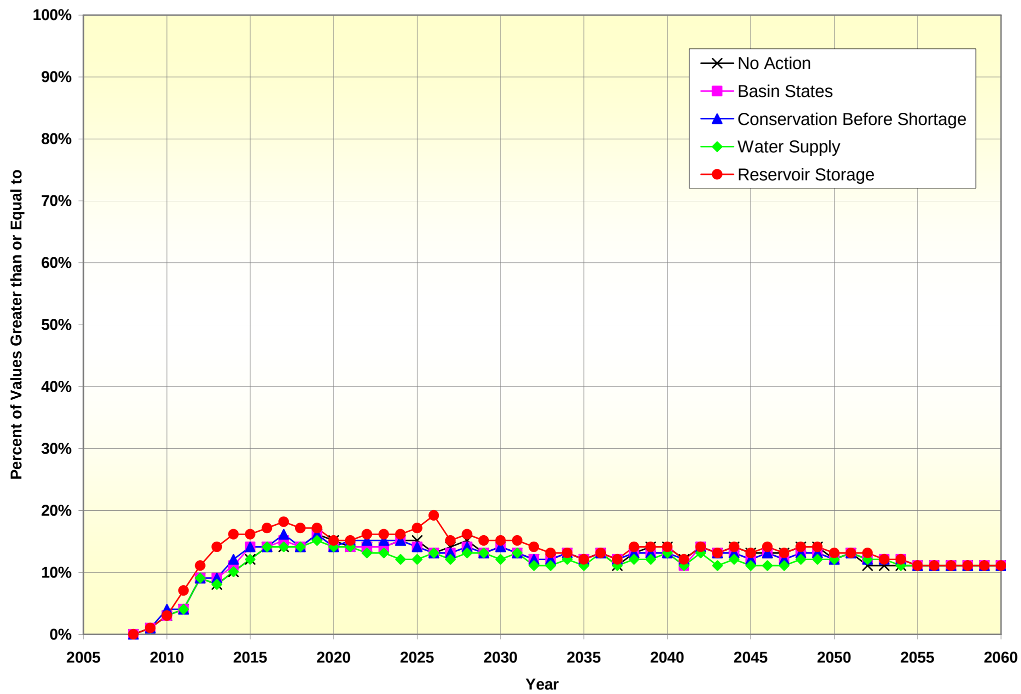


Table 4.3-16 provides a summary of the exceedence values for elevation 1,200 feet msl for selected years. As listed in this table, the exceedence values for the alternatives are similar, although the Reservoir Storage Alternative provides slightly higher exceedence values.

Table 4.3-16
Lake Mead End-of- December Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Greater Than or Equal to Elevation 1,200 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	14%	13%	14%	14%	12%	11%
Basin States	0%	14%	13%	14%	13%	12%	11%
Conservation Before Shortage	0%	14%	13%	14%	13%	12%	11%
Water Supply	0%	14%	13%	12%	13%	12%	11%
Reservoir Storage	0%	17%	19%	15%	14%	13%	11%

Figure 4.3-17 illustrates the frequency that future Lake Mead end-of-December elevations would drop below elevation 1,178 feet msl. Lake Mead elevations of 1,178 feet msl and 1,000 feet msl were used by the Clean Water Coalition as reference elevations for its Lake Mead water quality analysis (Systems Conveyance and Operations Program Final Environmental Impact Statement [SCOP FEIS] October 2006). The SCOP FEIS analyzed water quality changes corresponding to Lake Mead elevation drawdown from 1,178 feet msl to 1,000 feet msl. These potential Lake Mead water quality changes are discussed in Section 4.5. As shown in Figure 4.3-17, the results for the Basin States and Conservation Before Shortage alternatives are similar to those of the No Action Alternative. The water levels under the Reservoir Storage Alternative were observed to fall below elevation 1,178 feet msl less frequently than those under the No Action Alternative. The water levels under the Water Supply Alternative were observed to fall below elevation 1,178 feet msl more frequently than those under the No Action Alternative.

Table 4.3-17 provides a summary of the results illustrated in Figure 4.3-17 for elevation 1,178 feet msl in tabular form for selected years. As shown in Table 4.3-17, the water levels under the Basin States and Conservation Before Shortage alternatives are similar to those under the No Action Alternative. The water levels under the Reservoir Storage Alternative fell below elevation 1,178 feet msl less frequently than those under the No Action Alternative. The water levels under the Water Supply Alternative fell below elevation 1,178 feet msl more frequently than those under the No Action Alternative.

Figure 4.3-17
Lake Mead End-of-December Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,178 feet msl

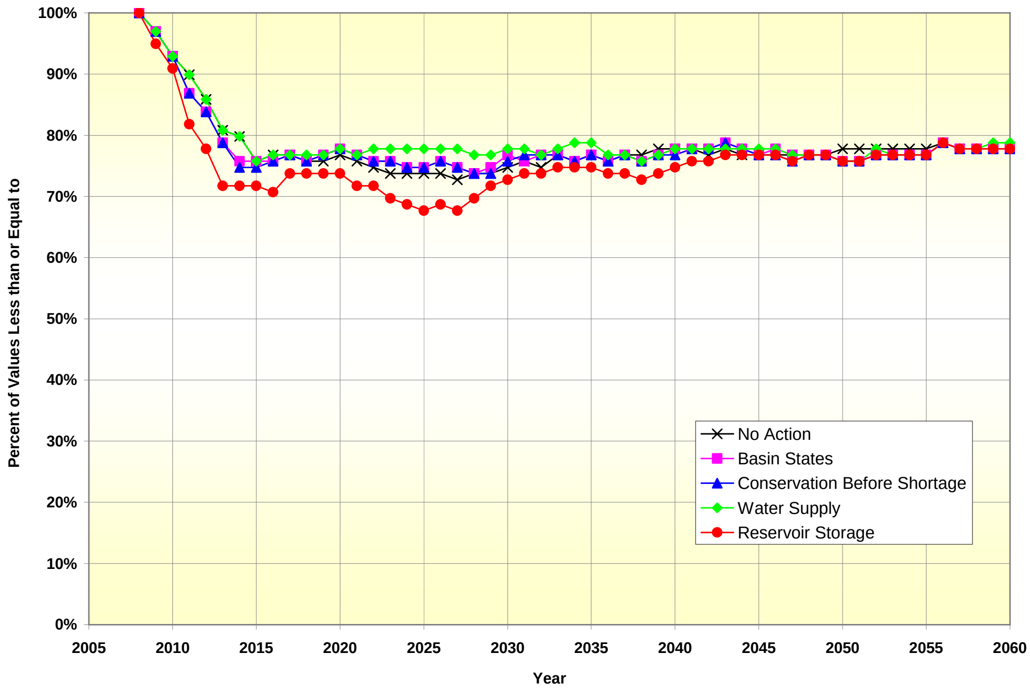


Table 4.3-17
Lake Mead End-of-December Water Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less than or Equal to Elevation 1,178 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	100%	77%	74%	75%	78%	78%	78%
Basin States	100%	76%	76%	77%	78%	76%	78%
Conservation Before Shortage	100%	76%	76%	76%	77%	76%	78%
Water Supply	100%	77%	78%	78%	78%	76%	79%
Reservoir Storage	100%	71%	69%	73%	75%	76%	78%

Figure 4.3-18 illustrates the frequency that future Lake Mead end-of-July elevations would drop below elevation 1,175 feet msl. Below this elevation, the Pearce Bay Launch Ramp is closed and whitewater boaters must paddle an additional 16 miles to South Cove. As illustrated in Figure 4.3-18, the results for the Basin States, Conservation Before Shortage, and Water Supply alternatives are similar to those of the No Action Alternative. The water levels under the Reservoir Storage Alternative were observed to fall below elevation 1,175 feet msl less frequently than those under the No Action Alternative.

Figure 4.3-18
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,175 feet msl

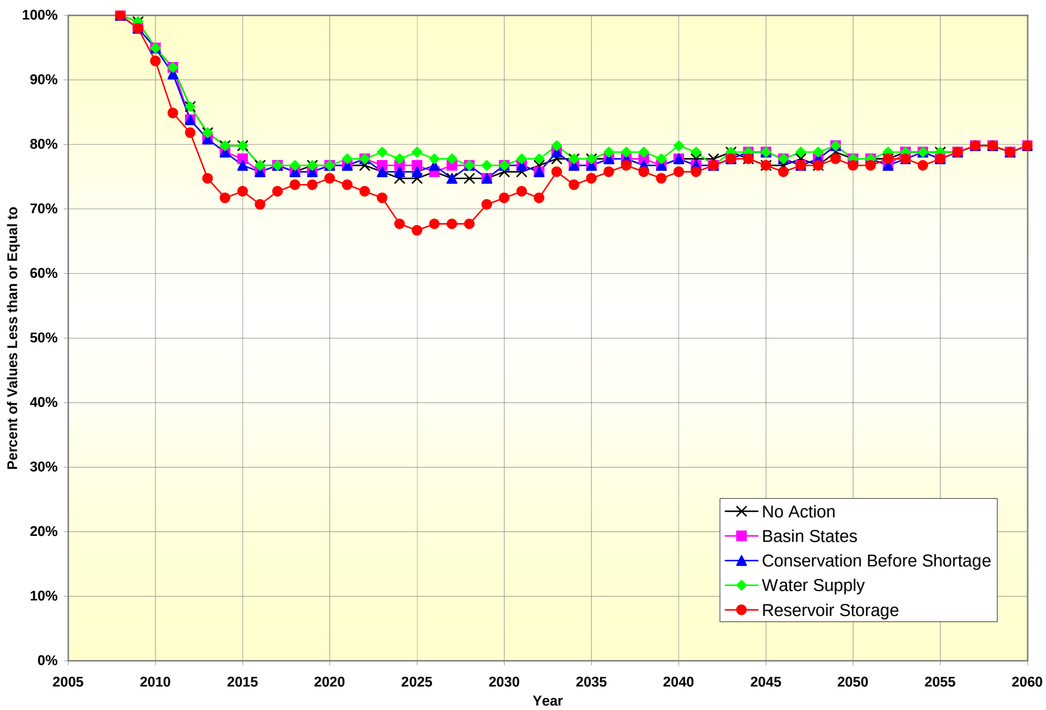


Table 4.3-18 provides a summary of the results illustrated in Figure 4.3-18 for elevation 1,175 feet msl for selected years. As shown in Table 4.3-18, the water levels under the Basin States, Conservation Before Shortage, and Water Supply alternatives are similar to those under the No Action Alternative. The water levels under the Reservoir Storage Alternative fell below elevation 1,175 feet msl less frequently than those under the No Action Alternative through about 2040.

Table 4.3-18
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,175 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	100%	77%	76%	76%	78%	78%	80%
Basin States	100%	76%	76%	77%	78%	78%	80%
Conservation Before Shortage	100%	76%	77%	77%	78%	78%	80%
Water Supply	100%	77%	78%	77%	80%	78%	80%
Reservoir Storage	100%	71%	68%	72%	76%	77%	80%

Figure 4.3-19 illustrates the frequency that Lake Mead end-of-July elevations would fall below elevation 1,170 feet msl. This Lake Mead elevation is the minimum water level needed to maintain navigation between Grand Wash and Pearce Ferry. At water levels below 1,170 feet msl, potential sediment aggradation could potentially impair navigation between these two locations. As illustrated in Figure 4.3-19, the results for the Basin States and Conservation Before Shortage alternatives are similar to those observed under the No Action Alternative. The water levels under the Water Supply alternative were observed to fall below elevation 1,170 feet msl more frequently than those under the No Action Alternative between 2019 and 2033. The water levels under the Reservoir Storage Alternative were observed to fall below elevation 1,170 feet msl less frequently than those under the No Action Alternative.

Table 4.3-19 provides a summary of the results illustrated in Figure 4.3-19 for the Lake Mead end-of-July elevation of 1,170 feet msl for selected years.

Figure 4.3-19
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,170 feet msl

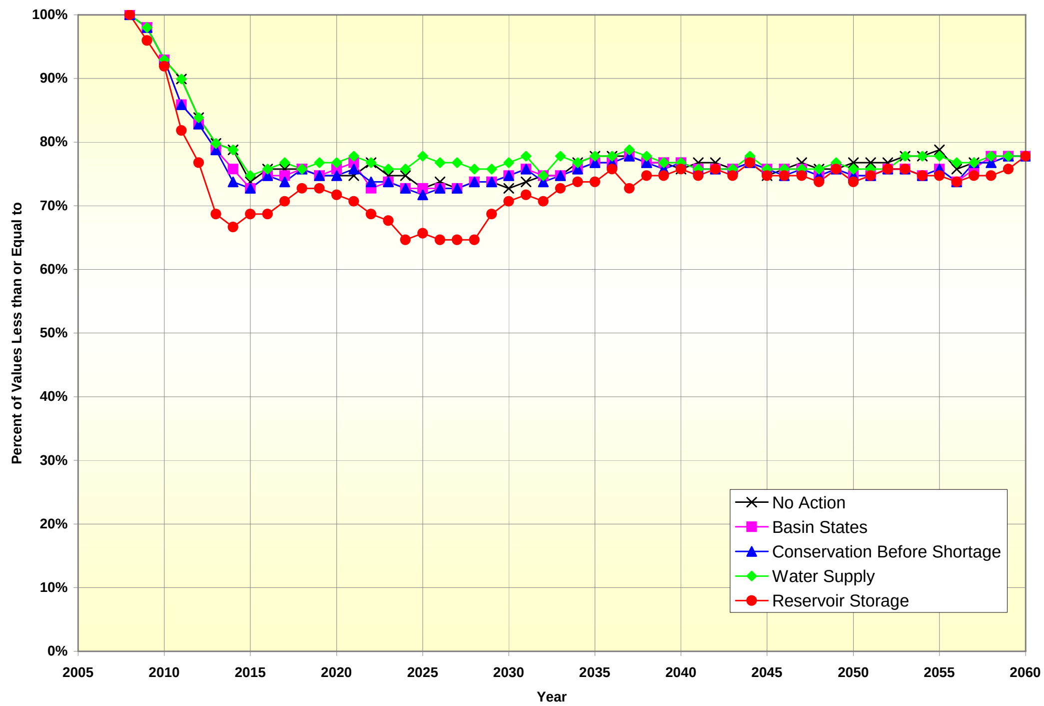


Table 4.3-19
Lake Mead End-of- July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,170 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	100%	76%	74%	73%	76%	77%	78%
Basin States	100%	75%	73%	75%	77%	75%	78%
Conservation Before Shortage	100%	75%	73%	75%	77%	75%	78%
Water Supply	100%	76%	77%	77%	77%	76%	78%
Reservoir Storage	100%	69%	65%	71%	76%	74%	78%

Figure 4.3-20 illustrates the frequency that Lake Mead end-of-July elevations fall below elevation 1,125 feet msl. At lake elevations lower than 1,125 feet msl, the Overton Beach Marina, Callville Ramp, and South Cove Ramp are closed. As illustrated in Figure 4.3-20, the frequency that elevations fall below elevation 1,125 feet msl for the Basin States and Conservation Before Shortage alternatives are similar to those observed under the No Action Alternative. The water levels under the Water Supply Alternative were observed to fall below elevation 1,125 feet msl more frequently than those under the No Action alternative between 2008 and 2035. The water levels under the Reservoir Storage Alternative were observed to fall below elevation 1,125 feet msl less frequently than those under the No Action Alternative between 2010 and 2037.

Figure 4.3-20
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,125 feet msl

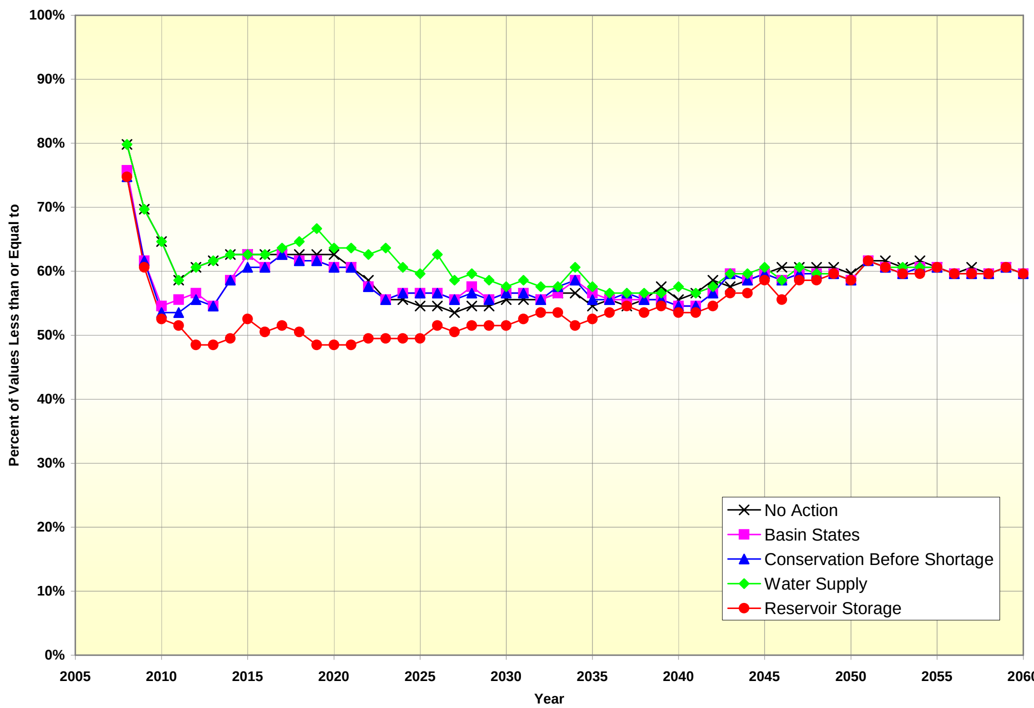


Table 4.3-20 provides a summary of the results for the Lake Mead end-of-July elevation of 1,125 feet msl for selected years.

Table 4.3-20
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,125 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	80%	63%	55%	56%	56%	60%	60%
Basin States	76%	61%	57%	57%	55%	59%	60%
Conservation Before Shortage	75%	61%	57%	57%	55%	59%	60%
Water Supply	80%	63%	63%	58%	58%	59%	60%
Reservoir Storage	75%	51%	52%	52%	54%	59%	60%

Figure 4.3-21 illustrates the frequency that Lake Mead end-of-July elevations would fall below elevation 1,080 feet msl. At lake elevations below 1,080 feet msl, the operations at the Lake Mead Marina Public Launch Ramp, Hemenway Public Launch Ramp, and Temple Bar Public Launch Ramp could potentially be affected. As illustrated in Figure 4.3-21, the Reservoir Storage Alternative was observed to fall below elevation 1,080 feet msl less frequently than under the No Action Alternative between 2010 and 2045. The water levels under the Basin States and Conservation Before Shortage alternatives were observed to fall below elevation 1,080 feet msl slightly less frequently than those under the No Action Alternative between 2013 and 2023 and then slightly more frequently between 2023 and 2038. The water levels under the Water Supply Alternative were observed to fall below elevation 1,080 feet msl more frequently than those under the No Action Alternative between 2012 and 2040.

Table 4.3-21 provides a summary of the results for the Lake Mead-end-of-July elevation of 1,080 feet msl for selected years. As shown in Table 4.3-21, the action alternatives vary from the No Action Alternative mostly between years 2016 and 2030 and are similar in subsequent years.

Figure 4.3-21
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,080 feet msl

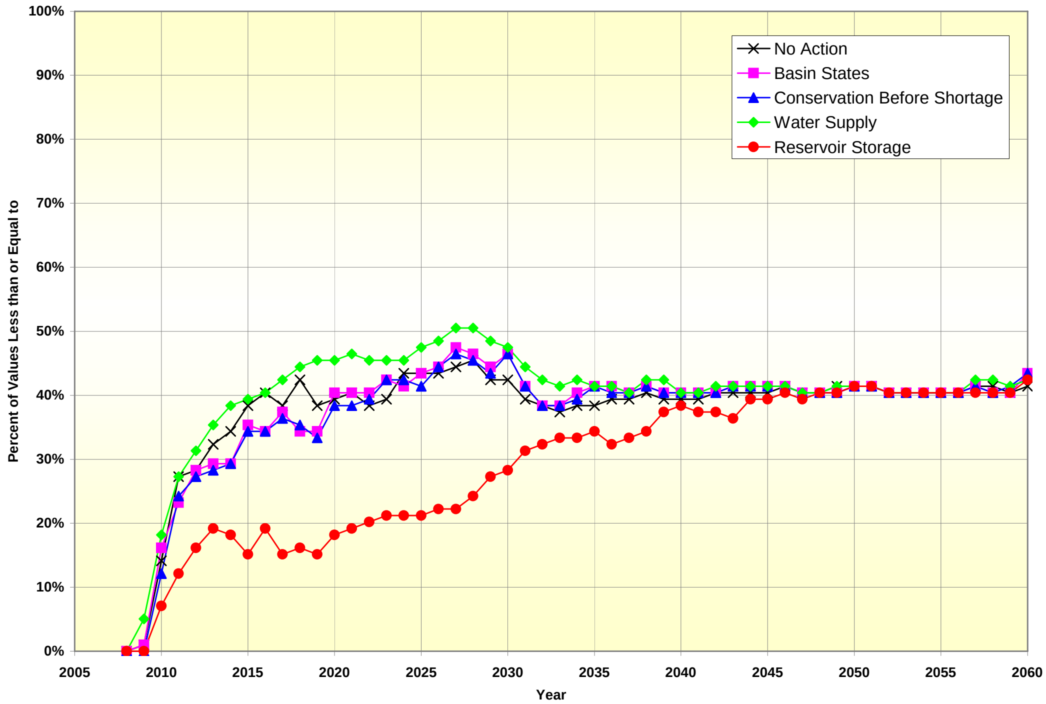


Table 4.3-21
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,080 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	40%	43%	42%	39%	41%	41%
Basin States	0%	34%	44%	46%	40%	41%	43%
Conservation Before Shortage	0%	34%	44%	46%	40%	41%	43%
Water Supply	0%	40%	48%	47%	40%	41%	42%
Reservoir Storage	0%	19%	22%	28%	38%	41%	42%

Figure 4.3-22 illustrates the frequency that Lake Mead end-of-July elevations would fall below elevation 1,050 feet msl. The Lake Mead elevation of 1,050 feet msl is the minimum elevation needed for efficient power generation at the Hoover Powerplant, the minimum elevation for operation of the upper intake of the SNWA and the minimum elevation for the Echo Bay Boat Launch. As illustrated in Figure 4.3-22, the water levels under the Basin States, Conservation Before Shortage, and Water Supply alternatives were observed to fall below elevation 1,050 feet msl less frequently than those under the No Action Alternative from 2016 through 2027. The water levels under the Reservoir Storage Alternative were observed to fall below elevation 1,050 feet msl less frequently than those under the No Action Alternative (lower by as much as 10 to 20 percent), reflecting higher reservoir elevations.

Figure 4.3-22
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,050 feet msl

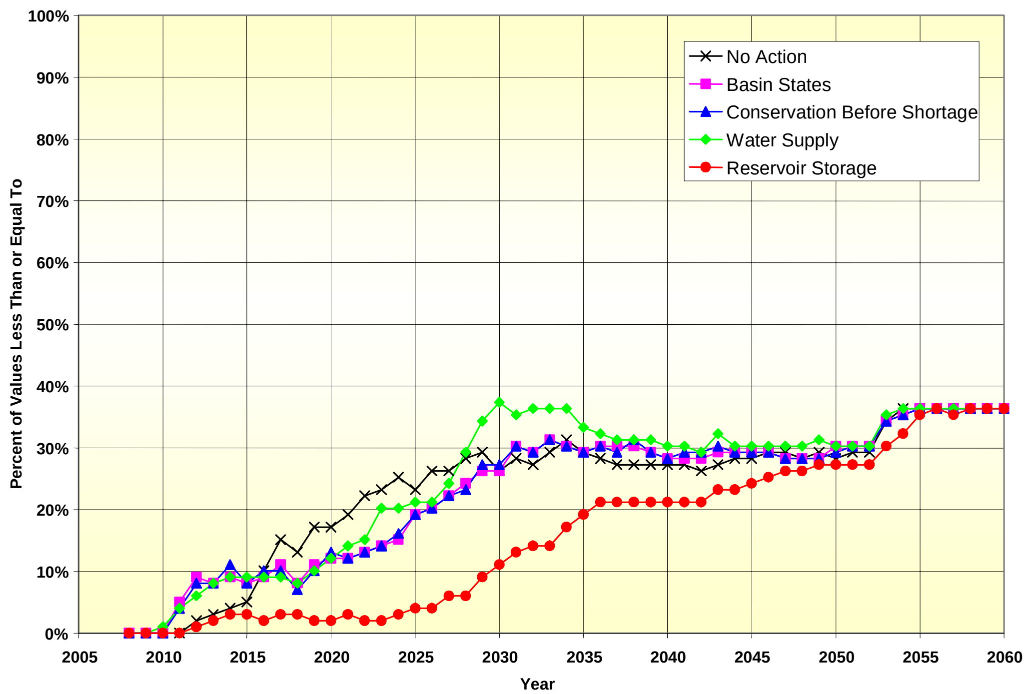


Table 4.3-22 provides a summary of the results illustrated in Figure 4.3-22 for the Lake Mead end-of-July elevation of 1,050 feet msl for selected years.

Table 4.3-22
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,050 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	10%	26%	26%	27%	28%	36%
Basin States	0%	9%	20%	26%	28%	30%	36%
Conservation Before Shortage	0%	10%	20%	27%	28%	29%	36%
Water Supply	0%	9%	21%	37%	30%	30%	36%
Reservoir Storage	0%	2%	4%	11%	21%	27%	36%

Figure 4.3-23 illustrates the frequency that Lake Mead end-of-July elevations would fall below elevation 1,000 feet msl. The Lake Mead elevation of 1,000 feet msl is the minimum elevation needed by the SNWA to pump water from Lake Mead through its lower intake. As illustrated in Figure 4.3-23, the Lake Mead end-of-July water levels under the No Action, Conservation Before Shortage, and Reservoir Storage alternatives do not fall below elevation 1,000 feet msl. The water levels under the Water Supply and Basin States alternatives do show some instances where the water levels fall below 1,000 feet msl, although the frequency and probability are low. The maximum observed probability for elevations falling below 1,000 feet msl under the Water Supply Alternative is six percent and occurs towards the end of the interim period. Under the Basin States Alternative, the maximum observed probability for elevations falling below 1,000 feet msl is two percent and also occurs toward the end of the interim period.

Table 4.3-23 provides a summary of the results illustrated in Figure 4.3-23 for the Lake Mead end-of-July elevation of 1,000 feet msl for selected years. The Water Supply and Basin States alternatives are the only alternatives that show instances where the water levels fall below elevation 1,000 feet msl, and they occur in year 2026.

Figure 4.3-23
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,000 feet msl

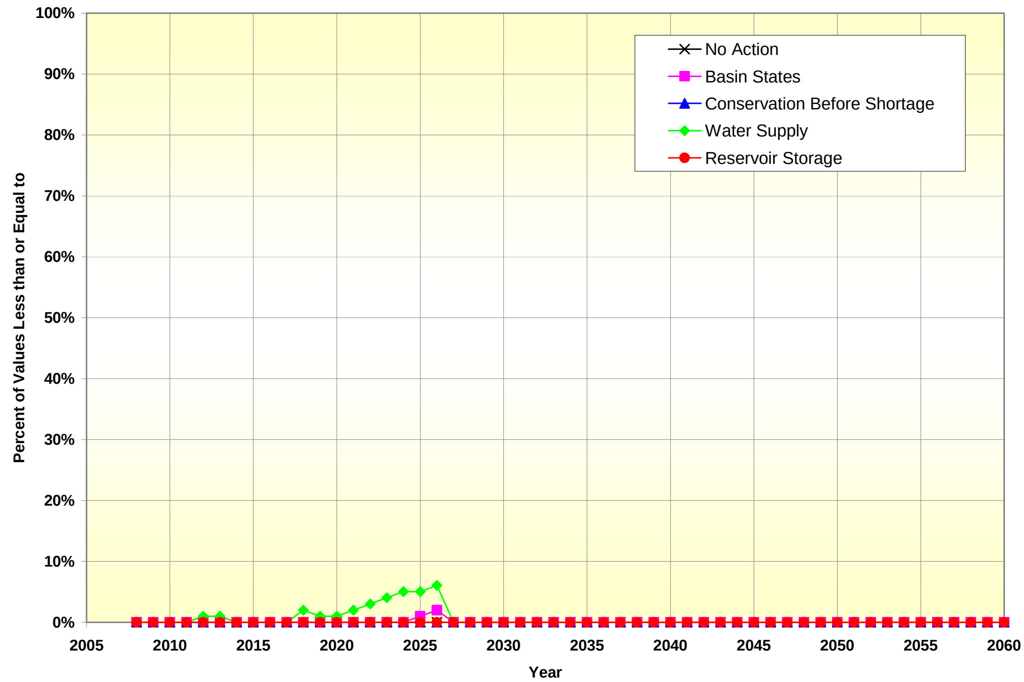


Table 4.3-23
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,000 feet msl

Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	0%	0%	0%	0%	0%	0%	0%
Basin States	0%	0%	2%	0%	0%	0%	0%
Conservation Before Shortage	0%	0%	0%	0%	0%	0%	0%
Water Supply	0%	0%	6%	0%	0%	0%	0%
Reservoir Storage	0%	0%	0%	0%	0%	0%	0%

Figure 4.3-24 illustrates the minimum Lake Mead end-of-July elevations that were observed in the modeling of the action alternatives and No Action Alternative during the period of analysis (2008 through 2060). The minimum lake elevations under the No Action Alternative never fall below Lake Mead elevation 1,000 feet msl throughout the period of analysis. Similarly, the minimum lake elevations under the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives never fall below Lake Mead elevation 1,000 feet

msl throughout the period of analysis. The minimum lake elevations under the Reservoir Storage Alternative are generally higher than those observed under the No Action Alternative. The minimum lake elevations under the Water Supply Alternative are generally lower than those observed under the No Action Alternative and fall below Lake Mead elevation 1,000 feet msl during the interim period. The minimum Lake Mead end-of-July elevation values under the action alternatives and the No Action Alternative all converge between 2027 through 2030 and generally remain at about 1,000 feet msl after 2030.

Figure 4.3-24
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Minimum Water Elevation Values (feet msl)

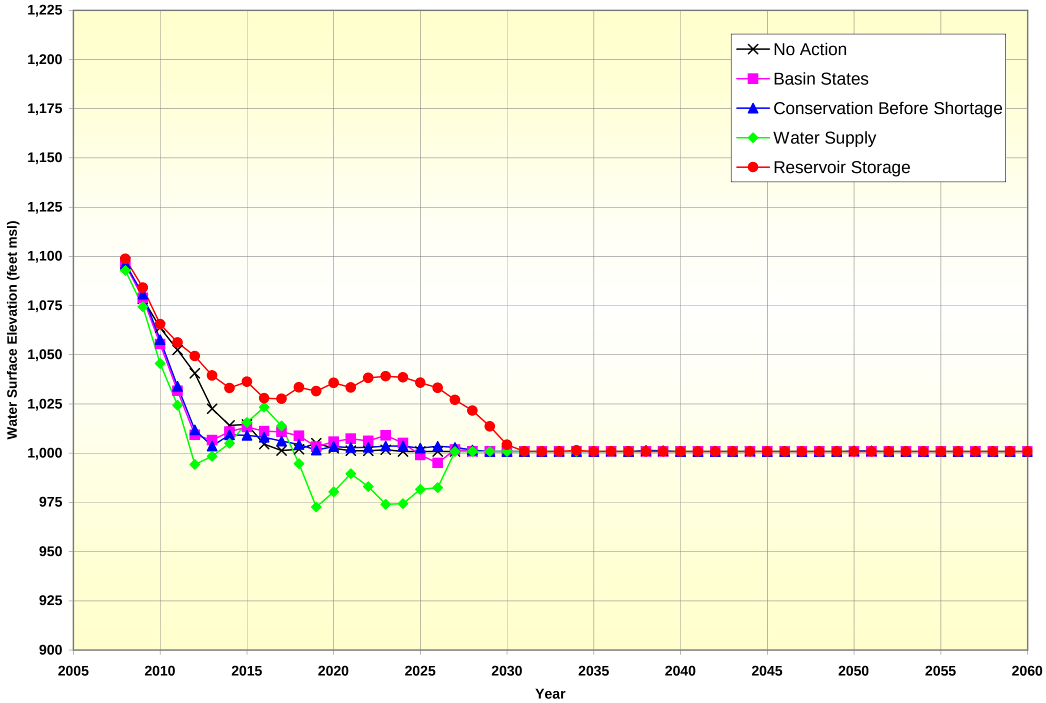


Table 4.3-24 provides a summary of the results illustrated in Figure 4.3-24 for the Lake Mead end-of-July minimum elevations. As shown on this table, the greatest variability between the action alternatives and the No Action Alternative occurs during the interim period. The Lake Mead elevations fall below elevation 1,000 feet msl under the Water Supply Alternative only.

Table 4.3-24
Lake Mead End-of-December Elevations
Comparison of Action Alternatives to No Action Alternative
Minimum Elevation Values (feet msl)

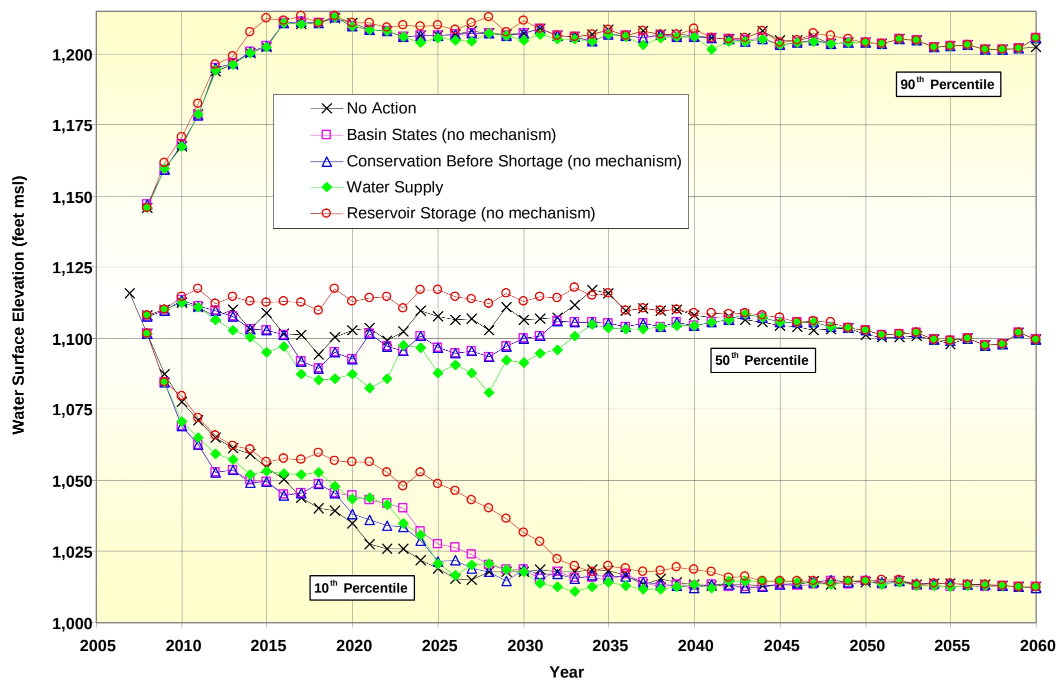
Alternatives	Year						
	2008	2016	2026	2030	2040	2050	2060
No Action	1,097.1	1,004.7	1,000.9	1,000.9	1,000.9	1,000.9	1,000.9
Basin States	1,095.7	1,011.3	995.0	1,000.9	1,000.9	1,000.9	1,000.9
Conservation Before Shortage	1,096.3	1,008.2	1,003.5	1,000.9	1,000.9	1,001.1	1,000.9
Water Supply	1,092.9	1,023.4	982.5	1,000.9	1,000.9	1,000.9	1,000.9
Reservoir Storage	1,098.8	1,028.0	1,033.2	1,004.2	1,000.9	1,000.9	1,000.9

4.3.4.1 Storage of Conserved Water in Lake Mead

One of the elements of the proposed federal action is a mechanism for the storage and delivery of conserved water and non-system waters in Lake Mead. The general concept of this proposed program is that water users would conserve water or secure non-system water which could then be stored in Lake Mead. One of the potential effects of this alternative is an increase in the amount of water that would remain in storage in Lake Mead. The three alternatives that include some form of the storage and delivery mechanism are the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives. The modeling results discussed previously for the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives all include the storage and delivery mechanism. The specific assumptions with respect to the storage and delivery mechanism considered and modeled under each of these alternatives are discussed in Section 4.2 and Appendix M.

A simulation was performed for each of these alternatives to isolate the effects of the storage and delivery mechanism on the behavior of the system. This was accomplished by holding all other assumptions constant and removing the storage and delivery mechanism. Figure 4.3-25 presents a comparison of the 90^{th}, 50^{th}, and 10^{th} percentile values observed for the action alternatives to those under the No Action Alternative. This figure illustrates the Lake Mead elevations for the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives if the storage and delivery mechanism is not in place. The Lake Mead elevations illustrated in Figure 4.3-25 for these alternatives can be contrasted to those shown in Figure 4.3-15 which shows the Lake Mead elevations for these alternatives if the storage and delivery mechanism is in place. As illustrated by this comparison, the inclusion of mechanism in these alternatives would have a tendency to provide higher Lake Mead elevations and also changes the relative difference of these alternatives to the No Action Alternative.

Figure 4.3-25
Lake Mead End-of-December Elevations
Comparison of Action Alternatives With Storage and Delivery Mechanism Removed to No Action Alternative
10th, 50th, and 90th Percentile Values



1

2 Figure 4.3-26 compares the 90th, 50th, and 10th percentile Lake Mead elevations for the
3 Basin States, Conservation Before Shortage, and Reservoir Storage alternatives with the
4 storage and delivery mechanism to the same alternatives without the mechanism.

Figure 4.3-26
Lake Mead End-of-December Elevations
Comparison of Action Alternatives With and Without a Storage and Delivery Mechanism
10th, 50th, and 90th Percentile Values

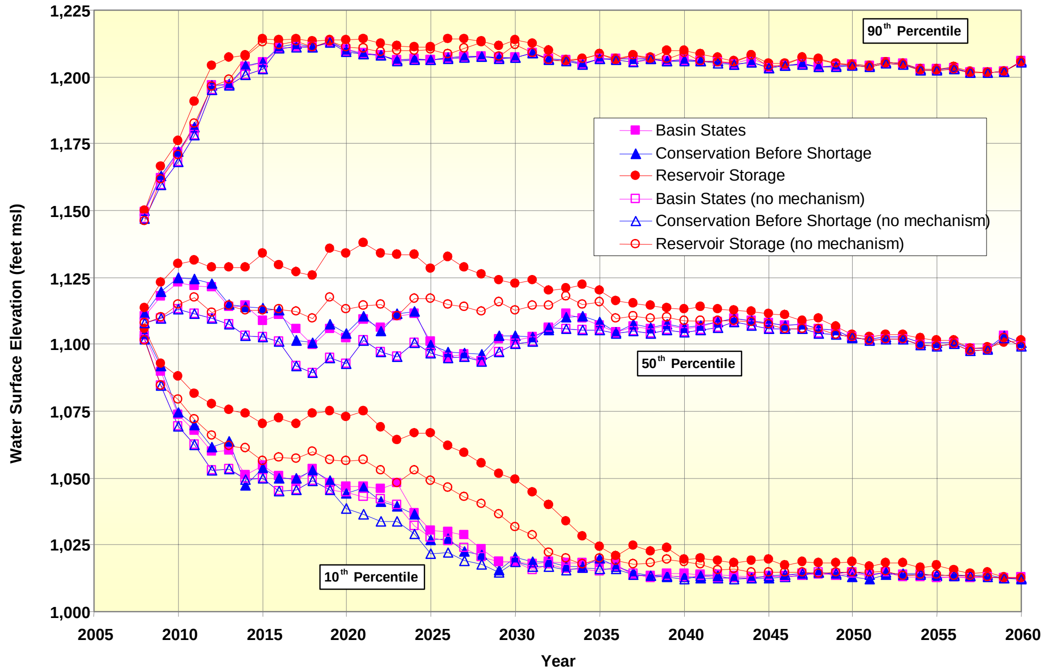


Table 4.3 25 provides a summary of the increases in Lake Mead elevations for selected years that can be attributed to the inclusion of the storage and delivery mechanism in the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives. As shown on this figure and table, for the 50th and 10th percentile values, the storage and delivery mechanism could potentially provide higher Lake Mead elevations, by as much as 17.8 feet under the Reservoir Storage Alternative, 11.6 feet under the Conservation Before Shortage Alternative, and nearly ten feet under the Basin States Alternative.

Table 4.3-25
Increase / Decrease ( ) in Lake Mead Elevations (feet msl) Resulting From a Storage and Delivery Mechanism
Comparison of Action Alternatives With and Without a Storage and Delivery Mechanism
90th, 50th, and 10th Percentile Values

Year	Basin States			Conservation Before Shortage			Reservoir Storage		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
2008	2.4	2.7	1.3	3.0	3.7	2.4	4.0	5.5	4.2
2016	(0.6)	9.9	5.7	0.1	11.6	5.1	1.9	16.5	14.8
2026	0.2	0.5	3.8	0.2	2.3	5.4	5.5	17.8	15.9
2030	0.2	1.3	0.1	0.2	3.3	1.8	1.9	9.8	17.6
2040	0.7	1.3	1.3	0.1	1.6	0.7	0.8	4.5	0.7
2050	0.4	(0.5)	0.1	0.4	(0.5)	(1.8)	0.4	0.8	3.8
2060	0.2	1.1	0.5	0.2	1.1	0.4	0.2	2.1	0.3

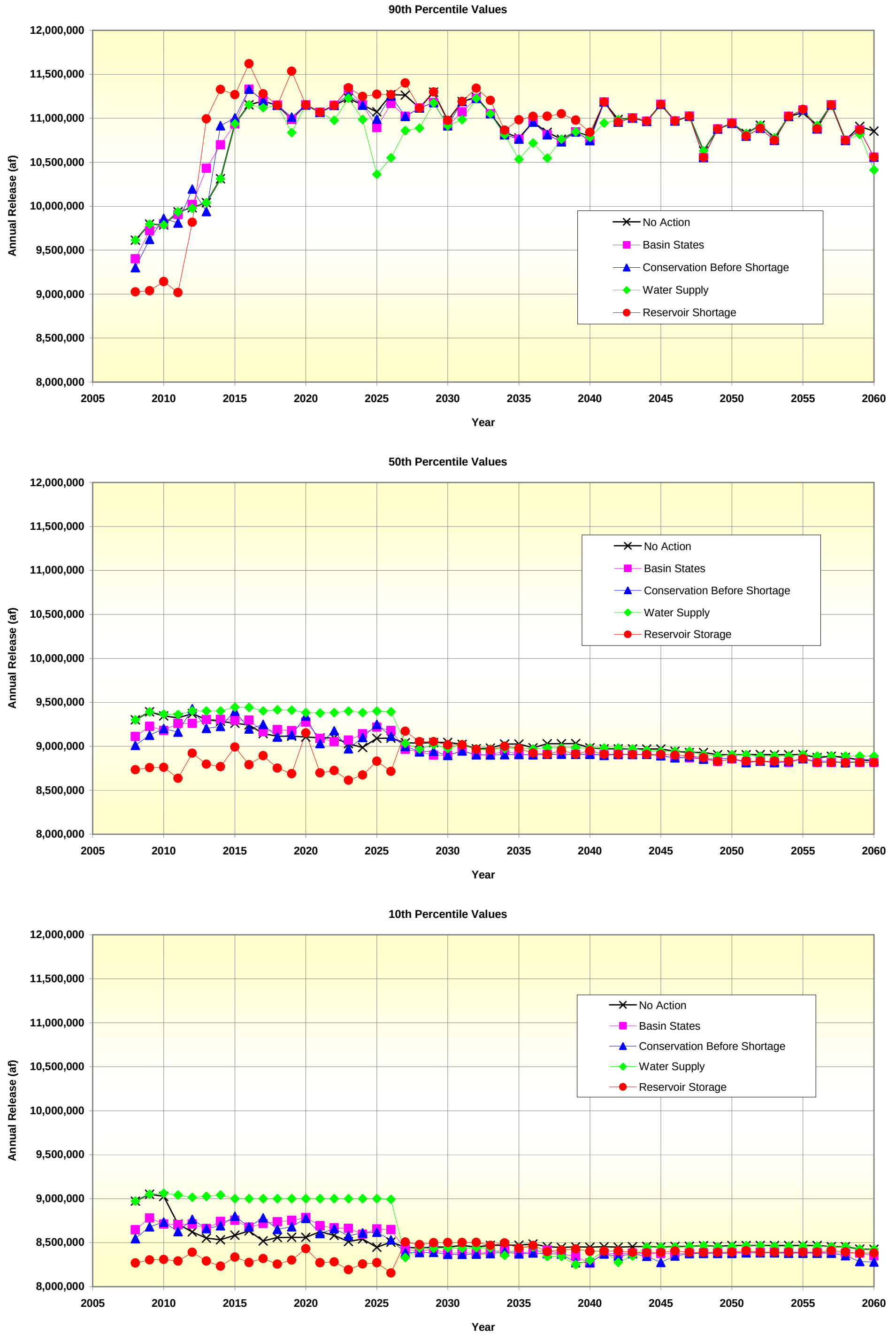
4.3.5 Hoover Dam to Davis Dam

The river flows between Hoover Dam and Lake Mohave are comprised mainly of releases from Hoover Dam (Lake Mead) and tributary inflows. These inflows, mostly from side washes, comprise less than one percent of the total annual flow in this reach. During the 10-year period between 1996 and 2005, the annual Hoover Dam releases have ranged between 8.274 maf and 12.774 maf and averaged 10.415 maf.

As noted in Section 3.3, future annual and monthly releases may be affected by the proposed federal action. Each alternative may alter the probability (when compared to the No Action Alternative) of the magnitude and timing of particular releases. However, as expressed in Section 3.3, due to the presence of Lake Mohave immediately downstream, these potential changes in releases will have an effect only on hydropower generation.

Figure 4.3-27 presents a comparison of the 90th, 50th, and 10th percentile values observed under the No Action and action alternatives for Hoover Dam annual (calendar year) releases. The greatest variability between the action alternatives and No Action Alternative generally occurs during the period between 2008 and 2026. Also, the greatest variability occurs between the Reservoir Storage Alternative and No Action Alternative and is consistent with the underlying strategy of the Reservoir Storage Alternative which is to maintain more water in storage. This is facilitated through more frequent voluntary and involuntary delivery reductions and is reflected in the 50th and 10th percentile values which are lower for this alternative between 2008 and 2026. Since more water is held in storage, as compared to the No Action Alternative, the Reservoir Storage Alternative provides more opportunities for more frequent and higher flood/surplus releases, which is reflected in the 90th percentile values for this alternative. In contrast, the strategy of the Water Supply Alternative is to meet the water users' delivery requirements with less regard to preserving water in storage. As such, the 50th and 10th percentile values under the Water Supply Alternative show that more water is delivered under this alternative between 2008 and 2026, as compared to the No Action Alternative. The range of water releases that occur under the Basin States and Conservation Before Shortage alternatives generally coincides with the range of releases under the No Action Alternative.

Figure 4.3-27
Hoover Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values



Another observation relates to the 50th and 10th percentile annual Hoover Dam release volumes that are consistently lower under the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives as compared to the No Action Alternative after 2026. This difference can be attributed to the assumption that SNWA would develop additional permanent non-system water supplies.

Figure 4.3-28 illustrates the cumulative distribution of Hoover Dam annual releases under the No Action and action alternatives for years 2008 through 2060. The observed annual releases under all the alternatives (including the No Action Alternative) fluctuate between 7.45 maf to about 17.3 maf. The lowest minimum annual release is 6.73 maf and occurs under the Water Supply Alternative, although it only occurs about one percent of the time.

Figure 4.3-28
Hoover Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
Years 2008 through 2060

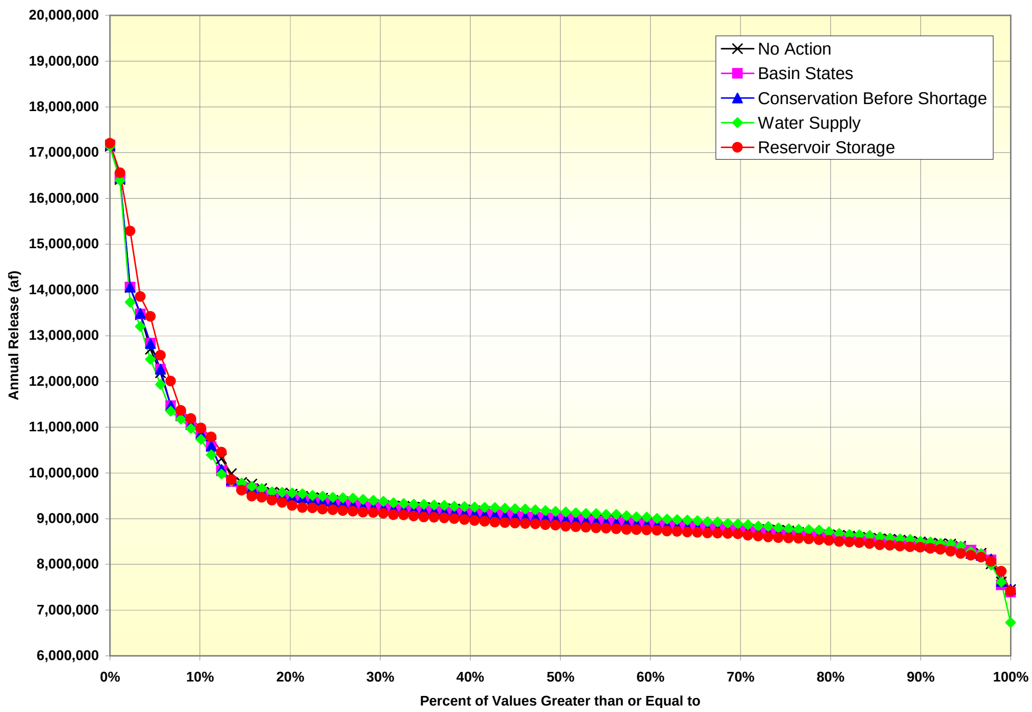


Table 4.3-26 provides a summary of the distribution of the Hoover Dam releases within different flow ranges of interest. As shown on this table, the Hoover Dam releases in the range identified as typical under Normal conditions (i.e. 8.5 mafy to 9.5 mafy) are similar under all the alternatives. The greatest variability between the action alternatives and the No Action Alternative occurs in the frequency of releases that are greater than 9.5 mafy and those between 7.50 and 8.49 mafy.

Table 4.3-26
Hoover Dam Annual Releases
Probability of Occurrence of Different Annual Release Volumes
Comparison of Action Alternatives to No Action Alternative
Calendar Years 2008 through 2060

Hoover Dam Release Volumes	Alternative				
	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
Greater than 9.50 mafy	20.2%	18.0%	18.0%	22.5%	14.6%
Between 8.50 to 9.50 mafy	68.6%	68.6%	66.3%	67.5%	65.2%
Between 7.50 to 8.49 mafy	10.1%	12.4%	14.6%	9.0%	19.1%
Less than 7.5 mafy	1.0%	1.0%	1.0%	1.0%	1.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

4.3.5.1 Lake Mohave Water Levels

Lake Mohave is operated under a rule curve that provides specific "target elevations" at the end of each month (Section 3.3). The same rule curve would be used and applied in the future operations under the No Action Alternative and the action alternatives. Therefore, end-of-month elevations in Lake Mohave are not affected by the proposed federal action.

4.3.6 Davis Dam to Parker Dam

4.3.6.1 River Flows

The flows between Davis Dam and Parker Dam are comprised mainly of releases from Davis Dam (Lake Mohave) and tributary inflows from the Bill Williams River. During the 10-year period between 1996 and 2005, the annual Davis Dam releases have ranged between 8.1 maf and 12.6 maf and averaged 10.2 maf. Releases greater than 9.5 maf generally correspond to years when surplus or flood flow releases are made at Hoover Dam and are passed through Lake Mohave. Flows less than 8.5 maf are associated with voluntary or involuntary delivery reductions to water users in the Lower Basin.

Figure 4.3-29 presents a comparison of the 90th, 50th, and 10th percentile values observed for the action alternatives to those under the No Action Alternative. The values and variability of the 90th, 50th, and 10th percentile values under the No Action Alternative and action alternatives are similar to those in Figure 4.3-27 (Hoover Dam releases) because the releases from Hoover Dam are passed through Lake Mohave. The differences are losses that are attributed to evaporation at Lake Mohave, which would be the same in all of the alternatives due to rule curve operations.

Figure 4.3-29
Davis Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

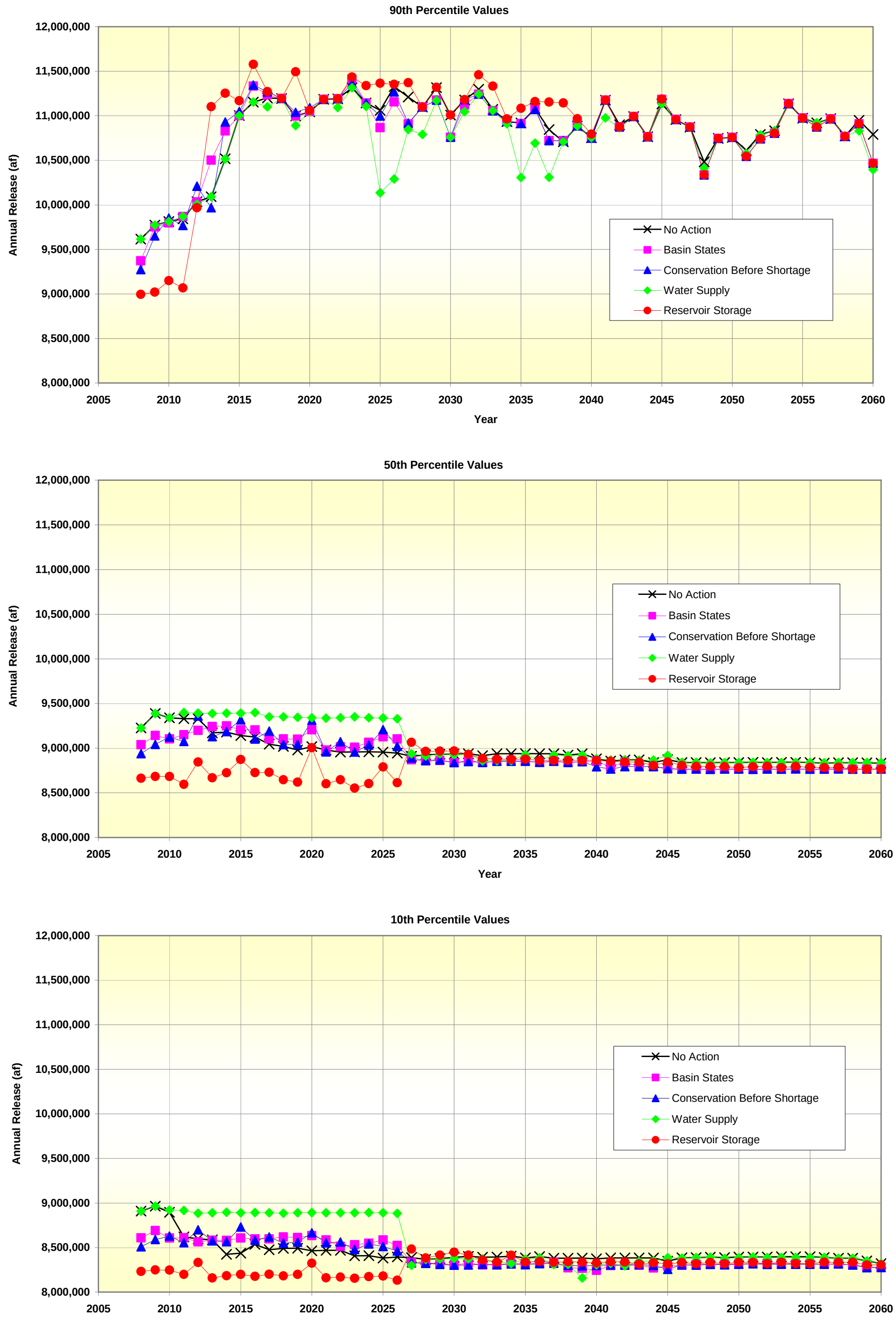
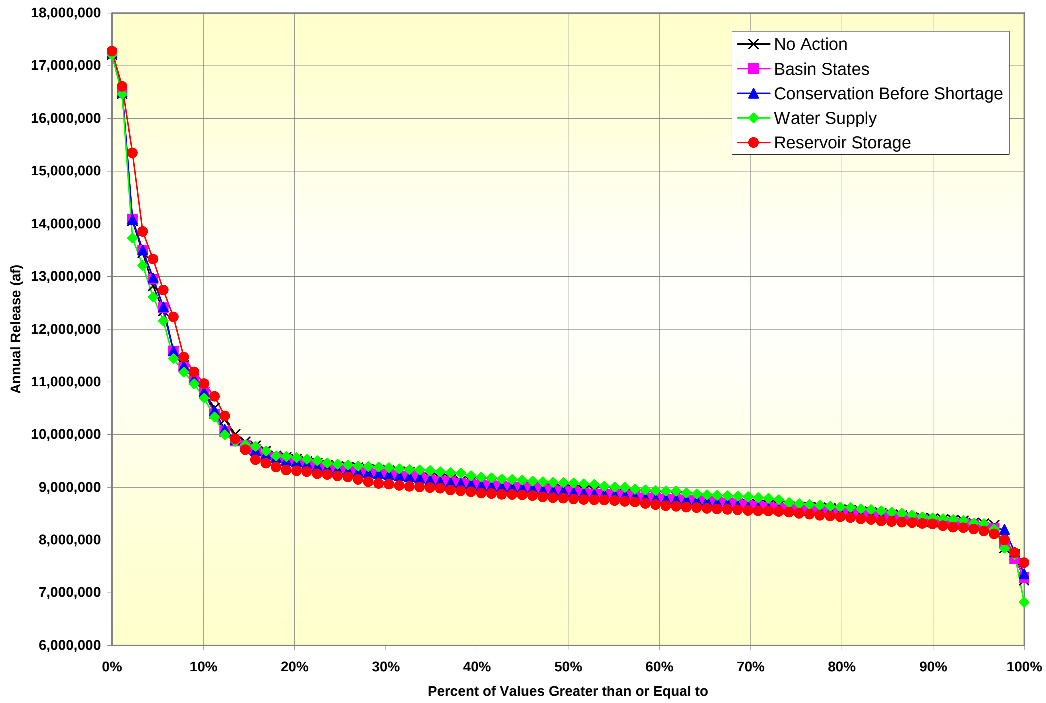


Figure 4.3-30 illustrates the cumulative distribution of the Davis Dam releases for the No Action Alternative and the action alternatives for the period 2008 through 2060. The range and frequency of the releases under the different alternatives are similar to those shown in Figure 4.3-28. Again, the reason for this is that releases from Hoover Dam are passed through Lake Mohave.

Figure 4.3-30
Davis Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
Years 2008 through 2060

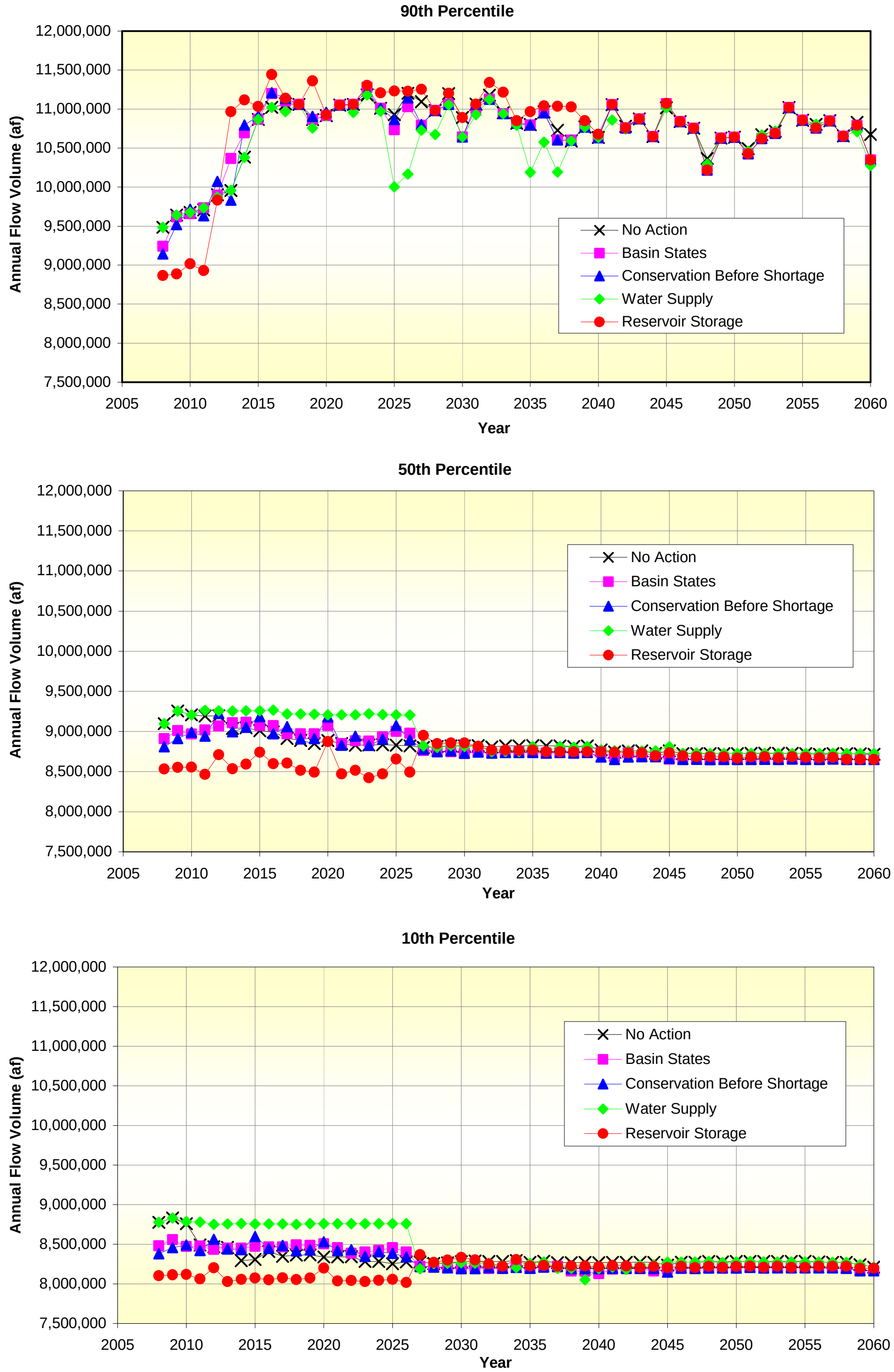


4.3.6.2 Colorado River Annual Flow Near Havasu NWR

A point located immediately downstream of the Havasu NWR was used to further analyze the river flows for this reach.

The 90^{th}, 50^{th}, and 10^{th} percentile annual flow volumes at this point are shown in Figure 4.3-31. The 90^{th} percentile for the Basin States, Conservation Before Shortage, and Water Supply alternatives were similar to those of the No Action Alternative. However, the values for the Water Supply Alternative periodically fell below those of the No Action Alternative during the period between 2025 through 2039. The 90^{th} percentile values for the Reservoir Storage Alternative fluctuated above and below those of the No Action Alternative from about 2008 to 2019.

Figure 4.3-31
Colorado River Annual Flow Near Havasu NWR - RM 242.3 (af)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values



The 50th percentile values of the Water Supply Alternative were similar to those under the No Action Alternative for the initial 5 years and then were higher by an average of about 250 kafy for the period between 2013 through 2026. This is a direct result of there being essentially no shortages under the Water Supply Alternative during the interim period. The 50th percentile flows of the Basin States and Conservation Before Shortage alternatives were similar to those of the No Action Alternative. The 50th percentile values of the Reservoir Storage Alternative were on average about 450 kaf lower than the No Action Alternative during the interim period (through 2026) and thereafter were similar to those of the No Action Alternative. During the interim period, the Reservoir Storage Alternative maintains more water in storage through more frequent shortages. At the 10th percentile level, although the magnitudes of the annual flows of all the alternatives are generally lower by about 500 kaf, the relative changes in flow volumes of the action alternatives compared to the No Action Alternative are similar to those at the 50th percentile level.

Table 4.3-27 provides a comparison of the 90th, 50th, and 10th percentile annual flow volumes between the action alternatives and the No Action Alternative for selected years.

Table 4.3-27
Colorado River Annual Flow Near Havasu NWR - RM 242.3 (maf)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

Alternative	Year 2016			Year 2026			Year 2040			Year 2060		
	90th	50th	10th	90th	50th	10th	90th	50th	10th	90th	50th	10th
No Action	11.021	8.992	8.409	11.202	8.822	8.276	10.636	8.770	8.267	10.673	8.716	8.212
Basin States	11.200	9.070	8.467	11.030	8.979	8.404	10.633	8.739	8.129	10.348	8.652	8.167
Conservation Before Shortage	11.212	8.970	8.448	11.144	8.896	8.341	10.633	8.682	8.192	10.348	8.652	8.167
Water Supply	11.021	9.265	8.758	10.166	9.205	8.759	10.636	8.770	8.194	10.278	8.724	8.212
Reservoir Storage	11.443	8.597	8.053	11.228	8.492	8.018	10.677	8.746	8.217	10.348	8.652	8.198

4.3.6.3 Groundwater

As discussed in Section 3.3, the flows in the Davis Dam to Parker Dam reach are primarily composed of water released from Davis Dam. Therefore, the annual median releases are representative of the annual median flows in the reach. When converted to stage, a comparison of the annual median releases for each alternative may be used as the indicator to analyze potential effects to groundwater adjacent to the river in this reach.

Figure 4.3-32 illustrates the annual median releases from Davis Dam for each alternative for the years 2008 through 2060. These are the same data shown in Figure 4.3-29 converted from acre-feet per year to cubic feet per second. In general, the median releases for the Water Supply and Reservoir Storage alternatives bracket the median releases for the other three alternatives due primarily to the different shortage assumptions for each of the alternatives. Table 4.3-28 compares the annual median values relative to the No Action Alternative for specific years (each action alternative value less the No Action Alternative value). Using appropriate relationships to convert flow-to-stage (LCR MSCP BA, Appendix J, Attachment D), these relative flow differences would result in minor reductions in river stage (on the order of 0.5 feet). Based on the relationships used in the LCR MSCP BA, Appendix K, such river stage reductions would result in corresponding reductions in groundwater elevations adjacent to the river (approximately 0.25 feet to 0.5 feet for gaining and losing reaches respectively).

Figure 4.3-32
Davis Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
Annual Median (50th Percentile) Values (cfs)

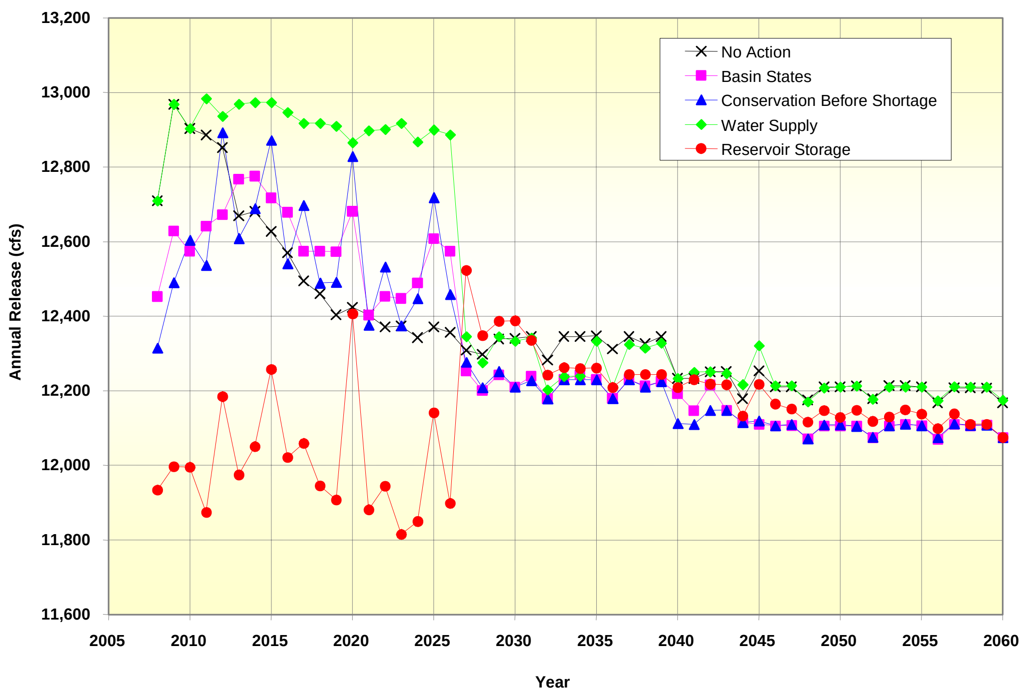


Table 4.3-28
Davis Dam Annual Median Releases
Differences of Action Alternatives Compared to No Action Alternative[1] (cfs)

Year	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	NA	-257	-395	0	-776
2011	NA	-245	-350	98	-1012
2016	NA	109	-29	377	-548
2017	NA	80	203	423	-435
2026	NA	217	102	530	-459
2027	NA	-56	-32	37	214
2040	NA	-41	-121	0	-24
2060	NA	-92	-92	7	-92

1 Value of Action Alternative minus the value from the No Action Alternative provides the difference shown. A negative value indicates that the value under the Action Alternative is lower than that of the No Action Alternative, i.e. a flow reduction.

4.3.6.4 Lake Havasu Water Levels

Similar to Lake Mohave, Lake Havasu is also operated under a rule curve. This method of operation provides specific "target elevations" at the end of each month (Section 3.3). The same rule curve would be used and applied in the future operations under the No Action Alternative and the action alternatives. Therefore, end-of-month elevations of Lake Havasu are not affected by the proposed federal action.

4.3.7 Parker Dam to Cibola Gage and Cibola Gage to Imperial Dam

As discussed in Section 3.3, Parker Dam provides the last opportunity to re-regulate Hoover Dam releases because Lake Havasu is the last facility in the lower Colorado River with significant storage. Releases from Parker Dam are made primarily to meet downstream water demands. Once released from Parker Dam, the flow is essentially unregulated until it reaches Imperial Dam.

4.3.7.1 River Flows

The river flows in this reach are essentially the releases from Parker Dam. Releases greater than 7.0 maf generally correspond to years when flood flow releases are being made from Hoover Dam and these flows are passed through Davis Dam and Parker Dam. Releases less than 6.0 maf are generally associated with delivery reductions, which occur more frequently under the Conservation Before Shortage and Reservoir Storage alternatives than under the No Action Alternative.

Figure 4.3-33 presents a comparison of the 90th, 50th, and 10th percentile lines for Parker Dam annual releases under the alternatives. The 90th percentile values represent releases due to flood control operations. The Reservoir Storage Alternative tends to release greater volumes during flood control when compared to the other alternatives since it keeps Lake Mead water levels higher. Beyond year 2045 all flow volumes converged to a release of about 7.40 maf. At the 50th percentile, the Basin States, Conservation Before Shortage and Reservoir Storage alternatives had less release volume than the No Action Alternative until the year 2026. The Water Supply Alternative generally released more volume over that same period. At year 2027, all alternatives converged to about 6.50 maf, with differences due to the assumption that SNWA would develop additional non-system water supplies that are permanent. The comparison of the 10th percentile showed similar results that mirror the 50th percentile values, except the release volumes were about 6.25 maf.

Figure 4.3-34 illustrates the cumulative distribution for the Parker Dam annual releases for the period of 2008 through 2060. The releases under the No Action Alternative range between 14.0 maf to 5.96 maf. The releases under the Basin States and Water Supply alternatives were similar to those observed under the No Action Alternative. The releases under the Conservation Before Shortage and Reservoir Storage alternatives had the lowest releases, 5.60 and 5.35 maf, respectively.

Figure 4.3-33
Parker Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

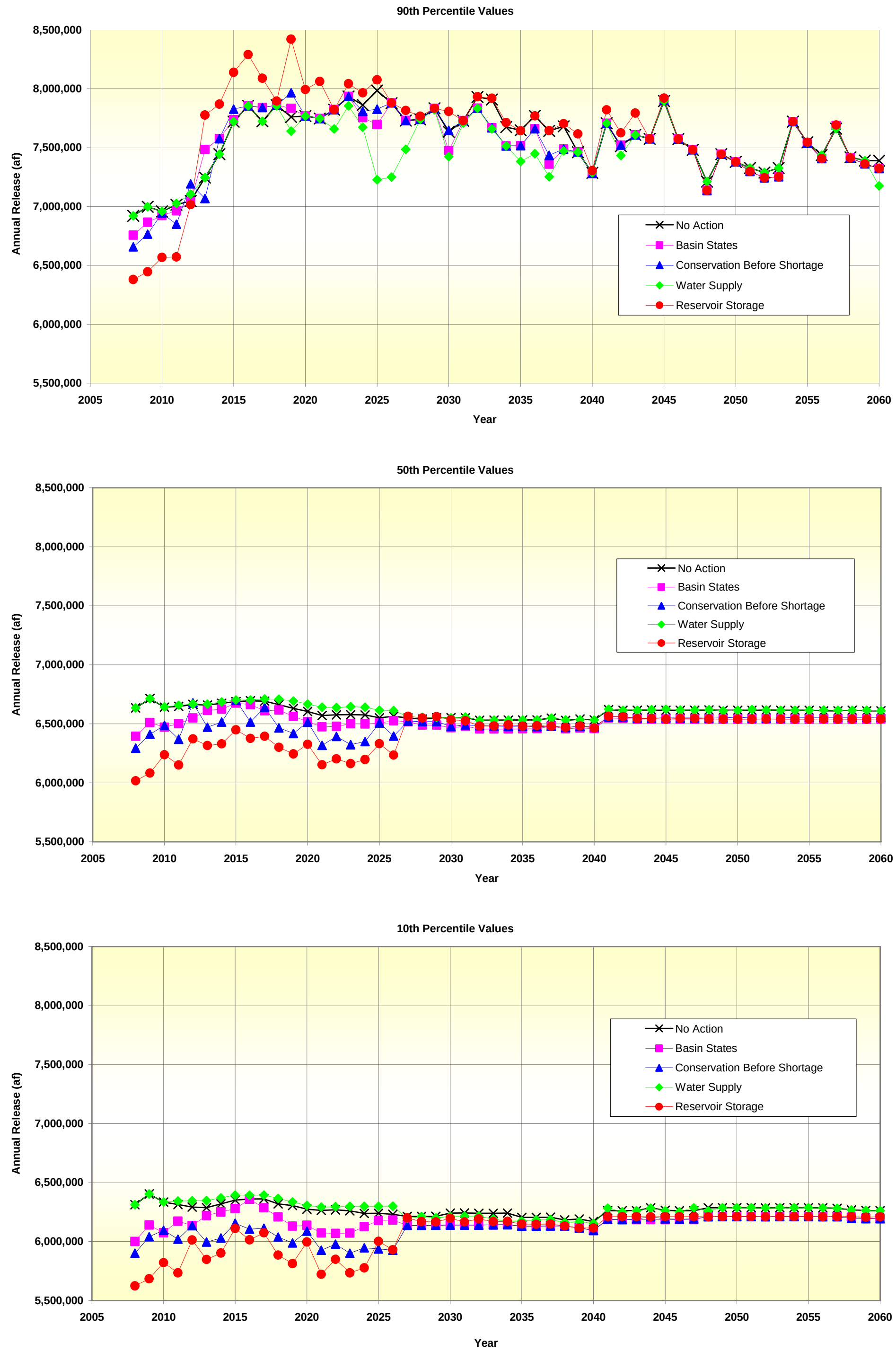
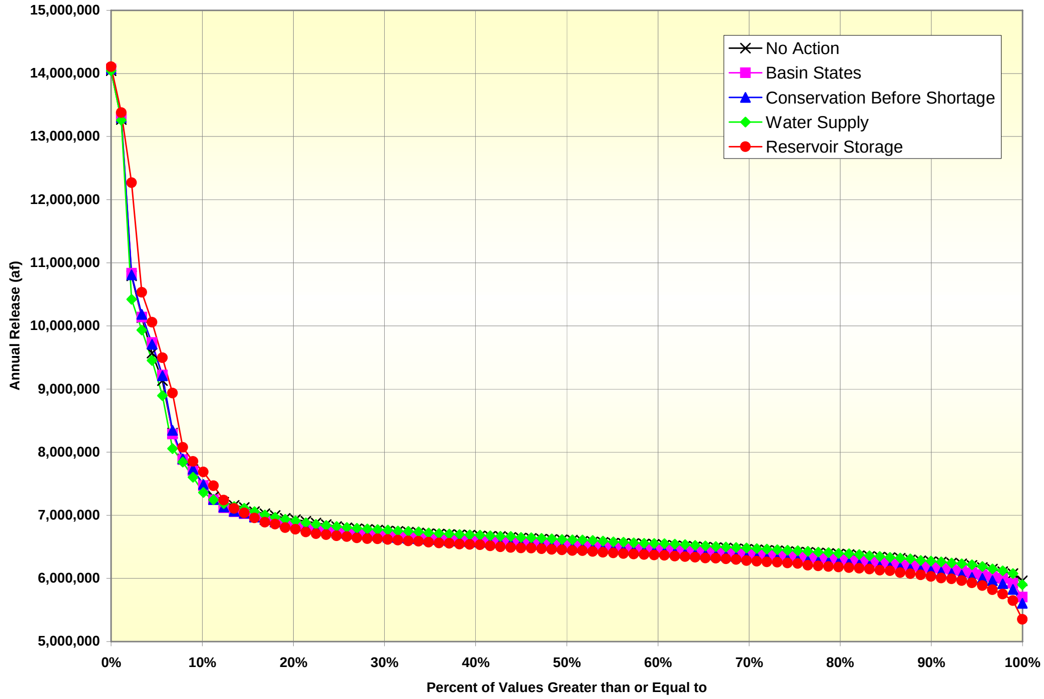


Figure 4.3-34
Parker Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
Years 2008 through 2060



River Flows Near the Colorado River Indian Reservation. Two other points on the Colorado River were used to analyze flows in the reach between Parker Dam and Imperial Dam. These include a point located immediately upstream of the Colorado River Indian Reservation (CRIR) and a point located immediately downstream of the Palo Verde Diversion Dam.

The CRIR diversion is located at Headgate Rock Dam, approximately 14 miles below Parker Dam. Flows in this reach of the river result primarily from releases at Parker Dam and would be affected by delivery reductions to water users located downstream from this location.

Figure 4.3-35 illustrates that the 90th, 50th, and 10th percentile annual flow values at this location generally reflect the releases from Parker Dam, as shown on Figure 4.3-33. Since there is no significant storage capacity above Headgate Rock Dam, the differences between the flows at this location and the Parker Dam releases are due only to the attenuation of the flows that occurs in the 14 miles of river within this reach.

Figure 4.3-35
Colorado River Annual Flow Upstream of CRIR Diversion - RM 180.8 (af)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

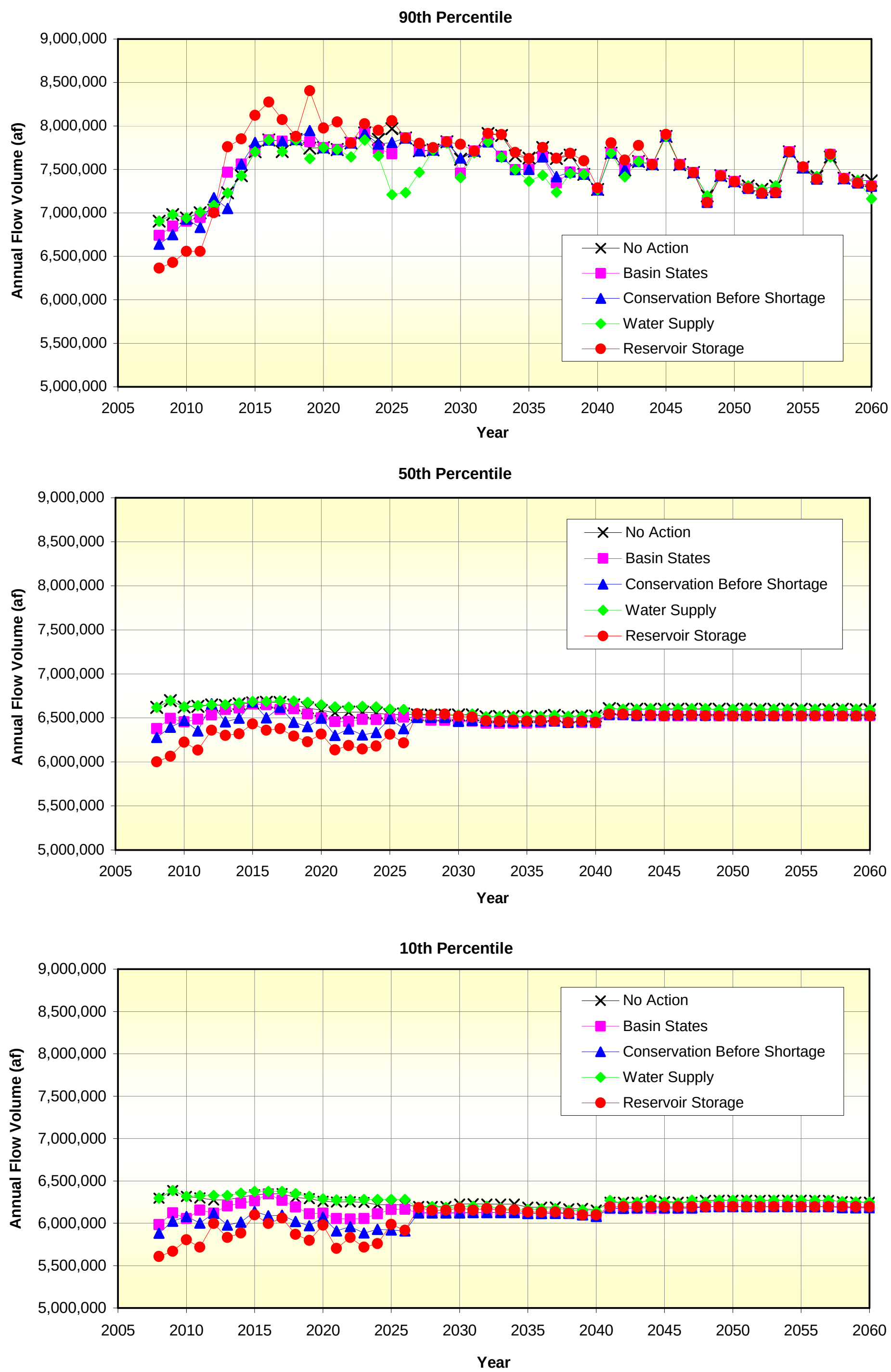


Table 4.3-29 provides a comparison of the 90th, 50th, and 10th percentile annual flow volumes upstream of the CRIR Diversion among the alternatives for selected years.

Table 4.3-29
Colorado River Annual Flow Upstream of CRIR Diversion - RM 180.8 (mafy)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

Alternative	Year 2016			Year 2026			Year 2040			Year 2060		
	90th	50th	10th	90th	50th	10th	90th	50th	10th	90th	50th	10th
No Action	7.838	6.678	6.347	7.861	6.546	6.216	7.269	6.520	6.156	7.371	6.592	6.248
Basin States	7.838	6.650	6.346	7.863	6.509	6.166	7.263	6.445	6.081	7.307	6.524	6.185
Conservation Before Shortage	7.838	6.500	6.088	7.863	6.378	5.909	7.263	6.467	6.081	7.307	6.541	6.183
Water Supply	7.838	6.685	6.375	7.232	6.596	6.281	7.269	6.520	6.141	7.163	6.592	6.248
Reservoir Storage	8.274	6.359	5.997	7.863	6.217	5.916	7.287	6.449	6.100	7.308	6.524	6.195

River Flows Downstream of the Palo Verde Diversion Dam. The flow of the Colorado River between Palo Verde Diversion Dam and Imperial Dam is normally the amount needed to meet both the United States diversion requirements downstream of the Palo Verde Diversion and deliveries to Mexico. The river location that was used to analyze the flows in the reach of the river between Palo Verde Diversion and Imperial Dam is located immediately downstream of the Palo Verde Diversion.

The 90th, 50th, and 10th percentile annual flow volumes for the Colorado River at this point are shown on Figure 4.3-36. The greatest variability between alternatives occurs during the interim period (2008 through 2026). After 2026, the action alternatives converge to the No Action Alternative.

The 90th percentile flow volumes for the action alternatives were generally similar to those of the No Action Alternative, although there was some variability observed under the Water Supply and Reservoir Storage alternatives. The greatest variability occurs during the interim period and reflects the difference in the assumptions with regard to shortage and water conservation.

The 50th percentile annual flow volumes for all alternatives are generally similar with the Reservoir Storage Alternative having the lowest values.

At the 10th percentile level, the Water Supply Alternative shows slightly higher flow volumes compared to the No Action Alternative. The Basin States, Conservation Before Shortage, and Reservoir Storage alternatives show progressively lower flow volumes than the No Action Alternative.

Figure 4.3-36
Colorado River Annual Flow Downstream of Palo Verde Diversion Dam - RM 133.8 (af)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

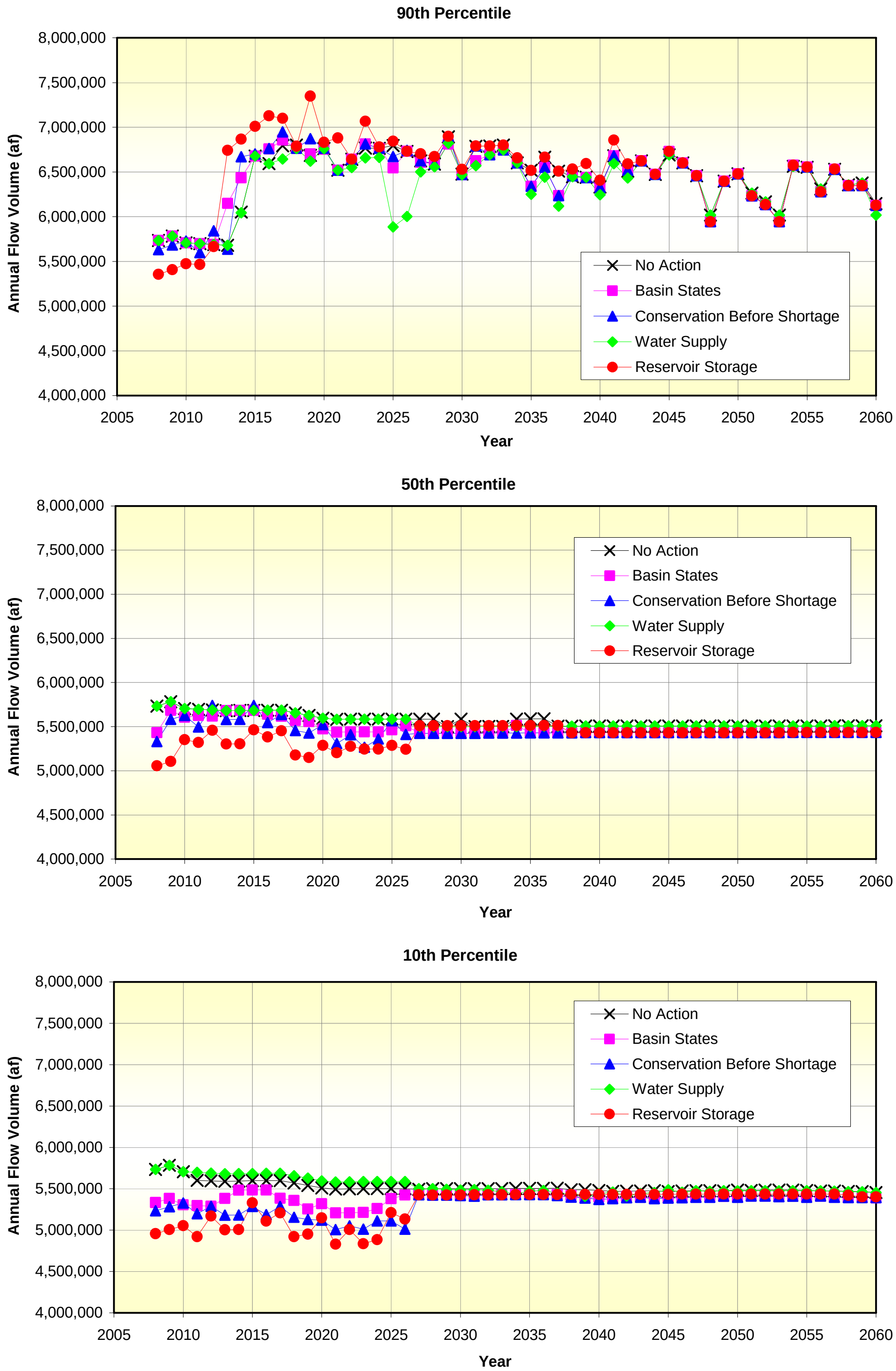


Table 4.3-30 provides a comparison of the 90th, 50th, and 10th percentile annual flow volumes downstream of the Palo Verde Diversion Dam.

Table 4.3-30
Colorado River Annual Flow Downstream of Palo Verde Diversion Dam - RM 133.8 (maf)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

Alternative	Year 2016			Year 2026			Year 2040			Year 2060		
	90th	50th	10th	90th	50th	10th	90th	50th	10th	90th	50th	10th
No Action	6.592	5.685	5.598	6.730	5.586	5.500	6.334	5.508	5.478	6.147	5.509	5.453
Basin States	6.758	5.641	5.485	6.731	5.511	5.423	6.326	5.433	5.402	6.126	5.434	5.389
Conservation Before Shortage	6.762	5.547	5.185	6.741	5.411	5.011	6.326	5.433	5.370	6.126	5.434	5.392
Water Supply	6.592	5.685	5.685	6.003	5.586	5.586	6.245	5.508	5.440	6.019	5.509	5.453
Reservoir Storage	7.128	5.384	5.109	6.731	5.244	5.134	6.407	5.433	5.433	6.127	5.434	5.402

4.3.7.2 Groundwater

As discussed in Section 3.3, the flows in the Parker Dam to Imperial Dam reach are primarily composed of water released from Parker Dam and therefore, the annual median releases are representative of the annual median flows in each reach. When converted to stage, a comparison of the annual median releases for each alternative may be used as the indicator to analyze potential effects to groundwater adjacent to the river in this reach.

Figure 4.3-37 illustrates the annual median releases from Parker Dam for each alternative for the years 2008 through 2060. As was the case for Davis Dam, the median releases for the Water Supply and Reservoir Storage alternatives bracket the median releases for the other three alternatives due primarily to the different shortage assumptions for each of the alternatives. Table 4.3-31 compares the annual median values relative to the No Action Alternative for specific years (each action alternative value less the No Action Alternative value). Using appropriate relationships to convert flow-to-stage (LCR MSCP BA, Appendix J, Attachment D), these relative flow differences would result in minor reductions in river stage (on the order of 0.25 feet). Based on the relationships used in the LCR MSCP BA ,Appendix K, such river stage reductions would result in corresponding reductions in groundwater elevations adjacent to the river (approximately 0.15 feet to 0.30 feet reduction for gaining and losing reaches respectively).

Figure 4.3-37
Parker Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
Annual Median (50th Percentile) Values

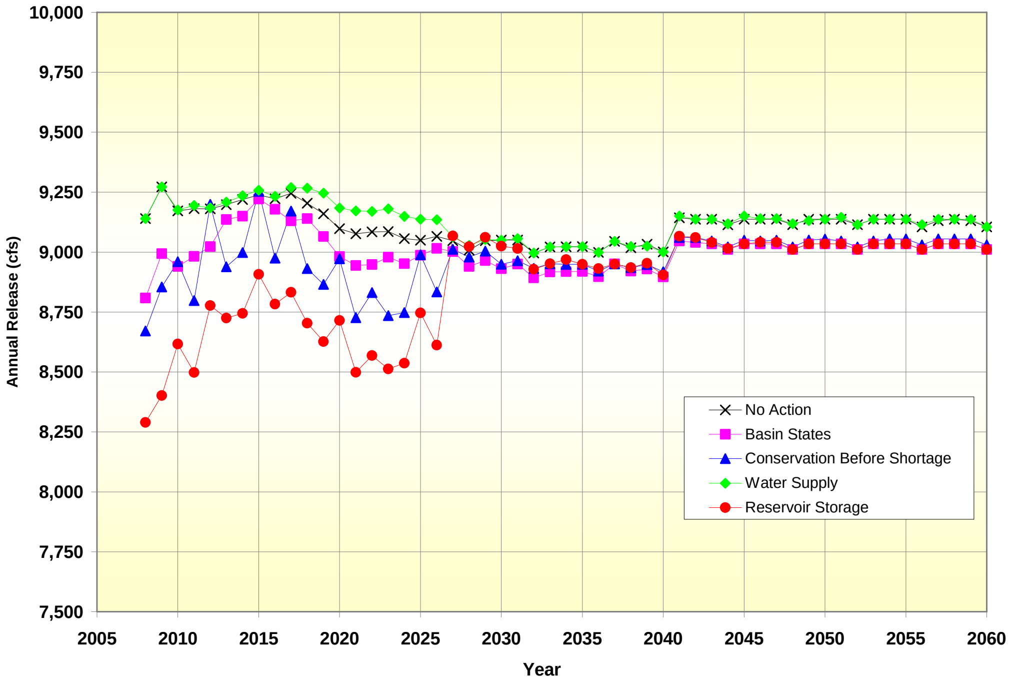


Table 4.3-31
Parker Dam Annual Median Releases
Differences of Action Alternatives Compared to No Action Alternative[1], (cfs)

Year	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	NA	-331	-469	0	-850
2011	NA	-200	-383	13	-684
2016	NA	-44	-248	10	-439
2017	NA	-115	-74	24	-413
2026	NA	-51	-232	69	-454
2027	NA	-45	-37	16	20
2040	NA	-103	-82	0	-96
2060	NA	-95	-75	0	-95

1 Value of Action Alternative minus the value from the No Action Alternative provides the difference shown. A negative value indicates that the value under the Action Alternative is lower than that of the No Action Alternative, i.e. a flow reduction.

4.3.8 Imperial Dam to NIB

As noted in Section 3.3, most of the water delivered to Mexico is diverted at Imperial Dam, conveyed via the AAC, and then returned to the Colorado River through the Pilot Knob and Siphon Drop Powerplants and their respective wasteway channels, 2.1 miles and 7.6 miles upstream of the NIB, respectively. The proposed federal action will not alter the operation of these diversions and wasteways and therefore, will not have an effect on this river reach.

4.3.9 NIB to SIB

As noted in Section 3.3, Mexico diverts most of its Colorado River water supply at the Morelos Diversion Dam, and except during flood control operations, only limited flows actually pass Morelos Diversion Dam. During flood control operations, releases are made from Hoover Dam as dictated by the flood control criteria established with the USACE (Section 3.3). These releases are dependent upon the amount of available storage in the system (including Lake Powell and Lake Mead) and the hydrologic inflow forecast. The proposed federal action could potentially change the amount of water in storage in Lake Powell and Lake Mead, thereby affecting the frequency and/or volume of flood control releases.

In addition, the modeling assumptions used to model the storage and delivery mechanism for the Conservation Before Shortage and Reservoir Storage alternatives could potentially alter the flows in this reach.[1] It was assumed that water conservation activities in Mexico would result in conserved water that would be stored in Lake Mead and delivered on a periodic basis to Mexico through the NIB to the SIB reach. These modeling assumptions were used in this Draft EIS in order to analyze the potential impacts to resources of the storage and delivery mechanism, particularly with regard to reservoir elevations and river flow impacts. The use of these modeling assumptions does not represent any determination by Reclamation as to whether, or how, any storage/delivery arrangements would actually be implemented in the future. These modeling assumptions are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico. Details of these assumptions are discussed in Section 4.2 and Appendix M.

The 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 4.3-38.

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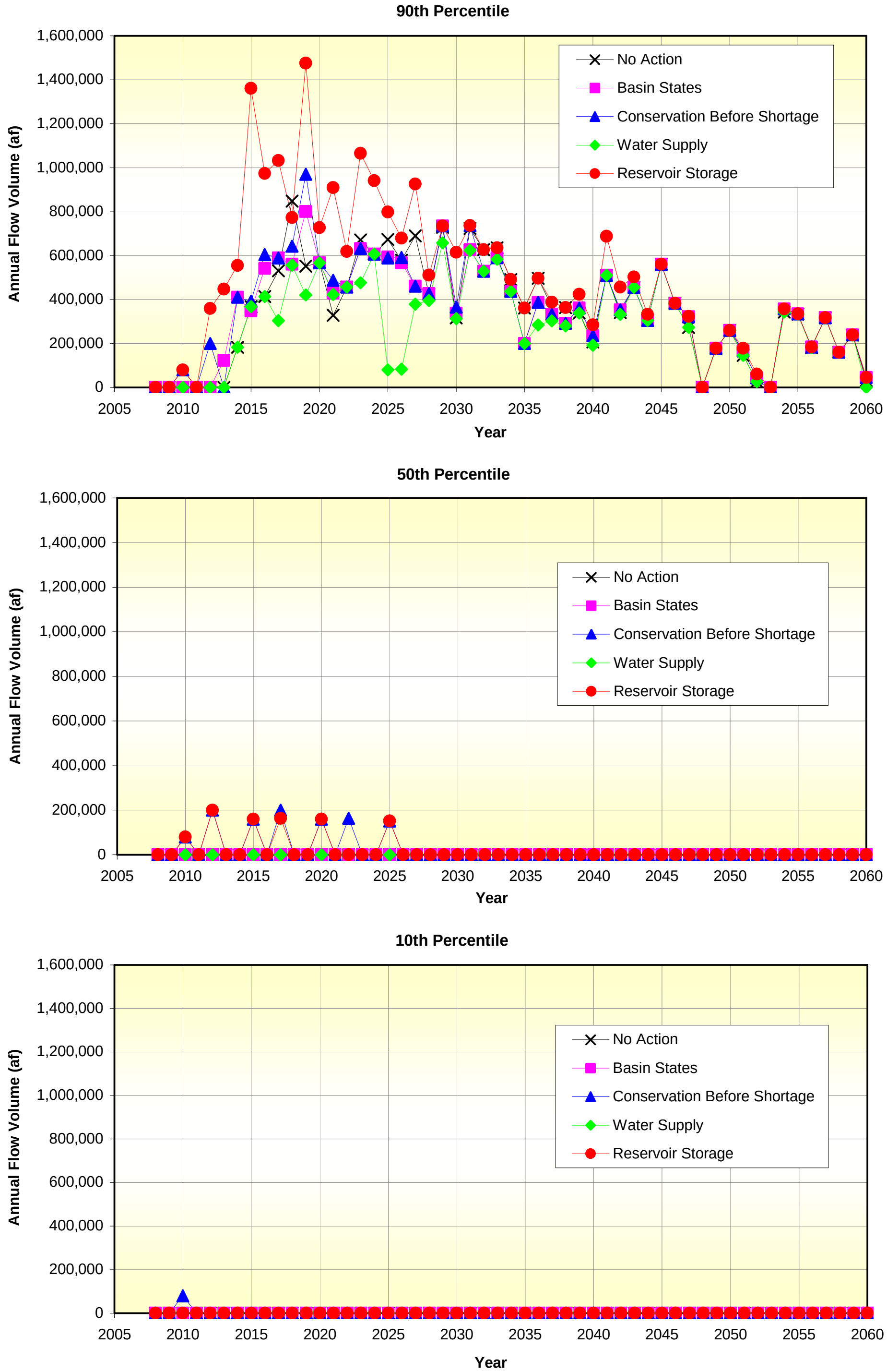
[1] These flows were modeled as part of the storage and delivery mechanism under the Conservation Before Shortage and Reservoir Storage alternatives. These modeling assumptions were utilized in this Draft EIS in order to analyze the potential impacts to environmental resources of the storage and delivery mechanism, particularly with regard to reservoir elevations and river flow impacts. The use of these modeling assumptions does not represent any determination by Reclamation as to whether, or how, these releases could be made under current administration of the Colorado River.

Figure 4.3-38
Colorado River Annual Flow Below Mexico Diversion at Morelos Diversion Dam - RM 21.1 (af)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values



Flows at the 90^{th} percentile are produced by flood control operations. The values for the Reservoir Storage Alternative were generally greater than for the other alternatives due to higher reservoir levels. After 2045, the 90^{th} percentile annual flow volumes are all similar. The 90^{th} percentile annual flow volumes for the Water Supply Alternative were generally lower than the other alternatives through about 2030.

Flows at the 50^{th} percentile are comprised solely of non-flood control flows. The No Action, Basin States, and Water Supply alternatives assume no activity with regard to delivery of conserved water to Mexico. The 50^{th} percentile flows for the Conservation Before Shortage and Reservoir Storage alternatives show intermittent annual flow volumes of from about 40 kaf to 200 kaf during the interim period.

At the 10^{th} percentile, the Conservation Before Shortage is the only alternative that shows an annual flow value that is greater than zero, in the year 2010 at a volume of 80 kaf.

Table 4.3-17 provides a summary of the results illustrated in Figure 4.3-17 for elevation 1,178 feet msl in tabular form for selected years. As shown in Table 4.3-17, the water levels under the Basin States and Conservation Before Shortage alternatives are similar to those under the No Action Alternative. The water levels under the Reservoir Storage Alternative fell below elevation 1,178 feet msl less frequently than those under the No Action Alternative. The water levels under the Water Supply Alternative fell below elevation 1,178 feet msl more frequently than those under the No Action Alternative.

Figure 4.3-39 shows the cumulative distribution for annual volumes of excess flows below the Mexico diversion at Morelos Diversion Dam for the period between 2008 through 2060. At flows less than about 250 kaf, the differences are due to the assumed delivery of conserved water to Mexico under the Conservation Before Shortage and Reservoir Storage alternatives. Flows greater than about 250 kaf are the result of flood control operations.

Table 4.3-32 provides a comparison of the 90^{th}, 50^{th}, and 10^{th} percentile annual flow volumes below the Mexico diversion at Morelos Diversion Dam between the action alternatives and No Action Alternative for selected years.

Figure 4.3-39
Excess Flows Below Mexico Diversion at Morelos Diversion Dam
Comparison of Action Alternatives to No Action Alternative
Cumulative Distribution - Years 2008 through 2060

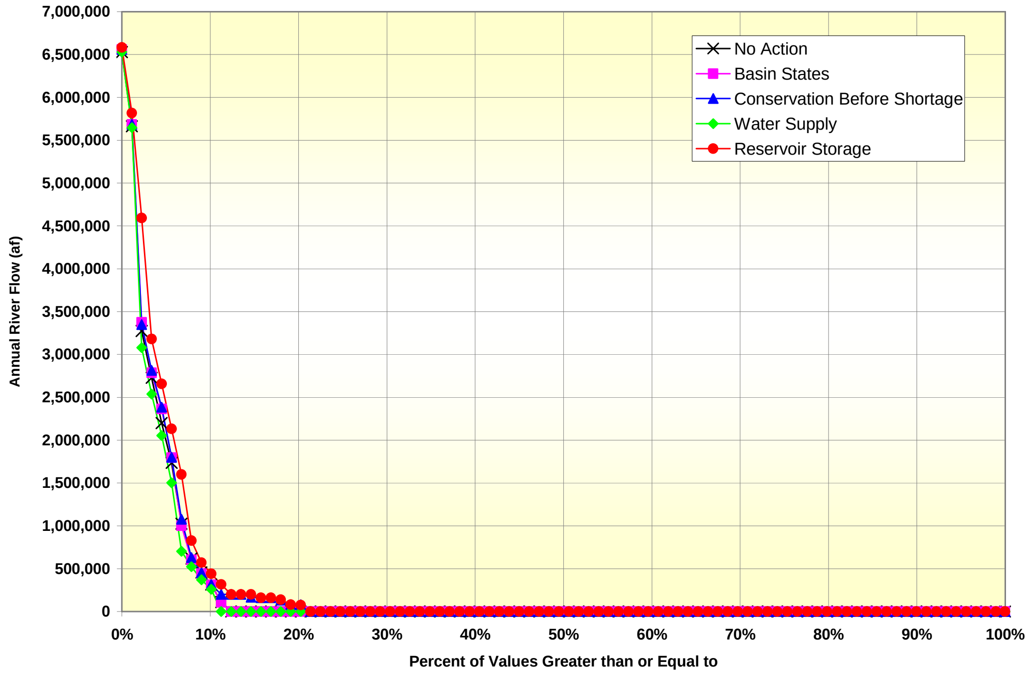


Table 4.3-32
Colorado River Annual Flow Below Mexico Diversion at Morelos Diversion Dam - RM 21.1 (maf)
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

Alternative	Year 2016			Year 2026			Year 2040			Year 2060		
	90th	50th	10th	90th	50th	10th	90th	50th	10th	90th	50th	10th
No Action	0.414	0.000	0.000	0.579	0.000	0.000	0.206	0.000	0.000	0.032	0.000	0.000
Basin States	0.542	0.000	0.000	0.567	0.000	0.000	0.235	0.000	0.000	0.045	0.000	0.000
Conservation Before Shortage	0.605	0.000	0.000	0.591	0.000	0.000	0.235	0.000	0.000	0.045	0.000	0.000
Water Supply	0.414	0.000	0.000	0.083	0.000	0.000	0.192	0.000	0.000	0.000	0.000	0.000
Reservoir Storage	0.974	0.000	0.000	0.680	0.000	0.000	0.284	0.000	0.000	0.045	0.000	0.000

4.3.10 Summary

The following conclusions were drawn from the analyses of hydrologic resources.

4.3.10.1 Reservoir Storage

The Water Supply Alternative generally provides lower Lake Powell water levels than the No Action Alternative. Conversely, the Reservoir Storage Alternative provides higher Lake Powell levels than the No Action Alternative. The observed Lake Powell water levels under the Basin States and Conservation Before Shortage alternatives are similar to each other. The 50^{th} and 10^{th} percentile values of these two alternatives vary less than those of the Water Supply and Reservoir Storage alternatives. The greatest difference in Lake Powell elevation between the Basin States and Conservation Before Shortage alternatives and the No Action Alternative in any one year is about 10 feet.

The Lake Mead 50^{th} percentile elevations under the Water Supply Alternative are generally lower than those under the No Action Alternative. However, the Lake Mead 10^{th} percentile elevations under the Water Supply Alternative vary and are sometimes higher and sometimes lower than those under the No Action Alternative. The Reservoir Storage Alternative generally provides higher Lake Powell levels than the No Action Alternative. The observed Lake Mead water levels under the Basin States and Conservation Before Shortage alternatives are similar to each other. The 50^{th} and 10^{th} percentile values of these two alternatives vary less than those of the Water Supply and Reservoir Storage alternatives. Both the 50^{th} and 10^{th} percentile values of the Basin States and Conservation Before Shortage alternatives vary from being higher and sometimes lower than those of the No Action Alternative.

Lake Mohave and Lake Havasu are operated on a rule curve and have target end-of-month elevations. This manner of operation will continue in the future and would apply to operations under any of the action alternatives. Therefore, future Lake Mohave and Lake Havasu water levels would be expected to be similar between the action alternatives and the No Action Alternative.

4.3.10.2 Reservoir Releases

Glen Canyon Dam releases less than the annual minimum objective release of 8.23 maf occurred less than one percent of the time under the No Action Alternative, approximately 3.7 percent under the Basin States, Conservation Before Shortage, and Water Supply alternatives, and approximately six percent under the Reservoir Storage Alternative. Releases greater than the annual minimum objective release of 8.23 maf occurred approximately 35.5 percent under the No Action Alternative, approximately 42.4 percent under the Basin States, Conservation Before Shortage, and Water Supply alternatives, and approximately 36.67 percent under the Reservoir Storage Alternative. Releases greater than 9.0 maf generally correspond to years where either equalization or spill avoidance releases are made from Lake Powell. Glen Canyon Dam releases greater than 9.0 maf occurred 29.80 percent of the time under the No Action Alternative, 35.53 percent under the Basin States and Conservation Before Shortage alternatives, 36.67 percent under the Water Supply Alternative, and 30.94 percent under the Reservoir Storage Alternative.

More water is held in storage in Lake Mead under the Reservoir Storage Alternative and therefore the releases from Hoover Dam are lower under this alternative during the interim period (2008 through 2026), as compared to the No Action Alternative. Conversely, the Hoover Dam releases under the Water Supply Alternative are greater than those under No Action Alternative because less water is held in storage under the Water Supply Alternative. The Hoover Dam releases under the Basin States and Conservation Before Shortage alternatives are slightly less than those under the No Action Alternative and the differences can be attributed to the assumption that SNWA would develop additional non-system water supplies that are permanent, such as desalination. The assumption is that these supplies would be exchanged with other downstream Colorado River water users and the point of delivery of the exchanged water would move from below Hoover Dam to Lake Mead, resulting in reduced releases from Hoover Dam. Other reductions in releases under the action alternatives can be attributed to both voluntary and involuntary delivery reductions, i.e. water conservation and shortages. The alternative with the greatest effect on Hoover Dam releases due to shortage related delivery reductions is the Reservoir Storage Alternative.

The releases from Davis Dam and Parker Dam generally reflect the same pattern of releases under the different action alternatives as those from Hoover Dam. The differences in the release volumes are mostly attributed to the depletions that occur upstream of each respective dam.

4.3.10.3 River Flows

The river flows in the Glen Canyon Dam to Lake Mead river reach could potentially be reduced below 8.23 maf under the different action alternatives, albeit the frequency of occurrence of these reductions is expected to low. River flow reductions below 8.23 mafy are expected to occur about 3.7 percent of the time under the Basin States, Conservation Before Shortage, and Water Supply alternatives about 3.7 percent of the time and about 6 percent of the time under the Reservoir Storage Alternative. The corresponding seasonal, daily and hourly flows will also be affected although these will continue to be managed consistent with the AMP.

The river flow reductions that were observed for the river reaches downstream of Hoover Dam under the action alternatives were similar to those previously analyzed in the LCR MSCP Final EIS and LCR MSCP BA/BO.

4.3.10.4 Groundwater

The river flow reductions were determined to have no effect on the groundwater resources within the river reach that extends from Glen Canyon Dam to Lake Mead. The river flow reductions that occur below Hoover Dam could potentially affect groundwater resources within the different river reaches where they occur. However, the potential river stage reductions and corresponding potential effects on groundwater resources within these river reaches were determined to be similar to those considered in the LCR MSCP Final EIS and LCR MSCP BA/BO.

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4.4 Water Deliveries

This section compares water deliveries from the Colorado River mainstream to the Lower Division states and Mexico under the No Action and action alternatives. In addition, potential impacts of shortages to water user categories (agricultural, M&I, and Tribal) within Arizona are compared. Details with regard to potential impacts to specific water users, particularly within the state of Arizona, are presented in Appendix G.

4.4.1 Methodology

The methodology used to analyze total water deliveries to each Lower Division state and Mexico for each alternative is based on the hydrologic model (CRSS) described in Section 4.2 and in Appendix A. The modeling assumptions with respect to the distribution of shortages to the Lower Division states and Mexico are summarized in Section 4.2.

4.4.1.1 Shortage Allocation Model

To analyze the potential impacts of shortages to water users within each Lower Division state, a more detailed model referred to as the Shortage Allocation Model was developed. The Shortage Allocation Model was used to estimate delivery of water to Colorado River water entitlement holders within the Lower Division states and Mexico under varying levels of shortages. The entitlements, along with consumptive use schedules and established priorities within each respective Lower Division state, were included as parameters in the Shortage Allocation Model. In addition, the shortage distribution within the CAP is consistent with the Arizona Water Settlement Act (AWSA).

The Shortage Allocation Model allocates shortages to the Lower Division states consistent with the shortage sharing assumptions used in the CRSS model. The Shortage Allocation Model then distributes Colorado River water to entitlement holders within each state based on the priority of water rights within each respective state using the assumption that shortages will be shared on a pro rata basis by users of the same priority. A detailed description of the Shortage Allocation Model and the methodologies used to distribute the shortages is provided in Appendix G. A list of each state's Colorado River water entitlement holders, listed by priority, is included in Appendix E.

Total Lower Basin shortages of 100 kaf to 2.5 maf (in increments of 100 kaf) were analyzed in the Shortage Allocation Model, fully covering the range of total Lower Basin shortages projected to occur under the No Action and action alternatives. The output for each model run shows how shortages were distributed to each entitlement holder within each state. The Shortage Allocation Model also summarized shortages into three water user categories in Arizona (agricultural, M&I, and Tribal), which are presented in Section 4.4.5. Detailed output from the Shortage Allocation Model is provided in Appendix G.

4.4.2 Apportionments to the Upper Division States

The proposed federal action will not affect the apportionments to the Upper Division states nor their ability to use their Compact apportionments and therefore no resource impact analysis was necessary.

4.4.3 Apportionments to the Lower Division States and Water Entitlements within Each State

The proposed federal action will not affect the apportionments to the Lower Division states or the water entitlements to water users within those states and therefore no resource impact analysis was necessary. However, water deliveries to each state and to users within each state may potentially be affected and are analyzed in the following sections.

4.4.4 Lower Division States Water Supply Determination

The proposed federal action would provide guidance to the Secretary's annual determination of the water supply condition (Surplus, Normal, or Shortage) for the Lower Division states. This section compares the probabilities of the determinations that would be made under each alternative.

4.4.4.1 Shortage Conditions

A Shortage condition exists in a particular year when the Secretary determines that there is insufficient mainstream water available to satisfy 7.5 maf of consumptive use in the Lower Division states. The elements of the proposed federal action include shortage guidelines and each alternative assumes a specific formulation for determining Shortage conditions (Chapter 2).

Probability of Involuntary and Voluntary Shortage. The Conservation Before Shortage proposal suggested an approach to the management of shortages in the Lower Basin whereby voluntary water reductions would occur at specific Lake Mead elevations in order to delay the onset of larger, involuntary water reductions. The voluntary water reductions would occur through a compensation program whereby willing Lower Basin Colorado River water users, including Mexico, would be paid to voluntarily and temporarily reduce their water use (Section 2.4). In Section 4.4 (this section), these water delivery reductions are termed voluntary shortages. Conversely, involuntary shortages would be water delivery reductions imposed by the determination of a Shortage condition by the Secretary.

The probability of a determination of Shortage conditions (and associated involuntary delivery reductions) for all alternatives is illustrated in Figure 4.4-1. Under the No Action Alternative, the probability of shortage increases throughout the interim period from about 20 percent in 2011 to about 50 percent in 2026. All action alternatives have lower probabilities of involuntary shortage when compared to the No Action Alternative from 2013 through 2026. Table 4.4-1 shows a comparison of the alternatives with respect to the first year of involuntary shortage. Table 4.4-2 shows the probability of any amount of involuntary Lower Basin shortage for specific years.

Figure 4.4-1
Involuntary Lower Basin Shortages
Comparison of Action Alternatives to No Action Alternative
Probability of Occurrence of Any Amount

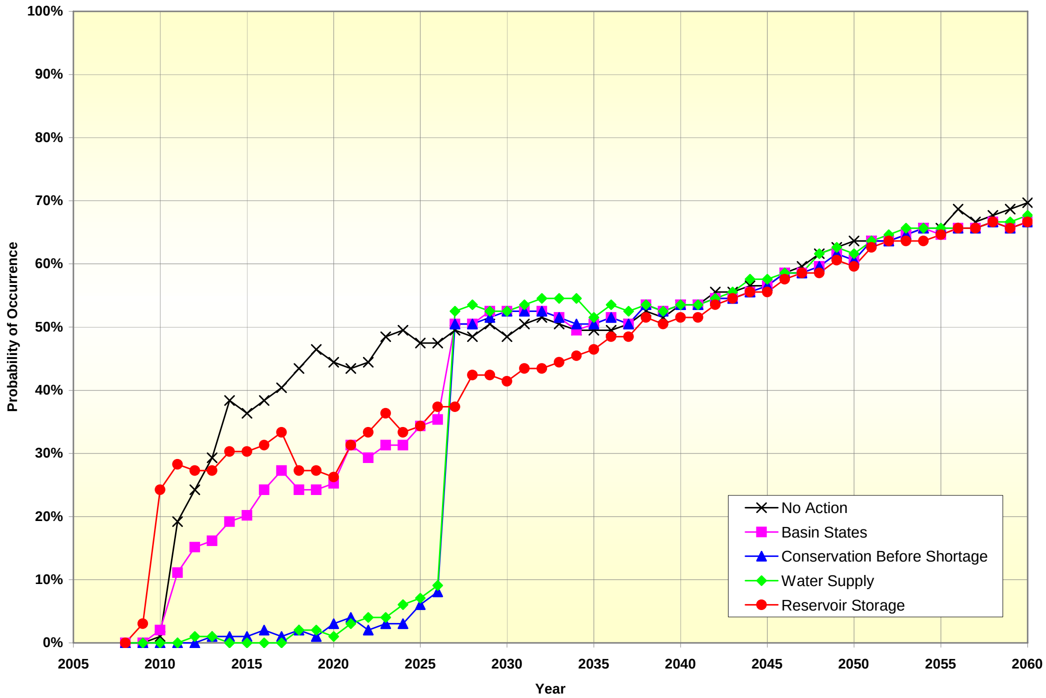


Table 4.4-1
First Year of Occurrence of Involuntary Shortage
Comparison of Action Alternatives and No Action Alternative

Alternative	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
Year	2010	2010	2013	2012	2009

Table 4.4-2
Probability of Occurrence of Any Amount of Involuntary Shortage
Comparison of Action Alternatives to No Action Alternative

Year	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	0%	0%	0%	0%	0%
2017	40%	27%	1%	0%	33%
2026	47%	35%	8%	9%	37%
2027	49%	51%	51%	53%	37%
2040	54%	54%	54%	54%	52%
2060	70%	67%	67%	68%	67%

The Conservation Before Shortage and Water Supply alternatives result in infrequent, involuntary shortages during the interim period due to quite different reasons. The Conservation Before Shortage Alternative assumes that voluntary shortages would occur prior to the determination of an involuntary Shortage condition, whereas the Water Supply Alternative imposes involuntary shortages only if Lake Mead storage approaches the dead pool. Under the Water Supply Alternative, a shortage will also occur to SNWA when Lake Mead's elevation falls below 1,000 feet msl (Section 4.2). Figure 4.4-1 shows that this occurs approximately one to nine percent for years in the interim period in the Water Supply Alternative. Figure 4.4-1 also shows that the probability of involuntary shortages under the Conservation Before Shortage Alternative is similar (approximately one to eight percent over the interim period) since involuntary shortages are imposed under that alternative to protect Lake Mead from falling below elevation 1,000 feet msl.

Figure 4.4-2, Table 4.4-3, and Table 4.4-4 show the comparisons for all alternatives when both involuntary and voluntary shortages are considered. When both involuntary and voluntary shortages are considered, the occurrence of the first shortage (in year 2010) is identical for the Basin States and Conservation Before Shortage alternatives. The probability of shortages is also very similar because the Conservation Before Shortage Alternative assumes an identical strategy to determine the occurrence and magnitude of voluntary shortages as is used by the Basin States Alternative to determine the occurrence and magnitude of involuntary shortages. The Conservation Before Shortage Alternative shows somewhat lower probabilities of both voluntary and involuntary shortage over the interim period when compared to the Basin States Alternative primarily because more water is retained in Lake Mead to greater participation in the storage and delivery mechanism assumed under the Conservation Before Shortage Alternative. Also, the increased amount of involuntary shortage required in certain years to keep Lake Mead above 1,000 feet msl under the Conservation Before Shortage Alternative tends to retain additional water in Lake Mead, as compared to the Basin States Alternative, which decreases the probability of future shortages.

Figure 4.4-2
Involuntary and Voluntary Lower Basin Shortages
Comparison of Action Alternatives to No Action Alternative
Probability of Occurrence of Any Amount

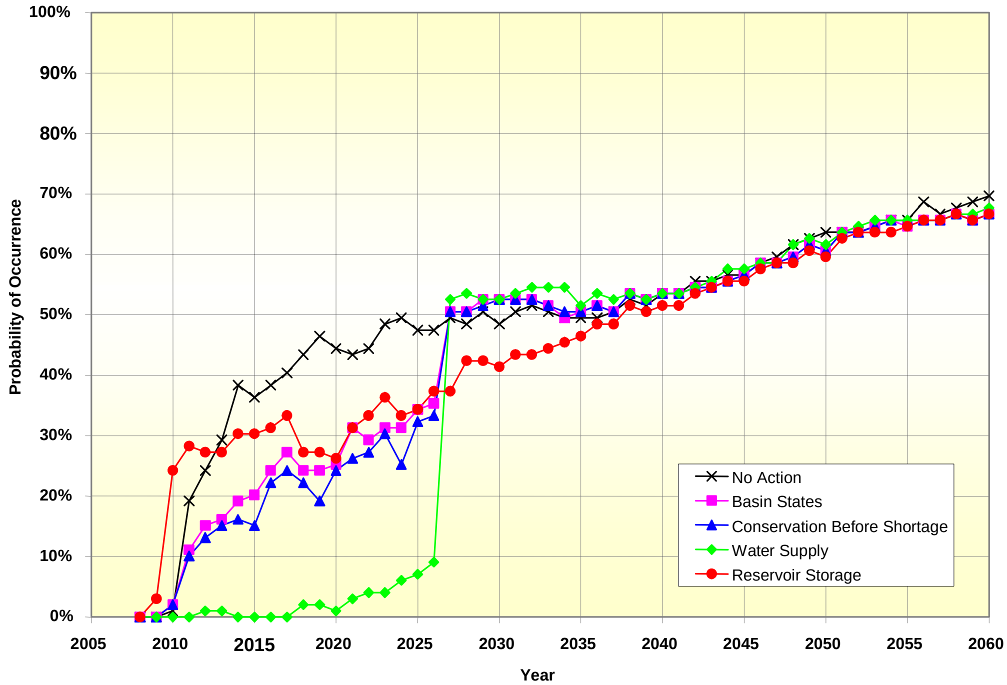


Table 4.4-3
First Year of Occurrence of Involuntary or Voluntary Shortage
Comparison of Action Alternatives to No Action Alternative

Alternative	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
Year	2010	2010	2010	2012	2009

Table 4.4-4
Probability of Occurrence of Involuntary and Voluntary Shortages of Any Amount
Comparison of Action Alternatives to No Action Alternative

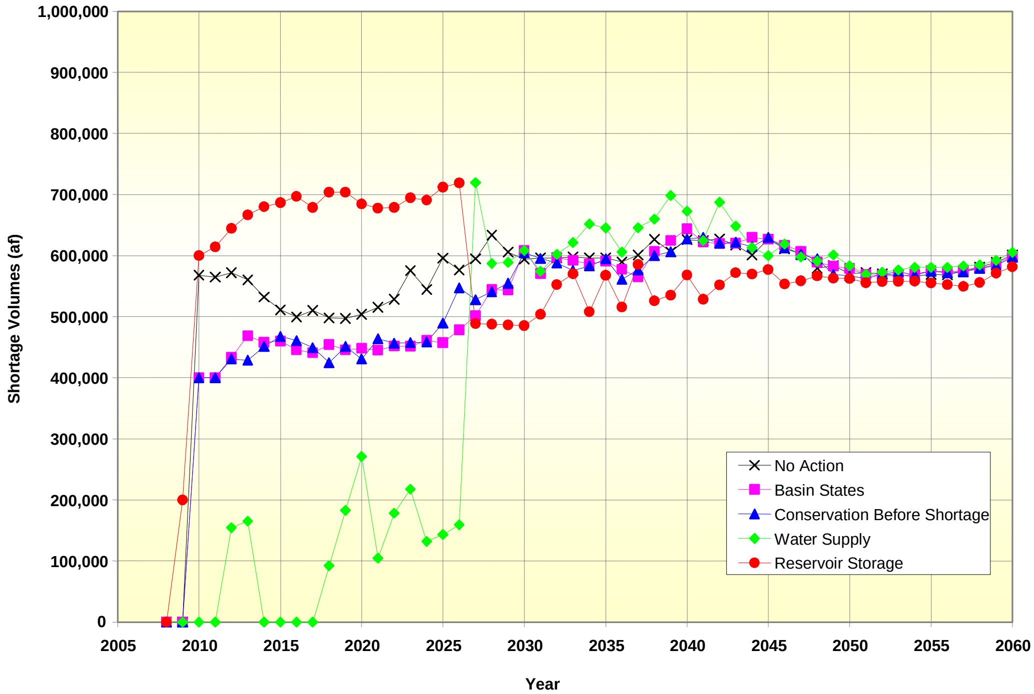
Year	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	0%	0%	0%	0%	0%
2017	40%	27%	24%	0%	33%
2026	47%	35%	33%	9%	37%
2027	49%	51%	51%	53%	37%
2040	54%	54%	54%	54%	52%
2060	70%	67%	67%	68%	67%

Magnitude of Involuntary and Voluntary Shortages. Although the probability of a shortage occurring is an important factor, the magnitude of the shortage is also important. Each alternative has specific assumptions with regard to when and by how much deliveries would be reduced.

The average shortage volumes for each year provide a weighted measure that considers both the frequency and magnitude of the potential shortages. The average shortage volumes are calculated by multiplying the observed volumes of shortages by their respective frequency of occurrence and summing calculated values for each year. A comparison of the average shortage volumes (of both involuntary and voluntary shortages) under the action alternatives to those of the No Action Alternative is provided in Figure 4.4-3.

The average values of the No Action Alternative range between about 500 and 600 kafy over the interim period and are reflective of the occurrence of the more frequent shortages which are on the order of 400 to 500 kafy based on Lake Mead trigger elevations (Section 2.2) as well as infrequent but larger shortages (on the order of 800 kafy to 2,000 kafy) necessary to keep Lake Mead above elevation 1,000 feet msl. The average value of shortages under the Water Supply Alternative are between zero and 270 kafy over the interim period and are indicative of the strategy which essentially determines no shortage except when Lake Mead is below elevation 1,000 feet msl and there is no delivery to SNWA. The Reservoir Storage Alternative shows average values of shortage between 600 and 720 kafy over the interim period since shortages are applied both more often and at higher magnitudes. The Basin States and Conservation Before Shortage alternatives show average values between 400 and about 500 kafy over the interim period. These average values are lower than the average values under the No Action Alternative since the shortages under these alternatives, although similar in magnitude, are applied less often than those under the No Action Alternative.

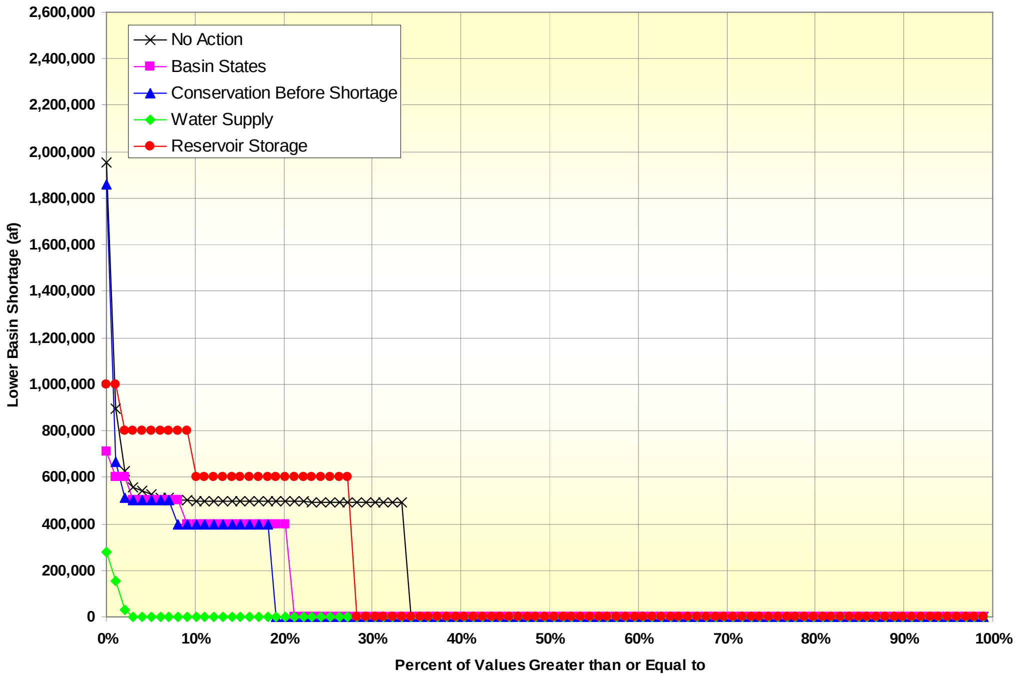
Figure 4.4-3
Involuntary and Voluntary Lower Basin Shortage
Comparison of Action Alternatives to No Action Alternative
Average Shortage Volumes



The Conservation Before Shortage Alternative also shows higher average shortage volumes in the latter years of the interim period when compared to the Basin States Alternative. This is due to involuntary shortages of higher magnitudes occurring at higher frequencies in the latter years under the Conservation Before Shortage Alternative to keep Lake Mead above elevation 1,000 feet msl. Conversely, the Basin States Alternative assumes that when Lake Mead is at or below elevation 1,025 feet msl, additional consultations will occur in order to determine what further actions might be necessary. For modeling purposes, it was assumed that shortages with a magnitude of 600 kaf would continue for Lake Mead elevations below 1,025 feet msl for the Basin States Alternative.

An alternative way to compare the probability and magnitude of shortages between alternatives is to compare the cumulative distribution of shortages over a period of time. Figure 4.4-4 presents the cumulative distributions of both voluntary and involuntary shortages for the interim period, 2008 through 2026.

Figure 4.4-4
Involuntary and Voluntary Lower Basin Shortages
Comparison of Action Alternatives to No Action Alternative
Years 2006 through 2026



Under the No Action Alternative, shortages between 400 and 500 kafy would be applied in about 30 percent of the time, with shortages of greater magnitudes occurring about five percent of the time over the interim period. Under the Basin States and Conservation Before Shortage alternatives, shortages occur less often than under the No Action Alternative (about 21 to 18 percent of the time respectively), with the slight lower probability of the Conservation Before Shortage Alternative due to the assumption of larger amounts of conserved water being stored in Lake Mead under that alternative. The Reservoir Storage Alternative shows that shortages of magnitudes greater than 600 kafy would occur about 10 percent of the time.

Figure 4.4-5 provides the cumulative distribution of shortages for the period between 2027 through 2060. Although all alternatives were assumed to revert back to the No Action assumptions in 2027, the differences in cumulative distributions are attributed to differences in Lake Powell and Lake Mead elevations between the alternatives at the end of the interim period (2026). For example, the occurrence of large shortages (on the order of 2,500 kaf) at low probabilities under the Water Supply Alternative is due to large shortages that must be applied in order to return Lake Mead above elevation 1,000 feet msl for some traces in 2027 and 2028.

Tables 4.4-5 through 4.4-9 present the probability of occurrence of shortages of various magnitudes for years 2017, 2026, 2027, 2040, and 2060 under all alternatives. Also shown are the probabilities for the Conservation Before Shortage Alternative for just involuntary shortages and both involuntary and voluntary shortages.

Figure 4.4-5
Involuntary and Voluntary Lower Basin Shortages
Comparison of Action Alternatives to No Action Alternative
Years 2027 through 2060

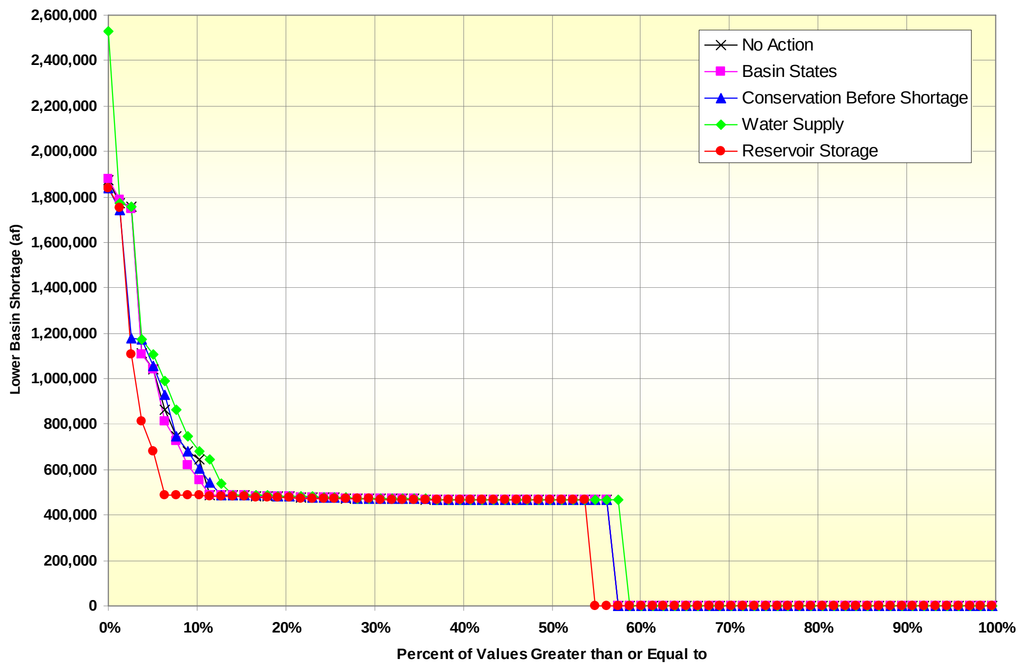


Table 4.4-5
Distribution of Shortages, Year 2017

Shortage (kaf)	No Action	Basin States	Conservation Before Shortage		Water Supply	Reservoir Storage
			Involuntary	Involuntary & Voluntary		
< 400	0%	0%	0%	0%	0%	0%
400 - 499	39%	18%	0%	16%	0%	0%
500 - 599	0%	7%	0%	7%	0%	0%
600 - 799	0%	2%	0%	0%	0%	22%
800 - 999	1%	0%	1%	1%	0%	9%
1,000 – 1,199	0%	0%	0%	0%	0%	2%
1,200 – 1,399	0%	0%	0%	0%	0%	0%
1,400 – 1,599	0%	0%	0%	0%	0%	0%
1,600 – 1,799	0%	0%	0%	0%	0%	0%
1,800 – 1,999	0%	0%	0%	0%	0%	0%
2,000 – 2,499	0%	0%	0%	0%	0%	0%
> 2,500	0%	0%	0%	0%	0%	0%

Table 4.4-6
Distribution of Shortages, Year 2026

Shortage (kaf)	No Action	Basin States	Conservation Before Shortage		Water Supply	Reservoir Storage
			Involuntary	Involuntary & Voluntary		
< 400	0%	0%	2%	2%	9%	0%
400 - 499	39%	16%	0%	16%	0%	0%
500 - 599	1%	12%	0%	11%	0%	0%
600 - 799	3%	7%	4%	4%	0%	19%
800 - 999	2%	0%	1%	1%	0%	14%
1,000 – 1,199	0%	0%	0%	0%	0%	4%
1,200 – 1,399	0%	0%	0%	0%	0%	0%
1,400 – 1,599	0%	0%	0%	0%	0%	0%
1,600 – 1,799	1%	0%	0%	0%	0%	0%
1,800 – 1,999	1%	0%	1%	1%	0%	0%
2,000 – 2,499	0%	0%	0%	0%	0%	0%
> 2,500	0%	0%	0%	0%	0%	0%

Table 4.4-7
Distribution of Shortages, Year 2027

Shortage (kaf)	No Action	Basin States	Conservation Before Shortage		Water Supply	Reservoir Storage
			Involuntary	Involuntary & Voluntary		
< 400	0%	0%	0%	0%	0%	0%
400 - 499	39%	48%	45%	45%	43%	37%
500 - 599	1%	1%	1%	1%	0%	0%
600 - 799	3%	0%	0%	0%	1%	0%
800 - 999	3%	0%	3%	3%	0%	0%
1,000 – 1,199	1%	1%	1%	1%	1%	0%
1,200 – 1,399	0%	0%	0%	0%	1%	0%
1,400 – 1,599	0%	0%	0%	0%	0%	0%
1,600 – 1,799	1%	0%	0%	0%	0%	0%
1,800 – 1,999	1%	0%	0%	0%	2%	0%
2,000 – 2,499	0%	0%	0%	0%	3%	0%
> 2,500	0%	0%	0%	0%	1%	0%

Table 4.4-8
Distribution of Shortages, Year 2040

Shortage (kaf)	No Action	Basin States	Conservation Before Shortage		Water Supply	Reservoir Storage
			Involuntary	Involuntary & Voluntary		
< 400	0%	0%	0%	0%	0%	0%
400 - 499	42%	41%	40%	40%	37%	46%
500 - 599	1%	1%	1%	1%	1%	0%
600 - 799	2%	2%	2%	2%	4%	0%
800 - 999	1%	1%	1%	1%	2%	2%
1,000 – 1,199	3%	3%	7%	7%	4%	0%
1,200 – 1,399	0%	0%	0%	0%	0%	0%
1,400 – 1,599	0%	0%	0%	0%	0%	0%
1,600 – 1,799	3%	4%	1%	1%	4%	2%
1,800 – 1,999	1%	1%	1%	1%	1%	1%
2,000 – 2,499	0%	0%	0%	0%	0%	0%
> 2,500	0%	0%	0%	0%	0%	0%

Table 4.4-9
Distribution of Shortages, Year 2060

Shortage (kaf)	No Action	Basin States	Conservation Before Shortage		Water Supply	Reservoir Storage
			Involuntary	Involuntary & Voluntary		
< 400	0%	0%	0%	0%	0%	0%
400 - 499	55%	53%	49%	49%	53%	54%
500 - 599	1%	0%	3%	3%	1%	0%
600 - 799	4%	5%	5%	5%	4%	5%
800 - 999	3%	2%	2%	2%	3%	1%
1,000 – 1,199	3%	3%	4%	4%	3%	4%
1,200 – 1,399	0%	0%	0%	0%	0%	0%
1,400 – 1,599	0%	0%	0%	0%	0%	0%
1,600 – 1,799	3%	3%	3%	3%	3%	3%
1,800 – 1,999	1%	1%	0%	0%	1%	0%
2,000 – 2,499	0%	0%	0%	0%	0%	0%
> 2,500	0%	0%	0%	0%	0%	0%

The maximum amounts of shortages for each alternative for each year is presented in Figure 4.4-6. Table 4.4-10 lists the maximum values for particular years. The large shortages in 2027 and 2028 are clearly shown for the Water Supply Alternative. By contrast, the Reservoir Storage Alternative has the lowest maximum shortage of any of the alternatives in 2027 because the reservoir would be maintained at relatively higher levels. By 2040, all alternatives have converged essentially to the No Action Alternative values.

Figure 4.4-6
Involuntary and Voluntary Lower Basin Shortages
Comparison of Action Alternatives to No Action Alternative
Maximum Amounts

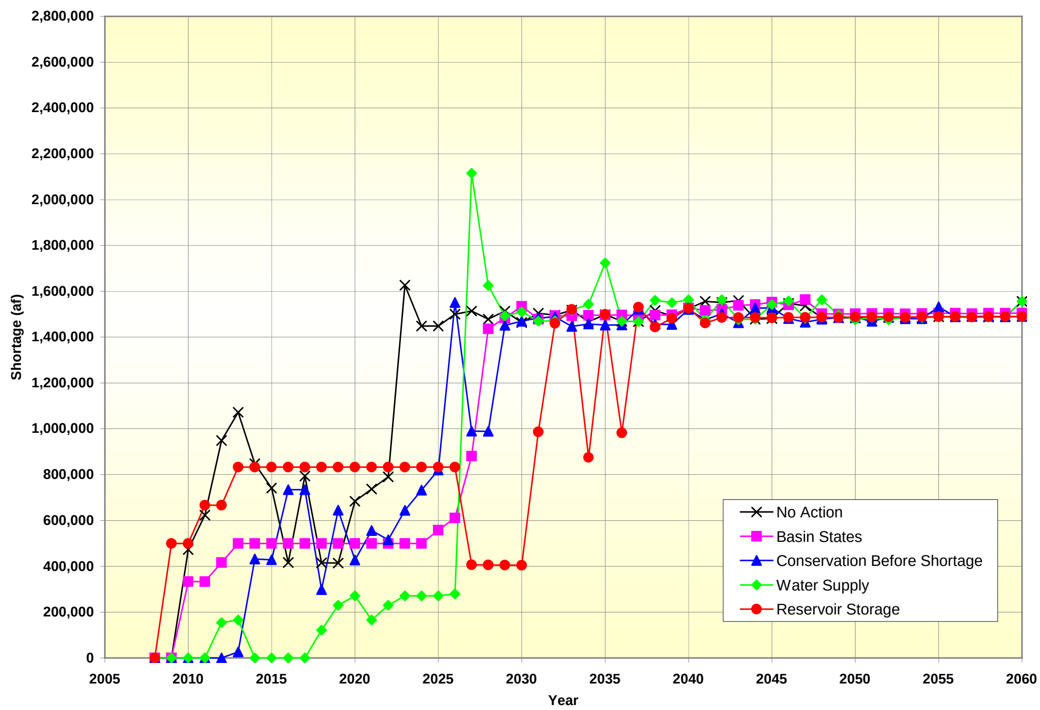
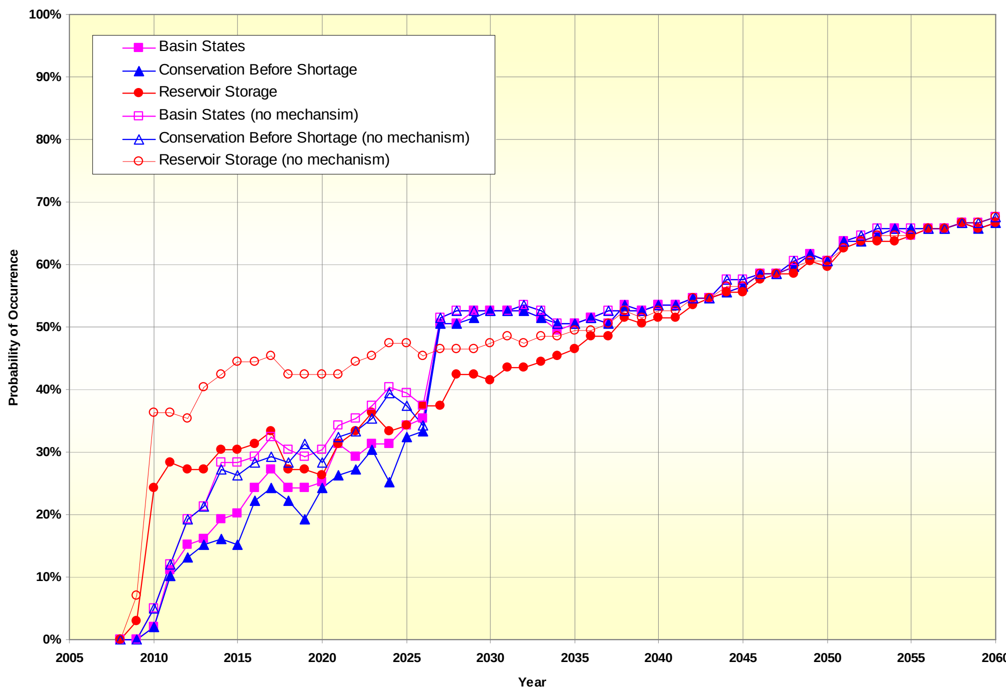


Table 4.4-10
Maximum Occurrence of Involuntary and Voluntary Shortage to the Lower Basin (af)
Comparison of Action Alternatives to No Action Alternative

Year	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	0	0	0	0	0
2017	952,520	600,000	881,221	0	1,000,000
2026	1,800,152	711,370	1,860,797	279,000	1,000,000
2027	1,816,966	1,057,098	1,187,524	2,528,644	488,644
2040	1,828,982	1,832,920	1,824,950	1,875,843	1,832,559
2060	1,867,379	1,805,615	1,788,542	1,867,379	1,787,370

Sensitivity of Shortage Conditions to Storage and Delivery Mechanism. The mechanism to deliver and store conserved system and non-system water assumed as part of the Basin States, Conservation Before Shortage and Reservoir Storage alternatives impacts the probability of shortage occurrences. Because a potential effect of the storage and delivery mechanism is an increase in the amount of water in Lake Mead, a Shortage condition is likely to occur less often with the storage and delivery mechanism in place. Figure 4.4-7 presents the sensitivity of the occurrence of a Shortage condition to the storage and delivery mechanism by comparing these three alternatives with and without the mechanism in place. For each alternative, the inclusion of the mechanism has the effect of decreasing the probability of shortages. Under the Basin States and Conservation Before Shortage alternatives the probability of shortage is reduced an average of about five percent from 2010 through 2026. Under the Reservoir Storage Alternative the reduction is greater, an average of 12 percent from 2010 through 2026, due to the greater amount of storage credits that are assumed to be generated under this alternative.

Figure 4.4-7
Involuntary and Voluntary Lower Basin Shortages
Comparison of Action Alternatives With and Without a Storage and Delivery Mechanism
Probability of Occurrence of Any Amount

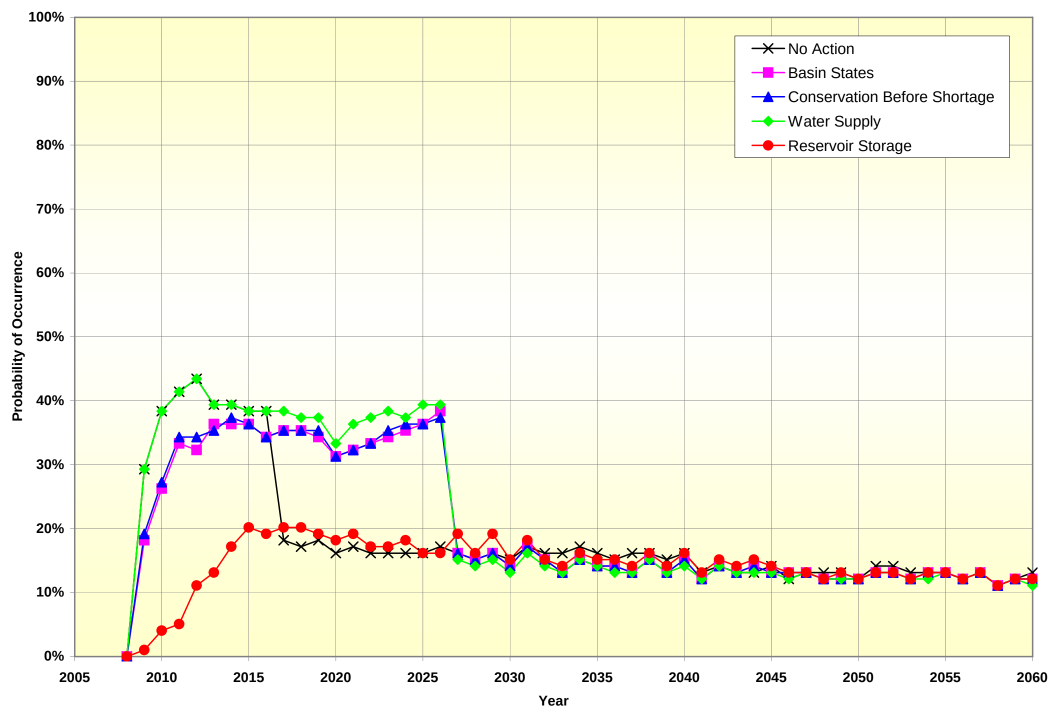


4.4.4.2 Surplus Conditions

A Surplus condition exists in a particular year when the Secretary determines that there is sufficient mainstream water available to satisfy in excess of 7.5 maf of consumptive use in the Lower Division states. The elements of the proposed federal action include a modification and/or extension of the ISG and each alternative expresses a particular assumption for determining Surplus conditions (Chapter 2).

Probability of Surplus of Any Amount. Figure 4.4-8 compares the probabilities of Surplus conditions between the alternatives. For the No Action Alternative, the probability of surplus drops from about 40 percent to 20 percent in 2017 due to the expiration of the ISG. For the Basin States, Conservation Before Shortage and Water Supply alternatives, the probabilities of surplus are between 30 percent and 40 percent through 2026 since they assume an extension of some provisions of the ISG. Probabilities for the Basin States and Conservation Before Shortage alternatives are lower compared to the Water Supply Alternative, however, since both assume that the ISG would be modified and the more permissive provisions (e.g., Partial Domestic Surplus) would be eliminated. For the Reservoir Storage Alternative, surplus determinations are limited to Quantified Surplus (70R Strategy) and Flood Control Surplus conditions, beginning in 2008, and that assumption is reflected in the lower probabilities compared to the other action alternatives throughout the interim period. The probabilities for all alternatives converge to between 10 percent and 20 percent after the interim period since they all revert to the No Action Alternative assumptions after 2026.

Figure 4.4-8
Surplus Conditions
Comparison of Action Alternatives to No Action Alternative
Probability of Occurrence



Probability of Various Types of Surplus. Figure 4.4-9 presents a comparison of the probability of occurrence of the Partial Domestic Surplus condition for each alternative. The probability is zero for the Basin States, Conservation Before Shortage and Reservoir Storage alternatives since no provisions for Partial Domestic Surplus are contained in those alternatives. The probability of Partial Domestic Surplus for the No Action and the Water Supply alternatives are identical through 2016. After 2016, the probability of Partial Domestic Surplus under the No Action Alternative drops to zero since the ISG expire, while the Water Supply Alternative assumes an extension of the existing ISG through 2026.

Figure 4.4-9
Partial Domestic Surplus Deliveries to Lower Basin States
Comparison of Action Alternatives to No Action Alternative
Probability of Occurrence

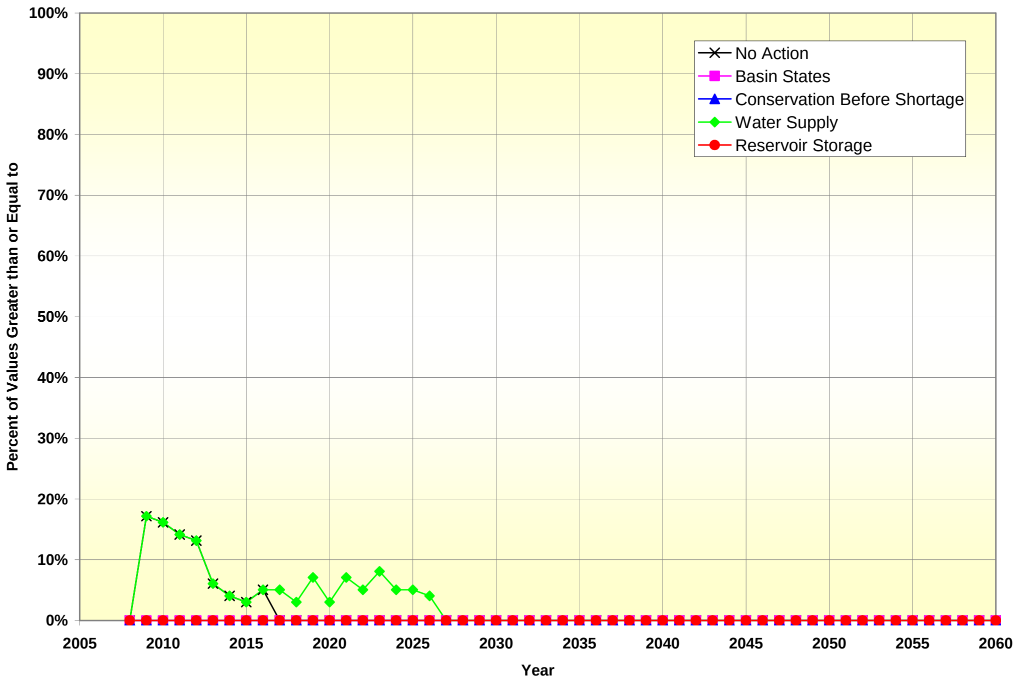


Figure 4.4-10 presents a comparison of the probability of occurrence of the Full Domestic Surplus condition for each alternative. The probability is zero for the Reservoir Storage Alternative since it does not include a provision for this condition. The probability of Full Domestic Surplus for the No Action and Water Supply alternatives are nearly identical through 2016 since they have the same assumptions during that period, with the Water Supply Alternative continuing the Full Domestic Surplus provision through 2026. The Basin States and Conservation Before Shortage alternatives also have nearly identical probabilities through 2026 since they have the same assumptions during

that period. The probabilities for the Basin States and Conservation Before Shortage alternatives are slightly higher than the No Action and Water Supply alternatives since they do not have a provision for Partial Domestic Surplus. This keeps the reservoir slightly higher increasing the chance of a Full Domestic Surplus determination.

Figure 4.4-10
Full Domestic Surplus Deliveries to Lower Basin States
Comparison of Action Alternatives to No Action Alternative
Probability of Occurrence

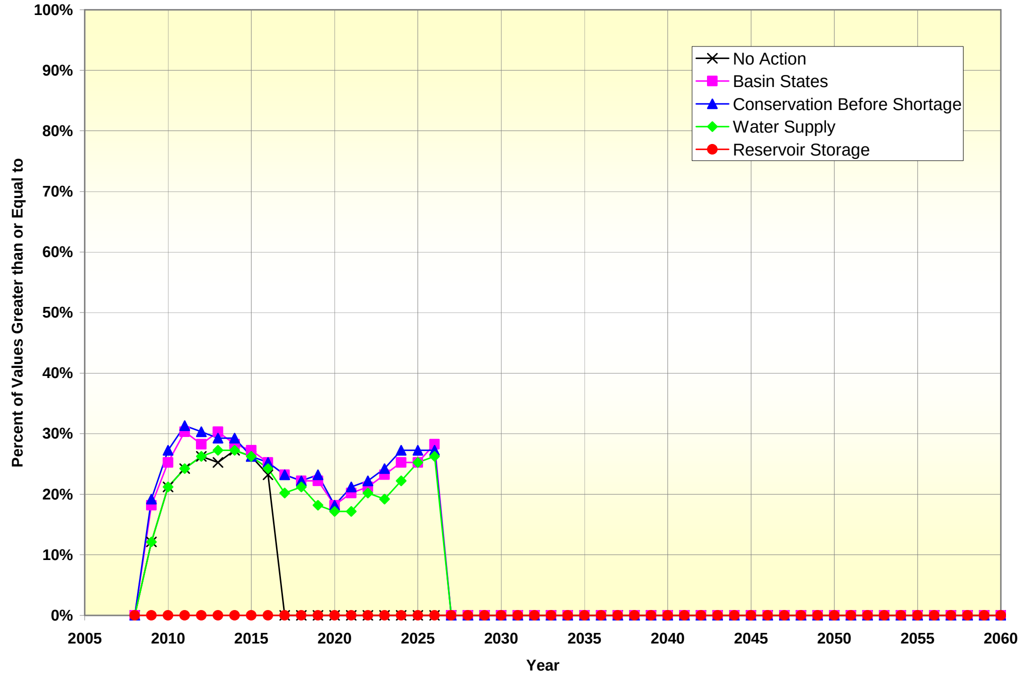


Figure 4.4-11 presents a comparison of the probability of the Quantified (70R) Surplus condition for each alternative. The probabilities for the No Action, Basin States, Conservation Before Shortage, and Water Supply alternatives are nearly identical, with the Reservoir Storage Alternative being slightly higher since it tends to keep the reservoir at higher elevations.

Figure 4.4-12 presents a comparison of the probability of the Flood Control Surplus condition for each alternative. The probabilities for the No Action, Basin States, Conservation Before Shortage, and Water Supply alternatives are nearly identical, with the Reservoir Storage Alternative being slightly higher since it tends to keep the reservoir at higher elevations.

Figure 4.4-11
Quantified Surplus (70R Strategy) Deliveries to Lower Basin States
Comparison of Action Alternatives to No Action Alternative
Probability of Occurrence

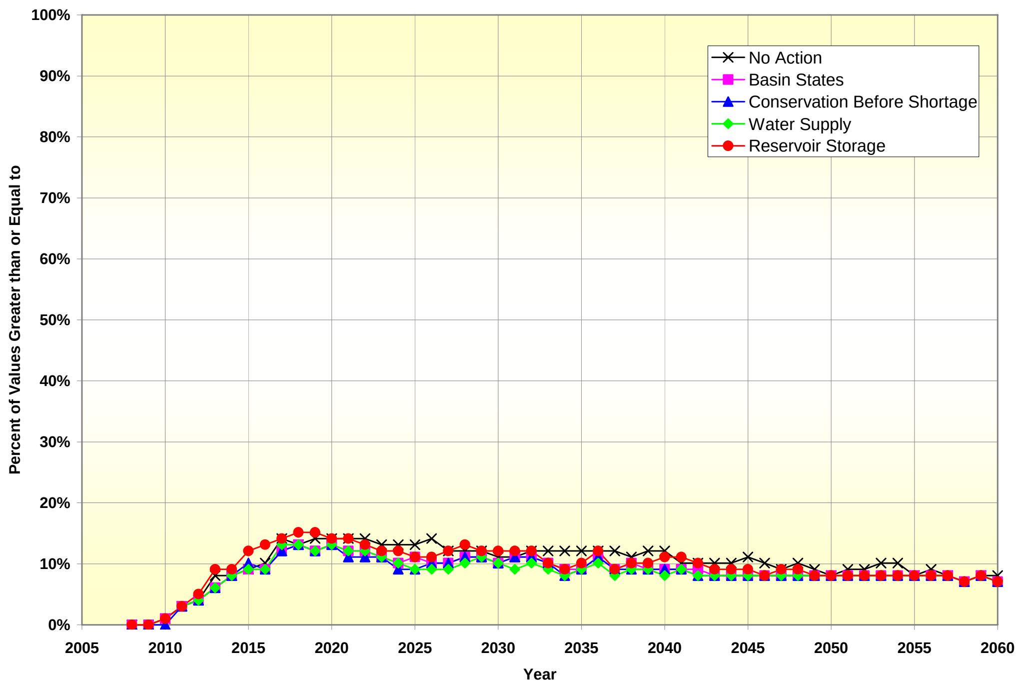
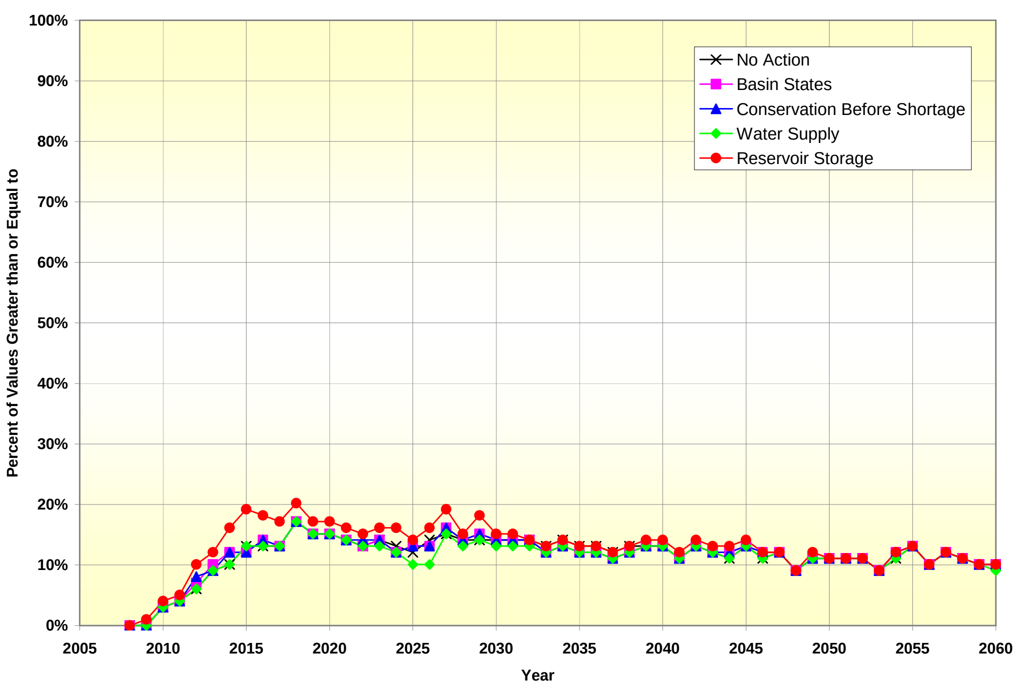


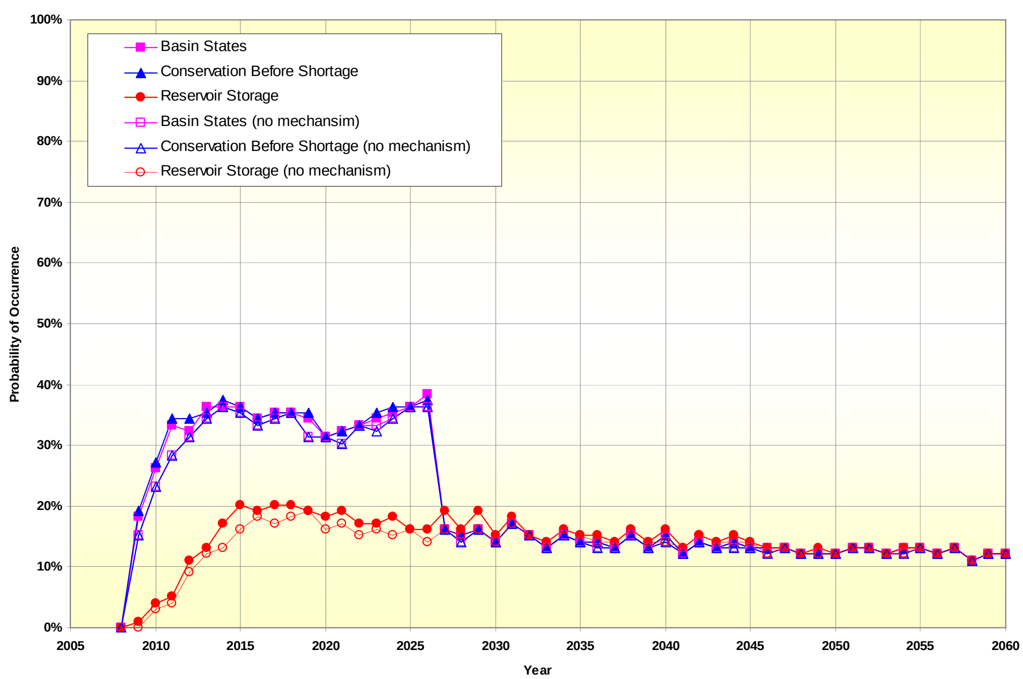
Figure 4.4-12
Flood Control Surplus Deliveries to Lower Basin States
Comparison of Action Alternatives to No Action Alternative
Probability of Occurrence



Sensitivity of Surplus Conditions to Storage and Delivery Mechanism. The mechanism to deliver and store conserved and non-system water assumed as part of the Basin States, Conservation Before Shortage and Reservoir Storage alternatives impacts the probability of Surplus occurrences. Because a potential effect of the storage and delivery mechanism is an increase in the amount of water in Lake Mead, a Surplus condition is likely to occur more often with the storage and delivery mechanism in place.

Figure 4.4-13 presents the sensitivity of the occurrence of a Surplus condition to the storage and delivery mechanism by comparing these three alternatives with and without the mechanism in place. For each alternative, the inclusion of the mechanism has the effect of slightly increasing the probability of a surplus. The maximum increase is about five percent under the Basin States and Conservation Before Shortage alternatives and occurs in 2011. The maximum increase is about four percent under the Reservoir Storage Alternative, occurring in 2014 and 2015.

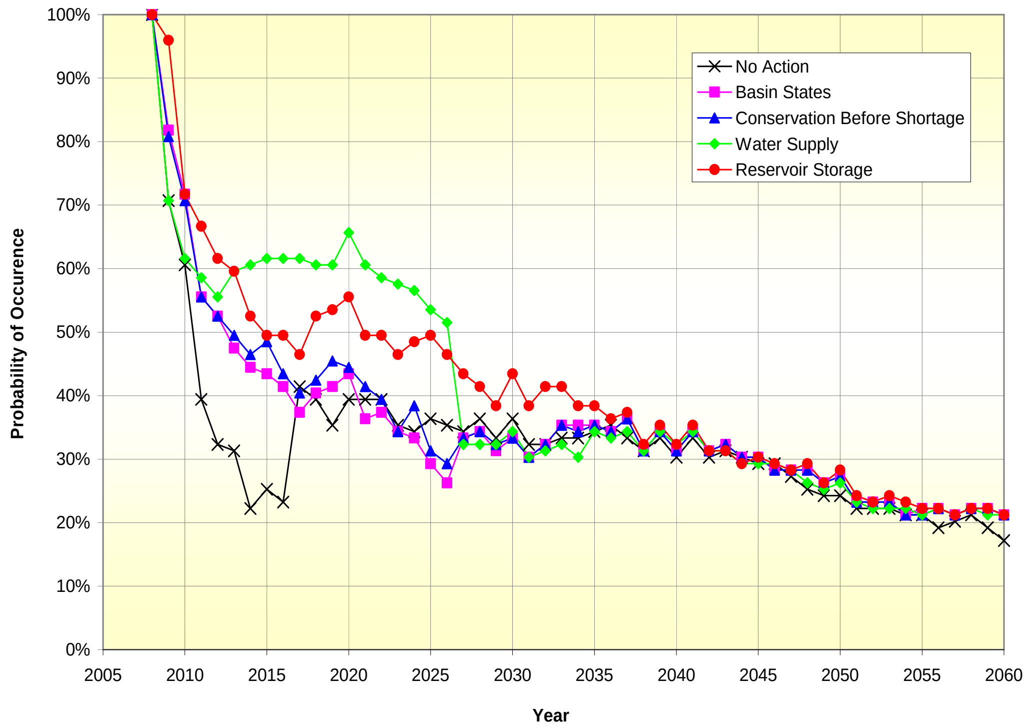
Figure 4.4-13
Surplus Deliveries to Lower Basin States
Comparison of Action Alternatives With and Without a Storage and Delivery Mechanism
Probability of Occurrence



4.4.4.3 Normal Conditions

The probability of a Normal condition is shown in Figure 4.4-14. Under the assumption of an initial Lake Mead elevation of 1,116.53 feet msl on January 1, 2008, the Normal condition would occur for all alternatives with a 100 percent probability in 2008.

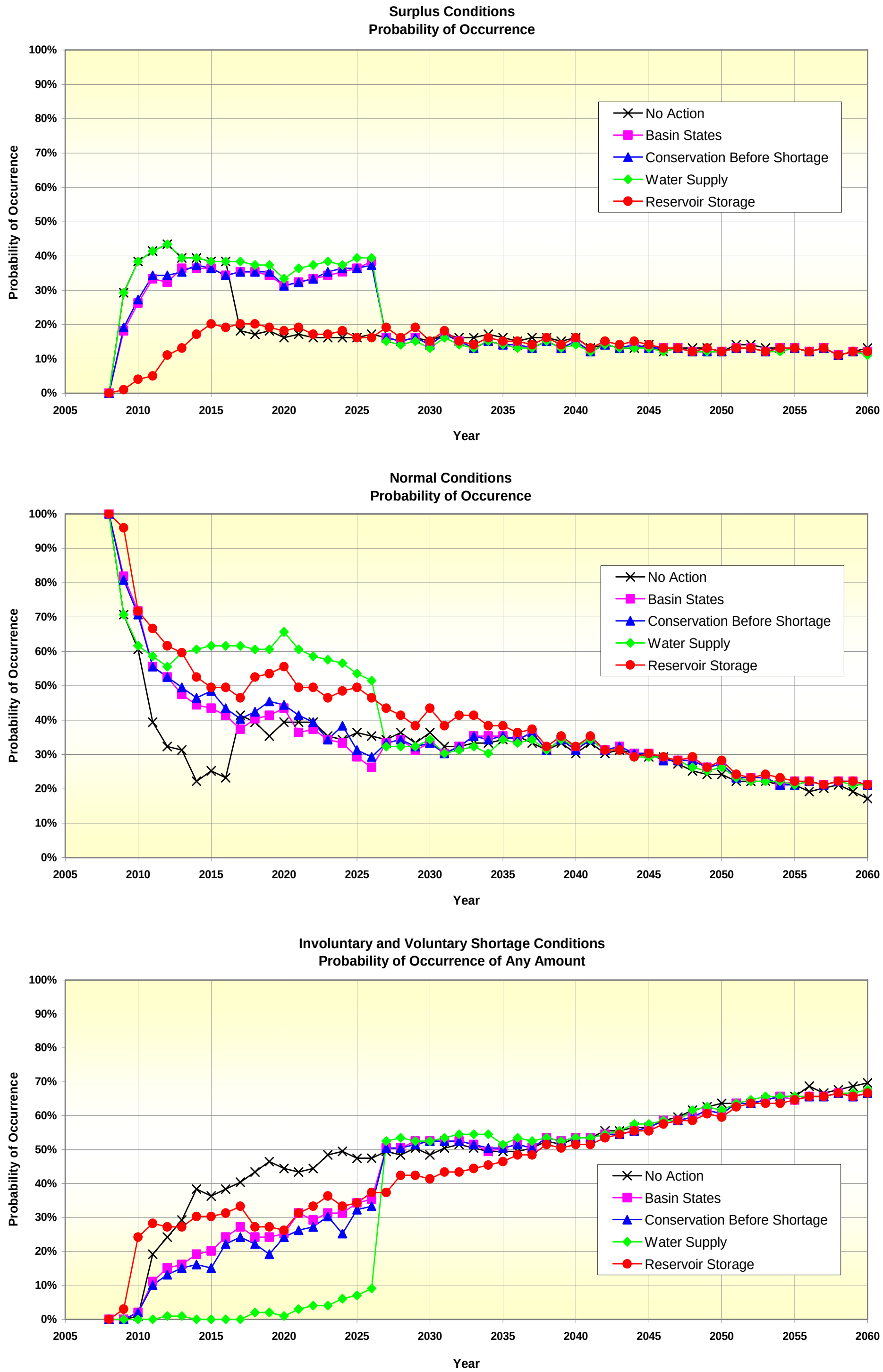
Figure 4.4-14
Probability of Normal Conditions
Comparison of Action Alternatives to No Action Alternative
Years 2008 through 2060



4.4.4.4 Summary of Water Supply Conditions

Figure 4.4-15 illustrates the probabilities of occurrence for the three water supply conditions (Surplus, Normal, and Shortage) under all alternatives.

Figure 4.4-15
Surplus, Normal, and Shortage (Involuntary and Voluntary) Conditions
Comparison of Action Alternatives to No Action Alternatives
Probability of Occurrence



4.4.5 Total Water Deliveries to the Lower Division States

This section presents the simulated water deliveries to the three Lower Division states. Deliveries to each state may deviate from a state's apportionment due to Surplus or Shortage conditions as well as the storage and delivery of conserved water to and from Lake Mead. For the alternatives that do not include some form of a storage and delivery mechanism (the No Action Alternative and the Water Supply Alternative), water deliveries above or below a state's apportionment occur only during Surplus conditions or Shortage conditions respectively. Water deliveries under the Basin States, Conservation Before Shortage and Reservoir Storage alternatives in excess of a state's apportionment can occur due to a Surplus conditions as well as when conserved water previously stored in Lake Mead is delivered. Also under these alternatives, water deliveries less than a state's apportionment can occur due to a Shortage condition as well as when water is being conserved within that state and stored in Lake Mead. In the following sections, the modeled water deliveries are presented with and without the storage and delivery mechanism to facilitate understanding of the differences.

4.4.5.1 Total Water Deliveries to Arizona

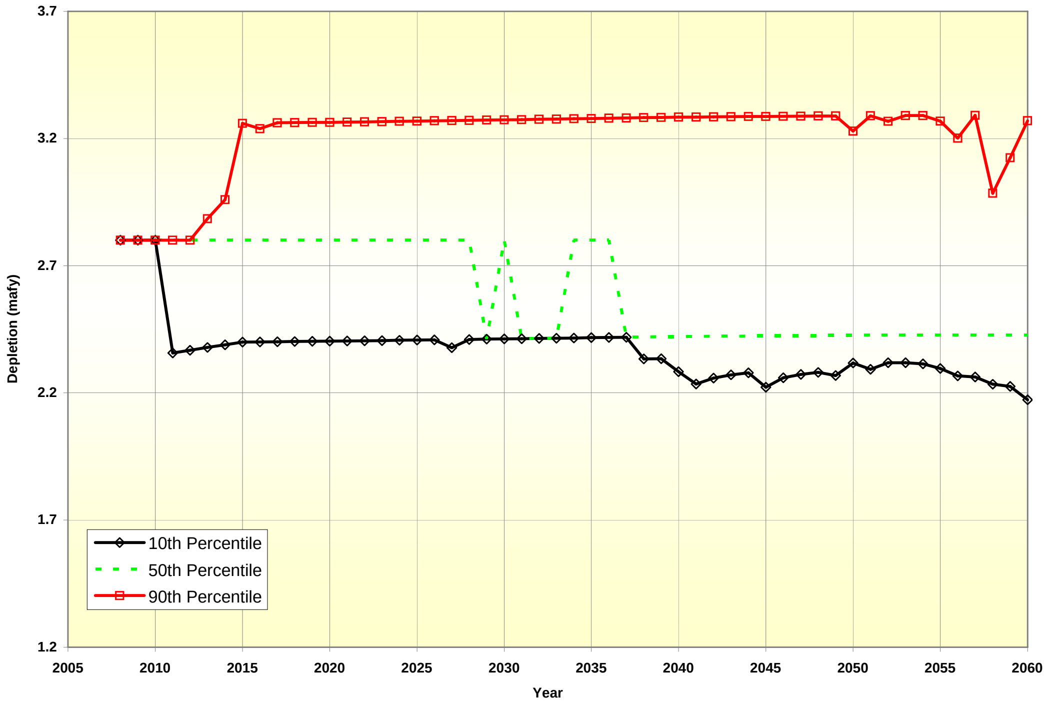
This section presents the simulated water deliveries to Arizona under the No Action Alternative and the action alternatives.

No Action Alternative. Water deliveries to Arizona are projected to fluctuate throughout the 53-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50^{th,} and 10th percentile ranking of modeled water deliveries to Arizona under the No Action Alternative are presented in Figure 4.4-16. Since the No Action Alternative does not include a storage and delivery mechanism, deviations from annual deliveries of 2.8 mafy are due to Shortage and Surplus conditions.

The 90th percentile line generally coincides with Arizona's depletion schedule during full surplus water supply conditions. The exceptions to this are the periods from 2008 through 2014 and 2055 through 2060. As indicated by this 90th percentile line, the probability that the No Action Alternative would provide Arizona's full surplus depletion schedule is at least 10 percent for the period 2015 through 2055.

The 50th percentile line represents the median annual depletion values. This 50th percentile line generally coincides with Arizona's projected depletion schedule under Normal conditions through year 2028. After 2028, the median annual Arizona modeled depletion values fluctuate between 2.41 maf and 2.80 maf.

Figure 4.4-16
Arizona Modeled Annual Depletions
No Action Alternative
90th, 50th, and 10th Percentile Values



The 10th percentile line represents the depletion values above which 90 percent of the annual depletion values were observed. The 10th percentile annual depletion values were 2.80 maf from 2008 through 2010, approximately 2.4 maf from 2011 through 2037. After 2037, the 10th percentile annual depletion values fluctuated between 2.17 maf and 2.33 maf.

Comparison of Action Alternatives Without the Storage and Delivery Mechanism to No Action Alternative. Figure 4.4-17 provides a comparison of the cumulative distribution of Arizona's depletions under the action alternatives without the storage and delivery mechanism to those of the No Action Alternative during the interim period (years 2008 through 2026). The results presented in Figure 4.4-17 can be used to compare how often Arizona might expect deliveries above and below its 2.8 mafy apportionment due to Surplus and Shortage conditions under the different alternatives.

Figure 4.4-17
Arizona Modeled Annual Depletions
Comparison of Action Alternatives (Without Storage and Delivery Mechanism) to No Action Alternative
Years 2008 through 2026

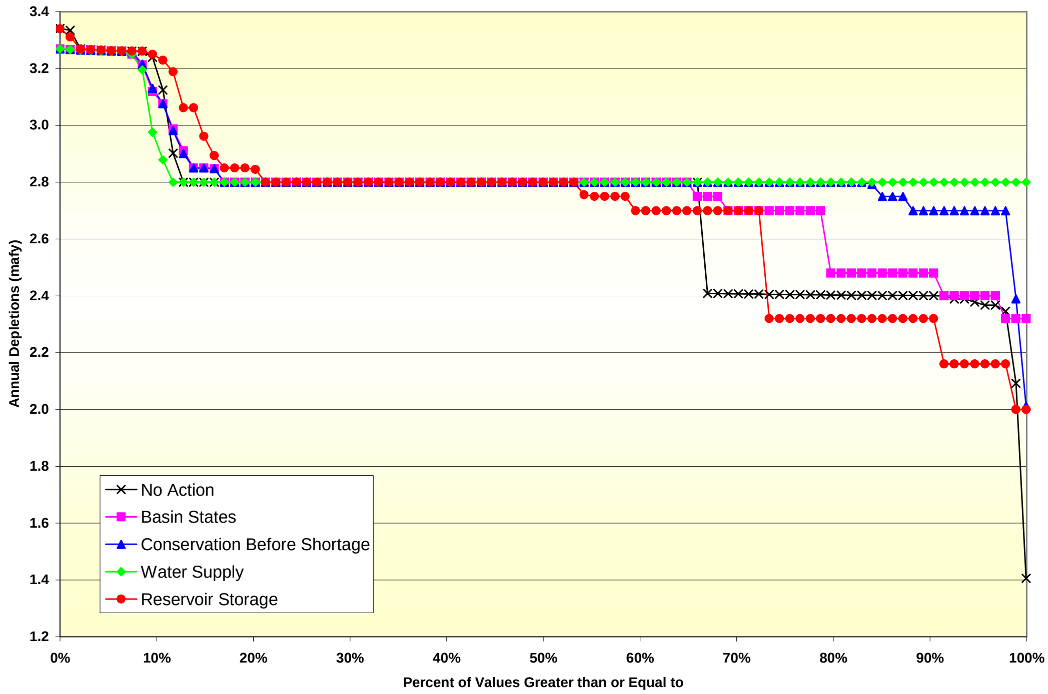


Figure 4.4-18 provides a similar comparison of the cumulative distribution of water deliveries to Arizona under the action alternatives without the storage and delivery mechanism to those of the No Action Alternative for the 34-year period (years 2027 through 2060) that would follow the interim period.

Sensitivity of Total Water Deliveries to Arizona to Storage and Delivery Mechanism. Arizona water deliveries under the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives are impacted by the modeling assumptions made to postulate potential future participation in a storage and delivery mechanism (Appendix M). This section isolates the impacts of those assumptions on Arizona's modeled depletions.

Figure 4.4-18
Arizona Modeled Annual Depletions
Comparison of Action Alternatives (Without Storage and Delivery Mechanism) to No Action Alternative
Years 2027 through 2060

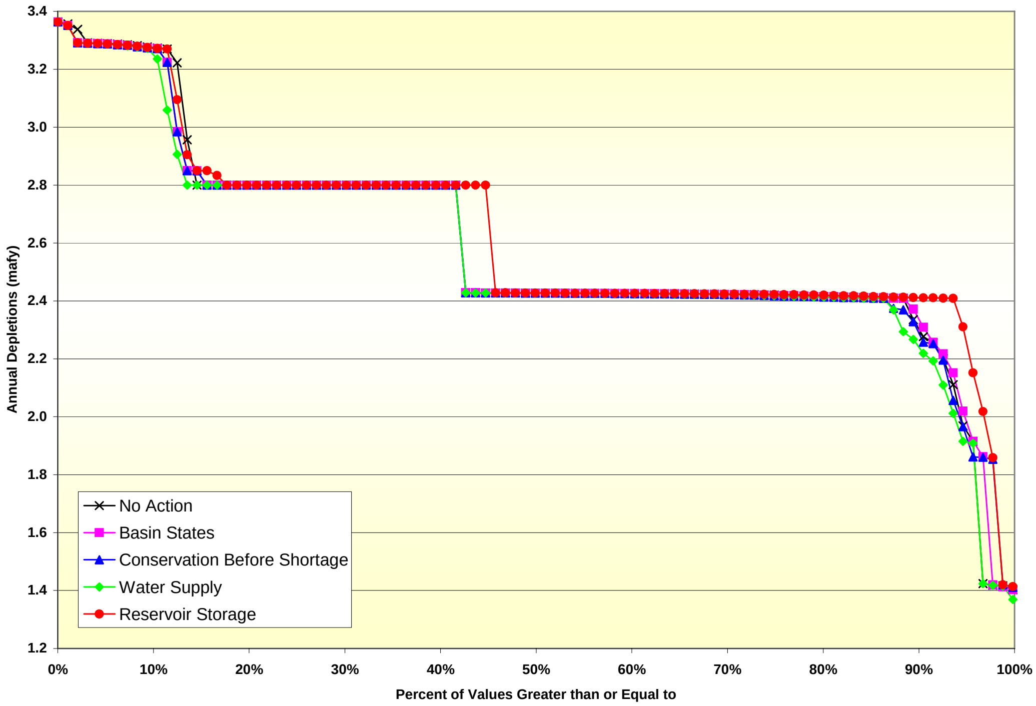


Figure 4-4.19 provides a comparison of the cumulative distribution of Arizona's depletions under the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives, with and without the mechanism in place during the interim period. With the mechanism in place, deliveries of approximately 2.7 mafy are due to the storage of conserved water. With the mechanism removed, occurrences of deliveries less than 2.8 mafy or greater than 2.8 mafy reflect only Shortage or Surplus conditions respectively. These observations mirror the effects of the mechanism on the probability of voluntary and involuntary total Lower Basin Shortage and Surplus Conditions presented in the previous subsection.

Figure 4.4-19
Arizona Modeled Depletions
Comparison of Action Alternatives With and Without Storage and Delivery Mechanism
Years 2008 through 2026

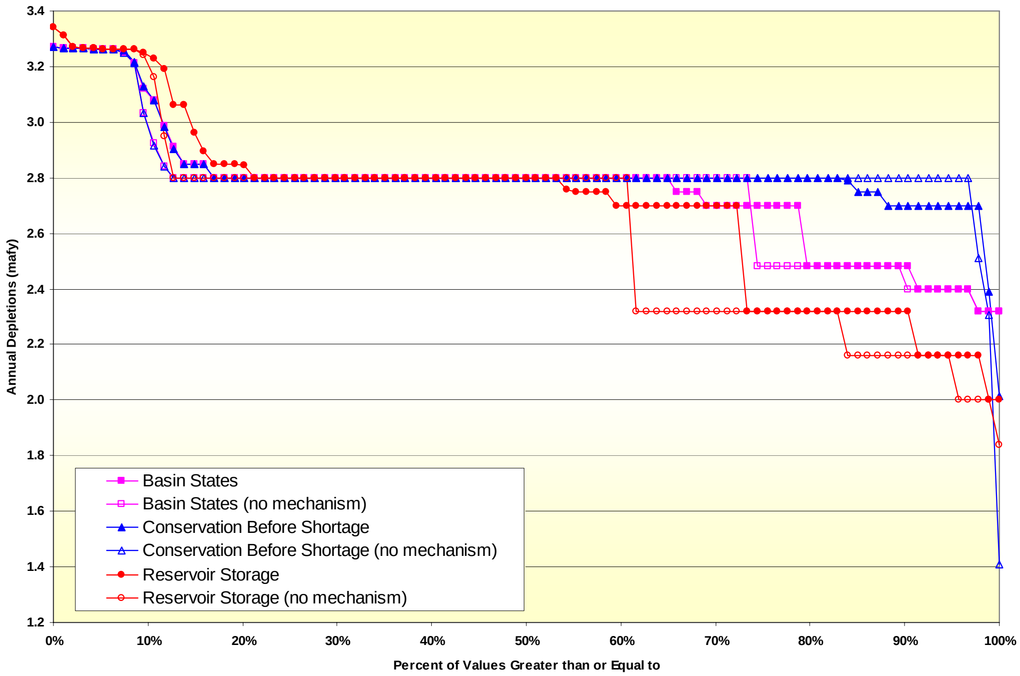
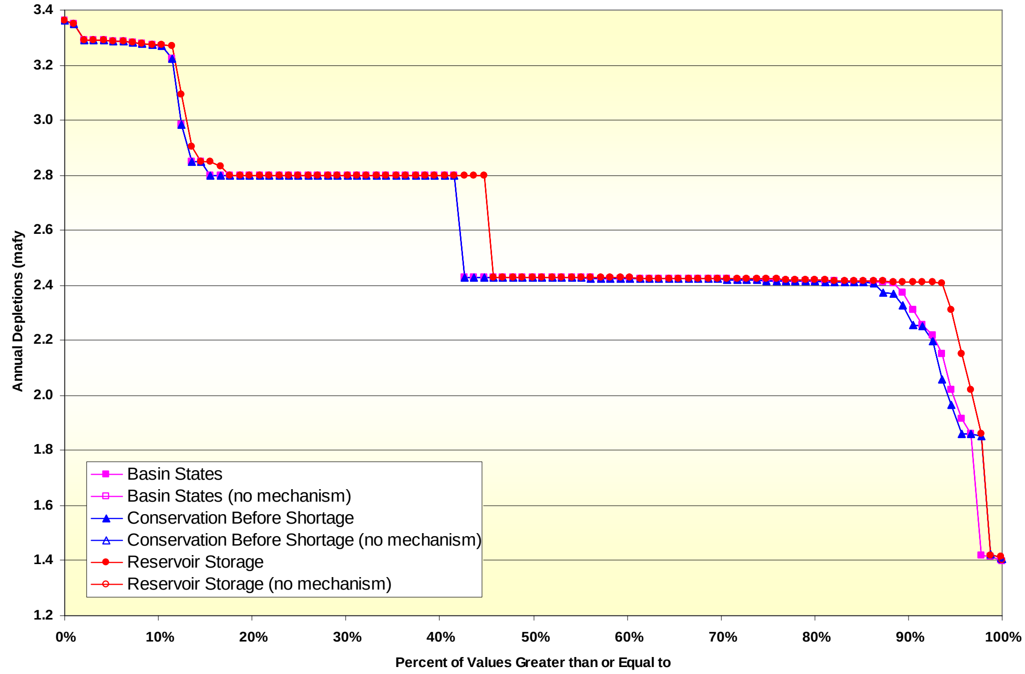


Figure 4-4.20 provides a comparison of the cumulative distribution of Arizona's depletions under the action alternatives that include a storage and delivery mechanism, with and without the mechanism in place for the 34-year period that would follow the interim period. There is almost no effect of the mechanism during these years as it is assumed only conserved water previously stored in Lake Mead may be delivered during this period.

Figure 4.4-20
Arizona Modeled Depletions
Comparison of Action Alternatives With and Without Storage and Delivery Mechanism
Years 2027 through 2060

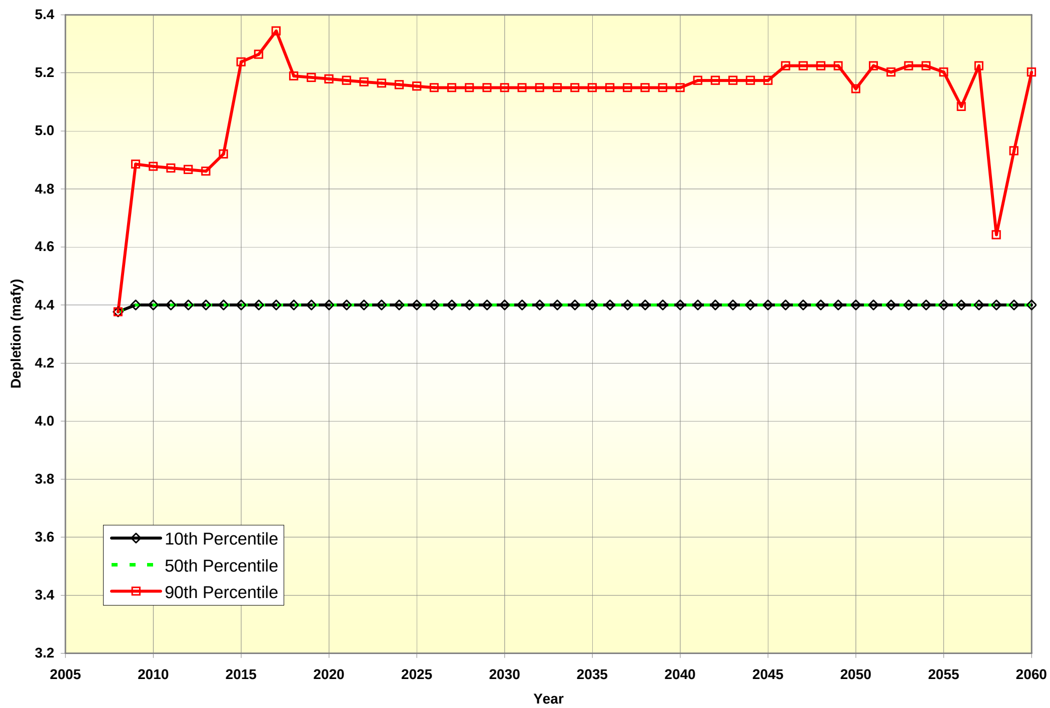


4.4.5.2 Total Water Deliveries to California

This section presents the simulated water deliveries to California under the No Action Alternative and the action alternatives.

No Action Alternative. Water deliveries to California are projected to fluctuate throughout the 53-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50th, and 10th percentile ranking of modeled water deliveries to California under the No Action Alternative are presented in Figure 4.4-21. Since the No Action Alternative does not include a storage and delivery mechanism, deviations from annual deliveries of 4.4 mafy are due to Shortage and Surplus conditions.

Figure 4.4-21
California Modeled Annual Depletions
No Action Alternative
90th, 50th, and 10th Percentile Values



The 90th percentile line generally coincides with California's depletion schedule during full surplus water supply conditions. The exceptions to this are the periods from 2008 through 2014 and from 2055 through 2060. As indicated by this 90th percentile line, the probability that the No Action Alternative would provide California's full surplus depletion schedule is at least 10 percent for the period from 2015 through 2055.

The 50th percentile line represents the median annual depletion values. This 50th percentile line generally coincides with California's projected depletion schedule under Normal conditions throughout the 53-year period of analysis.

The 10th percentile line represents the depletion values above which 90 percent of the annual depletion values were observed. The 10th percentile annual depletion values also generally coincide with California's projected depletion schedule under Normal conditions throughout the 53-year period of analysis. This means that there is at least a 90 percent probability that California will receive its Normal conditions scheduled deliveries from 2008 through 2060.

Comparison of Action Alternatives Without the Storage and Delivery Mechanism to No Action Alternative. Figure 4.4-22 provides a comparison of the cumulative distribution of California's depletions under the action alternatives without the storage and delivery mechanism to those of the No Action Alternative during the interim period (years 2008 through 2026). The results presented in Figure 4.4-22 can be used to compare how often California might expect deliveries above and below its 4.4 mafy apportionment due to Surplus and Shortage conditions under the different alternatives.

Figure 4.4-22
California Modeled Annual Depletions
Comparison of Action Alternatives (Without Storage and Delivery Mechanism) to No Action Alternative
Years 2008 through 2026

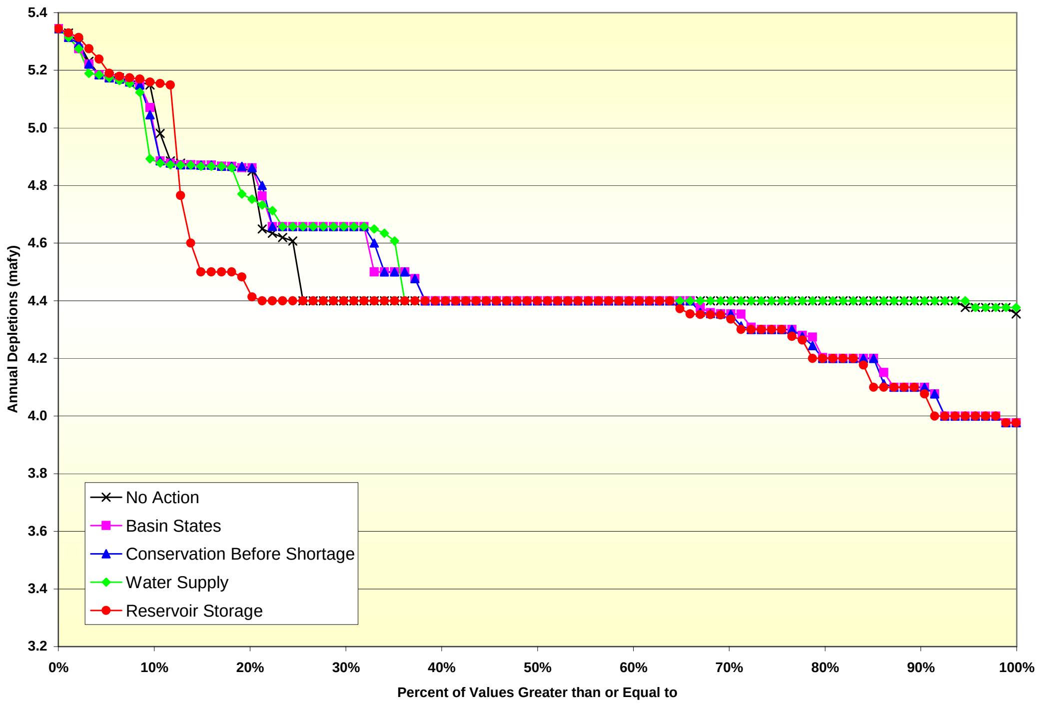
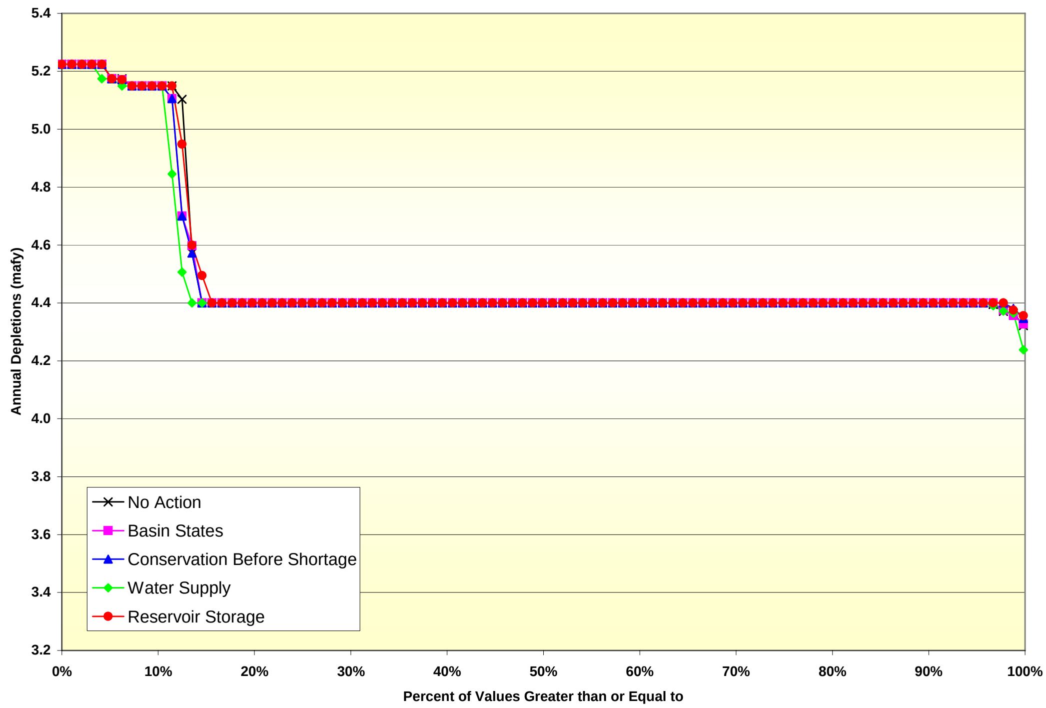


Figure 4.4-23 provides a similar comparison of the cumulative distribution of water deliveries to California under the action alternatives without the storage and delivery mechanism to those of the No Action Alternative for the 34-year period (years 2027 through 2060) that would follow the interim period.

Figure 4.4-23
California Modeled Annual Depletions
Comparison of Action Alternatives (Without Storage and Delivery Mechanism) to No Action Alternative
Years 2027 through 2060



Sensitivity of Total Water Deliveries to California to Storage and Delivery Mechanism. California water deliveries under the Basin States, Conservation Before Shortage and Reservoir Storage alternatives are impacted by modeling assumptions made to postulate potential future participation in a storage and delivery mechanism (Appendix M). This section isolates the impacts of those assumptions on California's depletions.

Figure 4-4.24 provides a comparison of the cumulative distribution of California's depletions under the action alternatives that include a storage and delivery mechanism, with and without the mechanism in place during the interim period. For alternatives with the mechanism removed, occurrences of deliveries less than 4.4 mafy reflect only Shortage conditions. Removing the mechanism shows that there is almost no occurrence of deliveries less than 4.4 mafy due to Shortage conditions. The five percent occurrence of deliveries less than 4.4 mafy when the mechanism is not in place reflects California's scheduled delivery of less than 4.4 maf in 2008 which coincides with scheduled repayment of inadvertent overruns by IID and CVWD.

Figure 4.4-24
California Modeled Annual Depletions
Comparison of Action Alternatives With and Without Storage and Delivery Mechanism
Years 2008 through 2026

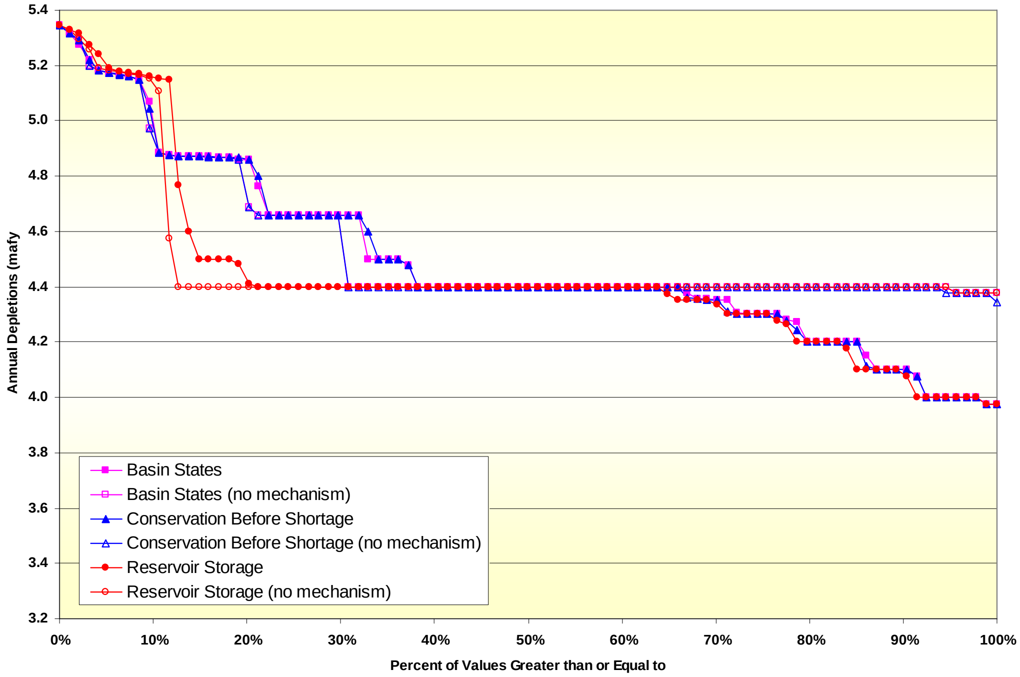
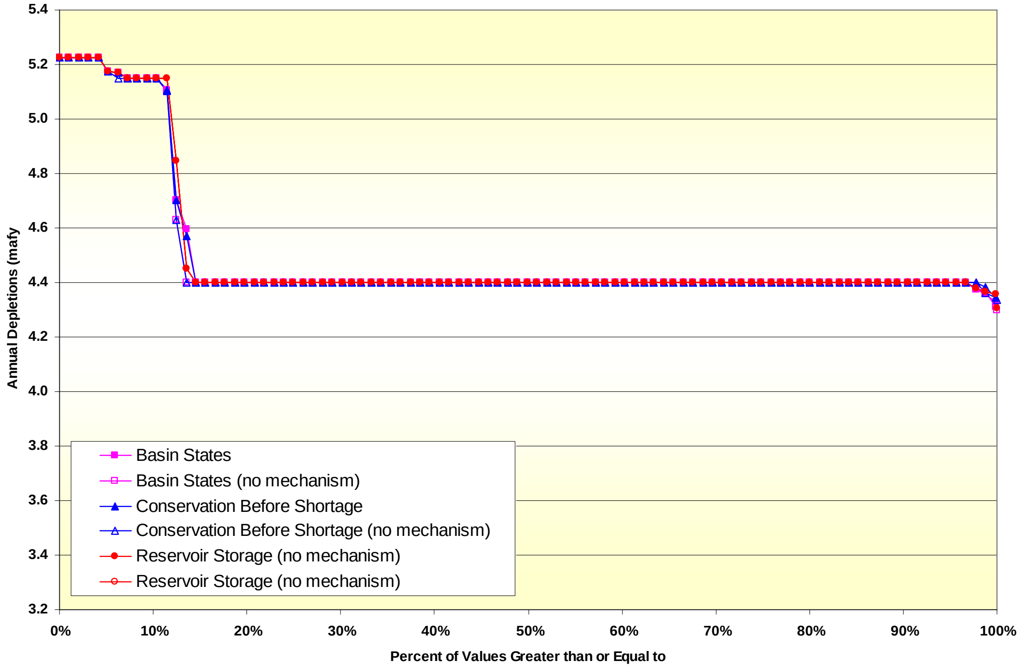


Figure 4-4.25 provides a comparison of the cumulative distribution of California's depletions under the action alternatives that include a storage and delivery mechanism, with and without the mechanism in place for the 34-year period that would follow the interim period. There is almost no effect of the mechanism during these years as it is assumed only conserved water previously stored in Lake Mead may be delivered during this period.

Figure 4.4-25
California Modeled Annual Depletions
Comparison of Action Alternatives With and Without Storage and Delivery Mechanism
Years 2027 through 2060



4.4.5.3 Total Water Deliveries to Nevada

This section presents the simulated water deliveries to Nevada under the No Action Alternative and the action alternatives.

No Action Alternative. Water deliveries to Nevada are projected to fluctuate throughout the 53-year period of analysis reflecting variations in hydrologic conditions. The 90^{th}, 50^{th}, and 10^{th} percentile ranking of modeled water deliveries to Nevada under the No Action Alternative are presented in Figure 4.4-26. Since the No Action Alternative does not include a storage and delivery mechanism, deviations from annual deliveries of 300 kafy are due to Shortage and Surplus conditions.

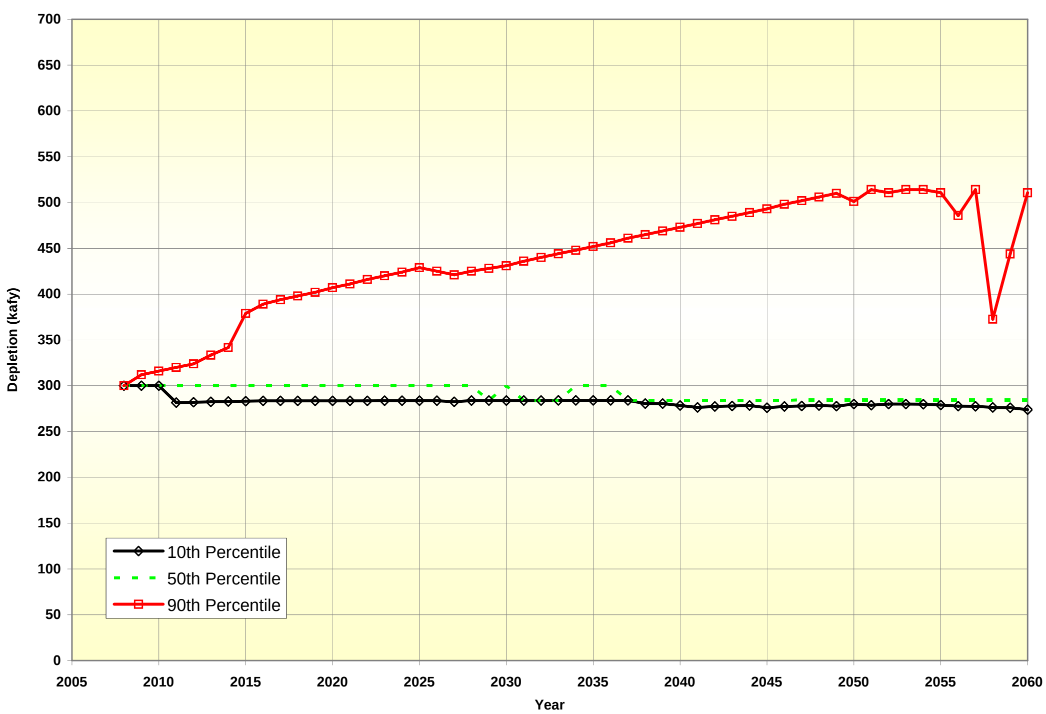
The 90th percentile line generally coincides with Nevada's depletion schedule during full surplus water supply conditions. The exception to this is the period of 2055 through 2060. As indicated by this 90th percentile line, the probability that the No Action Alternative would provide Nevada's full surplus depletion schedule is at least 10 percent for the period of 2008 through 2055.

The 50th percentile line represents the median annual depletion values. This 50th percentile line generally coincides with Nevada's projected depletion schedule under Normal conditions throughout the 53-year period of analysis.

The 50th percentile line represents the median annual depletion values. This 50th percentile line generally coincides with Nevada's projected depletion schedule under Normal conditions through year 2028. After 2028, the median annual Nevada modeled depletion values fluctuate between 283.8 kaf and 300 kaf.

The 10th percentile line represents the depletion values above which 90 percent of the annul depletion values were observed. The 10th percentile annual depletion values fluctuated between 273.9 kaf and 300 kaf.

Figure 4.4-26
Nevada Modeled Annual Depletions
No Action Alternative
90th, 50th, and 10th Percentile Values



Comparison of Action Alternatives Without the Storage and Delivery Mechanism to No Action Alternative. Figure 4.4-27 provides a comparison of the cumulative distribution of Nevada's depletions under the action alternatives without the storage and delivery mechanism to those of the No Action Alternative during the interim period (years 2008 through 2026). The results presented in Figure 4.4-27 can be used to compare how often Nevada might expect deliveries above and below its 300 kafy apportionment due to Surplus and Shortage conditions under the different alternatives.

Figure 4.4-27
Nevada Modeled Annual Depletions
Comparison of Action Alternatives (Without Storage and Delivery Mechanism) to No Action Alternative
Years 2008 through 2026

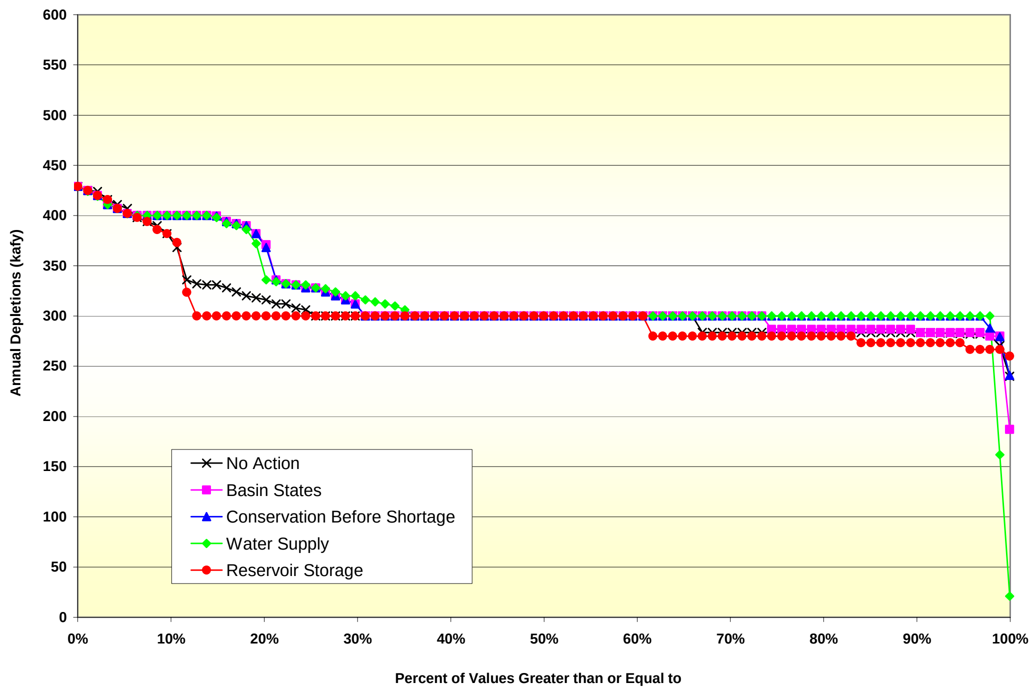
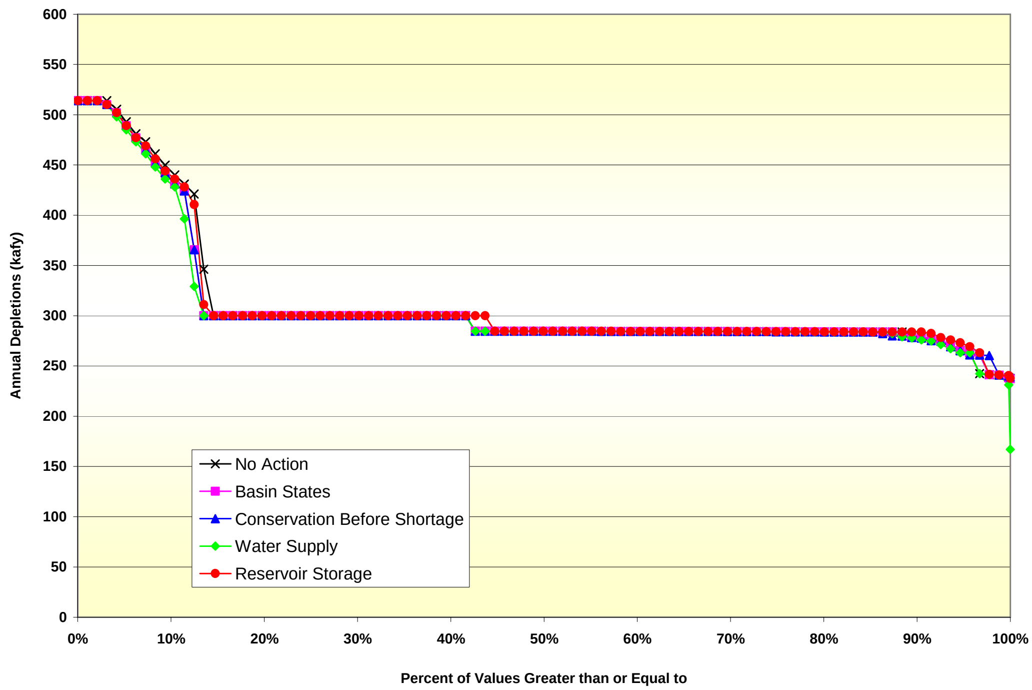


Figure 4.4-28 provides a similar comparison of the cumulative distribution of water deliveries to Nevada under the action alternatives without the storage and delivery mechanism to those of the No Action Alternative for the 34-year period (years 2027 through 2060) that would follow the interim period.

Figure 4.4-28
Nevada Modeled Annual Depletions
Comparison of Action Alternatives (Without Storage and Delivery Mechanism) to No Action Alternative
Years 2027 through 2060

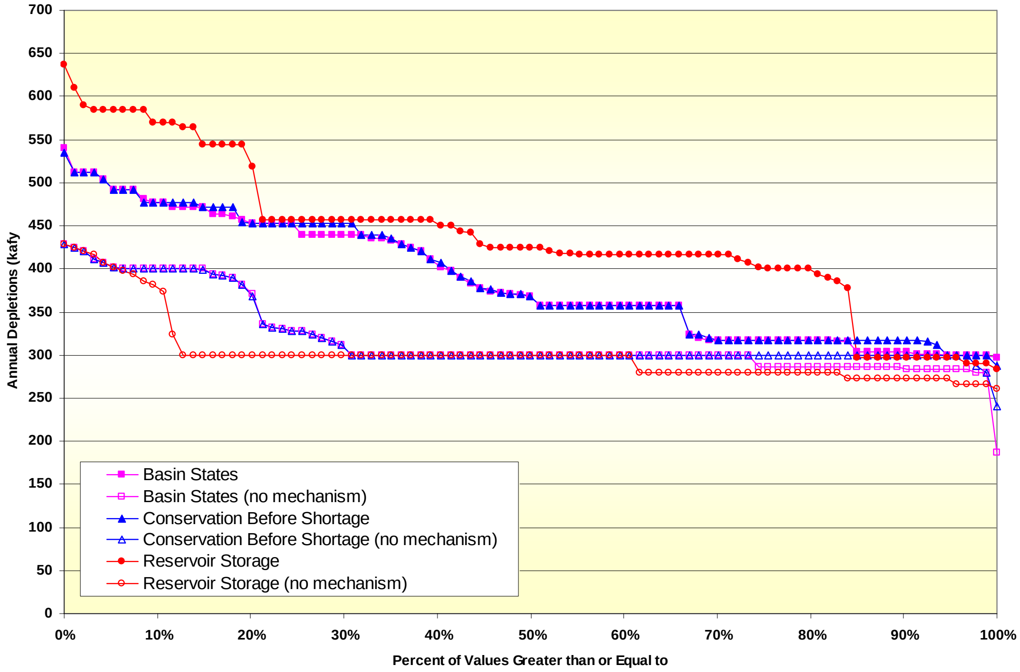


Sensitivity of Total Water Deliveries to Nevada to Storage and Delivery Mechanism. Nevada water deliveries under the Basin States, Conservation Before Shortage and Reservoir Storage alternatives are impacted by the modeling assumptions made to postulate potential future participation in a storage and delivery mechanism (Appendix M). This section isolates the impacts of those assumptions on Nevada's modeled depletions.

Figure 4-4.29 provides a comparison of the cumulative distribution of Nevada's depletions under the action alternatives that include a storage and delivery mechanism, with and without the mechanism in place during the interim period. With the mechanism removed the occurrence of deliveries greater than 300 kafy is about 55 percent less under the Basin States and Conservation Before Shortage alternatives. Under the Reservoir Storage Alternative the occurrence of deliveries above 300 kafy is about 70 percent less with the mechanism removed. This indicates that the majority of the occurrences of deliveries above 300 kafy in the Basin States, Conservation Before Shortage and Reservoir Storage alternatives can be attributed to the delivery of conserved and non-system water to Nevada. Also, the magnitude of the deliveries above 300 kafy is less with the storage and delivery mechanism not in place. Under the Basin States and

Conservation Before Shortage alternatives the deliveries range from about 55 kaf to 140 kaf less. Under the Reservoir Storage Alternative, the deliveries range from about 100 kaf to 265 kaf less.

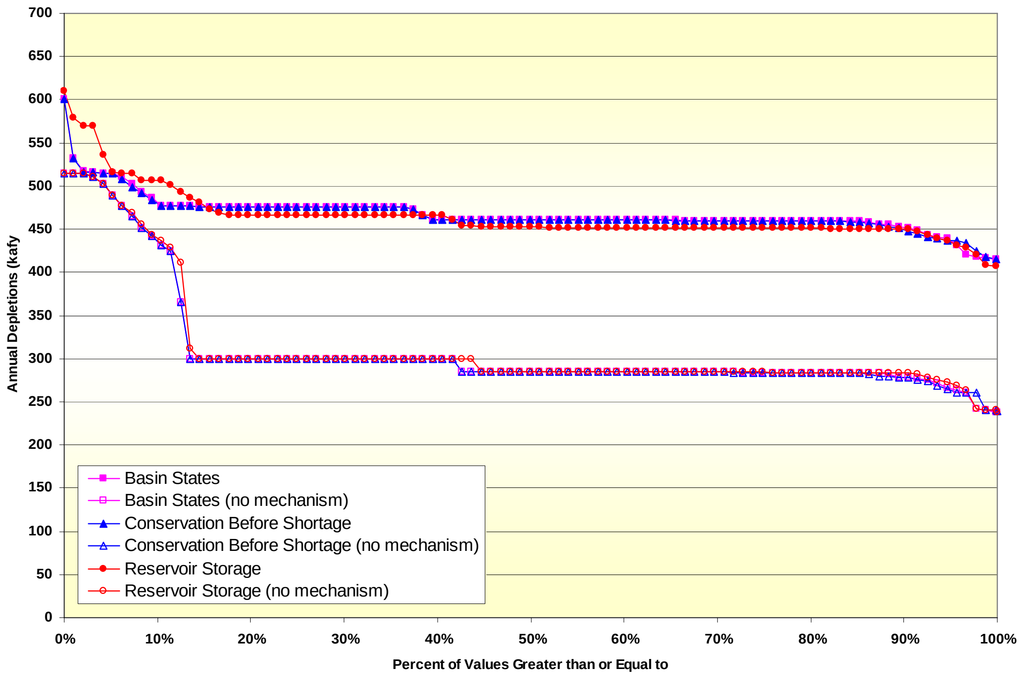
Figure 4.4-29
Nevada Modeled Annual Depletions
Comparison of Action Alternatives With and Without Storage and Delivery Mechanism
Years 2008 through 2026



With the mechanism removed the occurrence of deliveries less than 300 kafy is about 25 percent greater under the Basin States Alternative, two percent greater under the Conservation Before Shortage Alternative and about three percent greater under the Reservoir Storage Alternative. This indicates that as a result of the delivery of conserved and non-system water Nevada does not often receive deliveries less than 300 kafy.

Figure 4-4.30 provides a comparison of the cumulative distribution of Nevada's depletions under the action alternatives that include a storage and delivery mechanism, with and without the mechanism in place for the 34-year period that would follow the interim period. The results of the mechanism removed emphasize the modeling assumption that there about 150 kafy of conserved and non-system water available to Nevada after the interim period under these alternatives (Appendix M).

Figure 4.4-30
Nevada Modeled Annual Depletions
Comparison of Action Alternatives With and Without Storage and Delivery Mechanism
Years 2027 through 2060



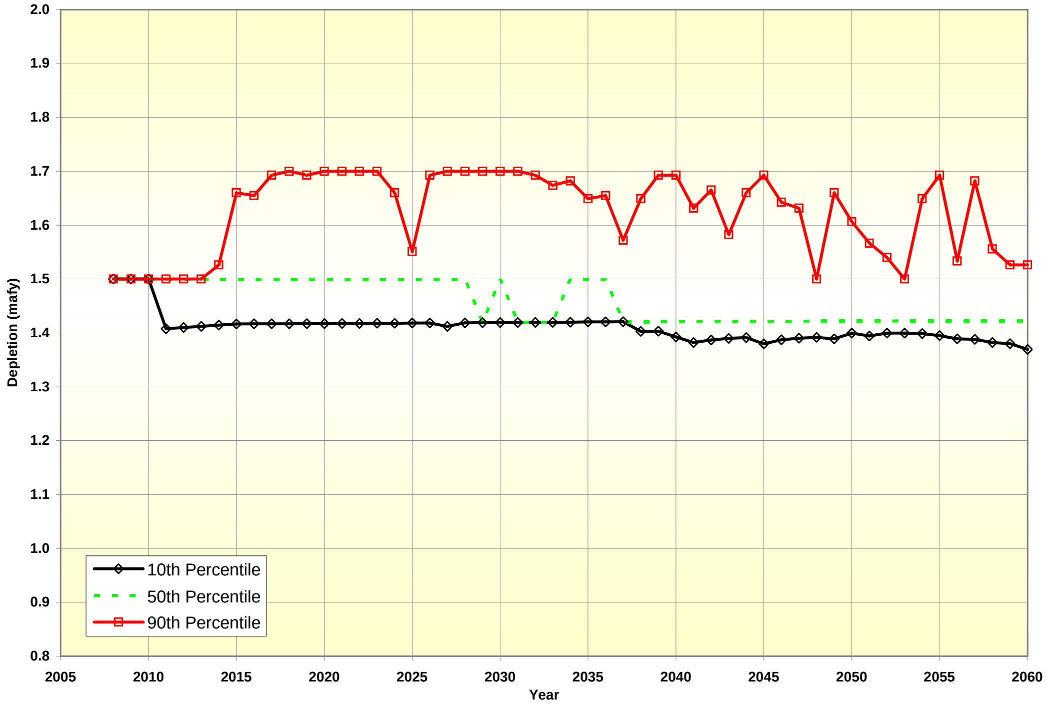
4.4.6 Water Deliveries to Mexico

This section presents the simulated water deliveries to Mexico under the No Action Alternative and action alternatives. The model assumes a delivery to Mexico of 1.5 mafy with additional deliveries of up to 200 kaf when Lake Mead is in flood control operations. Reductions in deliveries to Mexico are simulated consistent with the modeling assumptions noted in Section 2.2, Section 4.2, and Appendix A.

No Action Alternative. The water deliveries to Mexico are projected to fluctuate throughout the 53-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50th, and 10th percentile ranking of modeled water deliveries to Mexico under the No Action Alternative are presented in Figure 4.4-31. Since the No Action Alternative does not include a storage and delivery mechanism, deviations from annual deliveries of 1.5 mafy are due to Shortage conditions and when Lake Mead is in Flood Control operations.

The upper range of 90th percentile annual depletion values shown on Figure 4.4-31 generally coincides with Mexico's depletion schedule during Lake Mead flood control operations. The 90th percentile values fluctuate between 1.5 mafy to 1.7 mafy between 2014 through 2060.

Figure 4.4-31
Mexico Modeled Annual Depletions
No Action Alternative
90th, 50th, and 10th Percentile Values



The 50th percentile line represents the median annual depletion values in years 2008 and 2028. After 2028, the 50th percentile annual depletion values fluctuate between 1.419 maf and 1.5 maf. The drop in the modeled water deliveries to Mexico below Mexico's 1.5 maf allotment reflects the modeling assumptions with respect to shortages.

The 10th percentile line represents the median annual depletion values in years 2008 and 2010 and fall to 1.408 in 2011. After 2011, the annual depletion values fluctuate between 1.369 mafy and 1.421 mafy. The drop in the modeled water deliveries to Mexico below Mexico's 1.5 maf allotment reflects the modeling assumptions with respect to shortages.

Comparison of Action Alternatives Without the Storage and Delivery Mechanism to No Action Alternative. Figure 4.4-32 provides a comparison of the cumulative distribution of Mexico's depletions under the action alternatives without the storage and delivery mechanism to those of the No Action Alternative during the interim period (years 2008 through 2026). The results presented in Figure 4.4-32 can be used to compare how often Mexico might expect deliveries above and below its 1944 Treaty allocation of 1.5 maf due to Surplus and Shortage conditions under the different alternatives. The occurrences of deliveries greater than 1.5 afy reflect both times when additional water up to 200 kafy is made available during Flood Control conditions. The occurrences of deliveries less than 1.5 mafy reflect deliveries to Mexico during Shortage conditions and reflect the modeling assumptions with regard to the sharing of shortages between the Lower Division states and Mexico.

Figure 4.4-32
Mexico Modeled Annual Depletions
Comparison of Action Alternatives (Without Storage and Delivery Mechanism) to No Action Alternative
Years 2008 through 2026

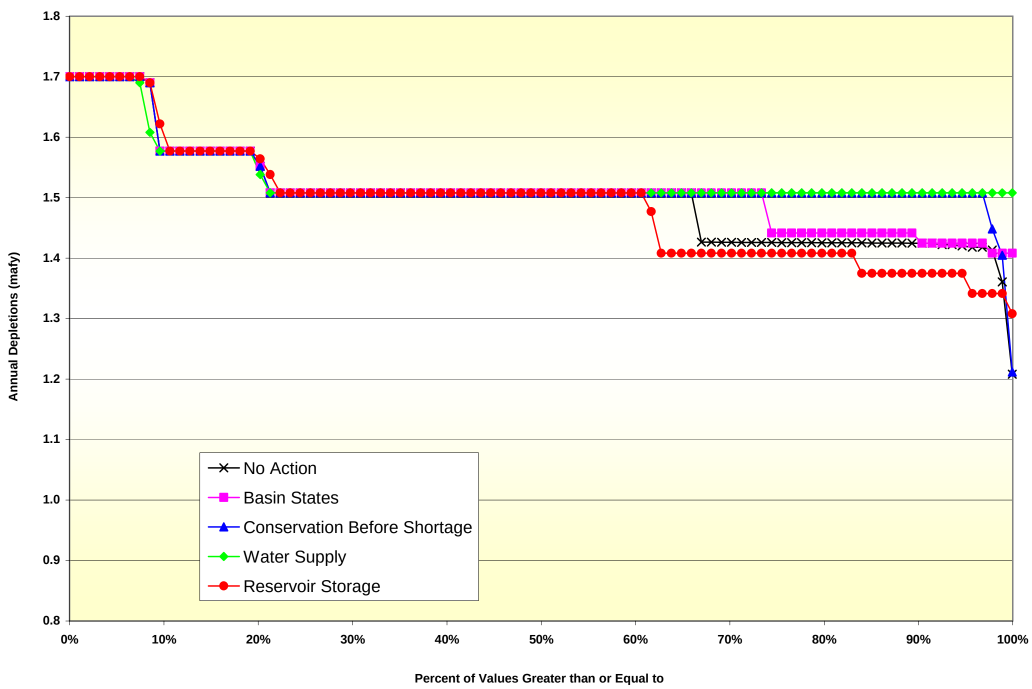
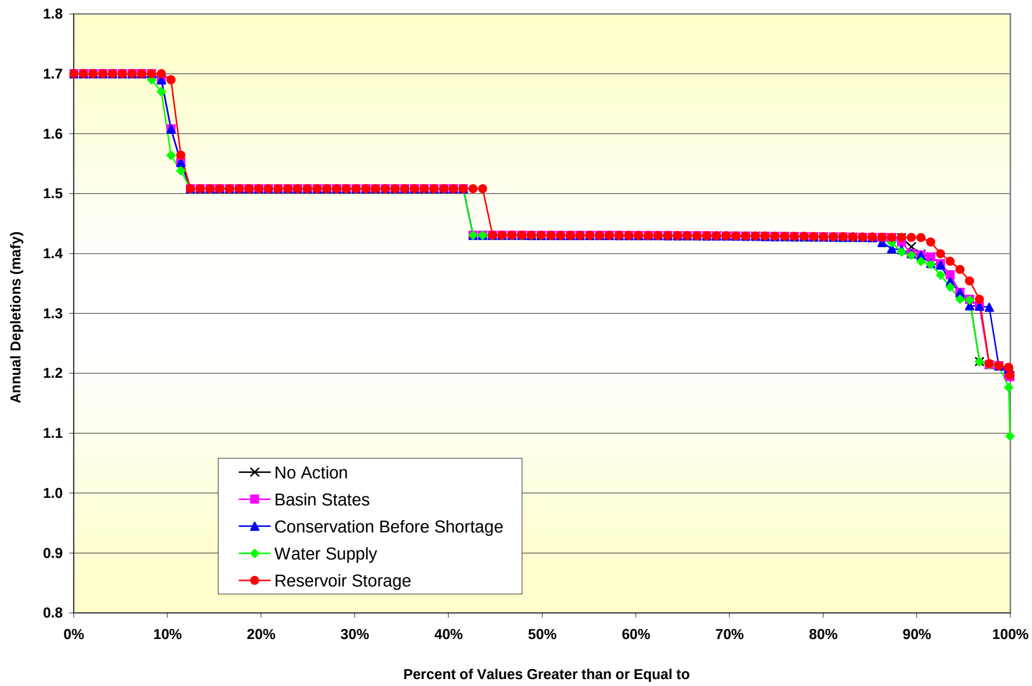


Figure 4.4-33 provides a similar comparison of the cumulative distribution of the water deliveries to Mexico under the action alternatives without the storage and delivery mechanism to those of the No Action Alternative for the 34-year period (years 2027 through 2060) that would follow the interim period.

Figure 4.4-33
Mexico Modeled Annual Depletions
Comparison of Action Alternatives (Without Storage and Delivery Mechanism) to No Action Alternative
Years 2027 through 2060



Sensitivity of Total Water Deliveries to Mexico to Storage and Delivery Mechanism. As noted before, modeling was performed to support the analysis of the storage and delivery mechanism (Appendix M). At this time, it is unknown which entities might participate in this proposed mechanism that allows the storage and delivery of conserved system and non-system water. Furthermore, the timing and magnitude of the storage and delivery of conserved water is unknown. However, modeling assumptions with respect to the entities that might participate and their respective level of participation were needed to enable the analysis of the mechanism and its potential effects on environmental resources, particularly to reservoir storage and river flows below Lake Mead.

The results of the analysis that compares the cumulative distribution of Mexico's depletions under the action alternatives with and without the storage and delivery mechanism to those of the No Action Alternative are provided in Appendix P. The modeling assumptions are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico.

4.4.7 Distribution of Shortages to and within the Lower Division States

Although the Consolidated Decree and the CRBPA provide some direction to the Secretary with regard to the distribution of shortages to the Lower Division states, no specific guidelines exist with regard to exactly how those shortages would be distributed. Furthermore, although priority systems exist within each state, exactly how shortages would be distributed to water users of equal priority within a state is unknown. Therefore, specific modeling assumptions were made in order to facilitate the comparison of each alternative. These assumptions are discussed in Section 4.2, Appendix A, and Appendix G and are consistent between all alternatives.

4.4.7.1 Distribution of Shortages within Arizona

Table 4.4-11 shows different Lower Basin shortage volumes and the portion of the shortage that was assumed to be distributed to Arizona. This table shows the shortage distribution in different years because the distribution changes at the higher magnitudes of shortage due to the changes in the scheduled use of the Arizona 4th Priority water users (Section 4.2).

Table 4.4-11
Shortage Allocation to Arizona (af)

Year	Total Lower Basin Shortage							
	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
2008	160,000	320,000	400,000	480,000	640,000	960,000	1,440,000	1,587,484
2017	160,000	320,000	400,000	480,000	640,000	960,000	1,397,578	1,533,925
2026	160,000	320,000	400,000	480,000	640,000	960,000	1,394,205	1,530,879
2027	160,000	320,000	400,000	480,000	640,000	960,000	1,393,837	1,530,547
2040	160,000	320,000	400,000	480,000	640,000	960,000	1,388,281	1,525,531
2060	160,00	320,000	400,000	480,000	640,000	960,000	1,388,281	1,525,531

As noted in Table 4.4-11, total Lower Basin shortages up to 2.5 maf were analyzed to fully analyze the range of total Lower Basin shortages that could occur.

Table 4.4-12 and Table 4.4-13 provide the probability of occurrence of the total Lower Basin Shortage volumes that are shown in Table 4.4-11 for two periods, 2008 through 2026 and 2027 through 2060, respectively. The probability of shortages with a magnitude of zero includes periods when Surplus or Normal conditions are in effect.

Table 4.4-12
Probability of Occurrence of Shortages Less Than or Equal to, Years 2008 through 2026 (percent)

Alternative	Total Voluntary or Involuntary Lower Basin Shortage								
	0	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
No Action	66.1	66.1	66.1	90.3	97.8	98.4	99.5	99.8	100
Basin States	78.8	78.8	91.3	97.7	99.8	100	100	100	100
Conservation Before Shortage	81.1	81.2	92.6	97.7	98.8	99.5	99.9	99.9	100
Water Supply	97.8	99.3	100	100	100	100	100	100	100
Reservoir Storage	72.5	72.5	72.5	72.5	90.8	98.1	100	100	100

Table 4.4-13
Probability of Occurrence of Shortages Less Than or Equal to, Years 2027 through 2060 (percent)

Alternative	Total Voluntary or Involuntary Lower Basin Shortage								
	0	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
No Action	42.5	42.5	42.5	88.7	89.5	93.1	96.7	99.6	100
Basin States	42.6	42.6	42.6	89.2	89.9	93.4	96.9	99.2	100
Conservation Before Shortage	42.6	42.6	42.6	87.3	89.8	92.7	98.1	99.8	100
Water Supply	41.6	41.6	41.6	86.6	88	91.8	96.3	99.4	99.9
Reservoir Storage	45.5	45.5	45.5	94	94.5	95.5	97.8	99.9	100

Under most circumstances, the probabilities of involuntary and voluntary shortages being allocated to Arizona are the same as the probability of shortage allocations to the Lower Basin under the No Action Alternative and for each of the action alternatives. The overall probabilities are shown in Table 4.4-13. Table 4.4-14 shows the maximum shortage that would be assigned to Arizona under the No Action Alternative and the action alternatives.

Table 4.4-14
Maximum Shortage Allocation to Arizona (af)

Year	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	0	0	0	0	0
2017	762,016	480,000	704,977	0	800,000
2026	1,395,118	621,896	1,406,802	233,200	800,000
2027	1,397,580	845,678	950,019	1,385,026	390,915
2040	1,394,587	1,395,404	1,393,740	1,403,706	1,395,330
2060	1,402,157	1,389,542	1,385,332	1,402,157	1,385,026

While shortage allocations to California and Nevada would affect single entities within each state (MWD in California and SWNA in Nevada) allocations within Arizona are distributed among a number of water users based upon Arizona's system of water rights priorities (Section 3.4 and Appendix G). This shortage distribution is based solely on current priorities and does not reflect management decisions that may be taken by Arizona entities to obtain additional water supplies to offset shortages. Table 4.4-15 summarizes how shortages of different volumes in Arizona would be distributed among Arizona's priorities and how this distribution changes over time. The table also does not show 5th priority users and the CAP Bank who now rely on unused and surplus water because by 2017 no unused water will be available to the 5th priority users and surplus water will not be available in shortage years.

Table 4.4-15
Distribution of Shortages Among Arizona Entities[1] (af)

Lower Basin Shortage Allocations	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Year 2017								
CAP Non-Indian Agricultural Priority	142,684	272,691	272,691	272,691	272,691	272,691	272,691	272,691
CAP Tribes	0	2,553	16,920	62,958	114,969	218,772	357,350	367,977
CAP M&I	0	10,124	67,099	92,402	183,074	364,639	605,637	610,313
4th Priority Users on Mainstream	9,807	19,614	24,517	29,421	39,227	58,841	84,825	84,825
2nd and 3rd Priority (Includes Some CAP Users)	0	0	0	0	0	0	13,653	149,999
Year 2026								
CAP Non-Indian Agricultural Priority	65,979	65,979	65,979	65,979	65,979	65,979	65,979	65,979
CAP Tribes	38,941	111,547	151,901	175,815	227,576	331,099	467,921	478,430
CAP M&I	37,378	107,070	137,866	185,101	275,637	456,711	694,543	699,167
4th Priority Users on Mainstream	10,212	20,425	25,531	30,637	40,850	61,275	88,046	88,046
2nd and 3rd Priority (Includes Some CAP Users)	0	0	0	0	0	0	14,785	151,460
Year 2027								
CAP Non-Indian Agricultural Priority	31,869	31,867	31,867	31,867	31,867	31,867	31,867	31,867
CAP Tribes	61,303	140,306	178,018	202,008	253,748	357,229	493,846	504,338
CAP M&I	49,070	112,307	145,717	192,848	283,349	464,351	701,812	706,429
4th Priority Users on Mainstream	10,272	20,544	25,680	30,817	41,089	61,633	88,529	88,529
2nd and 3rd Priority (Includes Some CAP Users)	0	0	0	0	0	0	14,909	151,620

Table 4.4-15 (continued)
Distribution of Shortages Among Arizona Entities (af)

Lower Basin Shortage Allocations	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Year 2040								
CAP Non-Indian Agricultural Priority	0	0	0	0	0	0	0	0
CAP Tribes	74,171	138,517	156,515	181,583	233,056	336,001	469,648	480,025
CAP M&I	55,727	132,886	185,640	231,324	321,356	501,419	733,523	738,089
4th Priority Users on Mainstream	11,048	22,096	27,620	33,144	44,192	66,288	94,702	94,702
2nd and 3rd Priority (Includes Some CAP Users)	0	0	0	0	0	0	16,791	154,042
Year 2060								
CAP Non-Indian Agricultural Priority	0	0	0	0	0	0	0	0
CAP Tribes	132,218	172,941	186,015	211,449	262,604	339,336	497,743	508,120
CAP M&I	90,217	190,126	247,367	292,248	381,725	560,677	791,351	795,917
4th Priority Users on Mainstream	11,968	23,935	29,919	35,903	47,870	71,806	102,584	102,584
2nd and 3rd Priority (Includes Some CAP Users)	0	0	0	0	0	0	16,791	154,042

1 CAP users incur five percent conveyance loss through the CAP system due to seepage and therefore the sum of the Arizona shortages in any one column do not add up to the total shortage volume allocated to Arizona at each Lower Basin Shortage increment noted at the top of the table.

A major change in the allocation of Arizona shortages occurs during 2017 and 2040 within the CAP and can be seen in Table 4.4-15. The allocation of shortages to individual users within the CAP is affected by the water priority scheme within the CAP, the AWSA, and the water use buildup schedules for the CAP users. Over time, the impact of a given shortage to the CAP increasingly impacts the higher priority Indian and M&I users as their use builds up and the shortage cannot be absorbed by the lower priorities.

Prior to the enactment of the AWSA, there were differing views as to how mild shortages would be distributed between the CAP Indian and M&I priority users. As part of the AWSA, a compromise was reached. Also, under the AWSA, the CAP irrigation districts agreed to relinquish their long-term water service subcontracts for Non-Indian Agricultural priority water. Approximately 300 kaf was relinquished, with approximately 200 kaf being made available for Indian water rights settlements and approximately 100 kaf was made available for future M&I use. In return, the irrigation districts obtained CAP distribution system debt relief, relief from the acreage limitation provisions of Federal Reclamation law, and a commitment from the CAP to receive an interim water supply at an affordable rate.

4.4.7.2 Distribution of Shortages within California

The preceding section discussed the modeled allocation of water to California under Normal, Surplus and Shortage water supply conditions. The following section provides a discussion of how shortages that are allocated to California are distributed to the Colorado River water entitlement holders, based on the shortage sharing assumptions programmed into the Shortage Allocation Model.

The distribution or allocation of California shortages among California's Colorado River water entitlement holders is based on California's system of water entitlement priorities. Of particular note is the frequency and magnitude of the shortages that are allocated to California. Because California's deliveries are not affected by Stage 1 shortages (Section 4.2), the total Lower Basin shortage has to exceed 1.7 maf (the upper limit of the Stage 1 Lower Basin shortages) before deliveries to California are affected. As a result of this, California receives less frequent shortages than Arizona and Nevada, and the magnitude of shortages to California are relatively smaller.

Table 4.4-16 provides an overview of the portion of the total Lower Basin shortage that is allocated to California. As shown on this table, only Stage 2 shortages (Section 4.2) affect California water deliveries. A Stage 2 shortage would occur if the total Lower Basin shortage exceeds 1.827 maf in year 2008. This threshold decreases to 1.714 maf in 2060.

Table 4.4-16
Shortage Allocation to California (af)

Lower Basin Shortage Allocations	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Shortage allocation to California – 2008	0	0	0	0	0	0	0	412,516
Shortage allocation to California – 2017	0	0	0	0	0	0	42,421	466,075
Shortage allocation to California – 2026	0	0	0	0	0	0	45,795	469,120
Shortage allocation to California – 2027	0	0	0	0	0	0	46,163	469,452
Shortage allocation to California – 2040	0	0	0	0	0	0	52,719	474,468
Shortage allocation to California – 2060	0	0	0	0	0	0	51,719	474,468

The probability of the shortage volumes shown in Table 4.4-16 are shown in Tables 4.4-2 and 4.4-13.

Table 4.4-17 shows the maximum shortage volumes that would be assigned to California under the No Action Alternative and the four action alternatives. Because of the large magnitude Lower Basin shortages assumed to be required to trigger shortages in California, many shortages declared in the Lower Basin would not trigger shortages in California.

Table 4.4-17
Maximum Shortage Allocation to California (af)

Year	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	0	0	0	0	0
2017	0	0	0	0	0
2026	45,798	0	81,835	0	0
2027	55,625	0	0	511,784	0
2040	68,599	70,931	66,220	96,968	70,717
2060	91,745	52,187	51,389	91,745	51,356

Maximum shortage values presented in Table 4.4-17 for California vary with both the maximum level of declared shortage in the Lower Basin and with the timing of the shortage. Under almost all conditions, the California shortage is allocated to the MWD. However, under the maximum shortage amount that occurs under the Water Supply Alternative, which occurs less than one percent of the time, the shortage allocated to California would include a very small portion of shortage (4,203 af) that would be allocated to other California users.

4.4.7.3 Distribution of Shortages to Nevada

Table 4.4-18 shows different Lower Basin shortage volumes and the portion of the shortage that is allocated to Nevada. The shortage allocation to Nevada represents approximately 3.33 percent of the total Lower Basin shortage amount. This percentage does not vary with time and is distributed among users served by the SNWA.

Table 4.4-18
Shortage Allocation to Nevada (af)

Lower Basin Shortage Allocations	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Shortage allocation to Nevada	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333

The probability of occurrence of the shortage volumes shown in Table 4.4-18 are shown in Tables 4.4-12 and 4.4-13.

Table 4.4-19 shows the maximum shortage volumes that would be assigned to Nevada under the No Action Alternative and action alternatives for selected years.

Table 4.4-19
Maximum Shortage Allocation to Nevada (af)

Year	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	0	0	0	0	0
2017	31,750	20,000	29,375	0	33,333
2026	60,000	23,710	62,025	9,300	33,333
2027	60,565	35,235	39,585	84,290	16,290
2040	60,965	61,100	60,630	65,530	61,085
2060	62,245	60,185	59,620	62,245	59,580

4.4.7.4 Distribution of Shortages to Mexico

As discussed in Section 4.2, for modeling purposes an assumption was made that Mexico's delivery would be reduced below 1.5 mafy when Lower Basin shortages occur. The amount of the reduction is 16.67 percent of the total Lower Basin shortage volume. The shortage distribution to Mexico is summarized in Table 4.4-20.

Table 4.4-20
Shortage Distribution to Mexico (af)[1]

Lower Basin Shortage Allocations	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Shortage allocation to Mexico	33,333	66,667	83,333	100,000	133,333	200,000	300,000	416,667

1. These modeling assumptions do not reflect policy decisions and are not intended to constitute an interpretation or application of the 1944 Treaty.

The probability of involuntary shortages being allocated to Mexico are the same as the probability of Lower Basin shortage. The probability of the shortage volumes shown in Table 4.4-20 under the No Action Alternative and for each of the action alternatives are shown in Tables 4.4-12 and 4.4-13.

This table indicates that, while the proportion of the Lower Basin shortage distributed to Mexico is constant, the probability of the occurrence of shortage increases over time. Table 4.4-21 below, shows the maximum shortage that would be distributed to Mexico under the No Action Alternative and the action alternatives.

Table 4.4-21
Maximum Shortage Allocation to Mexico[1] (af)

Year	No Action Alternative	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
2008	0	0	0	0	0
2017	158,750	100,000	146,870	0	166,667
2026	300,025	118,560	310,135	46,500	166,667
2027	302,830	176,185	197,920	421,440	81,440
2040	304,830	305,485	304,160	312,640	305,425
2060	311,230	300,935	298,090	311,230	297,895

1. These modeling assumptions do not reflect policy decisions and are not intended to constitute an interpretation or application of the 1944 Treaty.

4.4.8 Summary

The following conclusions were drawn from the analyses of water deliveries.

4.4.8.1 Normal Conditions

All of the action alternatives improve water supply conditions during the interim period relative to the No Action Alternative, improve the probability that normal deliveries will be met, and reduce the probability that Shortage condition deliveries will occur. The differences between the action alternatives and the No Action Alternative, in terms of the probability of occurrence for Normal conditions water supply deliveries, diminish after 2027 and converge by about 2038.

4.4.8.2 Surplus Conditions

The Water Supply Alternative exhibits the same probability of Surplus condition deliveries as the No Action Alternative (between about 30 to 40 percent) between 2008 and 2016 due to the provisions for the Partial Domestic Surplus as provided in the ISG. The ISG provisions terminate under the No Action Alternative in 2016. These conditions are retained in the Water Supply Alternative through 2026 and therefore this alternative consistently provides the highest probability of Surplus condition deliveries during the interim period. The Reservoir Storage Alternative exhibits the lowest probabilities (between about 10 to 20 percent) during the interim period because surplus determinations are limited to Quantified and Flood Control Surplus conditions beginning in 2008. The surplus provisions under the Basin States and Conservation Before Shortage alternatives are similar and the probability of Surplus conditions between 2010 and the probability of occurrence through 2016 is slightly less than under the No Action Alternative due to the absence of the Partial Domestic Surplus provision in these two alternative. After the end of the interim period in 2026 the probability for all alternatives converges to between 10 and 20 percent.

The mechanism to deliver and store conserved and system and non-system water assumed as part of the Basin States, Conservation Before Shortage and Reservoir Storage alternatives has the effect of increasing the occurrence of a Surplus Condition. The maximum increase observed is about four to five percent occurring in one to two years.

4.4.8.3 Shortage Conditions

During most of the interim period, the probability of involuntary and voluntary shortage is less under all of the action alternatives compared to the No Action Alternative. The probability of occurrence of shortages under the Water Supply Alternative is generally less than under the No Action Alternative and the action alternatives during the interim period because shortages under the Water Supply Alternative only occur if the Lake Mead water level is drawn down close to the top of the dead pool elevation or if Lake Mead's elevation falls below 1,000 feet msl. However, after 2026, the Water Supply Alternative has the highest probability of occurrence due to the depleted storage conditions and because the shortage determination method reverts back to the No Action Alternative provisions. In terms of magnitude, the average shortages that occur under the Water Supply Alternative (zero and 270 kafy) are significantly less than those observed under the No Action Alternative (500 and 600 kafy) during the interim period. After 2026, higher average and maximum shortage volumes are observed under the Water Supply Alternative relative to the No Action Alternative and the remaining action alternatives.

The probability of occurrence of shortages under the Reservoir Storage Alternative is slightly higher than under the No Action Alternative between 2008 and 2013. However, after 2013 and through about 2037, shortages under the Reservoir Storage Alternative occur less frequently as compared to the No Action Alternative. In terms of magnitude, the average shortage volumes that are observed during the interim period are highest under the Reservoir Storage Alternative (between 600 and 720 kafy). This occurs because the Reservoir Storage Alternative contains the most aggressive shortage strategy that applies shortages both more often and at higher magnitudes.

Shortages also occur less frequent under the Basin States and Conservation Before Shortage alternatives during the interim period as compared to the No Action Alternative and are similar after 2026. The probability values of the Basin States Alternative and Conservation Before Shortage Alternative differ a maximum of about five percent with those of the Conservation Before Shortage Alternative being generally slightly lower than those under the Basin States Alternative. In terms of magnitude, the average Involuntary and Voluntary Shortages that are observed under the Basin States and Conservation Before Shortage alternatives are similar to each other (between 400 and 500 kafy) and both are less than those observed under the No Action Alternative during the interim period. After 2026, the average shortage volumes are similar. The maximum observed Involuntary and Voluntary water delivery reduction in any one year to Arizona, California, and Nevada are 1.4 maf, 456 kaf, and 65 kaf, respectively.

The mechanism to deliver and store conserved system and non-system water assumed as part of the Basin States, Conservation Before Shortage and Reservoir Storage alternatives has the effect of decreasing the occurrence of shortages. The greatest reduction during the interim period occurs in the Reservoir Storage Alternative (about 12 percent) as it is assumed that a larger amount of storage credits are generated under this alternative. The Conservation Before Shortage Alternative is assumed to have a larger storage and delivery mechanism than the Basin States Alternative, resulting in a shortage probability of about two to three percent less during the interim period.

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4.5 Water Quality

4.5.1 Introduction

This section describes the methods used to determine the potential effects to water quality associated with each alternative considered in the proposed federal action, and discusses the results of these analyses.

4.5.2 Methodology

The salinity module of the CRSS RiverwareTM model was used to analyze changes in salinity concentration for all the alternatives from Lake Powell to Imperial Dam.

Using the hydrologic output from CRSS, the CE-QUAL-W2 model was used to simulate temperatures of Lake Powell releases and the Generalized Environmental Modeling System for Surface Waters (GEMSS) was used to simulate river temperatures between Glen Canyon Dam and Lake Mead for each of the alternatives. Detailed descriptions of these models are provided in Appendix F. Qualitative assessments of other water quality parameters in Lake Powell were based on historical data.

For all parameters other than salinity, the analysis of potential impacts to Lake Mead water quality were based on a combination of detailed water quality modeling and analysis conducted for the Systems Conveyance and Operations Program Final EIS (SCOP FEIS, Clean Water Coalition October 2006), historical data, and other information. The modeling for the SCOP FEIS analyzed the potential effects on water quality of rerouting effluent from the Las Vegas Wash to Lake Mead's Boulder Basin via a pipeline. The detailed modeling considered lake levels down to 1,000 feet msl and two levels of total annual average effluent flows (462 cfs expected by 2030 and 616 cfs expected by 2050). Under the SCOP FEIS preferred alternative (referred to as the Boulder Islands North Alternative), impacts to water quality are considered to be insignificant and negligible with no violation of drinking water standards for Lake Mead water levels drawn down to elevation 1,000 feet msl with projected 2050 effluent inflow levels. This information was combined with the probabilities of Lake Mead water levels reaching elevation 1,000 feet msl under No Action Alternative and action alternatives considered in this Draft EIS to assess potential impacts.

Furthermore, an adaptive management plan for Boulder Basin would be implemented as part of the SCOP preferred alternative. The Boulder Basin Adaptive Management Plan (BBAMP) would establish objectives regarding drinking water quality, downstream water quality, nutrient management, and recreational use including sport fisheries. As part of the BBAMP, water quality parameters would be monitored to establish baseline conditions and analyze the need for potential mitigation measures in the future. (Clean Water Coalition 2006). The qualitative assessments also used this information.

4.5.2.1 Salinity

Reclamation developed a computational model for salinity to aid in the development of salinity reduction targets for the Colorado River Basin Salinity Control Program (SCP) (Prairie and Callejo 2005). The salinity model simulates the effects of water development projects on future salinity concentration levels in the Colorado River. The model includes future salinity control units that have been authorized for construction but may not have yet been completed. The salinity control criteria are purposely designed to be long-term and non-degradational goals, rather than exceedence standards such as are used for industry or drinking water. Efforts of the SCP are designed to meet the standards by implementing, as needed, the most cost effective salinity control projects. This ensures that the salinity control criteria will continue to be met in the future, even with the salinity impacts produced by increasing Upper Basin depletions.

The salinity data used in the CRSS salinity model are based on a monthly regression of natural flow and salinity data from 1971 through 1995 in the Upper Basin (Prairie et al 2005). The Lower Basin monthly regressions are based on the 1971 through 2004 natural flow and salinity data. The monthly regression models allow extension of the CRSS salinity model data over the period 1906 through 2004, the period for which natural flow data is available. The CRSS salinity model data includes salinity control levels and salt loading due to agriculture return flows as used in the 2005 Triennial Review (Colorado River Salinity Control Forum 2005). The model simulates annual average salinity concentrations for locations below Hoover Dam, below Parker Dam, and at Imperial Dam.

The CRSS salinity model is intended for long-term (15 to 20 years) simulation and it is highly sensitive to initial conditions during the first 10 to 12 years. The model assumes salinity is a conservative water quality parameter, and reservoirs are modeled as fully mixed systems.

4.5.2.2 Temperature

Lake Powell undergoes seasonal transformations that can dramatically affect the temperatures of both the reservoirs and the dam releases. During the spring, solar radiation and warmer air temperatures begin to warm the upper surface layers of the reservoirs. This warming is also affected by spring inflow volumes and temperatures. Larger inflows bring greater volumes of warmer water that can cause higher release temperatures. Reservoir draw downs can bring the warmer surface water closer to the power plant intake penstocks, also producing warmer releases. As summer progresses, surface warming of reservoirs increases, as does the warming of releases as the water moves downstream. During the winter months, reservoir temperature stratification is usually eliminated by reservoir mixing, and both reservoir and downstream water cooling occurs. The CE-QUAL-W2 model simulates this annual process and can analyze reservoir and dam release temperatures for various reservoir starting elevations and inflows. The CRSS output of dam release and reservoir elevations was used in the CE-QUAL-W2 model to establish a relationship between reservoir elevations and dam release temperatures and project the impact of reservoir draw down on dam release temperatures. Calibration of the CE-QUAL-W2 model for Lake Powell used historic temperature profiles from 1990 to 2005 at 13 reservoir stations.

This 15-year data set provided a limited range of historic reservoir elevations, inflows and releases. By using a combination of historic and modeled data for various reservoir elevations, and by analyzing the impact of a repetition of the recent drought years, dam release temperatures for a larger range of reservoir elevations could be analyzed.

The GEMSS was used to route Glen Canyon Dam release temperatures through the Grand Canyon downstream to Lake Mead. The GEMSS model was calibrated for water temperature at three locations in this river reach: Lees Ferry, 15.9 miles downstream of Glen Canyon Dam; a point one mile downstream of the Little Colorado River confluence; and the Diamond Creek gaging station 240 miles downstream of Glen Canyon Dam. Below Diamond Creek, water temperatures approached equilibrium with the ambient air temperature, and the rate of temperature change decreased. Since Lees Ferry temperatures are nearly identical to dam release temperatures, only the results for the Little Colorado River confluence and Diamond Creek sites are included in this document.

For any specific reservoir starting elevation, there is a range of potential dam release temperatures because the reservoir is affected by the magnitude of spring inflow and summer meteorological conditions. Downstream water temperatures produced by a routing of these releases are also affected by meteorological conditions and the magnitude of dam releases. Thus, for a single reservoir elevation the CE-QUAL-W2 and GEMSS modeling resulted in a range of water temperatures.

The assessment of potential effects of the alternatives on temperature in Lake Mead was based on the Lake Mead water quality information provided in the SCOP FEIS.

4.5.2.3 Other Water Quality Parameters

Historic water quality data from Lake Powell and Lake Mead and water quality information from the SCOP FEIS for Lake Mead were used to develop qualitative assessments of potential effects of the alternatives on sediment, nutrients and algae, dissolved oxygen, metals, and perchlorate.

4.5.3 Salinity

Table 4.5-1, Table 4.5-2, and Table 4.5-3 present the SCP salinity control criteria and the CRSS salinity model simulations of salinity concentrations for the years 2008, 2026 and 2060, respectively. The projected salinity concentrations presented are the flow-weighted annual averages for the selected year under the No Action Alternative and the action alternatives. The results assume continuation of existing salinity control programs and projects. Therefore, the flow-weighted annual average salinity concentrations should not increase over time under the No Action Alternative for the current plan of implementation, which extends through 2025 (Colorado River Salinity Control Forum 2005).

The flow-weighted average annual salinity criteria for locations on the lower Colorado River listed in Table 4.5-1, Table 4.5-2, and Table 4.5-3 are not exceeded at any time under any of the alternatives. This is due in part to the presumed continuation of existing levels of salinity controls under the SCP in the CRSS salinity model. The Water Supply Alternative generally provides salinity concentrations equal to or lower than the No Action Alternative. During some years the Reservoir Storage Alternative produces higher salinity concentrations than the No Action Alternative. At all times the differences in salinity concentrations among the different alternatives is less than three percent.

Table 4.5-1
Projected Colorado River Salinity in 2008

Alternative	Below Hoover Dam SCP Criteria 723 mg/L	Below Parker Dam SCP Criteria 747 mg/L	At Imperial Dam SCP Criteria 879 mg/L
	Projected Value (mg/L)	Projected Value (mg/L)	Projected Value (mg/L)
No Action	635	654	767
Basin States	635	655	772
Conservation Before Shortage	635	655	774
Reservoir Storage	637	657	782
Water Supply	635	654	767

Table 4.5-2
Projected Colorado River Salinity in 2026

Alternative	Below Hoover Dam SCP Criteria 723 mg/L	Below Parker Dam SCP Criteria 747 mg/L	At Imperial Dam SCP Criteria 879 mg/L
	Projected Value (mg/L)	Projected Value (mg/L)	Projected Value (mg/L)
No Action	603	624	744
Basin States	607	628	751
Conservation Before Shortage	607	629	756
Reservoir Storage	615	637	764
Water Supply	598	619	740

Table 4.5-3
Projected Colorado River Salinity in 2060

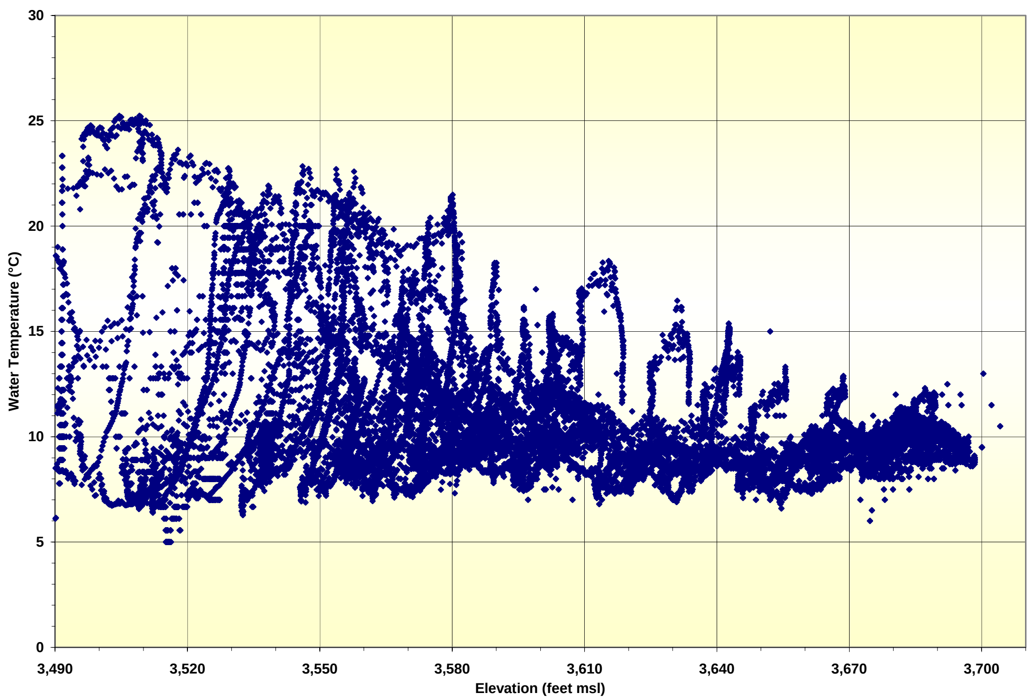
Alternative	Below Hoover Dam SCP Criteria 723 mg/L	Below Parker Dam SCP Criteria 747 mg/L	At Imperial Dam SCP Criteria 879 mg/L
	Projected Value (mg/L)	Projected Value (mg/L)	Projected Value (mg/L)
No Action	626	648	779
Basin States	630	653	786
Conservation Before Shortage	630	653	786
Reservoir Storage	630	653	786
Water Supply	626	648	780

4.5.4 Temperature

4.5.4.1 Lake Powell and Glen Canyon Dam

The release temperature ranges presented in Figure 4.5-1 are comprised of historic and modeled data and represent a yearly range including seasonal fluctuations. This graph shows that as Lake Powell's elevation decreases, the range of annual release temperature fluctuations increases. The minimum release temperature occurs in the winter and it is fairly consistent at about 7 °C to 10 °C (44.6ºF to 50 ºF). The peak summer release temperature varies significantly with elevation, peaking at about 25 °C (77 º F) as the reservoir elevation drops to near the minimum power pool elevation of 3,490 feet msl. The nearer the reservoir elevation is to the power plant penstock intakes, the higher the summer and fall release temperatures. Reservoir elevations near the full pool elevation of 3,700 feet msl show much less variation among seasons, with releases consistently cold from 8 °C to 12 °C (46.4 ºF to 53.6 ºF). During extreme drought events, the elevation of Lake Powell may drop below the minimum power pool elevation of 3,490 feet msl. If this occurs, releases would be discontinued from the powerplant penstocks and releases would be made through the river outlet tubes, which are located at elevation 3,374 feet msl. Under these conditions, the temperature of the water released from Glen Canyon Dam could potentially change from about 25 °C to less than 10 °C (77 ºF to less than 50 ºF). If the reservoir elevation were to drop further, closer to the elevation of the river outlet tubes, the releases would again gradually warm.

Figure 4.5 -1
Historic Data and CE-QUAL-W2 Model Results for Lake Powell Release Temperatures by Elevation



In addition to the seasonal ranges described above, Table 4.5-4 and Table 4.5-5 present projected release temperature ranges associated with the CRSS projected 90th, 50th, and 10th percentile elevations of Lake Powell in 2016, 2026, and 2060 for the months of July and October, respectively. This represents the period of time when maximum warming occurs in Lake Powell and the downstream releases. The release temperature ranges in Table 4.5-4 and Table 4.5-5 reflect the variability of hydrologic, meteorological, and hydraulic conditions. The sensitivity of release temperatures to these conditions increases with decreasing reservoir elevations. This sensitivity causes a wide range of possible release temperatures at similar reservoir elevations. In general, for a given month and reservoir elevation a higher release temperature is associated with an above average inflow volume and a lower release temperature is associated with a below average inflow volume. Therefore, the ranges shown in these tables reflect different release temperatures for these specific months and reservoir elevations, ranges which are due primarily to large differences in reservoir inflows.

For reservoir elevations at or above the 90th percentile elevation for all years there are no differences among the alternatives. Overall, the temperature ranges for July and October for the No Action Alternative, Basin States Alternative, and Conservation Before Shortage Alternative are similar for 2016, 2026, and 2060 for the 50th and 10th percentile reservoir elevations, respectively. The temperature range for the Water Supply Alternative is warmer due to the corresponding lower Lake Powell reservoir elevations for the 10th and 50th percentiles. The Reservoir Storage Alternative results in cooler water temperatures for the 10th and 50th percentile reservoir elevations for some years, due to higher reservoir elevations.

Table 4.5-4
Lake Powell July Elevations and Release Temperatures
90th, 50th, and 10th Percentile Values

Year	90th Percentile		50th Percentile		10th Percentile	
	Elevation (feet msl)	Temperature (°C)	Elevation (feet msl)	Temperature (°C)	Elevation (feet msl)	Temperature (°C)
2016						
No Action	3,698.7	9 to 11	2,650.3	8.5 to 11.5	3,583.5	9 to 17
Basin States	3,698.5	9 to 11	3,646.4	8.5 to 11.5	3,587.2	9 to 17
Conservation Before Shortage	3,698.1	9 to 11	3,646.4	8.5 to 11.5	3,587.7	9 to 17
Water Supply	3,698.5	9 to 11	3,642.0	8.5 to 11.5	3,572.0	10 to 19
Reservoir Storage	3,698.8	9 to 11	3,650.3	8.5 to 11.5	3,599.5	8.5 to 15
2026						
No Action	3,697.9	9 to 11	3,658.8	8.5 to 11	3,579.4	9.5 to 18
Basin States	3,697.7	9 to 11	3,648.6	8.5 to 11.5	3,572.6	10 to 19
Conservation Before Shortage	3,697.7	9 to 11	3,649.2	8.5 to 11.5	3,573.5	10 to 19
Water Supply	3,697.6	9 to 11	3,631.0	8.5 to 12	3,527.5	17 to 22
Reservoir Storage	3,698.8	9 to 11	3,664.2	8.5 to 11	3,600.3	8.5 to 15
2060						
No Action	3,699.3	9 to 11	3,657.0	8.5 to 11	3,558.6	10 to 20
Basin States	3,699.3	9 to 11	3,657.0	8.5 to 11	3,558.6	10 to 20
Conservation Before Shortage	3,699.3	9 to 11	3,657.0	8.5 to 11	3,558.6	10 to 20
Water Supply	3,699.3	9 to 11	3,657.0	8.5 to 11	3,55i8.6	10 to 20
Reservoir Shortage	3,699.3	9 to 11	3,657.0	8.5 to 11	3,558.6	10 to 20

Table 4.5-5
Lake Powell October Elevations and Release Temperatures
90th, 50th, and 10th Percentile Values

Year	90th Percentile		50th Percentile		10th Percentile	
	Elevation (feet msl)	Temperature (°C)	Elevation (feet msl)	Temperature (°C)	Elevation (feet msl)	Temperature (°C)
2016						
No Action	3,689.6	9 to 11.5	3,644.1	9 to 15	3,574.6	11 to 21
Basin States	3,689.6	9 to 11.5	3,640.5	9 to 15	3,574.2	11 to 21
Conservation Before Shortage	3,689.6	9 to 11.5	3,640.5	9 to 15	3,574.5	11 to 21
Water Supply	3,689.4	9 to 11.5	3,634.7	9 to 16	3,560.7	12 to 22
Reservoir Storage	3,690.0	9 to 11.5	3,647.0	9 to 15	3,588.0	10 to 20
2026						
No Action	3,689.2	9 to 11.5	3,656.6	8.5 to 14	3,569.8	11 to 21
Basin States	3,689.2	9 to 11.5	3,637.1	9 to 15.5	3,569.4	11 to 21
Conservation Before Shortage	3,689.2	9 to 11.5	3,640.6	9 to 15	3,570.1	11 to 21
Water Supply	3,689.2	9 to 11.5	3,622.4	9 to 18	3,512.9	16 to 24
Reservoir Storage	3,689.7	9 to 11.5	3,659.1	8.5 to 14	3,591.5	10 to 20
2060						
No Action	3,689.9	9 to 11.5	3,647.1	9 to 15	3,552.2	13 to 22
Basin States	3,689.9	9 to 11.5	3,647.1	9 to 15	3,552.2	13 to 22
Conservation Before Shortage	3,689.9	9 to 11.5	3,647.1	9 to 15	3,552.2	13 to 22
Water Supply	3,689.9	9 to 11.5	3,647.1	9 to 15	3,552.2	13 to 22
Reservoir Shortage	3,689.9	9 to 11.5	3,647.1	9 to 15	3,552.2	13 to 22

4.5.4.2 Glen Canyon Dam to Lake Mead

Using historic data and output from the CE-QUAL-W2 model as input, the GEMSS model analyzed monthly temperatures for July and October for the CRSS 90th, 50th, and 10th percentile projected reservoir releases. These monthly temperatures are presented for each alternative in Table 4.5-6 and Table 4.5-7 for the confluence with the Little Colorado River, and in Table 4.5-8 and Table 4.5-9 for the gage below Diamond Creek, and are consistently higher than the dam release temperatures shown in Table 4.5-4 and Table 4.5-5. The data listed in these tables are ranges, and refer to the variability of temperatures due to three factors: variable release volume; release temperature ranges; and downstream meteorology.

The ranges presented in Table 4.5-4 and Table 4.5-5 cascade in the downstream temperature modeling. The rate at which water that is released from a reservoir approaches ambient air temperature as it travels downstream depends on these factors. In general, warmer downstream water temperatures result from smaller release volumes, higher release temperatures, and warmer ambient air temperatures. However, the relationship between release temperature and downstream temperature was nonlinear (e.g., a 1 °C (33.8 º F) increase in release temperature does not necessarily result in a 1 °C

(33.8 ºF) increase downstream). In general, the temperature ranges for July and October for the No Action Alternative, Basin States Alternative, Conservation Before Shortage Alternative, and Water Supply Alternative are similar. The range of temperatures varies by less than about 2 ºC (35.6 º F) for each of these alternatives. The range of temperatures for the Reservoir Storage Alternative tended to be cooler for both the 50th and 10th percentile river flows. This is due to higher Lake Powell elevations in this alternative.

Table 4.5-6
Colorado River at Little Colorado River Confluence July Water Temperatures
90th, 50th, and 10th Percentile Values

Year	90th Percentile Temperature (°C)	50th Percentile Temperature (°C)	10th Percentile Temperature (°C)
2016			
No Action	10 to 14	10 to 14	12 to 22
Basin States	10 to 14	10 to 15	13 to 22
Conservation Before Shortage	10 to 14	10 to 15	13 to 22
Water Supply	10 to 14	10 to 15	13 to 23
Reservoir Storage	10 to 14	10 to 13	12 to 21
2026			
No Action	10 to 14	10 to 14	12 to 22
Basin States	10 to 14	10 to 15	13 to 22
Conservation Before Shortage	10 to 14	10 to 15	13 to 22
Water Supply	10 to 14	10 to 15	13 to 23
Reservoir Storage	10 to 14	10 to 13	12 to 21
2060			
No Action	10 to 14	10 to 14	12 to 22
Basin States	10 to 14	10 to 15	13 to 22
Conservation Before Shortage	10 to 14	10 to 15	13 to 22
Water Supply	10 to 14	10 to 15	13 to 23
Reservoir Storage	10 to 14	10 to 13	12 to 21

Table 4.5-7
Colorado River at Little Colorado River Confluence October Water Temperatures
90th, 50th, and 10th Percentile Values

Year	90th Percentile Temperature (°C)	50th Percentile Temperature (°C)	10th Percentile Temperature (°C)
2016			
No Action	10 to 11	12 to 16	11 to 21
Basin States	10 to 11	9 to 17	11 to 22
Conservation Before Shortage	10 to 11	9 to 17	11 to 22
Water Supply	10 to 11	9 to 16	14 to 22
Reservoir Storage	10 to 11	8 to 14	12 to 21
2026			
No Action	10 to 11	12 to 16	11 to 21
Basin States	10 to 11	9 to 17	11 to 22
Conservation Before Shortage	10 to 11	9 to 17	11 to 22
Water Supply	10 to 11	9 to 16	14 to 22
Reservoir Storage	10 to 11	8 to 14	12 to 21
2060			
No Action	10 to 11	12 to 16	11 to 21
Basin States	10 to 11	9 to 17	11 to 22
Conservation Before Shortage	10 to 11	9 to 17	11 to 22
Water Supply	10 to 11	9 to 16	14 to 22
Reservoir Storage	10 to 11	8 to 14	12 to 21

Table 4.5-8
Colorado River Below Diamond Creek July Water Temperatures
90th, 50th, and 10th Percentile Values

	90th Percentile	50th Percentile	10th Percentile
Year	Temperature (°C)	Temperature (°C)	Temperature (°C)
2016			
No Action	15 to 25	13 to 18	15 to 25
Basin States	15 to 25	14 to 19	16 to 25
Conservation Before Shortage	15 to 25	14 to 19	16 to 25
Water Supply	15 to 25	14 to 19	17 to 26
Reservoir Storage	15 to 25	14 to 18	15 to 24
2026			
No Action	15 to 25	13 to 18	15 to 25
Basin States	15 to 25	14 to 19	16 to 25
Conservation Before Shortage	15 to 25	14 to 19	16 to 25
Water Supply	15 to 25	14 to 19	17 to 26
Reservoir Storage	15 to 25	14 to 18	15 to 24
2060			
No Action	15 to 25	13 to 18	15 to 25
Basin States	15 to 25	14 to 19	16 to 25
Conservation Before Shortage	15 to 25	14 to 19	16 to 25
Water Supply	15 to 25	14 to 19	17 to 26
Reservoir Storage	15 to 25	14 to 18	15 to 24

Table 4.5-9
Colorado River Below Diamond Creek October Water Temperatures
90th, 50th, and 10th Percentile Values

Year	90th Percentile Temperature (°C)	50th Percentile Temperature (°C)	10th Percentile Temperature (°C)
2016			
No Action	11 to 16	13 to 18	13 to 22
Basin States	11 to 16	10 to 19	12 to 23
Conservation Before Shortage	11 to 16	10 to 19	12 to 23
Water Supply	11 to 16	10 to 18	14 to 23
Reservoir Storage	11 to 16	9 to 17	12 to 22
2026			
No Action	11 to 16	13 to 18	13 to 22
Basin States	11 to 16	10 to 19	12 to 23
Conservation Before Shortage	11 to 16	10 to 19	12 to 23
Water Supply	11 to 16	10 to 18	14 to 23
Reservoir Storage	11 to 16	9 to 17	12 to 22
2060			
No Action	11 to 16	13 to 18	13 to 22
Basin States	11 to 16	10 to 19	12 to 23
Conservation Before Shortage	11 to 16	10 to 19	12 to 23
Water Supply	11 to 16	10 to 18	14 to 23
Reservoir Storage	11 to 16	9 to 17	12 to 22

4.5.4.3 Lake Mead and Hoover Dam

Water quality modeling provided in the SCOP FEIS showed that lake temperatures would change by no more than 1 ºC (33.8 º F) when the Lake Mead elevations are drawn down from 1,178 feet to 1,000 feet msl (Clean Water Coalition 2006). For the No Action, Conservation Before Shortage, and Reservoir Storage alternatives, the hydrologic modeling shows the probability of Lake Mead being below elevation 1,000 feet msl is zero (Section 4.3). For the Basin States Alternative, the hydrologic modeling showed zero probability through 2024 with a small probability (of one and two percent in 2025 and 2026). For the Water Supply Alternative, the hydrologic modeling shows the probabilty is small through 2020, increasing to a six percent chance by 2026. Based on these results, potential effects of the alternatives on temperature in Lake Mead are considered negligible.

4.5.5 Sediment and Dissolved Oxygen

The maximum headcutting of reservoir deltas occurs when a deeply drawn down reservoir is followed by very high inflows, similar to that observed in Lake Powell in 2005. This condition is very dependent on the reservoir elevation and spring inflow volume. Compared to the No Action Alternative, the projected additional reservoir draw down for the Water Supply Alternative could result in additional headcutting in the sediment deltas and accompanying water quality impacts. The Reservoir Storage Alternative could result in a decrease in headcutting if the projected reservoir elevations remain higher than for the No Action Alternative. Since the projected reservoir draw down for the Conservation Before Shortage Alternative and the Basin States Alternative are similar, headcutting to the sediment deltas would likely be similar.

Quantified water quality impacts from reservoir sediment delta headcutting are not currently available, nor is it possible to quantitatively distinguish the impact of sediment headcutting among the alternatives. However, recent history shows that high inflows causing headcutting likely increases phosphorus release and biological oxygen demand. Large spring inflows then can bring this plume of low dissolved oxygen water near the powerplant intakes and result in low dissolved oxygen releases. There may be short term impacts to food base and trout resources between Glen Canyon Dam and Lees Ferry from these occurrences. Recurrences of low dissolved oxygen such as occurred in 2005 below Glen Canyon Dam may result from reservoir draw down cycles under any of the alternatives, but as described in Section 3.5.5 the river reaerates after passing through rapids downstream of Lees Ferry. Additionally, average or lower inflows do not seem to have the power to create adverse conditions such as in 2005.

With respect to riverine sediment transport in the Glen Canyon Dam to Lake Mead reach, annual releases lower than 8.23 maf associated with the action alternatives would transport less sediment through the Grand Canyon into Lake Mead than the No Action Alternative, but would be offset by equalization or balancing releases in these alternatives (Figure 4.3-13).

To estimate the sediment transport impacts of potentially modifying the annual release volumes from Glen Canyon Dam, the USGS prepared an analysis relating normalized sediment transport from the Grand Canyon to annual release volumes. Table 4.5-10 shows this relationship, with 8.23 maf release volumes as the basis for normalization.

Table 4.5-10
Relationship of Glen Canyon Dam Annual Release Volumes to Sediment Transport

Release (maf)	Normalized Sand Export
6.00	0.26
7.00	0.51
8.00	0.89
8.23	1.00
9.00	1.43
10.00	2.15
11.00	3.03
12.00	4.11
13.00	5.43
14.00	7.01
15.00	8.88
16.00	11.02
17.00	13.53

Table 4.5-10
Relationship of Glen Canyon Dam Annual Release Volumes to Sediment Transport

Release (maf)	Normalized Sand Export
18.00	16.67
19.00	19.72
20.00	23.40

Annual release volumes from all the traces of the RiverWare™ analysis for all the alternatives were applied to this sand export relationship for the years 2008, 2016, and 2026. Relative differences among the alternatives were calculated by comparing the action alternatives to the No Action Alternative at the 10th, 50th, and 90th percentiles of sand export. These normalized comparisons are shown in Tables 4.5-11 through 4.5-13 for the years 2008, 2016, and 2026, respectively.

Table 4.5-11
Comparison of Sediment Export among Alternatives (Normalized to 8.23 maf annual releases)
2008

Alternative	90th Percentile	50th Percentile	10th Percentile
No Action	4.4	1	1
Basin States	4.8	1	1
Conservation Before Shortage	4.8	1	1
Reservoir Storage	4.4	1	1
Water Supply	4.4	1	1

Table 4.5-12
Comparison of Sediment Export among Alternatives (Normalized to 8.23 maf annual releases)
2016

Alternative	90th Percentile	50th Percentile	10th Percentile
No Action	5.68	1	1
Basin States	5.7	1.4	1
Conservation Before Shortage	5.71	1.4	0.99
Reservoir Storage	5.68	1	0.81
Water Supply	5.33	1.8	1

Table 4.5-13
Comparison of Sediment Export among Alternatives (Normalized to 8.23 maf annual releases)
2026

Alternative	90th Percentile	50th Percentile	10th Percentile
No Action	4.76	1	1
Basin States	4.57	1.4	1
Conservation Before Shortage	4.54	1.4	1
Reservoir Storage	4.81	1	0.96
Water Supply	4.81	1.8	1

The data provided in the table above show that in the near term, the alternatives transport nearly the same amount of sediment, but that in 2016 and 2026, the Basin States and Conservation Before Shortage alternatives generally transport more sediment as water is moved from Lake Powell to Lake Mead to meet water supply demands, while the Water Supply Alternative transports even more sediment as greater volumes of water are moved to Lake Mead. The Reservoir Storage Alternative reduces the amount of transport as releases and water deliveries are reduced to keep Lake Mead, and subsequently Lake Powell, fuller.

Modeling completed for the SCOP FEIS determined that there would be no adverse effect on dissolved oxygen as a result from the SCOP project or from the drawdown of Lake Mead from elevation 1,178 feet to 1,000 feet msl. For the No Action, Conservation Before Shortage, and Reservoir Storage alternative, the hydrologic modeling shows the probability of Lake Mead being below elevation 1,000 feet msl is zero (Section 4.3). For the Basin States Alternative, the hydrologic modeling showed zero probability through 2024 with a small probability (of one and two percent in 2025 and 2026). For the Water Supply Alternative, the hydrologic modeling shows the probabilty is small through 2020, increasing to a six percent chance by 2026. Based on these results, potential effects of the alternatives on dissolved oxygen in Lake Mead are considered negligible. Futhermore, monitoring of dissolved oxygen levels in Lake Mead will be conducted as part of the SCOP BBAMP (Clean Water Coalition 2006).

4.5.6 Nutrients and Algae

Most of the 1.0 mg/L of total phosphorus concentration entering Lake Powell from the major tributaries is bound to the sediment and primarily settles out with the sediment (Section 3.5). Bioavailable phosphorus from the major inflows is generally only 0.007 to 0.009 mg/L and phosphorus concentrations released from Glen Canyon Dam and Hoover Dam generally range from only 0.004 to 0.008 mg/L with occasional spikes to near 0.012 mg/L. Sediment delta headcutting, as discussed above, releases phosphorus. This release can significantly boost primary productivity in reservoir inflow areas. A decrease in reservoir elevation could result in additional headcutting in the sediment deltas; however, data is not available to project the amount of headcutting and phosphorous release for different reservoir elevations.

When Lake Powell is full, Glen Canyon Dam release temperatures and inflow temperatures into Lake Mead are cool, and the plume of water entering Lake Mead drops to depths below which algae can grow. Therefore, much of the inflowing phosphorus that is not settled out with the sediment in Lake Mead travels to Hoover Dam. However, when Lake Powell elevations are low enough to produce warm Glen Canyon Dam releases and inflow temperatures into Lake Mead, the inflow plume into Lake Mead will remain nearer the surface where light would increase productivity. The algae thus produced would settle out, trap more phosphorus in the sediment in Lake Mead, and reduce the phosphorus transport down reservoir into Boulder Basin. Due to the complexity of the system, the direct impact due to the different alternatives can not be projected.

Modeling results provided in the SCOP FEIS showed that there would be no adverse effects on phosphorous concentrations, other nutrients or algae as a result of the SCOP or from Lake Mead being drawn down from elevation 1,178 feet to 1,000 feet msl (Clean Water Coalition 2006). For the No Action, Conservation Before Shortage, and Reservoir Storage alternatives, the hydrologic modeling shows the probability of Lake Mead being below elevation 1,000 feet msl is zero (Section 4.3). For the Basin States Alternative, the hydrologic modeling showed zero probability through 2024 with a small probability (of one and two percent in 2025 and 2026). For the Water Supply Alternative, the hydrologic modeling shows the probabilty is small through 2020, increasing to a six percent chance by 2026. Based on these results, the concentrations of phosphorus in Boulder Basin and Las Vegas Bay should remain within the Nevada TMDL under all alternatives. Furthermore, the SCOP BBAMP will monitor nutrients and chlorophyll levels in Lake Mead and manage nutrient loadings if water quality objectives are not met (Clean Water Coalition 2006).

4.5.7 Metals

The modeling results provided in the SCOP FEIS for Lake Mead show that the lake's ability to dilute contaminant and nutrient loadings from Las Vegas Valley wastewater treatment plants is not significantly diminished when Lake Mead elevation is 1,000 feet msl in comparison to 1,178 feet msl (Clean Water Coalition 2006). For the No Action, Conservation Before Shortage, and Reservoir Storage alternatives, the hydrologic modeling shows the probability of Lake Mead being below elevation 1,000 feet msl is zero (Section 4.3). For the Basin States Alternative, the hydrologic modeling showed zero probability through 2024 with a small probability (of one and two percent in 2025 and 2026). For the Water Supply Alternative, the hydrologic modeling shows the probabilty is small through 2020, increasing to a six percent chance by 2026. Therefore, it is anticipated that drawdown of Lake Mead under any of the alternatives will not increase metals concentrations as a result of reduced dilution.

4.5.8 Perchlorate

Since 1999, perchlorate containment and reduction strategies have resulted in the decline of detectable concentrations in Lake Mead, Willow Beach, and Lake Havasu and other sampling locations in the lower Colorado River, as well as in areas using Colorado River water in Arizona. Perchlorate concentrations are ranging from non-detectable levels to six ppb, indicating a slow and steady decline (Personal Communication, Blasius). The modeling provided for the SCOP FEIS included a perchlorate analysis and showed that the dilution capacity of Lake Mead did not significantly change when the Lake Mead water levels are drawn down from 1,178 feet msl to 1,000 feet msl. For the No Action, Conservation Before

Shortage, and Reservoir Storage alternatives, the hydrologic modeling shows the probability of Lake Mead being below elevation 1,000 feet msl is zero (Section 4.3). For the Basin States Alternative, the hydrologic modeling showed zero probability through 2024 with a small probability (of one tand two percent in 2025 and 2026). For the Water Supply Alternative, the hydrologic modeling shows the probabilty is small through 2020, increasing to a six percent chance by 2026. Therefore, Lake Mead draw down under any of the action alternatives is not expected to affect perchlorate concentrations.

4.5.9 Summary

The following conclusions were drawn from the analyses of potential effects on water quality constituents of concern.

4.5.9.1 Salinity

The future average annual salinity levels under the action alternatives are not expected to exceed the salinity numeric criteria established by the Colorado River Salinity Control Forum for different locations on lower Colorado River.

4.5.9.2 Temperature

The temperature range for Glen Canyon Dam releases under the Water Supply Alternative is warmer due to the corresponding lower Lake Powell reservoir elevations for the 10^{th} and 50^{th} percentiles. The Reservoir Storage Alternative results in cooler temperatures for Glen Canyon Dam release under the 10^{th} and 50^{th} percentile reservoir elevations for some years. The temperature of Glen Canyon Dam releases under the Basin States Alternative and Conservation Before Shortage Alternative are similar to those under the No Action Alternative.

For Lake Mead, modeling performed for the SCOP EIS showed that lake temperatures would change by no more than 1 ºC (33.8 º F) when the Lake Mead elevations are drawn down from 1,178 feet msl to 1,000 feet msl (Clean Water Coalition 2006). The probability of Lake Mead being drawn down below elevation 1,000 feet msl is small for all alternatives. Therefore, potential effects of the alternatives on temperature in Lake Mead are considered negligible.

4.5.9.3 Other Water Quality Parameters

The following findings relate to other water quality parameters analyzed for Lake Powell:

- Quantified water quality impacts from reservoir sediment delta headcutting are not currently available;
- The projected elevations and corresponding changes in dilution capacity are not expected to result in metals concentrations of concern; and
- It is not anticipated that any of the action alternatives would result in a significantly increased concentration of perchlorate.

For Lake Mead, hydrologic and water quality modeling provided in the SCOP FEIS determined that drawing the Lake Mead water level down to an elevation of 1,000 feet msl would not have a significant effect on water quality in Lake Mead, Hoover Dam releases, and the SNWA water pumped from Lake Mead. The probability of Lake Mead being drawn down below elevation 1,000 feet msl is small for all alternatives. Therefore, potential effects of the alternatives on water quality parameters in Lake Mead are considered negligible.

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4.6 Air Quality

This section describes the methods of analysis and potential effects on air quality at Lake Powell and Lake Mead, focusing on particulate matter. Potential effects on the Glen Canyon to Lake Mead reach from particulate emissions at the Lake Mead delta are also considered.

4.6.1 Methodology

Fugitive emissions can result from exposed sediment on the shorelines of Lake Powell and Lake Mead as a result of fluctuations in their elevations. The mass of particulates generated per acre of exposed shoreline will vary depending upon sediment characteristics and other factors such as saturation, sediment disturbance, wind speeds, and topography. The method for assessing potential fugitive emissions from exposed shoreline sediment at Lake Powell and Lake Mead includes the following assumptions.

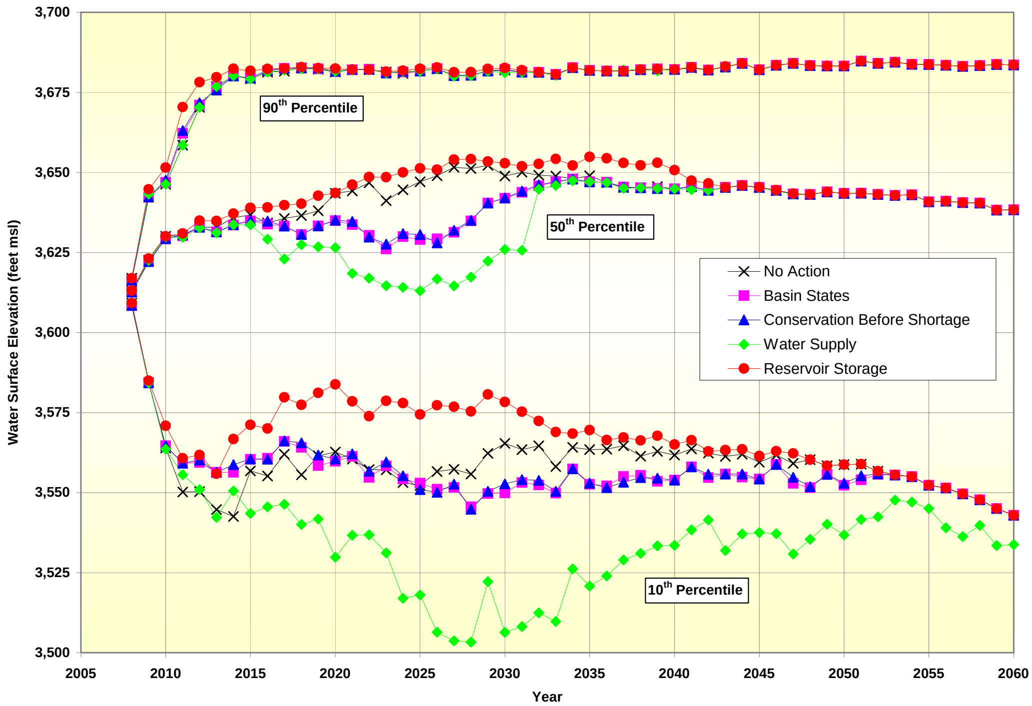
- The area of exposed shoreline for Lake Powell was developed using an average shoreline slope of 45 degrees. The area of exposed shoreline for Lake Mead was developed from bathymetry data.
- Incremental changes to Lake Powell and Lake Mead elevations were developed corresponding to the years 2008 through 2060 from the CRSS modeling output. The 10^{th} percentile elevations at the end of March for Lake Powell and the end of December at Lake Mead were selected as worst case assumptions that still have a reasonable probability of occurring. These are then correlated to the reservoir surface areas (acres) and compared to the maximum elevations for Lake Powell (3,700 feet msl) and Lake Mead (1,229 feet msl) to determine acres of exposed shoreline.

4.6.2 Lake Powell and Glen Canyon Dam

4.6.2.1 No Action Alternative

The lowest Lake Powell elevation occurs in March (Figure 4.6-1). For a comparative evaluation, the years 2008, 2016, 2025, 2040, 2050, and 2060 were examined under the No Action Alternative. The low Lake Powell elevation at the 10^{th} percentile was projected for the year 2025 with a maximum 16,656 acres of exposed shoreline.

Figure 4.6-1
Lake Powell End-of-March Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values



The potential for fugitive emissions is limited by the extent of the area containing fine sediment and that has the potential to generate dust. Areas of fine sediment at Lake Powell comprise about three percent of the 1,960 miles of shoreline (National Park Service 2002). The remainder of the Lake Powell shoreline consists of Navajo Sandstone and other Glen Canyon Group rock formations. These rock formations are not conducive to creating significant amounts of dust.

4.6.2.2 Basin States Alternative

At the 10th percentile, Lake Powell elevation is projected to be 3,553 feet msl in the year 2025, resulting in 16,582 acres of exposed shoreline. This would result in a decrease of less than one percent in exposed shoreline compared to the No Action Alternative (Table 4.6-1). With this decrease in acreage, the potential to exceed the federal PSD Class II threshold or state and national AAQS when compared to the No Action Alternative is slightly decreased.

Table 4.6-1
Lake Powell End-of-March 10th Percentile Elevation and Exposed Shoreline (Rounded to Nearest Whole Number)

Year	No Action Alternative	Basin States Alternative	Conservation Before Shortage Alternative	Water Supply Alternative	Reservoir Storage Alternative
2008 Surface Elevation (feet msl)	3,609	3,608	3,608	3,609	3,609
Exposed Shoreline Area (acres x 1,000)	10	10	10	10	10
Percent Difference Compared to No Action Alternative	0	1	1	0	0
2016 Surface Elevation (feet msl)	3,555	3,561	3,560	3,546	3,570
Exposed Shoreline Area (acres x 1,000)	16	16	16	17	15
Percent Difference Compared to No Action Alternative[1]	0	(4)	(4)	7	(10)
2025 Surface Elevation (feet msl)	3,552	3,553	3,551	3,518	3,574
Exposed Shoreline Area (acres x 1,000)	17	17	17	21	14
Percent Difference Compared to No Action Alternative	0	0	1	23	(15)
2040 Surface Elevation (feet msl)	3,562	3,554	3,554	3,534	3,565
Exposed Shoreline Area (acres x 1,000)	16	16	16	19	15
Percent Difference Compared to No Action Alternative	0	6	6	20	(2)
2050 Surface Elevation (feet msl)	3,559	3,552	3,553	3,537	3,559
Exposed Shoreline Area (acres x 1,000)	16	17	16	18	16
Percent Difference Compared to No Action Alternative	0	5	4	16	0
2060 Surface Elevation (feet msl)	3,543	3,543	3,543	3,534	3,543
Exposed Shoreline Area (acres x 1,000)	18	18	18	19	18
Percent Difference Compared to No Action Alternative	0	0	0	6	0

1 Parenthesis indicates a reduction in exposed shoreline compared to the No Action Alternative

4.6.2.3 Conservation Before Shortage Alternative

At the 10th percentile, Lake Powell elevation is projected to be 3,551 feet msl in the year 2025. Draw downs to this level could result in 16,806 acres of exposed shoreline. This would result in an increase of about one percent in exposed shoreline compared to the No Action Alternative (Table 4.6-1).

This slight increase in acreage would not increase the potential to exceed the PSD Class II threshold or the state or national AAQS when compared to the No Action Alternative. Because of the sandstone formations of Lake Powell, dust would not be of concern.

4.6.2.4 Water Supply Alternative

At the 10th percentile, Lake Powell elevation is projected to be 3,518 feet msl in the year 2025, resulting in 20,516 acres of exposed shoreline. This would cause an increase of 23 percent in exposed shoreline compared to the No Action Alternative (Table 4.6-1).

This increase would potentially have a negative impact on air quality compared to the No Action Alternative. As sediment comprises about three percent of the 1,960 miles of shoreline, this increase in acreage would not result in exceedance of the PSD Class II threshold or the state or national AAQS. Neither the small source area susceptible to wind erosion nor the geologic formations would be conducive to creating dust.

4.6.2.5 Reservoir Storage Alternative

At the 10th percentile, Lake Powell elevation is projected to be 3,574 feet msl in the year 2025. Draw down of the Lake Powell water level to this elevation would result in a decrease of 14,162 acres of exposed shoreline. The Reservoir Storage Alternative would result in a decrease of about 15 percent in exposed shoreline compared to the No Action Alternative (Table 4.6-1).

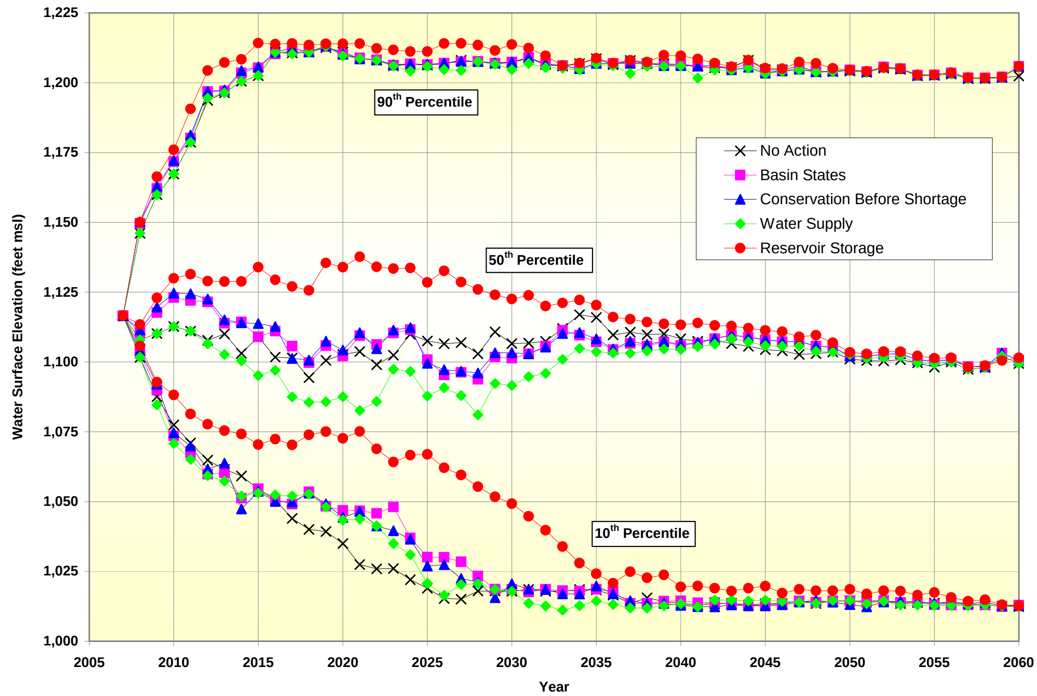
Compared to the No Action Alternative, the Reservoir Storage Alternative would result in the highest reduction in dust emissions and increased beneficial impact to air quality. Due to a decrease in exposed shoreline acreage, the potential to exceed the PSD Class II threshold or the state or national AAQS is also decreased.

4.6.3 Glen Canyon Dam to Lake Mead, Lake Mead and Hoover Dam

4.6.3.1 No Action Alternative

The lowest Lake Mead elevation occurs in December (Figure 4.6-2). Under the No Action Alternative, Lake Mead elevation would be drawndown to elevation 1,019 feet msl for the year 2025, resulting in 86,770 acres of exposed shoreline (Table 4.6-2).

Figure 4.6-2
Lake Mead End-of-December Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values



4.6.3.2 Basin States Alternative

At the 10th percentile, Lake Mead elevation is projected to be 1,030 feet msl in the year 2025, resulting in 83,920 acres of exposed shoreline. The Basin States Alternative would result in a decrease of about three percent in exposed shoreline when compared to the No Action Alternative (Table 4.6-2). This decrease in acreage would be directly proportional to the area susceptible to wind erosion and fugitive dust emission. With a decrease in exposed shoreline acreage, the potential to exceed the PSD Class I or II thresholds or the state or national AAQS would also decrease. The three percent decrease would result in a beneficial effect compared to the No Action Alternative.

Table 4.6-2
Lake Mead End-of-December 10th Percentile Elevation and Exposed Shoreline (Rounded to Nearest Whole Number)

Year	No Action Alternative	Basin States Alternative	Conservation Before Shortage Alternative	Water Supply Alternative	Reservoir Storage Alternative
2008 Surface Elevation (feet msl)	1,102	1,103	1,104	1,102	1,106
Exposed Shoreline Area (acres x 1,000)	90	90	87	90	88
Percent Difference Compared to No Action Alternative[1]	0	(1)	(3)	0	(2)
2016 Surface Elevation (feet msl)	1,051	1,051	1,050	1,052	1,072
Exposed Shoreline Area (acres x 1,000)	76	76	76	76	73
Percent Difference Compared to No Action Alternative	0	0	0	(1)	(4)
2025 Surface Elevation (feet msl)	1,019	1,030	1,027	1,021	1,069
Exposed Shoreline Area (acres x 1,000)	87	84	85	86	72
Percent Difference Compared to No Action Alternative	0	(3)	(2)	(1)	(17)
2040 Surface Elevation (feet msl)	1,014	1,014	1,013	1,013	1,019
Exposed Shoreline Area (acres x 1,000)	89	89	90	89	87
Percent Difference Compared to No Action Alternative	0	0	0	0	(3)
2050 Surface Elevation (feet msl)	1,014	1,015	1,013	1,015	1,019
Exposed Shoreline Area (acres x 1,000)	89	89	89.67	89	87
Percent Difference Compared to No Action Alternative	0	0	0.81	0	(2)
2060 Surface Elevation (feet msl)	1,012	1,013	1,013	1,012	1,013
Exposed Shoreline Area (acres x 1,000)	90	90	90	90	90
Percent Difference Compared to No Action Alternative	0	0	0	0	0

1 Parenthesis indicates a reduction in exposed shoreline compared to the No Action Alternative

4.6.3.3 Conservation Before Shortage Alternative

At the 10th percentile, Lake Mead elevation is projected to be 1,027 feet msl in the year 2025, resulting in more than 84,670 acres of exposed shoreline. The Conservation Before Shortage Alternative would result in a decrease of more than two percent in exposed shoreline when compared to the No Action Alternative (Table 4.6-2).

The decrease in acreage would be directly proportional to the area susceptible to wind erosion and fugitive dust emissions. With a decrease in exposed shoreline acreage, the potential to exceed the PSD Class I or II thresholds or the state or national AAQS would also decrease. The decrease would result in a beneficial impact to the environment compared to the No Action Alternative.

4.6.3.4 Water Supply Alternative

At the 10th percentile, Lake Mead elevation is projected to be 1,021 feet msl in the year 2025, resulting in more than 86,100 acres of exposed shoreline. The Water Supply Alternative would result in a decrease of about one percent in exposed shoreline when compared to the No Action Alternative (Table 4.6-2). The Water Supply Alternative would have no impact or a slight benefit compared to the No Action Alternative.

The decrease in acreage would be directly proportional to the area susceptible to wind erosion and fugitive dust emissions. With a small decrease in exposed shoreline acreage, the potential to exceed the PSD Class I or II thresholds or the state or national AAQS would also decrease. The decrease would have no impact or a slight benefit compared to the No Action Alternative.

4.6.3.5 Reservoir Storage Alternative

At the 10th percentile, Lake Mead elevation is projected to be 1,069 feet msl in the year 2025, resulting in more than 71,730 acres of exposed shoreline. The Reservoir Storage Alternative would result in a decrease of about 17 percent in exposed shoreline when compared to the No Action Alternative (Table 4.6-2). Compared to the No Action Alternative, the Reservoir Storage Alternative would have the most potential to reduce fugitive emissions and result in beneficial impact to air quality.

The decrease in acreage would be directly proportional to the area susceptible to wind erosion and fugitive dust emissions. With a decrease in exposed shoreline acreage, the potential to exceed the PSD Class I or II thresholds or the state or national AAQS would also be decreased. The decrease would result in a beneficial impact to the environment compared to the No Action Alternative.

4.6.4 Summary

As reservoir elevations decrease and more shoreline is exposed, the potential for increased fugitive dust emission increases. The exposed shoreline acreage under the Basin States Alternative and under the Conservation Before Shortage Alternative are similar to that under the No Action Alternative at both Lake Powell and Lake Mead and in the Glen Canyon Dam to Lake Mead reach. The Water Supply Alternative would have the greatest increase in exposed shoreline acreage compared to the No Action Alternative at Lake Powell, but would be similar to the No Action Alternative at Lake Mead and the Glen Canyon Dam to Lake

Mead reach. The Reservoir Storage Alternative would have the greatest reduction in exposed shoreline acreage compared to the No Action Alternative for both Lake Powell (15 percent in 2025) and Lake Mead (17 percent in 2025) and the Glen Canyon Dam to Lake Mead reach.

An increase in fugitive emissions as a result of increased exposed shoreline would be limited in Lake Powell because the increased exposure of acreage would be comprised largely of sandstone, which is not conducive to generating fugitive emissions of PM-10s. All of the action alternatives have the potential to decrease acreage of exposed shoreline at Lake Mead compared to the No Action Alternative and thus decrease particulate emissions at Lake Mead and in the Glen Canyon Dam to Lake Mead reach.

4.7 Visual Resources

This section describes the methods and potential effects on visual resources at Lake Powell and Lake Mead, focusing on selected attraction features, calcium carbonate rings, and sediment deltas.

4.7.1 Methodology

To determine how changes in reservoir elevation might affect visual resources, data provided in Table 4.3-3 were used to compare effects of the alternatives for Lake Powell attraction features. Table 4.3-3 provides percentage of values less than or equal to a given elevation for multiple years. The narrative describes effects for year 2026 because the greatest differences among alternatives are projected then.

For calcium carbonate rings, the lowest water surface elevation reached under the 10^{th} percentile projections was used to provide a worst case or maximum extent of the calcium carbonate ring. The height of the calcium carbonate ring was calculated as the distance in feet from full pool elevations for Lake Powell and Lake Mead, to the lowest projected elevation during the modeling time period (3,700 feet msl for Lake Powell and 1,221 feet msl for Lake Mead).

4.7.2 Lake Powell and Glen Canyon Dam

4.7.2.1 Attraction Features

Views of attraction features may be altered due to changes in reservoir elevations, with the key elevations ranging from 3,650 feet to 3,550 feet msl.

No Action Alternative. In 2026, there is a 59 percent probability of water being visible under or near Rainbow Bridge. There is a four percent probability of exposing Cathedral in the Desert. The upstream face of Glen Canyon Dam will be slightly more exposed, but this is not considered a measurable visual impact.

Basin States Alternative and Conservation Before Shortage Alternative. In 2026, there is a 49 percent chance of water being visible under or near Rainbow Bridge. Under these two action alternatives, there is a six percent chance of exposing Cathedral in the Desert.

Water Supply Alternative. In 2026, there is a 40 percent probability of viewing water under or near Rainbow Bridge and a 17 percent chance of exposing Cathedral in the Desert.

Reservoir Storage Alternative. In 2026, there is a 62 percent chance of viewing water under or near Rainbow Bridge and a one percent chance of exposing Cathedral in the Desert.

4.7.2.2 Calcium Carbonate Ring

No Action Alternative. The 10^{th} percentile projections result in a maximum decrease to elevation 3,540 feet msl, thus creating a potential calcium carbonate ring of 160 feet in height.

Basin States Alternative and Conservation Before Shortage Alternative. Under these two action alternatives, the 10th percentile projections result in a maximum decrease to elevation 3,550 feet msl, thus creating a potential calcium carbonate ring of 150 feet in height.

Water Supply Alternative. Under the Water Supply Alternative, the 10th percentile projections result in a maximum decrease to elevation 3,505 feet msl, thus creating a potential calcium carbonate ring of 195 feet in height.

Reservoir Storage Alternative. Under this alternative, the 10th percentile projections result in a maximum decrease to elevation 3,540 feet msl, thus creating a potential calcium carbonate ring of 160 feet in height.

4.7.2.3 Sediment Deltas

No Action Alternative. Sediment deltas will continue to build up over time and be visible under the No Action Alternative. Ferrari's (2006) longitudinal profile indicates that the sediment delta is visible for at least 15 miles upstream of Hite. At 10th percentile projections, the delta may be visible from as far away as 25 miles, essentially from Hite to Gypsum Canyon. The primary effect is to Cataract Canyon boaters.

Basin States Alternative and Conservation Before Shortage Alternative. Under these two action alternatives, the visual effects of the sediment delta would be similar to the No Action Alternative. For most of the modeled timeframe, the sediment delta would be slightly more visible to boaters than under the No Action Alternative due to the slightly reduced Lake Powell elevation. The difference with the No Action Alternative is so slight and incremental over time, that there would be no visual impact.

Water Supply Alternative. The Water Supply Alternative results in the lowest Lake Powell elevations for most of the modeled timeframe; consequently, the sediment delta would be most visible under this alternative. As with the calcium carbonate ring, while there is a difference between the Water Supply Alternative and the No Action Alternative, for most visitors, there would probably not be a measurable visual impact. Thus, there would be low visual impact when compared to the No Action Alternative.

Reservoir Storage Alternative. Under this action alternative, Lake Powell elevations for most of the modeled timeframe are higher than the No Action Alternative; consequently, the sediment delta and visual impact on Cataract Canyon boaters will be reduced. Thus, there is no visual impact when compared to the No Action Alternative.

4.7.3 Glen Canyon Dam to Lake Mead

The proposed federal action would have no effects on the visual resources in this reach.

4.7.4 Lake Mead and Hoover Dam

4.7.4.1 Attraction Features

Hoover Dam is a major destination and a national landmark. The proposed federal action would not have any visual effects on this resource.

4.7.4.2 Calcium Carbonate Ring

No Action Alternative. The 10th percentile projections for Lake Mead result in a maximum decrease to elevation 1,012 feet msl, thus creating a potential calcium carbonate ring of 209 feet in height.

Basin States Alternative and Conservation Before Shortage Alternative. The 10th percentile projections for Lake Mead result in a maximum decrease to elevation 1,012 feet msl, thus creating a potential calcium carbonate ring of 209 feet in height.

Water Supply Alternative. The 10th percentile projections for Lake Mead result in a maximum decrease to elevation 1,011 feet msl, thus creating a potential calcium carbonate ring of 210 feet in height.

Reservoir Storage Alternative. The 10th percentile projections for Lake Mead result in a maximum decrease to elevation 1,013 feet msl, thus creating a potential calcium carbonate ring of 208 feet in height.

4.7.4.3 Sediment Deltas

No Action Alternative. Studies at Lake Mead (Ferrari 2006) show that sediment deltas 47 miles long will continue to be present through the Lower Granite Gorge to about Iceberg Canyon. This sediment delta will continue to build up over time and be visible under the No Action Alternative. The primary visual effect is to visitors using upper Lake Mead, Pearce's Ferry, the Overton Arm, and Overton Beach.

Basin States Alternative and Conservation Before Shortage Alternative. Under these two action alternatives, the visual effects of the deltas will be virtually indistinguishable from those of the No Action Alternative.

Water Supply Alternative. The Water Supply Alternative only deviates from the No Action Alternative around the year 2025, when it results in slightly lower Lake Mead elevations. Consequently, the visual effect of the deltas is slightly worse than under the No Action Alternative. Thus, the visual effect would be minimal when compared to the No Action Alternative.

Reservoir Storage Alternative. Under the Reservoir Storage Alternative, Lake Mead elevations for the modeled timeframe through 2030 are higher than under the No Action Alternative; consequently, the visual impact of the deltas will be less than that under the No Action Alternative or not visible at all.

4.7.5 Summary

For attraction features, the percent probability of water being visible under or near Rainbow Bridge ranged from a low of 40 percent in Water Supply Alternative to 62 percent under the Reservoir Storage Alternative. There was a range from 17 percent probability of exposing Cathedral in the Desert to one percent under the Water Supply Alternative and under the Reservoir Storage Alternative, respectively. Some visitors consider water under or near Rainbow Bridge a negative impact, because it is a change from pre-dam conditions. However, for other visitors, the view is improved with water under the bridge. Most would agree that Cathedral in the Desert was one of the most spectacular geological features in Glen Canyon before inundation; seeing this feature would be considered a positive visual impact. There would be no visual effect on attraction features at Lake Mead.

For calcium carbonate rings at Lake Powell, the maximum height ranged from 195 feet under the Water Supply Alternative to 150 feet under the Basin States and Conservation Before Shortage alternatives. At Lake Mead, the maximum height was essentially unchanged under any of the alternatives with the range from 208 to 210 feet. For both reservoirs, the presence of the calcium carbonate ring is more of an effect that the height at any given reservoir elevation. Therefore, while there are numeric differences in the projected height of the rings, the overall difference in visual impact among the alternatives is not significant.

At both Lake Powell and Lake Mead sediment deltas will continue to build up over time and be visible under all alternatives. The differences among all alternatives are negligible for both Lakes Powell and Mead.

4.8 Biological Resources

This section describes the environmental consequences related to biological resources and describes the methods used to determine the effects associated with implementation of the proposed federal action. This section also provides a description of two ongoing environmental protection programs within the study area.

4.8.1 Related Environmental Programs

Reclamation is committed to compliance with environmental statutes such as the Endangered Species Act and the Grand Canyon Protection Act. The following are ongoing collaborative programs intended to meet environmental compliance requirements.

4.8.1.1 Glen Canyon Dam Adaptive Management Program

Impacts to biological resources below Glen Canyon Dam are considered in the AMP, which was established to monitor the effects of Glen Canyon Dam operations and other management actions on the downstream environment. This program makes recommendations to the Secretary regarding ways to fulfill the resource protection requirements of the Grand Canyon Protection Act while complying with all applicable federal law. This program will continue to analyze the effects of varied conditions on biological resources below Lake Powell under the No Action Alternative and the action alternatives.

4.8.1.2 Lower Colorado Multi-Species Conservation Program

For a portion of the study area, Reclamation is the implementing agency for the LCR MSCP. This program mitigates potential flow-related and non-flow related impacts to biological resources along the lower Colorado River. These impacts result from various federal and non-federal actions over the next 50 years along the lower Colorado River from Lake Mead to the SIB. This habitat-based program is being implemented to mitigate impacts to special status species, although benefits of the LCR MSCP will accrue to all species that utilize those habitats. This program covers potential impacts to the same types of habitats that may be impacted by flow-related impacts of the action alternatives. For NEPA purposes, the No Action Alternative is used as baseline. If needed, LCR MSCP mitigation would be the primary source of mitigation to offset the impacts of the final selected action alternative within the LCR MSCP study area. For example, the LCR MSCP identified and it is mitigating impacts on LCR MSCP covered species and their habitats. These impacts included the potential loss of up to:

- 2,008 acres of cottonwood-willow habitats;
- 133 acres of marsh habitat; and
- 399 acres of backwater habitat.

To address these impacts, the LCR MSCP would:

- restore 5,940 acres of cottonwood-willow habitat;

- restore 512 acres of marsh habitat;
- restore 360 acres of backwater habitat;
- stock 660,000 razorback sucker over the term of the LCR MSCP; and
- stock 620,000 bonytail over the term of the LCR MSCP.

In addition, these habitats would be actively managed to provide habitat values greater than those of the impacted habitats. The quality and in most cases the quantity of restored habitat will be greater than the impacted habitats. Restoration and management of these habitats for LCR MSCP covered species would provide benefit to all flora and fauna that utilize cottonwood-willow, marsh and backwater habitats along the Lower Colorado River.

LCR MSCP flow-related covered activities include flow reductions due to implementation of future shortages in the Lower Basin. Reclamation is committed to enacting the conservation measures of the LCR MSCP and these measures will effectively offset any potential minor impacts identified in this Draft EIS to cottonwood willow, marsh, and backwaters from Lake Mead to the SIB.

4.8.2 Methodology

Two types of modeling results were used to perform the biological analysis, as follows:

- hydrologic modeling (CRSS) – reservoir elevations, dam releases, river flows; and
- water quality modeling (CE-QUAL-W2 and GEMMS) – temperatures.

This analysis evaluates the relative difference between the action alternatives and the No Action Alternative. The level of available information varies with the study reaches; therefore, the methodology is adjusted according to the availability of information for a particular reach or group of reaches.

4.8.2.1 Assumptions

Desert scrub plant communities would not be affected by lowered reservoir elevations, river stage, or groundwater. Cottonwood/willow/marsh vegetation types could be adversely affected by lowered reservoir elevations, river stage, or groundwater and may be lost. Tamarisk and mesquite communities would not be adversely affected by lowered groundwater. For example, it has been reported that groundwater declines of approximately 3.6 feet caused 92 to 100 percent of cottonwoods and willows to die, while only zero to 13 percent of tamarisk died at their sample sites along the Bill Williams River (Shafroth et. al. 2000).

Davis Dam and Parker Dam will continue to be operated to meet target reservoir elevations and these operations will not vary between alternatives, thus the proposed federal action will not impact riparian and marsh vegetation or wildlife habitats supported by these reservoirs.

The biological analyses are dependent upon the data inputs, modeling assumptions and validity of the CE-QUAL-W2 and GEMMS models for water quality. The historic data and water temperature models represent limited combinations of weather patterns, hydrology, discharge patterns, and reservoir elevations. The upper and lower temperature bounds from this analysis are the best estimates of probable discharge temperature ranges at the indicated elevations. Additional discussion and data on temperature is provided in Chapter 4.5 and in Appendix P.

Inflow temperatures to Lake Mead often do not warm to equilibrium temperatures during much of the year. This is due to upstream cold releases from Lake Powell. The cool inflows restrict the depth of surface water warming and contribute to cooler discharge temperatures from Hoover Dam. If Lake Powell releases were significantly warmer, then inflow temperatures to Lake Mead could reach equilibrium and discharge temperatures would be warmer.

4.8.2.2 Vegetation Assessment Methodology

Lake Powell and Lake Mead. Reservoir elevations for the action alternatives were compared to the No Action Alternative to determine whether shoreline vegetation is more or less likely to establish and/or be inundated.

Glen Canyon Dam to NIB. Vegetation impacts were assumed to be limited to those plant communities that consist of obligate phreatophytes (reliant on alluvial groundwater). The LCR MSCP vegetation analysis anticipated that flow-related effects would have limited impact on saltcedar and mesquite land cover types because these species are facultative phreatophytes (not solely reliant on alluvial groundwater) and are more tolerant to reductions in surface and groundwater water levels than cottonwood/willow or marsh land cover types. The same assumption was used for this analysis.

Projections of monthly releases from Glen Canyon Dam, Hoover Dam, Davis Dam, and Parker Dam for each action alternative were compared to the No Action Alternative. The differences between the alternatives primarily at the 10th percentile were used as an indicator of potential low-flow conditions, which has the most potential to adversely affect vegetation. To estimate the significance of potential impacts, the potential flow differences were analyzed to determine if they would fall inside or outside the annual range of flows that have historically occurred in the Colorado River. Both Scott et. al. (1999) and Shafroth et. al. (2000) indicated that phreatophytes may develop root systems according to the hydrologic regime under which they developed. Flow variations of several thousand cfs within one month and between months are considered within the range of normal conditions.

Since the groundwater elevation along the Colorado River responds slowly to the releases from the dams and the corresponding changes in river stage, it was assumed that annual median changes in releases indicate potential changes in the alluvial water table elevation near the river. These potential water table changes could impact riparian phreatophytes and other riparian vegetation. A comparison of the median annual releases under each alternative to the median annual releases under the No Action Alternative showed minor reductions in river stage and corresponding water table elevations (Section 4.3.6.3 and 4.3.7.2).

NIB to SIB. Potential flow changes below the NIB as a result of implementation of the proposed federal action would primarily be the result of potential changes in excess flows (flood flows) arriving at the NIB. The differences in probability of these excess flows under each of the alternatives could potentially affect vegetation between the NIB and the SIB. Probabilities of these excess flows passing below the Morelos Diversion Dam under the action alternatives were compared against the No Action Alternative to analyze potential vegetation impacts.

4.8.2.3 Wildlife Assessment Methodology

Terrestrial wildlife was assumed to be affected only where the vegetation shows substantial changes from the No Action Alternative.

An analysis of river sport fishery and aquatic food base impacts was based on release temperature modeling, surface temperature data for Lake Powell and review of the temperature conclusions in the SCOP FEIS (Clean Water Coalition 2006) for Lake Mead. Since the sport fishery is primarily of interest to anglers, effects on this resource are discussed in the Recreation Section 4.12.

4.8.2.4 Special Status Species Assessment Methodology

Lake Powell and Lake Mead. Impacts to terrestrial special status species at these reservoirs were based primarily on the vegetation impact assessment. Potential impacts to special status fish were assessed by comparing reservoir elevations under each action alternative to the No Action Alternative. The potential range of release temperatures from Lake Powell was also used to analyze potential impacts to special status fish between Glen Canyon Dam and Lake Mead. Previous impact analysis for Lake Mead used elevation 1,160 feet msl as a threshold for potential impact to razorback sucker spawning areas in the lake. However, recent monitoring has shown the two subpopulations of razorback sucker in Lake Mead would change their spawning locations in response to lower reservoir elevations (Albrecht and Holden 2006). Lake Mead is currently below elevation 1,160 feet msl. The elevation range of 1,120 feet msl to 1,150 feet msl was used for comparison purposes in this analysis.

Glen Canyon Dam to NIB. Impacts to terrestrial special status species along the river were based primarily on the vegetation impact assessment. Impacts to special status fish were based on comparing the range of potential dam release temperatures (available for Glen Canyon Dam) to the life history temperature tolerances. Fishery impacts were also based on comparing the monthly Lake Mead elevations and monthly releases from Davis Dam and Parker Dam, where temperature data were not available. Changes in dam releases that would fall outside the range of flows that typically occur were deemed to cause impacts. Changes in release temperatures from Glen Canyon Dam under the No Action Alternative were used to determine whether impacts to the aquatic food base could in turn impact the special status fishery in the Grand Canyon. This analysis used larval chironomids, larval simuliids, *Gammarus lacustris*, and *Cladophora glomerata* as indicator organisms. If a particular alternative would substantially affect non-native sport fish (Section 4.12), this was included in the special status fishery assessment.

NIB to SIB. Special status fish species do not exist in this reach so the analysis was limited to terrestrial special status species. Flows in this reach of the river are sporadic, with the river channel in the lower portion of the reach being frequently dry.

4.8.3 Effects on Vegetation and Wildlife

This section discusses the potential impacts to vegetation and wildlife that may result from implementation of the proposed federal action.

4.8.3.1 Lake Powell and Lake Mead

No Action Alternative. Under the No Action Alternative, fluctuation of these reservoirs will continue to inhibit plant growth around the reservoirs over the long term. Lake Powell elevations trend upward under the 50th and 90th percentiles and somewhat downward under the 10th percentile. Figures P-7, P-8 and P-9 provide Lake Powell end-of-March, July, and September elevations. Lake Mead exhibits a slight downward trend under the 50th percentile and a more pronounced downward trend under the 10th percentile. Figures P-10, P-11, and P-12 provide Lake Mead end-of-month elevations for March, July, and September. To the extent that lake elevations may be reduced, these lower lake elevations may have effects on biological resources, as described in the following paragraphs.

The sediment deltas in both reservoirs are expected to continue to be colonized by weeds and tamarisk. The Lake Mead delta and the lower portion of the Grand Canyon especially have had riparian vegetation become established and persist over long periods of time, until inundated by rising reservoir elevations. The type of vegetation that becomes established in these delta areas is dependent on two factors. The first factor is timing. If the sediment becomes exposed during seed fall for cottonwood or willow, then those species are likely to become established. If the sediment becomes exposed during the fall months, then saltcedar is likely to be established and become the dominant vegetation.

A second factor that may influence the type of plant community that would become established in the delta areas is the depth to groundwater or river elevation from these exposed sediments. As the reservoir elevation declines and the sediment becomes exposed, the river elevation as it downcuts through the newly exposed delta would help determine whether cottonwoods or willows can survive, even if they become established. If the river elevation drops too far below the root zone of cottonwoods and willows, plant mortality would begin to occur, thus, opening gaps for saltcedar and other species to become established.

Wildlife that utilizes these reservoirs and their shorelines are affected by the fluctuating nature of these habitats to some extent. Reservoir fluctuation would continue into the future, which would continue to alter habitat along the shoreline and below full-pool elevation as has occurred in the past.

Action Alternatives. While the action alternatives differ from the No Action Alternative to some degree, all the action alternatives exhibit similar fluctuations compared to the No Action Alternative. Temporary establishment and loss of vegetation and wildlife habitat below the full-pool elevation would occur similarly under all alternatives. In general, the Reservoir Storage Alternative tends to result in higher reservoir elevations and the Water Supply Alternative tends to result in lower reservoir elevations than the No Action Alternative. The Conservation Before Shortage and Basin States alternatives tend to have similar reservoir elevations as the No Action Alternative, though somewhat lower in some years. Lower elevations would provide increased exposed shoreline where desirable and undesirable plants could temporarily colonize. Higher elevations would provide decreased exposed shoreline for plant colonization and would thus provide less opportunity for temporary desirable and undesirable plant communities to develop. The higher elevations under the Reservoir Storage Alternative may occur during the interim period and modeling period. Tenth percentile Reservoir Storage Alternative lake elevations return to the No Action Alternative conditions in approximately 2034 for Lake Powell and in 2036 for Lake Mead. Lower elevations would increase the distance between permanent shoreline vegetation and aquatic habitats, which would increase the distance wildlife would need to travel between cover habitat and the lake edge. Higher elevations would decrease the distance between permanent shoreline vegetation and the lake edge.

The lower reservoir elevations that may occur with the Water Supply Alternative would fall outside the potential range of the No Action Alternative. At these low reservoir elevations, there would be a greater potential for sediment headcutting at the inflow areas causing movement of sediment further into the reservoirs. The Water Supply Alternative would have the greatest potential effect on these deltas due to increased reservoir drawdown, which would impact vegetation and wildlife habitats. These impacts may occur in the interim period and the modeling period. The lower lake elevations under the Water Supply Alternative may remain lower than under the No Action Alternative until approximately 2036 for Lake Powell and until 2040 for Lake Mead at the 50th percentile, and until 2055 for Lake Powell at the 10th percentile.

4.8.3.2 Glen Canyon Dam to Lake Mead

No Action Alternative. The No Action Alternative at the 10th and 50th percentile average monthly releases range from approximately 9,000 cfs to 14,000 cfs (Table 4.3-12). Additional data on Glen Canyon Dam releases is provided in Figures P-13 through P-24 in Appendix P. This range is similar to the range observed from 2000 to the present, though lower than the high water years between 1995 and 2000. Therefore, the release conditions which the vegetation and wildlife below Glen Canyon Dam have experienced since 2000 would continue into the future at these percentile levels. The vegetation and wildlife are likely adjusting or have adjusted to these lower flows. Stabilized flows have been observed to favor riparian vegetation development at numerous locations in the Western United States (Reclamation 1995 and USGS 2004). This trend benefits species that utilize shrubby riparian vegetation. The overall release trend indicates that the magnitude of monthly releases would generally be lower in the future in many months.

Action Alternatives. The action alternatives at the 10th percentile release all tend to be lower than the No Action Alternative, with the Reservoir Storage Alternative being the closest to the No Action Alternative. Tenth percentile release reductions are typically between 700 and 2,000 cfs, though the Water Supply Alternative may be lower than the No Action Alternative by up to 3,800 cfs in July and September. Low flows have the greatest likelihood of negatively impacting riparian and marsh vegetation and wildlife that utilize such habitats. The impacts would be minor because for the most part, these reduced releases remain within the range of annual fluctuation and would be temporary. The impacts may cause stress to phreatophytes, but would not be expected to cause significant plant die-off. These impacts would affect obligate phreatophytes such as willow more than facultative phreatophytes such as tamarisk. Thus these minor impacts may favor continued tamarisk expansion, though tamarisk is expanding along the Colorado River under existing conditions. Because Glen Canyon Dam releases under all the alternatives generally return to the No Action Alternative conditions near the end of the interim period, conditions causing these impacts would end after the interim period. However, the effects on phreatophytes and continued tamarisk expansion may be observable even after conditions return to the No Action Alternative conditions.

The magnitude of flows exceeding the No Action Alternative that may occur under the action alternatives (90th percentile releases) is relatively small, with the exception of the Reservoir Storage Alternative. Releases under the Reservoir Storage Alternative in June may be up to 6,800 cfs above the No Action Alternative and approach 30,000 cfs. These high flows may cause scouring of vegetation that may have developed lower on the banks under previously lower flow conditions. These flows are below the levels of the experimental high flows that have occurred in the past, which have exceeded 40,000 cfs. Despite scouring losses from these higher flows, they would provide an overall benefit to vegetation and wildlife in the long term.

Minor negative impacts to riparian vegetation from lower 10th percentile releases with all alternatives would impact the habitats for herptofauna, small mammals, waterfowl, and songbirds that utilize those habitats. Snakes found below Glen Canyon Dam are typically found in drier portions of the reach and should not be impacted by these alternatives. Fiftieth percentile elevation releases from Lake Powell will have similar temperatures as the No Action Alternative for all the action alternatives and would thus cause no temperature related impacts to amphibians along the river. Only the Water Supply Alternative may result in higher temperatures in some years and may provide some thermal benefit to amphibian reproduction along the river. It would be difficult to measure these potential impacts as the impacts to vegetation should be minor and thus indirect impacts to species using those habitats would be small. These potential small habitat impacts are unlikely to impact large mammals in the canyon. Due to the potential minor impacts to riparian vegetation, all the alternatives would have a similar minor impact to wildlife between Glen Canyon Dam and Lake Mead.

4.8.3.3 Hoover Dam to Davis Dam

No Action Alternative. The Hoover Dam to Davis Dam reach consists primarily of the reservoir pool of Lake Mohave, the elevation of which is controlled by operation of Davis Dam. Lake Mohave and Lake Havasu are operated on a monthly rule curve and end-of-month target elevations and therefore significant fluctuations do not occur. No change in vegetation or wildlife is expected over the interim period or the modeling period. Figures P-25 through P-36 of Appendix P provide information on monthly Hoover Dam releases.

Action Alternatives. Elevations in these reservoirs under the action alternatives would not deviate from the No Action Alternative elevations. Accordingly, there would be no impacts to vegetation or wildlife at the reservoirs. Because vegetation is limited between Hoover Dam and Lake Mohave, potential flow differences among alternatives in this reach of the Colorado River would not substantially impact vegetation or wildlife.

4.8.3.4 Davis Dam to Parker Dam

No Action Alternative. Fluctuations below Davis Dam of several thousand cfs have occurred in the recent past and would continue into the future. Vegetation and wildlife habitat along the Colorado River are constantly making minor adjustments as these flows fluctuate, which would continue into the future.

Action Alternatives. Release rates for Davis Dam fall within a relatively narrow band for all months at the 50th and 90th percentiles. Figures P-37 through P-48 in Appendix P provide monthly Davis Dam releases. The Reservoir Storage Alternative results in lower releases during the interim period, while the Water Supply Alternative results in higher releases. The higher releases would benefit vegetation and wildlife, but these benefits would be minor. Lower releases under the Reservoir Storage Alternative would negatively impact vegetation and wildlife compared to the releases under the No Action Alternative. The Conservation Before Shortage and Basin States alternatives essentially follow the No Action Alternative, and where there are differences they are isolated small differences. Therefore, the Conservation Before Shortage and Basin States alternatives should have no measurable impacts on vegetation between Davis Dam and Parker Dam. The Reservoir Storage Alternative may cause some higher releases due to increased flood control releases not seen in the other alternatives. These typically occur in winter months, outside the growing season. These flows may be up to 6,000 cfs over the No Action Alternative at the 90th percentile although would still not be large enough to cause significant scouring or over bank flooding. Thus no substantial riparian benefits are expected. The No Action Alternative and the action alternatives converge relatively quickly after the end of the interim period. Conditions under the action alternatives generally return to the conditions under the No Action Alternative relatively soon after the interim period, though effects on the vegetation of interim period conditions may be observed beyond the interim period.

Impacts of the lower releases under the Reservoir Storage Alternative would have similar impacts to wildlife as discussed for lower releases between Glen Canyon Dam and Lake Mead.

4.8.3.5 Parker Dam to Imperial Dam

No Action Alternative. Figures P-49 through P-60 in Appendix P provide data on monthly Parker Dam releases. At the 90th percentile level, monthly releases from Parker Dam exhibit a downward trend through a reduction in high winter flows. Flows above Imperial Dam exhibit a small downward trend at the 10th and 50th percentiles, but generally level-off after the interim period. At the 90th percentile, high flows above Imperial Dam in winter become less common into the future as well. Vegetation and wildlife below Parker and above Imperial Dam would experience a fluctuating release pattern over time. Vegetation and wildlife would need to adjust to these reduced high flows but the gradual nature of the declines should not substantially affect vegetation or wildlife. Fluctuations below Parker Dam and above Imperial Dam of several thousand cfs have occurred in the recent past and are expected to continue into the future. The plant communities along the Colorado River are constantly making minor adjustments as these flows fluctuate.

Action Alternatives. Parker Dam releases under the Water Supply and Basin States alternatives follow the No Action Alternative closely and would therefore not impact vegetation or wildlife. Releases under the Conservation Before Shortage and Reservoir Storage alternatives trend somewhat lower than the No Action Alternative, though still within the range of flow variation that occurs. These lower releases would have minor negative impacts to cottonwood/willow, marsh, and the wildlife that depend on these habitats. The Reservoir Storage Alternative shows some higher releases during the winter, but given the capacity of the channel in this reach, it is not likely that these flows would substantially benefit riparian vegetation or wildlife habitat from over bank flooding. These differences from the No Action Alternative releases tend to return to the No Action Alternative conditions relatively soon after the interim period.

Flows above Imperial Dam under the Water Supply Alternative are similar to the No Action Alternative and would therefore not impact vegetation or wildlife. Flows above Imperial Dam during the growing season tend to be less than under the No Action Alternative for the Reservoir Storage, Basin States, and Conservation Before Shortage alternatives. Of these three alternatives, the Basin States Alternative exhibits the least reduction from the No Action Alternative, while the Reservoir Storage Alternative exhibits the most reduction. At the 10th percentile, these three alternatives would have minor negative impacts on cottonwood-willow and marsh habitats and the wildlife that rely on these habitats. These impacts would only occur during the interim period. The impacts are expected to be minor because the flow reductions are typically 1,000 cfs and less for the Reservoir Storage Alternative and 500 cfs and less for the Basin States Alternative, which are within the range of variation that regularly occurs.

4.8.3.6 Imperial Dam to NIB

As noted in Section 3.3, most of the water delivered to Mexico is diverted at Imperial Dam, conveyed via the AAC, and then returned to the Colorado River through the Pilot Knob and Siphon Drop Powerplants and their respective wasteway channels, 2.1 and 7.6 miles upstream of the NIB, respectively (Section 3.3). The proposed federal action will not alter the operation of these diversions and wasteways and therefore will not have an effect on the river reach between Imperial Dam and the NIB.

4.8.3.7 NIB to SIB

No Action Alternative. The frequency and magnitude of flows are important factors in maintaining riparian habitat and wildlife between Morelos Diversion Dam and the SIB; however, the potential biological effects downstream of the NIB cannot be specifically determined because of the uncertainty of water use once it flows to the NIB and becomes available to Mexico.

The volume of water passing by Morelos Diversion Dam (Section 3.3) as a result of cancelled water orders by contract users is rare enough to not have much effect on vegetation or wildlife below the NIB. The hydrologic models assume that any water in excess of Mexico's scheduled normal or surplus deliveries would not be diverted by Mexico and would continue down the Colorado River channel between Morelos Diversion Dam to the SIB. This assumption results in the probability of flows passing Morelos Diversion Dam that might be somewhat higher than may actually occur, and the potential impacts discussed in the following section are based on this assumption.

Under the No Action Alternative conditions, flows below the Morelos Diversion Dam will continue to be primarily the result of dam leakage and agricultural return flows. Flows past the Morelos Diversion Dam will continue to be relatively rare events. It is expected that the riparian and marsh vegetation and wildlife will continue to experience some year-round flow in the upper part of the reach and sporadic flow in the lower part of this reach under the No Action Alternative. Thus, historical conditions will generally continue under the No Action Alternative.

Action Alternatives. During the interim period and beyond, the Basin States and Water Supply alternatives are just as likely to cause excess flows below Morelos Diversion Dam as the No Action Alternative, and would therefore cause no impact over the No Action Alternative. Further, the probabilities of occurrence are low and are mostly between 10 percent and 15 percent. In representative years (2016, 2026, and 2060), the magnitude of excess flows past Morelos Diversion Dam is zero for 80 percent to 90 percent of the model traces for those years. The Reservoir Storage Alternative may increase the magnitude of these flood control excess flows by as much as one mafy over the No Action Alternative. The Conservation Before Shortage Alternative may increase the magnitude of these flood control excess flows by as much as 0.4 mafy over the No Action Alternative. Figure P-61 in Appendix P provides data on excess flows below the Morelos Diversion Dam.

Due to modeling assumptions under the Conservation Before Shortage and Reservoir Storage alternatives, water is also delivered to Mexico through this reach via periodic flows of about 40 kafy to 200 kafy (Appendix M). These pulse flows[1] would occur approximately every other year during the interim period only. The probability of flows past Morelos Diversion Dam under these two alternatives returns to No Action Alternative conditions after the interim period. These flows would benefit vegetation and wildlife below Morelos Diversion Dam because they would increase river flow, scour and redistribute sediment and provide opportunities for establishment of cottonwood-willow and marsh vegetation. These fluvial processes are valuable to aquatic and riparian systems in the long-term, though temporary losses of riparian or marsh vegetation may occur from scouring, which could temporarily disrupt wildlife.

Table 4.8-1 summarizes impacts to vegetation and wildlife for the alternatives.

4.8.4 Special Status Species

4.8.4.1 Lake Powell

No Action Alternative. Fluctuations of the Lake Powell elevations would continue into the future, precluding the development of stable vegetated terrestrial habitats below elevation 3,700 feet msl because vegetation that develops is periodically dewatered and inundated.

Fish. The Colorado pikeminnow, bonytail chub, razorback sucker and flannelmouth sucker are all occurring in Lake Powell, primarily at the inflow areas of the Colorado River and the San Juan River. Flannelmouth sucker population has been decreasing since the reservoir was formed (Reclamation 2000). Lower elevations would increase the amount of riverine habitat for these species in the river inflow areas, which may be a temporary benefit to these fish.

Birds. Special status birds that currently may be affected by elevation fluctuations at Lake Powell include California condor, Bald eagle, osprey, belted kingfisher, Clark's grebe, and American peregrine falcon. California condors are scavengers, primarily on large mammals and sometimes on fish. The lower reservoir elevations projected for the future may expose additional shoreline for scavenging.

[1] These flows were modeled as part of the storage and delivery mechanism under the Conservation Before Shortage and Reservoir Storage alternatives. The modeling assumptions were utilized in this Draft EIS in order to analyze the potential impacts to environmental resources of the storage and delivery mechanism, particularly with regard to reservoir elevations and river flow impacts. The use of these modeling assumptions does not represent any determination by Reclamation as to whether, or how, these releases could be made under current administration of the Colorado River.

Table 4.8-1
Vegetation and Wildlife Impact Summary
Comparison of Action Alternatives to No Action Alternative

Location	Alternative	Impact	Rationale
Lake Powell and Lake Mead	Conservation Before Shortage and Basin States	No impact	Elevations and fluctuation similar to the No Action Alternative.
	Water Supply	Minor – negative	Reservoir elevations tend to be lower than under the No Action Alternative, with increased opportunities for undesirable plants to colonize shoreline and delta headcutting. Level fluctuations inundate all vegetation below full pool elevation. Lower elevations would increase distance between shoreline vegetation and the Lakes.
	Reservoir Storage	Minor-positive	Elevations tend to be higher than under the No Action Alternative, with decreased opportunities for undesirable plant to colonize shoreline and delta headcutting. Level fluctuations inundate all vegetation below full pool elevation. Higher elevations would decrease distance between shoreline vegetation and Lakes.
Glen Canyon Dam to Lake Mead	All Action Alternatives	Minor – negative	Decreased releases at 10th percentile (for all alternatives there are similar reductions overall). Release differences are within the range of recent history and annual fluctuation.
Hoover Dam to Davis Dam and Lake Havasu to Parker Dam	All Action Alternatives	No impact	Relatively small Hoover Dam release differences and very limited vegetation above Lake Mohave. Monthly rule curves at Lakes Mohave and Havasu prevent water level deviations from the No Action Alternative.
Davis Dam to Lake Havasu	Conservation Before Shortage, Basin States	No impact	Monthly releases closely follow the No Action Alternative.
	Water Supply	Minor-positive	Monthly releases higher than under the No Action Alternative at 10th and 50th percentiles.
	Reservoir Storage	Minor – Negative	Monthly releases lower than under the No Action Alternative at 10th and 50th percentiles.
Parker Dam to Imperial Dam	Water Supply	No impact	Monthly releases closely follow the No Action Alternative.
	Basin States, Conservation Before Shortage and Reservoir Storage	Minor – Negative	Monthly releases lower than under the No Action Alternative at 10th and 50th percentiles (the Reservoir Storage Alternative has the greatest reduction; the Basin States Alternative has the least reduction). The Reservoir Storage Alternative higher flows in the winter are unlikely to have substantial benefits due to channel capacity.
Imperial Dam to NIB	All Action Alternatives	No impact	Flow changes are routed through AAC and Pilot Knob/Siphon Drop power plants rather than river below Imperial Dam.
NIB to SIB	Basin States and Water Supply	No impact	Probability of excess flows past Morelos Diversion Dam is very close to the No Action Alternative.
	Reservoir Storage and Conservation Before Shortage	Moderate – positive	Relatively likely high flows expected past Morelos Diversion Dam, which would benefit the riparian corridor.

Bald eagles in this area are primarily winter residents that feed on fish, waterfowl and carrion. Though there may be effects on fisheries as reservoir elevations decline, no effects on the population of fish are anticipated. Therefore, this food source is expected to remain available for bald eagles under the No Action Alternative.

Ospreys are a rare transient in summer along the Colorado River. However, they could potentially utilize Lake Powell during migration. Fluctuating reservoir elevations would have no direct impacts to ospreys, and no substantial indirect effects on food sources (fish) are expected.

Peregrine falcons may utilize Lake Powell for hunting songbirds, bats and small mammals. Reservoir elevation fluctuations would not directly impact peregrine falcons. Nearby populations in Grand Canyon are considered stable and the species was delisted from federal listing in 1999 (Gloss et. al. 2005).

Belted kingfishers inhabit riparian areas in Arizona and mainly consume fish. Kingfishers could be affected as fish availability fluctuates over time. Given the gradual downward trend for Lake Powell elevations in the future, it is anticipated that fish populations would be able to adjust to the changing conditions. Increased inflow areas as the elevations recede may provide improved shallow water hunting area.

Clark's grebe inhabit marshes and may be found in marsh habitat at the Lake Powell inflow areas. They are common breeders in Utah and utilize lakes and shoreline vegetation for breeding habitat. Future conditions under the No Action Alternative project a decline in reservoir elevations. These declines may dewater marshes at the inflow areas, causing temporary loss of marsh habitat until the marsh re-establishes at a lower elevation, or the lake levels recover.

Mammals. Special status mammals that may utilize Lake Powell include spotted bat, Townsend's big-eared bat, pale Townsend's big eared bat, fringed myotis, and occult little brown bat. All of these species may utilize riparian habitats around the shoreline of Lake Powell. As elevations fluctuate, these habitats may be dewatered or inundated and localized effects on food source populations may occur. Given the wide-ranging nature of these species, the No Action Alternative or any of the action alternatives would not be expected to substantially impact these species. Accordingly, these species would not be discussed further for this reach.

Amphibians. Northern leopard frog populations are found in side canyons of Lake Powell above the fluctuating reservoir elevations (Gloss et. al. 2005). These populations are above elevation 3,700 feet msl and would not be impacted by reduced elevations of Lake Powell. However, continued fluctuations of Lake Powell elevations would likely limit marsh and riparian vegetation at the shoreline, or only allow it to establish temporarily, thus continuing to limit the potential for leopard frogs and other amphibians to utilize areas below the full-pool elevation of Lake Powell.

Action Alternatives.

Fish. Flannelmouth suckers, razorback sucker, Colorado pikeminnow and bonytail chub occur in the inflow areas of the Colorado River and the San Juan River but do not spawn in Lake Powell, and changing elevations would be unlikely to affect habitat within the reservoir for any individuals remaining in the reservoir.

The lower elevations under the Water Supply, Conservation Before Shortage and Basin States alternatives would increase the amount of riverine habitat for these species in the river inflow areas, which may be a temporary benefit. The amount of lowering would generally be less than 20 feet for the 50th percentile elevation in March, 12 feet in July, and 17 feet in September (Figures P-7, P-8, P-9 in Appendix P). For the 10th percentile reservoir elevations, the elevation changes could range from 16 feet higher to 13 feet lower, with most of the elevations being lower, than under the No Action Alternative in all three months (March, July, and September). The lower elevations would provide a small benefit to razorback sucker, bonytail, Colorado pikeminnow and flannelmouth sucker in the river inflow areas by increasing the amount of flowing water habitat, though this is expected to be a minor benefit. These impacts may occur during the interim period and the modeling period.

The Reservoir Storage Alternative tends to result in higher lake elevations of less than approximately 8 feet relative to the No Action Alternative for the 50th percentile elevation in March, July, and September. For the 10th percentile reservoir elevations, the elevation may be up to 26 feet higher in all three months. This would reduce the amount of riverine habitat for razorback sucker, bonytail, Colorado pikeminnow and flannelmouth sucker in the river inflow areas compared to the No Action Alternative and create a minor negative impact. These impacts may occur during the interim period and the modeling period.

Birds. Since bald eagles, peregrine falcons, California condor and osprey are all wide ranging species that utilize many different habitat types in the area, none of the action alternatives differ substantially enough to impact these species at Lake Powell.

Clark's grebe would be impacted predominantly by impacts to marsh habitats. As indicated in the Vegetation and Wildlife section, the Water Supply Alternative would have a minor negative impact on vegetation, including marshes (at the inflow areas), and the Reservoir Storage Alternative would have a minor-positive impact on vegetation. Conservation Before Shortage and Basin States alternatives would not impact Clark's grebe. These impacts may occur during the interim period and the modeling period.

Belted kingfishers would be most impacted by potential changes in fish food supplies. Substantial impacts to fish food supplies at Lake Powell are not anticipated with any action alternative, thus no impacts to belted kingfishers are anticipated.

Amphibians. Northern leopard frog populations are found in side canyons above elevation 3,700 feet msl, so none of the action alternatives would impact special status amphibians at Lake Powell.

Table 4.8-2 summarizes the impacts to special status species by alternative.

Table 4.8-2
Lake Powell Special Status Species Impact Summary
Comparison of Action Alternatives to No Action Alternative

Species	Alternative	Impact	Rationale
Razorback sucker, bonytail, Colorado Pikeminnow, flannelmouth sucker	Water Supply, Conservation Before Shortage, Basin States	Minor - positive	Reservoir elevations tend to be lower than under the No Action Alternative, increasing riverine conditions at the inflows.
	Reservoir Storage	Minor-negative	Reservoir elevations tend to be higher than under the No Action Alternative, decreasing riverine conditions at the inflows.
Bald eagle, peregrine falcon, osprey, California Condor, belted kingfisher	All Action Alternatives	No impact	Wide ranging species and action alternatives do not differ substantially enough to cause indirect impacts.
Clark's grebe	Conservation Before Shortage and Basin States	No impact	Reservoir elevations trend close to the No Action Alternative. Impacts to marsh not anticipated.
	Water Supply	Minor - negative	Lower reservoir elevations would have minor negative impact on marshes at inflows, by increased likelihood of headcutting sediment deltas.
	Reservoir Storage	Minor – positive	Higher reservoir elevations would have minor positive impact on marshes at inflows, by decreased likelihood of headcutting sediment deltas.
Mammals	All Action Alternatives	No impact	Wide ranging species and action alternatives do not differ substantially enough to cause indirect impacts.
Northern leopard frog	All Action Alternatives	No Impact	Known populations above level of lake fluctuation.

4.8.4.2 Glen Canyon Dam to Lake Mead

No Action Alternative. Releases from Glen Canyon Dam would remain relatively stable during the interim period, but would be reduced over the later years of the modeling period. Reduced river flows have the potential to affect phreatophytes, marshes, and associated special status species.

Plants. Grand Canyon evening primrose grows on beaches along or near the mainstream Colorado River in the vicinity of Separation Canyon and downstream of Diamond Creek (Reclamation 2000). Lower releases could allow this species to colonize lower beaches exposed during reduced releases. Reduced high flows would favor encroachment of riparian vegetation towards the Colorado River, which would compete with the species. High flows and sediment, which are needed to maintain beach habitats and discourage riparian vegetation encroachment, would continue to be limited in the future. Beach habitat occupied by this species is also utilized by recreationists, which limits Grand Canyon evening primrose establishment.

Invertebrates. The Kanab ambersnail occurs in semi-aquatic habitat associated with springs and seeps. In the Grand Canyon, Kanab ambersnail were originally known to occur only at Vasey's Paradise, a large perennial spring. As part of an effort to recover the species, Kanab amber snails were translocated from Vasey's Paradise to three other locations. One of the criteria used to select these sites was that it be above the elevation of any potential future flood flows past Glen Canyon Dam. These translocated populations would not be affected by the proposed federal action. The Vasey's Paradise population and vegetation are not flooded until flows exceed 17,000 cfs (Reclamation 2002, EA, FONSI Proposed Experimental Releases from Glen Canyon Dam). Future conditions under the No Action Alternative may exceed 17,000 cfs for more than a single year in January, February, May, June, July, August, September, and December at the 90th percentile release (Figures P-13 to P-24 in Appendix P).

Niobrarra ambersnail occur in wetland habitats at several locations below Glen Canyon Dam. The population near Lees Ferry is subject to inundation from even moderate flows of the Colorado River (>25,000 cfs), and more than 90 percent of the entire habitat is inundated at 45,000 cfs or more. The Indian Gardens population persisted through the 1996 experimental flow. The population has not been monitored since May 1998 and March 1999 at which time it was abundant. However, flows exceeded 22,000 cfs for extended periods in the summer of 1998 and in May 1999, and no snails were found during habitat searches in those periods. Flows over 20,000 cfs inundate the Indian Gardens habitat (Arizona Game and Fish 2004). Future conditions under the No Action Alternative release may exceed 20,000 cfs at the 90th percentile releases in June, July, August, September, and December, which could cause a loss of wetland vegetation and individual snails.

MacNeill's sootywing skipper is a butterfly found along the Colorado River from southern Utah and Nevada to Arizona and southeastern California (Reclamation 1996a). Confirmed records of this species are reported for the Arizona counties of Mohave, La Paz, Yuma, Yavapai, Maricopa and Pinal. The MacNeill's sootywing skipper is also present in San Bernardino, Riverside and Imperial counties in California. This species also occurs along the Muddy River above Lake Mead (Austin & Austin 1980).

The larval host plant for MacNeill's sootywing skipper is quailbrush (*Atriplex lentiformis*). Quailbrush is the largest salt bush found in Arizona and forms dense thickets along the drainage system of the Colorado River (Emmel and Emmel 1973). Quailbrush is associated with floodplains located in alkaline soil areas with adequate water resources (Kearney and Peebles 1951). Specific surveys for this species and larval host plants have not been conducted in the lower Grand Canyon; however, the documented occurrence of MacNeill's sootywing skipper along the Muddy River above Lake Mead indicates there is a likelihood of occurrence in the lower Grand Canyon. Suitable habitat for this species likely requires stands of more than one host plant (W. Wiesenborn 1999). Future conditions under the No Action Alternative are not expected to affect floodplains where quailbrush is typically found.

Fish. Water releases from Glen Canyon Dam would continue to follow the guidelines provided in the 1996 Glen Canyon Dam ROD under the No Action Alternative, although the annual water releases may decrease in the future. Thus, the amount and physical characteristics of habitat available to native special status fish species (humpback chub, bluehead sucker, flannelmouth sucker) may vary over time under the No Action Alternative. Little information is available to quantitatively assess the potential effects of monthly release trends on the habitat of these fish. In general, the daily operations and Glen Canyon Dam releases will continue to be consistent with the 1996 Glen Canyon Dam ROD, therefore, the proposed federal action is not expected to substantially affect daily fluctuation overall. For example, a study of backwaters in the Grand Canyon (Goeking et al. 2003) found that the number and area of backwaters present varied with river discharge between years at any given site and varied among sites within one year. Given that there is little information to correlate differences in monthly releases to impacts on the physical characteristics of special status fish habitat availability, water temperature was selected as a better metric to analyze the impacts to special status fish species. Cold river temperatures and the presence of non-native fish species appear to be the key reasons for adverse native fish conditions in this reach.

Temperature of water released from Glen Canyon Dam would vary depending on the reservoir elevation, and these changes have been modeled (Section 4.5 and Appendix P). Native fish, such as the humpback chub, flannelmouth sucker and bluehead sucker could benefit from warmer water temperatures during their spawning season, because releases of cold water from Lake Powell generally keep water temperature downstream to Lake Mead below that needed for spawning to occur. Thus, spawning could only occur in warmer tributaries or backwaters. When reservoir elevations in Lake Powell fall below about 3,600 feet msl (approximately 10^{th} percentile level), water above 15 ºC (59 ºF) could be released. This water may warm approximately 2 ºC (35.6 ºF) by the time it reaches the Little Colorado River confluence and by up to 5 ºC (41 ºF) near the Diamond Creek confluence. For the 10^{th} percentile, water temperatures could be warm enough for humpback chub spawning and egg incubation from approximately May through July near Diamond Creek and from June through July below the Little Colorado River confluence. Figures P-62 through P-79 in Appendix P provide information on modeled water temperatures at selected locations for the No Action Alternative and the action alternatives.

Flannelmouth and bluehead suckers are also present in this reach of the Colorado River although they use the warmer tributaries for spawning (Table 4.8-3). Only under low Lake Powell elevations (10^{th} percentile), could suitable temperatures for spawning occur in the river for the bluehead sucker over a portion (about June to October) of their spawning season above the Little Colorado River confluence, and from about May to October near Diamond Creek. Egg incubation requires temperatures about 2 ºC (35.6 ºF) warmer than for spawning and thus would not occur for up to a month later in the spring, and then primarily near Diamond Creek.

For the 50th percentile elevations, water temperatures near Diamond Creek could be warm enough for their spawning from about June to October, while the 90th percentile elevation could result in suitable temperatures from about June through August. However, temperatures may only be suitable for egg incubation in August to early September for the 50th percentile and periodically in July and August for the 90th percentile. For flannelmouth suckers, water temperatures could be warm enough for spawning below the Little Colorado River in May and June, and in June at Lees Ferry under 10th percentile reservoir elevations, while egg incubation could occur only in June. Near Diamond Creek, temperatures could be warm enough for flannelmouth spawning from about late April through June during their spawning season at the 10th, 50th, and 90th percentiles and egg incubation could occur in May and June. Water temperatures may be adequate to support growth of these three fish species as summarized in Table 4.8-3.

Table 4.8-3
Months When Water Temperatures may be Adequate to Support Growth of Fish Under the No Action Alternative

Location	Species		
	Humpback Chub	Flannelmouth Sucker	Bluehead Sucker
Lees Ferry	June through October at 10th percentile	June through October at 10th percentile	June through mid November at 10th percentile
Below Little Colorado River	June through October at 10th percentile	June through October at 10th percentile	June through October at 10th percentile September and October at 50th percentile
Diamond Creek	May through October at 10th percentile	May through October at 10th percentile	May through October at 10th percentile
	June through October at 50th percentile	June through October at 50th percentile	June through October at 50th percentile
	June through August at 90th percentile	June through August at 90th percentile	May through August at 90th percentile

At lower Lake Powell elevations, which may occur in the future under the No Action Alternative, there is a higher potential for non-native fish to be released from Lake Powell into the Glen Canyon Dam to Lake Mead reach. Warmer temperatures in the future under No Action Alternative conditions at the Diamond Creek confluence could create conditions that would favor the upstream migration of non-native fish into the Grand Canyon. Warmer river temperatures may also promote the migration of non-native warmwater fish from tributaries that provide inflow to this river reach. These conditions would be a temporary occurrence. Since many non-native fish prey on native fish, the potentially increased number of non-native warmwater fish may adversely affect native species in this reach. However, there are many species of non-native fish species already present in this reach (Table 3.8-4).

Glen Canyon Dam releases made when Lake Powell water levels are drawdown to levels coinciding with the 10th Percentile Lake Powell water elevation values (under the No Action Alternative), could potentially result in warmer river flow temperatures. Under the No Action Alternative, these warmer river flow temperatures may exceed 20 °C (68 °F) and may reach 25 °C (77 °F). These warmer river flow temperatures could increase the potential for expansion of the Asian tapeworm (*Bothriocephalus acheilognathi*) and anchorworm (*Lernaea cyprinacea*) in the mainstream Colorado River in some years. Currently, these non-native fish parasites are found primarily in fish in the Little Colorado River and other side tributaries and mostly affect native fish. Under current conditions, these parasites are less likely to infect fish in the Colorado River because water temperatures are less than optimal for these parasites. The increased potential for these parasites to infect fish when Glen Canyon Dam releases occur at low Lake Powell elevations could adversely affect native fish including the humpback chub. Glen Canyon Dam releases made when Lake Powell water levels are at the higher 50th and 90th percentile Lake Powell elevation values result in cooler downstream temperatures and are mostly below 20 °C.

Historically, the release temperatures from Glen Canyon Dam have exhibited a relatively narrow seasonal variability and typically ranged from approximately 7 °C to 12 °C (44.6 ºF to 53.6 ºF) between 1990 and 2002 (Appendix F, Figure F-5). After 2002, the temperatures began to increase and the seasonal variability widened and ranged from approximately 8 °C to 16 °C (46.4 ºF to 60.8 ºF). Modeled future release temperatures for the No Action Alternative at the 50th percentile Lake Powell elevations indicate similar potential conditions to those that began in 2002. Modeled release temperatures at the 10th percentile Lake Powell elevation indicate the possibility of warmer release temperatures and a wider seasonal variability (a range of 11 °C to 22 °C) (Table 4.5-5). These warmer release temperatures under the No Action Alternative could affect the aquatic foodbase below Glen Canyon Dam. However, larval chironomids, larval simuliids, *Cladophora* and *Gammarus* are key components of the aquatic foodbase below Glen Canyon Dam and they are tolerant of a wide range in temperature. No potential effects on the aquatic foodbase due to changes in the water clarity, particularly algae, are expected as a result of the implementation of the proposed federal action.

The favorable temperature ranges are 8 °C to 25 °C (46.4 °F to 77 °F) for larval chironomids (LeSage and Harrison 1980; Laville and Vincon 1991; Sublette et. al. 1998; Stevens et. al. 1998; Danks 1978; Maier et. al. 1990), 10 °C to 26 °C (50 °F to 78.8 °F) for larval simuliids (Becker 1973; Ross and Merritt 1978; Colbo and Porter 1981; Hauer and Benke 1987), 13 °C to 17 °C (55.4 °F to 62.6 °F) for *Cladophora* (Graham et. al. 1982; Wong et. al. 1978), and 7 °C to 29 °C (44.6 °F to 84.2 °F) for *Gammarus* (Smith 1973; Pennak and Rosine 1976; Macneil et. al. 1997). The potential future release temperatures for the No Action Alternative should be similar to or higher than historic release temperatures. The warmer releases that may occur at the 10th percentile Lake Powell elevations may be warmer than the preference of *Cladophora* in some years, but in general, these potential warmer releases may provide some overall benefit to the aquatic foodbase. This potential benefit is anticipated to benefit special status fish that rely on these organisms as their food source. Effects of the No Action Alternative on the aquatic foodbase and special status fish would be similar to historic effects. Substantial temperature-related effects to the aquatic foodbase are not anticipated with the No Action Alternative.

Mammals. Western small-footed myotis, pale Townsend's big eared bat, spotted bat, Allen's big-eared bat, western red bat, Yuma myotis, occult little brown bat, and Fringed myotis all may utilize this reach. Colorado River flows do not directly impact these species as they generally roost in caves and trees well above potential flow-related impacts. They are not obligate riparian species but may utilize such habitats for hunting. Impacts to these bat species from changes in vegetation, insect populations, from flow and water temperature changes are not likely under the No Action Alternative or the action alternatives. Accordingly, these species are not discussed further for this reach.

Amphibians. For the leopard frog population above Lees Ferry, reduced flows would not affect the spring-fed site. Inundation at this site occurs at approximately 21,000 cfs (Figures P-18 through P-21 in Appendix P). Inundation of this site would potentially occur under the No Action Alternative from June through September, as the 90th percentile releases in these months could exceed 21,000 cfs. Leopard frog reproduction has only been observed in warm (ca. 20 °C or 68 °F) pool and marsh areas, away from the direct influence of the river (Drost 2005). Colder pools (10 °C to 15 °C [50 °F to 59 °F]) that receive water from the Colorado River appear to be avoided. Water temperature at the spring site remains above 15 °C throughout the year and above 20 °C for several months (Spence 1996). Most of the warmer pools are located above the 21,000 cfs level; larvae and any remaining eggs still present during spring release peak flows would only infrequently be exposed to Colorado River flows. Lake Powell release temperatures under the No Action Alternative may exceed 15 °C (59 °F) when the reservoir is at the 10th percentile elevation. At the 50th and 90th percentiles, the Lake Powell release temperatures are expected to remain predominantly below 15 °C (59 °F) under the No Action Alternative (Figures P-68, P-69, P-70 in Appendix P). Thus, release temperatures would continue to remain below ideal temperatures for leopard frog under the No Action Alternative for most of the time.

Birds. Special status birds in this reach include bald eagle, California condor, southwestern willow flycatcher, Clark's grebe, osprey, belted kingfisher, snowy egret, and American Peregrine falcon. For the same reasons that California condor, osprey, belted kingfisher, and American peregrine falcon would be unaffected in Lake Powell, the proposed federal action would not impact these species between Glen Canyon Dam and Lake Mead. Between Glen Canyon Dam and Lake Mead, steep shorelines limit the establishment of significant marshes. It is unlikely that Clark's grebe or snowy egret would be impacted in this reach. Accordingly, only the bald eagle and southwestern willow flycatcher are discussed further in this reach.

Bald eagles in this area are primarily winter residents and they feed largely on fish, waterfowl and carrion. Bald eagles feed on trout in the Lees Ferry area, and often congregate at Nankoweap Creek. Less than ideal river temperatures for trout may occur in the future in some years; however, despite such potential adverse effects on trout in some years, it is anticipated that trout will remain a food source for eagles under the No Action Alternative. Potential increases in river flow temperatures under the No Action Alternative or action alternatives may result in an increase in the warmwater fish population which could serve as a supplemental food source for eagles. Future conditions under the No Action Alternative are not anticipated to affect roost or nest sites.

Southwestern willow flycatchers nest in riparian shrub habitats of tamarisk and willow downstream of Glen Canyon Dam. Reduced flows in the future would tend to continue favoring the establishment of riparian shrub vegetation in this reach. These conditions benefit southwestern willow flycatchers since they inhabit willow and tamarisk plant communities and have generally benefited from post-Glen Canyon Dam conditions. This trend would continue into the future.

Action Alternatives. Releases will only deviate from No Action Alternative conditions during the interim period for this reach. Though conditions causing potential impacts would cease after the interim period, effects on vegetation communities from interim period conditions may be observed beyond the interim period.

Plants. At the 90th percentile June Glen Canyon Dam releases, the Reservoir Storage Alternative may have spill avoidance releases that would exceed the No Action Alternative. June releases are the highest for the year at the 90th percentile and were used to gage potential impacts to Grand Canyon primrose habitat (Figure P-18 in Appendix P). These higher releases have a greater potential to adversely impact beach habitat and thus Grand Canyon evening primrose. These high flows may approach 34,000 cfs, which is still less than recent experimental releases that have exceeded 40,000 cfs, so the impacts should be negligible. The Conservation Before Shortage, Water Supply and Basin States alternatives sometimes exceed the No Action Alternative at the 90th percentile, but they are typically in months that are not the annual high release and they still remain relatively close to the No Action Alternative. Therefore, the action alternatives are not expected to result in impacts on Grand Canyon evening primrose. The Reservoir Storage Alternative could potentially have a minor negative impact on Grand Canyon primrose due to occasional spill avoidance releases.

Invertebrates. Kanab ambersnail habitat is impacted when flows exceed 17,000 cfs. During the interim period, the Conservation Before Shortage and Basin States alternatives may exceed the flows observed under the No Action Alternative and 17,000 cfs in April and May at the 90th percentile (Figures P-16, P-17). The other two action alternatives have only a few isolated years above the No Action Alternative and 17,000 cfs in these months. July releases at the 90th percentile under the Conservation Before Shortage and Basin States Alternatives would be above 17,000 cfs, but lower than the No Action Alternative, therefore possibly inundating less Kanab ambersnail habitat in this month. The Conservation Before Shortage and Basin States alternatives could also be above the No Action Alternative and 17,000 cfs at the 50th percentile in August, thus inundating more Kanab ambersnail habitat. The Water Supply Alternative could also have 50th percentile flows that are higher than the No Action Alternative and above 17,000 cfs in August, though this is the only month where this may occur for the Water Supply Alternative, and most of the time flows would be similar to the No Action Alternative when above 17,000 cfs. In June, the Reservoir Storage Alternative's occasional spill avoidance releases up to 6,000 cfs above the No Action Alternative (to 29,500 cfs) would flood additional Kanab ambersnail habitat (Figure P-18 in Appendix P). The Kanab ambersnail population at Vasey's Paradise survived and recovered from innumerable similar and higher flows during the pre-dam era, and has survived six flows in excess of 45,000 cfs during the post-dam era (1965, 1980, 1983, and 1986). The Reservoir Storage Alternative could also exhibit flows above 17,000 cfs and exceeding the flows observed under the No Action Alternative in December.

At the 10th percentile, all the action alternatives may have lower releases from Glen Canyon Dam in some months. Though it is not possible to accurately project under which months those release levels would occur or how many months in a row this would occur, these lower releases would allow spring vegetation at Vasey's Paradise to develop lower down on the canyon. Ambersnail's could move into this lower habitat if releases are lower for long enough for such habitat to develop. When releases rise again, this habitat would be inundated and could impact ambersnails. However, this type of impact also occurs under the No Action Alternative. Accordingly, these potential impacts are expected to be minor and the action alternatives should not impact the population that occurs above the zone of fluctuating releases. Reclamation has consulted with the FWS (FWS 1994) on the effects to the Vasey's Paradise population from the operations of Glen Canyon Dam.

The Reservoir Storage Alternative may exceed the No Action Alternative release and 20,000 cfs in June and December at the 90th percentile and would thus have a greater potential for a negative impact on Niobrarra ambersnail habitat. When Glen Canyon Dam releases are above 20,000 cfs at the 90th percentile release level, the frequency and magnitude of releases under the Conservation Before Shortage, the Basin States and Water Supply alternatives are equal or less than those under the No Action Alternative, which has a greater potential for a positive impact on Niobrarra ambersnail habitat.

The Conservation Before Shortage, Basin States and Water Supply alternatives are not expected to affect the alluvial floodplain in the lower Grand Canyon area and would thus not impact MacNeill's sooty-winged skipper habitat. Occasional spill avoidance releases in June under the Reservoir Storage Alternative have the greatest potential to impact floodplains and quailbrush, and therefore would have the greatest potential impact on MacNeill's sooty-winged skipper habitat.

Fish. Water temperatures in the Colorado River below Glen Canyon Dam under the Conservation Before Shortage and Basin States alternatives should be similar to those for the No Action Alternative, although the water may be warmer a few weeks earlier under 10th percentile below the Little Colorado River and near Diamond Creek. This would allow the humpback chub and bluehead sucker to spawn and egg incubation to occur a little earlier, which would provide conditions that could benefit these species.

Flannelmouth potentially could spawn under 50th percentile levels below the Little Colorado River, but egg incubation would not occur. Temperatures suitable for growth may occur for about one month longer below the Little Colorado River at 10th percentile elevations and at Diamond Creek under 50th percentile elevations for all three species. Some growth could potentially occur under 50th percentile elevations for all three species below the Little Colorado River as well.

Under the Reservoir Storage Alternative, water temperatures in the river would usually be as cold as or sometimes colder than under the No Action Alternative. For the 10th percentile elevation, lower water temperatures could occur in January and February as well as in June through July (near Diamond Creek) or August (at Lees Ferry and below the Little Colorado River). For the 50th percentile elevation, lower water temperatures could occur from September through February at Lees Ferry, from August through March below the Little Colorado River confluence, and from August through February near Diamond Creek. These lower temperatures would not improve spawning or incubation temperatures for any of the native fish. Lower temperatures would have the potential to reduce growth rates for native fish in the Colorado River but would not affect those individuals residing in tributaries.

Under the Water Supply Alternative, water released to the Colorado River could be warmer at times. From about May through September, water temperatures at and below the Little Colorado River confluence may be 2 ºC to 5 ºC (35.6 ºF to 41 ºF) warmer than under the No Action Alternative and could be warm enough for humpback chub, flannelmouth, and bluehead sucker spawning to occur in the Colorado River. For the humpback chub, water temperatures near Diamond Creek could be warm enough for spawning and egg incubation May through July under 10th percentile elevations and in June and July under 50th and 90th percentile elevations. Just below the Little Colorado River confluence, temperatures have the potential to be warm enough for humpback chub spawning and egg incubation in May through July under 10th percentile elevations. These 10th percentile temperatures would increase the spawning and incubation time by about one month near the Little Colorado River and provide a greater likelihood of warmer temperatures than under the No Action Alternative.

For bluehead sucker, 10th percentile water temperatures could be warm enough for spawning below the Little Colorado River from about June through October and near Diamond Creek from May through October under the Water Supply Alternative. Water temperatures suitable for flannelmouth sucker spawning may occur near Diamond Creek in May and June and under 10th percentile levels in May and June below the Little Colorado River. The timing of these temperatures is similar to that for the No Action Alternative, but the likelihood of their occurrence is greater than under the No Action Alternative. How much of a benefit this could be to these species would depend on the frequency of these warmer temperatures, which is not known.

For the Water Supply Alternative, water temperatures may support growth of all three species for one to two months longer from Glen Canyon Dam to Lake Mead than under the No Action Alternative. Near the Little Colorado River, some growth could occur under 50th percentile elevations in the late summer to fall (August to October) for all three species.

The warmer water temperatures under the Water Supply Alternative would also benefit existing populations of non-native, non-game warmwater species such as carp, fathead minnows, catfish, and red shiner. This could increase competition for resources or predation on the native species that would have a negative impact on the native species, thereby at least partially offsetting the benefits of the warmer temperatures on the native species.

The passage of non-native fish through Glen Canyon Dam may occur as the lake levels drop, and the greatest potential for this to occur is under the Water Supply Alternative, which tends to have lower lake levels than all the other alternatives. The Reservoir Storage Alternative has the least potential for non-native fish passage because the lake levels tend to be higher than those under the other alternatives. The Conservation Before Shortage and Basin States alternatives tend to have Lake Powell elevations that are close but somewhat lower than the No Action Alternative, which would result in a small increase in the potential to pass non-native fish through Glen Canyon Dam. These trends occur during the interim period and for varied lengths of time into the modeling period. The Water Supply Alternative could take the longest to return to No Action Alternative conditions after the interim period. As indicated in the No Action Alternative discussion, the increased potential to pass non-native fish could adversely affect native fish below Glen Canyon Dam.

The Water Supply Alternative may result in higher Glen Canyon Dam release temperatures than the No Action Alternative. This has the potential to create conditions favorable for upstream migration of warmwater non-native fish into the Grand Canyon and the migration of non-native warmwater fish into the Colorado River from warmer side tributaries. The Reservoir Storage Alternative may have the lowest water temperatures at the Diamond Creek confluence, but similar to the No Action Alternative. The Conservation Before Shortage and Basin States alternatives would have effects similar to the No Action Alternative on conditions favoring upstream migration of non-native warmwater fish into the Grand Canyon and the migration of non-native warmwater fish into the Colorado River from warmer side tributaries. However, there are numerous non-native warmwater fish species that already inhabit the Grand Canyon.

Temperatures potentially favoring expansion of the Asian tapeworm and anchorworm into the Colorado River may occur when Lake Powell water levels are drawdown and warmer water is released from Glen Canyon Dam. As noted before, these warmer water temperatures generally coincide with Lake Powell water levels coinciding with the 10th Percentile lake elevation values observed under the No Action Alternative and the action alternatives, a condition that has a low probability of occurrence. Glen Canyon Dam releases made when the Lake Powell water levels are higher, at levels coinciding with the 50th and 90th Percentile elevation values, typically result in cooler downstream river flow temperatures. Under these latter conditions, the river flow temperatures typically remain below 20 °C the majority of the time and these cooler temperatures are less conducive for migration of the non-native parasites into the mainstream of the Colorado River. The Water Supply Alternative has a greater probability of providing favorable conditions for the migration of the Asian tapeworm and anchorworm into the mainstream of the Colorado River because this alternative provides the lowest Lake Powell water levels and potentially, warmer Glen Canyon Dam release temperatures. The Reservoir Storage Alternative provides higher Lake Powell water levels and generally cooler Glen Canyon Dam release temperatures. As such, the Reservoir Storage Alternative has a lower potential to increase Asian tapeworm and anchorworm expansion into the mainstream Colorado River, compared to the No Action Alternative. The Conservation Before Shortage and Basin States alternatives will have a similar effect as that as of the No Action Alternative.

The Conservation Before Shortage and Basin States alternatives should have very similar release temperatures as the No Action Alternative. Temperatures at Lees Ferry, Little Colorado River, and Diamond Creek would also be similar to the No Action Alternative (Appendix P). Therefore, these two alternatives should not have temperature-related impacts on the aquatic foodbase or the food sources for special status fish. The Water Supply Alternative may have warmer releases than No Action at the 10^{th} percentile Lake Powell elevations, which may potentially result in warmer temperatures downstream. The Reservoir Storage Alternative may have colder releases than No Action Alternative at the 10^{th} percentile Lake Powell elevations, which results in colder temperatures downstream. The warmer releases under the Water Supply Alternative may trend further from the preferences of *Cladophora*, which could affect the other invertebrates which feed on it. However, *Cladophora* should remain present despite the potential release temperatures above its preferred thermal range, and invertebrates may benefit from warmer temperatures overall. The predominance of *Cladophora* below Glen Canyon Dam appears to be linked to water clarity. The action alternatives are not expected to have any substantial effects on river clarity trends in the river reach between Glen Canyon Dam and Lake Mead. The Reservoir Storage Alternative tends to create conditions for the aquatic foodbase closer to historic conditions, though still potentially warmer at the 10^{th} percentile lake level releases. Future river flow temperatures are expected to remain within the preferred temperature range for larval chironomids, simuliids, and *Gammarus* in most years. None of the action alternatives are expected to result in substantial temperature-related impacts to the aquatic foodbase below Glen Canyon Dam, despite the potential differences indicated above.

Amphibians. Because leopard frogs preferentially select warmer water for breeding, occasional introduction of warmer water would presumably benefit the frogs. Lake Powell releases and temperatures at Lees Ferry at the 50^{th} percentile reservoir elevations may be almost always colder than 15 °C for all of the alternatives, so there would be no temperature impact to leopard frogs at the 50^{th} percentile Lake Powell elevation releases. The Water Supply Alternative may result in temperatures above 15 °C starting in May at the 10^{th} percentile Lake Powell elevations, which would provide a thermal benefit from less thermal shock to eggs and larvae. Modeling indicates this may occur at Glen Canyon Dam and at Lees Ferry. Lake Powell 10^{th}

percentile release temperatures for the Conservation Before Shortage, Basin States and Reservoir Storage alternatives do not exhibit significant increases in temperature and would result in similar conditions as the No Action Alternative. Following Atkinson (1996), it is possible that the warmer water would increase the rate of metamorphosis but result in a smaller size class of metamorphs.

Action alternative flows may inundate the Lees Ferry leopard frog habitat from June through September at 90th percentile releases from Glen Canyon Dam. During the interim period, these high releases may differ from the No Action Alternative. There are no differences from the No Action Alternative beyond the interim period at these higher end releases. When above 21,000 cfs, occasional June spill avoidance releases under the Reservoir Storage Alternative may exceed the releases that occur under the No Action Alternative by up to 6,000 cfs. Though these higher flows would presumably have a greater impact on the Lees Ferry leopard frog habitat, they occur in years where the No Action Alternative may also exceed 21,000 cfs, so the inundation impacts would be similar, though the habitat may be under deeper water than the No Action Alternative. The Conservation Before Shortage, Basin States and Water Supply alternatives may have lower 90th percentile flows in July and September, but still above 21,000 cfs, so the inundation impacts would be similar to that under the No Action Alternative, though the habitat may be under shallower water.

Birds. Bald eagles may be indirectly impacted by alterations to the trout fishery. At the 10th percentile, the greatest potential temperature impact to the trout fishery would occur under the Water Supply Alternative. However, these potential temperature effects are mitigated by trout's ability to move to thermal refugia at different water levels in the Colorado River and because warmer temperatures will occur in some years. Accordingly, despite these potential occasional changes in temperature, population-level impacts to the Lees Ferry trout fishery are not anticipated as a result of the proposed federal action. As noted before, warmer river flow temperatures may affect trout in some years and may benefit warmwater fish which could provide an alternative food source for eagles. The levels of potential flow impacts to vegetation communities anticipated under some alternatives are not likely to cause significant impact to bald eagles. Given bald eagle's mobility, varied diet, lack of impacts to roost or nest sites, none of the action alternatives would substantially impact bald eagles that inhabit areas downstream of Glen Canyon Dam.

Though higher flows, particularly with the Reservoir Storage Alternative in June, may flood riparian habitats, these would not be expected to impact southwestern willow flycatcher populations. Nests are typically above the 45,000 cfs stage. Reclamation concluded that long-term effects of the 42,000 to 45,000 cfs test flow in 2002 on Southwestern willow flycatcher habitat are expected to be beneficial (Reclamation 2002). Tamarisk are expected to withstand potential increased flows that may occur under Reservoir Storage peaks in June. The Conservation Before Shortage, Basin States and Water Supply alternatives are higher than the No Action Alternative by up to a few thousand cfs in some months, though these higher flows would not inundate southwestern willow flycatcher nests. When the action alternatives (all at least in some months) are lower than the No Action Alternative (typically at 10th percentile), these levels would not be expected to kill tamarisk, which is what southwestern willow flycatcher typically nest in below Glen Canyon Dam.

The Conservation Before Shortage, Basin States and Water Supply alternatives would have lower 10th percentile releases from April through September and the Reservoir Storage Alternative would have lower 10th percentile releases from June through September. These lower releases may reduce moist soil conditions below nesting sites, which is a preference of southwestern willow flycatcher. Lack of moist soil below nest sites may degrade the habitat for this species, at least temporarily. A lack of moist soil conditions is more likely for all of the action alternatives than for the No Action Alternative at the 10th percentile releases. At the 50th percentile release, the action alternatives would be at or above the No Action Alternative during the southwest willow flycatcher nesting season. So potential impacts to southwest willow flycatcher are only expected at lower releases.

Table 4.8-4 displays impacts to special status species in the Glen Canyon Dam to Lake Mead reach for all alternatives.

Table 4.8-4
Glen Canyon Dam to Lake Mead Special Status Species Impact Summary
Comparison of Action Alternatives to No Action Alternative

Species	Alternative	Impact	Rationale
Mammals	All Action Alternatives	No impact	Flow differences not expected to rise to the level of indirectly impacting special status mammals.
Grand canyon evening primrose	Conservation Before Shortage, Basin States, Water Supply	No impact	Similar 90th percentile releases to the No Action Alternative.
	Reservoir Storage	Minor-negative	Higher 90th percentile releases than the No Action Alternative may affect beach habitat more than the No Action Alternative. Interim period only. High flows still less than experimental releases.
Kanab ambersnail	All Action Alternatives	Minor-negative	90th percentile releases exceed the No Action Alternative and 17,000 cfs. Interim period only. High flows still less than past high flows from which Kanab ambersnail has recovered from.
Niobrarra ambersnail	Reservoir Storage	Minor-negative	90th percentile releases exceed the No Action Alternative and 20,000 cfs. Interim period only. High flows still less than past high flows.
	Conservation Before Shortage, Basin States and Water Supply	Minor-positive	When above 20,000 cfs at the 90th percentile release, the alternatives are equal or less than the No Action Alternative.

Table 4.8-4
Glen Canyon Dam to Lake Mead Special Status Species Impact Summary
Comparison of Action Alternatives to No Action Alternative

Species	Alternative	Impact	Rationale
MacNeill's sooty-winged skipper	Conservation Before Shortage, Basin States and Water Supply	No impact	High releases do not differ substantially from the No Action Alternative. Interim period only.
	Reservoir Storage	Minor - negative	90^{th} percentile releases in June have greatest potential to impact quailbrush along Colorado River. Interim period only.
Humpback chub, bluehead sucker, flannelmouth sucker	Conservation Before Shortage and Basin States	No impact	Release temperatures similar to those for the No Action Alternative but warming a little earlier in the year.
	Reservoir Storage	Minor-negative	Release temperatures may be as cold or colder that under the No Action Alternative most of the time which would adversely affect spawning, swimming ability, and reduce growth of humpback chub, bluehead sucker, and flannelmouth sucker.
	Water Supply	Minor-positive	Release temperature may be warmer than for the No Action Alternative sometimes, a benefit for native fish spawning, incubation, swimming ability, and growth. Temperature benefits to native species tempered because non-native warmwater fish competitors, Asian tapeworm, and anchorworm fish parasites may also benefit.
Northern leopard frog	Conservation Before Shortage, Basin States and Reservoir Storage	No Impact	Release temperatures trend close to the No Action Alternative. High flows inundate Lees Ferry frog habitat, but the No Action Alternative also inundates habitat.
	Water Supply	Minor-positive	Release temperatures higher than 15°C at 10^{th} percentile releases may provide thermal benefit to frog reproduction. High flows inundate Lees Ferry frog habitat, but the No Action Alternative also inundates habitat.
Bald eagle	All Action Alternatives	No impact	Substantial indirect impacts through impacts to food sources not anticipated. Wide ranging species with the varied diet. Impacts to roost or nest sites are not anticipated.
Southwestern willow flycatcher	All Action Alternatives	Minor-negative	Lower 10^{th} percentile flows may impact willow but not tamarisk. Lower 10^{th} percentile flows may reduce moist soil conditions below nest sites and degrade habitat value. Occurs under all action alternatives at 10^{th} percentile release.

4.8.4.3 Lake Mead

No Action Alternative.

Birds. Lake Mead water levels may exhibit a downward trend into the future under the No Action Alternative. This trend would have effects on the riparian and marsh habitats at the inflow areas and on the special status bird species that utilize such habitats for breeding, roosting or foraging. The downward trend would increase the potential for dewatering and headcutting of the sediment deltas, which would adversely affect riparian and marsh vegetation that has developed on the deltas. This has the greatest potential to adversely affect special status birds that utilize cottonwood-willow and marsh habitats such as the bald eagle, southwestern willow flycatcher, yellow-billed cuckoo, long-eared owl, American kestrel, osprey, Cooper's hawk, American peregrine falcon, northern harrier, Clark's grebe, snowy egret, Yuma clapper rail, California black rail, American bittern, western least bittern, great egret, white-faced ibis, belted kingfisher and American white pelican.

Mammals. Townsend's big-eared bat, pale Townsend's big-eared bat, occult little brown bat, spotted bat, Allen's big-eared bat, western red bat, Yuma myotis, western yellow bat, cave myotis, greater western mastiff bat, and small-footed myotis may utilize the riparian and marsh habitats at Lake Mead for foraging and roosting. These bat species utilize a variety of habitats for roosting, including dead trees, so potential vegetation effects should not substantially impact roosting opportunities for these bats. Substantial effects to insect food sources for special status bats is not expected because the Lake Mead water levels will continue to experience annual fluctuations and the downward trend will be gradual over time. The No Action Alternative conditions at Lake Mead would not impact the Yuma hispid cotton rat or Colorado River cotton rat as these species are found further south along the lower Colorado River.

Amphibians. Relict leopard frog populations at Lake Mead would not be affected under the No Action Alternative because the known populations are at springs above the influence of Lake Mead's fluctuation. Colorado River toads are not known at Lake Mead. The No Action Alternative conditions are not expected to affect special status amphibians at Lake Mead.

Plants. Sticky buckwheat, Geyer's milkvetch and Las Vegas bear poppy all occur at the shorelines of Lake Mead. These species typically benefit from lower reservoir levels that expose additional shoreline habitat. Lake Mead would continue to experience lake level fluctuation under the No Action Alternative, which would result in varied levels of exposed shoreline through the year. The general downward lake level trend of Lake Mead that may occur under the No Action Alternative would generally result in increased shoreline exposure which would benefit these species while this trend continues.

Invertebrates. MacNeill's sooty-winged skipper is not known at Lake Mead and would thus not be affected by future conditions under the No Action Alternative.

Fish. Under the No Action Alternative, special status fish would experience Lake Mead elevations less than 1,120 feet msl all year for the 50^{th} and 10^{th} percentile conditions. The 90^{th} percentile elevations are generally projected to be near or above 1,200 feet msl all year. Modeled Lake Mead elevations for end of March, July and September are provided in Figures P-10 through P-12 in Appendix P. Razorback sucker spawning is known to occur between elevations 1,120 feet msl and 1,150 feet msl, and as elevations have dropped within this range and exposed areas used for spawning in earlier years, the fish have moved their spawning to nearby suitable areas

(Albrecht and Holden 2006). Based on the modeled reservoir elevations under the No Action Alternative, the preferred spawning sites would be out of the water over 50 percent of the time. Razorback sucker would have to move to suitable spawning habitat at lower reservoir elevations, where such habitat is available.

Action Alternatives. Lake Mead elevations will deviate from the No Action Alternative conditions during the interim period and the modeling period.

Birds. No impacts to riparian or marsh habitats were anticipated at Lake Mead for the Conservation Before Shortage or Basin States alternatives because the Lake Mead elevations under these action alternatives trend close to the No Action Alternative. Therefore, the action alternatives would not impact special status bird species at Lake Mead.

The Water Supply Alternative would result in a minor negative impact to cottonwood-willow, tamarisk and marsh vegetation at Lake Mead inflow areas and sediment deltas. These negative impacts would be caused by lower reservoir elevations, increased dewatering of the sediment deltas and delta erosion. However, depending on duration of the lower elevations, the impact may be offset by new vegetation growing on the newly exposed sediments. These vegetation impacts would cause minor negative impact to those special status bird species that forage, breed or roost in cottonwood-willow, tamarisk and marsh habitats. Impacted species include: southwestern willow flycatcher, Clark's grebe, snowy egret, Yuma clapper rail, yellow-billed cuckoo, California black rail, American bittern, western least bittern, great egret, white faced ibis, long-eared owl, American kestrel, osprey, northern harrier, Cooper's hawk, bald eagle, belted kingfisher, American peregrine falcon, and American white pelican.

The Reservoir Storage Alternative would result in a minor positive impact to vegetation at Lake Mead, primarily at the inflow areas and sediment deltas. These positive impacts would be caused by higher reservoir elevations than under the No Action Alternative, and thus less potential dewatering or sediment delta headcutting than under the No Action Alternative. Positive impacts are anticipated for the southwestern willow flycatcher, Clark's grebe, snowy egret, Yuma clapper rail, yellow-billed cuckoo, California black rail, American bittern, western least bittern, great egret, white faced ibis, long-eared owl, American kestrel, osprey, northern harrier, Cooper's hawk, bald eagle, belted kingfisher, American peregrine falcon, and American white pelican.

Mammals. Impacts to special status mammals at Lake Mead are not expected to occur for the same reasons provided under the No Action Alternative discussion.

Amphibians. Impacts to special status amphibians at Lake Mead are not expected for the reasons described under the No Action Alternative.

Plants. Sticky buckwheat, Geyer's milkvetch and Las Vegas bear poppy all occur at the shorelines of Lake Mead. These species typically benefit from lower reservoir elevations that expose additional shoreline habitat. The Conservation Before Shortage and Basin States alternatives would not impact these species since reservoir elevations trend close to the elevations under the No Action Alternative. The Water Supply Alternative would provide a minor beneficial impact to these species through lowered elevations. The Reservoir Storage Alternative would cause a minor negative impact to these species through raised elevations and inundation of shoreline habitats.

Invertebrates. MacNeill's sooty winged skipper is not known at Lake Mead, and would thus not be impacted by any action alternative.

Fish. Under the Basin States and Conservation Before Shortage alternatives, reservoir elevations may vary from 16 feet above to 12 feet below 50th percentile levels under the No Action Alternative (Figures P-10, P-11, P-12 in Appendix P). The maximum elevation may be 1,128 feet msl with most elevations below 1,100 feet msl. These two alternatives could have minor positive impacts in years when the reservoir elevation is above 1,120 feet msl and no impacts to minor negative impacts when elevations are below that of the No Action Alternative. The Water Supply Alternative would have 50th percentile reservoir elevations near or below those under the No Action Alternative, and a minor negative impact compared to the No Action Alternative. The Reservoir Storage Alternative, however, would have 50th percentile elevations above those under the No Action Alternative with many occurrences of elevations above 1,125 feet msl and the maximum at elevation 1,139 feet msl. Thus, the Reservoir Storage Alternative would maintain reservoir elevations within the range currently used by razorback suckers for spawning more than 50 percent of the time, a moderate positive impact. At the 10th percentile reservoir elevations, all action alternatives would have elevations near or above those under the No Action Alternative but none would be near the current elevations used for razorback spawning. Impacts could range from no effect to a minor positive impact but overall would likely be no impact.

Lowered reservoir elevations are known to allow vegetation to grow on the exposed lake bed, and these areas are then inundated at higher reservoir elevations. These submerged vegetated areas can provide cover for juvenile razorback suckers and enhance their survival. Thus, periodic lower reservoir elevations may have some benefits (minor positive impact) to razorback sucker spawning success and recruitment after the reservoir elevations rise and inundate the vegetation growing on the edge.

Lowered reservoir elevations under the No Action Alternative and all of the action alternatives would extend the riverine habitat where the Colorado River and the Virgin River enter the reservoir. This would increase habitat for the humpback chub, razorback sucker, flannelmouth sucker, and bluehead sucker that could move downstream and for the woundfin and the Virgin River chub in the Virgin River. Under 50th percentile elevations, the Water Supply Alternative would provide the greatest benefit to those species while the Reservoir Storage Alternative would provide the least benefit. Both alternatives would provide minor positive impacts for these species. The other two action alternatives would provide little benefit (essentially no impact) relative to the No Action Alternative. At the 90th percentile elevations, none of the action alternatives differ substantially from the No Action Alternative, i.e., no impact, while under 10th percentile elevations, all but the Reservoir Storage Alternative are similar to the No Action Alternative resulting in no impact. The Reservoir Storage Alternative would provide the least riverine habitat increase, a minor negative impact. The Virgin River chub and bonytail are not known to be present in Lake Mead.

Table 4.8-5 describes potential special status species impacts of the action alternatives at Lake Mead.

Table 4.8-5
Lake Mead Special Status Species Impact Summary
Comparison of Action Alternatives to No Action Alternative

Species	Alternative	Impact	Rationale
Birds	Conservation Before Shortage, Basin States	No impact	Reservoir elevations trend close to the No Action Alternative.
	Reservoir Storage	Minor-positive	Reservoir elevations trend higher than the No Action Alternative.
	Water Supply	Minor-negative	Reservoir elevations trend lower than the No Action Alternative.
Mammals	All Action Alternatives	No Impact	Substantial impacts to insect food sources for bats not anticipated.
Relict leopard frog	All Action Alternatives	No impact	Overton arm population is located at a spring above Lake Mead's influence.
MacNeill's sooty-winged skipper	All Action Alternatives	No impact	Species not known at Lake Mead.
Sticky buckwheat, Geyer's milkvetch and Las Vegas bearpoppy	Conservation Before Shortage and Basin States	No impact	Reservoir elevations trend close to the No Action Alternative.
	Reservoir Storage	Minor-negative	Reservoir elevations trend higher than the No Action Alternative, inundating shoreline habitat. Habitats below full pool elevation considered temporary due to reservoir fluctuation.
	Water Supply	Minor-positive	Reservoir elevations trend lower than the No Action Alternative, exposing additional shoreline habitat. Habitats below full-pool elevation considered temporary due to reservoir elevation fluctuation.

Table 4.8-5
Lake Mead Special Status Species Impact Summary
Comparison of Action Alternatives to No Action Alternative

Species	Alternative	Impact	Rationale
Fish	Conservation Before Shortage and Basin States	No impact	Elevations above 1,120 feet msl could have a slight benefit to razorback sucker spawning while lower elevations could be less valuable; at 10th percentile elevations, these alternatives would be similar to the No Action Alternative. Essentially no increased amount of riverine habitat at 10th, 50th, or 90th percentile elevations.
	Water Supply	Minor negative Minor positive	Reservoir elevations would be near to or less than that under the No Action Alternative under 50th percentile elevations. Lower reservoir elevation would provide more riverine habitat for fish from Separation Canyon and the Virgin River under 50th percentile elevations.
	Reservoir Storage	Moderate positive Minor positive Minor negative	Reservoir elevations would be above 1,120 feet msl over 50 percent of the time; at 10th percentile elevations, no impact. Lower reservoir elevation would provide more riverine habitat for fish from Separation Canyon and the Virgin River under 50th percentile elevations. The 10th percentile elevations would provide less riverine habitat than under the No Action Alternative.

4.8.4.4 Hoover Dam to Davis Dam and Lake Havasu to Parker Dam

Due to lack of differences among alternatives in these reaches, and the lack of change in vegetation or habitat, there will be no impacts to special status species at these locations.

4.8.4.5 Davis Dam to Lake Havasu

No Action Alternative. Monthly releases from Davis Dam exhibit a downward trend in the future at the 90th percentile (Figures P-37 through P-48 in Appendix P). While special status species along the Colorado River are constantly making minor adjustments as flows fluctuate, downward trending releases could result in special status species habitat impacts.

Birds. Downward trending Davis Dam releases in the future under the No Action Alternative may have gradual adverse effects on cottonwood-willow and marsh habitats, which are utilized by many special status bird species. These species include: bald eagle, osprey, belted kingfisher, peregrine falcon, southwestern willow flycatcher, vermillion flycatcher, Clark's grebe, snowy egret, Yuma clapper rail, western yellow-billed cuckoo, California black rail, elf owl, gilded flicker, Gila woodpecker, Arizona Bell's vireo, Sonoran yellow warbler, summer tanager, American white pelican, double crested cormorant, American least bittern, Western bittern, great egret, black-crowned night heron, white faced ibis, black tern, long-eared owl, brown crested flycatcher, Lucy's warbler, yellow-breasted chat, northern cardinal, northern harrier, Cooper's hawk and American kestrel. Since lower flows are more likely to affect cottonwood willow than tamarisk, the No Action Alternative conditions are expected to favor continued tamarisk expansion along the lower Colorado River.

Mammals. Townsend's big-eared bat, Pale Townsend's big-eared bat, spotted bat, Allen's big-eared bat, Western red bat, occult little brown bat, Yuma myotis, Western Yellow bat, cave myotis, greater western mastiff bat and small-footed myotis utilize riparian and marsh habitats in this reach for foraging and roosting. Downward trending Davis Dam releases under No Action Alternative conditions are expected to be gradual, though they may affect the composition of riparian habitats. Such gradual changes are not expected to substantially affect insect food sources for special status bats. Since these bats typically utilize a variety of roost sites, including live and dead trees, substantial impacts to these species roost sites are not anticipated under the No Action Alternative.

The Yuma hispid cotton rat and Colorado River cotton rat are only known from Yuma south. The No Action Alternative will not affect these species in this reach.

Amphibians. Relict leopard frogs are known below Hoover Dam at several springs to the north of this reach and are above the influence of the Colorado River. The Lowland Leopard frog is known along the Bill Williams River, but not in this reach. Though potential Colorado River toad occurs in this reach, the species is not known here. The No Action Alternative will have no effects on special status amphibians in this reach.

Invertebrates. MacNeill's sooty-winged skipper is known at scattered sites along the lower Colorado River and is associated with quailbrush (*Atriplex*) and mesquite communities. The Atriplex land cover type is present in this reach (Table 3.8-2). However, quailbrush typically grows on alluvial floodplains and flow-related impacts from the No Action Alternative are not anticipated to affect alluvial floodplains. Downward trending releases may result in groundwater table impacts in the future. However, because the declines will likely be gradual and that mesquite and quailbrush are not obligate phreatophytes, groundwater-related effects under No Action Alternative conditions are not anticipated. The No Action Alternative should not affect MacNeill's sooty-winged skipper in this reach.

Fish. In the Colorado River between Davis Dam and Lake Havasu, some backwaters are present that could be used by razorback suckers, bonytail, and flannelmouth suckers, the only special status fish species present. Reduced flows in the future in this reach may result in more frequent dewatering of backwaters, resulting in a reduction of habitat for these special status fish species. Backwaters may become vegetated with marsh plants under reduced flow conditions. Non-native fish would continue to be present in this reach and compete with native fish.

Action Alternatives. The Conservation Before Shortage and Basin States alternatives would not impact any special status species in this reach because Davis Dam monthly releases trend close to the No Action Alternative. These two action alternatives are not discussed further for this reach. Flow deviations from the No Action Alternative under the Water Supply Alternative and Reservoir Storage alternatives generally return to No Action conditions at the end of the interim period, though the vegetation and associated special status species effects of interim period conditions may be observed beyond the interim period.

Birds. The Reservoir Storage and Water Supply alternatives may result in lower and higher monthly releases respectively. Respective impacts to special status birds would be similar to impacts discussed at Lake Mead. However, a higher number of species may be impacted since this reach includes California special status birds not considered at Lake Mead. The Reservoir Storage Alternative would have a minor negative impact on the following special status birds through flow-related negative impacts to their habitats: bald eagle, osprey, belted kingfisher, peregrine falcon, southwestern willow flycatcher, vermillion flycatcher, Clark's grebe, snowy egret, Yuma clapper rail, western yellow-billed cuckoo, California black rail, elf owl, gilded flicker, Gila woodpecker, Arizona Bell's vireo, Sonoran yellow warbler, summer tanager, American white pelican, double crested cormorant, American least bittern, Western bittern, great egret, black-crowned night heron, white faced ibis, black tern, long-eared owl, brown crested flycatcher, Lucy's yellow warbler, yellow-breasted chat, northern cardinal, northern harrier, Cooper's hawk and American kestrel. The Water Supply Alternative is expected to have a minor positive impact on these same species. The groundwater changes anticipated for this reach may be on the order of 0.5 feet or less (Section 4.3), which contributes to these impacts being minor.

Mammals. Though there may be higher and lower Davis Dam releases under the Water Supply and Reservoir Storage alternatives, respectively, these differences are not expected to substantially impact foraging or roosting conditions for special status bats. Impacts from the action alternatives on special status mammals are expected to be similar to the conditions expected under the No Action Alternative.

Yuma hispid cotton rat and Colorado River cotton rat are only known along the Colorado River from Yuma south. Therefore, this proposed federal action would not impact these species in this reach.

Amphibians. There will be no impacts from the Water Supply and Reservoir Storage alternatives to the Colorado River Toad, relict leopard frog or lowland leopard frog in this reach for the same reasons as described for the No Action Alternative.

Invertebrates. There will be no impacts from the Water Supply and Reservoir Storage alternatives to MacNeill's sooty-winged skipper in this reach for the same reasons as described for the No Action Alternative.

Fish. The Reservoir Storage alternative may result in slightly less flow while the Water Supply alternative may result in slightly more flow than under the No Action Alternative in most months of the year under 50^{th} and 10^{th} percentile elevations. Reductions in Colorado River flow below Davis Dam could affect the flannelmouth sucker through loss of spawning habitat in the riverine sections and rearing habitat in backwaters. This would be a minor negative impact for this species. Reduced flows could also have a minor negative impact on razorback sucker and bonytail through loss of rearing habitat. The slightly higher flows under the Water Supply Alternative could have a minor positive impact on all three species. Under the 90th percentile, higher releases in the winter for the Reservoir Storage Alternative could have potential benefits or detriments to backwater habitats depending on the amount of sediment scour or deposition. Overall, however, no impact would be expected from higher winter releases.

Table 4.8-6 provides a summary of potential impacts that may occur under the action alternatives to special status species in the Davis Dam to Lake Havasu reach.

Table 4.8-6
Davis Dam to Lake Havasu Special Status Species Impact Summary
Comparison of Action Alternatives to No Action Alternative

Location	Alternative	Impact	Rationale
Birds	Conservation Before Shortage and Basin States	No Impact	Monthly releases closely follow the No Action Alternative.
	Water Supply	Minor-positive	Monthly releases higher than the No Action Alternative at 10th and 50th percentiles.
	Reservoir Storage	Minor-negative	Monthly releases lower than the No Action Alternative at 10th and 50th percentiles.
Mammals	All Action Alternatives	No impact	Conservation Before Shortage and Basin States alternatives monthly releases trend close to the No Action Alternative. Reservoir Storage and Water Supply alternatives differences are not substantial enough to cause indirect impacts to special status mammals.
Amphibians	All Action Alternatives	No Impact	Species not known in this reach.
Invertebrates	All Action Alternatives	No impact	Action alternatives not expected to adversely impact quailbrush or mesquite communities on alluvial floodplains.
Fish	Conservation Before Shortage and Basin States	No impact	Davis Dam releases trend close to the No Action Alternative.
	Water Supply	Minor- positive	Increased releases at 10th and 50th percentile elevations could benefit razorback sucker, bonytail, and flannelmouth sucker.
	Reservoir Storage	Minor-negative	Decreased releases at 10th and 50th percentile elevations could result in habitat reduction for razorback sucker, bonytail, and flannelmouth sucker.

4.8.4.6 Parker Dam to NIB

No Action Alternative. Monthly flows from Parker Dam to Imperial Dam exhibit a level to slightly downward trend in the future mostly because of a reduction in magnitude of 90th percentile flows in some months (Figures P-49 through P-60 in Appendix P). While special status species along the Colorado River are constantly adjusting as flows fluctuate, the slight downward trend in the future could adversely affect cottonwood and marsh communities and the special status species that rely on such habitats. Under the No Action Alternative, shortage conditions would occur without specific operating criteria. The gradual nature of this slight downward trend is such that terrestrial special status species and habitat conditions would not change abruptly or substantially. The No Action Alternative will not affect the Colorado River below Imperial Dam because flows between Imperial Dam and the NIB consist primarily of leakage from Imperial Dam and return flows from water diverted at Imperial Dam. Accordingly there will be no effects from the proposed federal action on special status species below Imperial Dam. The following discussion applies only to the Colorado River reach between Parker Dam and Imperial Dam.

Birds. The gradual and slight downward trend of flows in this reach in the future may adversely affect cottonwood-willow and marsh habitats and thus the special status birds that utilize such habitats. These species include: bald eagle, osprey, belted kingfisher, peregrine falcon, southwestern willow flycatcher, vermillion flycatcher, Clark's grebe, snowy egret, Yuma clapper rail, western yellow-billed cuckoo, California black rail, elf owl, gilded flicker, Gila woodpecker, Arizona Bell's vireo, Sonoran yellow warbler, summer tanager, American white pelican, double crested cormorant, American bittern, Western least bittern, great egret, black-crowned night heron, white faced ibis, black tern, long-eared owl, brown crested flycatcher, Lucy's warbler, yellow-breasted chat, northern cardinal, northern harrier, Cooper's hawk, and American kestrel. Lower flows would continue to favor expansion of tamarisk along this reach, which tends to reduce the value of the habitats the species invades.

Mammals. The gradual and slight downward trend of flows in this reach in the future under the No Action Alternative would have similar effects on special status bats as was described for the No Action Alternative for the Davis Dam to Lake Havasu reach.

The Yuma hispid cotton rat and Colorado River cotton rat do occur in this reach and they inhabit moist grassy areas along the lower Colorado River, including wetlands (Arizona Game and Fish 2004) from Yuma and downstream. The downward trend of releases from Parker Dam under the No Action Alternative may have minor effects on the moist riparian habitats these two species prefer. However, since these species also utilize agricultural fields and the downward release trend is gradual and small, effects under the No Action Alternative on these two rat species is expected to be minor.

Amphibians. Special status amphibians do not occur in this reach, thus no effects from the No Action Alternative are anticipated.

Invertebrates. MacNeill's sooty-winged skipper may occur in the quailbrush and mesquite communities that are present in this reach. However, the No Action Alternative is not expected to affect alluvial floodplains or otherwise impact these vegetation communities through groundwater effects. The No Action Alternative will not affect MacNeill's sooty-winged skipper in this reach.

Fish. The only listed fish species present in the Colorado River or in-stream reservoirs from Parker Dam to the NIB are the razorback sucker and bonytail chub. The effects of the No Action Alternative on these fish below Parker Dam would be similar to effects below Davis Dam.

Action Alternatives. Between Parker Dam and the NIB, the Water Supply Alternative flows from Parker Dam to Imperial Dam are similar to the No Action Alternative flows. Therefore, the Water Supply Alternative would have no impacts to special status species and is not discussed further for this reach. Flow deviations from No Action Alternative under the remaining action alternatives generally return to No Action Alternative conditions at the end of the interim period, though the vegetation and associated special status species effects of interim period conditions may be observed beyond the interim period.

Birds. Between Parker Dam and Imperial Dam, flows of the Conservation Before Shortage, Basin States, and Reservoir Storage alternatives would be lower than under the No Action Alternative at the 10^{th} and 50^{th} percentiles. The Reservoir Storage Alternative results in the greatest reduction from the No Action Alternative, while the Basin States Alternative results in the least reduction. These lower releases would have a minor negative impact on cottonwood-willow and marsh habitats and thus a correspondingly minor negative impact to special status birds that rely on those habitats. Impacted species include the following: bald eagle, osprey, belted kingfisher, peregrine falcon, southwestern willow flycatcher, vermillion flycatcher, Clark’s grebe, snowy egret, Yuma clapper rail, western yellow-billed cuckoo, California black rail, elf owl, gilded flicker, Gila woodpecker, Arizona Bell’s vireo, Sonoran yellow warbler, summer tanager, American white pelican, double crested cormorant, American bittern, Western least bittern, , great egret, black-crowned night heron, white faced ibis, black tern, long-eared owl, brown crested flycatcher, Lucy’s yellow warbler, yellow-breasted chat, northern cardinal, northern harrier, Cooper’s hawk, and American kestrel.

Mammals. The special status bat species would not be impacted in this reach for the same reasons as described for the Davis Dam to Lake Havasu reach.

Departures of the action alternatives from the No Action Alternative may be at most 0.25 feet stage reduction in the reach from Parker Dam to Imperial Dam. The action alternatives would not alter the historic operational methodology or range of flow volumes in the river channel below Imperial Dam. Therefore, none of the action alternatives would impact the Yuma hispid cotton rat or Colorado River cotton rat, which occur below Imperial Dam.

Amphibians. Special status amphibians do not occur in this reach.

Invertebrates. MacNeill’s sooty-winged skipper would not be impacted in this reach because alluvial floodplains with quailbrush and mesquite are not expected to be substantially impacted by any alternative.

Fish. The Conservation Before Shortage, Basin States and Reservoir Storage alternatives have monthly releases that would be less than those under the No Action at the 10^{th} and 50^{th} percentiles. These lower flows could have impacts on Razorback Sucker and Bonytail chub similar to those described for the Reservoir Storage Alternative in the Davis Dam to Lake Havasu reach. The use of High Levee Pond on the Cibola NWR for native fishes would not be affected by changes in releases from Parker Dam.

Table 4.8-7 summarizes the potential impacts to special status species in the Parker Dam to NIB reach for the action alternatives.

Table 4.8-7
Parker Dam to NIB Special Status Species Impact Summary
Comparison of Action Alternatives to No Action Alternative

Location	Alternative	Impact	Rationale
Birds	Water Supply	No Impact	Monthly releases closely follow the No Action Alternative. No flow-related impacts anticipated below Imperial Dam.
	Conservation Before Shortage, Basin States, Reservoir Storage	Minor-negative	Monthly releases lower than the No Action Alternatives at 10th and 50th percentiles. Small anticipated groundwater level impacts. No flow-related impacts anticipated below Imperial Dam.
Mammals	All Action Alternatives	No impact	Monthly flows for Water Supply alternative are similar to No Action Alternative. Reservoir Storage, Conservation Before Shortage and Basin States alternatives are not substantially different than No Action Alternative to cause indirect impacts to special status bats. Two cotton rat species occur below Imperial Dam, where flow impacts are not anticipated.
Amphibians	All Action Alternatives	No Impact	Species not known in this reach.
Invertebrates	All Action Alternatives	No impact	Action alternatives not expected to adversely impact quailbrush or mesquite communities on alluvial floodplains.
Razorback Sucker and Bonytail chub	Water Supply	No Impact	Monthly flows closely follow the No Action Alternative.
	Conservation before Shortage, Basin States and Reservoir Storage	Minor-negative	Monthly flows are lower than No Action Alternative at the 10th and 50th percentiles and could result in habitat reduction.

4.8.4.7 NIB to SIB

No Action Alternative. The lack of flows precludes the presence of a significant river fishery in the Colorado River reach between Morelos Diversion Dam and the SIB (Limitrophe Division) and the riparian, marsh habitats, and the special status species that rely on those habitats are adversely affected by this condition. Flows past Morelos Diversion Dam tend to benefit downstream vegetated habitats and associated special status species. The probability of these excess flows occurring in the future under the No Action Alternative is relatively low, typically less than 20 percent. The infrequency of flows under the No Action Alternative would continue to maintain less than ideal conditions for cottonwood-willow and marsh habitats and the species that rely on such habitats. The special status bird and mammal species identified in the Parker Dam to the NIB reach will continue to experience these adverse effects on their habitat below

Morelos Diversion Dam under the No Action Alternative. The No Action Alternative will not have effects on special status amphibians, plants or fish because none are present in this reach. Infrequent flows in this reach under the No Action Alternative will continue to favor the expansion of tamarisk which may compete with mesquite and quailbrush communities, thus limiting the habitat potential for MacNeill's sooty-winged skipper in this reach.

Action Alternatives. The likelihood of flood control excess flows passing Morelos Diversion Dam under the Basin States and Water Supply alternatives is approximately equal to the No Action Alternative. Therefore these action alternatives would have no impact on special status species in this reach. The Reservoir Storage and Conservation Before Shortage alternatives have a higher likelihood of flood control excess flows passing Morelos Diversion Dam than under the No Action Alternative (Figure P-61 in Appendix P). In addition, due to modeling assumptions under the Reservoir Storage and Conservation Before Shortage alternatives, water is delivered to Mexico through this reach via periodic flows[2] of about 40 kafy to 200 kafy (Section 2.4). These pulse flows would occur approximately every other year during the interim period only. The probability of flows past Morelos Diversion Dam under these two action alternatives returns to flows under No Action Alternative conditions after the interim period. These flows would have overall benefits to river flow, riparian and marsh vegetation and special status species that utilize these habitats since substantial flow in this reach is relatively rare. The Reservoir Storage and Conservation Before Shortage alternatives would have a moderate, positive impact on special status species between Morelos Diversion Dam and the SIB.

Birds. The species identified as impacted in the Parker Dam to the NIB would be positively impacted by the increased likelihood of flows past Morelos Diversion Dam under the Reservoir Storage and Conservation Before Shortage alternatives. The Basin States and Water Supply alternatives would not impact special status birds since these action alternatives are just as likely as the No Action Alternative to have flows past Morelos Diversion Dam.

Amphibians, Plants and Fish. There are no special status amphibians, plants or fish in this reach.

Mammals. The increased likelihood of flows past Morelos Diversion Dam under the Reservoir Storage and Conservation Before Shortage alternatives would provide a moderate benefit to riparian and marsh habitats below Morelos Diversion Dam, which

[2] These flows were modeled as part of the storage and delivery mechanism under the Conservation Before Shortage and Reservoir Storage alternatives. The modeling assumptions were utilized in this Draft EIS in order to analyze the potential impacts to environmental resources of the storage and delivery mechanism, particularly with regard to reservoir elevations and river flow impacts. The use of these modeling assumptions does not represent any determination by Reclamation as to whether, or how, these releases could be made under current administration of the Colorado River.

would potentially benefit special status bats and the Yuma hispid cotton rat and Colorado River cotton rat in this reach.

Invertebrates. The *Atriplex* land cover type is present in this reach, which may provide habitat for MacNeill's sooty-winged skipper. Though not specifically known in this reach, the species has been documented in Yuma County, Arizona. The Basin States and Water Supply alternatives are as likely as the No Action Alternative to result in flows past Morelos Diversion Dam. The Reservoir Storage and Conservation Before Shortage alternatives are more likely to have flows past Morelos Diversion Dam. Though an overall benefit to habitat conditions, flows past Morelos Diversion Dam could scour riparian vegetation, potentially including *Atriplex*, which serves as potential habitat for MacNeill's sooty-winged skipper. Thus these alternatives would potentially have a minor negative impact on this species, despite overall benefits to the conditions in this reach.

Table 4.8-8 summarizes the impacts to special status species in the NIB to the SIB reach for the action alternatives.

Table 4.8-8
NIB to SIB Special Status Species Impact Summary
Comparison of Action Alternatives to No Action Alternatives

Location	Alternative	Impact	Rationale
Birds	Basin States and Water Supply	No Impact	Flows past Morelos Diversion Dam just as likely under the No Action Alternative.
	Reservoir Storage and Conservation Before Shortage	Moderate – positive	Flows past Morelos Diversion Dam more likely than under the No Action Alternative. Flows are rare in this reach, so increased likelihood would benefit the riparian corridor and associated special status species.
Mammals	Basin States and Water Supply	No impact	Flows past Morelos Diversion Dam just as likely under the No Action Alternative.
	Reservoir Storage and Conservation Before Shortage	Moderate-positive	Flows past Morelos Diversion Dam more likely than the No Action Alternative. Flows are rare in this reach, so increased likelihood would benefit the riparian corridor and associated special status species.
Amphibians, Plants and Fish	All Action Alternatives	No Impact	Fish occurrence is problematic due to lack of steady flows. No special status plants or amphibians are known from this reach.
MacNeill's sooty-winged skipper	Basin States and Water Supply	No impact	Flows past Morelos Diversion Dam just as likely under the No Action Alternative.
	Reservoir Storage and Conservation Before Shortage	Minor-negative	Atriplex vegetation occurs in this reach and could be impacted from scouring by increased likelihood of flow past Morelos Diversion Dam.

4.8.5 Summary

4.8.5.1 Vegetation and Wildlife

Lake Powell and Lake Mead. The Water Supply Alternative may have a minor negative impact on obligate phreatophytes, marsh and the wildlife that use such habitats because lake levels tend to be lower than under the No Action Alternative. The Reservoir Storage Alternative may have a minor positive impact on obligate phreatophytes, marsh and associated wildlife because lake levels tend to be higher than under the No Action Alternative.

Glen Canyon Dam to Lake Mead. All four action alternatives tend to have lower 10^{th} percentile releases from Glen Canyon Dam than under the No Action Alternative. These lowered releases may negatively impact obligate phreatophytes, marsh and associated wildlife below Lake Powell. The impacts are expected to be minor because though lower, they are within the range of recent history and are anticipated for the interim period only.

Hoover Dam to Davis Dam and Lake Havasu to Parker Dam. All four action alternatives would have no impact to vegetation or wildlife in these areas because there may be only small differences in Lake Mead releases and these areas are dominated by Lake Mohave and its backwater and Lake Havasu. Vegetated habitats potentially affected by flow changes between Hoover Dam and Lake Mohave are limited. Lake Mohave and Lake Havasu are operated on monthly rule curves so vegetation and wildlife effects at the lakes under the action alternatives are identical to those under the No Action Alternative.

Davis Dam to Lake Havasu. The Water Supply Alternative may have higher 10^{th} and 50^{th} percentile monthly releases from Davis Dam and this may cause a minor positive impact to obligate phreatophytes, marsh and associated and wildlife compared to the No Action Alternative. The Reservoir Storage Alternative may have lower 10^{th} and 50^{th} percentile monthly releases from Davis Dam and this may cause a minor negative impact to obligate phreatophytes, marsh and wildlife compared to the No Action Alternative. These differences remain within the range of annual fluctuation that has occurred and may occur during the interim period only.

Parker Dam to Imperial Dam. The Conservation Before Shortage, Basin States and Reservoir Storage alternatives all have lower 10^{th} and 50^{th} percentile releases and may thus have a minor negative impact on obligate phreatophytes, marsh and associated wildlife.

Imperial Dam to NIB. All of the action alternatives will have no impact to vegetation and wildlife in this reach. Flow changes in this reach will show up in the AAC rather than in the Colorado River below Imperial Dam. No impacts to vegetation or wildlife are anticipated from flow differences in the AAC.

NIB to SIB. Mexico diverts its water at Morelos Diversion Dam (at the NIB) and flows below this dam are rare. There is a higher probability of excess flows passing Morelos Diversion Dam under the Conservation Before Shortage and Reservoir Storage alternatives than under the No Action Alternative, which is expected to cause a moderate positive benefit to river flow, obligate phreatophytes, marsh and associated wildlife below Morelos Diversion Dam. These benefits were deemed moderate because flows in this reach are currently rare and any additional flow in this reach is assumed to be beneficial.

4.8.5.2 Special Status Species

Lake Powell. Lower Lake Powell elevations under the Conservation Before Shortage, Basin States and Water Supply alternatives may increase the amount of riverine habitat available at the inflow areas to Lake Powell. This may provide a minor positive benefit to Razorback sucker, bonytail, Colorado pikeminnow and flannelmouth sucker found in the lake. The higher lake levels under the Reservoir Storage Alternative may decrease the amount of riverine habitat at the inflow areas, which may not provide this benefit.

Clark's grebe that may inhabit Lake Powell could be impacted by water level changes in Lake Powell that affect marsh habitat at the inflow areas. The Reservoir Storage and Water Supply alternatives may have higher and lower lake levels respectively, which translate into a minor positive and minor negative impact respectively to Clark's grebe.

Glen Canyon Dam to Lake Mead. The Reservoir Storage and Water Supply alternatives may result in lower and higher river temperatures respectively below Glen Canyon Dam. Higher temperatures may provide a minor positive impact to humpback chub, bluehead sucker and flannelmouth sucker. However, these warmer temperatures also benefit non-native fish species, which compete with native fish. Lower temperatures may provide a minor negative impact to these native fish species. The warmer river temperatures that may occur under the Water Supply Alternative may have a minor positive impact on Leopard Frogs from reduced thermal shock. Higher 90^{th} percentile releases under the Reservoir Storage Alternative have the potential to have increased impact to beach habitat in the lower Grand Canyon, which could adversely impact Grand Canyon Evening primrose that may inhabit such beaches. All four action alternatives may have flows that could exceed the No Action Alternative and 17,000 cfs in some months, which may cause additional impact to Kanab ambersnail habitat at Vasey's paradise. The Reservoir Storage Alternative may have flows in June that could exceed the No Action Alternative and exceed 20,000 cfs, thus causing greater impact to Niobrarra ambersnail habitat. The Conservation Before Shortage, Basin States and Water Supply alternatives may have 90^{th} percentile flows that when above 20,000 cfs are equal or less than No Action Alternative, which would provide a minor positive benefit to the Niobrarra ambersnail. High flows in June under the Reservoir Storage Alternative have the greatest potential to impact quailbrush in the Grand Canyon, which could impact MacNeill's sooty winged-skipper. All four action alternatives may have a minor negative impact on the Southwestern Willow Flycatcher because 10^{th} percentile releases trend lower than No Action Alternative. These lower potential flows could adversely impact Southwestern Willow Flycatcher habitat in the Grand Canyon.

Lake Mead. The lower and higher Lake Mead elevations that may occur under the Water Supply and Reservoir Storage Alternatives, respectively, could cause minor negative and minor positive impacts, respectively, to special status bird species. Bird impacts may be caused by increased or decreased potential for dewatering of riparian habitats and headcutting at the Lake Mead inflow areas. Higher lake levels under the Reservoir Storage Alternative may inundate additional shoreline habitat for the sticky buckwheat, Geyer's milkvetch and Las Vegas Bearpoppy and be a minor negative impact. Lower Lake Mead water levels under the Water Supply Alternative may expose additional shoreline habitat for these plants and be a minor positive impact. These impacts were deemed minor because all habitats below the full-pool elevation of Lake Mead are subject to periodic inundation and exposure as the lake fluctuates in the future. The Reservoir Storage and Water Supply alternatives may have both minor positive and negative impacts to special status fish species. This may occur because the amount of riverine habitat for these species at the inflow areas are more and less than under the No Action Alternative at the 10th and 50th percentile levels, respectively. The Reservoir Storage Alternative may result in water levels over elevation 1,120 feet msl 50 percent of the time, which may benefit special status fish spawning in the lake.

Hoover Dam to Davis Dam and Lake Havasu to Parker Dam. There is no substantial difference between any of the alternatives in this reach. Accordingly, there will be no special status species impacts here.

Davis Dam to Lake Havasu. Lower monthly releases from Davis Dam under the Reservoir Storage Alternative may have a minor negative impact on obligate phreatophytes, marsh and the associated special status bird species. Impacts to these species may occur through adverse effects to their habitats from reduced dam releases. Razorback sucker, flannelmouth sucker and bonytail may experience a minor negative impact because lower potential releases could have adverse impacts to riverine spawning habitat and backwater rearing habitats that these species utilize. Higher monthly releases from Davis Dam under the Water Supply Alternative may have a minor positive impact on obligate phreatophytes, marsh and the associated special status bird species. Razorback sucker, flannelmouth sucker and bonytail may also benefit from these higher flows because there is a reduced likelihood that spawning and rearing habitats may be adversely impacted from flow-related effects.

Parker Dam to Imperial Dam. Lower monthly flows under the Conservation Before Shortage, Basin States and Reservoir Storage alternatives may have minor negative impacts to the habitats of the special status bird species. Obligate phreatophytes, marsh and the associated special status bird species would be negatively impacted by lower releases. Razorback sucker and bonytail chub may be negatively impacted by lower flows under the Conservation Before Shortage, Basin States and Reservoir Storage alternatives. Lower flows may negatively impact spawning and rearing habitats for these species.

Imperial Dam to NIB. The No Action Alternative and the action alternatives will have no impact to special status species in this reach. Flow changes in this reach will show up in the AAC rather than in the Colorado River below Imperial Dam. No impacts to special status species are anticipated from flow differences in the AAC.

NIB to SIB. Flows past Morelos Diversion Dam are more probable under the Reservoir Storage and Conservation Before Shortage alternatives. The increased probability of flows may have a moderate positive impact on the special status bird species through positive impacts to riparian and marsh habitats these species utilize. These higher probabilities of flows may also positively impact the special status bat species listed in Section 4.8.3.7, the Yuma hispid cotton rat and the Colorado River cotton rat through positive impacts to their riparian and marsh habitats. Though these flows are an overall benefit to the riparian corridor below the NIB, the increased probability of high flows could increase the likelihood of scouring *Atriplex* vegetation in this reach, which would be a minor impact.

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4.9 Cultural Resources

This section describes the methods used in the analysis and potential effects to cultural resources, including historic properties, Indian sacred sites, and issues of Tribal concern as a result of implementing the alternatives developed under the proposed federal action.

4.9.1 Methodology

This section provides a general analysis that considers how cultural sites might be exposed and affected by implementation of the proposed federal action. However, the specifics about current integrity of the submerged sites and the impacts that might occur to these sites once they are exposed are mostly unknown. Because of this, Reclamation and the NPS will work together to develop an agreement (acceptable to the consulting parties) that implements an appropriate strategy to identify, analyze, and address potential effects to cultural sites as they are exposed in the future as a consequence of implementing the proposed federal action.

For Lake Powell, the 10^{th} percentile was selected as the basis for effect determination because it represents the “worst case” that still has a reasonable probability of occurring. At Lake Mead, elevation 1,080 feet msl was selected as the basis for effect determination.[1] Processes that might result in a loss of integrity vary by reach and property type; consequently, methods of assessing effects differ by reach.

4.9.2 Lake Powell and Glen Canyon Dam

4.9.2.1 No Action Alternative

For the No Action Alternative, the lowest projected elevation of Lake Powell under the 10^{th} percentile modeled Lake Powell elevations would be 3,540 feet msl (Appendix P, Figure P-7). Some 193 unexcavated archaeological sites are at or above this elevation.

4.9.2.2 Basin States Alternative and Conservation Before Shortage Alternatives

For the Basin States and Conservation Before Shortage alternatives, the lowest projected elevation of Lake Powell under the 10^{th} percentile modeled Lake Powell elevations is projected to be 3,550 feet msl. Some 190 unexcavated archaeological sites are at or above this elevation and would therefore be subject to erosion or visitor impacts. This is essentially the same effect as under the No Action Alternative.

[1] Elevation 1,083 feet msl is the lowest elevation historically observed since Lake Mead filled

4.9.2.3 Water Supply Alternative

For the Water Supply Alternative, the lowest projected elevation of Lake Powell under the 10th percentile modeled Lake Powell elevations is projected to be 3,505 feet msl. Some 222 unexcavated archaeological sites are at or above this Lake Powell elevation and would therefore be subject to erosion or visitor impacts. This is a greater number of affected sites than under the No Action Alternative.

4.9.2.4 Reservoir Storage Alternative

For the Reservoir Storage Alternative, the lowest projected elevation of Lake Powell under the 10th percentile modeled Lake Powell elevations is projected to be 3,540 feet msl. Some 193 unexcavated archaeological sites are at or above this elevation and would therefore be subject to erosion or visitor impacts. This is essentially the same result as under the No Action Alternative.

4.9.3 Glen Canyon Dam To Lake Mead

The Colorado River corridor between Glen Canyon Dam and Separation Canyon contains 336 NRHP-eligible properties. These are actively managed by the NPS, Navajo Nation and Hualapai Indian Tribe. In addition, Reclamation's NHPA Section 106 responsibilities for effects of Glen Canyon Dam operations are managed through a programmatic agreement. A treatment plan for mitigation of adverse impacts to historic properties is in development and will be implemented in 2008. The Grand Canyon Protection Act of 1992 ensures long-term mitigation of effects. Thus, the alternatives currently under analysis pose no additional threat to historic properties not already considered by existing programs.

4.9.4 Lake Mead and Hoover Dam

Some 32 previously recorded cultural resources are located at or below elevation 1,080 feet msl, although many more undocumented cultural resources are probably submerged in Lake Mead at or below this elevation. If these cultural resources were to emerge, additional impacts would be anticipated as a result of invasion by invasive species of plants and animals (specifically as seen at St. Thomas by tamarisk and Asiatic freshwater clams), cracking and fissuring of sediments as a result of repeated wetting and drying and freeze/thaw cycles (Wyskup 2006), and as a result of visitor impacts. Resources like the B-29 Bomber aircraft and the aggregate classification plant are currently at depths where they cannot be reached without specialized breathing-gas mixture and diving equipment, but a lowering of the reservoir elevation would bring these resources into the range of recreational scuba divers.

4.9.4.1 No Action Alternative

The probability of Lake Mead pool elevation falling below 1,080 feet msl was analyzed in Section 4.3 (Table 4.3-21). Figure 4.3-21 presents the probabilities of Lake Mead elevation falling below 1,080 feet msl over the period of analysis for all alternatives. Under the No Action Alternative, the probability begins at zero percent in 2008 and increases to 41 percent in 2060. From 2017 through 2040, the probability fluctuates between 38 percent and 44 percent.

4.9.4.2 Basin States and Conservation Before Shortage Alternatives

In 2008, the probability of the Lake Mead elevation falling below elevation 1,080 feet msl is zero under these alternatives. In years 2017 through 2040, the probability is slightly lower than under the No Action Alternative for several years and ranges between 36 percent and 47 percent. Given these small differences compared to the No Action Alternative, the differential effect on cultural resources would be negligible.

4.9.4.3 Water Supply Alternative

In 2008, the probability of the Lake Mead elevation falling below elevation 1,080 feet msl is zero. From 2017 through 2040, the probability fluctuates between 39 percent and 51 percent, a relative difference of about one to seven percent under the Water Supply Alternative compared to the No Action Alternative. Consequently, there is a higher probability that cultural resources submerged at or below elevation 1,080 feet msl would emerge under the Water Supply Alternative.

4.9.4.4 Reservoir Storage Alternative

In 2008, the probability of the Lake Mead elevation falling below elevation 1,080 feet msl is zero. The probability of the Lake Mead elevation falling below elevation 1,080 feet msl is substantially lower (one percent to 23 percent) under this alternative compared to the No Action Alternative. Consequently, there is a lower probability that cultural resources submerged at or below elevation 1,080 feet msl would emerge under the Reservoir Storage Alternative.

4.9.5 Hoover Dam to Davis Dam

Under all alternatives, Lake Mohave would continue to be operated to meet monthly target elevations. Because there would be no change in reservoir operations, there is no potential for adverse effects to occur to cultural resources submerged in Lake Mohave as a result of the proposed federal action.

4.9.6 Davis Dam to Parker Dam

Geomorphic processes in lacustrine and fluvial environments differ so the Havasu Reach has been subdivided into sub-reaches for this analysis, a river reach and Lake Havasu.

4.9.6.1 Davis Dam to Upper Lake Havasu.

There are 10 previously recorded cultural resources located along the reach of the Colorado River from Davis Dam to the upper end of Lake Havasu. Three of these cultural resources span the Colorado River with their end-points anchored in positions well above the river surface. A lowering of the elevation of the river in the area of these sites would have no direct or indirect effect on these resources. Examination of the site forms and map plots for two other previously recorded cultural resources (both segments of railroads) indicate these sites are located in elevated positions back from the riverbank. No direct or indirect effects to these resources are anticipated as a result of the proposed federal action due to their elevated locations.

Of the five additional cultural resources in this reach, only two would be directly affected by a drop in river elevation. These two sites represent the remnants of two bridges used by contractors during the construction of Davis Dam.

Although the proposed federal action may result in reductions in the annual volume released from Davis Dam and the corresponding mean daily releases, the hourly releases will continue to fluctuate between the historical minimum and maximum ranges due to operational considerations and constraints. The corresponding river flows and associated elevations would also continue to fluctuate between the historical minimum and maximum ranges and therefore it is unlikely there would be any changes in depositional or erosional processes along tributary streams or washes, or the Colorado River itself. Furthermore, it is highly unlikely that daily or hourly changes in elevation would result in conditions that would allow for more ready access to cultural resources located immediately adjacent to or in the river.

4.9.6.2 Lake Havasu and Parker Dam.

Under the alternatives, Lake Havasu will continue to be operated to meet monthly target elevations. Because there will be no change in the manner in which the reservoir has been operated historically, there is no potential for effects to occur to cultural resources submerged in Lake Havasu.

4.9.7 Parker Dam to Imperial Dam

The IA FEIS identified several cultural resource sites within or proximal to the Parker Dam to Imperial Dam reach. However, most of the historic resources that may be present in the APE, as suggested from plats and site records, have been destroyed by meandering and relocation of the mainstream channel of the Colorado River and agricultural development. Further, the proposed federal action will have no effect on Parker Dam, Imperial Dam or the Old Parker Road.

Although the proposed federal action may result in reductions in the annual volume released from Parker Dam and the corresponding mean daily releases, the hourly releases will continue to fluctuate between the historical ranges due to operational considerations and constraints. The corresponding river flows and associated elevations would also continue to fluctuate between the historical minimum and maximum ranges and therefore it is unlikely there would be any changes in depositional or erosional processes along tributary streams or washes, or the Colorado River. Eleven of the twelve sites located proximate to the APE are situated in locations above the river channel, its connected lakes and backwaters, and floodplain. The anticipated changes in elevations would therefore not impact these sites. Also, the prehistoric habitation site listed on the National Register would not be directly impacted by a drop in river elevation. It is conceivable that it could be indirectly impacted by better accessibility if the river drops in elevation more frequently or for longer periods of time. The probability of this occurring is small and would be countered by the emergence of impenetrable vegetation behind the retreating water line. Furthermore, it is highly unlikely that daily or hourly changes in elevation would result in conditions that would allow for more ready access to cultural resources located immediately adjacent to or in the river.

4.9.8 Sacred Sites and Other Issues of Tribal Concern

As a result of prior government-to-government consultations, several tribes had identified Indian sacred sites located on federal lands within the affected environment. During consultations regarding this proposed federal action, the Hualapai Indian Tribe was the only tribe who specifically raised a concern regarding how the alternatives might adversely affect the physical integrity of sacred sites. The Hualapai Indian Tribe also raised concerns regarding biological resources located in the Grand Canyon and on Hualapai Tribal land.

Reclamation, the NPS, and the FWS (federal agencies who manage lands within the affected environment) remain committed to accommodating access to and ceremonial use of Indian sacred sites by Indian religious practitioners. The agencies also remain committed to avoiding any adverse effects to the physical integrity of such sites in compliance with Exec. Order No. 13007. None of the alternatives are believed to adversely affect any identified Indian sacred site or alter access to such a site.

During consultation for this proposed federal action, several tribes expressed concern that the alternatives might result in inadvertent discoveries of Native American human remains or cultural items as defined under the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA). Reclamation and the federal land-managing agencies remain committed to compliance with both the inadvertent discovery and museum inventory sections of this law and its implementing regulations.

With respect to museum inventories from the original Glen Canyon archaeological project, Reclamation is working on cultural affiliation determinations on behalf of tribes seeking repatriation of inventory items from the Glen Canyon archaeological project.

4.9.9 Summary

For Lake Powell, under the Water Supply Alternative at the 10th percentile, there are at least 222 unexcavated sites subject to effect, as compared to about 193 sites under the other alternatives. Consultation is underway regarding eligibility and effect.

For the reach from Glen Canyon to Lake Mead, the alternatives pose no additional threat to cultural resources because of the programs already underway.

For Lake Mead, there are at least 32 cultural resources located below elevation 1,080 feet msl. The probability of exposing sites below this elevation vary by alternative, with the Reservoir Storage Alternative having the lowest probability (up to 23 percent lower compared to the No Action Alternative) and the Water Supply Alternative having the highest probability (up to seven percent higher compared to the No Action Alternative). The Basin States and Conservation Before Shortage alternatives have probabilities similar to those of the No Action Alternative.

For reaches below Lake Mead, no adverse effects are anticipated from any of the alternatives. However, consultation regarding eligibility and effect will be undertaken.

For Indian sacred sites and other issues of Tribal concern (not including ITAs), none of the alternatives are expected to restrict access or result in loss of physical integrity to sacred sites. Consultations with Indian tribes are ongoing with respect to these issues and other issues and concerns.

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4.10 Indian Trust Assets

4.10.1 Water Rights and Trust Lands

No vested water right of any kind, quantified or unquantified, including federally reserved Indian rights to Colorado River water, rights pursuant to the Consolidated Decree or Congressionally-approved water right settlements utilizing CAP water, will be altered as a result of any of the alternatives under consideration.

To the extent that additional Tribal water rights are developed, established or quantified during the interim period of the proposed federal action, the United States will manage Colorado River facilities to deliver water consistent with such additional water rights, if any, pursuant to federal law. Thus, modifications to system operation, in accordance with pertinent legal requirements, will be considered as Tribal water rights and will be exercised in accordance with applicable law.

Water deliveries to the Fort Mojave, Chemehuevi, CRIT, and Fort Yuma Indian Reservations will not be affected by the proposed federal action due to their early priority dates. For the Cocopah Indian Reservation, its 1915 and 1917 PPRs would also not be affected. However, the 1974 priority date of 2,026 afy of the Cocopah Indian Reservation may be reduced during certain shortage conditions, as summarized in the Water Delivery Section 4.4. Similarly, the CAP Settlement tribes, with their post-1968 CAP Priority, would also be subject to shortages. However, even when water deliveries are reduced to these Indian Reservations, the underlying water right would not be affected.

Water delivery reductions may result in fallowing of some Indian lands; however, these changes in land-use are expected to be temporary and no permanent changes in land-use would occur. In terms of effects to the shorelines of reservations, the fluctuations that might occur as a result of this action downstream of Lake Mead are within historic levels.

For the No Action Alternative under the 10^{th} and 50^{th} percentiles, monthly releases from Glen Canyon Dam would range from approximately 9,000 to 14,000 cfs past the Navajo and Hualapai Indian Reservation boundaries. Under the action alternatives, flows would occasionally be reduced by approximately 700 to 2,000 cfs. These slight reductions in flow and concomitant sediment transport differences would not affect Indian trust lands.

4.10.2 Hydroelectric Power Generation and Distribution

As described in Section 4.11, the energy generated at Headgate Rock Powerplant under the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives could potentially be less than under the No Action Alternative. These reductions in energy generated range from 1.3 percent to 2.5 percent. However, Reclamation has determined that the water appropriated to non-CRIT entities that flows through Headgate Rock Dam and generates electricity is not an ITA.

4.10.3 Cultural Resources

As discussed in the Cultural Resources section (Section 4.9), Reclamation is currently in the process of identifying cultural resources and evaluating potential effects. However, based on what is currently known of Hualapai Indian Tribe historic and traditional cultural properties, there would be no effect on cultural resources of concern to the tribe. Furthermore, under Exec. Order No. 13007, there will be no change in access to Hualapai Indian Tribe or other Indian tribe sacred sites as a result of the proposed federal action.

4.10.4 Biological Resources

While not necessarily ITAs, the Navajo Nation and Hualapai Indian Tribe have expressed concern over biological resources located on their reservations and in the intervening Grand Canyon. As discussed in the Biological Resources Section (Section 4.8), the action alternatives would result in occasional reductions of approximately 700 to 2,000 cfs past the Navajo Nation and the Hualapai Indian Reservations, compared with the No Action Alternative. These flows would have some potential to impact obligate native phreatophytes such as willow (a plant of concern to many tribes); however the effects on vegetation are likely to be short-term, especially in comparison to the long-term trends favoring tamarisk expansion.

The Navajo Nation and the Hualapai Indian Tribe also expressed concern over native fish. The Hualapai Indian Tribe is particularly concerned with razorback sucker in the upper end of Lake Mead. As discussed in the Biology Resources Section, the modeling of Lake Mead elevations indicate that the minimum Lake Mead water levels under the action alternatives would be similar to those under the No Action Alternative. Therefore, the proposed federal action is expected to have either no effects or only minor effects on razorback sucker and other fish of Tribal concern.

4.10.5 Summary

After analyzing each resource, it is concluded that Tribal trust resources identified in the study area would not be adversely affected by any of the anticipated environmental impacts stemming from the proposed federal action.

4.11 Electrical Power Resources

This section analyzes the potential effects of the proposed federal action on electrical power (or hydropower) resources. The following issues are addressed:

- change in electrical power generated and the associated change in economic value;
- effect on Upper and Lower Colorado funds that pay for operation, maintenance, replacements of power facilities, and other programs supported by these funds;
- financial implications associated with implementation of surcharge;
- potential impact to ancillary services; and
- change in annual cost of electrical power for pumping water associated with the Navajo Generating Station, City of Page water supply system, SNWA water supply system, and CAP pumping load.

4.11.1 Methodology

Reclamation conducted a study of the potential effects of the action alternatives on electrical power resources of the Colorado River system that included all major facilities with the exception of generation capacity at Glen Canyon Powerplant. Western conducted a parallel analysis of the potential effects of the action alternatives only on Glen Canyon Powerplant (Appendix O). The two studies show very similar trends among the alternatives and the relative findings of each study are comparable. Western's analytical methodology includes a more detailed hourly analysis of capacity of the Glen Canyon Powerplant because of operational limitations of hydropower facilities resulting from the 1996 Glen Canyon Dam ROD. The results of Reclamation's analysis are used throughout this section with the exception of the analysis of generation capacity and the economic value of generation capacity of the Glen Canyon Powerplant, which uses the results of the hourly analysis conducted by Western.

4.11.1.1 Electrical Energy Generated

The basis for the electrical power analysis is the CRSS model described in Section 4.2 and Appendix A. Among other variables, the model simulates monthly turbine release (af) and end-of-month (EOM) reservoir elevation (feet above msl) and calculates monthly generation (MWh) and monthly capacity (MW). The monthly generation data were then aggregated to produce estimates of annual generation. Using the resulting annual data, the mean, median, 90th percentile, and 10th percentile annual energy generation statistics were calculated for each year for Glen Canyon, Hoover, Davis, and Parker Powerplants.

Since the elevation behind Headgate Rock Dam is maintained at a relatively constant elevation, electrical power generation at the Headgate Rock Powerplant was calculated based on modeling changes in river flows provided by the CRSS model for the No Action Alternative and action alternatives. The modeled flows available to pass through the

Headgate Rock Powerplant were first reduced by a 5.96 percent factor to account for water that is likely to be bypassed through the river gates. This factor was derived from actual data from 2001 through 2005. Energy was then calculated using a conversion factor of 12.97 kWh /af, derived by averaging the monthly kWh/af values for the Headgate Rock Powerplant from 1996 through 1998.

In general, mean values provide an assessment of the overall impact to hydropower. The mean is the average of all modeled traces, which includes all hydrologic extremes, while the median is the midpoint of all values. Mean energy values higher than median values reflect water released from Glen Canyon Dam for equalization and the existence of the minimum objective release. Mean energy values lower than median values at the Hoover Powerplant are likely due to extreme dry conditions when the Hoover Powerplant may not be generating power.

4.11.1.2 Generation Capacity

Using the capacity relationships for each powerplant, their respective monthly availability factors and the monthly forebay elevations simulated by the CRSS model, the monthly capacity for each powerplant was computed. The mean, median, 90th percentile and 10th percentile capacity values were then computed for the No Action Alternative and the action alternatives for the Hoover, Davis, and Parker Powerplants. For the Glen Canyon Powerplant, the analysis was conducted by Western (Appendix O) and only the mean, median, and 10th percentile values are presented. The 90th percentile values were not calculated for the Glen Canyon Powerplant because at this level there is no substantial difference among the alternatives. Capacity was not calculated for Headgate Rock Powerplant because no changes in capacity are anticipated.

4.11.1.3 Economic Values

The economic value of operating an existing hydroelectric powerplant varies considerably with time of day. The cost of meeting demand varies on a second-by-second basis depending on the load, the mix of powerplants being operated to meet load, and their output levels. During off-peak periods, demand is typically satisfied with lower-cost coal, run-of-river hydropower, and nuclear units. During on-peak periods, the additional load is met with more expensive sources such as gas turbine units. Consequently, the economic value of hydropower is greatest during the hours when the demand for electricity, and the variable cost of meeting demand, is the highest.

The electrical energy prices used in this analysis were developed from both an hourly price forecast keyed to the Palo Verde Interchange and mean monthly reported price indices for the Palo Verde Interchange obtained from Dow Jones, Inc. The hourly forecast of 2004 electricity prices at the Palo Verde Interchange was developed using the AURORA model (Electric Power Information Solutions, Inc. 2005).

AURORA model simulations used in this analysis were developed for and used in the Northwest Power and Conservation Council's (NWPCC) Fifth Northwest Electric Power and Conservation Plan (NWPCC 2005). The NWPCC is primarily interested in Northwestern electricity markets. Relatively less attention is devoted to characterizing market conditions in other areas. Consequently, the forecast described in this analysis primarily reflects the default data supplied with the AURORA model.

For purposes of this analysis, the hourly prices developed using the AURORA model were scaled to match the mean monthly reported prices purchased from Dow Jones, Inc. The resulting (scaled) hourly prices exhibit the expected daily, weekly and monthly patterns of price behavior and reflect the mean values actually observed in each month.

The underlying hourly prices yielded by this process are for 2004. These prices were escalated by 2.2 percent per year to estimate 2008 prices. For this analysis, estimation of the economic value for the No Action Alternative and each of the action alternatives were analyzed using monthly generation data simulated by the CRSS model as described previously. The value of the monthly generation was then analyzed using the escalated mean price of electricity for that month. The monthly economic value was then aggregated to produce estimates of annual economic value.

The costs and benefits associated with electrical power generation are incurred at different times over a long period of time. Because the timing of these costs and benefits differ across the alternatives, the present value of the future stream of costs and benefits for each alternative was computed as a means of assessing the economic value of electrical power for each alternative.

All economic value estimates reported in this Draft EIS are measured in present value 2008 dollars (PV 2008 $). All annual costs and benefits subsequent to 2008 were escalated at 2.2 percent per year and discounted back to the 2008 base year using a discount rate of 4.875 percent.

Similar to the process used in the economic analysis of electrical energy generation, the present value of generation capacity was analyzed. In this instance, the capacity was valued at $6.32/kW-month based upon the alternative market cost of capacity.

For Glen Canyon Powerplant, the economic value of electrical energy generated was derived from Reclamation's analysis, whereas the value of generation capacity was derived from Western's analysis.

4.11.2 Electrical Power Generation Facilities

4.11.2.1 Glen Canyon Powerplant

No Action Alternative. The No Action Alternative values for annual energy generation, monthly generation capacity, and economic value at Glen Canyon Powerplant for the mean, median, 90th percentile, and 10th percentile values are presented in Table 4.11-1.

Table 4.11-1
No Action Alternative Values at Glen Canyon Powerplant

Measure	Mean	Median	90th Percentile	10th Percentile
Annual Energy Generation (MWh)	4,265,749	3,795,040	6,315,161	3,197,806
Monthly Capacity (MW)	603	546	Not available	455
Economic Value of Electrical Power Generation - Total (PV 2008 $ millions)	6,808	6,823	Not available	5,881

Comparison of Action Alternatives to No Action Alternative. Table 4.11.2 shows the change in annual electrical energy generation for each alternative in MWh in comparison to the No Action Alternative, for the mean, median, 90th percentile and 10th percentile values.

Table 4.11-2
Change in Glen Canyon Powerplant Annual Energy Generation (MWh)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(10,516)	24,121	(39,058)	(68,219)
Conservation before Shortage	(9,093)	24,121	(37,368)	(64,149)
Water Supply	(95,799)	6,768	(67,401)	(219,755)
Reservoir Storage	26,668	23,265	55,966	(24,324)

Table 4.11-3 shows the percent change in annual energy generation for each alternative, in comparison to the No Action alternative, for each hydrologic level.

Table 4.11-3
Percent Change in Glen Canyon Powerplant Annual Generation

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(0.25)	0.64	(0.62)	(2.1)
Conservation before Shortage	(0.21)	0.64	(0.59)	(2.0)
Water Supply	(2.2)	0.18	(1.1)	(6.9)
Reservoir Storage	0.63	0.61	0.89	(0.76)

Figure 4.11-1
Glen Canyon Powerplant
Average Values of Annual Electrical Energy Production

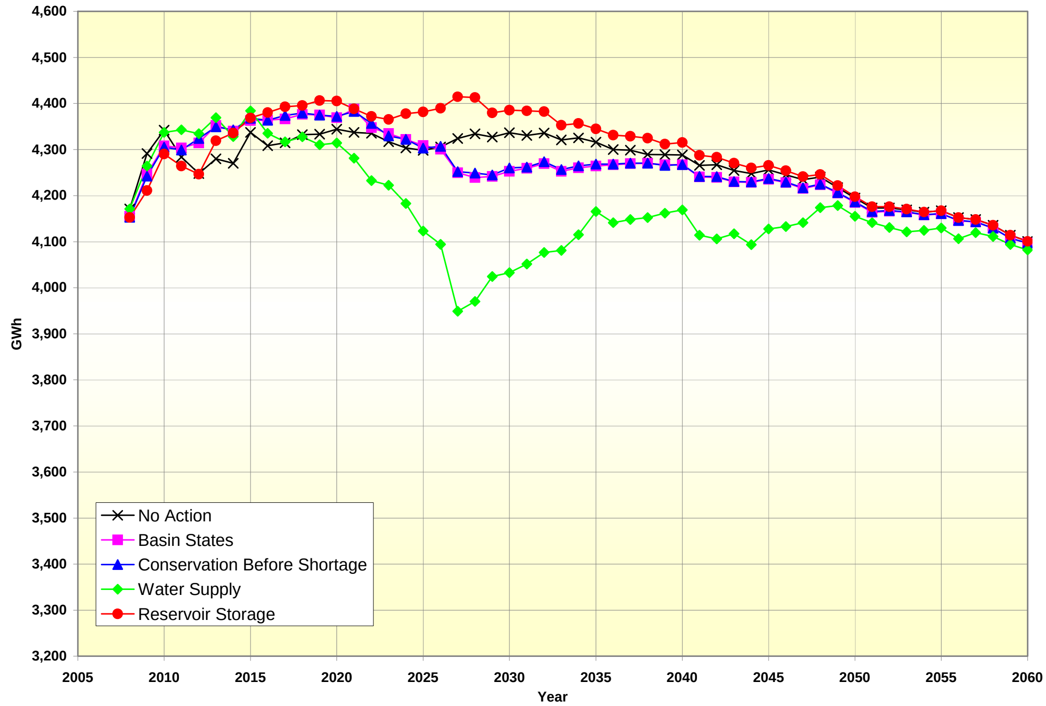


Figure 4.11-1 shows average values of annual electrical energy production for the Glen Canyon Powerplant, over the period of study, for each alternative, including the No Action Alternative. Differences in mean generation values between the No Action Alternative and the action alternatives are the greatest from 2020 through 2050.

As noted above, Western conducted a complementary study of energy generation and associated economic value using an hourly time step to simulate hourly Glen Canyon Powerplant generation levels. Western's model was used to determine the hourly operation schedule that maximized the economic value of the hydropower resource. Hourly pricing data, inflation and discount rates used in Western's study were the same as those used by Reclamation.

The Western study also included an analysis of the impacts to generation capacity at Glen Canyon Powerplant. Table 4.11-4 shows the change in generation capacity for each alternative, as compared to the No Action Alternative, for the mean, median, and 10th percentile hydrologic levels. The corresponding percentage changes are identified in Table 4.11-5.

Table 4.11-4
Change in Glen Canyon Powerplant Generation Capacity

Alternatives	Change in Capacity (Megawatts)		
	Mean	Median	10th Percentile
Basin States	3.44	6.18	(12.67)
Conservation Before Shortage	3.63	6.20	(11.45)
Water Supply	(11.21)	4.08	(30.11)
Reservoir Storage	9.59	2.85	(2.48)

Table 4.11-5
Change in Glen Canyon Powerplant Generation Capacity (Percent)

Alternatives	Change in Generation Capacity		
	Mean	Median	10th Percentile
Basin States	0.57	1.1	(2.8)
Conservation Before Shortage	0.60	1.1	(2.5)
Water Supply	(1.9)	0.75	(6.6)
Reservoir Storage	1.6	0.52	(0.55)

Table 4.11-6 shows the change in total economic value of electrical power generation for each alternative, as compared to the No Action Alternative, for the mean, median and 10th percentile values. Table 4.11-7 shows the corresponding percentage change in net present value for each alternative as compared to the No Action Alternative for the same hydrologic levels.

Table 4.11-6
Change in Glen Canyon Powerplant Total Economic Value of Electrical Power Generation (PV 2008 $ million)

Alternatives	Mean	Median	10th Percentile
Basin States	(4.72)	59.52	(129.49)
Conservation Before Shortage	(2.79)	61.10	(135.88)
Water Supply	(139.27)	36.04	(427.83)
Reservoir Storage	62.43	63.06	42.86

Table 4.11-7
Change in Glen Canyon Powerplant Total Economic Value of Electrical Power Generation (Percent)

Alternatives	Mean	Median	10th Percentile
Basin States	(0.07)	0.87	(2.20)
Conservation Before Shortage	(0.04)	0.90	(2.31)
Water Supply	(2.05)	0.53	(7.27)
Reservoir Storage	0.92	0.92	0.73

Under all the action alternatives, the greatest impact to power would occur in the dry years. The Reservoir Storage Alternative provides an increased electrical power generation value, a result of higher reservoir elevations, while the other action alternatives show generally decreased electrical power generation values.

4.11.2.2 Hoover Powerplant

No Action Alternative. The No Action Alternative values for annual energy generation, monthly generation capacity, and economic value at Hoover Powerplant for the mean, median, 90th percentile and 10th percentile values are presented in Table 4.11-8.

Table 4.11-8
No Action Alternative Values at Hoover Powerplant

Measure	Mean	Median	90th Percentile	10th Percentile[1]
Annual Energy Generation (MWh)	3,156,820	3,680,235	5,233,791	0.0
Monthly Capacity (MW)	1,201	1,428	2,067	0.0
Economic Value of Electrical Power Generation - Total (PV 2008 $ millions)	7,351	8,472	10,503	3,592

1 The 10th percentile value for capacity and energy is zero on cumulative distribution function graphs of end-of-December capacity and energy, a result of Lake Mead elevation being less than 1,050 feet msl (the assumed minimum power head). This result cascades in calculating total generation and percentage changes in Tables 4.11-9 through 4.11-14.

Comparison of Action Alternatives to No Action Alternative. Table 4.11-9 presents the change in annual electrical energy generation for each action alternative, in comparison to the No Action Alternative, for the mean, median, 90th percentile and 10th percentile values.

Table 4.11-9
Change in Hoover Powerplant Annual Electrical Energy Generation (MWh)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	14,369	(29,186)	(15,301)	0.0
Conservation Before Shortage	18,570	(35,081)	(1,313)	0.0
Water Supply	(48,281)	(19,062)	(66,444)	0.0
Reservoir Storage	274,019	(29,970)	56,864	0.0

Table 4.11-10 presents the percent change in annual electrical energy generation for each action alternative, in comparison to the No Action Alternative, for the mean, median, 90th percentile and 10th percentile values.

Table 4.11-10
Change in Hoover Powerplant Annual Electrical Energy Generation (Percent)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	0.46	(0.79)	(0.29)	0.0
Conservation Before Shortage	0.59	(0.95)	(0.02)	0.0
Water Supply	(1.5)	(0.52)	(1.27)	0.0
Reservoir Storage	8.7	(0.81)	1.1	0.0

Figure 4.11-2 depicts average values of annual electrical energy production for the Hoover Powerplant over the period of study for each alternative, including the No Action Alternative. Differences in mean generation values between the No Action Alternative and the action alternatives are the greatest from 2020 through 2050.

Figure 4.11-2
Hoover Powerplant
Average Values of Annual Electrical Energy Production

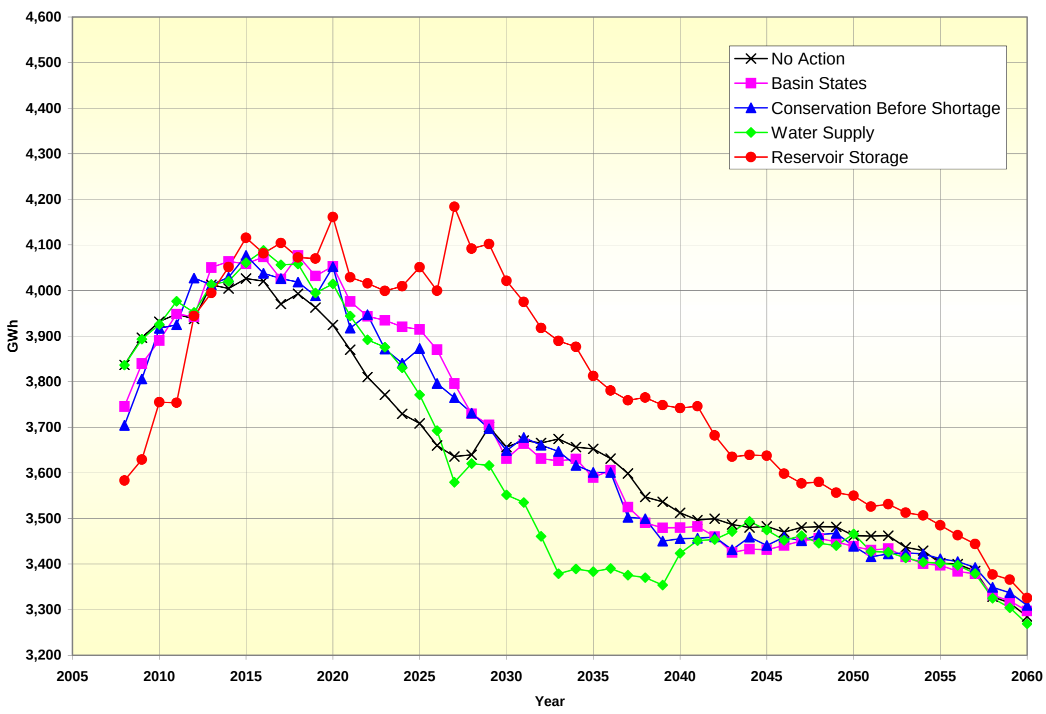


Table 4.11-11 shows the change in the Hoover Powerplant monthly generation capacity (MW) for the action alternatives compared to the No Action Alternative.

Table 4.11-11
Change in Hoover Powerplant Monthly Generation Capacity (MW)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	12.7	6.1	1.4	0.0
Conservation Before Shortage	15.5	8.7	1.5	0.0
Water Supply	(22.9)	(14.5)	(2.5)	0.0
Reservoir Storage	136.0	60.4	5.8	0.0

Table 4.11-12 presents the percentage change in Hoover Powerplant monthly capacity for each of the action alternatives as compared to the No Action Alternative.

Table 4.11-12
Change in Hoover Powerplant Monthly Generation Capacity (Percent)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	1.1	0.43	0.06	0.0
Conservation Before Shortage	1.3	0.61	0.07	0.0
Water Supply	(1.9)	(1.0)	(0.12)	0.0
Reservoir Storage	11.3	4.2	0.28	0.0

Table 4.11-13 presents the change in each of the action alternatives as compared to the net present value of the total electrical power generation under the No Action Alternative. Table 4.11-14 presents the corresponding percentage change in net present value for each alternative as compared to the No Action Alternative for the same hydrologic levels.

Table 4.11-13
Change in Hoover Powerplant Total Economic Value of Electrical Power Generated (PV 2008 $ million)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	75.39	(250.17)	(12.23)	144.33
Conservation Before Shortage	89.97	(226.51)	(5.53)	162.20
Water Supply	(88.36)	(420.49)	(41.62)	38.76
Reservoir Storage	742.48	272.25	34.90	1,417.97

Table 4.11-14
Change in Hoover Powerplant Total Economic Value of Electrical Power Generated (Percent)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	1.03	(2.95)	(0.12)	4.02
Conservation Before Shortage	1.22	(2.67)	(0.05)	4.52
Water Supply	(1.2)	(4.96)	(0.40)	1.08
Reservoir Storage	10.10	3.21	0.33	39.48

In general, the Reservoir Storage Alternative provides the greatest increase in electrical power generation value at Hoover Powerplant, while the Water Supply Alternative proves most adverse to power generation. The Basin States and Conservation Before Shortage alternatives show similar results and they are ranked between the Reservoir Storage Alternative and the Water Supply Alternative in their effect on power resources at Hoover Powerplant.

4.11.2.3 Parker and Davis Powerplants

No Action Alternative. The No Action Alternative values for annual energy generation, monthly generation capacity, and total economic value for Parker and Davis Powerplants for the mean, median, 90th percentile and 10th percentile values are presented in Table 4.11-15.

Table 4.11-15
No Action Alternative Values at Parker and Davis Powerplants

Measure	Mean	Median	90th Percentile	10th Percentile
Annual Energy Generation (MWh)	1,618,736	1,559,622	1,812,884	1,483,907
Monthly Capacity (MW)	331	364	364	286
Economic Value of Electrical Power Generation - Total (PV (2008 $ millions)	2,243	2,258	2,357	2,129

Comparison of Action Alternatives to No Action Alternative. Table 4.11-16 presents the change in annual electrical energy generation in MWh for each action alternative, in comparison to the No Action Alternative, for the mean, median, 90th percentile and 10th percentile values.

Table 4.11-16
Change in Parker and Davis Powerplants Annual Electrical Energy Generation (MWh)

Alternatives	Mean	Median	9^{0th} Percentile	10th Percentile
Basin States	(9,318)	(8,328)	(3,969)	(10,010)
Conservation Before Shortage	(11,210)	(12,258)	(846)	(10,392)
Water Supply	1,593	14,085	(13,162)	2,728
Reservoir Storage	(18,252)	(24,034)	25,035	(22,156)

Table 4.11-17 presents the percent change in generation between the No Action Alternative and the action alternatives for the Parker and Davis Powerplants.

Table 4.11-17
Change in Parker and Davis Powerplants Annual Electrical Energy Generation (Percent)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(0.58)	(0.53)	(0.22)	(0.67)
Conservation Before Shortage	(0.69)	(0.79)	(0.05)	(0.70)
Water Supply	0.10	0.90	(0.73)	0.18
Reservoir Storage	(1.1)	(1.5)	1.4	(1.5)

Table 4.11-18 shows that no changes are anticipated in monthly generation capacity under the action alternatives.

Table 4.11-18
Change in Parker and Davis Powerplants Monthly Generation Capacity (MW)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	0.0	0.0	0.0	0.0
Conservation Before Shortage	0.0	0.0	0.0	0.0
Water Supply	0.0	0.0	0.0	0.0
Reservoir Storage	0.0	0.0	0.0	0.0

Figure 4.11-3 and Figure 4.11-4 depict average values of annual electrical energy production for the Davis Powerplant and the Parker Powerplant, respectively, comparing the No Action Alternative and the action alternatives.

Figure 4.11-3
Davis Powerplant
Average Values of Annual Electrical Energy Production

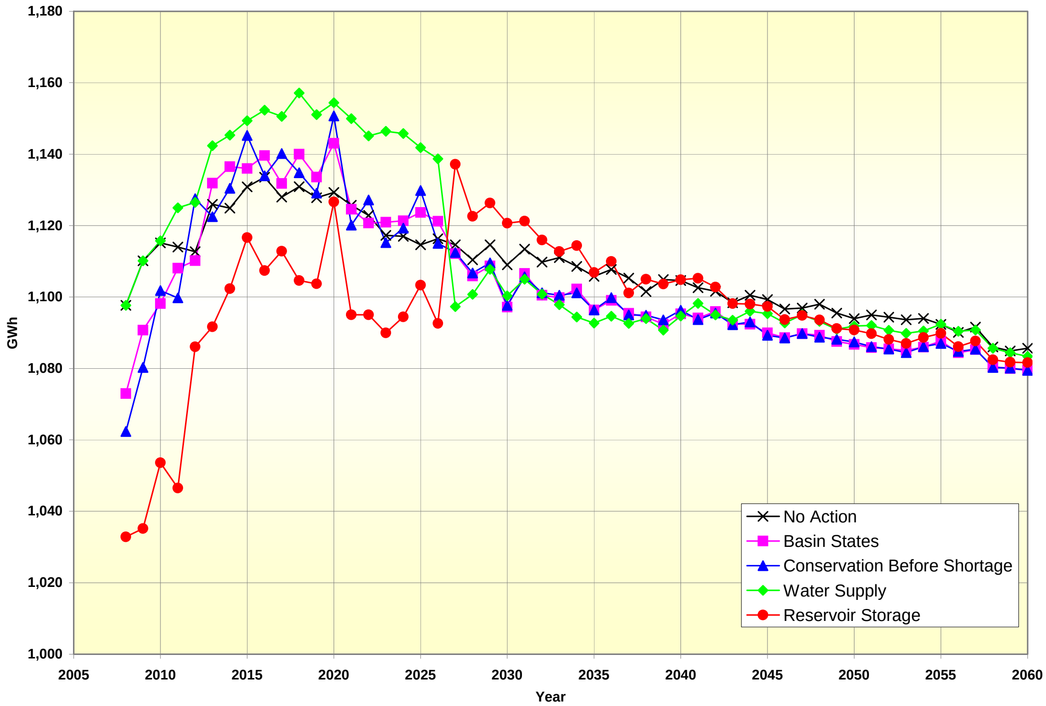
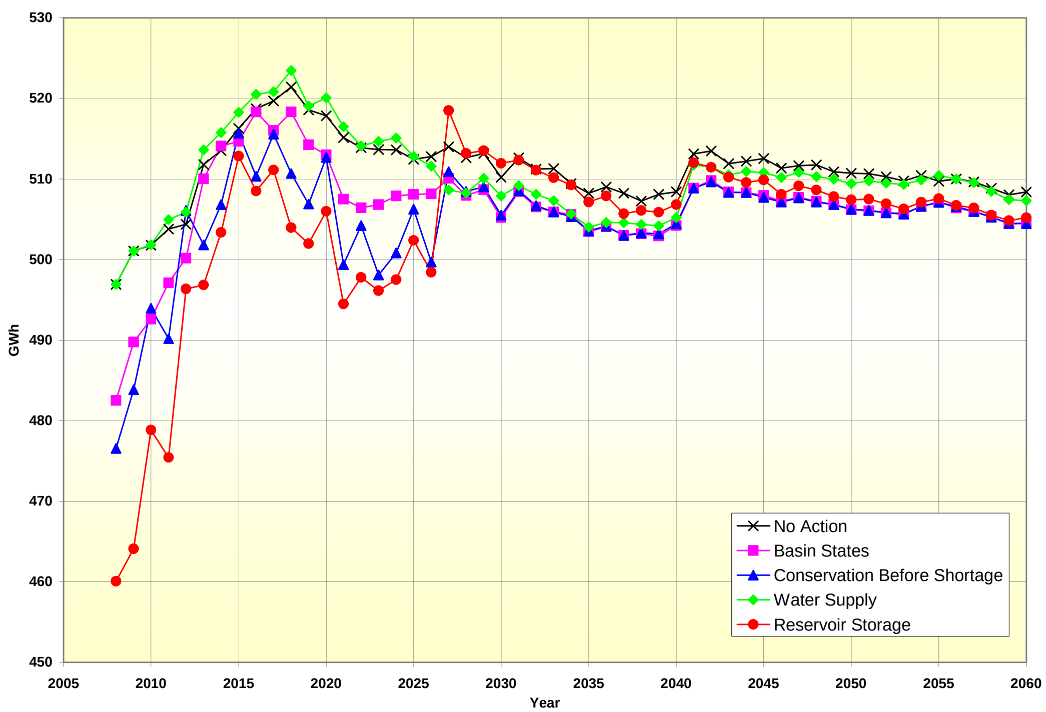


Figure 4.11-4
Parker Powerplant
Average Values of Annual Electrical Energy Production



Economic value comparisons between the No Action Alternative and the action alternatives are presented in Table 4.11-19.

Table 4.11-19
Change in Parker and Davis Powerplants Total Economic Value of Electrical Power Generation (PV 2008 $ million)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(12.39)	(11.32)	(10.17)	(12.05
Conservation Before Shortage	(16.43)	(18.14)	(11.09)	(16.26)
Water Supply	6.23	7.90	1.46	10.73
Reservoir Storage	(36.91)	(33.95)	(26.16)	(50.50)

Table 4.11-20 presents the change in economic value between the No Action Alternative and each of the action alternatives.

Table 4.11-20
Change in Parker and Davis Powerplants Total Economic Value of Electrical Power Generated (Percent)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(0.55)	(0.50)	(0.43)	(0.57)
Conservation Before Shortage	(0.73)	(0.80)	(0.47)	(0.76)
Water Supply	0.28	0.35	0.06	0.50
Reservoir Storage	(1.6)	(1.5)	(1.1)	(2.4)

In general, the Basin States and Conservation Before Shortage alternatives could potentially provide a slight decline in the economic value of electrical power generated at the Parker and Davis Powerplants. The Reservoir Storage Alternative is expected to result in a greater decline in economic values. The Water Supply Alternative results in slight increases in economic value for the Parker and Davis Powerplants.

Because of downstream requirements (i.e., environmental, plant operations and water requirements) the forebay elevations at Davis and Parker Dam Powerplants remain relatively constant and electrical power generation is proportional to inflow. Consequently, the maximum generation capacity at the Parker and Davis Powerplants will not be affected by the any of the action alternatives.

4.11.2.4 Headgate Rock Powerplant

No Action Alternative. The No Action Alternative values for annual generation and economic value at Headgate Rock Powerplant for the mean, median, 90th percentile and 10th percentile values are presented in Table 4.11-21.

Table 4.11-21
No Action Alternative Values at Headgate Rock Power Plant

Measure	Mean	Median	90th Percentile	10th Percentile
Annual Energy Generation (MWh)	77,386	73,666	85,452	69,634
Economic Value of Electrical Power Generation (PV 2008 $)	102,892,840	98,096,022	113,356,265	92,748,408

Comparison of Action Alternatives to No Action Alternative. Table 4.11-22 presents the change in annual generation for each action alternative relative to the No Action Alternative. The Water Supply Alternative provides higher median electrical energy generation due to the higher observed flows as compared to the No Action Alternative. The Basin States, Conservation Before Shortage, and Reservoir Storage alternatives provided lower electrical energy generation as compared to the No Action Alternative.

Table 4.11-22
Change in Headgate Rock Powerplant Annual Electrical Energy Generation (MWh)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(934)	(956)	(438)	(1,223)
Conservation Before Shortage	(1261)	(1,187)	(415)	(1,853)
Water Supply	(222)	161	(999)	69
Reservoir Storage	(1,366)	(2,084)	556	(2,371)

Table 4.11-23 presents the percent change in annual electrical energy generation for each action alternative relative to the No Action Alternative.

Table 4.11-23
Change in Headgate Rock Powerplant Annual Electrical Energy Generation (Percent)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(1.2)	(1.3)	(0.51)	(1.8)
Conservation Before Shortage	(1.6)	(1.6)	(0.49)	(2.7)
Water Supply	(0.29)	0.22	(1.2)	0.10
Reservoir Storage	(1.8)	(2.8)	0.65	(3.4)

Figure 4.11-5 depicts average values of annual electrical energy production for Headgate Rock Powerplant, comparing the No Action Alternative and the action alternatives.

Figure 4.11-5
Headgate Rock Powerplant
Average Values of Electrical Energy Production

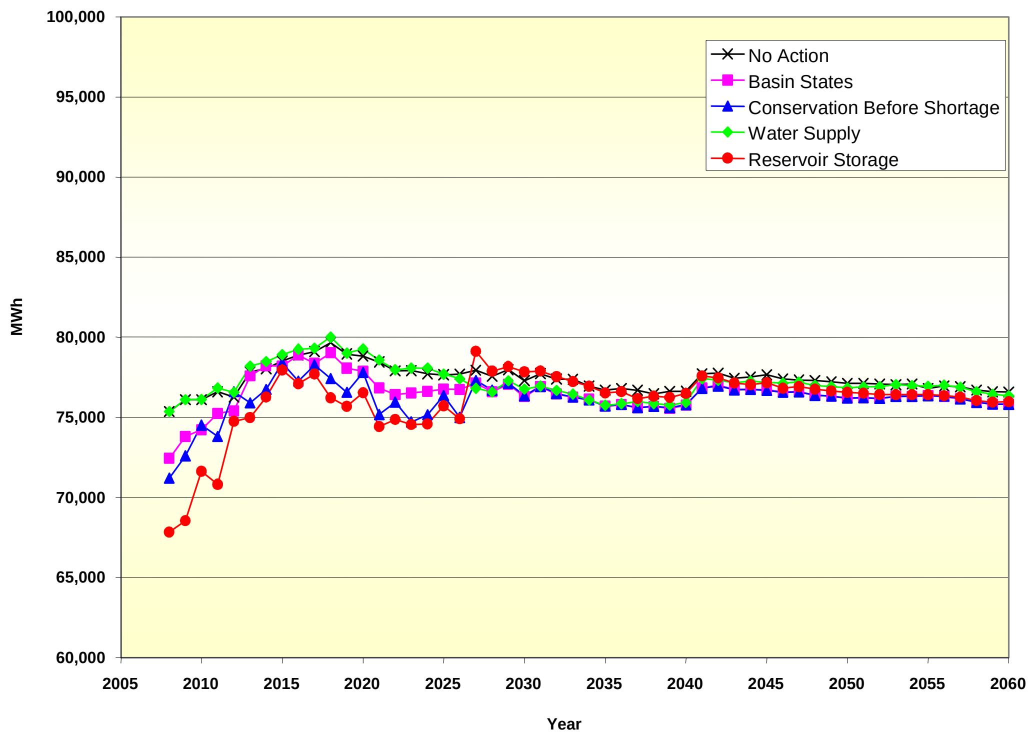


Table 4.11-24 provides an overview of the potential change in economic value of electrical power generated for each action alternative relative to the No Action Alternative.

Table 4.11-24
Change in Headgate Rock Powerplant Total Economic Value of Electrical Power Generated (PV 2008 $ million)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(1.3)	(1.4)	(0.5)	(1.9)
Conservation Before Shortage	(2.0)	(1.9)	(0.6)	(3.1)
Water Supply	(0.20)	0.26	(1.3)	0.18
Reservoir Storage	(2.6)	(3.7)	0.8	(4.3)

Table 4.11-25 provides an overview of the potential percent change in economic value of electrical power generated for each action alternative relative to the No Action Alternative.

Table 4.11-25
Change in Headgate Rock Powerplant Total Economic Value of Electrical Power Generated (Percent)

Alternatives	Mean	Median	90th Percentile	10th Percentile
Basin States	(1.3)	(1.4)	(0.44)	(2.0)
Conservation Before Shortage	(1.9)	(1.9)	(0.53)	(3.3)
Water Supply	(0.19)	0.27	(1.2)	0.20
Reservoir Storage	(2.5)	(3.8)	0.71	(4.6)

In general, the value of electrical power generated under the Water Supply Alternative could potentially be slightly higher than under the No Action Alternative. The value of electrical power generated under the Basin States, Conservation Before Shortage, and Reservoir Storage alternatives could potentially be less than under the No Action Alternative.

Currently the Headgate Rock Powerplant generates more electrical power than is needed by CRIT. Implementation of either of the action alternatives will not impact the Headgate Rock Powerplant's ability to meet CRIT's current electrical power demands. However, a reduction in Headgate Rock Powerplant generation could impact BIA's ability to meet new Tribal energy demands.

4.11.2.5 Basin Power Funds

Upper Colorado River Basin Fund. As noted in section 3.11, approximately $175 million is needed each year to fund Reclamation and Western operating needs. Western is responsible for transmission and marketing of CRSP power, collecting payment for the power, and the transfer of revenues for repayment to the General Treasury.

Implementation of the various alternatives could result in more variation in the Upper Colorado River Basin Fund (Basin Fund), and could lead to additional actions such as power rate adjustments, rate surcharges, or reductions to customer allocations to respond to shortfalls in revenue under dry conditions. Western and its power customers need to quickly respond to changing hydrological conditions to forestall possible financial problems.

In addition, if an alternative were to increase or decrease Glen Canyon Powerplant electrical power generation over an extended period of time, Western and its power customers might decide to increase or decrease allocations in response, which could, in turn, affect the rate Western charges for the power and its financial reserves in the Basin Fund. A rate increase could affect customers' generation and power purchase decisions as well as their overall financial condition.

An important aspect associated with power delivery is whether and how much one or more of the alternatives alters the probability of a total loss of generation from Glen Canyon Powerplant. Loss of Glen Canyon Powerplant generation would result in a loss of revenue to Western, Reclamation, and various environmental programs in the Upper Basin; loss of generation and replacement costs for power customers; and degradation to power system reliability.

Figure 4.11-6 shows the percentage of end-of-March elevations from Reclamation's CRSS modeling output that are less than or equal to elevation 3,490 feet msl. March typically has the lowest reservoir elevation of the year and elevation 3,490 feet msl is the point at which electrical power can no longer be produced at the Glen Canyon Powerplant. Using this measure, the Water Supply Alternative is more likely to provide conditions that would result in the Lake Powel elevation falling below the minimum power pool elevation of 3,490 feet msl, as compared to the No Action Alternative. The Reservoir Storage, Basin States, and Conservation Before Shortage alternatives have equal or slightly lower probabilities than the No Action Alternative. An analysis of end-of-July elevations indicated that these values are less pronounced than the end-of-March elevations, but similar.

Lower Colorado River Basin Development Fund. The functions of the Development Fund are to collect revenues and repayment associated with CAP, and to fund expenses related to the Colorado River Salinity Control Program and projects as directed by the Arizona Water Rights Settlements Act (P.L. 108-451).

An important aspect associated with power delivery is whether and how much one or more of the alternatives alters the probability of a total loss of generation from the Hoover Powerplant. Loss of Hoover Powerplant generation would result in a loss of revenue to Western, Reclamation and various environmental programs in the Lower Basin; loss of generation and replacement costs for power customers; and, degradation to power system reliability.

Figure 4.11-7 shows the percentage of end-of-December elevations from Reclamation's CRSS modeling output that are less than or equal to elevation 1,050 feet msl. This elevation is the point at which it is currently assumed that power can no longer be produced at the Hoover Powerplant.

Figure 4.11-6
Lake Powell End-of-March Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3,490 feet msl

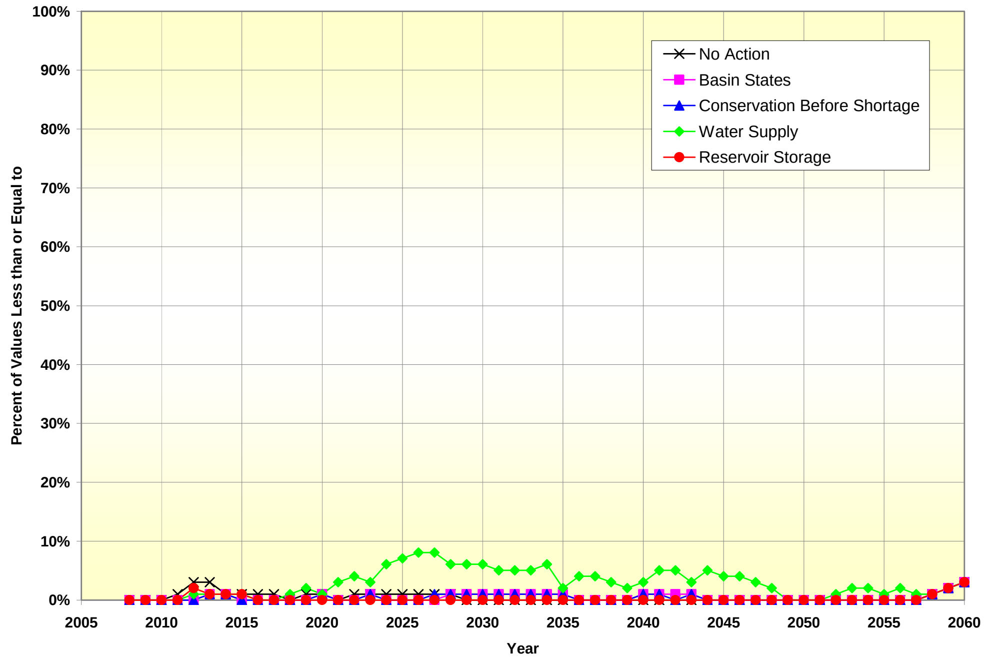
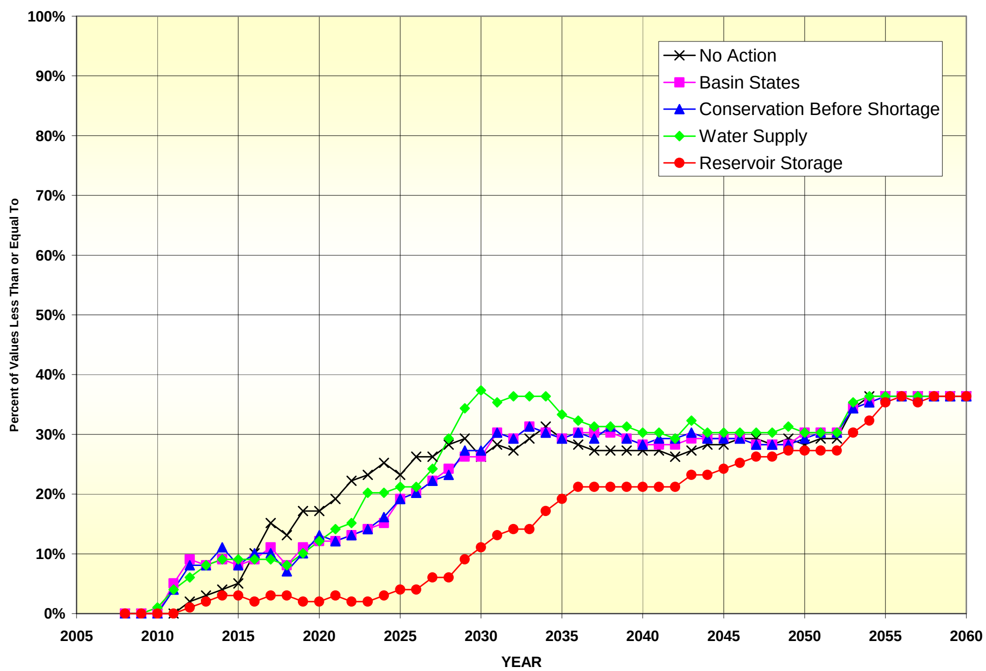


Figure 4.11-7
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 1,050 feet msl



Using this measure, the Water Supply Alternative is slightly more prone to fall below the minimum power pool than the No Action Alternative, while the Basin States and Conservation Before Shortage alternatives have equal or slightly lower probabilities than the No Action Alternative. The Reservoir Storage Alternative has much lower probabilities of falling below this elevation. Values for end-of-December elevations are less pronounced, but similar.

Any of the alternatives that reduce electrical power production would reduce the surcharge revenues available to defray costs associated with the Colorado River Basin Salinity Control Act (Title II) and the CAP repayment.

Colorado River Dam Fund. The Colorado River Dam Fund (Dam Fund) is utilized to fund operation and maintenance payments to states, visitor services, up-rating program, replacements, investment repayment and interest expenses of the Boulder Canyon Project. The Annual Revenue Requirement is typically approximately $60 to $70 million per fiscal year.

Since implementation of the various alternatives could result in more variation in the Dam Fund cash reserves, this could lead to additional actions, such as power rate adjustments, or reductions to contractors allocations to respond to shortfalls in capacity, energy and revenues under dry conditions.

4.11.2.6 System-Wide Electrical Power Issues

Conservation Before Shortage Surcharge. The Conservation Before Shortage Alternative imposes a power customer surcharge that is expected to amount to between $1.5 million and $12.3 million depending on the level of a voluntary water conservation shortage implemented in a particular year (e.g. 400,000, 500,000, or 600,000 af) and the cost of conserved water. The surcharge on a 600,000 af declared shortage is to cover at a minimum the cost of 122,500 af of water. It is estimated that this would cost between $20 - $100 per af.

This surcharge is not included in the current economic analysis at any of the Upper or Lower Basin facilities or Basin Funds. Surcharges imposed are typically not included within Western's or Reclamation's electrical power rate structure. For example, the current 4.5 mil and the 2.5 mil rate imposed on Hoover Powerplant and P-DP power contractors to help repay Reclamation’s CAP project construction costs and to provide funding for salinity projects are a separate part of the contractor’s bill.

Imposing a surcharge on power revenues would require separate legislation. Rate making authority, except for Reclamation project use power, lies with Western, therefore such changes would be under the purview of the Secretary of the Department of Energy and the United States Congress.

Ancillary Service Impacts. In addition to generating electrical power, each of the power generation facilities in the study area provides other electrical products and services referred to as ancillary services. Ancillary services are those services necessary to keep the power grid functioning continuously, safely, and reliably.

Western, as an operator of multiple control areas (referred to also as balancing authorities), is required by the Federal Energy Regulatory Commission to offer ancillary services to entities purchasing transmission services in its control areas. Entities purchasing transmission are required to self supply ancillary services or purchase ancillary services from third parties. The Hoover Powerplant capacity and energy is dynamically scheduled to the contractors which allows certain ancillary services to be utilized in other control areas. The Hoover Powerplant is also a significant source of reserves, regulation and frequency control for non-Western control areas in California, Arizona, and Nevada.

Reserves. Because of low load factors at the Glen Canyon Powerplant and the Hoover Powerplant, at any given time there are hundreds of megawatts of spinning or supplemental reserves that can be called on to respond to generating unit outages and power system emergencies. The available unscheduled capacity at Davis Powerplant and Parker Powerplant is used primarily for reserves. In addition, the generation units at Davis Powerplant have a portion of their capacity that are used exclusively for reserves.

Action alternatives that reduce or eliminate capacity at the Glen Canyon Powerplant and the Hoover Powerplant will reduce or eliminate reserve capacity as well, impacting reliability of the power system, and impacting revenue to Western or specific projects. None of the proposed alternatives are expected to have a significant impact on reserves at Davis Powerplant and Parker Powerplant since the associated lake elevations are not affected. A reduction in electrical power production at these powerplants would create a slight increase in the average reserve capacity available.

Regulation and Frequency Control. Regulation and frequency control is needed to maintain power system stability and the moment-to-moment balance between load and generation. Reductions in electrical power generation from the Glen Canyon Powerplant and the Hoover Powerplant would impact the ability of the powerplants to provide regulation services. Although the generating units are able to regulate throughout most of their operating range, the amount of regulation available decreases as generating capability decreases.

The Hoover Powerplant is primarily used to provide regulation for the control area. However, the Davis Powerplant has some capability for regulation and frequency control, but the available unscheduled capacity at the Davis Powerplant is used almost exclusively for reserves.

Any of the alternatives that cause the Glen Canyon Powerplant or the Hoover Powerplant to stop generating completely due to low reservoir elevation (below the minimum power pool elevation), could potentially eliminate regulation as well. As shown on Figures 4.11-

6 and 4.11-7, the Water Supply Alternative poses the greatest risk to regulation and frequency control at the Glen Canyon and Hoover Powerplants.

Reactive Supply and Voltage Control. Reactive power is power required to “charge” the transmission lines and associated electrical equipment that comprise the power grid. Unlike other ancillary services that can assist the power system over large geographical areas, reactive supply and voltage control are limited to small areas. Glen Canyon Powerplant supplies reactive power to northern Arizona and southern Utah. For the Hoover Powerplant, that area would include northwestern Arizona, Southern Nevada and southeastern California. Without an adequate supply of reactive power and constant monitoring, power system voltages can increase or decrease beyond acceptable limits, leading to system instability, cascading outages, and damage to electrical equipment.

Black Start Capability. Black Start Service, also referred to as Startup Service consists of providing the electrical power needed to start up a generating plant, usually after a system emergency (e.g. large scale blackout) that causes loss of electricity from the generating station.

The Glen Canyon Powerplant is relied upon to provide black start capability to the power system. The Hoover Powerplant is relied upon to provide the same capability to the power system and also for Palo Verde Nuclear Generating Station located outside of Phoenix, Arizona. Similar to regulation and frequency control, the Water Supply Alternative is most prone to cause the Glen Canyon Powerplant and Hoover Powerplant to stop generating completely due to low reservoir elevation conditions. The Davis Powerplant and Parker Powerplant do not provide Black Start Service.

Contract Commitments. Western contracts with preference power customers to supply firm energy and capacity. Currently, about 243 municipalities, rural electric cooperatives, Indian tribes, irrigation districts, and state and federal facilities in Arizona, Nevada, New Mexico, Colorado, Utah, and Wyoming are served from Salt Lake City Area Integrated Project (SLCA/IP) power facilities, which includes the Glen Canyon Powerplant. The Hoover Powerplant contractors have an allocation from Western for a specific quantity of contingent capacity and associated firm energy.

At the Glen Canyon Powerplant, the current contracts went into effect in October, 2004 and extend through September, 2024. At the Hoover Powerplant, the current contracts went into effect in June, 1987 and extend through September, 2017. For the P-DP, current contracts went into effect in October, 1988 and extend through September, 2008. Western is near concluding the process of finalizing these contractual commitments through September 2028.

Each contractor has an allocation from Western for a specific quantity of energy and capacity each month. Western guarantees that the minimum quantity of energy will be available for contractors, and purchases power to meet that level whenever hydropower generation is insufficient to supply the required amount (referred to as firming purchases). Hydropower generation above the minimum level is also allocated to contractors on an as-available basis as operational and hydrological conditions allow.

As has been described earlier in this section, an alternative may increase or decrease energy generation and capacity at the Glen Canyon Powerplant or the Hoover Powerplant. Western has the ability to modify its contract commitments to its electrical power customers when a change in the volume of water released at these dams results in changes in electrical generation and capacity. For example, if an alternative reduced energy generation and capacity at the Glen Canyon Powerplant over the long-term average, Western would have the ability to lower its contract commitments to those customers who have contracts that include Glen Canyon Powerplant electrical power. The lower commitments would cause these customers (electrical utilities) to add new generating facilities, speed up planned construction of new generating facilities or take other action to make up for the reduction in Western's contract commitment. The estimated values of these actions by customers are what is portrayed in the tables in this section.

Energy and capacity allocations to contractors can be revised when the contracts are renewed. Allocations to contractors after contract terms expire will depend upon projections of future capacity and energy.

4.11.2.7 Electrical Power Use Associated with Water Supply Systems

This section discusses potential changes in pumping costs for the following entities that pump water from Lake Powell: the NGS which obtains cooling water from Lake Powell, the City of Page which obtains municipal water from Lake Powell; SNWA which obtains water from Lake Mead; and CAP and MWD which divert water from Lake Havasu. Incremental differences in pumping costs are associated with differences in modeled average Lake Powell, Lake Mead, and Lake Havasu elevations between the No Action Alternative and the action alternatives.

River system modeling provided the average elevations for Lake Powell, Lake Mead, and Lake Havasu under the No Action Alternative and the action alternatives. Increases or decreases in net effective pumping head correspond with decreases or increases in reservoir elevations. Estimates of the differences in pumping costs were calculated using these changes in pumping head, as well as estimates of annual pumping volumes, unit electrical power costs and pump efficiency.

Navajo Generating Station. The SRP estimates that water use at NGS will be approximately 29,000 afy in the future. Power for the intake pumps is obtained from auxiliary power units at the NGS at a cost of $0.0104 per kWh. Table 4.11-26 identifies changes in electrical power requirements for the alternatives and the associated increase or decrease in cost.

Table 4.11-26
Change in Navajo Generating Station Intake Electrical Power Requirements at Lake Powell [1]

Alternatives	Change in Annual Electrical Power Requirement (kWh)[2]	Change in Associated Annual Cost ($)
Basin States	124,365	$1,293
Conservation Before Shortage	114,167	$1,187
Water Supply	277,648	$2,888
Reservoir Storage	(75,925)	($790)

1. *Assumes 29,000 afy of Pumping, Cost = E (kWh) = $0.0104*
2. *E (kwh) = 1.024 * V (afy) * H (ft)/E (%)*

City of Page Water Supply. As noted in Section 3.12, the average annual water demand by the City of Page in recent years has been around 2,650 afy. Annual electrical power demand to deliver the water has averaged around 3,900,000 kWh per year over the past 10 years. Under the No Action Alternative, using the current rate of $.03286 per kWh (includes overhead), the annual cost of electrical power for pumping the water is around $130,000 per year.

Table 4.11-27 summarizes the differences in pumping costs for the Reclamation-operated raw water intake serving the City of Page. The greatest increase would be under the Water Supply Alternative which would be an average $829 per year or, in comparison to the total annual the No Action Alternative cost of $130,000, an approximate increase of less than one percent. In general the effect on City of Page pumping costs would be minor under all alternatives.

Table 4.11-27
Change in City of Page Intake Electrical Power Requirements at Lake Powell [1]

Alternatives	Change in Annual Electrical Power Requirement (kWh)[2]	Change in Associated Annual Cost ($)
Basin States	11,364	$371
Conservation Before Shortage	10,433	$341
Water Supply	25,371	$829
Reservoir Storage	(6,938)	($227)

1. *Assumes 2,650 afy of Pumping, Cost = E (kWh) = $0.03286*
2. *E (kWh) = 1.024 * V (afy) * H (ft) / E(%)*

SNWA Water Supply. Pumping costs under the No Action Alternative were not calculated. However, under the No Action Alternative, the average elevation of Lake Mead declines from 2008 through 2060. Also, the chance that lake elevations could drop below the minimum power pool elevation of 1,050 feet msl increases for all alternatives, with the Reservoir Storage Alternative resulting in the smallest increase in probability. These results also suggest that under the No Action Alternative, SNWA can expect pumping costs to increase due to the increase in net effective pumping head. The cost of pumping varies with each of the action alternatives as an increase or decrease compared to the No Action Alternative. Table 4.11-28 shows the potential differences between pumping costs under the action alternatives to those under the No Action Alternative.

Table 4.11-28
Change in Estimated SNWA Pumping Costs

Alternative	Change in Cost ($)
Basin States	(45,560.76)
Conservation Before Shortage	(68,341.14)
Water Supply	273,364.56
Reservoir Storage	(1,870,198.68)

The change in pumping costs shown in Table 4.11-28 consider the difference in the average of the 50th percentile (median) Lake Mead annual elevation values from 2008 to 2060 under each action alternative to that of the No Action Alternative. The differences in the average of the median elevations (between each action alternative and the No Action Alternative) was multiplied by the estimated annual SNWA combined pumping costs for the two SNWA intake pump stations (Levy 2006 personal communication) corresponding to the respective Lake Mead elevations. A positive number in Table 4.11-28 indicates an increase in annual SNWA pumping costs and a negative number (in parenthesis) indicates a potential savings in annual SNWA pumping costs.

CAP Pumping Load. Under all alternatives, when shortages are imposed on CAP there is an associated reduction in electrical power requirements to pump water and more of CAP's share of NGS generation is available to be marketed (after 2011). For a 500,000 af shortage (at $48/MWh), the annual market value of the electrical power available to be marketed is approximately $41 million.

This revenue would benefit all CAP users to the extent it would be used to offset CAWCD's repayment obligation, as well as Indian tribes that benefit from the AWSA. The Reservoir Storage Alternative would result in the greatest overall shortages, and therefore the greatest reduction in CAP pumping load.

4.11.2.8 Summary Comparison of Alternatives

Table 4.11-29 summarizes effects of each of the action alternatives compared to the No Action Alternative for electrical energy generation, generation capacity, and associated economic effects.

Table 4.11-29
Summary Comparison of Action Alternatives to No Action Alternative
Mean Values for Electrical Energy Generation, Generation Capacity, and Economic Value

	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
Glen Canyon Powerplant					
Annual Energy Generation (MWh)	4,265,749	4,255,233	4,256,656	4,169,950	4,292,417
Change in Annual Energy Generation (MWh)	0.0	(10,516)	(9,093)	(95,799)	26,668
Change in Annual Energy Generation (Percent)	0.0	(0.25)	(0.21)	(2.2)	0.63
Monthly capacity (MW)	603	606	607	592	613
Change in Monthly Capacity (MW)	0.0	3.4	3.6	(11.2)	9.6
Change in Monthly Capacity (Percent)	0.0	0.57	0.60	(1.9)	1.6
Economic Value of Electrical Power Generation – Total (PV 2008 $ Million)	6,808	6,803	6,805	6,669	6,870
Change in present value of Electrical Power Generation (PV 2008 $ Million)	0.0	(4.72)	(2.79)	(139.27)	62.43
Change in Present Value of Electrical Power Generation (Percent)	0.0	(0.07)	(0.04)	(2.05)	0.92
Hoover Powerplant					
Annual Energy Generation (MWh)	3,156,820	3,171,189	3,175,390	3,108,539	3,430,839
Change in Annual Energy Generation (MWh)	0	14,369	18,570	(48,281)	274,019
Change in Annual Energy Generation (Percent)	0.0	0.46	0.59	(1.5)	8.7
Monthly capacity (MW)	1,201	1,214	1,217	1,178	1,337
Change in Monthly Capacity (MW)	0.0	12.7	15.5	(22.9)	136.0
Change in Monthly Capacity (Percent)	0.0	1.1	1.3	(1.9)	11.3
Economic Value of Electrical Power Generation – Total (PV 2008 $ Million)	7,351	7,426	7.441	7,263	8,093
Change in present value of Electrical Power Generation (PV 2008 $ Million)	0.0	75.4	90.0	(88.4)	742.5
Change in Present Value of Electrical Power Generation (Percent)	0.0	1.03	1.22	(1.2)	10.1

Table 4.11-29
Summary Comparison of Action Alternatives to No Action Alternative
Mean Values for Electrical Energy Generation, Generation Capacity, and Economic Value

	No Action	Basin States	Conservation Before Shortage	Water Supply	Reservoir Storage
Parker and Davis Powerplant					
Annual Energy Generation (MWh)	1,618,736	1,609,419	1,607,527	1,620,329	1,600,484
Change in Annual Energy Generation (MWh)	0	(9,318)	(11,210)	1,593	(18,253)
Change in Annual Energy Generation (Percent)	0.0	(0.58)	(0.69)	0.10	(1.1)
Monthly capacity (MW)	331.4	331.4	331.4	331.4	331.4
Change in Monthly Capacity (MW)	0	0	0	0	0
Change in Monthly Capacity (Percent)	0.0	0.0	0.0	0.0	0.0
Economic Value of Electrical Power Generation – Total (PV 2008 $ Million)	2,243	2,230	2,226	2,249	2,206
Change in present value of Electrical Power Generation (PV 2008 $ Million)	0.0	(12.4)	(16.4)	6.2	(36.9)
Change in Present Value of Electrical Power Generation (Percent)	0.0	(0.55)	(0.73)	0.28	(1.6)
Headgate Rock Powerplant					
Annual Energy Generation (MWh)	77,386	76,452	77,059	78,425	76,242
Change in Annual Energy Generation (MWh)	0	(934)	(1,261)	(222)	1,366
Change in Annual Energy Generation (Percent)	0.0	(1.2)	(1.6)	(0.29)	(1.8)
Economic Value of Electrical Power Generation – Total (PV 2008 $ Million)	103	102	101	103	100
Change in present value of Electrical Power Generation (PV 2008 $ Million)	0.0	(1.3)	(2.0)	(0.20)	(2.6)
Change in Present Value of Electrical Power Generation (Percent)	0.0	(1.3)	(1.9)	(0.19)	(2.5)

4.11.2.9 Generation Facilities

Glen Canyon and Hoover Powerplants. Table 4.11-29 presents the potential changes in generation, capacity, and economic value of electrical power. The Basin States, Conservation Before Shortage Alternative, and Water Supply alternative result in minor variations for each of these parameters. Because of generally lower elevations, the Water Supply Alternative would have the greatest adverse effect on electrical power production and value. Most of these changes are less than one percent, however, and these alternatives result in both positive and negative variations. Therefore, these impacts are considered minor. The Reservoir Storage Alternative generally results in greater positive changes with respect to electrical power production and value because of higher reservoir elevations and would result in moderate beneficial effects, particularly in the case of the Hoover Powerplant.

Parker-Davis Project and Headgate Rock Powerplants. These facilities are generally considered to be "run of the river" electrical power generation facilities and are affected primarily by release volumes from Hoover Dam. As shown in Table 4.11-29, the Basin States, Conservation Before Shortage, and Reservoir Storage Alternatives all generally result in minor decreases in electrical power production and value at these facilities as compared to the No Action Alternative because they result in lower release volumes downstream of Hoover Dam, with the Reservoir Storage Alternative having the greatest adverse effects. Again, these changes are relatively minor (most less than one percent). The Water Supply Alternative results in greater release volumes downstream and therefore slight increases in electrical power production and value as compared to the No Action Alternative. These increases are considered beneficial but also minor as compared to overall electrical power production at these facilities.

Water Supply Systems. As presented in Table 4.11-29, the Basin States, Conservation Before Shortage, and Water Supply alternatives would generally result in lower elevations at Lake Powell, as compared to the No Action Alternative, and therefore could potentially result in increased pumping costs for the NGS and City of Page, with the Water Supply Alternative resulting in approximately twice the increase in costs as compared to the other action alternatives

The Reservoir Storage Alternative would result in generally higher reservoir elevations and therefore reduced pumping costs as compared to the No Action Alternative. This beneficial effect is also considered minor.

Basin Power Funds. Reductions in power revenues could reduce the amount of money available to meet the intended uses of these funds, possibly leading to reductions in allocations to power contractors or power rate adjustments. The action alternatives generally have a minor impact on the economic value of electrical power generation at Glen Canyon and Hoover Powerplants. However, total loss of electrical power generation capabilities would have a substantial effect on the basin power funds. At the Glen Canyon Powerplant, the probability this type of loss in electrical power generation capability is very small (less than five percent) except for the Water Supply Alternative, which would result in as much as a nine percent probability. At the Hoover Powerplant, the probability of total loss of generation is higher, increasing from the current negligible probability to about 30 percent in 2026. As shown in Figure 4.11-7, the Reservoir Storage Alternative is the exception to this, while the remaining alternatives are very similar to the No Action Alternative.

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4.12 Recreation

This section discusses the recreational resources within the study area that may be affected by the proposed federal action. Topics include:

- Shoreline public use facilities;
- Reservoir boating;
- River and whitewater boating; and
- Sport fishing.

4.12.1 Methodology

The following methods were used to determine effects of the alternatives on recreation resources.

4.12.1.1 Method Used to Assess Shoreline Public Use Facilities

These sections examine the probabilities that reservoir elevations would decrease below critical thresholds for use of selected marinas, boat docks, and boat launch ramps. These sections also assess whether impacts would occur in access to or use of attraction features. Threshold reservoir elevations were determined by reviewing published sources and through personal communication with Reclamation, NPS, and resource specialists, and from public comments provided during scoping for this Draft EIS. The threshold elevations were used as indicators of recreational facilities that might be rendered inoperable or require relocation or modification to maintain their operation. Projections of reservoir elevations for 2008, 2016, 2025, 2040, 2050, and 2060 are provided in Section 4.3. The narrative of effects of the alternatives is provided below for selected facilities in July or September, representing relatively high visitation months for both Lake Powell and Lake Mead. These facilities are representative of potential effects of the alternatives on shoreline recreation opportunities at each reservoir. Results are described for 2026, representing the end of the interim period. For Lake Powell, Wahweap Marina was selected for description in the narrative due to its popularity with boaters. For Lake Mead, Pearce Ferry at the in-flow area to the reservoir is described. Effects on Echo Bay Public Launch Ramp are also described in the narrative because it represents a facility that closes at a relatively low reservoir elevation of 1,050 feet msl.

4.12.1.2 Method Used to Assess Reservoir Boating

This analysis assesses the probabilities that reservoir elevations would decrease below critical thresholds for boating navigation hazards and change navigable areas and passageways, and whether decreases in reservoir surface area might affect safe boating capacities. Threshold pool elevations were determined by reviewing published sources and through personal communication with Reclamation, NPS, and resource specialists, and from public comments.

In general, the surface area of the reservoirs available for boating is reduced when the reservoir elevation drops and this may affect the number of boats that can safely operate at one time referred to as safe boating density. Safe boating density could be used to assess the effects of each alternative on boating safety if daily boating levels for the reservoirs were available. However, recent and consistent information on the level of daily or peak boating use, such as whether the current boating densities on the reservoirs have approached or exceeded the safe boating density is not available. Without information on current reservoir boating densities, it cannot be determined whether any reductions in pool elevations at Lake Powell and Lake Mead associated with the alternatives would result in unsafe boating conditions due to a corresponding increase in boating density. Personal communications with boaters and NPS managers suggest that Lake Mead and Lake Powell have not exceeded safe boating densities.

Navigation hazards and shallow waters require boaters to take detours around inaccessible areas. This may add mileage to trips and may influence recreational boaters to remain in specific areas, which can result in congestion in those areas. Additionally, as reservoir elevations drop and surface area decreases, congestion may become more noticeable in popular areas that receive high-use or where narrow travel corridors exist.

4.12.1.3 Method Used to Assess River and Whitewater Boating

This analysis uses river flow data from Section 4.3 to analyze whether there would be increased exposures to boating navigation hazards, changes in access or use of rest areas and take-outs, or changes in trip durations resulting from the action alternatives compared to the No Action Alternative. Whitewater boating is the key recreational activity in the Grand Canyon below Lees Ferry and above Lake Mead. Other reaches do not provide whitewater boating opportunities and, therefore, are not addressed.

Threshold river flows were determined by reviewing published sources and through personal communication with river managers and from comments received during scoping. These representative river flows were chosen as indicators for whitewater boating safety and the availability of rest areas and take-out points.

This analysis also includes a discussion of areas on the river that could become unsafe for whitewater boating at certain flows due to hazards such as exposed rocks, changes in navigation patterns caused by obstructions, and increased or decreased river velocities. These flows were also analyzed to determine elevations at or below which various whitewater boating facilities (rest areas and take-out points) might be rendered inoperable or require modification to maintain their operation.

4.12.1.4 Method Used to Assess Sport Fishing

This analysis evaluates changes in sport fishing opportunities by reach among the action alternatives compared to the No Action Alternative. The assessment of sport fishing was based on a literature review to determine the current status of fish assemblages in the study area. No specific reservoir pool elevation thresholds related to sport fishing were found. A general discussion about changes in flow and salinity and possible effects on sport fish is also provided.

A more detailed analysis of effects to rainbow trout based on changes in water temperature is used for the Colorado River reach between Glen Canyon Dam and Lake Mead. Water temperature changes may affect sport fish. Rainbow trout were chosen for the analysis based on the importance of its recreational fishery in the Colorado River reach below Glen Canyon Dam.

Striped bass and threadfin shad in Lake Powell and Lake Mead were selected to represent the reservoir sport fishery; striped bass are a sports fish and threadfin shad are their food source. Striped bass feed on threadfin shad, and when shad are abundant, striped bass are able to reproduce and grow quickly. The resulting increased bass population continues feeding on the threadfin shad, and they deplete the shad populations. Striped bass decline in numbers and predation on shad decreases. This causes the threadfin population to increase again. This cycle has been occurring since the first introduction of striped bass into Lake Powell in 1974 and is expected to continue in the future (Gustaveson 1999).

Rainbow trout and its water temperature thresholds were used to analyze potential differences in impacts between the alternatives below Glen Canyon Dam. Minimum, maximum, and lethal water temperatures for various life history stages were determined and months that spawning, incubation and growth occur were established. The 10th percentile data were used to analyze potential effects because the 50th and 90th percentile data are essentially identical between the alternatives and no meaningful differences exist. It is important to note that the 10th percentile elevations are unlikely to occur in any given year or consistently over time (Section 4.2). Modeled temperature data at Glen Canyon Dam, the Little Colorado River confluence, and at Diamond Creek were used in the trout fishery analysis. A qualitative analysis of potential water temperature changes and effects on rainbow trout were made by comparing the differences between water temperatures under the No Action Alternative and the action alternatives.

Water Temperature Assessment. Surface minimum and maximum monthly water temperature data (up to 10 feet below the surface) for Lake Powell were provided and compared to striped bass and threadfin shad thresholds to determine whether potential surface temperatures would exceed the lethal tolerances of striped bass or threadfin. Striped bass lower lethal limit is 5°C and upper lethal limit is 33°C. Threadfin shad have an upper lethal limit of 37°C and a lower lethal limit of 5°C.

Modeled river temperatures (Section 4.5 and Appendix P) were used to assess the possible effects on rainbow trout in the river section from Glen Canyon Dam to Diamond Creek (Tables 4.5-4 to 4.5-9 and Appendix P). Conditions supporting rainbow trout spawning and incubation were assumed to deteriorate as temperature warms beyond 15ºC (Table 4.12-1). Trout eggs that are subjected to temperatures warmer than 15ºC are prone to increased mortality (Table 4.12-1). Juvenile rearing success is assumed to deteriorate at water temperatures ranging from 17ºC to 25ºC. Rainbow trout can be expected to show significant mortality at temperatures exceeding 25ºC (Myrick and Cech 2001; Raleigh et. al. 1984) (Table 4.12-1).

Table 4.12-1
Water Temperature Tolerances of Rainbow Trout (ºC)

Species	Species Code	Spawning			Incubation			Growth			Lethal	
		Minimum	Maximum	Optimum	Minimum	Maximum	Optimum	Minimum	Maximum	Optimum	Low	High
Rainbow Trout	RBT	8	13	10	7	15	10	12	21	16	0	25

In the Colorado River, rainbow trout are year-round residents. Spawning typically begins in January and continues into May, with peak spawning occurring in March and April (Korman et. al. 2005) (Table 4.12-2). During spawning, the female digs a redd (i.e., gravel nest) where the eggs are deposited, and they are then fertilized by the male. The optimal water temperature for trout spawning and incubation has been reported to fall between 7ºC and 15ºC (Table 4.12-1). Incubation lasts from 1.5 months to 4 months, depending on water temperature (Table 4.12-2).

Newly emerged fry move to shallow, protected areas along stream banks, but as they grow, they move to faster, deeper areas of the river. Shallow riffles are the most important channel type for trout during their first year (Barnhart 1986). Juvenile trout generally use riffles and runs in the main and secondary channels, along with the head and tail of pools. Juvenile rearing success is assumed to deteriorate at water temperatures ranging from 17ºC to 25ºC. Juvenile trout feed on a variety of aquatic and terrestrial insects and other small invertebrates.

Table 4.12-2
Life History of the Rainbow Trout, Phases by Months

Phases	Citations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning	2,4,5	■	■	■	■	■							
Egg Incubation	2,4,5	■	■	■	■	■	■	■	■				
Juvenile Rearing	2,4,5	■	■	■	■	■	■	■	■	■	■	■	■
Residence	1, 2, 3	■	■	■	■	■	■	■	■	■	■	■	■

1 Lake Powell n.d. Available at: http://www.waterquality.utah.gov/watersheds/lakes/LAKEPOWL.pdf. Accessed October 27, 2006.

2 GCDAMP (Glen Canyon Dam Adaptive Management Program). n.d. Lees Ferry trout fishery. Available at: http://www.pn.usbr.gov/keyresc/tf.html. Accessed October 27, 2006.

3 Fishing in Laughlin, Nevada. 2006. Available at: http://www.laughlinnevadaguide.com/fish.htm. Accessed October 27, 2006.

4 Valdez 1993. Non-native fishes of Grand Canyon. Available at: http://www.gcrg.org/bqr/6-4/fishes.htm. Accessed: October 27, 2006.

5 Korman et. al. 2005, 21.

Salinity Assessment. Salinity levels were assessed below Hoover Dam and it was determined that future salinity levels would not affect rainbow trout (Section 4.5). Striped bass are naturally a brackish to salt water species, so the slight increase in salinity should have no effect on striped bass or threadfin shad. Therefore this issue is not discussed further.

Flow Assessment. Flow reductions that occur outside of spawning periods of fish are expected to have minimal impacts on fish species because habitat is likely not a factor limiting their populations. Extreme reductions, however, could result in the loss of fish through stranding and reduction in water quality (e.g., dissolved oxygen, temperature). The abundance of sports fishes, however, would be expected to recover following flow reduction periods through natural reproduction and through augmentations under fish stocking programs.

Flow reductions during the spawning period could desiccate eggs or strand juvenile fish. Impacts on sport fishes are expected to be minimal because their populations are relatively large and would be expected to recover following reduced flow conditions through natural reproduction and through augmentations under fish stocking programs.

Given that releases from Glen Canyon Dam would remain within their historic range, its was concluded that changes in flow would not be a useful tool to analyze effects on sport fish in this reach of the river. The reaches below Hoover Dam are also expected to continue with operations similar to historic conditions. Therefore flow assessment was not used in this analysis.

4.12.2 Recreation at Lake Powell

Table 3.12-3 identifies the threshold elevations below which shoreline recreational facilities at Lake Powell could be affected. Below these elevations, facility adjustments or capital improvements would be required, creating potential impacts on recreation at Lake Powell. Figures 4.3-3 through 4.3-11 and Tables 4.3-2 through 4.3-10 show the percentage of values less than or equal to these threshold elevations during the study period.

4.12.2.1 Access or Use of Lake Powell Boating Facilities

No Action Alternative. In July 2026, there is a six percent chance that elevations will be less than 3,560 feet msl, resulting in the closure or modification of Wahweap and lower Bullfrog launch ramps. Table 4.3-7 and Figure 4.3-8 provide the data for all years and all alternatives.

Basin States and Conservation Before Shortage Alternatives. In July 2026, there is an eight percent chance of closing Wahweap and lower Bullfrog launch ramps under these two alternatives.

Water Supply Alternative. In July 2026, there is a 20 percent chance of closing Wahweap and lower Bullfrog launch ramps under this alternative.

Reservoir Storage Alternative. In July 2026, there is a two percent chance of closing Wahweap and lower Bullfrog launch ramps under this alternative.

4.12.2.2 Safe Boating Capacities and Exposure to Navigation Hazards

In general, as reservoir elevations drop, hazards such as submerged snags and boulders can become exposed or are closer to the surface, increasing the likelihood that boats can come in contact with such hazards. The elevations of such hazards are often unknown until they become exposed. At elevation 3,620 feet msl, hazardous obstructions result in the NPS prohibiting boating around Castle Rock and Gregory Butte. Table 4.3-5 and Figure 4.3-6 provide the data for all years and all alternatives.

No Action Alternative. In September 2026, there is a 29 percent chance the NPS would have to prohibit boating around Castle Rock and Gregory Butte due to navigational hazards.

Basin States and Conservation Before Shortage Alternatives. In September 2026, there is a 36 percent chance of boating restrictions around Castle Rock and Gregory Butte.

Water Supply Alternative. In September 2026, there is a 47 percent chance of boating restrictions around Castle Rock and Gregory Butte.

Reservoir Storage Alternative. In September 2026, there is a 21 percent chance of boating restrictions around Castle Rock and Gregory Butte.

4.12.2.3 Lake Powell Sport Fish Populations

Potential surface temperatures under any alternative could get close to the upper lethal limits for both striped bass and threadfin shad, especially in July and August when maximum temperatures could reach 29°C. However, the maximum lethal limits of 37°C and 33°C for threadfin shad and striped bass, respectively, would not be exceeded. Further, these water temperatures are for the upper 10 feet of the reservoir, and lower depths provide cooler water. It is assumed that striped bass and threadfin shad would be able to move into the cooler thermocline during the summer months (Gustaveson 1999). Water temperatures would not drop below the lower lethal limit of 5°C for striped bass or threadfin shad under any alternative. The coldest winter temperature could be 7°C. Because surface temperatures would not exceed the lethal tolerances of either species, and it is assumed that both species would have adequate thermal refugia, substantial temperature-related impacts to the reservoir sport fishery are not anticipated to occur under any of the alternatives.

The general trend for the alternatives indicates that Lake Powell water under the Conservation Before Shortage and Basin States alternatives do not differ substantially from the No Action Alternative. Therefore, Lake Powell conditions are expected to be similar to the No Action Alternative for lake sport fish under these two action alternatives. The Water Supply Alternative tends to have lower reservoir elevations, which makes the lake more susceptible to atmospheric temperature influence. The Reservoir Storage Alternative has generally higher Lake Powell elevations compared to the No Action Alternative, which makes the lake less susceptible to atmospheric temperature influence. However, threadfin shad and striped bass should still be able to survive potential winter and summer temperature variations.

4.12.2.4 Access or Use of Rainbow Bridge

Above a Lake Powell elevation of 3,650 feet msl, Rainbow Bridge is visible from the floating walkway and interpretive platforms at Rainbow Bridge National Monument. If Lake Powell elevations fall below 3,650 feet msl, Rainbow Bridge is no longer visible from the lake and the floating walkway and interpretive platforms are removed and stored. Under this circumstance, dock facilities would be moved to a lower elevation and connected to the land trail with a short walkway, and the old land trail through Bridge Canyon (submerged at full-pool elevation) would be used. Table 4.3-3 and Figure 4.3-4 provide the reservoir elevation data for all years and all alternatives.

No Action Alternative. In July 2026, there is a 41 percent chance that the NPS would have to close or modify facilities at Rainbow Bridge.

Basin States and Conservation Before Shortage Alternatives. In July 2026, there is a 51 percent chance that the NPS would have to close or modify facilities at Rainbow Bridge.

Water Supply Alternative. In July 2026, there is a 60 percent chance that the NPS would have to close or modify facilities at Rainbow Bridge.

Reservoir Storage Alternative. In July 2026, there is a 38 percent chance that the NPS would have to close or modify facilities at Rainbow Bridge.

4.12.3 Recreation from Glen Canyon Dam to Lake Mead

4.12.3.1 Boating

Current operation of Glen Canyon Dam requires a minimum flow release of 8,000 cfs between a.m. and 7 p.m., and 5,000 cfs at night. Therefore, daytime flows will not drop lower than the safe whitewater boating threshold flow of 5,000 cfs. In addition, flow releases from Glen Canyon Dam will be within historical operating range. As shown in Tables 4.3-12 through 4.3-14, releases from Glen Canyon Dam would generally be much higher than these minimum flows under all alternatives and hydrological conditions. Therefore, there would be no change in exposure to unsafe boating conditions caused by change in river elevation. Minor changes in exposure to boating navigation hazards caused by change in river velocity; changes in access or use of rest areas and take-out points; changes in trip duration caused by changes in river velocity; or ability to use sport fishing sites caused by change in flows may occur under all alternatives. These changes would not be substantial and would not affect recreation use or opportunities.

4.12.3.2 Sport Fish Populations

For the reach of the river between Glen Canyon Dam and Lake Mead, water temperatures were used (See Appendix P) from Glen Canyon Dam, Little Colorado River confluence, and below Diamond Creek gage to compare the No Action Alternative with the action alternatives. Rainbow trout are the major sport fish in this reach and are used for the assessment.

Glen Canyon Dam Releases and Lees Ferry Reach:

- **No Action Alternative.** As discussed in Section 4.8.4.2, the historical range of release temperatures from Glen Canyon Dam was relatively stable between 1990 and 2002 and typically ranged from 7 °C to12 °C (44.6 °F to 53.6 °F). These relatively stable cold temperatures were favorable for rainbow trout. Beginning in 2002, the range of release temperatures increased and the higher end of the range approached 16 °C (60.8 °F) (Appendix F, Figure F-5). Under the No Action Alternative for Glen Canyon Dam releases, the 10th percentile water temperatures were compared against the preferred water temperatures for spawning, incubation, growth and mortality of rainbow trout. In all months (January through December) minimum potential temperatures are below the preferred lowest water temperature (12 °C) suitable for growth. The minimum potential temperatures are below the minimum suitable spawning temperature of 8 °C from January through April (Table 4.12-1). The potential temperature range for the Glen Canyon Dam release and river temperature at Lees Ferry are not expected to exceed 25° C but may reach 20 °C at the 10th percentile Lake Powell elevation release. As indicated in Chapter 4.8, substantial impacts to the aquatic foodbase are not anticipated.

- **Action Alternatives.** While the action alternatives compared to the No Action Alternative are similar, the 10th percentile water temperatures show a potential slight warming trend for all of the alternatives except the Reservoir Storage Alternative. The Reservoir Storage Alternative shows only November as being potentially above the preferred temperature for growth. The Water Supply Alternative shows the most potential warming and water temperatures in August and September may exceed the preferred growth temperature. Incubation temperatures may be exceeded from May through August, which could cause egg mortality. The amount of egg mortality would depend on the duration of water temperatures above the limits for incubation, which is not known. Lethal limits for rainbow trout are not exceeded in any month. The Water Supply Alternative may result in a shorter spawning season since the river flow temperatures in this river reach may increase and become too warm for spawning in May. As indicated in Chapter 4.8, substantial impacts to the aquatic foodbase are not anticipated.

Little Colorado River Confluence:

- **No Action Alternative.** Under the No Action Alternative, the 10th percentile water temperatures were compared against the preferred water temperatures for spawning, incubation, growth and mortality of rainbow trout. In almost all months (January through June, October through December) minimum temperatures may be below the preferred ranges for growth. The minimum temperatures may be below the preferred minimum temperature for spawning (8 °C or 46 °F) in January and February (Table 4.12-1).

- **Action Alternatives.** While the action alternatives compared to the No Action Alternative are similar, the 10th percentile water temperatures show a slight potential warming trend for all of the alternatives except the Reservoir Storage Alternative, which is slightly cooler. The Reservoir Storage Alternative shows the least potential variation in temperatures. The Water Supply Alternative shows the most potential warming of water from June through October and may exceed suitable thresholds for growth and incubation. (Table 4.12-1 and Table 4.12-2). Preferred growth temperatures may be exceeded from June to October and incubation temperatures (> 15 °C) may be exceeded from April through August. The amount of egg mortality would depend on the duration of water temperatures above the limits for incubation, which is not known. All action alternatives may result in shorter spawning seasons since potential spring high temperatures may exceed the upper spawning threshold. The Water Supply Alternative could potentially provide the shortest spawning season. Lethal limits for rainbow trout are not exceeded in any month.

Diamond Creek:

- **No Action Alternative.** Under the No Action Alternative for Diamond Creek the 10th percentile water temperatures show that from January through May and November and December, minimum temperatures may be below the suitable range for growth. The minimum temperatures may be below the minimum temperature for spawning (8° C or 46.4 °F) in January and February (Table 4.12-1). Lethal water temperatures may be reached in the summer under the No Action Alternative though fish should be able to find thermal refugia.

- **Action Alternatives.** While the action alternatives compared to the No Action Alternative are similar, the 10th percentile water temperatures show a potential warming trend for all of the alternatives, except for the Reservoir Storage Alternative. The Reservoir Storage Alternative shows the least potential variation in temperatures but temperatures may exceed all life history thresholds for March, May, September, and December (Table 4.12-1 and Table 4.12-2). The Water Supply Alternative shows the most potential warming of water from April through October. Preferred growth temperatures may be exceeded from May to October and incubation temperatures (> 15 °C) may be exceeded from April through August. The amount of egg mortality would depend on the duration of water temperatures above the limits for incubation, which is not known. Lethal water temperature limits above 25 °C, may be reached in July, August and September. These summer high temperatures would be greater than under the No Action Alternative for these months. The potential spawning season in this reach may be the most limited because the water warms above 13 °C (55.4 °F) earlier in the year than other reaches. The Water Supply and Reservoir Storage alternatives may potentially provide the shortest and longest spawning seasons, respectively, of the action alternatives. However, juvenile and adult fish are able to find thermal refugia by moving upstream into cooler water habitats such as pools and may not be substantially affected by warmer water temperatures. Further, this section of river is not as important for trout as the Lees Ferry reach is.

4.12.4 Recreation at Lake Mead

Table 3.12-7 identifies the threshold elevations below which shoreline recreational facilities at Lake Mead could be affected. Below these elevations, facility adjustments or capital improvements would be required, creating potential impacts on recreation at Lake Mead. Figures 4.3-18 through 4.3-23 and Tables 4.3-18 through 4.3-23 show the percentage of values less than or equal to these thresholds during the study period.

4.12.4.1 Access or Use of Lake Mead Boating Facilities

No Action Alternative. In July 2026, there is a 76 percent probability that Lake Mead elevations may be lower than elevation 1,175 feet msl, resulting in the closure of the Pearce Bay Launch Ramp and the addition of another 16 miles that boaters would have to travel downstream to take-out. Table 4.3-17 and Figure 4.3-17 provide the data for all years and all alternatives. The Echo Bay Public Launch Ramp would close at an elevation of 1,050 feet msl (Figure 4.3-21 and Table 4.3-21). In July 2026, there is a 26 percent chance that this facility would close under the No Action Alternative.

Basin States and Conservation Before Shortage Alternatives. In July 2026, there is a 76 and 77 percent chance of closing the Pearce Bay Launch Ramp under these two alternatives, respectively. In July 2026, there is a 20 percent chance under both these alternatives that the Echo Bay Public Launch Ramp would close due to low reservoir elevations.

Water Supply Alternative. In July 2026, there is a 78 percent chance of closing the Pearce Bay Launch Ramp and adding 16 miles to river trips. In July 2026, there is a 21 percent chance that the Echo Bay Public Launch Ramp would close due to low reservoir elevations.

Reservoir Storage Alternative. In July 2026, there is a 68 percent chance of closing the Pearce Bay Launch Ramp and adding 16 miles to river trips. In July 2026, there is a four percent chance that the Echo Bay Public Launch Ramp would close.

4.12.4.2 Safe Boating and Navigation Hazards

Over the years, sediment has built up in the section of the reservoir between Grand Wash Cliffs and Pearce Ferry. When the Lake Mead elevation drops below elevation 1,170 feet msl, there is no well-defined river channel in this upper portion of Lake Mead, making it dangerous for boaters (NPS 2005a).

No Action Alternative. In July 2026, there is a 74 percent probability that boaters may encounter navigational hazards in upper Lake Mead.

Basin States and Conservation Before Shortage Alternatives. In July 2026, there is a 73 percent probability that boaters may encounter navigational hazards in upper Lake Mead.

Water Supply Alternative. In July 2026, there is a 77 percent probability that boaters may encounter navigational hazards in upper Lake Mead.

Reservoir Storage Alternative. In July 2026, there is a 65 percent probability that boaters may encounter navigational hazards in upper Lake Mead.

4.12.4.3 Sport Fish Populations

No Action Alternative. Rainbow trout (and razorback suckers) are raised in the Lake Mead Fish Hatchery by Nevada Department of Wildlife (NDOW). NDOW obtains its water supply for the fish hatchery from Lake Mead. Their water comes from the Basic Management, Inc. (BMI) intake at reservoir elevation 1,060 feet msl. Under recent conditions, the hatchery has experienced problems with water temperature and total dissolved solids in its water from the intake (Parke 2006). Water temperatures taken from the intake are approximately 24°C (75°F), which is too warm for trout. NDOW has noticed the increase in water temperatures starts when Lake Mead's elevation is less than 100 feet above the BMI intake (elevation 1,160 feet msl and less). The 50^{th} and 10^{th} percentile monthly elevations are never above elevation 1,160 feet msl so temperature problems are likely to persist for future hatchery operations. The 90^{th} percentile elevations are identical for all alternatives and would alleviate the hatchery's temperature problems. The 50^{th} percentile elevations are always above elevation 1060 feet msl, but the 10^{th} percentile elevations for all alternatives will fall below 1,060 feet msl in the future. Thus, the hatchery may have water supply problems at the 10^{th} percentile elevation values.

The situation for striped bass and threadfin shad in Lake Powell is expected to be similar at Lake Mead. However, threadfin shad are near the northern limit of their range at Lake Powell so threadfin shad are less likely to be affected by cold winter temperatures at Lake Mead.

Action Alternatives. The Basin States and Conservation Before Shortage alternatives would be similar to the No Action Alternative. The Reservoir Storage Alternative is the most beneficial to the hatchery's water supply and the Water Supply Alternative would have the most adverse effects on water temperature. Effects on threadfin shad and striped bass are expected to be similar to the effects at Lake Powell.

4.12.5 Recreation from Hoover Dam to SIB

Flow releases from Hoover Dam, Davis Dam, Parker Dam, and Imperial Dam will all be within historical operating range. Therefore, there would be minimal changes in exposure to boating navigation hazards caused by changes in river elevation; changes in exposure to boating navigation hazards caused by changes in river velocity; changes in access or use of rest areas and take-out points; changes in trip duration caused by changes in river velocity; or decrease in access or use of sport fishing sites caused by changes in flows. The sport fishery in this reach is primarily warm water. The minor changes in water temperatures that may occur below Hoover Dam are not expected to affect warmwater sport fish.

4.12.6 Summary

4.12.6.1 Shoreline Facilities

For shoreline public use facilities at Lake Powell, the No Action, Basin States, Conservation Before Shortage, and Reservoir Storage alternatives provide a two to eight percent probability that the Wahweap and Lower Bullfrog Launch ramps may close in 2026, while the Water Supply Alternative provides a 20 percent probability of this occurrence. Other marinas and launch ramps are similarly affected under the different alternatives.

For Rainbow Bridge National Monument, in 2026 there is a 41 percent probability under the No Action Alternative that the NPS would have to close or modify recreational facilities at this location. The action alternatives provide a 38 to 60 percent probability of facility closures.

At Lake Mead, all of the alternatives provide a 76 to 78 percent probability that the Pearce Bay launch ramp would be closed to boaters, except for the Reservoir Storage Alternative, which provides a 68 percent probability. Similarly, all of the alternatives provide a 20 to 26 percent probability of closure of the Echo Bay Public Launch Ramp (in the north end of the reservoir), except for the Reservoir Storage Alternative which provides only a four percent probability of this occurrence.

4.12.6.2 Safe Boating and Navigation

For safe boating at Lake Powell, under the No Action Alternative and Reservoir Storage Alternative, probabilities range from 21 to 29 percent that the NPS would have to prohibit boating around Castle Rock and Gregory Butte. Under the Basin States and Conservation Before Shortage alternatives, there is a 36 percent probability that boating prohibitions would need to be put in place. Under the Water Supply Alternative, the probability of this occurrence is 47percent.

For Lake Mead, all the alternatives in July 2026 provide a 73 to 77 percent probability that boaters may encounter navigational hazards in the upper end of Lake Mead due to reservoir elevations being drawn down below elevation 1,170 feet msl. The Reservoir Storage Alternative provides a 65 percent probability of a similar recreational impact. Similar effects would occur in the Overton Arm of Lake Mead.

For whitewater boating through Grand Canyon, the Glen Canyon Dam ROD flows will be maintained. Even in a 7.0 maf Glen Canyon Dam release year, the minimum daily flow will remain at or above 5,000 cfs, a safe boating threshold.

4.12.6.3 Sport Fish Populations

Sport fish populations would not be adversely affected at Lake Powell under any of the alternatives. Although water surface temperatures may approach lethal levels in the upper 10 feet of the reservoir under any alternative, lethal levels for striped bass and threadfin shad should not be exceeded by any alternative. Moreover, cooler temperatures below the lake surface would serve as a refuge for the fish. The situation for striped bass and threadfin shad in Lake Mead is similar to Lake Powell. Higher water temperatures could impair the Lake Mead Fish Hatchery, particularly under the Water Supply Alternative.

High water temperatures could affect the rainbow trout in the Lees Ferry reach. Under the No Action Alternative, 10^{th} percentile temperatures are suitable for growth, spawning, and incubation in the months shown in Table 4.12-2. Under the action alternatives, 10^{th} percentile modeling results indicate there could be minor impacts to rainbow trout due to warmer temperatures. The Water Supply Alternative shows the most warming from April through November. The Reservoir Storage Alternative shows only November as being higher than the growth threshold.

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4.13 Transportation

This section describes the methods of analysis and potential effects on transportation, focusing on ferry services, and river taxis.

4.13.1 Methodology

4.13.1.1 Effects on Lake Powell Ferry Service

The John Atlantic Burr Ferry becomes inoperable when the Lake Powell elevation falls below elevation 3,550 feet msl, requiring additional driving of approximately 130 miles between the Bullfrog and Halls Crossing marinas. Consequently, for each action alternative, the analysis evaluates the probability the ferry would be inoperable and compares that to the probability under the No Action Alternative. These comparisons were based on the Lake Powell end-of-September elevations between years 2008 through 2060.

4.13.1.2 Effects on Laughlin River Taxis and Tour Boats

Changes in releases from Davis Dam have the potential to impact the operations of the river taxi services and tour boats in Laughlin, Nevada. The projected discharges or flows in cfs were compared to the flows required by the river taxis and the tour boats.

4.13.1.3 Effects on Lake Havasu Ferry Service

Changes in Lake Havasu elevations could affect the existing ferry service and recreational uses. Effects of changes in Lake Havasu elevations on recreational uses are discussed in the recreational impacts discussion (Section 4.12). The discussion presented below is limited to the potential effects on ferry service provided on Lake Havasu.

4.13.2 Lake Powell Ferry Service

Table 4.13-1 lists the range of probabilities of Lake Powell elevations being less than or equal to elevation 3,550 feet msl for each alternative. An analysis for each alternative is provided below.

Table 4.13-1
Range of Probabilities of Lake Powell Elevations Less Than or Equal to Elevation 3,550 feet msl

Alternative	2008 through 2025	2026 through 2060
No Action	0% to 8.1%	3% to 10.1%
Basin States	0% to 6.1%	5.1% to 10.1%
Conservation Before Shortage	0% to 6.1%	5.1% to 10.1%
Water Supply	0% to 17.1%	7.1% to 17.2%
Reservoir Storage	0% to 5.1%	0.1% to 10.1%

4.13.2.1 No Action Alternative

The likelihood that Lake Powell elevations would fall below 3,550 feet msl under the No Action Alternative is not greater than 10 percent for all years until 2060 (zero to 10 percent; Figure 4.3-10 and Table 4.13-1). Consequently, the Lake Powell Ferry Service would be able to operate about 90 percent of the time under No Action Alternative conditions.

4.13.2.2 Basin States Alternative

The Basin States Alternative would result in very similar or slightly lower probabilities (zero to six percent) of Lake Powell elevations being less than 3,550 feet msl when compared to the No Action Alternative from the period 2008 through 2025 (Figure 4.3-10 and Table 4.13-1). For the period 2026 through 2060, the Basin States Alternative would result in similar or slightly higher probabilities (five to 10 percent) as compared to the No Action Alternative. The net effect under this alternative is minor.

4.13.2.3 Conservation Before Shortage Alternative

The Conservation Before Shortage Alternative would result in very similar or slightly lower probabilities (zero to 6.1 percent) of Lake Powell elevations being less than elevation 3,550 feet msl when compared to the No Action Alternative for the period 2008 through 2025 (Figure 4.3-10 and Table 4.13-1). For the period 2026 through 2060, the Conservation Before Shortage Alternative would result in similar or slightly higher probabilities (five to 10 percent) as compared to the No Action Alternative. The net effect under this alternative is minor.

4.13.2.4 Water Supply Alternative

The Water Supply Alternative would result in similar or higher probabilities (zero to 17 percent) of Lake Powell elevations being less than elevation 3,550 feet msl when compared to the No Action Alternative for the period 2008 through 2025 (Figure 4.3-10 and Table 4.13-1). For the period 2026 through 2060, the Water Supply Alternative would result in higher probabilities (seven to 17 percent) as compared to the No Action Alternative. The net effect under this alternative is moderately adverse.

4.13.2.5 Reservoir Storage Alternative

The Reservoir Storage Alternative would result in similar or slightly lower probabilities (zero percent to five percent) of Lake Powell elevations being less than 3,550 feet msl compared to the No Action Alternative for the period 2008 through 2025 (Figure 4.3-10 and Table 4.13-1). For the period 2026 through 2060, the Reservoir Storage Alternative would result in similar or slightly lower probabilities (zero percent to 10 percent) as compared to the No Action Alternative. The net effect under the Reservoir Storage Alternative is beneficial.

4.13.3 Laughlin River Taxis and Tour Boats

The minimum future flow under the No Action Alternative and under the action alternatives will continue to be 2,300 cfs, the minimum flow needed to run one turbine of Davis Powerplant at about one-half capacity. The duration of flows in the 2,300 to 4,600 cfs range would not be affected by the proposed federal action. However, the duration of flows in the 4,600 cfs to 9,200 cfs range may be affected by the proposed federal action. For example, due to changes in annual releases, the duration of hourly flows in the 4,600 to 9,200 cfs range may increase during some days under the Water Supply Alternative and decrease during some days under the Reservoir Storage Alternative. These potential effects would be minor effects on transportation. The duration of hourly flows in the 4,600 cfs to 9,200 cfs range under the Basin Sates Alternative and the Conservation Before Shortage Alternative are expected to be nearly the same as those under the No Action Alternative.

4.13.4 Lake Havasu Ferry Service

Lake Havasu will continue to be operated to meet monthly elevation targets; therefore, adoption of any of the alternatives would not affect the operation of the Lake Havasu ferry service.

4.13.5 Summary

For the Lake Powell ferry, the Basin States and Conservation Before Shortage alternatives would have minor effects on ferry service; the Water Supply Alternative would result in moderate adverse effects; and the Reservoir Storage Alternative would have beneficial effects. The probability varies from year to year, but there is up to a 17 percent probability that the Lake Powell ferry may become inoperable under the Water Supply Alternative for some period of time. Conversely, the ferry remains operable with the highest probabilities and greatest durations of time under the Reservoir Storage Alternative.

For the Colorado River ferry service below Davis Dam, only under the Reservoir Storage Alternative are there measurable effects and these potential effects would most likely be minor. The other alternatives show no difference from the No Action Alternative.

The Lake Havasu ferry service would be unaffected under all of the action alternatives.

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4.14 Socioeconomics and Land Use

This section describes the environmental consequences related to socioeconomics, agricultural production and other land uses for the alternatives considered in the proposed federal action, and describes the methods used to determine the effects resulting from each alternative. The study area and issues associated with these resources are described in Section 3.14. Additional information on the assessment of socioeconomic and land use effects is provided in Appendix H. Cumulative impacts related to socioeconomics and land use are discussed in Chapter 5.

4.14.1 Methodology

This section describes the methods used to estimate the effects on socioeconomics resulting from the proposed federal action. The assessment focused on estimating the socioeconomic effects that would occur as a result of potential changes in agricultural production, reservoir-related and river-related recreation, and the change in M&I water availability.

4.14.1.1 Agriculture

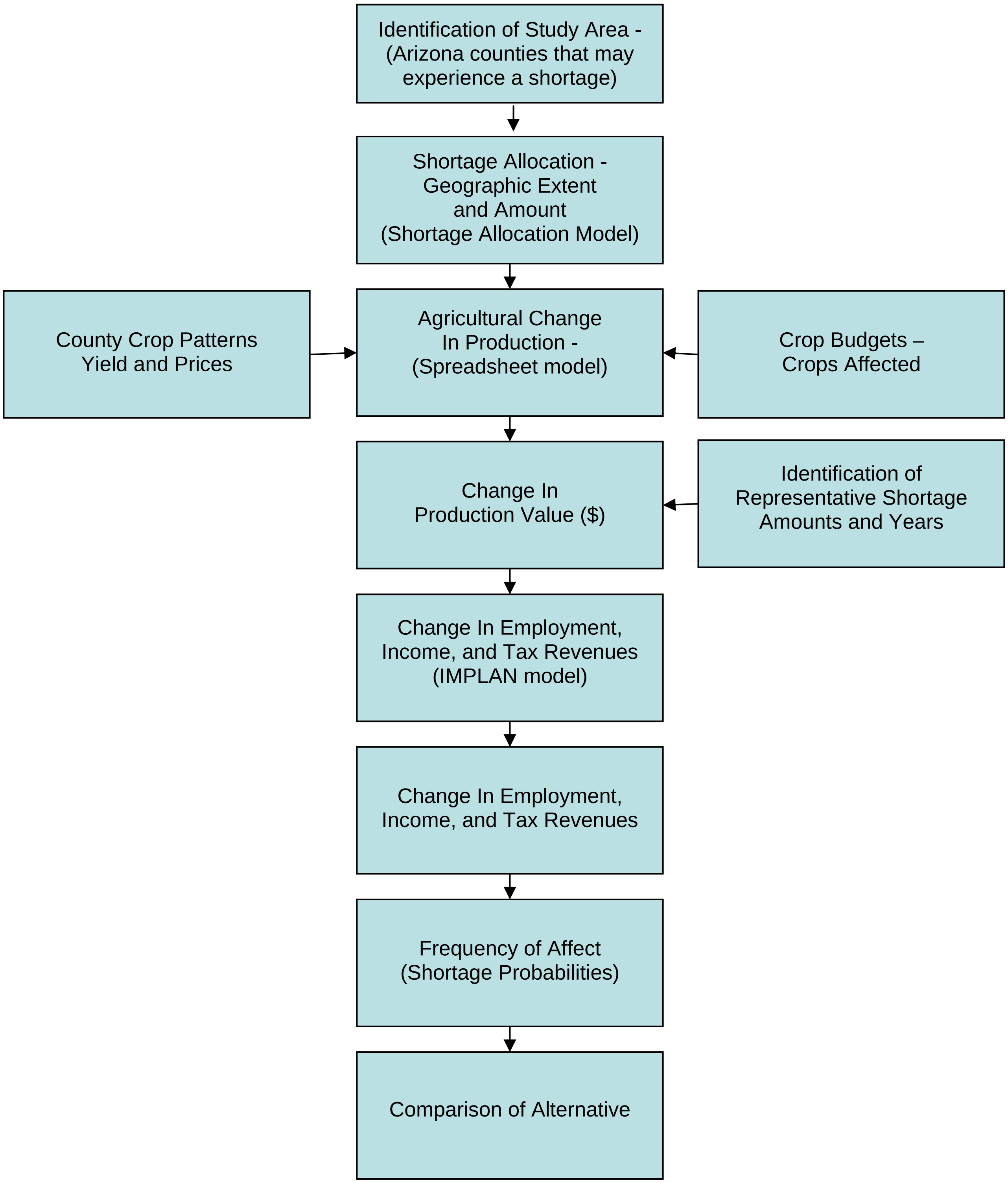
The socioeconomic effects of changes in agricultural production were quantitatively and qualitatively assessed. A quantitative assessment was conducted for Arizona counties that may experience a shortage whereas a qualitative assessment was conducted for California and Nevada counties. The quantitative assessment was limited to Arizona counties since a shortage event would potentially have the greatest effect on the CAP service area and the CAP has a large amount of agriculture within its service area. In contrast, Nevada has very little agricultural production, and shortages to California would be unlikely to occur and would only affect the M&I sector.

The quantitative assessment was conducted in three major steps:

- estimating changes in agricultural production as the result of reduced water deliveries;
- estimating the potential changes in employment, income, and tax revenue as a result of reduced water deliveries; and
- applying the shortage probabilities for a particular shortage amount and year to understand the likelihood that the potential changes would occur.

Figure 4.14-1 provides an overview of the steps followed in conducting the assessment of changes in agricultural production and resulting changes in employment, income, and tax revenues.

Figure 4.14-1
Steps in Analyzing Changes in Agricultural Production
and Resulting Changes in Employment, Income, and Tax Revenue



4.14.1.2 Estimating Changes in Agricultural Production Value

Involuntary Shortages. The purpose of the impact assessment for agriculture is to estimate the change in agricultural production values as a result of the proposed federal action. Specifically, this section focuses on the incidence of these impacts on non-Indian and Indian agricultural production in Pinal, Maricopa, Pima, Mojave, La Paz, Yuma, and Graham Counties for 2008, 2017, 2026, 2027, 2040, and 2060. The seven counties were selected because the irrigation districts that may experience shortages are located within these counties. Impacts to agriculture in the seven-county area were examined by observing modeled changes in industry output and acreage of fallowed lands for agriculture. The years 2008, 2017, and 2026, were selected because they represent the beginning, midpoint, and end of the interim period. The years 2027, 2040, and 2060 were selected because they represent the beginning, midpoint, and end of the recovery period.

The objectives of this study were to quantify potential:

- changes in agricultural production for various levels of shortage; and
- amounts of fallowed land for various levels of shortage.

Key to this impact analysis is the assumption that the most conservative way to estimate impacts is to assume that, if a shortage occurs, farmers would react by fallowing irrigated lands. The decision to fallow lands would rest on the ability of the farmer to cover the variable costs of production for crops grown in the study area. These assumptions are discussed in more detail later in this section.

While fallowing of lands may occur during shortages, there are other sources of water that may be used by farmers in order to offset shortages. For example, a farmer may have a groundwater well available and may be able to mitigate shortages in surface water supply by pumping additional groundwater. Other farmers may be able to take delivery of groundwater that is recovered from a groundwater bank. It is difficult, if not impossible, to project exactly how individual farmers, irrigation districts, or the Lower Division states may mitigate potential, future agricultural impacts from shortages. Therefore, for the purposes of this analysis, the projected change in agricultural production was based on the conservative assumption that other sources of water would not be available.

The crops considered included cotton, wheat, alfalfa, vegetables and melons, and trees and vines. The primary focus is on cotton, wheat, and alfalfa because these crops have lower earnings per af of water than fruit, vegetable, and nut crops and, therefore, are more vulnerable to changes in water costs and shortages. Farm budgets were developed for cotton, wheat, and alfalfa to determine the maximum water cost a farmer can pay and still produce a particular crop. These budgets represent a generalization of the variable production costs for a particular crop exclusive of water costs. When the cost of water exceeds the maximum water cost a farmer can pay or if water is not available, a crop is taken out of production and the land is fallowed for the year in which a shortage occurs. The data from all of the model runs were compared to the No Action Alternative.

4.14.1.3 General Assumptions and Data Sources

Crop Patterns, Yields, and Prices. Crop patterns, yield per acre, and prices were assumed to remain constant for non-Indian and Indian agricultural output for all alternatives during the study period. Crop patterns for the CAP and other irrigation districts in this study are based on historical crop patterns that were reported by irrigation districts to Reclamation for the years 1999 through 2004. These data were averaged and aggregated at the county level for the impact analysis. Cropping patterns for Indian agriculture come from a variety of sources and may be incomplete. Accordingly, it was assumed that cropping patterns on Indian lands were similar to that of nearby irrigation districts. Appendix H includes information on cropping patterns for CAP and other irrigation districts.

Yield data was based on five-year average county-level yields for the period 2000 through 2005. Prices are based on five-year average statewide prices for Arizona for the period 2000 to 2005. The yield and price data are published by the USDA's National Agricultural Statistics Service (NASS) for Arizona. Information on county-level yield and price data is provided in Appendix H.

Water Costs. The cost of water used in the analysis of agricultural impacts is a blended cost that reflects the price of CAWCD excess water pools, groundwater pumping, and other water. The price of CAWCD excess water was obtained directly from the CAWCD. Cost estimates for groundwater pumping and other water were obtained from various irrigation districts. These data were aggregated to a county-level basis for use in the agricultural impacts analysis. The blended cost of water data for each county is included in Appendix H.

Crop Budgeting and Impacts upon Crop Selection due to Water Cost and Water Shortages. Crop budgets were developed to determine the crop types that would be affected as a result of water shortages. A detailed description of how the crop budgets were developed is included in Appendix H.

Assessment of Changes in Agricultural Production. It is assumed that the agricultural impacts for involuntary shortages are the same for various levels of shortage for each alternative. As an example, a 600,000 af shortage occurring under the Reservoir Storage Alternative would result in the same change in agricultural production as a 600,000 af shortage occurring under the Basin States Alternative. Shortages may occur more or less frequently under various alternatives, but the change in agricultural production during a particular volume of shortage was assumed to be the same across the alternatives. This is due to the modeling assumptions made with regard to how shortages might be distributed to various water users (Section 4.2, Appendix A, and Appendix G). These assumptions are the same across all alternatives. Changes in agricultural production and resulting changes in production value due to voluntary shortages would likely be different than the changes due to involuntary shortages, discussed in additional detail below.

Output from Reclamation's Shortage Allocation Model (Section 4.2 and Appendix G) was used as input for assessing changes in agricultural production during the involuntary fallowing of agricultural lands. The various levels of shortage were input into the model and the amount of shortage that would be allocated to various agricultural users was generated. These results were aggregated on a county-level basis for use in the agricultural impacts analysis.

Agricultural impacts for both non-Indian and Indian agriculture were analyzed independently. For both analyses, the amount of shortage allocated to non-Indian and Indian water users in each county for various levels of overall shortage were input into a spreadsheet model developed by Reclamation that estimates changes in agricultural production and production value. Model input includes output from the partial crop budgets, the amount of available surface water in each county, county-wide shortage amounts from the water allocation model, the amount of water applied per acre for each crop, and county-wide water distribution patterns with respect to cotton, wheat, and alfalfa production. Based on the amount of shortage realized in each county, the model estimates the amount of land that would be fallowed using the relative profitability of each crop. The model assumes that the least profitable crops are fallowed first. Once all of the irrigated land associated with the least profitable crop is fallowed, the model assumes that fallowing of the next-least profitable crop would commence. The irrigated acreage associated with fallowing is estimated based on the amount of water allocated to various crops and the crop water use per acre associated with those crops. The resulting direct economic impacts are calculated by multiplying the number of acres fallowed for various crops by the gross output for those crops.

The federal government has reserved a volume of CAP water in the range of 47,000 to 67,000 af for future water settlements. At some time, this water may be allocated to tribes in Arizona for agricultural or M&I use. Once allocated, this water would potentially be vulnerable to shortages. However, it is not known where or when this water may be allocated. Because of this uncertainty, the reserved federal water has not been included in the analysis.

Shortages. The partial farm budgets used in the analysis of involuntary shortages are a potential means to estimate the minimum amount of compensation a farmer would accept to fallow agricultural ground. However, compensation rates included in recently established fallowing programs do not reflect these minimum amounts. It appears that market forces have contributed significantly to the compensation rates paid in fallowing programs for conserved water. As a result, available data from several fallowing programs were used to estimate a range of costs for conserved water and to estimate potential amounts of land that would be fallowed under various levels of shortage.

Data from several sources suggest that fallowing agricultural lands would result in a reduction in the consumptive use of water ranging between 4.2 and 6.9 af per acre (Colby et. al. 2006). The amount of acreage that would be fallowed would be dependent on the crops grown and the consumptive use of those crops. However, again, it is difficult to project which irrigators or districts would fallow their land and what crops would not be grown. In lieu of attempting to project the crops that would not be grown, for the purposes of this study, it was assumed that the amount of fallowed land per af of conserved water would be similar to the range shown above. It was assumed that all of the potentially conserved water results from agricultural water conservation.

Voluntary shortages may result in a beneficial effect on farmers rather than a detriment. The minimum amount of water a farmer would likely accept would be at a break-even price. However, given the demand for water conservation under voluntary shortages, a farmer would be less likely to accept a minimum payment and would be more likely to attempt to maximize economic gain.

Implementation of voluntary shortages is the focus of the Conservation Before Shortage Alternative. The water conservation (voluntary shortage) prior to involuntary shortage included in this alternative assumes that farmers would be paid to initiate voluntary water conservation measures. These conservation measures could be implemented in a variety of ways such as on-farm efficiency improvements, canal lining, etc. It is, however, very difficult to project what actions individual farmers or irrigation districts might take in the future to conserve water. Land fallowing programs have frequently been used as a means to voluntarily conserve water and fallowing would likely result in the most significant impacts with regard to land use. For the purposes of this study, it is assumed that land fallowing would be the means of conserving water for the Conservation Before Shortage Alternative.

Estimating Changes in Employment, Income, and Tax Revenue. The socioeconomic effects of changes in agricultural production in Arizona were analyzed using the IMPLAN model (Minnesota IMPLAN Group 2006). IMPLAN is a regional economic model that describes the flows from producers to intermediate and final consumers using a series of economic multipliers. The IMPLAN model describes for each county the transfers of money between all industries and institutions. This model of county-level economic interactions is used to project, using the input-output multipliers, total regional economic activity based on a change in expenditures.

In addition to the direct loss in agricultural output, reduced expenditures occur from a drop in business-to-business purchases and in reduced household expenditures. These changes, known as indirect and induced economic effects and were also estimated using IMPLAN. The resulting socioeconomic effects were quantified as changes in employment, income, and tax revenue.

The qualitative assessment for changes in agricultural production and resulting changes in employment, income, and tax revenues was based on the probability of shortages occurring in the agricultural sector in California and Nevada.

Municipal and Industrial Water Uses. The potential socioeconomic consequences of shortages occurring in the M&I sector were qualitatively assessed for Arizona, California, and Nevada. The effects were qualitatively assessed because it was not known to what degree a specific economic sector considered an M&I use would be affected. The analysis was based on the shortage amounts and shortage allocations reported in Section 4.4.

The analysis first examined the probability of a range of water shortages occurring in different years. The shortages analyzed included 400,000 af, 500,000 af, 600,000 af, 800,000 af, 1 maf, 1.2 maf, 1.8maf, and 2.5 maf. Consistent with the assessment of the effects to agriculture, the M&I analysis examined years 2008, 2017, 2026, 2027, 2040, and 2060 for each of the shortage amounts.

The analysis focused on those years and shortage levels having the highest probability of occurring and where the probability was substantially different compared to the No Action Alternative. The analysis then examined whether a particular shortage event would affect the M&I sector as compared to the No Action Alternative. For example, a shortage in Arizona would affect the agricultural sector first. In contrast, a shortage in Nevada would affect M&I, primarily because Nevada has a small agricultural sector.

For situations likely to have an effect on the M&I sector, the ability of each state to manage shortages to the M&I sector were analyzed. The M&I shortages allocated to each state were compared to the drought plans or actions that state or local agencies could institute during a shortage. The analysis then qualitatively discussed whether such drought planning mechanisms are adequate to address shortages to the M&I sector.

Recreation. The recreation-related socioeconomic effects resulting from changes in Lake Powell and Lake Mead elevations and flows in the Colorado River downstream of Lake Powell and Lake Mead were qualitatively assessed. The conclusions regarding the extent of changes in reservoir elevations and river flows reported in Section 4.3 and recreation opportunities reported in Section 4.12 were used to help determine the magnitude of socioeconomic effects.

Lake Powell and Lake Mead. The assessment of changes in recreation-related economic activity was based on changes in Lake Powell and Lake Mead elevations. As indicated in Sections 4.3 and 4.12, particular months representative of the primary recreational season were selected for each lake to analyze the potential elevation changes (September for Lake Powell; July for Lake Mead).

Figure 4.14-2 depicts the end-of-September Lake Powell elevations and Figure 4.14-3 depicts the end-of-July Lake Mead elevations used in this analysis. The years considered in the assessment are 2008, 2016, 2026, and 2060. For each year, lake elevations for each alternative were compared to the No Action Alternative. This comparison was conducted for the 90^{th}, 50^{th}, and 10^{th} percentiles shown in Figures 4.14-2 and 4.14-3.

Colorado River Downstream of Lake Powell and Lake Mead. The assessment of socioeconomic effects as result of changes in recreation-related economic activity was based on the results of the recreation assessment. The results of this assessment are provided in Section 4.12.

Figure 4.14-2
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values

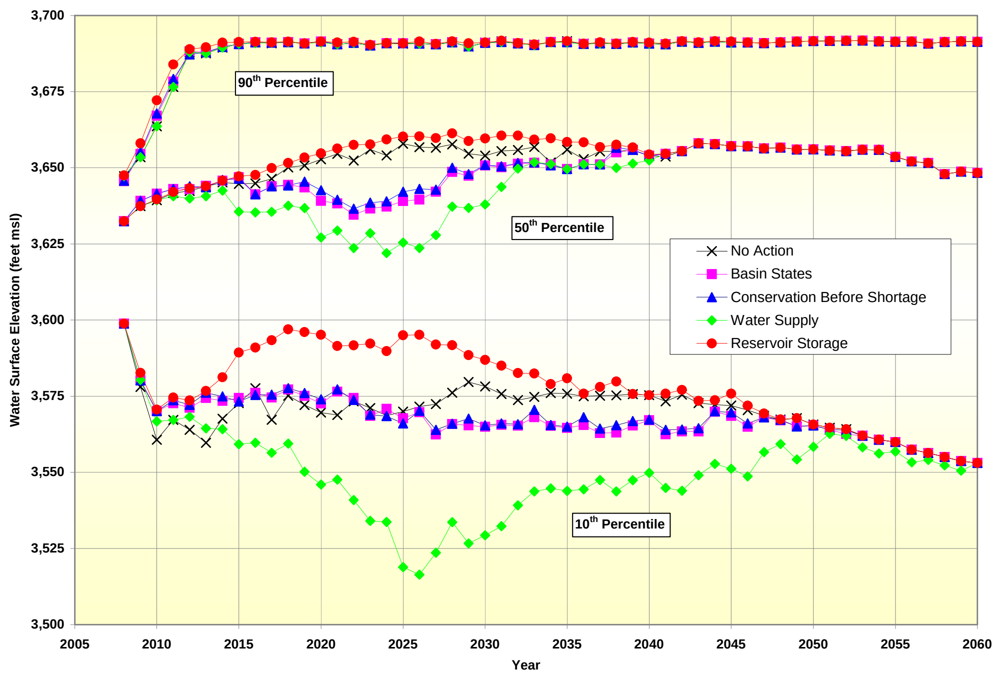
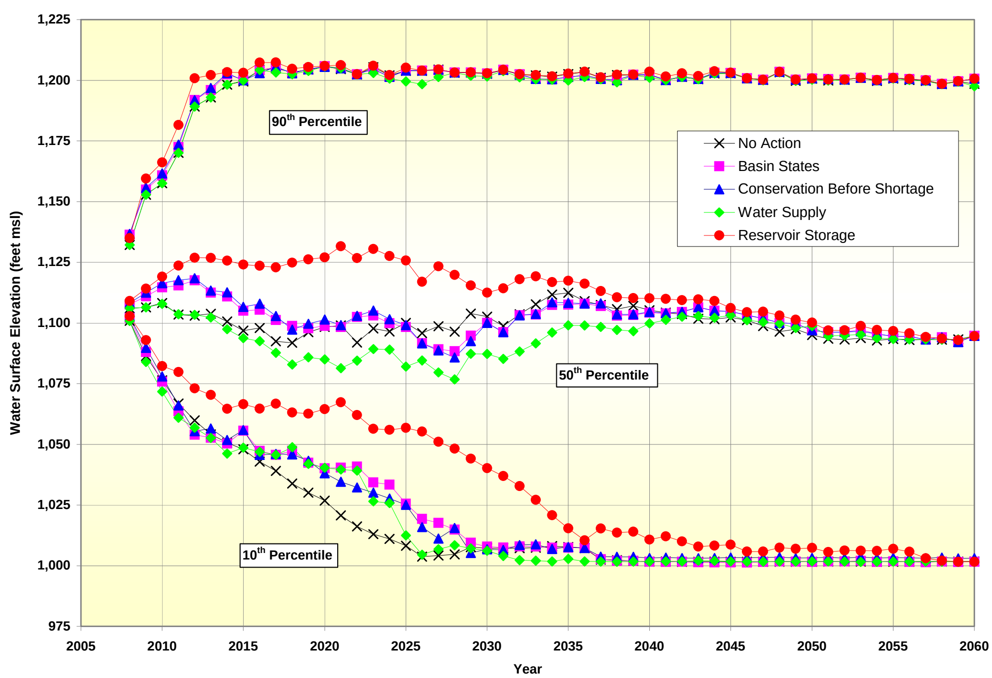


Figure 4.14-3
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th, and 10th Percentile Values



4.14.2 Agriculture

This section provides the assessment of potential effects on agricultural production and resulting changes in employment, income, and taxes. Table 4.14-1 provides estimates of involuntary fallowed agricultural land for each shortage amount. Table 4.14-2 provides estimates of changes in agricultural production value for each shortage amount. The change in production value was used as input to IMPLAN to estimate changes in employment, income, and tax revenue.

Table 4.14-1
Estimate of Involuntarily Fallowed Acres
in Arizona under Various Levels of Shortage for Various Years

Shortage (af)	Non-Indian Agriculture					
	2008	2017	2026	2027	2040	2060
400,000	-	75,824	28,940	-	-	-
500,000	-	77,150	30,255	17,667	6,034	6,099
600,000	-	78,476	31,569	18,986	7,383	7,460
800,000	-	80,945	34,012	21,436	9,887	9,989
1,000,000	-	83,094	36,134	23,551	11,960	12,043
1,200,000	-	-	-	25,582	14,083	14,183
1,800,000	-	-	-	-	26,447	26,590
2,500,000	-	-	-	-	-	-
Shortage (af)	Indian Agriculture					
	2008	2017	2026	2027	2040	2060
400,000	-	1,015	21,912	-	-	-
500,000	-	3,697	35,403	40,621	38,773	44,185
600,000	-	18,961	40,876	45,692	45,497	49,322
800,000	-	40,824	53,122	56,460	56,469	68,407
1,000,000	-	50,883	62,228	66,832	66,820	72,673
1,200,000	-	-	-	79,265	78,904	84,723
1,800,000	-	-	-	-	110,010	114,911
2,500,000	-	-	-	-	-	-
Shortage (af)	Total Agriculture					
	2008	2017	2026	2027	2040	2060
400,000	-	76,840	50,852	-	-	-
500,000	-	80,847	65,658	58,288	44,808	50,283
600,000	-	97,437	72,446	64,678	52,880	56,782
800,000	-	121,769	87,134	77,897	66,356	78,396
1,000,000	-	133,978	98,361	90,383	78,780	84,716
1,200,000	-	-	-	104,847	92,987	98,906
1,800,000	-	-	-	-	136,457	141,501

Note: a dash indicates that a shortage of the given magnitude did not occur in the particular year

Table 4.14-1 provides the total estimated fallowed acreage for each shortage amount for 2008, 2017, 2026, 2027, 2040, and 2060. No change in production would occur in 2008 because no shortages are projected to occur in that year. In general, for each shortage amount, the amount of fallowed non-Indian agricultural land decreases between 2017 and 2060 reflecting the trend of fewer acres of agricultural land being in production in the future. No permanent change in land uses would occur under any of the alternatives because shortages would be of a temporary nature and agricultural lands would likely not be permanently removed from production.

The changes in agricultural production values are shown in Table 4.14-2. These changes are a direct result of the amount of land fallowed for each shortage amount. Similar to the acreages of fallowed land, the changes in production value is expected to decrease as a result of less land being fallowed in the future for non-Indian agriculture.

Table 4.14-2
Estimated Change in Agricultural Production Value Resulting from Involuntary Land Fallowing in Arizona under Various Levels of Shortage for Various Years

Shortage (af)	Non-Indian Agriculture					
	2008	2017	2026	2027	2040	2060
400,000	-	$51,195,179	$12,387,806	-	-	-
500,000	-	$51,953,661	$13,149,411	$8,006,656	$3,270,691	$3,296,452
600,000	-	$52,712,002	$13,910,889	$8,770,989	$4,051,276	$4,082,213
800,000	-	$54,433,982	$15,643,948	$10,510,445	$5,830,923	$5,872,090
1,000,000	-	$56,268,414	$17,322,373	$12,192,218	$7,566,566	$7,652,684
1,200,000	-	-	-	$13,929,676	$9,340,389	$9,443,813
1,800,000	-	-	-	-	$16,709,801	$16,857,520
2,500,000	-	-	-	-	-	-
Shortage (af)	Indian Agriculture					
	2008	2017	2026	2027	2040	2060
400,000	-	$414,478	$9,312,403	-	-	-
500,000	-	$1,519,888	$14,973,885	$17,968,660	$17,145,722	$22,004,969
600,000	-	$7,647,965	$17,934,942	$20,962,163	$20,778,353	$23,911,269
800,000	-	$17,103,947	$25,412,798	$28,397,854	$28,403,141	$40,722,440
1,000,000	-	$23,748,789	$33,894,540	$38,696,649	$38,675,888	$44,848,932
1,200,000	-	-	-	$51,659,413	$51,279,840	$57,414,819
1,800,000	-	-	-	-	$83,717,890	$88,879,486
2,500,000	-	-	-	-	-	-

Table 4.14-2
Estimated Change in Agricultural Production Value Resulting from Involuntary Land Fallowing in Arizona under Various Levels of Shortage for Various Years

Shortage (af)	Total Agriculture					
	2008	2017	2026	2027	2040	2060
400,000	-	$51,609,657	$21,700,209	-	-	-
500,000	-	$53,473,550	$28,123,296	$25,975,317	$20,416,414	$25,301,421
600,000	-	$60,359,967	$31,845,830	$29,733,152	$24,829,629	$27,993,482
800,000	-	$71,537,929	$41,056,747	$38,908,299	$34,234,064	$46,594,531
1,000,000	-	$80,017,202	$51,216,914	$50,888,868	$46,242,454	$52,501,616
1,200,000	-	-	-	$65,589,088	$60,620,229	$66,858,632
1,800,000	-	-	-	-	$100,427,690	$105,737,006
2,500,000	-	-	-	-	-	-

Note: a dash indicates that a shortage of the given magnitude did not occur in the particular year

4.14.2.1 Changes in Agricultural Production and Resulting Changes in Employment and Income in Arizona

This section describes the potential changes in employment and income for each alternative as a result of changes in agricultural production. The discussion is a summary of the impact analysis conducted for the Arizona counties that may experience a shortage resulting in changes in agricultural production. The results of this county-level assessment of changes in employment and income for each shortage amount, year, and county are provided in Appendix H. The counties analyzed are Maricopa, Pinal, Pima, Mohave, La Paz, Yuma, and Graham. A summary comparison of the effects on employment and income among the alternatives is provided at the end of this subsection.

Table 4.14-3 presents a comparison of the shortage amounts with the estimated changes in employment and income and lists the probabilities of occurrence for each alternative, based on Tables 4.4-5 through 4.4-9. Shortages generated by the alternatives that were not exactly equal to the amounts shown in Table 4.14-3 were counted at the next highest value for the probabilities listed in Table 4.14-3.

Table 4.14-3
Estimated Changes in Employment as a Result of Shortages to Agricultural Lands for the No Action, Basin States, and Conservation Before Shortage, Water Supply and Reservoir Storage Alternatives, by Selected Years and Shortage Amounts

Shortage Amount (af)	2017						
	Shortage Probabilities for Each Alternative (percent)					Jobs	Income ($ million)
	NA	BS	CBS	WS	RS		
400,000	-	18	-	-	-	(534)	(21.0)
500,000	39	7	-	-	-	(597)	(21.3)
600,000	-	2	-	-	22	(707)	(25.3)
800,000	-	-	-	-	9	(853)	(29.4)
1,000,000	1	-	1	-	2	(929)	(32.8)
1,200,000	-	-	-	-	-	-	-
1,800,000	-	-	-	-	-	-	-
2,500,000	-	-	-	-	-	-	-
Shortage Amount (af)	2026						
	Shortage Probabilities for Each Alternative (percent)					Jobs	Income ($ million)
	NA	BS	CBS	WS	RS		
400,000	-	16	2	9	-	(316)	(8.8)
500,000	39	12	-	-	-	(406)	(11..4)
600,000	1	7	-	-	19	(453)	(12.9)
800,000	3	-	4	-	14	(561)	(16.7)
1,000,000	2	-	1	-	4	(656)	(21.7)
1,200,000	-	-	-	-	-	-	-
1,800,000	1	-	1	-	-	(1,206)	(42.5)
2,500,000	-	-	-	-	-	-	-
Shortage Amount (af)	2027						
	Shortage Probabilities for Each Alternative (percent)					Jobs	Income ($ million)
	NA	BS	CBS	WS	RS		
400,000	-	-	-	-	-	-	-
500,000	39	48	45	43	37	(356)	(10.5)
600,000	1	1	1	-	-	(402)	(11.7)
800,000	3	-	-	1	-	(515)	(16.0)
1,000,000	3	-	3	-	-	(634)	(21.1)
1,200,000	1	1	1	1	-	(780)	(29.2)
1,800,000	1	-	-	3	-	(1,204)	(43.8)
2,500,000	-	-	-	4	-	-	-

Table 4.14-3
Estimated Changes in Employment as a Result of Shortages to Agricultural Lands for the No Action, Basin States, and Conservation Before Shortage, Water Supply and Reservoir Storage Alternatives, by Selected Years and Shortage Amounts

Shortage Amount (af)	2040						
	Shortage Probabilities for Each Alternative (percent)					Jobs	Income ($ million)
	NA	BS	CBS	WS	RS		
400,000	-	-	-	-	-	-	-
500,000	42	41	40	37	46	(221)	(5.7)
600,000	1	1	1	1	-	(352)	(10.2)
800,000	2	2	2	4	-	(454)	(14.2)
1,000,000	1	1	1	2	2	(571)	(18.4)
1,200,000	3	3	7	4	-	(715)	(25.2)
1,800,000	4	5	2	5	3	(1,066)	(41.6)
2,500,000	-	-	-	-	-	-	-
Shortage Amount (af)	2060						
	Shortage Probabilities for Each Alternative (percent)					Jobs	Income ($ million)
	NA	BS	CBS	WS	RS		
400,000	-	-	-	-	-	-	-
500,000	55	53	49	53	54	(354)	(10.1)
600,000	1	-	3	1	-	(388)	(11.6)
800,000	4	5	5	4	5	(569)	(19.2)
1,000,000	3	2	2	3	1	(640)	(21.8)
1,200,000	3	3	4	3	4	(783)	(27.9)
1,800,000	4	4	3	4	3	(1,164)	(42.9)
2,500,000	-	-	-	-	-	-	-

Note:

NA = No Action Alternative

WS = Water Supply Alternative

CBS = Conservation Before Shortage Alternative

BS = Basin States Alternative

RS = Reservoir Storage Alternative

- = No shortage occurring

No Action Alternative. Potential decreases in employment attributable to a shortage occurring under the No Action Alternative for the period 2008 through 2026 would range from a low of 406 jobs during a 500,000 af shortage in 2026 to a high of 1,206 jobs during a 1.8 maf shortage in 2026. Resulting losses in personal income range from a low of approximately $11.4 million to a high of approximately $42.5million (Table 4.14-3).

For the period 2008 through 2026, a shortage of approximately 500,000 af would have the greatest probability of occurring, estimated at 39 percent. This shortage amount would result in an estimated loss of up to 597 jobs and resulting reduction in personal income of approximately $21.3 million (Table 4.14-3). Even if considered to be permanent, these potential changes in jobs and personal income are not considered substantial because the changes represent less than one percent of total employment and personal income generated within the seven-county study area in Arizona.

Potential decreases in employment attributable to a shortage occurring under the No Action Alternative for the period 2027 through 2060 would range from a low of 221 jobs during a 500,000 af shortage in 2040 to high of 1,164 jobs during a 1.8 maf shortage in 2060. Resulting losses in personal income over the same period would range from a low of approximately $5.7 million to a high of approximately $42.9 million (Table 4.14-3).

For the period 2027 through 2060, a shortage of approximately 500,000 af would have the greatest probability of occurring, ranging from 39 percent in 2027 to 55 percent in 2060. In 2060, a 500,000 af shortage would result in an estimated loss of 354 jobs and reduction in personal income of approximately $10.1 million (Table 4.14-3). Even if considered to be permanent, these potential changes in jobs and personal income are not considered substantial because the changes represent less than one percent of total employment and personal income within the seven-county study area in Arizona.

Basin States Alternative. Potential decreases in employment attributable to a shortage occurring under the Basin States Alternative for the period 2008 through 2026 would range from a low of 316 jobs during a 400,000 af shortage in 2026 to a high of 707 jobs during a 600,000 af shortage in 2017 resulting in a loss in personal income ranging from approximately $8.8 million to $25.3 million (Table 4.14-3).

For the period 2008 through 2026, a shortage of 400,000 af would have the greatest probability of occurring, 18 percent in 2017 and 16 percent in 2026, with corresponding estimated losses of 534 and 316 jobs respectively, and reductions in personal income of approximately $21.0 and 8.8 million respectively. Even if considered to be permanent, these potential changes in jobs and personal income are not considered substantial because the changes represent less than one percent of total employment and personal income within the seven-county study area in Arizona. As with the No Action Alternative, the probabilities of shortages of 600,000 af or greater occurring between 2008 and 2026 are very low for the Basin States Alternative.

Potential decreases in employment attributable to a shortage occurring under the Basin States Alternative between 2027 and 2060 would range from a low of 221 jobs during a 500,000 af shortage in 2040 to a high of 1,164 jobs during a 1.8 maf shortage in 2060. Resulting losses in personal income would range from a low of approximately $5.7 million to a high of approximately $42.9 million (Table 4.14-3).

For the period 2027 through 2060, a shortage of 500,000 af would have the greatest probability of occurring, ranging from 41 to 53 percent. The 500,000 af shortage amount would result in an estimated loss of up to 354 jobs and reduction in personal income of up to $10.1 million (Table 4.14-3). Even if considered to be permanent, these changes in jobs and personal income are not considered substantial because the changes represent less than one percent of total employment and personal income within the seven-county study area in Arizona. The probabilities of shortages of 600,000 af or greater occurring for the period 2027 through 2060 for the Basin States Alternative are higher than during the period 2008 to 2026, but are very similar to the No Action Alternative.

Conservation Before Shortage Alternative. It should be noted that the results of the analysis reported in this discussion may underestimate the socioeconomic effects of particular shortages occurring under the Conservation Before Shortage Alternative. This analysis assumes that the voluntary conservation targets (400 kaf, 500 kaf, and 600 kaf at Lake Mead elevations 1,075 feel msl, 1,050 feel msl, and 1,025 feet msl respectively) would be met, assuming that farmers would participate voluntarily in the program and that losses resulting from voluntary shortages would be offset by payments made to farmers to forgo raising crops. With these assumptions, the only the potential impacts of involuntary shortages have been analyzed in this section.

Potential decreases in employment attributable to an involuntary shortage occurring under the Conservation Before Shortage Alternative for the period 2008 through 2026 would range from a low of 316 jobs during a 400,000 af shortage in 2026 to a high of 1206 jobs during a 1.8 maf shortage in 2017. Similarly, estimated losses in personal income would range from a low of approximately $8.8 million to a high of approximately $42.5 million (Table 4.14-3).

Shortages of 500,000 af have a much greater probability of occurring under the No Action Alternative than under than under the Conservation Before Shortage Alternative. This suggests for the period 2008 through 2026 the probability of adverse socioeconomic effects occurring under the Conservation Before Shortage Alternative would be much less when compared to the No Action Alternative.

Potential decreases in employment attributable to a shortage occurring under the Conservation Before Shortage Alternative for the period 2027 through 2060 would range from a low of 221 jobs during a 500,000 af shortage in 2040 to a high of 1,164 jobs during a 1.8 maf shortage in 2060. Similarly, estimated losses in personal income over the same period would range from a low of approximately $5.7 million to a high of approximately $42.9 million (Table 4.14-3).

For the period 2027 through 2060, a shortage of 500,000 af would have the greatest probability of occurring, ranging from 40 percent to 49 percent. This 500,000 af shortage amount would result in an estimated loss of up to 356 jobs and reduction in personal income of approximately $10.5 million (Table 4.14-3). Even if considered permanent, these job losses and reductions in personal income are not considered substantial because the changes represent less than one percent of total employment and personal income within both the seven-county study area in Arizona.

When compared to the No Action Alternative, the probabilities of shortages in 2027 under the Conservation Before Shortage Alternative are higher for shortages of 500,000 af and less for greater shortages. However, in 2060 shortages of 500,000 af have a slightly lower probability of occurring under the Conservation Before Shortage Alternative and similar probabilities for higher shortage levels.

Water Supply Alternative. For the period 2008 through 2026, potential decreases in employment attributable to a shortage under the Water Supply Alternative would occur only during a 400,000 af shortage in 2026. This would result in an estimated loss of 316 jobs and reduction in personal income of $8.8 million (Table 4.14-3). This lack of shortages is a result of this alternative's strategy to provide full water deliveries until no water remains in Lake Mead, a reservoir draw down situation which has a low probability of occurring during the interim period.

Potential decreases in employment attributable to a shortage occurring under the Water Supply Alternative for the period 2027 through 2060 would range from a low of 221 jobs during a 500,000 af shortage in 2040 to a high of 1,164 jobs during a 1.8 maf shortage in 2060. Resulting losses in personal income over the same period would range from a low of approximately $5.7 million to a high of approximately $42.9 million (Table 4.14-3).

For the period 2040 through 2060, the probability of shortages under the Water Supply Alternative are very similar to those of the other alternatives, and shortages of 500,000 af would have the greatest probability of occurring, ranging from 37 percent to 53 percent. A 500,000 af shortage would result in an estimated loss of up to 356 jobs and reduction in personal income of up to $10.5 million. Even if considered to be permanent, these changes in jobs and personal income are not considered substantial because the changes represent less than one percent of total employment and personal income within the seven-county study area in Arizona.

Reservoir Storage Alternative. Potential decreases in employment attributable to a shortage occurring under the Reservoir Storage Alternative for the period 2008 through 2026 would range from a low of 453 jobs during a 600,000 af shortage in 2026 to a high of 929 jobs during a one maf shortage in 2017. Resulting losses in personal income over the same period would range from a low of approximately $12.9 million to a high of approximately $32.8 million (Table 4.14-3).

For the period 2008 through 2026, a shortage of 600,000 af would have the greatest probability of occurring, ranging from 19 percent to 22 percent. A 600,000 af shortage would result in an estimated loss of up to 707 jobs and reduction in personal income of approximately $25.3 million (Table 4.14-3). Even if considered to be permanent, these changes in jobs and personal income are not considered substantial because the changes represent less than one percent of total employment and personal income within the seven-county study area in Arizona.

When compared to the No Action Alternative, the probabilities of shortages of one maf or greater occurring for the period 2008 through 2026 are similar. However, shortages of 500,000 af have a much greater potential of occurring under the No Action Alternative whereas shortages of 600,000 af and 800,000 af have a greater probability of occurring under the Reservoir Storage Alternative. This suggests that for the period 2008 through 2026 the probability of adverse socioeconomic effects occurring under the Reservoir Storage Alternative may be slightly less than the No Action Alternative, but when shortages do occur, they are greater in magnitude with increased socioeconomic effects.

Potential decreases in employment attributable to a shortage occurring under the Reservoir Storage Alternative for the period 2027 through 2060 would range from a low of 221 jobs during a 500,000 af shortage in 2040 to a high of 1,164 jobs during a 1.8 maf shortage in 2060 (Table 4.14-3). Resulting losses in personal income would range from a low of approximately $5.7 million to a high of approximately $42.9 million (Table .14-3).

For the period 2027 through 2060, a shortage of 500,000 af would have the greatest probability of occurring, ranging from 37 percent to 54 percent. A 500,000 af shortage would result in an estimated loss of up to 356 jobs and reduction in personal income of up to $10.5 million (Table 4.14-3). Even if considered to be permanent, these changes in jobs and personal income are not considered substantial because the changes represent less than one percent of total employment and personal income within the seven-county study area and Arizona.

When compared to the No Action Alternative, the probabilities of shortages occurring under the Reservoir Storage Alternative are lower than the other alternatives in 2027 but very similar in 2060.

4.14.2.2 Changes in Tax Revenues in Arizona

This section describes the potential changes in tax revenue for each alternative as a result of changes in agricultural production. Changes in tax revenue would result from the direct reduction in agricultural production, from reduced business-to-business activity, and from reductions in personal income. The tax revenue discussion summarizes the impacts for those Arizona counties that may experience a water shortage resulting in changes in agricultural production. The results of the county-level assessment on tax revenues for each shortage amount, year, and county are provided in Appendix H. The counties analyzed are Maricopa, Pinal, Pima, Mohave, La Paz, Yuma, and Graham. A summary comparison of the effects on tax revenue is provided at the end of this subsection.

Table 4.14-4 presents a comparison of the shortage amounts with the estimated changes in tax revenues and lists the probabilities of occurrence for each alternative. Shortages generated by the alternatives that were not exactly equal to the amounts shown in Table 4.14-4 were counted at the next highest value for the probabilities listed in Table 4.14-4.

Table 4.14-4
Estimated Changes in Tax Revenues as a Result of Shortages to Agricultural Lands under the No Action, Basin States, Conservation Before Shortages, Water Supply, and Reservoir Storage Alternatives, by Selected Year and Shortages

Shortage Amount (af)	2017					
	Shortage Probabilities for Each Alternative (percent)					Changes in Tax Revenues ($ million)
	NA	BS	CBS	WS	RS	
400,000	-	18	-	-	-	(7.3)
500,000	39	7	-	-	-	(7.5)
600,000	-	2	-	-	22	(8.6)
800,000	-	-	-	-	9	(10.1)
1,000,000	1	-	1	-	2	(11.3)
1,200,000	-	-	-	-	-	-
1,800,000	-	-	-	-	-	-
2,500,000	-	-	-	-	-	-
Shortage Amount (af)	**2026**					
	Shortage Probabilities for Each Alternative (percent)					Changes in Tax Revenues ($ million)
	NA	BS	CBS	WS	RS	
400,000	-	16	2	9	-	(3.1)
500,000	39	12	-	-	-	(4.0)
600,000	1	7	-	-	19	(4.5)
800,000	3	-	4	-	14	(5.8)
1,000,000	2	-	1	-	4	(7.3)
1,200,000	-	-	-	-	-	-
1,800,000	1	-	1	-	-	(14.3)
2,500,000	-	-	-	-	-	-
Shortage Amount (af)	**2027**					
	Shortage Probabilities for Each Alternative (percent)					Changes in Tax Revenues ($ million)
	NA	BS	CBS	WS	RS	
400,000	-	-	-	-	-	-
500,000	39	48	45	43	37	(3.5)
600,000	1	1	1	-	-	(4.1)
800,000	3	-	-	1	-	(5.5)
1,000,000	3	-	3	-	-	(7.2)
1,200,000	1	1	1	1	-	(9.3)
1,800,000	1	-	-	3	-	(14.8)
2,500,000	-	-	-	4	-	-

Table 4.14-4
Estimated Changes in Tax Revenues as a Result of Shortages to Agricultural Lands under the No Action, Basin States, Conservation Before Shortages, Water Supply, and Reservoir Storage Alternatives, by Selected Year and Shortages

Shortage Amount (af)	2040					
	Shortage Probabilities for Each Alternative (percent)					Changes in Tax Revenues ($ million)
	NA	BS	CBS	WS	RS	
400,000	-	-	-	-	-	-
500,000	42	41	40	37	46	(2.0)
600,000	1	1	1	1	-	(3.5)
800,000	2	2	2	4	-	(4.9)
1,000,000	1	1	1	2	2	(6.6)
1,200,000	3	3	7	4	-	(8.7)
1,800,000	4	5	2	5	3	(11.3)
2,500,000	-	-	-	-	-	-
Shortage Amount (af)	2060					
	Shortage Probabilities for Each Alternative (percent)					Changes in Tax Revenues ($ million)
	NA	BS	CBS	WS	RS	
400,000	-	-	-	-	-	-
500,000	55	53	49	53	54	(3.6)
600,000	1	-	3	1	-	(4.0)
800,000	4	5	5	4	5	(6.6)
1,000,000	3	2	2	3	1	(7.5)
1,200,000	3	3	4	3	4	(9.4)
1,800,000	4	4	3	4	3	(14.6)
2,500,000	-	-	-	-	-	-

Note:

NA = No Action Alternative

WS = Water Supply Alternative

CBS = Conservation Before Shortage Alternative

BS = Basin States Alternative

RS = Reservoir Storage Alternative

- = No Shortage Occurring

Arizona reported a total of $8.477 billion in state taxes collected and $5.943 billion in local government taxes collected for 2001–2002 (<http://ftp2.census.gov/govs/estimate/02slsstab1a.xls>). These values are compared to the tax impacts associated with the project alternatives, discussed in the following paragraphs and referring to Table 4.14-4 and Appendix H.

No Action Alternative. Potential decreases in tax revenue for the period 2008 through 2026 would range from a low of $4 million during a 500,000 af shortage in 2026 to a high of $14.3 million during a 1.8 maf shortage in 2026. For the period 2008 through 2026, a shortage of approximately 500,000 af would have the greatest probability of occurring, estimated at 39 percent.

Potential decreases in tax revenue for the period 2027 through 2060 would range from a low of $2 million during a 500,000 af shortage in 2040 to a high of $14.8 million during a 1.8 maf shortage in 2027. For the period 2027 through 2060, a shortage of 500,000 af would have the greatest probability of occurring, estimated at between 39 percent in 2027 to 55 percent in 2060. These changes in tax revenues represent a small percentage of total state and local taxes collected.

Basin States Alternative. Potential decreases in tax revenue occurring under the Basin States Alternative for the period 2008 through 2026 would range from a low of $3.1 million during a 400,000 af shortage in 2026 to a high of $8.6 million during a 600,000 af shortage in 2017. For the period 2008 through 2026, a shortage of 400,000 af would have the greatest probability of occurring, estimated at 16 to 18 percent.

Potential decreases in tax revenue attributable to a shortage occurring during the Basin States Alternative during the period 2027 through 2060 would range from a low of $2 million during a 500,000 af shortage in 2040 to a high of $14.6 million during a 1.8 maf shortage in 2060. For the period 2027 through 2060, a shortage of 500,000 af would have the greatest probability of occurring, estimated at between 41 percent in 2040 to 53 percent in 2060. Although these tax effects are substantial, they represent a small percentage of total state and local taxes collected.

Conservation Before Shortage Alternative. This analysis assumes that the voluntary conservation targets (400 kaf, 500 kaf, and 600 kaf at Lake Mead elevations 1,075 feet msl, 1,050 feel msl, and 1,025 feet msl respectively) would be met and therefore only the potential impacts of involuntary shortages have been analyzed. Potential decreases in tax revenue due to an involuntary shortage occurring under the Conservation Before Shortage Alternative during the period 2008 through 2026 would range from a low of $3.1 million during a 400,000 af shortage in 2026 to a high of $11.3 million during a 1 maf shortage in 2017. For the period 2008 through 2026, a shortage of 800,000 af would have the greatest probability of occurring, estimated at only four percent.

Potential decreases in tax revenue attributable to a shortage occurring under the Conservation Before Shortage Alternative during the period 2027 through 2060 would range from a low of $2 million during a 500,000 af shortage in 2040 to a high of $14.6 million during a 1.8 maf shortage in 2060. For the period 2027 through 2060, a shortage of 500,000 af would have the greatest probability of occurring, estimated at between 40 percent in 2040 to 49 percent in 2060. Although these tax effects are substantial, they represent a small percentage of total state and local taxes collected.

Water Supply Alternative. Potential decreases in tax revenue occurring under the Water Supply Alternative during the period 2008 through 2026 would be limited to a loss of $3.1 million during a 400,000 af shortage in 2026. This lack of shortages is a result of this alternative's strategy to provide full water deliveries until no water remains in Lake Mead, a reservoir draw down situation which has a low probability of occurring during the interim period.

Potential decreases in tax revenue attributable to a shortage occurring under the Water Supply Alternative during the period 2027 through 2060 would range from a low of $2 million during a 500,000 af shortage in 2040 to a high of $14.6 million during a 1.8 maf shortage in 2060. For the period 2027 through 2060, a shortage of 500,000 af would have the greatest probability of occurring, estimated at between 37 percent in 2040 to 53 percent in 2060. Although these tax effects are substantial, they represent a small percentage of total state and local taxes collected.

Reservoir Storage Alternative. Potential decreases in tax revenue attributable to a shortage occurring under the Reservoir Storage Alternative during the period 2008 through 2026 would range from a low of $4.5 million during a 600,000 af shortage in 2026 to a high of $11.3 million during a 1 maf shortage in 2017. For the period 2008 through 2026, a shortage of 600,000 af in 2017 would have the greatest probabilities of occurring, estimated at 19 to 22 percent.

Potential decreases in tax revenue attributable to a shortage occurring under the Reservoir Storage Alternative during the period 2027 through 2060 would range from a low of $2 million during a 500,000 af shortage in 2040 to a high of $14.6 million during a 1.8 maf shortage in 2060. For the period 2027 through 2060, a shortage of 500,000 af would have the greatest probability of occurring, estimated at between 37 percent in 2027 to 54 percent in 2060. Although these tax effects are substantial, they represent a small percentage of total state and local taxes collected.

4.14.2.3 Changes in Agricultural Production in California and Resulting Changes in Employment and Income in California

The results of the water allocation modeling indicate that although a portion of the shortages may be shared by California, agricultural users would not be affected in the event a shortage occurs. In California, agricultural rights are senior enough that they are not expected to share in a shortage. None of the alternatives are expected to result in a change in agricultural production.

4.14.2.4 Changes in Agricultural Production in Nevada and Resulting Changes in Employment and Income in Nevada

The results of the water allocation modeling indicate that although a portion of the shortages may be shared by Nevada, agricultural users would not be affected in the event a shortage occurs. There are very few agricultural users that receive part of Nevada's Colorado River water allocation. None of the alternatives are expected to result in a change in agricultural production.

Shortages occurring in Nevada are expected to be limited to the M&I sector. No changes in employment and income as a result of changes in agricultural production in Nevada are expected under any of the alternatives.

4.14.3 Municipal and Industrial Water Uses

This section provides the results of the assessment of potential changes in M&I water use and resulting socioeconomic effects. The analysis is a qualitative discussion supported by the assessment of the shortage probabilities and volumes described in Section 4.4.

For the period 2008 through 2060 the probability of a shortage occurring is highest for shortages ranging from 400,000 to 800,000 af and the probabilities of shortages occurring greater than 800,000 af are very similar among all the alternatives, including the No Action Alternative. Accordingly, the focus of the M&I analysis was to describe the effects of shortages that range from 400,000 af to 800,000 af.

For the period 2008 through 2026, the greatest differences in shortage probabilities would occur under the Basin States Alternative and the Reservoir Storage Alternative. In 2017, a 600,000 af shortage would have a 22 percent chance of occurring under the Reservoir Storage Alternative compared to a zero percent chance under the No Action Alternative. Conversely, a 500,000 af shortage would have a much greater likelihood of occurring under the No Action Alternative compared to all the action alternatives.

For the period 2027 through 2060, the probability of a shortage occurring under each alternative is highest at the 500,000 af shortage level. When compared to the No Action Alternative, shortages of 500,000 af in 2027 have a greater probability of occurring under all the action alternatives. Conversely, in 2040 and in 2060 shortages of 500,000 af have a slightly lower probability of occurring under all the action alternatives when compared to the No Action Alternative.

4.14.3.1 Changes in Municipal and Industrial Water Uses In Arizona

This section describes the potential socioeconomic effects that would result from changes in deliveries to M&I users in Arizona. As described above, the analysis is based on an analysis of shortage amounts in the range of 400,000 af to 800,000 af.

Arizona's Drought Management Plan serves as an umbrella that provides direction to Arizona state agencies and guidance to regional and local agencies regarding responses to drought conditions (Arizona 2004). Shortages to the Arizona M&I sector would be addressed through the state's and each local jurisdiction's drought responses and plans. These responses include supply-side and demand-side actions. Supply-side actions may include groundwater recharge, water purchase agreements, and alternative water supplies such as brackish water and reclaimed water. Demand-side strategies focus on implementing different stages of water conservation measures as a drought progresses. Shortages to the Arizona M&I sector would be addressed through each entity's supply-side and demand-side drought response actions and programs.

Arizona M&I shortages of up to 283,000 af could occur during shortages in the range of 400,000 af to 800,000 af. Implementing statewide and local demand-side and supply-side strategies are expected to minimize adverse socioeconomic effects occurring during the maximum M&I shortage.

4.14.3.2 Changes in Municipal and Industrial Water Uses In California

The section provides the results of the analysis of changes of potential socioeconomic effects as a result of changes in deliveries to M&I users. The conclusion is based on information provided in the water supply section. In summary, deliveries to MWD are not anticipated to be adversely affected for the Lower Basin shortages up to 1.8 maf because of California's higher priority relative to Arizona's and Nevada's Colorado River water supply priorities. In addition, shortages of 1.8 maf or greater have a low probability of occurring. MWD has or is working on putting in place storage and transfer programs that are expected to provide full supplies when needed even when Colorado River surplus supplies are not available. MWD has implemented and continues to expand storage and transfer programs that could be implemented to make up for water supply shortfalls in the event of a shortage. Examples of MWD actions include agreements with irrigation districts and individual landowners to reduce water use by fallowing lands, funding water efficiency improvements, and banking and exchange programs.

MWD is not expected to experience a substantial reduction in deliveries to M&I users during a shortage because of the priority of California's water rights in combination with the availability of alternative water supplies. The action alternatives are not expected to result in a substantial change in economic activities dependent on M&I deliveries.

4.14.3.3 Changes in Municipal and Industrial Water Uses in Nevada

This section describes the potential socioeconomic effects that would result from changes in deliveries to M&I users in Nevada. The analysis is based on a comparison of the action alternatives to the No Action Alternative.

Shortages to the M&I sector of Southern Nevada would mostly be borne by the SNWA, which has prepared a drought plan (SNWA Drought Plan 2005) to address water shortages. That plan includes two levels – a drought watch and a drought alert and calls for landscape watering restrictions to private lawns, community use recreational turf areas, and golf courses. The plan also includes restrictions on surface, building, equipment, and vehicle washing.

Each action alternative would have shortage allocations that are less than or almost equivalent to those under the No Action Alternative. The largest differential would occur under the Water Supply Alternative in 2027, where the shortage would equal 84,290 af as compared to 60,565 af under the No Action Alternative. Even under this most extreme scenario, however, the drought plan would be used to make up the water supply shortfall of less than 25,000 af. For each scenario, the probability of shortages in southern Nevada would not be substantially different than under the No Action Alternative. In addition, with Nevada's drought plan in place, shortages to the M&I sector (under the No Action Alternative or under either of the action alternatives) would be minimized. Consequently, socioeconomic effects on southern Nevada's M&I sector resulting from the proposed alternatives would not be substantial.

4.14.4 Recreation

This section describes the changes in reservoir-related and river-related economic activity attributable to implementing the shortage criteria alternatives. The assessment is based, in part, on the conclusions provided in Section 4.3 and Section 4.12.

4.14.4.1 Change in Economic Activity as a Result of Changes in Recreation Occurring at Lake Powell

The following qualitative assessment of changes in recreation-related economic activity is based on a comparison of Lake Powell elevations modeled for the No Action Alternative and each action alternative.

As shown in Figure 4.14-2, at the 90th percentile, there are no differences in Lake Powell end-of-September lake elevations between the alternatives. This suggests that at higher lake elevations there would be no differences in recreation opportunities and associated economic activity among the alternatives.

At the 50th percentile, end-of-September reservoir elevations under the Reservoir Storage Alternative would be nearly the same as conditions under the No Action Alternative. This suggests that recreation opportunities and resulting economic activity would not change. Reservoir elevations would be lower under the Conservation Before Shortage, Basin States, and the Water Supply Alternatives when compared to the No Action Alternative, with the Water Supply Alternative showing the lowest 50th percentile elevations. Because the reservoir would have substantial storage under all alternatives at the 50th percentile level, these lower elevations are not expected to result in substantial change in recreation opportunities at Lake Powell and would not result in a substantial change in recreation-related economic activity.

The greatest differences in Lake Powell elevations would occur at the 10th percentile. Lake Powell elevations would be higher under the Reservoir Storage Alternative when compared to the No Action Alternative. These higher elevations would benefit recreation opportunities at Lake Powell and resulting economic activity. Reservoir levels would be nearly the same for the Basin States, Conservation Before Shortage, and the No Action Alternative. This suggests that recreation-related economic activity would be the same among these three alternatives. Reservoir elevations would be lowest under the Water Supply Alternative and would result in the greatest adverse effect on recreation opportunities and associated reduction in economic activity.

4.14.4.2 Change in Economic Activity as a Result of Changes in Recreation Occurring in the Colorado River Below Lake Powell

Recreation opportunities and use would not be adversely affected on the Colorado River reach below Lake Powell because flows would not drop below safe boating thresholds for all of the alternatives. There would be no resulting changes in recreation-related economic activity among the alternatives because recreation use is not expected to change.

4.14.4.3 Change in Economic Activity as a Result of Changes in Recreation Occurring at Lake Mead

The following qualitative assessment of changes in recreation-related economic activity is based on a comparison of Lake Powell elevations modeled for the No Action Alternative and each action alternative.

As illustrated in Figure 4.14-3, at the 90th percentile, there are essentially no differences in Lake Mead end-of-July lake elevations among the alternatives. This suggests that at the higher lake elevations there would no differences in recreation opportunities and associated economic activity.

At the 50th percentile, end-of-July reservoir elevations under the Reservoir Storage Alternative would be higher when compared to the No Action Alternative. This suggests that recreation opportunities and resulting economic activity would be greater under the Reservoir Storage Alternative. Reservoir levels for the Basin States, Conservation Before Shortage, and No Action alternatives would be nearly the same. No substantial differences in economic activity would occur under the Conservation Before Shortage, Basin States, and Water Supply alternatives.

The greatest differences in Lake Mead elevations would occur at the 10th percentile. The Lake Mead elevations under the Basin States, Conservation Before Shortage, and Water Supply alternatives would be slightly higher during the interim period when compared to the No Action Alternative. This suggests that there would be only a small, if any, increase in economic activity when compared to the No Action Alternative. The Reservoir Storage Alternative would result in the greatest increase in Lake Mead elevations compared to the No Action Alternative. These higher elevations would benefit recreation opportunities and resulting economic activity.

4.14.4.4 Changes in Economic Activity as a Result of Changes in Recreation Occurring in the Colorado River Below Lake Mead

Recreation opportunities and use would not be adversely affected on the reach of the Colorado River below Lake Mead because releases from Hoover Dam, Davis Dam, Parker Dam, and Imperial Dam would remain within historical ranges. As a result, there would be no change in recreation-related economic activity among the alternatives because recreation opportunities and use are not expected to change.

4.14.5 Summary

4.14.5.1 Employment and Income

When compared to the No Action Alternative, none of the action alternatives would result in a substantial change in employment or income attributable to changes in agricultural production. Although a loss in employment and income would occur under each alternative, the probability of shortages occurring would be greater under the No Action Alternative. This suggests that the loss in employment and income estimated for the No Action Alternative would be reduced under each of the action alternatives. Among the action alternatives, shortages would have the greatest probability of occurring under the Reservoir Storage and Basin States alternatives, with the Reservoir Storage Alternative producing larger shortages during the interim period. This indicates that these alternatives could potentially result in the greatest loss in employment and income. However, none of the changes in employment and income are considered substantial when compared to total employment and income generated within the study area.

For the period 2027 through 2060, the change in employment and income would be similar between the No Action Alternative and the action alternatives. The greatest difference would be in 2027 in which the probabilities would be slightly higher when compared to the No Action Alternatives. However, by 2040, the probabilities of shortages occurring under all alternatives are very similar.

4.14.5.2 Tax Revenues

When compared to the No Action Alternative, none of the action alternatives would result in a greater change in tax revenues attributable to changes in agricultural production. Although a reduction in tax revenues would occur under each alternative, the probability of a shortage occurring would be greatest under the No Action Alternative. The loss in tax revenue estimated for the No Action Alternative would be lower under each of the action alternatives. Among the action alternatives, shortages would have the greatest probability of occurring under the Reservoir Storage and Basin States alternatives, suggesting that these alternatives would result in the greatest loss in tax revenues. However, none of the changes in tax revenues are considered substantial when compared to total tax revenue generated within the study area.

For the period 2027 through 2060, the change in tax revenue would be similar between the No Action Alternative and the action alternatives. The greatest difference would be in 2027 in which the shortage probabilities would be slightly higher when compared to the No Action Alternative. However, by 2040, the probabilities of shortages occurring under all alternatives are very similar, suggesting that the change in tax revenues among all alternatives would be similar.

4.14.5.3 Municipal and Industrial Water Uses

Adverse effects on employment and income in Arizona and Nevada during shortages would be minimized as a result of drought plans being in place. No adverse effects are expected in California because of priority of apportionment and the availability of alternative water supplies.

4.14.5.4 Recreation

Recreation opportunities and associated economic activity at Lake Powell are not expected to be substantially different between the No Action, Basin States, and Conservation Before Shortage alternatives. Recreation opportunities and associated economic activity would be adversely affected under the Water Supply Alternative. Conversely, recreation opportunities and associated economic activity would benefit under the Reservoir Storage Alternative as a result of higher Lake Powell elevations.

Recreation opportunities and associated economic activity at Lake Mead are not expected to be substantially different between the No Action Alternative or the Basin States, Conservation Before Shortage, and Water Supply alternatives. Recreation opportunities and associated economic activity would benefit under the Reservoir Storage Alternative as a result of higher Lake Mead elevations.

Because flows in the Lake Powell to Lake Mead reach and in the reach downstream of Lake Mead would remain within ranges suitable for boating, there would be no change in river-related economic activity.

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4.15 Environmental Justice

This section describes the methods of analysis, and potential effects on environmental justice communities at the county level.

4.15.1 Methodology

The nine environmental justice counties were examined by resource to identify whether any of the alternatives are likely to have disproportionate and adverse human health or environmental impacts.

4.15.2 Hydrology, Water Deliveries, and Socioeconomics

Potential water shortages will not impact water deliveries in Utah (Section 3.2) and would only rarely affect water deliveries in California (Table 4.4-16 and Table 4.4-17). Five of the eight Arizona counties are environmental justice communities. Two of the three counties served by the CAP are environmental justice communities (Pinal and Pima). Under all alternatives, a shortage would cause the reduction of water deliveries first to the CAP and other post-1968 Colorado River contractors in Arizona. While some would consider this a disproportionate impact on these Arizona counties as compared to other Colorado River contractors, this shortage allocation is mandated under the CRBPA, and would occur under all of the action alternatives as well as under the No Action Alternative.

As an example of the magnitude of potential socioeconomic impacts, in 2026 a 500,000 af shortage has a 39 percent chance of occurring under the No Action Alternative. This would potentially result in a loss of about 270 jobs. In comparison, under the Basin States Alternative, the probability of occurrence is approximately 12 percent and would result in a loss of the same number of jobs. Under the Conservation Before Shortage Alternative and the Water Supply Alternative, there would be a zero percent probability of this shortage in 2026. Under the Reservoir Storage Alternative, there is a zero percent probability of shortage in 2026. The biggest difference in the probability of shortage occurs in 2017 with a 22 percent probability of occurrence under the Reservoir Storage Alternative and a zero percent probability of occurrence under the No Action Alternative. Even so, this effect is projected to only result in the loss of approximately 215 jobs. The loss in the number of jobs is so small compared to the total number of jobs in the environmental justice counties that the effects of the alternatives are negligible.

Accordingly, there is no substantive difference among the alternatives with respect to environmental justice impacts from water deliveries and socioeconomics.

4.15.3 Water Quality

Potential changes to water quality were evaluated for salinity, temperature, metals, and perchlorate. Effects on these parameters would be minor and would not disproportionately affect any environmental justice communities in the study area. For example, in Imperial County, California, the predicted salinity values would range from 740 mg/L to 764 mg/L. All values are below the 879 mg/L numeric criterion established by the Colorado River Salinity Control Forum.

4.15.4 Air Quality

Potential changes to fugitive dust emissions due to exposed shoreline are minor at Lake Powell (San Juan County) and there is no significant difference among alternatives at Lake Mead or downstream. Therefore, the proposed federal action would not disproportionately impact any environmental justice communities.

4.15.5 Visual Resources

Potential impacts to visual resources were considered for calcium carbonate rings, attraction features, and sediment deltas. While some of these features are located within San Juan County, Utah, (e.g. Rainbow Bridge) an environmental justice community, effects are not disproportionate or unique to any environmental justice community.

4.15.6 Biological Resources

Potential impacts to biological resources would not disproportionately impact any environmental justice community identified within the study area. Potential impacts to vegetation, wildlife, and fish due to the action alternatives would be minor.

Scoping and subsequent consultation did not result in the identification of any environmental justice community for whom indigenous fish, vegetation, or wildlife constituted a significant portion of their diet. There will not be any difference in rates or patterns of subsistence consumption by environmental justice communities, including Indian tribes, in comparison to the general population in the study area.

4.15.7 Cultural Resources

Potential impacts or access to cultural resources are not expected to be unique to the environmental justice communities identified in the study area. Reclamation and the cooperating agencies are committed to compliance with all laws and regulations associated with historic properties, sacred sites, and cultural resources. Consultations are ongoing with concerned Indian tribes.

4.15.8 Indian Trust Assets

Reclamation has concluded that the proposed federal action will have no significant impacts on ITAs. Reclamation is committed to protecting and maintaining ITAs and rights reserved by or granted to Indian tribes or individual Indians by treaties, statutes, and executive orders.

4.15.9 Electrical Power Resources

Changes to electrical power production among the alternatives have the potential to affect environmental justice communities disproportionately through possible minor increases in electricity rates resulting from decreased electrical power generation under some of the action alternatives. However, these changes in electrical power production are generally very minor (less than one percent) and the facilities potentially affected produce less than four percent of the total power produced in the region. Therefore no substantial environmental justice effects are anticipated.

4.15.10 Recreation

Potential recreational impacts are primarily associated with shoreline facilities around Lake Powell and Lake Mead. San Juan County, Utah, which is greater than 50 percent minority, includes a portion of Lake Powell and could be affected by these recreational impacts; however, the effect would not be disproportionate to the recreational impacts experienced by other counties adjacent to Lake Powell and Lake Mead.

4.15.11 Transportation

Potential transportation impacts are associated primarily with ferry services on Lake Powell and on the Colorado River below Davis Dam. At Lake Powell, both San Juan County and Kane County would be equally affected by any disruption to the ferry service due to low reservoir levels. San Juan County would not be disproportionately affected. Below Davis Dam, the ferry service across the river serves two non-environmental justice counties.

4.15.12 Summary

After evaluating each resource, it is concluded that the environmental justice communities identified in the study area would not be disproportionately affected by any of the anticipated environmental impacts stemming from the proposed federal action.

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Chapter Five

Other Considerations and Cumulative Impacts

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5.1 Federal Statutes and Policies

In compliance with NEPA, this Draft EIS is intended to provide decision makers and the public with information regarding compliance with other environmental laws, rules, and regulations that are applicable to the proposed federal action as well as the environmental impacts of the proposed federal action, as presented below.

5.1.1 Endangered Species Act of 1973, as Amended (16 U.S.C. §§ 1531-1544)

Section 7 of the ESA requires federal agencies to consult with the FWS to ensure that undertaking, funding, permitting, or authorizing an action is not likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, as defined under the law.

Adoption of the proposed federal action by the Secretary is a discretionary federal action and it is, therefore, subject to compliance with the ESA. Reclamation will request a species list from the FWS and subsequently prepare a biological assessment to address the potential effects of the proposed federal action on listed species. Once a preferred alternative is identified, the BA will be finalized and formal consultation will be initiated, if appropriate. Reclamation and the FWS will consult during 2007, with the intent of completing a BO for inclusion in the Final EIS.

5.1.2 Fish and Wildlife Coordination Act of 1934, as Amended (16 U.S.C. §§ 661-667d)

The Fish and Wildlife Coordination Act of 1934, as amended, requires consultation and coordination with federal and state wildlife agencies to ensure that fish and wildlife are given equal consideration when developing water resources projects. The proposed federal action is not a water resources development project and specific consultation and coordination under the Fish and Wildlife Coordination Act, as amended, is not necessary. FWS is a cooperating agency and has been involved in the preparation of this Draft EIS.

5.1.3 National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. § 668dd)

The National Wildlife Refuge System Administration Act of 1966 provides for the administration and management of the national wildlife refuge system, including wildlife refuges, areas for the protection and conservation of fish and wildlife threatened with extinction, wildlife ranges, game ranges, wildlife management areas and waterfowl production areas. The study area includes the following four national wildlife refuges on the Colorado River below Hoover Dam: Havasu NWR, Bill Williams NWR, Cibola NWR, and Imperial NWR. Only minor changes in Colorado River flow through these refuges would occur under the action alternatives. No adverse impacts to refuges would result from the proposed federal action; thus, it would be consistent with the National Wildlife Refuge System Administration Act.

5.1.4 Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§ 1271-1287)

The Wild and Scenic Rivers Act of 1968 establishes a National Wild and Scenic Rivers System for the protection of rivers with important scenic, recreational, fish and wildlife, and other values. Rivers are classified as wild, scenic or recreational. The Congressional policy behind the National Wild and Scenic Rivers System is not to halt use of a river; instead, the goal is to preserve the character of a river. Uses compatible with the management goals of a particular river are allowed; however, development must ensure the river's free flow and protect its "outstandingly remarkable resources." The Wild and Scenic Rivers Act designates specific rivers for inclusion in the National Wild and Scenic Rivers System and prescribes the methods and standards by which additional rivers may be added. There are no designated wild and scenic rivers within the study area.

However, pursuant to Section 5(d) of the Wild and Scenic Rivers Act, the NPS has compiled and maintains a Nationwide Rivers Inventory (NRI), a register of river segments that potentially qualify as national wild, scenic, or recreational river areas. The NRI is a listing of more than 3,400 free-flowing river segments in the United States that are believed to possess one or more "outstandingly remarkable" natural or cultural values judged to be of more than local or regional significance. Under a 1979 Presidential directive, and related Council on Environmental Quality procedures, all federal agencies must seek to avoid or mitigate actions that would adversely affect one or more NRI segments. Within the study area, the NPS has identified four river segments (with segment lengths provided in parentheses) on the NRI:

- Colorado River from Paria Riffle (RM 1) to 237-Mile Rapid in Grand Canyon National Park (236 miles);
- Colorado River from Glen Canyon Dam to Lake Mead (228 miles);
- Colorado River from upper end Lake Havasu (Blankenship Bend) to Interstate Highway 40 bridge crossing in Topock (11 miles); and
- Colorado River from gaging station below Cibola Lake to Martinez Lake (Fishers Landing) (31 miles).

The relatively minor changes in flow associated with the proposed federal action would not adversely affect the values for which these Colorado River segments were identified.

5.1.5 Migratory Bird Treaty Act of 1918 (16 U.S.C. §§ 703-712)

The Migratory Bird Treaty Act of 1918 protects migratory birds by limiting the hunting, capturing, selling, purchasing, transporting, importing, exporting, killing, or possession of these birds or their nests or eggs. The specific migratory birds covered are identified in separate agreements between the United States and Great Britain, Mexico, and Japan. No significant adverse impacts to migratory birds would result from the proposed federal action; thus, it would be consistent with the Migratory Bird Treaty Act.

5.1.6 Migratory Bird Conservation Act of 1929 (16 U.S.C. § 715)

The Migratory Bird Conservation Act of 1929 protects migratory birds by creating the Migratory Bird Conservation Commission. This Commission's purpose is to consider and approve the purchase, rental, or other acquisition of any areas of land or water that may be recommended by the Secretary for the purpose of establishing sanctuaries for migratory birds. No significant adverse impacts on migratory birds would result from the proposed federal action; thus, it would be consistent with the Migratory Bird Conservation Act.

5.1.7 Bald Eagle Protection Act of 1940 (16 U.S.C. § 668)

The Bald Eagle Protection Act of 1940 imposes criminal and civil penalties on anyone in the United States or within its jurisdiction who, unless excepted, takes, possesses, sells, purchases, barters, offers to sell or purchase or barter, transports, exports or imports at any time or in any manner a bald or golden eagle, alive or dead; or any part, nest or egg of these eagles; or violates any permit or regulations issued under the Bald Eagle Protection Act. No adverse impacts to bald eagles would result from the proposed federal action; thus, it would be consistent with the Bald Eagle Protection Act.

5.1.8 Clean Air Act of 1963, as Amended (42 U.S.C. § 7506)

The primary objective of the Clean Air Act is to establish federal standards for air pollutants from stationary and mobile sources and to work with the states to regulate polluting emissions. The Clean Air Act is designed to improve air quality in areas of the country that do not meet federal standards and to prevent significant deterioration in areas where air quality exceeds those standards. The proposed federal action would not result in any emissions from stationary or mobile sources or violate air quality standards. Therefore the proposed federal action is consistent with the Clean Air Act.

5.1.9 Federal Water Pollution Control Act (Clean Water Act) of 1972, as Amended (33 U.S.C. Chapter 26)

Section 404 of the Clean Water Act, as amended, identifies conditions under which a permit is required for construction projects that result in the discharge of fill or dredged materials into waters of the United States. Section 402 of the Clean Water Act requires a permit for the discharge of pollutants into waters of the United States. No construction activities are associated with implementation of the proposed federal action. Therefore it is consistent with the Clean Water Act.

5.1.10 River and Harbors Act of 1899 (33 U.S.C. §§ 401-403)

The River and Harbors Act of 1899 protects the public’s right to free navigation in navigable waters of the United States as described by the USACE Section 10/404 implementing regulations at 33 C.F.R. pt. 329. The River and Harbors Act also prohibits unauthorized construction in navigable waters of the United States. No construction activities are associated with implementation of the proposed federal action. Therefore it is consistent with the River and Harbors Act.

5.1.11 National Historic Preservation Act of 1966, as Amended (16 U.S.C. § 470)

Federally funded undertakings that have the potential to impact historic properties are subject to Section 106 of the NHPA and its implementing regulations under 36 C.F.R. pt. 800. Under the National Historic Preservation Act, as amended, federal agencies are responsible for the identification, management, and nomination to the NRHP of cultural resources and if a proposed undertaking would affect historic properties, the agency must afford the Advisory Council on Historic Preservation the opportunity to comment. Reclamation's compliance with the National Historic Preservation Act, as amended, is described in Section 4.10.

5.1.12 Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. §§ 3001-3013)

Native American Graves Protection and Repatriation Act assigns ownership to Indians of human burials and associated grave goods, which are excavated or discovered on federal or Tribal lands. Implementation of the proposed federal action has no potential to disturb Indian human remains or associated funerary objects; however, Reclamation and the other Department agencies with compliance responsibilities under this act or its implementing regulations are committed to compliance with the inadvertent discovery process in the law and regulations.

5.1.13 Archaeological Resources Protection Act of 1979 (16 U.S.C. § 470)

The Archaeological Resources Protection Act (ARPA) of 1979 provides for the protection of archaeological resources on public and Indian lands. Protection of archaeological resources, under the guidelines of ARPA, includes consideration of excavation and removal of resources, enforcement of ARPA, and confidentiality of information concerning the nature and location of archaeological resources. It also provides substantial criminal and civil penalties for those who violate the terms of ARPA. Should any data recovery be proposed as a result of cultural resources compliance and consultation, Reclamation or its contractors shall seek the appropriate ARPA permits.

5.1.14 Farmland Protection Policy Act of 1981 (7 U.S.C. §§ 4201-4209)

The purpose of the Farmland Protection Policy Act is to minimize the extent to which federal programs contribute to the unnecessary conversion of farmland to nonagricultural uses. The proposed federal action will not permanently convert any farmland, prime or otherwise. The Farmland Protection Policy Act also stipulates that federal programs be compatible with state, local, and private efforts to protect farmland. While there is a potential under some of the proposed federal action alternatives to result in increased temporary land fallowing during droughts, the proposed federal action would not likely result in the conversion of farmland to nonagricultural uses. Any impact from the storage and delivery mechanism would not result in the permanent conversion of any prime farmland. Therefore the proposed federal action is consistent with the Farmland Protection Policy Act.

5.1.15 Executive Order No. 11988, Floodplain Management, May 24, 1977

This executive order requires avoiding or minimizing harm associated with the occupancy or modification of a floodplain. The proposed federal action would not involve modifications or occupancy of any floodplain, therefore the proposed federal action is consistent with Exec. Order No. 11988.

5.1.16 Executive Order No. 11990, Protection of Wetlands, May 24, 1977

This executive order provides for protection of wetlands through avoidance or minimization of adverse impacts. The proposed federal action would not involve modifications of or construction within jurisdictional wetlands, therefore the proposed federal action is consistent with Exec. Order No. 11990. Minor changes in river flow and its potential effect on backwaters and marsh habitat is discussed in Section 4.8.

5.1.17 Executive Order No. 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 11, 1994

This executive order directs agencies to identify and address, as appropriate, disproportionately high and adverse human health and environmental impacts of their programs, policies, and activities on minority and low-income populations. An analysis of the effects of the proposed federal action on minority and low-income populations is included in Section 4.15 of this Draft EIS. No significant disproportionate impacts on minority or low income populations were identified.

5.1.18 Executive Order No. 13007, Indian Sacred Sites, May 24, 1996

This executive order requires that all Executive Branch agencies that have responsibility for the management of federal lands will, where practicable, permitted by law, and not clearly inconsistent with essential agency functions, provide access to Indian sacred sites for ceremonial use by Indian religious practitioners, and will avoid adversely impacting the integrity of these sites. When possible, federal agencies must also maintain the confidentiality of sacred sites. Implementation of the proposed federal action would not conflict with the requirements of Exec. Order No. 13007.

5.1.19 Executive Order No. 12114, Environmental Impacts Abroad of Major Federal Actions, January 4, 1979

The 1944 Treaty between the United States and Mexico (including its implementing Minutes) establishes the obligations of the United States regarding the delivery of Colorado River water to Mexico.

This Draft EIS incorporates appropriate information regarding potential hydrologic and water quality impacts to Mexico (at the border) that have been prepared after coordination with the USIBWC, as well as with representatives of the Department of State. This Draft EIS complies with Exec. Order No. 12114, and addresses the appropriate treatment of international effects in environmental compliance documents.

This executive order provides among other things that: (1) federal agencies involved in actions with potential significant environmental impacts outside of the United States must provide information to federal decision makers so that the potential effects may be analyzed with other pertinent considerations of national policy; (2) activities involving foreign governments be coordinated through the Department of State; and (3) pertinent information may be withheld from other agencies and nations when necessary to avoid adverse impacts to foreign relations and ensure appropriate reflection of diplomatic factors. Section 1 of Exec. Order No. 12114 provides that it is the United States' "exclusive and complete determination of the procedural and other actions to be taken by the federal agencies to further the purpose of the National Environmental Policy Act, with respect to the environment outside the United States, its territories and possessions."

Reclamation has complied with Exec. Order No. 12114 by informing the Department of State of the proposed federal action and by providing technical support to the USIBWC for its consultation with Mexico.

National Environmental Policy Act. Reclamation notes that the statutory provisions of NEPA (and the CEQ's regulations implementing NEPA) do not require assessment of environmental impacts within the territory of a foreign country. However, as a voluntary measure to further the purposes of Exec. Order No. 12114, and for the purpose of efficiency and convenience, this Draft EIS includes information with regard to Colorado River water flowing to the United States-Mexico boundary including deliveries to Mexico pursuant to the 1944 Treaty, under all analyzed alternatives.

Endangered Species Act. Reclamation will analyze potential impacts of the proposed federal action on species listed as endangered or threatened pursuant to the ESA. The FWS has informed Reclamation that neither Section 7 of the ESA, nor the Section 7 consultation and analysis process under the ESA's implementing regulations address species outside the borders of the United States. Section 8 of the ESA addresses ESA issues beyond the borders of the United States through the mechanisms of financial assistance, encouragement of foreign programs, and "research abroad." In addition, under Section 8 of the ESA, with appropriate consultation through the Secretary of State, the Secretary of the Interior has the ability to assist in conservation efforts for listed species outside of the United States. In the event that Reclamation identifies any potential impact of its final proposed federal action on United States listed species that are found in Mexico, Reclamation will identify such potential impacts and transmit its analysis of potential impacts, as appropriate, to the FWS, to facilitate consideration of such potential impacts under Section 8 of the ESA.

5.1.20 Secretarial Order No. 3206, American Indian Tribal Rights, Federal-Tribal Trust Responsibility, and the Endangered Species Act, June 7, 1997

This Secretarial Order directs that Department of the Interior and it's sub-bureaus carry out their responsibilities under the Endangered Species Act in a manner "that harmonizes the Federal trust responsibility to tribes, tribal sovereignty, and statutory missions of the Departments, and that strives to ensure that Indian tribes do not bear a disproportionate burden for the conservation of listed species, so as to avoid or minimize the potential for conflict and confrontation." Implementation of the proposed federal action will be undertaken consistent with the requirements of this Secretarial Order.

The CEQ's regulations (40 C.F.R. pt. 1500 through 1508) implementing the procedural provisions of NEPA defines cumulative impacts as the following:

> "…the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes

such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 C.F.R. pt. 1508.7)."

Cumulative impacts refer to two or more individual impacts that, when considered together, are significant or that compound or increase other environmental impacts. Cumulative impacts can be categorized as additive and interactive. An additive impact results from additions from one kind of source either through time or space. An interactive impact results from more than one kind of source.

Generally, other actions that could result in cumulative impacts when considered in tandem with the effects of the proposed federal action (as identified in Chapter 4) have been incorporated into modeling of future system conditions. Such actions include future increases in consumptive use of Colorado River water in the Upper Division states, intrastate water transfers in the Lower Division states (e.g. QSA water transfers), implementation of the LCR MSCP, and various requirements and constraints applied to the operation of the Colorado River system.

This section addresses the cumulative impacts of the proposed federal action combined with other regional water supply or closely related projects in the region. Closely related projects that could result in significant cumulative impacts are briefly described below.

5.1.21 SNWA Virgin River and Muddy River Surface Water Development Project

As part of an ongoing initiative to protect southern Nevada from drought and augment future water supplies, SNWA proposed a project in 2004 to develop surface flows from the Virgin River and Muddy River for which it holds water rights. The SNWA currently holds water right Permit 58591 for an annual maximum diversion from the Virgin River of 190 kafy, with a not to exceed amount of 113 kaf average annual diversion, with a priority date of 1989; and also owns pre-BCPA water rights in the form of shares which were purchased from irrigation companies on the Muddy River and Virgin River.

In October 1, 2004, the SNWA applied for a permanent Right of Way from the BLM to develop Permit 58591 as a diversion and pipeline from the Virgin River and irrigation shares from the Muddy River. Proposed facilities included: a diversion structure across the Virgin River, an associated off-stream reservoir, pump stations, water transmission facilities, brine evaporation ponds, overhead electrical distribution lines, and access roads. The Right of Way application required preparation of an EIS by the BLM, which was initiated in 2004.

However, early in 2007, the seven Basin States entered into an agreement, whereby SNWA agreed not to pursue the Right of Way application for the Virgin River diversion project and EIS, so long as SNWA is allowed to utilize pre-BCPA Virgin River and Muddy River rights by diverting them out of Lake Mead, and so long as an interim water supply made available to Nevada is reasonably certain to remain available to Nevada. SNWA also agreed not to seek to pursue the Right of Way application so long as diligent pursuit of system augmentation is proceeding to provide or has provided Nevada with an annual supply of 75 kaf by 2020.

5.1.22 SNWA Coyote Spring Well and Moapa Transmission System Project

This project includes a proposal by SNWA for groundwater production and conveyance facilities, and power conveyance facilities for groundwater from Coyote Spring Valley in Clark County, Nevada. The project would develop and convey Coyote Spring Valley groundwater rights to the Moapa Valley, for use by Moapa Valley Water District and future use by SNWA. This project would increase diversification of SNWA's current water resources to include non-Colorado River water resources.

SNWA applied to BLM for a Right of Way for the project facilities in November 2002. The application required BLM to prepare an EA which was initiated in July 2003.

5.1.23 SNWA Clark, Lincoln, and White Pine Counties Groundwater Development Project

This project includes groundwater production, conveyance and treatment facilities, and power conveyance facilities located in central and eastern Nevada. The project as proposed would develop and convey up to 167 kafy of groundwater from Clark, Lincoln, and White Pine Counties to the Las Vegas Valley for use in the SNWA service area to supplement the SNWA water supplies. This project will assist SNWA in meeting southern Nevada's projected future water demands and increase the diversification of SNWA's current water resources to include non-Colorado River groundwater resources.

SNWA applied to BLM for the Rights of Way for the pipelines and other facilities and BLM is the lead federal agency preparing the SNWA groundwater EIS to analyze the environmental issues associated with the SNWA's request for Rights of Way. It is not currently anticipated that this project will be completed prior to 2014. Water from this project will be consumptively used in southern Nevada.

5.1.24 SNWA Lake Mead Intake No. 3 Project

SNWA presently operates two water intakes at Saddle Island on the west shore of Lake Mead, approximately five miles northwest of Hoover Dam and approximately 20 miles east of the center of Las Vegas, within the LMNRA. Drought has caused declining water levels in Lake Mead during recent years. Long-term water supply modeling indicates that the lake elevation is expected to decline even further in future years, even under normal hydrologic conditions in the Colorado River basin, until the system recovers from the recent drought conditions.

SNWA proposes to construct a third deep-water intake, Intake No. 3, in Lake Mead, and other associated project components to protect the existing water system capacity against the potential loss of pumping capability of Intake No. 1 should the lake elevations fall below 1,050 feet msl. An EA is being prepared for NPS, lead federal agency, to grant SNWA's application for an expansion of an existing Right of Way associated with the construction of the proposed Intake No. 3 facilities. The major project components would include a new intake structure and intake tunnel beneath the lake and beneath Saddle Island, Intake Pumping Station (IPS)-3 on Saddle Island, the caverns or forebays beneath Saddle Island and shafts around IPS-3 for construction and connections, a conveyance pipeline from IPS-3 connecting with Alfred Merritt Smith Water Treatment Facility, and a tunnel interconnecting the Intake No. 3 tunnel with the existing Intake No. 2 tunnel beneath Saddle Island.

The Intake No. 3 project would:

- preserve water delivery system capacity;
- provide reliable water delivery system back-up capability; and
- provide operational flexibility for accessing the best available water quality for the public water supply.

The construction of the Intake No. 3, a new intake would provide for SNWA maintaining full system capacity at lake elevations as low as 1,000 feet msl. The Intake No. 3 project does not propose any change or increase in the quantity of Colorado River water authorized for diversion and use by the SNWA. The project is a modification of the location from which SNWA's existing contractual rights to water are withdrawn from the Colorado River at Lake Mead, giving the SNWA flexibility to take water from different elevations and locations in Lake Mead depending on seasonal lake conditions and lake water elevations.

5.1.25 Systems Conveyance and Operations Program

Reclamation and NPS prepared an EIS as joint lead federal agencies to analyze the potential impacts associated with the construction, operation, and maintenance of the SCOP. The Clean Water Coalition (CWC) is comprised of the three agencies currently responsible for wastewater treatment in the Las Vegas Valley: the City of Las Vegas, the City of Henderson, and the Clark County Water Reclamation District. The CWC proposes to implement the SCOP, which would include optimization of the treatment plants, increased treatment (as needed), and a pipeline to discharge the highly treated effluent into Lake Mead, while minimizing impacts to water quality and other natural resources. The SCOP would provide an alternate discharge point for the effluent, which is currently discharged to Lake Mead through the Las Vegas Wash. The purpose of the project is to maintain water-quality standards and NPS recreational and resource values by operating a system that would allow for flexible management of wastewater flow from the Las Vegas Valley (Valley) to Lake Mead. The quantity of effluent treated and discharged in the Valley will increase as the population of the Valley increases. The wastewater facilities must accommodate the additional flows while continuing to meet current or future water quality standards for the Las Vegas Wash, Las Vegas Bay, and Lake Mead.

The SCOP EIS analyzed the potential environmental impacts associated with three pipeline alternatives, a Process Improvements Alternative (no pipeline), the No Action Alternative (no pipeline); and the Boulder Islands North (pipeline) alternative, which was identified as the preferred alternative.

5.1.26 Lower Colorado River Multi-Species Conservation Program

This program was developed to address potential effects to listed and other selected special status species (covered species) from identified ongoing and future anticipated federal discretionary actions and non-federal activities on the lower Colorado River (covered actions). The development and implementation of shortage criteria on the lower Colorado River was one of the federal covered actions included in the LCR MSCP and covered under the LCR MSCP BO (FWS 2005). The LCR MSCP BO covered the effects of covered actions for a reduction of Lake Mead reservoir elevations to 950 feet msl and flow reductions of up to 0.845 maf from Hoover Dam to Davis Dam, 0.860 maf from Davis Dam to Parker Dam, and 1.574 maf from Parker Dam to Imperial Dam. The LCR MSCP identified, and it is mitigating for impacts to the covered species and their habitats from the flow reduction conditions described above. These impacts included the potential loss of up to:

- 2,008 acres of cottonwood-willow habitats;
- 133 acres of marsh habitat; and
- 399 acres of backwater habitat.

To address these impacts, the LCR MSCP will:

- restore 5,940 acres of cottonwood-willow habitat;
- restore 512 acres of marsh habitat;
- restore 360 acres of backwater habitat;
- stock 660,000 razorback sucker over the term of the LCR MSCP; and
- stock 620,000 bonytail over the term of the LCR MSCP.

In addition, these habitats will be actively managed to provide habitat values greater than those of the impacted habitats. While the LCR MSCP is geared toward special status species, it is important to understand that all species that use the habitats impacted by the LCR MSCP covered activities benefit by the conservation actions currently being carried out under the LCR MSCP, and are therefore fully mitigated for within the limits of the LCR MSCP analysis. Impacts of the LCR MSCP are addressed in the LCR MSCP documents (LCR MSCP 2004a-e) incorporated by reference into this EIS.

5.1.27 Lower Colorado River Drop 2 Storage Reservoir Project

The proposed lower Colorado River Drop 2 Storage Reservoir Project (Drop 2 Reservoir Project) is one of many potential actions that will be taken to maximize beneficial use of Colorado River water in the United States. Reclamation issued a draft EA on November 30, 2006 for public review. The specific objectives of the proposed Drop 2 Reservoir Project include:

- providing additional storage capacity to reduce non-storable flows of the Colorado River below Parker Dam; and
- providing additional operational flexibility in the lower Colorado River system for the Imperial Irrigation District, Coachella Valley Water District, and other Colorado River system users.

The Drop 2 Reservoir Project has four primary physical components: 1) the reservoir itself; 2) an inlet canal; 3) an outlet canal; and 4) a location for storage of silt periodically removed from the reservoir:

- **Reservoir.** Two 4,000-af capacity reservoir cells would be formed by excavating below the existing ground surface elevation. The approximate depth of the reservoir would be 20 feet. The reservoir would occupy approximately 621 acres.
- **Inlet Canal.** The inlet canal would be from five to seven miles in length depending on alignment. Inlet canal capacity would be 1,700 cfs.
- **Outlet Canal.** The outlet canal would be approximately 3,500 feet in length connecting the reservoir to the AAC near Drop 2 Reservoir Project. Outlet canal capacity would be 1,700 cfs.

The Drop 2 Reservoir Project operations would be relatively simple: a new inlet canal would convey water from the existing Coachella Canal Turnout to a new storage reservoir, and as needed, water would be returned to the AAC via a new outlet canal. Both the inlet and outlet canals would be designed to use gravity flow. To maintain capacity, silt would have to be periodically removed from the bottom of the reservoir.

Recent legislation passed by Congress in late 2006[1] requires that the Secretary proceed "without delay" with the "construction, operation and maintenance" of the Drop 2 Reservoir Project. As this Draft EIS goes to publication, Reclamation is preparing detailed plans and schedules for implementation of the Drop 2 project.

5.1.28 Long-Term Experimental Plan for the Operation of Glen Canyon Dam and Other Associated Management Activities

The Upper Colorado Region of Reclamation has filed a NOI to Prepare an EIS regarding experimental actions to benefit resources downstream of Glen Canyon Dam in the GCNRA and the Grand Canyon National Park (71 Fed. Reg. 74556).

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[1] The full text of the legislation, contained in Public Law 109-432 provides:
: "SEC. 396. REGULATED STORAGE WATER FACILITY.
(a) CONSTRUCTION, OPERATION, AND MAINTENANCE OF FACILITY.—
Notwithstanding any other provision of law, upon the date of enactment of this Act, the Secretary shall, without delay, pursuant to the Act of January 1, 1927 (44 Stat. 1010, chapter 47) (commonly known as the ''River and Harbor Act of 1927''), as amended, design and provide for the construction, operation, and maintenance of a regulated water storage facility (including all incidental works that are reasonably necessary to operate the storage facility) to provide additional storage capacity to reduce nonstorable flows on the Colorado River below Parker Dam.

(b) LOCATION OF FACILITY.—
The storage facility (including all incidental works) described in subsection (a) shall be located at or near the All American Canal."

The purpose of the Long-Term Experimental Plan is to increase understanding of the ecosystem downstream from Glen Canyon Dam and to improve and protect important downstream resources. The NEPA process would analyze the implications and impacts of each of the alternatives on all of the purposes and benefits of Glen Canyon Dam as well as on downstream resources. The Long-Term Experimental Plan would implement a structured, long-term program of experimentation (including dam operations, modifications to Glen Canyon Dam intake structures, and other non-flow management actions, such as removal of non-native fish species) and monitoring in the Colorado River below Glen Canyon Dam.

The proposed Long-Term Experimental Plan is intended to ensure a continued, structured application of adaptive management in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and GCNRA were established, including, but not limited to natural and cultural resources and visitor use, consistent with applicable federal law.

The Long-Term Experimental Plan will build on a decade of scientific experimentation and monitoring that has taken place as part of the Glen Canyon Dam Adaptive Management Program, and will build on the knowledge gained by experiments, operations, and management actions taken under the program. Accordingly, Reclamation intends to tier from earlier NEPA compliance documents prepared as part of the Department's Glen Canyon Adaptive Management Program efforts (40 C.F.R. pt. 1500.4(i), 1502.20, and 1508.20(b)), such as the 2002 EA prepared on adaptive management experimental actions at Glen Canyon Dam (Proposed Experimental Releases from Glen Canyon Dam and Removal of Non-Native Fish).

The anticipated implementation of a Long-Term Experimental Plan for the operation of Glen Canyon Dam should not contribute to cumulative adverse effects to the resources described below.

5.1.29 Cumulative Impacts by Resource

5.1.29.1 Hydrologic Resources and Water Delivery

SNWA's development of pre-BCPA water rights on the Virgin River and Muddy River, and the development of Coyote Spring Valley groundwater could potentially result in increased flows into Lake Mead, and increased deliveries from Lake Mead, under the storage and delivery mechanism element of the proposed federal action. These hydrologic effects were included in the modeling conducted for this EIS, and these impacts are already included in the analysis in Sections 4.3 and 4.4. Similarly, the increase in return flows to Lake Mead for the northern Nevada groundwater projects were also included in the hydrologic analysis.

The LCR MSCP would not result in any cumulative effects because it would not alter water system operations.

The Drop 2 Reservoir Project would result in a reduction in over-deliveries to Mexico. These hydrologic effects were included in the hydrologic modeling for Lake Mead conducted for this EIS, and any resulting impacts are already included in the analysis in Sections 4.3 and 4.4.

5.1.29.2 Water Quality

For the reasons described immediately above, the potential cumulative impacts on water quality were included in the modeling assumptions, and are included in the analysis in Section 4.5. The Long-Term Experimental Plan for Glen Canyon Dam could result in some alteration of water quality parameters, particularly temperature, in the Colorado River reach between Glen Canyon Dam and Lake Mead.

The SCOP has the potential to affect water quality in Lake Mead. However, the SCOP is intended to accommodate Lake Mead's lowering elevations since the amount of mixing and dilution available in the inner Las Vegas Bay would decrease as Lake Mead elevations decrease. The SCOP also intends to provide flexibility to avoid possible impacts to source water quality at SNWA's intake structure. As a result of these project planning criteria, no significant cumulative impacts are anticipated.

5.1.29.3 Air Quality

SNWA's development of pre-BCPA water rights on the Virgin River and Muddy River and the development of Coyote Springs Valley groundwater could potentially result in annual storage and release of limited quantities of water from Lake Mead under the storage and delivery mechanism element of the proposed federal action. Any effect from these operations was taken into account in the modeling performed for this project, and any impacts of wind blown dust from exposed reservoir shoreline is already included in the analysis in Section 4.6. The slight increase in return flow credits from the northern Nevada groundwater projects would have no cumulative effect on air quality. The LCR MSCP may result in minor reductions in fugitive dust emissions through the creation of habitat on lands that currently may be less vegetated and therefore potentially producing more fugitive dust. The Drop 2 Reservoir Project would not result in any cumulative air quality effects. Although emissions will occur during construction of the project, they are generally separated in time and location from any potential effects of the other actions.

5.1.29.4 Visual Resources

Potential cumulative impacts related to the exposure of the calcium carbonate ring around Lake Mead was included in the modeling for Lake Mead elevations, as described above.

Implementation of the LCR MSCP will result in the creation of new habitat areas, which viewers may perceive as attractive. The proposed federal action would not affect the creation of this habitat.

The Drop 2 Reservoir Project will result in localized visual impacts during construction, but this project is separated in time and location from any potential effects of the other actions discussed above. The proposed location for the Drop 2 Reservoir Project is a former working farm and the location has no visually unique characteristics.

5.1.29.5 Biological Resources

SNWA's development of pre-BCPA water rights on the Virgin River and Muddy River and development of Coyote Springs Valley groundwater could potentially result in beneficial effects to habitat for sensitive and listed fish species that reside in the lower Virgin River and Muddy River. Potential effects to species within Lake Mead from increased flows from the Virgin River and Muddy River were addressed in the LCR MSCP.

The LCR MSCP will result in substantial habitat creation along the lower Colorado River. This habitat creation will provide benefits to biological resources. There are no cumulative effects anticipated.

The Drop 2 Reservoir Project will reduce the amount of over-deliveries to Mexico, resulting in reduced frequency of these flows in the limitrophe reach of the Colorado River.

The Conservation Before Shortage Alternative and the Reservoir Storage Alternative include periodic releases of water (pulse flows) which are assumed to pass through the limitrophe reach.[2] If implemented, these two alternatives could have a beneficial effect on the vegetation and wildlife habitat in this reach. The alternatives considered in this Draft EIS also vary slightly in terms of the probability of larger flows (i.e. flood releases) to Mexico. While the same reach of the river may be affected, these impacts are generally not additive, and no significant cumulative impacts are anticipated.

5.1.29.6 Cultural Resources

The proposed federal action's effects on cultural resources result from hydrologic changes in reservoir levels and river flows. As noted above, the projects with potential for cumulative impacts were included in the hydrologic modeling. Therefore, cumulative impacts are already addressed in Section 4.9.

5.1.29.7 Indian Trust Assets

The proposed federal action would not result in any significant effects on ITAs. Therefore, it would not contribute to any cumulative effects.

5.1.29.8 Electrical Power

Effects on electrical power production related to the proposed federal action are described in Section 4.11. The hydrologic effects of the related projects discussed above were included in the modeling assumptions, and are in the analysis.

[2] These flows were modeled as part of the storage and delivery mechanism under the Conservation Before Shortage Alternative and Reservoir Storage Alternative. These modeling assumptions were utilized in this Draft EIS in order to analyze the potential impacts to environmental resources of the storage and delivery mechanism, particularly with regard to reservoir elevations and river flow impacts. The use of these modeling assumptions does not represent any determination by Reclamation as to whether, or how, these releases could be made under current administration of the Colorado River.

5.1.29.9 Recreation

Effects on recreation activities related to the proposed federal action are described in Section 4.12. To the extent these recreation impacts are reservoir elevation dependent, the effects of the projects listed above are included in the analysis. The LCR MSCP would not contribute to any cumulative effects on recreation.

5.1.29.105.2.6.10 Transportation

Effects on transportation related to the proposed federal action are described in Section 4.13. To the extent these transportation impacts are reservoir elevation dependent, the effects of the projects listed above are included in the analysis. The LCR MSCP would not contribute to any cumulative effects on transportation.

5.1.29.11 Socioeconomics

Effects on socioeconomics related to the proposed federal action are described in Section 4.14. The projects listed above would not contribute to any cumulative effects on socioeconomic conditions. The Drop 2 Reservoir Project and implementation of the LCR MSCP conservation projects will result in short-term economic benefits from the creation of jobs. However, these temporary effects would not contribute to any cumulative effects associated with the proposed federal action.

5.1.29.12 Environmental Justice

Effects on environmental justice communities related to the proposed federal action are described in Section 4.15. The projects listed above would not contribute to any cumulative effects on low-income and minority communities.

5.2 Relationship Between Short-term Uses of the Environment and Long-term Productivity

For purposes of this required regulatory assessment, Reclamation considers the interim period of the proposed federal action (through 2026) short-term, especially when compared with the longer modeling period of 2060 or even longer durations. Within this time frame, Reclamation would implement water management practices that would result in an increased predictability of water operations, particularly under drought and low reservoir conditions. This predictability is expected to have a stabilizing effect on the use of water in the region by ensuring that all parties have a better understanding of how the system would operate and, therefore, what management actions water users may need to undertake under such conditions, thus ensuring long-term productivity.

Thus the tradeoff between short-term uses of the environment and long-term productivity is that Reclamation and state and local water managers and users will gain valuable experience operating under shortage conditions, and this should ultimately result in enhanced long-term productivity throughout the region. Adoption of the proposed federal action would contribute to the long-term predictability of water use through more defined water operations.

5.3 Irreversible and Irretrievable Commitments of Resources

Irreversible commitments are decisions impacting non-renewable resources such as soils, wetlands, and waterfowl habitat or commitments that cannot be reversed. Such decisions are considered irreversible because their implementation would impact a resource to the point that renewal can occur only over a extreme long period of time or at great expense or because they would cause the resource to be destroyed, become extinct, or removed. The term “irreversible” describes the loss of future options and applies to the impacts of using nonrenewable resources or resources that are renewable only over a long period of time. Irretrievable commitments are those that are lost for a period of time.

Implementation of the proposed federal action would not result in the irreversible or irretrievable commitment of resources. Managing water supplies in a more structured way will help conserve resources. In addition, the proposed guidelines are intentionally interim to provide opportunities to gain valuable operation experience under a wide range of reservoir conditions.

Chapter Six

Consultation and Coordination

6.1 Introduction

This chapter describes Reclamation's public involvement program and coordination with specific federal, state and local agencies, NGOs, and the general public for the preparation of this Draft EIS. In addition, this chapter describes Reclamation's government-to-government consultation with Indian tribes and with Mexico.

6.2 General Public Involvement Activities

The public involvement program leading to this Draft EIS included project scoping, consultation, and coordination with interested stakeholders and the public.

In a May 2, 2005 letter to the Governors of the Colorado River Basin States issued to complete the 2005 AOP mid-year review, the Secretary directed Reclamation to develop additional strategies to improve coordinated management of the reservoirs in the Colorado River system. Pursuant to that direction, Reclamation conducted a public consultation workshop on May 26, 2005 in Henderson, Nevada; issued a *Federal Register* notice on June 15, 2005 soliciting public comments (70 Fed. Reg. 34794); and conducted public meetings on July 26 and July 28, 2005, in Henderson, Nevada, and Salt Lake City, Utah, respectively. Reclamation received a broad range of comments and suggestions from the public, and based in part on these comments, Reclamation determined that a process consistent with NEPA would be the appropriate method to use for the development of the of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions.

On September 30, 2005 Reclamation published a NOI (70 Fed. Reg. 57322) to prepare an EIS. The NOI also initiated a public scoping process for soliciting input on the scope of specific shortage guidelines and coordinated reservoir management strategies, and the issues and alternatives to be considered and analyzed in this Draft EIS. As part of this process, Reclamation conducted public scoping meetings on November 1, 2, 3, and 8, 2005. The meetings took place in Salt Lake City, Utah; Denver, Colorado; Phoenix, Arizona; and Henderson, Nevada, respectively. Reclamation also consulted with representatives from the Basin States, Tribal representatives, NGOs, and other interested parties. A 62-day public comment period was noticed by the NOI which started on September 30, 2005 and ended on November 30, 2005. A total of 1,153 written comment letters were received during the scoping process. The comment letters were submitted by a wide-range of interested parties that included businesses; federal, state and local agencies; Indian tribes; special interest groups; and individuals.

Reclamation prepared and published a Scoping Summary Report on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead. A NOA was published on March 31, 2006 (71 Fed. Reg. 16341). This Scoping Summary Report provided a summary of the comments received and the issues raised during the scoping process and provided a summary of the proposed scope of the environmental analysis to be included in this Draft EIS.

Reclamation discussed the development of the proposed federal action with various agencies and organizations at (1) agency/organization regular meetings, (2) public conferences and events sponsored by the agency/organizations, and (3) meetings sponsored by Reclamation. The entities included the Basin States' water resource departments, water agencies within these states, contractors and associations for federal hydropower, and NGOs. Reclamation also consulted with Indian tribes and Mexico. The coordination activities with each agency, entity or group are summarized below in this chapter. Table 6.9-1 in Section 6.9 lists the agencies and organizations that were invited to such meetings by letter, met with Reclamation and/or invited Reclamation to their meetings or events. Entities participating in these meetings and the meeting dates are listed in Appendix I. Public conferences and events that Reclamation attended and presented information on the proposed federal action are also listed in Appendix I.

6.3 Cooperating Agency Involvement

In compliance with NEPA and its implementing regulations, Reclamation worked with five cooperating agencies in the preparation of this Draft EIS. The primary role of the cooperating agencies was in the development of alternatives considered in this Draft EIS. Specific contributions of the cooperating agencies are summarized here.

6.3.1 Bureau of Indian Affairs

The BIA is a cooperating agency in recognition of its administration of the federal trust responsibility to Indian tribes. The BIA staff provided updated lists of Tribal governmental representatives, assisted in government-to-government consultations, and assisted in the preparation of Indian trust asset analyses. The BIA also assisted Reclamation with the Tribal consultations described in Section 6.4 and generally served in an advisory capacity to Reclamation and the Indian tribes.

6.3.2 Fish and Wildlife Service

The FWS is a cooperating agency in recognition of its jurisdiction by law and special expertise with respect to the ESA and biological resources within the study area, and its administration of several wildlife refuges in the study area.

Under Section 7(a)(2) of the ESA, each federal agency must, in consultation with the Secretary (either the Secretary of Commerce through the National Marine Fisheries Service or the Secretary of the Interior through the FWS), insure that any proposed discretionary action authorized, funded or carried out by that agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat. To assist agencies in complying with the requirements of Section 7(a)(2), ESA's implementing regulations set out a detailed consultation process for determining the biological impacts of a proposed discretionary activity. The consultation process is described in regulations promulgated at 50 C.F.R. pt. 402.

Adoption of the proposed federal action by the Secretary is a discretionary federal action and it is, therefore, subject to compliance with the ESA. Reclamation will request a species list from the FWS and subsequently prepare a BA to address the potential effects of the proposed federal action on listed species. Once a preferred alternative is identified, the BA will be finalized and formal consultation will be initiated, if appropriate. Reclamation and the FWS will consult during 2007, with the intent of completing a BO for inclusion in the Final EIS.

Reclamation is also analyzing information that will identify any potential impact of the proposed federal action on United States listed species that are found in Mexico. Consistent with Section 8 of the ESA, Reclamation intends to conduct appropriate consultation through the Secretary of State, to assist in conservation efforts for listed species outside of the United States. Reclamation will identify such potential impacts and transmit its analysis of potential impacts, as appropriate, to the FWS, to facilitate consideration of such potential impacts under Section 8 of the ESA.

6.3.3 National Park Service

The NPS is a cooperating agency in recognition of its administration of park units along the Colorado River. The NPS staff participated in developing the Reservoir Storage Alternative (along with Western), and in providing data on visual resources and recreation. The Colorado River Coordinator, Mr. Norman Henderson, and staff at GCNRA, Grand Canyon National Park, and the LMNRA, assisted in the preparation of this Draft EIS.

6.3.4 Western Area Power Administration

Western is a cooperating agency in recognition of its role in marketing and transmitting electricity from various Reclamation-operated powerplants located within the study area. Western customers include municipalities, cooperatives, public utility and irrigation districts, federal and state agencies, investor-owned utilities (only one of which purchases firm power from Western), marketers and Indian tribes located throughout the Colorado River Basin who in turn, provide retail electric service to millions of consumers within the seven Colorado River Basin states. Western participated in developing the Reservoir Storage Alternative (along with the NPS), and in preparing the hydropower analyses contained in this Draft EIS.

6.3.5 United States Section of the International Boundary and Water Commission

The USIBWC is a cooperating agency in recognition of its administration of the 1944 Treaty obligations with Mexico. As such, USIBWC staff participated in numerous meetings with Reclamation's project evaluation team and participated in internal document reviews as sections of the Draft EIS were prepared. These activities facilitated close coordination with the USIBWC in developing information needed for this Draft EIS and in Reclamation's participation in support of the USIBWC's consultations with Mexico as discussed further below. The USIBWC's input on this Draft EIS was coordinated through the Commissioner of the USIBWC, as well as USIBWC staff located in their offices in El Paso, Texas, Yuma, Arizona, and San Ysidro, California.

6.4 Tribal Consultation

For purposes of this NEPA process, Reclamation, assisted by the BIA, conducted government-to-government consultations with the Indian tribal entities with entitlements to or contracts for Colorado River water, and those that may be affected by or have interests in the proposed federal action. The correspondence concerning consultation efforts are provided in Appendix I.

Representatives of various Indian tribes also attended the scoping meetings in November 2005, and some provided Reclamation with written and oral comments on the proposed federal action and its potential effects on resources of Tribal concern, including ITAs. Table 6.9-1 lists the federally-recognized Indian tribes that participated in this NEPA process.

6.5 State and Local Water and Power Agency Coordination

Since the June 15, 2005 *Federal Register* notice announcing Reclamation's interest in soliciting comments on the development of management strategies for Lake Powell and Lake Mead, including Lower Basin shortage guidelines, Reclamation has had various discussions with state and local water agencies regarding the proposed federal action. These meetings are listed in Appendix I by entity and date. However, the Basin States have been continuously engaged in drought mitigation discussions since 2004, at the request of the Secretary, to develop recommendations on how to lessen the impacts of droughts. Reclamation provided the Basin States technical support during these discussions by modeling various strategies, including protection of key elevations of Lake Powell and Lake Mead.

As a result of these ongoing discussions, the Basin States provided Reclamation with projections of the future depletions of the Colorado River water anticipated in each state. The Upper Colorado River Commission compiled Upper Basin depletions, and the Lower Division states compiled their respective depletions. The projections were used as input to Reclamation's operational modeling analysis, as discussed in this Draft EIS.

In 2004, the Basin States began formulation of a proposal for management strategies for Lake Powell, Lake Mead, and Lower Basin shortage guidelines. The Basin States submitted their "Seven Basin States' Preliminary Proposal Regarding Colorado River Interim Operations" in a letter addressed to the Secretary dated February 3, 2006. A copy of this proposal is included in Appendix J. Reclamation subsequently conducted several consultations with representatives from the Basin States and several water agencies and worked with them to formulate an alternative (Basin States Alternative) that reflected the contents of the Seven Basin States' proposal.

6.6 Non-Governmental Organizations Coordination

Reclamation contacted and coordinated the preparation of this EIS with multiple recreational and environmental groups. A consortium of environmental NGOs that included the Defenders of Wildlife, Environmental Defense, National Wildlife Federation, The Nature Conservancy, Pacific Institute, Sierra Club, Sonoran Institute, and Rivers Foundation of the Americas, developed what became the Conservation Before Shortage Alternative analyzed in this Draft EIS.

This consortium of environmental NGOs developed and submitted its first proposal, "Conservation Before Shortage", on July 18, 2005. After publication of the Summary Scoping Report, this consortium of environmental NGOs modified elements of its proposal. The final proposal of this consortium, "Conservation Before Shortage II," was submitted to Reclamation on July 7, 2006. A copy of this proposal is included in Appendix K. From 2005 through 2006, Reclamation met with representatives of the consortium of environmental NGOs and worked with them to formulate what became the Conservation Before Shortage Alternative, as analyzed herein. These meetings are listed in Appendix I by entity and date.

6.7 Other Consultations

In compliance with the NHPA, Reclamation will initiate the process of consultation with SHPO in Arizona, California, Nevada, and Utah. Consultations regarding eligibility of cultural resources to the National Registry and effect of the proposed federal action are ongoing. In addition, consultations are underway with THPO (e.g., Navajo Nation THPO, Hualapai Indian Tribe THPO). Indian tribes with concerns under Exec. Order No. 13007 and the Native American Graves Protection and Repatriation Act are also being consulted.

6.8 Consultation with Mexico

The USIBWC has begun consultation with Mexico regarding the proposed federal action. Reclamation has assisted USIBWC in conducting this consultation by providing information on the proposed federal action and by participating in briefings with the Mexican Section of the IBWC and the Mexico National Water Commission. Meetings with representatives of Mexico were conducted, during which representatives of Mexico provided their views, input, and concerns regarding the potential effects of the proposed federal action. These meetings are listed in Appendix I by entity and date.

Exec. Order No. 12114 instructs federal agencies to investigate the effects of proposed federal actions in other countries. This Draft EIS documents the hydrologic and water quality effects of the proposed federal action on deliveries to Mexico.

As indicated elsewhere, the modeling assumptions used in this Draft EIS are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico or potential storage of conserved water by Mexico.

6.9 Summary of Coordination and Consultation Contacts

Table 6.9-1 lists those Indian tribes, agencies, organizations, interest groups, and representatives of Mexico that Reclamation notified, consulted and coordinated with regarding the proposed federal action. Consultations are ongoing with most of these entities. These entities, meeting dates and related correspondence are listed and/or provided in Appendix I.

Table 6.9-1
Consultation and Coordination Regarding the EIS

Federal Agencies
National Oceanographic and Atmospheric Administration
Bureau of Indian Affairs – Cooperating Agency
Fish And Wildlife Service - Cooperating Agency
National Park Service
U.S. Department of State
U.S. Section of the International Boundary and Water Commission – Cooperating Agency
Western Area Power Administration – Cooperating Agency
State and Local Water and Power Organizations and Agencies
Arizona Department of Water Resources
California Department of Water Resources
Central Arizona Water Conservation District
Coachella Valley Water District
Colorado Department of Natural Resources
Colorado River Board of California
Colorado River Commission of Nevada
Colorado River Energy Distributors Association
Colorado River Water Conservation District
Colorado Water Conservation Board
Imperial Irrigation District
Interstate Stream Commission
Las Vegas Valley Water District
Metropolitan Water District, California
Nevada Department of Justice
New Mexico Interstate Stream Commission
Office of the State Engineer, Wyoming
Palo Verde Irrigation District
Parker Valley Natural Resources Conservation District
San Diego County Water Authority
Southern Nevada Water Authority
Upper Colorado River Commission
Utah Attorney General's Office
Utah Division of Water Resources
Wyoming Water Association
Environmental and Recreational Organizations (NGOs)
Center for Biodiversity
Defenders of Wildlife
Environmental Defense
Glen Canyon Action Network

Table 6.9-1
Consultation and Coordination Regarding the EIS

Grand Canyon River Guides
High County Citizen's Alliance
Living Rivers
National Wildlife Federation
Nature Conservancy in Arizona
Pacific Institute
Sierra Club
Sonoran Institute
Southwest Rivers
Utah Water & Sierra Club Southwest Water Committee
American Indian Tribe, Community, Pueblo[1]
Ak-Chin Indian Community of the Maricopa Indian Reservation
Chemehuevi Indian Tribe of the Chemehuevi Reservation, California
Cocopah Tribe of Arizona
Colorado River Indian Tribes of the Colorado River Indian Reservation, Arizona and California
Fort McDowell Yavapai Nation
Fort Mojave Indian Tribe of Arizona, California, and Nevada
Gila River Indian Community
Havasupai Indian Tribe of the Havasupai Reservation
Hopi Tribe of Arizona
Hualapai Indian Tribe of the Hualapai Indian Reservation
Jicarilla Apache Nation
Kaibab Band of Paiute Indians of the Kaibab Indian Reservation
Las Vegas Tribe of Paiute Indians of the Las Vegas Indian Colony
Moapa Band of Paiute Indians of the Moapa River Indian Reservation
Navajo Nation, Arizona, New Mexico, and Utah
Paiute Indian Tribe of Utah
Pascua Yaqui Tribe of Arizona
Pueblo of Acoma
Pueblo of Cochiti
Pueblo of Jemez
Pueblo of Laguna
Pueblo of Nambe
Pueblo of Pojoaque
Pueblo of San Felipe
Pueblo of San Juan
Pueblo of Sandia
Pueblo of Santa Ana
Pueblo of Santa Clara

Table 6.9-1
Consultation and Coordination Regarding the EIS

Pueblo of Tesuque
Pueblo of Zia
Quechan Tribe of the Fort Yuma Indian Reservation, California and Arizona
Salt River Pima-Maricopa Indian Community of the Salt River Reservation
San Carlos Apache Tribe of the San Carlos Reservation
San Juan Southern Paiute Tribe of Arizona
Southern Ute Indian Tribe of the Southern Ute Reservation
Tohono O'odham Nation of Arizona
Tonto Apache Tribe of Arizona
Ute Indian Tribe of the Uintah and Ouray Reservation
Ute Mountain Tribe of the Ute Mountain Reservation, Colorado, New Mexico, and Utah
White Mountain Apache Tribe of the Fort Apache Reservation
Yavapai-Apache Nation of the Camp Verde Indian Reservation
Yavapai-Prescott Tribe of the Yavapai Reservation
Zuni Tribe of the Zuni Reservation
United Mexican States Agencies
International Boundary and Water Commission, Mexican Section
National Water Commission
Secretariat of Foreign Relations

1 Source of Names: Bureau of Indian Affairs, Tribal Leaders Directory. Accessed on-line, December 2006 at http://library.doi.gov/internet/native.html.

6.10 Federal Register Notices

Several *Federal Register* notices have been issued to inform the public about the formulation of interim operational guidelines and the preparation and availability of this Draft EIS. Table 6.10-1 lists the *Federal Register* notices and their full text is provided in Appendix L. In addition to the notices issued, additional notices are planned for the publication of this Draft EIS and the subsequent Final EIS to announce their availability and the Secretary's ROD based on the Final EIS.

Table 6.10-1
Federal Register Notices Regarding the Proposed Federal Action

Notice	Title
70 Fed. Reg. 34794 (June 15, 2005)	Notice to solicit comments and hold public meetings on the development of management strategies for Lake Powell and Lake Mead, including Lower Basin shortage guidelines, under low reservoir conditions.
70 Fed. Reg. 57322 (September 30, 2005)	Notice of intent to prepare an environmental impact statement (EIS) and notice to solicit comments and hold public scoping meetings on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead
71 Fed. Reg. 16341 (March 31, 2006)	Notice of public availability of a Scoping Summary Report on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead, particularly under low reservoir conditions.

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Acronyms

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Acronyms

1944 Treaty	1944 Treaty between the United States and Mexico relating to the utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande (February 3, 1944)
602(a) storage	Section 602(a) of the CRBPA
°C	degrees Celsius
°F	degrees Fahrenheit
µg/L	microgram per liter
µg/m^3	microgram per cubic meter
§	chapter
§§	section
AAC	All-American Canal
AAQS	Ambient Air Quality Standards
ACHP	Advisory Council on Historic Preservation
af	acre-feet
afy	acre-feet per year
AGC	Automatic Generation Control
AMP	Adaptive Management Program
AMWG	Adaptive Management Work Group
AOP	Annual Operating Plan for Colorado River Reservoirs
APE	area of potential effect
ARPA	Archaeological Resources Protection Act
AWBA	Arizona Water Banking Authority
AWSA	Arizona Water Settlement Act
BA	Biological Assessment
Basin Fund	Upper Colorado River Basin Fund
Basin States	Colorado River Basin States
BBAMP	Boulder Basin Adoptive Management Plan
BCP	Boulder Canyon Project
BCPA	Boulder Canyon Project Act of 1928
BHBF	beach/habitat-building flow
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMI	Basic Management, Inc.
BO	Biological Opinion
CA PLAN	California's Colorado River Water Use Plan
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CEQ	Council on Environmental Quality
C.F.R.	Code of Federal Regulations
cfs	cubic feet per second
Commission	Upper Colorado River Commission
Compact	Colorado River Compact of 1992
Consolidated Decree	Entered by the United States Supreme Court on March 27, 2006 in the case of *Arizona v. California*
Council	Advisory Council on Historic Preservation
Court	United States Supreme Court
Cr(VI)	hexavalent chromium
CRBPA	Colorado River Basin Project Act of 1968
CRIR	Colorado River Indian Reservation

CRIT	Colorado River Indian Tribes of the Colorado River Indian Reservation, Arizona and California
CRSP	Colorado River Storage Project
CRSPA	Colorado River Storage Project Act of 1956
CRSS	Colorado River Simulation System
CVWD	Coachella Valley Water District
CWA	Clean Water Act
CWC	Clean Water Coalition
Dam Fund	Colorado River Dam Fund
DBP	disinfection by-product
Decree	The 1964 United States Supreme Court Decree in the case of *Arizona v. California*
Department	Department of the Interior
Development Fund	Lower Colorado River Basin Development Fund
DO	dissolved oxygen
Draft EIS	Draft Environmental Impact Statement
DTSC	California Environmental Protection Agency Department of Toxic Substances Control
EA	Environmental Assessment
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EOM	end-of-month
ESA	Endangered Species Act of 1973, as amended
Exec. Order	Executive Order
Fed. Reg.	Federal Register
FEIS	Final Environmental Impact Statement
FONSI	Finding of No Significant Impact
Forum	Colorado River Basin Salinity Control Forum
FWS	United States Fish and Wildlife Service
GCDAMP	Glen Canyon Dam Adoptive Management Program
GCNRA	Glen Canyon National Recreation Area
GEMSS	Generalized Environmental Modeling System for Surface Waters
GWh	gigawatt-hour
HRR	Hualapai River Runners
HVID	Harquahala Valley Irrigation District
IBWC	International Boundary and Water Commission
ICS	Intentionally Created Surplus
ICUA	Intentionally Created Unused Apportionment
IID	Imperial Irrigation District
Indian	American Indian
IPS	Intake Pumping Station
ISG	Interim Surplus Guidelines
ISM	Indexed Sequential Method
ITA	Indian Trust Asset
kaf	thousand acre-feet
kafy	thousand acre-feet per year
kW	kilowatt
kWh	kilowatt-hour

LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LMNRA	Lake Mead National Recreation Area
Lower Basin	Colorado River Lower Basin – Arizona, California, Nevada, New Mexico, and Utah, within and from which waters drain naturally into the Colorado River system below Lee Ferry Compact Point
Lower Division States	Arizona, California, and Nevada
LROC	Long-Range Operating Criteria
M&I	municipal and industrial
maf	million acre-feet
mafy	million acre-feet per year
Mexico	United Mexican States
mg/L	milligram per liter
msl	mean sea level
MW	megawatt
MWD	Metropolitan Water District of Southern California
MWh	megawatt-hour
NAAQS	National Ambient Air Quality Standards
NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NASS	National Agricultural Statistics Service
NAU	Northern Arizona University
NDEP	Nevada Division of Environmental Protection
NDOW	Nevada Department of Wildlife
NEPA	National Environmental Policy Act of 1969, as amended
NERC	North American Electric Reliability Council
NGO	non-governmental organization
NGS	Navajo Generating Station
NHPA	National Historic Preservation Act of 1966, as amended
NIA	Non-Indian Agriculture
NIB	Northerly International Boundary
NNAD	Navajo Nation Archaeological Department
NOA	Notice of Availability
NOI	Notice of Intent
NPS	National Park Service
NRA	National Recreation Area
NRHP	National Register of Historic Places
NRI	Nationwide Rivers Inventory
NWPCC	Northwest Power and Conservation Council
NWR	National Wildlife Refuge
O&M	operation and maintenance
P-DP	Parker/Davis Project
P.L.	Public Law
PG&E	Pacific Gas and Electric
PM	particulate matter
PM2.5	particulate matter less than 2.5 micrograms per cubic meter
PM10	particulate matter less than 10 micrograms per cubic meter
ppb	parts per billion

ppm	parts per million
PPR	present perfected rights
PSD	Prevention of Significant Deterioration
pt.	part
PUP	Priority Use Projects
PV 2008$	Present Value in 2008 dollars
PVID	Palo Verde Irrigation District
Reclamation	Bureau of Reclamation
RM	river mile
ROD	Record of Decision
SCOP	Systems Conveyance and Operations Plan
SCP	Colorado River Basin Salinity Control Program
SCUBA	Self-Contained Underwater Breathing Apparatus
SDCWA	San Diego County Water Authority
SDWA	Safe Drinking Water Act of 1974
Secretary	Secretary of the Department of the Interior
Section 7	Section 7 of the Federal Endangered Species Act
Section 10	Section 10 of the Federal Endangered Species Act
SHPO	State Historic Preservation Officer
SIA	Secretarial Implementation Agreement
SIB	Southerly International Boundary
SIRA	Storage and Interstate Release Agreements
SLCA/IP	Salt Lake City Area Integrated Projects
SNWA	Southern Nevada Water Authority
SRA	State Recreation Area
SRP	Salt River Project
TCP	traditional cultural property
TDS	total dissolved solids
THPO	Tribal Historic Preservation Officer
TMDL	Total Maximum Daily Load
Upper Basin	Colorado River Upper Basin – Colorado, Utah, Wyoming, Arizona, and New Mexico within and from which waters drain naturally into the Colorado River system below Lee Ferry Compact Point
Upper Division States	Wyoming, Utah, Colorado, and New Mexico
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USIBWC	United States Section of the International Boundary and Water Commission
USU	Utah State University
Water Control Manual	Water Control Manual for Flood Control, Hoover Dam and Lake Mead, Colorado River, Nevada and Arizona, dated December 1982, published by USACE
WECC	Western Electricity Coordinating Council
Western	Western Area Power Administration
WSCC	Western States Coordinating Council
ZCRE	Zuni Cultural Resource Enterprise

1

Glossary

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Glossary

A

acre-foot (af)	Volume of water (43,560 cubic feet) that would cover one acre to a depth of one foot.
active storage	Reservoir capacity that can be used for authorized purposes.
adaptive management	A method for examining alternative strategies for meeting measurable biological goals and objectives, and then if necessary, adjusting future conservation management actions according to what is learned.
affected environment	Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as the result of a proposed human action.
algae	Simple plants containing chlorophyll; most live submerged in water.
allocation, allotment	Refers to a distribution of water through which specific persons or legal entities are assigned individual rights to consume pro rata shares of a specific quantity of water under legal entitlements. For example, a specific quantity of Colorado River water is distributed for use within each Lower Division state through an apportionment. Water available for consumptive use in that state is further distributed among water users in that state through the allocation. An allocation does not establish an entitlement; the entitlement is normally established by a written contract with the United States government.
alluvium	Sedimentary material transported and deposited by the action of flowing water.
ambient	Surrounding natural conditions (or environment) in a given place and time.
amphibian	Vertebrate animal that has a life stage in water and a life stage on land (e.g., salamanders, frogs and toads).
annual flow-weighted average concentration	A weighted average of monthly total dissolved solids (TDS) concentrations for a year, where the weight for each month is based on the relative flow for each month.
Annual Operating Plan for Colorado River Reservoirs (AOP)	The AOP describes how Reclamation will manage Colorado River resources over the 12-month period, consistent with the Long-Range Operating Criteria and the Arizona v. California 1964 Supreme Court Decree. The AOP is prepared annually by Reclamation in cooperation with the Basin States, appropriate federal agencies, Indian tribes, state and local agencies and the general public, including governmental interests as required by federal law. As part of the AOP process, the Secretary makes annual determinations regarding the availability of Colorado River water for deliveries to the Lower Division states as described below.
apportionment	Refers to the distribution of water available to each Lower Division state in normal, surplus or shortage years, as set forth, respectively in Articles II (B)(1), II (B)(2) and II (B)(3) or the Decree in the case of *Arizona v. California*.
appropriative rights	The right to divert a specified quantity of water at a specified point of diversion for reasonable and beneficial uses at a specified place of use for a specified manner of use. Appropriative rights are generally “first-in-time, first-in-right”; that is, one appropriative right has priority over appropriative rights established later.

B

backwater	A relatively small, generally shallow area of a river with little or no current.
banked groundwater	Water that has been stored temporarily in a groundwater aquifer. Banked groundwater can be recovered for use at a later time.
base load	Minimum load in a power system over a given period of time.
Basin States	The seven states referred to in the Compact as making up the Colorado River watershed; Wyoming, Colorado, Utah, Nevada, Arizona, New Mexico and California.
Biological Assessment (BA)	To facilitate compliance with Section 7(a)(2), federal agencies must prepare a BA, pursuant to Section 7(c)(1) that identifies the likely effects of the proposed federal action on threatened and endangered species.
Biological Opinion (BO)	Document stating the United States Fish and Wildlife Service and/or the National Marine Fisheries Service opinion as to whether a federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat.

C

candidate species	Plant or animal species not yet officially listed as threatened or endangered under the ESA, but which is undergoing status review by the United States Fish and Wildlife Service.
catch	At a recreational fishery, refers to the number of fish captured, whether they are kept or released.
channel (watercourse)	An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. River, creek, run, branch, and tributary are some of the terms used to describe natural channels. Natural channels may be single or braided. Canal and floodway are some of the terms used to describe artificial channels.
Cladophora	Filamentous green alga important to the food chain in the Colorado River below Glen Canyon Dam.
Colorado River Basin	All of the drainage area of the Colorado River system, with a total area of approximately 250,000 square miles. The Colorado River is approximately 1,400 miles in length.
Colorado River Basin Project Act of 1968	This Act authorized construction of a number of water development projects, including the Central Arizona Project (CAP) and required the Secretary to develop the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs (LROC).
Colorado River Basin Salinity Control Forum	The organization dedicated to controlling Colorado River salinity consisting of representatives of the seven Basin States.
Colorado River Compact	The agreement concerning the apportionment of the use of the waters of the Colorado River System dated November 24, 1922, executed by Commissioners for the States of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming, approved by Herbert Hoover, representative of the United States of America, and proclaimed effective by the president of the United States of America, June 25, 1929.
Colorado River Simulation System	An operational model of the Colorado River system based on a monthly time step.

Colorado River System	That portion of the Colorado River and its tributaries within the United States of America.
Compact	The Colorado River Compact of 1922.
Compact Point	The reference point designated by the Colorado River compact dividing the Upper and Lower Colorado River basins – Lee Ferry, Arizona.
conservation storage	Storage of water for later release for useful purposes such as municipal water supply, power, or irrigation in contrast with storage capacity used for flood control.
Consolidated Decree	Consolidated Decree entered by the United States Supreme Court in the case of *Arizona v. California*, 547 U.S. ___ (2006)
consumptive use	The total diversion of water from the main stream of the Colorado River, including water withdrawn from the main stream through underground pumping, less any measured and unmeasured return flows.
Contractors	Those who hold entitlements to Colorado River water are referred to as Contractors. Contractors consist of the federal government, states, Indian tribes, and various public and private entities that are recognized under the Decree, hold a Section 5 Contract with the Secretary, or have a Secretarial Reservation of water.
conveyance loss	Water that is lost in transit from a pipe, canal, conduit, or ditch by leakage or evaporation. If the water is lost due to leakage, it may be considered return flow if it percolates to an aquifer and is available for reuse. If the water evaporates, it is considered consumptive use.
Cooperating Agency	With respect to the NEPA process, an agency having jurisdiction by law or special expertise concerning an aspect of a proposed federal action that is requested by the lead agency to participate in the preparation of an Environmental Impact Statement.
coordinated operation	Generally, the operation of two or more interconnected electrical systems to achieve greater reliability and economy. As applied to hydropower resources, the operation of a group of hydropower plants to obtain optimal power benefits with due consideration for all other uses.
Coordinated Reservoir Management (or Operation)	The existing Law of the River contains provisions that tie releases from Lake Powell to storage conditions in Lake Powell and Lake Mead, including minimum objective releases and equalization of storage between the two reservoirs. The alternatives consider various options designed to better utilize existing reservoir storage during droughts, both to enhance water supplies and to help balance benefits of the reservoir system to the two Colorado River Basins.
covered species	Those species addressed in the LCR MSCP for which conservation measures would be implemented and for which authorization for take is being requested under Section 10 of the ESA.
criteria	Standards used for making a determination.
critical habitat	Specific areas with physical or biological features essential to the conservation of a listed species and which may require special management considerations or protection. These areas have been legally designated via *Federal Register* notices.
cubic foot per second (cfs)	A measure of water flow equal to one cubic foot of water passing a point on the stream in one second of time.
cultural resource	Building, site, district, structure, or object significant in history, architecture, archeology, culture or science.

D

dead storage	Reservoir space from which stored water cannot be evacuated by gravity.
delta	Sediment deposit formed at the mouths of the Colorado River and other rivers where they enter Lake Powell, Lake Mead or the Gulf of California.
depletion	Loss of water from a stream, river, or basin resulting from consumptive use.
deposition	Settlement of material out of the water column and on to the streambed. Occurs when the energy of flowing water is unable to support the load of suspended sediment.
discharge (flow)	Volume of water that passes a given point within a given period of time; expressed in this document in cubic feet per second.
dissolved oxygen (DO)	Amount of free oxygen found in water; perhaps the most commonly employed measurement of water quality. Low DO levels adversely affect fish and other aquatic life. The ideal dissolved oxygen for fish life is between seven and 9 mg/L; most fish cannot survive when DO falls below 3 mg/L.
domestic use	Refers to the use of water for household, stock, municipal, mining, milling, industrial, and other like purposes, but shall exclude the generation of electrical power.
draw down	Lowering of a reservoir's elevation; process of depleting reservoir or groundwater storage.

E

ecosystems	Complex system composed of a community of fauna and flora and that system's chemical and physical environments.
electric power system	Physically connected electric generating, transmission, and distribution facilities operated as a unit under one control.
electrical demand	Energy requirement placed upon a utility's generation at a given instant or averaged over any designated period of time.
endangered species	A species or subspecies whose survival is in danger of extinction throughout all or a significant portion of its range.
Endangered Species Act (ESA)	The Endangered Species Act (ESA) of 1973 (16 U.S.C. §§ 1531-1544), as amended, under Section 9, provides for the prohibition of "take" of any fish or wildlife species listed as threatened or endangered under the ESA unless specifically authorized by regulation.
energy	Electric capacity generated and/or delivered over time.
entitlement	Refers to an authorization to beneficially consume Colorado River water pursuant to (1) a decreed right, (2) a contract with the United States through the Secretary of the Department of the Interior, or (3) a Secretarial Reservation of water.
epilimnion	*See stratification.*

F

firm energy or power	Non-interruptible energy and power guaranteed by the supplier to be available at all times except for reasons of uncontrollable forces or "continuity of service" contract provisions.
flood	An overflow or inundation that comes from a river or other body of water, and causes or threatens damage. Any relatively high streamflow overtopping the natural or artificial banks in any reach of a stream. A relatively high flow as measured by either gage height or discharge quantity.
flood control pool	Reservoir volume above the active conservation and joint-use pool that is reserved for flood runoff and then evacuated as soon as possible to keep that space in readiness for the next flood.
flood control release	The release of water from Lake Mead and the operation of Hoover Dam for flood control purposes pursuant to the reservoir operating criteria specified in the February 8, 1984 Field Working Agreement between the USACE and the Bureau of Reclamation, and the USACE regulations contained in 33 C.F.R. pt 208.11.
flow	Volume of water passing a given point per unit of time expressed in cfs.
forage fish	Generally, small fish that reproduce prolifically and are consumed by predators.
forebay	Impoundment immediately above a dam or hydroelectric plant intake structure. The term is applicable to all types of hydroelectric developments (storage, run-of-river, and pumped-storage).
fry	Life stage of fish between the egg and fingerling stages.
Full Domestic Surplus determination	A water supply determination made by the Secretary that governs the amount of water available for consumptive use by the Lower Division states for a specific calendar year. Under a Full Domestic Surplus determination the amount of water available to domestic water users and specifically to MWD, SNWA and domestic users in Arizona is greater than the amount that would be available under a Normal condition determination.
full pool	Volume of water in a reservoir at maximum design elevation.

G

gaging station	Specific location on a stream where systematic observations of hydrologic data are obtained through mechanical or electrical means.
gigawatt-hour (GWh)	One billion watt-hours of electrical energy.

H

headwater	The source and upper part of a stream.
hydroelectric power	Electrical capacity produced by falling water.
hypolimnetic zone	The deep portion of a lake or reservoir volume generally classified as below the level of the thermocline.
hypolimnion	*See* stratification.

I

Important Farmland	As defined by the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service), Important Farmlands include Prime Farmland, Unique Farmland, Farmland of Statewide Importance, and Farmland of Local Importance. The categorization of farmland is based upon a soil classification system which accounts for the physical and chemical characteristics of the land and the suitability of the land for producing crops. Important Farmlands are afforded special protection due to their importance to agricultural production.
impoundment	Body of water created by a dam.
incidental take	Incidental take is defined by the ESA as take that is “incidental to, and not the purpose of, the carrying out of an otherwise lawful activity” (50 C.F.R. pt. 17.22 and 17.32).
Indian Trust Assets (ITAs)	Indian Trust Assets are ‘legal interests’ in ‘assets’ held in ‘trust’ by the federal government for federally recognized Indian tribes or individual Indians.
inflow	Water flowing into a lake or reservoir from a river and/or its tributaries; or water entering a river from tributaries.
Interim Surplus Criteria (ISC)	*see* "Interim Surplus Guidelines"
Interim Surplus Guidelines (ISG)	Interim Surplus Guidelines were implemented in 2001 to provide structure and certainty to water deliveries in excess of the apportionments of the Lower Basin states. The ISG are due to expire in 2016, and since the Lower Basin shortage guidelines are anticipated to extend through 2025, consideration of an extension of the ISG is one of the elements of the proposed federal action. This element of the alternatives varies from a reduction in surplus deliveries to an extension and modification of the existing surplus guidelines. This element of the alternatives helps establish an operational strategy for the full range of reservoir operations.
irrigated area	The gross farm area upon which water is artificially applied for the production of crops, with no reduction for access roads, canals, or farm buildings.
irrigation	The controlled application of water to arable lands to supply water requirements not satisfied by rainfall.

J-K

juvenile	Young fish older than one year but not having reached reproductive age.
kilowatt-hour (kWh)	One thousand watt-hours of electrical energy.

L

land cover type	A classification system to describe vegetation and other habitat types (e.g., cotton-wood willow, honey mesquite type III, marsh, etc.).
Las Vegas Valley	The topographic basin containing the City of Las Vegas, the City of North Las Vegas, the City of Henderson and certain unincorporated townships of Clark County.
Las Vegas Wash	The natural drainage channel for the entire Las Vegas Valley. It is dominated by wastewater flows from the City of Las Vegas, Clark County Sanitation District, and City of Henderson wastewater treatment plants. It terminates in the Las Vegas Bay of Lake Mead.

Law of the River	As applied to the Colorado River, the collective set of compacts, federal laws, court decisions and decrees, contracts, and formally determined and adopted operating criteria (or guidelines) that apportions the water and regulates the use and management of the Colorado River among the seven Basin States and Mexico.
lead agency	A lead agency is an agency initiating and overseeing the preparation of an environmental impact report or EIS. For this project, Reclamation is the lead agency for compliance with NEPA.
Lee Ferry	A reference point marking division between the Upper and Lower Colorado River Basins. The point is located in the mainstream of the Colorado River one mile below the mouth of the Paria River in Arizona.
Lees Ferry	Location of Colorado River ferry crossings (1873 to 1928) and site of the USGS stream gage above the Paria River confluence.
limnology	Scientific study of the physical characteristics and biology of lakes, ponds, and streams.
load	Amount of electrical power or energy delivered or required at a given point.
Lower Basin	Includes those parts of the states of Arizona, California, Nevada, New Mexico and Utah within and from which waters drain naturally into the Colorado River System below Lee Ferry, Arizona.
Lower Division	A division of the Colorado River system that includes the states of Arizona, Nevada and California.
Lower Division states	The states of Arizona, California, and Nevada as defined by Article II of the Colorado River Compact of 1922.

M

magnitude	A number characteristic of a quantity and forming a basis for comparison with similar quantities such as flows. A number representing the intrinsic or apparent brightness of a celestial body on a logarithmic scale in which an increase of one unit corresponds to a reduction in the brightness of light by a factor of 2.512.
mean monthly flow	Average flow for the month, usually expressed in cubic feet per second.
mean sea level (msl)	The average height of the sea surface for all stages of the tide, serving as the reference surface for all altitudes in atmospheric studies.
median	Middle value in a distribution, above and below which lie an equal number of values.
megawatt (MW)	One million watts of electrical power (capacity).
megawatt-hour (MWh)	One million watt-hours of electrical energy.
milligram per liter (mg/L)	Equivalent to one part per million.

N

National Environmental Policy Act (NEPA)	Law requiring federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet this requirement, federal agencies prepare a detailed statement known as an Environmental Impact Statement (EIS).
National Register of Historic Places (NRHP)	The nation's official list of cultural resources worthy of preservation. Authorized under the National Historic Preservation Act of 1966, the National Register is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources. Properties listed in the Register include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archeology, engineering, and culture.
natural flow	The flow of any stream undepleted by the activities of man.
Normal conditions determination	A water supply determination made by the Secretary that governs the amount of water available for consumptive use by the Lower Division states for a specific calendar year. Under a Normal conditions determination consumptive use within the Lower Division states is limited to 7.5 million acre-feet.

O

oligotrophic	A body of water characterized by low dissolved plant nutrient and organic matter, and rich in oxygen at all depths.

P-Q

peak flow	Maximum instantaneous flow in a specified period of time.
peak load	Maximum electrical demand in a stated period of time.
penstock	Conduit pipe used to convey water under pressure to the turbines of a hydroelectric plant.
percentile	A statistical term. A descriptive measure that splits ranked data into 100 parts, or hundredths. For example, the 10^{th} percentile is the value that splits the data in such a way that 10 percent of the values are less than or equal to the 10^{th} percentile.
Piscivorous	Habitually feeding on fish.
PM_{10} (PM10)	Particulate matter (dust particles) less than 10 micrograms per cubic meter
power	Electrical capacity generated, transferred or used.
Present Perfected Right (PPR)	With respect to the Colorado River, a water right exercised by the actual diversion of a specific quantity of water, prior to June 25, 1929, the effective date of the Boulder Canyon Project Act.
priority	A ranking with respect to diversion of water relative to other water users.
probability	In this EIS, the relative frequency with which a range of modeled values occurs. For example, the probability of Lake Mead elevation exceeding 1,180 ft msl in June 2005 is equal to the number of modeled elevations greater than 1,180 ft msl in June 2005, divided by the total number of modeled elevations in June 2005.

public involvement	Process of obtaining citizen input into each stage of development of planning documents. Required as a major input into any EIS.

R

ramp rate	The rate of change in instantaneous output from a powerplant. The ramp range is established to prevent undesirable effects due to rapid changes in loading or, in the case of hydroelectric plants, discharge.
rated head	Water depth for which a hydroelectric generator and turbines were designed.
reach	A specified segment of a stream, channel, or other water conveyance facility.
recruitment	Survival of young plants and animals from birth to a life stage less vulnerable to environmental change.
re-regulating reservoirs	A reservoir for reducing diurnal fluctuations resulting from the operation of an upstream reservoir for power production.
reserved water	In the case of Indian reservations, rights based on the doctrine of Indian reserved rights, and in the case of federal establishments other than Indian reservations, a federal reservation of water for use on property under Federal jurisdiction.
reservoir	A pond, lake, or basin, either natural or artificial, for the storage, regulation, and control of water.
return flow	Portion of water previously diverted from a stream and subsequently returned to that stream and is available for consumptive use by others.
return flow credit	Water returned to the Colorado River that can be rediverted in the same year. Diverted Colorado River water that is returned to the river in the year in which it was diverted is credited against a water user's total diversions.
riffle	A stretch of choppy water caused by an underlying rock shoal or sandbar.
riparian	Of, on, or pertaining to the bank of a river, pond, or lake.
river mile (RM)	River miles are numbered along the Colorado River from south to north starting with RM 0.0 at the Southerly International Border (SIB) with Mexico. Dam locations are noted at their respective river miles.
river stage	Water surface elevation above a datum.
RiverWare™	A commercial river system simulation computer program that was configured to simulate operation of the Colorado River for this EIS.
run-off	That part of the precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of man in or on the stream channels.

S

salinity	A term used to refer to the dissolved minerals in water, also referred to as total dissolved solids (TDS).
Secretary	The Secretary of the Department of the Interior, and duly appointed successors, representatives and others with properly delegated authority.

Glossary

Section 10(a)(1)(B) permit	Section 10(a)(1)(B) of the ESA authorizes the FWS to issue non-federal entities a permit for the incidental take of endangered and threatened wildlife species. This permit allows the non-federal entity to proceed with an activity that is legal in all other respects, but that results in the "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity."
sediment	Unconsolidated solid material that comes from weathering of rock and is carried by, suspended in, or deposited by water or wind.
sediment load	Mass of sediment passing through a stream.
seepage	Relatively slow movement of water through a medium, such as sand.
Shortage condition determination	A water supply determination made by the Secretary that governs the amount of water available for consumptive use by the Lower Division states for a specific calendar year. Under a Shortage condition determination consumptive use within the Lower Division states may be limited to an amount less than 7.5 million acre-feet.
Shortage Guidelines	This element is the primary aspect of the proposed federal action. Its purpose is the orderly rationing of water supplies particularly during drought and low reservoir conditions. While Lake Powell and Lake Mead have large amounts of storage, water supply demands are steadily increasing and careful management of existing water supplies will help ensure sufficient supplies are available. The Shortage Guidelines apply to the Lower Basin states and range from aggressive shortages to no reduction of water supplies until the reservoirs are empty. Most of the alternatives have discrete stepped levels of shortage associated with Lake Mead reservoir elevations.
spawn	To lay eggs, especially fish.
spills	Water releases from a dam in excess of powerplant capacity.
spillway	Overflow facility at a dam, usually consisting of a sill at the full-reservoir water surface elevation.
spinning reserves	Available capacity of generating facilities synchronized to the interconnected electric system so that it can be called upon for immediate use in response to system problems or sudden load changes.
stage	Water surface elevation.
Standards	A means established by authority as a rule for the measure of quality, such as cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.
Storage	Water artificially impounded in surface or underground reservoirs, for future use. The term regulation refers to the action of this storage in modifying streamflow. See also Conservation storage, Total storage, Dead storage, and Usable storage. Water naturally detained in a drainage basin, such as ground water, channel storage, and depression storage. The term "drainage basin storage" or simply "basin storage" is sometimes used to refer collectively to the amount of water in natural storage in a drainage basin.
Storage and Delivery of Conserved Water	One mechanism to increase water deliveries during droughts and low reservoir conditions is the conservation and enhancement of existing water supplies. The alternatives consider options for the creation of a system of credits in Lake Mead established through extraordinary conservation, with various limits on the maximum size, storage and delivery of the credit water..

stratification	Thermal layering of water in lakes and streams. Lakes usually have three zones of varying temperature: (1) *epilimnion* – top layer with essentially uniform warmer temperature; (2) *metalimnion* – middle layer of rapid temperature decrease with depth; and (3) *hypolimnion* – bottom layer with essentially uniform colder temperatures.
streamflow	The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than runoff, as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.
system storage	The total volume of water available in the Colorado River system at a specific point in time.

T

tail water	Water immediately downstream of the outlet from a dam or hydroelectric powerplant.
take	As defined by the ESA, "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 U.S.C. §§ 1531[18]).
thermocline	The zone of maximum change in temperature in a water body, separating upper (epilimnetic) from lower (hypolimnetic) zones.
threatened species	A species or subspecies that is likely to become endangered in the foreseeable future.
total dissolved solid (TDS)	A measure of the inorganic or mineral content of water, commonly expressed in milligrams per liter.
traditional cultural property	A site or resource that is eligible for inclusion in the *National Register of Historic Places* because of its association with cultural practices or beliefs of a living community.
tributary	River or stream flowing into a larger river or stream.
turbidity	Cloudiness of water, measure by how deeply light can penetrate into the water from the surface.

U-V

Upper Basin	Those parts of the States of Arizona, Colorado, New Mexico, Utah and Wyoming within and from which waters drain naturally into the Colorado River system above Lee Ferry, Arizona.
Upper Colorado River Commission	Commission established by the Upper Colorado River Basin Compact of appointed members from the Upper Division States whose purpose is to secure the storage of water for beneficial consumptive use in the Upper Basin.
Upper Division	A division of the Colorado River system that includes the states of Colorado, New Mexico, Utah and Wyoming.
Upper Division states	The states of Colorado, New Mexico, Utah and Wyoming as defined by Article II of the Colorado River Compact of 1922.

W-X

Water Year	That period of twelve months ending September 30 of each year.
Waters of the United States	In accordance with the Clean Water Act, Waters of the United States include: (1) all waters which may be susceptible to use in interstate or foreign commerce; (2) all interstate waters including interstate wetlands; (3) all other waters such as intrastate lakes rivers, streams (including intermittent streams), mud flats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters; (4) all impoundments of waters otherwise defined as waters of the United States; (5) tributaries of waters identified in this section; (6) the territorial seas; and (7) wetlands adjacent to waters (other than waters that are themselves wetlands) identified in this section.
watershed	The drainage area upstream of a specified point on a stream.

Y-Z

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List of Preparers

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List of Preparers

This Draft Environmental Impact Statement was prepared by the Bureau of Reclamation, Upper and Lower Colorado Regions. A list of persons who prepared various section, significant background material or participated to a significant degree in preparing the statement is presented below

Alan G.K. Solbert
1950-2006

Alan Solbert of Jones & Stokes, a dear friend and colleague, contributed substantially to the completion of the document. The project team as well as many others will miss Alan's leadership, enthusiasm, and friendship. This effort is dedicated to his memory.

BUREAU OF RECLAMATION, LOWER COLORADO REGION

Name	Education	Qualifications	Experience	Project Role
Belew, Stephen	B.S., Civil Engineering	GIS	10	GIS
Blasius, Becky	B.S., Physiology M.S., Entomology	Aquatic ecology	9	Water Quality
Callejo, Russell	M.S., Civil Engineering	Hydrologic modeling and data analysis	5	Hydrologic Resources/Modeling Team
Cunningham, Amber	Economics degree from UNLV	Economics and Colorado River contracts	3	Water Supply/ Modeling Team
Dwyer, Colleen	B.S. Engineering	Writing/Editing	23	Public Outreach
Ellis, Bruce	B.A., Anthropology	NEPA/ESA compliance	30	Quality Control and Assurance
Fulp, Terry	Ph.D., Mathematical and Computer Sciences	Hydrology and water operations	20	Project Manager
Gould, Glen	M.S. Fisheries Management	Ecology of Lower Colorado River	26	Biology
Harpman, David	M.S., Agricultural Economics Ph.D., Natural Resource Economics	Water resource economics, the economics of hydropower, nonmarket valuation and the valuation of instream flow	17	Electric Power Generation
Hvinden, Steve	M.S., B.S., Agricultural Economics	Water entitlements and priorities, water contracts, Indian trust assets	27	Hydrologic Resources/Modeling Team
Jamrog, John	B.S. Forestry	Natural resources management	30	Agriculture
Jerla, Carly	B.S., Civil Engineering, B.S., Engineering Public Policy M.S., Civil Engineering	Water resources rngineering - hydrologic modeling	5	Hydrologic Resources/Modeling Team
Kleinman, Alan	B.S., M.S., Ph.D. Economics	Agricultural economics	35	Hydrologic Resources/Modeling Team
Lichtkoppler, Rich	B.S., Business Administration M.S., Park and Recreation Administration Ph.D., Resource Economics	Natural resource economics, recreation economics, Economic damage assessment, national park planning, environmental justice	22	Sociological

BUREAU OF RECLAMATION, LOWER COLORADO REGION

Name	Education	Qualifications	Experience	Project Role
Martin, Bill	B.S., Natural Resources, and Business Administration	Outdoor recreation management	10	Recreation
Saint, Debby	B.A. Geography	Environmental specialist, social factors analyst, Lower Colorado Region Native American Affairs Program Manager	33	Indian Trust Assets
Selig, Margot	M.S., Agricultural Economics	Land use, shortage allocation model, entitlements	14	Sociological
Simms, Ron	B.A., Anthropology M.S., Geology	Land use, settlements, shortage allocation model	21	GIS
Smith, Ron	B.S., Electrical Engineering	Power generation	23	Electric Power Generation
Watt, Dennis	B.S., Geology	Groundwater	32	Groundwater
Yoder, Nan	B.A., Economics	Project management	10	Project Coordinator, Quality Control and Assurance

BUREAU OF RECLAMATION, UPPER COLORADO REGION

Name	Education	Qualifications	Experience	Project Role
Barnett, Karen	B.S., Biology	Biology	15	Biology
Berry, Mike	Ph.D., Anthropology M.A., Anthropology B.A., History	Archaeology	30	Cultural Resources
Blair, Jane	B.S., Civil Engineering M.S., Civil Engineering	Hydropower	25	Agency Review
Clayton, Rick	B.S., Economics B.S., Civil Engineering	Hydrology	9	Hydrologic Resources/Modeling Team
Coulam, Nancy	B.A., M.A., Ph.D., Anthropology	Environmental compliance	20	Quality Control and Assurance
Cutler, Amy	B.S., Civil Engineering M.E., Environmental Civil Engineering	Water quality	8	Water Quality/Modeling

BUREAU OF RECLAMATION, UPPER COLORADO REGION

Name	Education	Qualifications	Experience	Project Role
Cutler, Chris	B.S., Civil Engineering M.E., Environmental Civil Engineering	Hydrology	5	Hydrologic Resources/Modeling Team
Gilmore, Andrew	M.S., Civil Engineering	Hydrology	7	Hydrologic Resources/Modeling Team
Kelleher, Jayne		Technical writing	28	Project Coordinator
Liljegren, Fred	B.S., Landscape Architecture	Landscape architecture	32	Recreation
Loring, Mike	M.S., Resource Economics	Economics	21	Socioeconomics, Hydropower
Parry, Brian	J.D.	Water right and Indian Trust Assets	30	Indian Trust Assets
Miller, Jerry	B.S., Geology/Chemistry	Water quality/modeling	30	Water Quality
Peterson, Randall	B.S., Civil Engineering	Environmental compliance	30	Project Manager
Prairie, Jim	Ph.D., Civil Engineering	Water quality/modeling	6	Hydrologic Resources/Modeling Team
Ryan, Tom	B.A., Psychology B.S., Civil Engineering	Hydrology	18	Hydrologic Resources/Modeling Team

COOPERATING AGENCY REPRESENTATIVES

Name	Education	Qualifications	Experience	Project Role
Henderson, Norman	B.S., Biology M.S., Ecology	Park management/recreation	25	Recreation
Loftin, Sam	A.S., Casper College B.S.E.E. (Electrical Engineering)	CRSP hydro resources, forecasting power purchases	27	Electric Power Generation
Palmer, Clayton	M.A. Economics	Natural resource economics, hydroelectric power economics	22	Electric Power Generation
Young, Brian	B.S., Engineering	Hydropower generation & marketing	22	Electric Power Generation

BROWN AND CALDWELL

Name	Education	Specialty Area	Experience	Project Role
Beavers, Kathleen		Project management and administrative coordination	5	Administrative coordinator
Biggs, John	B.S., Civil Engineering M.S., Civil Engineering	Odor/Air emissions monitoring & control, Buried infrastructure assessment, water/wastewater treatment.	3	Hydrological Resources
Dow, Sarahann	B.S., Biology M.S., Ph.D., Environmental Engineering	Water chemistry, microbial assessments, and advanced treatment technologies	7	Resource Lead – Water Quality
Duren, Sabre	B.A., Environmental Studies M.S., Environmental Engineering	Watershed water quality and hydrology assessments	5	Visual, Hydrological
Ennis, Renee		Word processing management, document preparation, database maintenance	15	Word Processor Lead
Gain, Jenny	B.S., Civil and Environmental Engineering M.S., Environmental Engineering	Watershed management, water quality monitoring, water supply and conservation, ecosystem restoration	4	Recreation
Herencia, Chris	B.S., Civil Engineering Facilities Management	Storm water management, hydraulic applications, and storm water characterization and monitoring	19	Hydrology

BROWN AND CALDWELL

Name	Education	Specialty Area	Experience	Project Role
Kadaster, Omer	B.S., Civil Engineering M.S., Civil Engineering Registered Professional Civil and Geotechnical Engineer in California	Civil and Environmental Engineering; CERCLA process; technical writing	40	Technical Writer
Lindburg, Matt	B.S., Agricultural Engineering M.S., Agricultural and Biological Systems Engineering	Project management and water resources planning and engineering for irrigation and hydrogenation facilities	12	Agricultural
Marshall, Laura	B.S., Civil Engineering M.S., Environmental Engineering	Ecosystem restoration planning and analysis, surface water and groundwater quality, environmental services	5	Recreation
Martin, Eric	B.S., Natural Resources	Environmental permitting, groundwater investigations, groundwater and soil remediation, and data management	7	Project Coordinator, Quality Control and Assurance
Moshier, Emily	B.S., Environmental Engineering M.S., Environmental Engineering	Water quality assessments and models, environmental services	4	Water Quality
Meyer, Dave	B.S., Range Forest Management MEPM Environmental Policy and Management	Multi-media compliance and permitting, environmental impact evaluations, sustainable management systems	27	Resource Lead – Electrical Power Resources
Miller, David	M.A., English Literature M.S. Irrigation Engineering Ph.D. Agricultural Engineering	Agricultural water management, water resources planning, agricultural water quality	26	Resource Lead - Agricultural
Nienberg, Mike	B.S., Biology MPH, Environmental Health Management DrPH, Environmental Management and Planning	NEPA/CEQA compliance, environmental impact assessment, public health	28	Quality Control and Assurance
Plude, Bryan	B.A., Biology M.A., Management and Business M.S., Civil Engineering	Restoration and conservation of ecosystems as well as design, planning, and restoration of wetlands	28	Resource Lead - Visual; Recreation
Reichard, Chris	B.S., Natural Resources	Wetland, riparian and threatened/endangered species assessments, environmental permitting, and ecological mitigation design and planning	8	Resource Lead - Biology

BROWN AND CALDWELL

Name	Education	Specialty Area	Experience	Project Role
Schmucker, Betty	B.A., Anthropology M.A., Anthropology	Community coordination for environmental remediation, environmental impact assessments, and cultural resources	22	Resource Lead - Cultural Resources and Archeology
Yee, Wellington	B.S., Microbiology Registered Environmental Health Specialist in California Registered Environmental Assessor in California	Environmental regulatory compliance	20	Resource Lead – Air Quality
Yoshida, Kathleen		Word processor, document preparation (format, spelling, QA/QC; data entry)	10	Word Processing
Zubia, Ruben	B.S., Civil Engineering M.B.A. Registered Professional Civil Engineer in California	Project management, water resource planning, NEPA compliance, agency coordination	20	Project Manager, Resource Lead - Hydrology, Water Deliveries

JONES AND STOKES

Name	Education	Qualifications	Experience	Project Role
Elliott, Chris	B.S., Landscape Architecture	Licensed Landscape Architect (CA 4247), restoration ecology, open space and recreational planning, landscape architecture	13	Resource Lead - Recreation
Engels, Tom	B.A., English; Ph.D., Biological Sciences	NEPA compliance, regulatory compliance, water resource planning	11	Recreation
Glines, Harlan	B.A., Environmental Studies	NEPA compliance, regulatory compliance, water resource planning	21	Assistant Project Manager
Hick, Carol-Anne	B.S., Environmental and Resource Sciences	MS Office systems, document production	4	Document Production
Lingappaiah, Colleen	B.A., Biology with emphasis in Chemistry	NEPA compliance, regulatory compliance, water resource planning	14	Document Production, Project Coordinator
Maniscalco, Donna	B.S., Wildlife Fish & Conservation Biology	Fisheries biology	6	Biology

JONES AND STOKES

Name	Education	Qualifications	Experience	Project Role
McConnaha, Willis	B.A., Geology; M.S. Fisheries; Ph.D., Environmental Science and Resources	Fisheries biology, aquatic ecology, urban and regional planning	28	Biology
McGowan, Dana	B.A., Anthropology; Minor in Geology; M.A., Anthropology	Historical archaeology, prehistoric archaeology	25	Resource Lead—Indian Trust Assets; Cultural Resources
Norgaard, Ingrid	B.A., Political Science	Public outreach/ education, public involvement/ facilitation, community affairs	8	Resource Lead—Environmental Justice
Oakes, Harry	B.S., Wildlife and Fisheries Biology; Minor, Forestry	Restoration ecology, riparian ecology, vegetation management	12	Biology
Rimpo, Tim	B.A., Economics; M.S., Economics	Natural resource economics, NEPA/SEPA/CEQA compliance	17	Resource Lead—Transportation
Rogers, Jennifer	B.A., Journalism	Public outreach/education	1	Population and Housing
Roy, Gregg	B.S., Political Economy of Natural Resources	NEPA compliance documents and socioeconomic studies	16	Resource Lead—Socioeconomics; Project Team
Solbert, Alan	B.S., Biology and Zoology; M.S., Wildlife Sciences and Ecology	Project management, NEPA compliance, environmental impact analysis, flood protection and water resource planning, habitat restoration planning, local government and interagency coordination, land use planning, interagency facilitation, mitigation planning	23	Assistant Project Manager
Stock, Jennifer	B.S., Landscape Architecture	Licensed Landscape Architect open space and recreational planning, Computer Aided Design & Drafting	8	Recreation
Unhold, Claudia	B.A., Geography; M.S., City and Regional Planning	Urban and regional planning, public involvement/facilitation, environmental data analysis	20	Resource Lead—Population and Housing, Land Use
Williams, Karen	B.A., Anthropology	Prehistoric archaeology, public involvement/ facilitation	19	Population and Housing; Land Use

SAIC

Name	Education	Specialty Area	Experience	Project Role
Rawlings, Pete	B.S., Wildlife Management	Wildlife biology and management, conservation planning, and endangered species compliance	26	Biology
Springer, Lisbeth	B.A., Sociology Master of City and Regional Planning Certified Planner: American Institute of Certified Planners (AICP) Certificate in Negotiation and Mediation	Certified Planner: American Institute of Certified Planners (AICP) Certificate in Negotiation and Mediation	25	Biology
Thompson, Rosemary	B.A., Zoology Ph.D., Marine Biology	Threatened, Endangered, and Special Status fish	32	Biology

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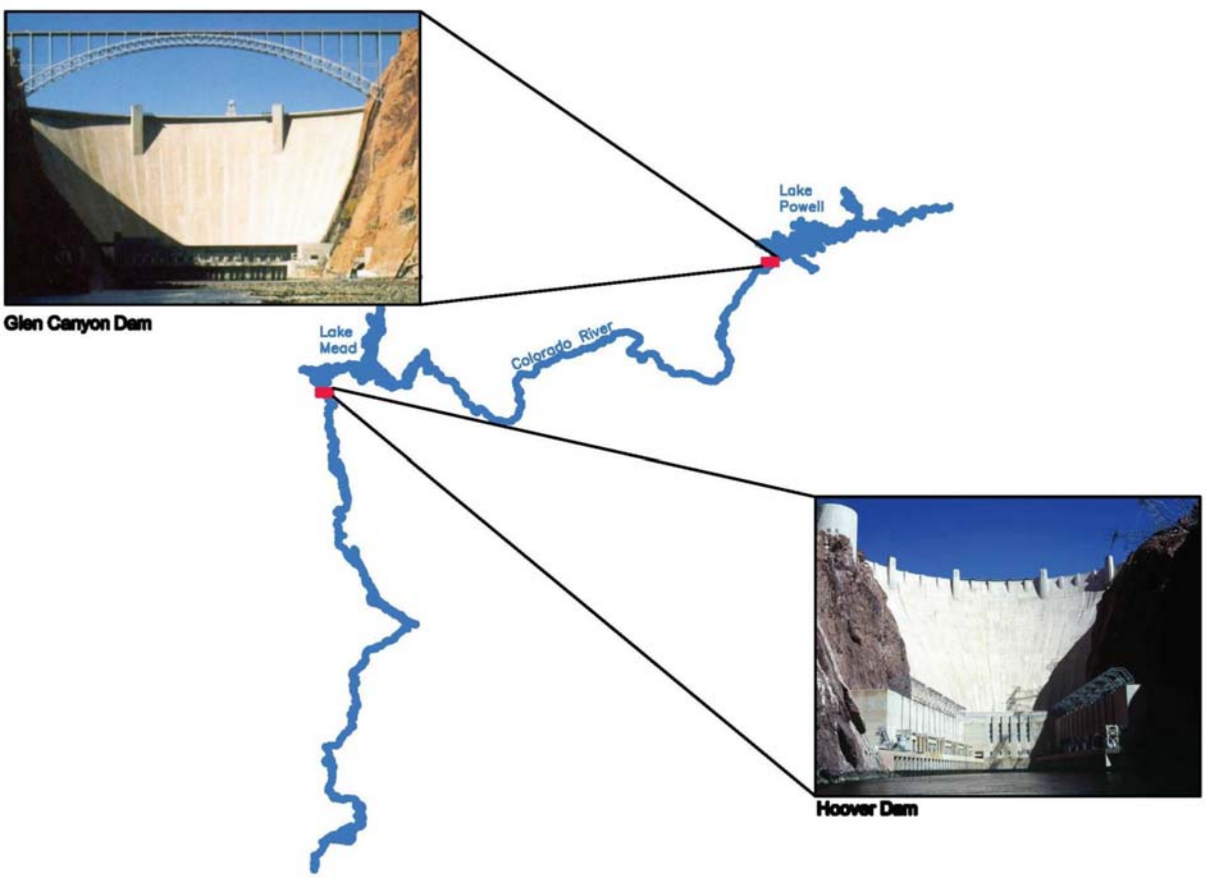
Managing Water in the West

Draft

Environmental Impact Statement



Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead

Volume II - Appendices

U.S. Department of the Interior
Bureau of Reclamation
Upper and Lower Colorado Regions

February 2007

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Draft Environmental Impact Statement

Volume II - Appendices

U.S. Department of the Interior
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Appendix A

CRSS Model Documentation

This appendix describes the reservoir operating rules and related data used in the Reclamation's Colorado River Simulation System (CRSS), as implemented in the RiverWare™ modeling system.

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A.1 Background

Long-term policy and planning studies on the Colorado River have typically used computer modeling results from CRSS. Developed in the 1980's as a Fortran-based modeling system, CRSS originally ran on a Cyber mainframe computer. CRSS modeled twelve major reservoirs and approximately 115 diversion points throughout the Upper and Lower Basins on a monthly time step. A major drawback of the Fortran-based CRSS was that the operating policies or rules were "hardwired" into the modeling code, making modification of those policies difficult.

Based on the need to initiate surplus and shortage studies for the Lower Basin in the early 1990s, Reclamation developed an annual time step model, CRSSez, implemented in Visual Basic (Bureau of Reclamation 1998). CRSSez primarily modeled the operation of Lake Powell and Lake Mead, representing the reservoirs above Lake Powell as one aggregate reservoir, and the effect of reservoirs below Lake Mead as part of the water demand necessary from Lake Mead. CRSSez was used in the Interim Surplus Criteria EIS process to facilitate the development of possible alternatives to be analyzed.

In 1994, Reclamation began a collaborative research and development program with the University of Colorado and the Tennessee Valley Authority with the goal of developing a general-purpose modeling tool that could be used for both operations and planning on any river basin. This modeling tool, known as RiverWare™, is now being used by the Upper and Lower Colorado Regions for both planning and operations (Fulp 1999). A major advantage of RiverWare™ is that the operational policies or rules are no longer "hardwired" into the modeling code (Zagona et al. 2001). The user expresses and prioritizes the rules through the RiverWare™ graphical user interface, and RiverWare™ then interprets the rules when the model is run. Multiple rule sets can be run with the same model and this provides the capability for efficient "what-if" analysis with respect to different policies.

Reclamation replaced the original CRSS model with a new model implemented in RiverWare™ in 1996. The new model has the same spatial and temporal resolution, uses the same basic input data (hydrology and consumptive use schedules), and uses the same physical process algorithms as the original CRSS. A rule set was also developed to mimic the policies contained in the original model. Comparison runs were made between the original CRSS and the new model and rule set, with typical differences of less than 0.5 percent (Bureau of Reclamation 1996).

Since 1996 enhancements to CRSS have consisted of developing new rule sets to reflect current operational policy as well as investigating and improving, where necessary, the physical process methodologies. A team of Reclamation engineers from the Upper and Lower Colorado Regions has been established for these purposes and continues to assess the need to further enhance CRSS to reflect new operational policies.

In 2005 a policy-screening model, CRSS-Lite was developed to replace CRSSez (Bureau of Reclamation 2005). CRSS-Lite was developed in RiverWare™ and preserves the complexity and accuracy of CRSS with a significantly shorter model execution time, an advantage over CRSSez. CRSS-Lite was used extensively to evaluate and compare a multitude of operational strategies to facilitate the development of the alternatives analyzed in this Draft EIS.

A.2 Description of the Model

In summary, twelve reservoirs are modeled (Fontenelle, Flaming Gorge, Taylor Park, Blue Mesa, Morrow Point, Crystal, Navajo, Starvation, Powell, Mead, Mohave, Havasu). Critical to this Draft EIS was the allocation of shortages, which required breaking out several of the approximately 115 modeled diversions (demands and return flows) throughout the basin that had been aggregated in the original CRSS, specifically within the state of Arizona. The hydrologic "natural" inflows (flows corrected for upstream regulation and consumptive uses and losses) at 29 inflow points throughout the basin were also used from the standard CRSS hydrology data set covering the period 1906–2004.

A.3 Initial Reservoir Conditions

Table A-1 provides the initial conditions for the Upper and Lower Basin reservoirs. Since the simulation begins in January, 2008, these values reflect the end-of-calendar year 2007 elevations, as projected by the August 2006 24-Month Study.

Table A-1
Initial Reservoir Conditions

Reservoir	Elevation (feet msl)	Storage (af)
Fontenelle	6,486.29	203,787
Flaming Gorge	6,029.67	3,336,300
Starvation	5,734.92	255,000
Taylor Park	9,308.32	67,260
Blue Mesa	7,489.99	581,270
Morrow Point	7,153.73	112,000
Crystal	6,753.04	16,970
Navajo	6,080.33	1,629,760
Powell	3,614.80	13,219,550
Mead	1,116.53	13,023,940
Mohave	638.71	1,582,960
Havasu	445.80	539,520

A.4 Reservoirs Above Lake Powell

The reservoirs above Lake Powell are operated to meet monthly storage targets (or "rule curves") and downstream demands. The basic procedure is that given the inflow for the current month, the release will be either the release necessary to meet the target storage or the release necessary to meet demands downstream of the reservoir, whichever is greater. The rule curves are input for each reservoir, but are modified during the run for Flaming Gorge, Blue Mesa, and Navajo to simulate operations based on the imperfect inflow forecasts that are encountered in actual reservoir operations. Furthermore, each reservoir is constrained to operate within user-supplied minimum and maximum releases (mean monthly release in cubic feet per second [cfs]) as specified in Table A-2:

Table A-2
Release Constraints for Reservoirs above Lake Powell

Reservoir	Minimum Release (cfs)	Maximum Release (cfs)
Fontenelle	500	18,700
Flaming Gorge	800	4,900
Starvation	100	5,000
Taylor Park	50	5,000
Blue Mesa	270	5,000
Morrow Point	300	5,000
Crystal	300	4,200
Navajo	300	5,900

For Flaming Gorge, Blue Mesa, and Navajo, the target storage is computed by using an inflow forecast for the spring runoff season (January to July), again to mimic the imperfect forecasts seen in actual operations. The forecast inflow (for the current month through July) is computed as a weighted average of the long-term average natural inflow and the natural inflow assumed for the year being modeled. The weights used are:

Table A-3
Weights for Inflow Forecast for Reservoirs above Lake Powell

Month	Natural Inflow Weight	Average Natural Inflow weight
January	0.3	0.7
February	0.4	0.6
March	0.5	0.5
April	0.7	0.3
May	0.7	0.3
June	0.7	0.3
July	0.6	0.4

The long-term, average natural inflows into each reservoir are (in thousand acre-feet [kaf]):

Table A-4
Average Natural Inflows for Reservoirs above Lake Powell (kaf)

Reservoir	Jan	Feb	Mar	Apr	May	Jun	Jul
Flaming Gorge	23.3	20.9	33.8	87.9	250.4	327.8	157.5
Blue Mesa	34.0	39.5	94.6	176.0	339.8	561.6	346.8
Navajo	18.8	24.6	69.3	176.9	297.3	284.7	120.1

Based on the inflow forecast, the rule computes the volume necessary to release from the current month through July, assuming the reservoir will fill in July:

Release needed for the current month = (current contents - live capacity + predicted remaining inflow) divided by the number of months remaining until the end of July

The target storage for the current month is then computed, adjusting for any gains or losses above the reservoir:

Target storage = previous storage - release needed + gains – losses

A.5 Lake Powell Operation

The operation of Lake Powell depends on a rule curve consisting of a forecast-driven, spring runoff operation (January through July) that attempts to fill the reservoir to a July target storage and a fall operation (August through December) that attempts to draw down the reservoir to a December target storage. The July and December targets are 23.822 million acre-feet (maf) (500,000 af of space) and 21.900 maf (2.422 kaf of space), respectively. Another rule simulates the occurrence of Beach Habitat Building Flows (BHBFs or "spike" flows). Two other higher priority rules ensure that the minimum objective release of 8.23 million acre-feet per year (mafy) is met and that equalization of Lake Powell and Lake Mead is accomplished when necessary. Release constraints that reflect the 1996 Record of Decision on the Operation of Glen Canyon Dam are also part of the Lake Powell rule set.

Sections A.5.1 through A.5.6 that follow describe modeling assumptions for Lake Powell operation that are common to all five alternatives. A summary comparison of the Lake Powell operational strategy for each alternative is provided in Table A-21, located in Section A.10.

A.5.1 Lake Powell Inflow Forecast

The unregulated Lake Powell inflow forecast from the current month through July is computed as:

Unregulated Lake Powell inflow = natural flow into Lake Powell - estimated Upper Basin depletions + the forecast error

where; the forecast error is computed using equations derived from an analysis of past Colorado River forecasts and runoff data for the period 1947 to 1983.

As detailed in the original CRSS overview document (Bureau of Reclamation 1985), analysis of these data reveals two strongly established patterns: (1) high runoff years are under-forecast, and low runoff years are over-forecast; (2) the error in the current month's seasonal forecast is strongly correlated with the error in the preceding month's forecast. A regression model was developed to aid in determining the error to be incorporated into the seasonal forecast for each month from January to June. The error is the sum of a deterministic and a random component. The deterministic component is computed from the regression equation. The random component is computed by multiplying the standard error of the regression equation by a random mean deviation selected from a standard normal distribution.

The forecast error equation has the following form (all runoff units are maf):

$$E_i = a_i X_i + b_i E_{(i-1)} + c_i + Z_r d_i$$

where:

i	=	month,
E_i	=	error in the forecast for month "i,"
X_i	=	natural runoff into Lake Powell from month "i" through July,
a_i	=	linear regression coefficient for Xi,
$E_{(i-1)}$	=	previous month's forecast error,
b_i	=	linear regression coefficient for E(i-1),
c_i	=	constant term in regression equation for month "i,"
Z_r	=	randomly determined deviation, and
d_i	=	standard error of estimate for regression equation for month "i."

Table A-5 summarizes the regression equation coefficients for each month:

Table A-5
Lake Powell Inflow Forecast Regression Coefficients

Month	a_i	b_i	c_i	d_i
January	0.70	0.00	-8.195	1.270
February	0.00	0.80	-0.278	0.977
March	0.00	0.90	0.237	0.794
April	0.00	0.76	0.027	0.631
May	0.00	0.85	0.132	0.377
June	0.24	0.79	0.150	0.460

The magnitude of the June forecast error is constrained to not exceed 50 percent of the May forecast error and the July forecast error is equal to 25 percent of the June forecast error.

A.5.2 Spring Runoff Operation (January to July)

To accomplish the spring operation, the unregulated forecast is first adjusted to account for potential reservoir regulation above Lake Powell. This potential regulation is currently computed as just the sum of the available space (live capacity – previous month's storage) in Fontenelle, Flaming Gorge, Blue Mesa, and Navajo. Using the regulated forecast inflow, the total volume of water necessary to release from the current month through July is computed as:

total volume to release = previous storage – July target storage + forecast regulated inflow – loss due to evaporation – loss due to bank storage

The release for the current month is then computed by multiplying the total volume to release by a fraction for the current month, where the fraction reflects a user-supplied preferred weighting pattern. The weights and resulting fractions used for this study are as follows:

Table A-6
Lake Powell Spring Runoff Operation Weights

Spring Season	Weights	Fractions
January	0.170	0.170
February	0.160	0.193
March	0.130	0.194
April	0.100	0.185
May	0.100	0.227
June	0.160	0.471
July	0.180	1.000

The fraction is computed as current month's weight divided by the sum of the current and remaining month's weights for the season.

During the spring operation, however, the computed release is constrained to be at least as great as the total volume divided by the number of months remaining. This constraint ensures that sufficient water is released early in the season during high forecast years. Lake Powell's spring operational release is further constrained in each month to be within a minimum and maximum range (currently set to 6,500 and 25,000 cfs, respectively).

An additional constraint is placed on computed monthly release during spill avoidance. If the calculated average flow for a given month is in excess of 1.0 maf, then it is held to a maximum of 1.0 maf each month.

A.5.3 Fall Operation (August to December)

Conceptually, the computation for the fall operation is identical to that done for the spring operation. The regulated inflow forecast is simply the natural inflow, adjusted for Upper Basin depletions, and potential reservoir regulation with no forecast error added. The potential reservoir regulation is again computed as the sum of the available space in Fontenelle, Flaming Gorge, Blue Mesa, and Navajo, where the space is the target storage in December for each reservoir minus the previous month's storage. User-supplied weights are also used to compute the current month release from the total volume to release in the fall. The weights and resulting fractions are as follows:

Table A-7
Lake Powell Fall Operation Weights

Fall Season	Weights	Fractions
August	0.266	0.266
September	0.200	0.272
October	0.156	0.292
November	0.156	0.413
December	0.222	1.000

Two additional constraints are placed on the computed monthly release to ensure a smooth operation. In July, the release is constrained to be at least 1.0 maf if Lake Powell's storage is greater than 23.0 maf. From July through December, the release is constrained to not exceed 1.5 maf, as long as a 1.5 maf release results in a storage at Lake Powell less than 23.822 maf. Lake Powell's fall operational release is further constrained in each month to be within a minimum and maximum range (currently set to 6,500 and 25,000 cfs, respectively).

A.5.4 602(a) Storage Requirement

As stated in the CRSS overview document (Bureau of Reclamation 1985), "602(a) storage refers to the quantity of water required to be in storage in the Upper Basin so as to assure future deliveries to the Lower Basin without impairing annual consumptive uses in the Upper Basin." The current implementation of that storage requirement duplicates the original CRSS calculation. It computes the storage necessary in the Upper Basin to meet the minimum objective release and Upper Basin depletions over the next "n" years, assuming the inflow over that period would follow that seen in the most "critical period on record." The critical period in the Colorado River basin occurred in 1953–1964, a length of 12 years. Inflows from these years are used in the calculation of 602(a) storage.

At the beginning of each calendar year, a value for 602(a) storage is computed by the following formula:

$$\text{602a} = \{(\text{UBDepletion} + \text{UBEvap}) * (1 - \text{percentShort}/100) + \text{minObjRel} - \text{criticalPeriodInflow}\} * 12 + \text{minPowerPoolStorage}$$

where:

602a	=	the 602(a) storage requirement
UBDepletion	=	the average over the next 12 years of the Upper Basin scheduled depletions
UBEvap	=	the average annual evaporation loss in the Upper Basin (currently set to 560 kaf)
percentShort	=	the percent shortage that will be applied to Upper Basin depletions during the critical period (currently set to zero)
minObjRel	=	the minimum objective release to the Lower Basin (currently set to 8.23 maf)
criticalPeriodInflow	=	average annual natural inflow into the Upper Basin during the critical period (1953–1964) (currently set to 12.18 maf)
minPowerPoolStorage	=	the amount of minimum power pool to be preserved in Upper Basin reservoirs (currently set to 5.179 maf)

All parameter values currently used were as found in the original CRSS data files ported from the Cyber mainframe in 1994.

Additionally, since 2004, the Interim 602(a) Storage Guideline has been included in CRSS. This guideline necessitates that for the 602(a) storage requirement to be met, Lake Powell storage must be greater than 14.85 maf (elevation 3,630 feet msl) on September 30. This guideline is in effect through the year 2016. In CRSS simulation, following the 602(a) storage computation described above, a subsequent rule checks to see if Lake Powell is above 3,630 feet msl on September 30. The 602(a) requirement is not met if projected September 30 elevation of Lake Powell is below 3,630 feet msl, through the year 2016.

A.5.5 Predicting End-of-Water Year Volumes of Lake Powell and Lake Mead

Lake Powell end-of-water year (EOWY) volume is predicted each month by taking the previous month's storage, adding the estimated inflow, subtracting the estimated release, and subtracting the estimate of evaporation and change in bank storage. All estimated values are for the period from the current month through September. The estimated inflow is just the regulated inflow forecast previously discussed, where the forecast error is included through July. The estimated release is based on the spring operation (through July) and the fall operation for August and September. The estimated evaporation and bank storage losses are based on an initial estimate of the EOWY volume.

Similarly, the Lake Mead EOWY volume is predicted each month by taking the previous month's volume, adding the estimated Lake Powell release, subtracting the estimated Lake Mead release, adding the average gain between Lake Powell and Lake Mead, subtracting the Southern Nevada depletion, and subtracting the estimate of evaporation and change in bank storage. Again, all values are for the period from the current month through September. Lake Mead's release is estimated as the sum of the depletions downstream of Lake Mead and the reservoir regulation requirements (including evaporation losses) for Lakes Mohave and Havasu minus the gains below Lake Mead.

A.5.6 Beach/Habitat Building Flows

Under the current rule that implements Beach/Habitat Building Flows (BHBF), a BHBF is triggered for the current month if the following conditions are met:

- In January, if the unregulated inflow forecast for January through July (the natural flow – Upper Basin depletions plus forecast error) is greater than the "January trigger volume" (currently set to 13.0 maf).

- In January through July, if the current month's Lake Powell release is greater than the "release trigger" (currently set to 1.5 maf) or if the release volume for the current month through July equally distributed over those months would result in a release greater than the "release trigger."

Once a BHBF has been triggered, if Lake Powell would have had to spill in that month anyway, the total outflow from Lake Powell is not increased; rather the volume for the BHBF (currently set to 200 kaf) is taken from the total outflow already determined by the operational rule. If Lake Powell was not going to spill in that month, then the total outflow from Lake Powell is increased (i.e., the volume for the BHBF is taken from Lake Powell's storage). Under the case where the BHBF is triggered even though the current month's release is less than the "release trigger", the rule re-sets Lake Powell's outflow for that month to the trigger release amount (1.5 maf).

Under all circumstances, only one BHBF is made per calendar year.

A.5.7 Minimum Objective Release

Only under the No Action Alternative is a minimum objective release required from Lake Powell. The minimum release required under the action alternatives varies by alternative and Lake Powell volume. These releases are described in Section A.5.9.

A.5.7.1 No Action Alternative

Under the No Action Alternative, a higher priority rule ensures that the previously described Lake Powell operation will satisfy a minimum objective release to the Lower Basin, currently equal to 8.23 maf over each water year (October through September). Similar to the weighting and release fraction scheme used for the operational rule, a preferred release pattern for each month to meet the minimum objective release is supplied and a fraction is computed. The release pattern (in kaf) and resulting fractions are as follows:

Table A-8
No Action Alternative Lake Powell Release Pattern

Month	8,230 kaf	
	Release (kaf)	Fraction
October	600	0.073
November	600	0.079
December	800	0.114
January	800	0.128
February	600	0.110
March	600	0.124
April	600	0.142
May	600	0.165
June	650	0.215
July	850	0.357
August	900	0.588
September	630	1.000
Total	8,230	-----

The fraction is computed as current month's release divided by the sum of the current and remaining months' releases through September.

Each month the rule computes the volume of water remaining to meet the minimum objective release for the current water year (accounting for the water released previously in the water year) and multiplies that volume by the release fraction. The release determined by the operational rule must then be at least as great as this resulting minimum objective release for the month.

A.5.8 Equalization of Lake Powell and Lake Mead

A.5.8.1 No Action Alternative

Under the No Action Alternative, the equalization of storage between Lake Powell and Lake Mead is implemented in a rule that first determines if equalization needs to occur, and if so, determines how much water to release from Lake Powell to accomplish it. The rule is in effect from January through September of each year. The rule states that equalization needs to occur if two criteria are met: (1) if the storage in the Upper Basin meets the 602(a) storage requirement, and (2), if the projected EOWY storage in Lake Powell is greater than that in Lake Mead.

The storage in the Upper Basin is computed for each month (January–September) and consists of the predicted EOWY storage in Lake Powell, plus the sum of the previous month's storage for Flaming Gorge, Blue Mesa, and Navajo. That storage is then compared to the computed value of 602(a) storage, described above, to determine if the 602(a) storage requirement is met each month. The method of estimating the EOWY storage is described above.

The release for equalization is computed by taking half of the difference between the predicted EOWY volumes of Lake Powell and Lake Mead and dividing by the number of months remaining through September. Evaporation and bank storage losses at Lake Powell and Lake Mead are included in the calculation, resulting in an iterative procedure to arrive at the computed equalization release. The iteration stops when the forecast EOWY volumes of Lake Powell and Lake Mead are within a user-specified tolerance. That tolerance is currently set to 25,000 af.

The computed equalization release for each month is constrained in three ways: (1) if the additional release due to equalization would cause the total Upper Basin storage to drop below the 602(a) storage requirement, then the amount of the equalization release is reduced to prevent this from happening; (2) the equalization release is reduced if it would cause Lake Mead volumes to exceed its exclusive flood control space; and (3) the equalization release is constrained to be not greater than 25,000 cfs, the maximum normal release as per the Glen Canyon Operating Criteria.

A.5.8.2 Basin States Alternative

Under the Basin States Alternative, the equalization of storage between Lake Powell and Lake Mead is implemented in a rule that first determines if equalization needs to occur, and if so, then determines how much water to release from Lake Powell to accomplish it. The rule is in effect from January through September of each year. The rule states that equalization needs to occur if two criteria are met: (1) if the EOWY elevation of Lake Powell is predicted to be equal to or higher than the Equalization Level (see Table A-9); and (2) if the EOWY storage in Lake Powell is greater than EOWY storage in Lake Mead. The Basin States Alternative substitutes the 602(a) Storage and Interim 602(a) Storage Guideline with the Equalization Level for each year 2008 through 2026.

Table A-9
Basin States Alternative Lake Powell Equalization Elevation

Year	Equalization Level (feet msl)
2008	3636
2009	3639
2010	3642
2011	3643
2012	3645
2013	3646
2014	3648
2015	3649
2016	3651
2017	3652
2018	3654
2019	3655
2020	3657
2021	3659
2022	3660
2023	3662
2024	3663
2025	3664
2026	3666

In years when Lake Powell EOWY elevation is projected to be equal to or above the Equalization Level and the EOWY volume of Lake Powell is projected to be above the EOWY volume of Lake Mead, a volume of water greater than 8.23 maf is scheduled for annual release from Lake Powell to the extent necessary to equalize storage in the two reservoirs. Otherwise, if Lake Powell EOWY volume is not higher than Lake Mead EOWY volume, the annual release volume from Lake Powell is scheduled at 8.23 maf.

The release for equalization is computed by taking half of the difference between the predicted EOWY volumes of Lake Powell and Lake Mead and dividing by the number of months remaining through September. Evaporation and bank storage losses at Lake Powell and Lake Mead are included in the calculation, resulting in an iterative procedure to arrive at the computed equalization release. The iteration stops when the forecast EOWY volumes of Lake Powell and Lake Mead are within a user-specified tolerance. That tolerance is currently set to 25,000 af.

The computed equalization release for each month is constrained in four ways: (1) if the additional release due to equalization would cause the total Upper Basin storage to drop below the Equalization Line, then the amount of the equalization release is reduced to prevent this from happening; (2) the equalization release is reduced if it would cause

Lake Mead volumes to exceed its exclusive flood control space; (3) the equalization release is constrained to be not greater than 25,000 cfs, the maximum normal release as per the Glen Canyon Operating Criteria.

A.5.8.3 Conservation Before Shortage Alternative

The equalization method for Lake Powell with the Conservation Before Shortage Alternative are identical to those of the Basin States Alternative.

A.5.8.4 Water Supply Alternative

The equalization criteria for Lake Powell with the Water Supply Alternative are identical to those of the No Action Alternative.

A.5.8.5 Reservoir Storage Alternative

The equalization criteria for Lake Powell with the Reservoir Storage Alternative are identical to those of the No Action Alternative.

A.5.9 Water Year Releases When Equalization Does Not Apply

A.5.9.1 No Action Alternative

Under the No Action Alternative Lake Powell water releases are constrained by the minimum objective release as described in Section A.5.7.

A.5.9.2 Basin States Alternative

Under the Basin States Alternative, when the EOWY level of Lake Powell is below the equalization level (see Table A-9), a higher priority rule ensures that the Lake Powell operation will satisfy a water year release to the Lower Basin, between 7.00 maf and 9.50 maf, depending on elevations in Lake Powell and Lake Mead. Similar to the weighting and release fraction scheme used for the operational rule in the No Action Alternative, a preferred release pattern for each month to meet the water year release is supplied and a fraction is computed. The fraction is computed as current month’s release divided by the sum of the current and remaining months’ releases through September. Each month the rule computes the volume of water remaining to meet the release for the current water year (accounting for the water released previously in the water year) and multiplies that volume by the release fraction. The release determined by the operational rule must then be at least as great as this resulting release for the month.

Specific release patterns (in kaf) and resulting fractions for the Basin States Alternative are as follows:

Table A-10
Basin States Alternative Lake Powell Release Patterns

Month	7,000 kaf		7,480 kaf		8,230 kaf		9,000 kaf		9,500 kaf	
	Release (kaf)	Fraction	Release (kaf)	Fraction	Release (kaf)	Fraction	Release (kaf)	Fraction	Release (kaf)	Fraction
October	400	0.057	480	0.064	600	0.073	600	0.067	600	0.063
November	480	0.073	500	0.071	600	0.079	600	0.071	600	0.067
December	700	0.114	600	0.092	700	0.100	800	0.103	800	0.096
January	620	0.114	800	0.136	800	0.126	800	0.114	850	0.113
February	600	0.125	600	0.118	700	0.127	650	0.105	650	0.098
March	500	0.119	600	0.133	600	0.124	650	0.117	650	0.108
April	500	0.135	500	0.128	600	0.142	600	0.122	650	0.121
May	500	0.156	600	0.176	600	0.165	650	0.151	800	0.170
June	600	0.222	600	0.214	700	0.231	800	0.219	900	0.231
July	800	0.381	800	0.364	800	0.343	1000	0.351	1050	0.350
August	800	0.615	800	0.571	900	0.588	1050	0.568	1100	0.564
September	500	1.000	600	1.000	630	1.000	800	1.000	850	1.000
Total	7,000	-----	7,480	-----	8,230	-----	9,000	-----	9,500	-----

In years when Lake Powell EOWY elevation is projected to be lower than the Equalization Level and equal to or above 3,575 feet msl, and the projected Lake Mead EOWY elevation is equal to or above 1,075 feet msl, then the annual release volume is scheduled to be 8.23 maf. If the projected Lake Mead EOWY elevation is below 1,075 feet msl, however, then a volume of water is scheduled for annual release from Lake Powell to the extent necessary to balance storage in the two reservoirs, constrained by being no more than 9.00 maf and no less than 7.00 maf.

In years when Lake Powell EOWY elevation is projected to be lower than 3,575 feet msl and at or above 3,525 feet msl, and the projected Lake Mead EOWY elevation is equal to or above 1,025 feet msl, then the annual release volume is scheduled at 7.48 maf. However, if Lake Powell EOWY elevation is projected to be lower than 3,575 feet msl and at or above 3,525 feet msl, but the projected Lake Mead EOWY elevation is below 1,025 feet msl, then the annual release volume is scheduled at 8.23 maf.

In years when Lake Powell EOWY elevation is projected to be below 3,525 feet msl, then a volume of water is scheduled for annual release from Lake Powell to the extent necessary to balance storage in the two reservoirs, constrained by being no more than 9.50 maf and no less than 7.00 maf.

A.5.9.3 Conservation Before Shortage Alternative

Water year releases for Lake Powell with the Conservation Before Shortage Alternative are identical to those of the Basin States Alternative.

A.5.9.4 Water Supply Alternative

Under the Water Supply Alternative, when projected EOWY storage in the Upper Basin is less than the 602(a) storage requirement, a higher priority rule ensures that the Lake Powell operation will satisfy a water year release to the Lower Basin between 7.00 maf and 9.50 maf, depending on projected EOWY elevations in Lake Powell and Lake Mead. Similar to the weighting and release fraction scheme used for the operational rule, a preferred release pattern for each month to meet the water release is supplied and a fraction is computed. The fraction is computed as current month's release divided by the sum of the current and remaining months' releases through September. Each month the rule computes the volume of water remaining to meet the release for the current water year (accounting for the water released previously in the water year) and multiplies that volume by the release fraction. The release determined by the operational rule must then be at least as great as this resulting release for the month.

Specific release patterns (in kaf) and resulting fractions for the Water Supply Alternative are as follows:

Table A-11
Water Supply Alternative Lake Powell Release Patterns

Month	7,000 kaf		8,230 kaf		9,500 kaf	
	Release (kaf)	Fraction	Release (kaf)	Fraction	Release (kaf)	Fraction
October	400	0.057	600	0.073	600	0.063
November	480	0.073	600	0.079	600	0.067
December	700	0.114	700	0.100	800	0.096
January	620	0.114	800	0.126	850	0.113
February	600	0.125	700	0.127	650	0.098
March	500	0.119	600	0.124	650	0.108
April	500	0.135	600	0.142	650	0.121
May	500	0.156	600	0.165	800	0.170
June	600	0.222	700	0.231	900	0.231
July	800	0.381	800	0.343	1050	0.350
August	800	0.615	900	0.588	1100	0.564
September	500	1.000	630	1.000	850	1.000
Total	7,000	-----	8,230	-----	9,500	-----

In years when the Lake Powell EOWY volume is projected to be below the 602(a) storage requirement and equal to or above 3,575 feet msl, and the projected Lake Mead EOWY elevation is equal to or above 1,075 feet msl, then the annual release volume is scheduled to be 8.23 maf. If the projected Lake Mead EOWY elevation is below 1,075 feet msl, however, then a volume of water is scheduled for annual release from Lake Powell to the extent necessary to balance storage in the two reservoirs, constrained by being no more than 9.50 maf and no less than 7.00 maf.

In years when the Lake Powell EOWY elevation is projected to be less than 3,575 feet msl, then a volume of water is scheduled for annual release from Lake Powell to the extent necessary to balance storage in the two reservoirs, constrained by being no more than 9.50 maf and no less than 7.00 maf.

A.5.9.5 Reservoir Storage Alternative

Under the Reservoir Storage Alternative, when projected EOWY storage in the Upper Basin is less than the 602(a) storage requirement, a higher priority rule ensures that the Lake Powell operation will satisfy a water year release to the Lower Basin between 7.80 maf and 9.50 maf, depending on projected EOWY elevations in Lake Powell and Lake Mead. Similar to the weighting and release fraction scheme used for the operational rule, a preferred release pattern for each month to meet the water year release is supplied and a fraction is computed. The fraction is computed as current month's release divided by the sum of the current and remaining months' releases through September. Each month the rule computes the volume of water remaining to meet the release for the current water year (accounting for the water released previously in the water year) and multiplies that volume by the release fraction. The release determined by the operational rule must then be at least as great as this resulting release for the month.

Specific release patterns (in kaf) and resulting fractions for the Reservoir Storage Alternative are as follows:

Table A-12
Reservoir Storage Alternative Lake Powell Release Patterns

Month	7,800 kaf		8,230 kaf		9,500 kaf	
	Release (kaf)	Fraction	Release (kaf)	Fraction	Release (kaf)	Fraction
October	600	0.077	600	0.073	600	0.063
November	600	0.083	600	0.079	600	0.067
December	600	0.091	700	0.100	800	0.096
January	800	0.133	800	0.126	850	0.113
February	600	0.115	700	0.127	650	0.098
March	600	0.130	600	0.124	650	0.108
April	600	0.150	600	0.142	650	0.121
May	600	0.176	600	0.165	800	0.170
June	600	0.214	700	0.231	900	0.231
July	800	0.364	800	0.343	1050	0.350
August	800	0.571	900	0.588	1100	0.564
September	600	1.000	630	1.000	850	1.000
Total	7,800	-----	8,230	-----	9,500	-----

In years when Lake Powell EOWY volume is projected to be below the 602(a) storage requirement, and Lake Powell EOWY elevation is equal to or above 3,595 feet msl, then the annual release volume is scheduled at 8.23 maf.

In years when the Lake Powell EOWY elevation is projected to be lower than 3,595 feet msl and equal to or above 3,560 feet msl, then the annual release volume is scheduled at 7.80 maf.

In years when Lake Powell EOWY elevation is projected to be below 3,560 feet msl, the annual release is scheduled at the volume of water required to balance the volumes of Lake Powell and Lake Mead, constrained by being no more than 9.50 maf and no less than 7.80 maf.

A.6 Lake Mead Operation

Lake Mead is operated primarily to meet downstream demand, including downstream depletions (both U.S. and Mexico) and reservoir regulation requirements. In any month, the rule computes the downstream depletions based on schedules that have been set as input data (or by other rules) and the amount of water necessary to meet the storage targets for Lake Mohave and Lake Havasu and to overcome evaporation losses at those lakes. The rule sets the total release necessary each month from Lake Mead to meet the total downstream demand, taking into account gains and losses below Lake Mead.

The depletions from Lake Mead and downstream of Hoover Dam are affected by the determination of the water supply conditions (Normal, Surplus or Shortage). Additional rules determine the water supply condition and set the appropriate depletion schedule for the entities affected, as described in Sections A.6.2 and A.6.3.

Under certain conditions, Lake Mead may release water in addition to downstream demand. This condition is termed “flood control” and is guided by the U.S. Army Corps of Engineers’ [USACE]) flood control regulations as contained in the USACE’s Water Control Manual for Flood Control, Hoover Dam and Lake Mead, Colorado River, Nevada and Arizona (Water Control Manual) dated December 1982. These flood control operations and their simulation in the CRSS model are described in Section A.6.1.

A.6.1 Lake Mead/Hoover Dam Flood Control

There are three flood control procedures currently in effect for different times of the year. These procedures were developed in the original CRSS and were based on the Field Working Agreement between Reclamation and the Corps (U.S. Army Corps of Engineers 1982). The first procedure is in effect throughout the year. Its objective is to maintain a minimum space of 1.5 maf in Lake Mead, primarily for extreme rain events. This space is referred to as the exclusive flood control space and is represented by the space above elevation 1,219.61 feet msl. The second procedure is used during the spring runoff forecast season (January–July). The objective during this period is to route the maximum forecast inflow through the reservoir system using specific rates of Hoover Dam discharge, assuming that the lake will fill (to elevation 1,219.61 feet msl) at the end of July. The third procedure is used during the space building or drawdown period (August–December). The objective during this period is to gradually draw down the reservoir system to meet the total system space requirements in each month in anticipation of the next year's runoff.

A.6.1.1 Exclusive Flood Control Space Requirement

As previously noted, this requirement states that space in Lake Mead must be a minimum of 1.5 maf at all times. If the release computed to meet downstream demand results in a Lake Mead storage that would violate this space requirement, the rule computes the additional release necessary to maintain that space.

A.6.1.2 Spring Runoff Season (January to July)

The flood control policy requires that the maximum forecast be used where that forecast is defined as the estimated inflow volume that, on average, will not be exceeded 19 times out of 20 (a 95 percent non-exceedance). The rule first computes the inflow forecast to Lake Mead by taking the Lake Powell forecast previously described and adds the long-term, average natural tributary inflows between Lake Powell and Lake Mead. The maximum forecast is then estimated by adding an additional volume (the "forecast error term") to that inflow forecast. The forecast error term (in maf) is given in Table A-13, taken from the original CRSS data:

Table A-13
Lake Mead Spring Runoff Forecast Error

Forecast Period	Forecast Error Term
January – July	4.980
February – July	4.260
March – July	3.600
April – July	2.970
May – July	2.525
June – July	2.130
July – July	0.750

The Field Working Agreement defines an iterative algorithm by which the current month's release (in cfs) is determined. Certain release levels are specified and are given in Table A-14:

Table A-14 Lake Mead Flood Control Release Levels		
Release Level	Release	Description
1	19,000	Parker Power Plant capacity
2	28,000	Davis Power Plant capacity
3	35,000	Hoover Power Plant capacity (in 1987)
4	40,000	Approximate maximum flow non-damaging to streambed
5	73,000	Hoover controlled discharge capacity

The flood control release needed for the current month is determined by:

> release needed for the current month = maximum forecast inflow – current storage space in Lake Powell (below 3,700 feet msl) – current storage space in Lake Mead (below 1,229 feet msl) + 1.5 maf (exclusive space) – evaporation and bank storage losses from Lake Powell and Lake Mead – Southern Nevada depletion – future volume of water released (assuming a release level from the table for the remaining months through July)

If the computed release for the current month is greater than that assumed for the future months, the future level is increased and the current month release is re-computed. The computation stops once the computed release for the current month is less than or equal to that assumed for the future months. If the computed release is greater than the previously assumed level, that release is used for the current month; otherwise, the previously assumed level is used.

The rule sets Lake Mead's release to the flood control release if it is greater than the release previously computed to meet downstream demands.

A.6.1.3 Space Building (August to December)

The flood control policy states the flood control storage space (in maf) in Lake Mead (storage below elevation 1,229 feet msl) required at the beginning of each month from August through January:

Table A-15 Lake Mead Flood Control Required Storage Space	
Date	Space Required (maf)
August	1.50
September	2.27
October	3.04
November	3.81
December	4.58
January	5.35

However, these targets may be reduced to the minimum of 1.5 maf in each month if additional space is available upstream in active storage. Certain upstream reservoirs are specified with a maximum creditable space (in maf) for each:

Table A-16
Lake Mead Flood Control Creditable Storage Space

Reservoir	Maximum Creditable Storage Space (maf)
Powell	3.8500
Navajo	1.0359
Blue Mesa	0.7485
Flaming Gorge plus Fontenelle	1.5072

In each month (July–December), if the release computed to meet downstream demands results in an end-of-month Lake Mead storage that would violate the space requirement adjusted for upstream storage, the rule computes the additional release necessary to maintain that space. However, these releases are constrained to be less than or equal to 28,000 cfs.

A.6.2 Lower Basin Surplus Strategies

Under the No Action Alternative the Interim Surplus Guidelines (ISG) are assumed to be in effect through calendar year 2016. Beginning in 2017, surpluses are determined based on the 70R Strategy. The action alternatives use some or all of the Surplus conditions and vary by the duration that each type is in effect. A summary comparison of the surplus strategy for each alternative is provided in Table A-22, located in Section A.10. Surplus schedules by entity are provided in Appendix D. The ISG are specified in the Record of Decision (ROD), Colorado River ISG, Final Environmental Impact Statement, January 2001, and the model implements those as follows:

A.6.2.1 Normal Conditions

If the modeled January 1 Lake Mead elevation is below 1,125 feet msl, the model assigns the Normal schedules to all diversion points in the Lower Basin. The Normal schedules total 7.5 maf of annual consumptive use in the Lower Basin.

A.6.2.2 Partial Domestic Surplus

If the modeled January 1 Lake Mead elevation is at or above 1,125 feet msl and below 1,145 feet msl, the model assigns the Partial Domestic Surplus schedules to MWD and the SNWA. All other diversion points remain at Normal schedules. The Partial Domestic Surplus schedules yield the amount of surplus for MWD and SNWA as specified in the ROD, and are documented in the Final Environmental Impact Statement, Implementation Agreement, Inadvertent Overrun and Payback Policy, and Other Federal Actions (SIA-EIS, Bureau of Reclamation 2002).

A.6.2.3 Full Domestic Surplus

If the modeled January 1 Lake Mead elevation is at or above 1,145 feet msl but below the spill avoidance strategy assuming the runoff value of the 70th percentile of exceedance based on the historic record of runoff above Lake Powell (i.e., the 70R Strategy), the model assigns the Full Domestic Surplus schedules to MWD and SNWA. All other diversion points remain at Normal schedules. The Full Domestic Surplus schedules yield the amount of surplus for MWD and SNWA as specified in the ROD, and are documented in the SIA-EIS (Bureau of Reclamation 2002).

A.6.2.4 Quantified Surplus (70R Strategy)

If the modeled January 1 Lake Mead storage provides insufficient space for the coming year (based on the 70R Strategy), and is below the flood control release criteria listed below, the Secretary would determine annually the quantity of surplus water available. The quantity is determined by assuming the 70th percentile historical runoff, along with normal 7.5 maf delivery to Lower Division states, for the next year. Applying these values to current reservoir storage, the projected reservoir storage at the end of the next year is calculated. The surplus is determined if the estimated space available at the end of the next year is less than the space needed by flood control criteria. The quantity of the surplus is the difference between the space required and the estimated available space. Once the quantity of surplus water is known, the model computes each state’s share (50 percent to California, 46 percent to Arizona, and 4 percent to Nevada). The model then assigns the Full Domestic Surplus schedules to MWD and SNWA. Arizona’s share of the surplus is assigned to the CAP, up to their Full Surplus schedule. If surplus water is still available for California, up to 300 kaf is made available to the Imperial Irrigation District (IID) and the Coachella Valley Water District (CVWD).

A.6.2.5 Flood Control Surplus

If the modeled January 1 system volumes projects Hoover Dam flood control releases based on the Field Working Agreement between Reclamation and the Corps (U.S. Army Corps of Engineers 1982), the model assigns the Full Surplus schedules to MWD, SNWA, CAP, IID, and CVWD. All other diversion points remain at Normal schedules. The Full Surplus schedules are documented in the SIA-EIS (Bureau of Reclamation 2002).

A.6.3 Lower Basin Shortage Strategies

A summary comparison of the shortage strategy for each alternative is provided in Table A-22, located in Section A.10.

A.6.3.1 No Action Alternative

In the absence of specific shortage guidelines, modeling assumptions were made that follow assumptions for previous environmental compliance documents. Based on these assumptions a “two-level” shortage protection strategy was employed. These levels established the elevations in Lake Mead to protect and the protection strategy (probabilistic or absolute). Within the two protection levels are two methods or stages for allocating the required shortage amount as explained below. See Section 4.2 for a description of the methodology regarding the shortage sharing assumptions under the two stages of shortage.

In Level 1 protection, the shortage determination is based on comparing the January 1 Lake Mead elevation to a user-input trigger elevation, where the trigger elevations are determined from other modeling studies to protect a significant elevation within a given degree of confidence. The trigger elevations are presented in Table A-17.

Table A-17
Level 1 Shortage Trigger Elevations

Year	Elevations (feet msl)	Year	Elevations (feet msl)	Year	Elevations (feet msl)
2008	1,079	2026	1,101	2043	1,127
2009	1,082	2027	1,103	2044	1,129
2010	1,083	2028	1,104	2045	1,132
2011	1,084	2029	1,106	2046	1,133
2012	1,085	2030	1,107	2047	1,135
2013	1,086	2031	1,108	2048	1,137
2014	1,086	2031	1,108	2049	1,138
2015	1,087	2032	1,109	2050	1,140
2016	1,088	2033	1,110	2051	1,142
2017	1,090	2034	1,112	2052	1,144
2018	1,091	2035	1,113	2053	1,145
2019	1,093	2036	1,114	2054	1,147
2020	1,094	2037	1,116	2055	1,149
2021	1,095	2038	1,117	2056	1,151
2022	1,096	2039	1,119	2057	1,152
2023	1,097	2040	1,120	2058	1,154
2024	1,098	2041	1,123	2059	1,156
2025	1,100	2042	1,125	2060	1,157

Under Level 1 protection, if Lake Mead's elevation at the beginning of the year is less than the trigger elevation, a Stage 1 shortage is declared and certain Lower Basin depletions are reduced. The shortage remains in effect for that calendar year. A Stage 1 shortage is defined as a shortage of magnitude less than that which would cause Arizona 4th priority uses to be reduced to zero.

Level 1 protection of elevation 1,050 feet msl (minimum water level for operation of Southern Nevada's upper diversion intake and minimum power pool) was used in this study. Trigger elevations were input to protect each elevation with an approximately 80 percent probability; however, actual model runs showed that the protection was less (approximately 70% over the entire simulation period). Under Level 1 protection a Stage 1 shortage is declared and the Central Arizona Project (CAP) depletion is set to 1.0 maf and other Arizona 4th priority uses are reduced proportionately, as described in the equations below.

$$CAP_{short} = CAP_{norm} - 1.0maf$$

$$OtherAZP4_{short} = (CAP_{short} * \frac{CAP_{norm} + OtherAZP4_{norm}}{CAP_{norm}}) - CAP_{short}$$

Where: the subscript norm denotes the normal depletion amount and the subscript short denotes the shortage amount. The shortage amount is subtracted from the normal depletion amount to solve for the shorted depletion amount.

The percent shortage applied to each Arizona 4th priority in OtherAZP4 is computed as a fraction of their normal use divided by the total other Arizona 4th priority use.

Other Lower Basin depletions are reduced according to the percents presented in Table A-18.

Table A-18
Modeling Assumptions for Distribution of Stage 1 Shortages[a]

Entity	Percentage of Total Lower Basin Shortage	Calculation
Arizona[b]	80%	▪ Computed assuming that Arizona takes the remaining amount of shortage after Nevada and Mexico take their respective shares ▪ Calculated as: 1.0 – 0.1667 – 0.0333 = 0.80 or 80.0%
California	0%	▪ Does not receive shortage under Stage 1
Nevada	3.33%	▪ Computed as a ratio of Nevada's apportionment to the total apportionments of the Lower Division states and Mexico ▪ Calculated as: 0.3 maf / 9.0 maf – 0.0333 or 3.33%
Mexico [1]	16.67%	▪ Computed as a ratio of Mexico's allotment to the total allotments of the Lower Division states and Mexico ▪ Calculated as: 1.5 maf / 9.0 maf = 0.1667 or 16.67%

a. These modeling assumptions do not reflect policy decisions and are not intended to constitute an interpretation or application of the 1944 Treaty. They have been developed for comparison of the alternatives.

b. Within the CAP, Ak-Chin and Salt River Pima-Maricopa Indian Community tribes have pre-1968 contracts for the delivery of 72 kaf that is not reduced until a Stage 2 Shortage is applied.

[1] The proposed federal action is for the purpose of adopting additional operational strategies to improve the Department's annual management and operation of key Colorado River reservoirs for an interim period through 2026. However, in order to assess the potential effects of the proposed federal action in this Draft EIS, certain modeling assumptions (discussed in Chapter 2) are used that display projected water deliveries to Mexico. Reclamation's modeling assumptions are not intended to constitute and interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico.

The United States will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Treaty with Mexico through the IBWC in consultation with the Department of State.

The percent shortage applied to each Arizona 4th priority in OtherAZP4 is computed as a fraction of their normal use divided by the total other Arizona 4th priority use. Both Mexico and the Southern Nevada Water Authority (SNWA) are reduced by 16.67 and 3.33 percent of the total Stage 1 shortage, respectively. The Metropolitan Water District of Southern California (MWD) does not take a Stage 1 shortage. The total Stage 1 shortage is computed as,

$$TotalStage1Short = \frac{CAP_{short} + OtherAZP4_{short}}{100\% - (3.33\% + 16.67\%)}$$

Under Level 2 protection, further cuts are imposed to keep Lake Mead above 1,000 feet msl (minimum water level for operation of Southern Nevada's lower diversion intake). In each month January through September, a rule estimates the end-of-April through end-of-September Lake Mead elevation (using Stage 1 shortage schedules and normal schedules for other users). April through September is generally the high demand period from Lake Mead. If in any month during the high demand period the estimated Lake Mead elevation is below 1,000 feet msl, Arizona 4th priority users are reduced to zero and SNWA and Mexico take their respective percents of the total shortage, for the current month. This type of pre-emptive shortage approach is required to avoid the situation when, in a given month, the shortage required to keep Lake Mead above 1,000 feet msl is greater than the available demand. If, in the current month the shortage required to protect 1,000 feet msl does not require Arizona 4th priority users to be reduced to zero, the lesser shortage amount is allocated.

If, in any month additional shortage beyond Stage 1 is required to protect Lake Mead elevation 1,000 feet msl, a Stage 2 shortage is declared. The Stage 2 shortage amount is the amount in excess of the Stage 1 shortage amount required to protect 1,000 feet msl absolutely. In a Stage 2 shortage Mexico and SNWA are further reduced and Arizona 2nd and 3rd priority uses and MWD are reduced. These entities are reduced according to the percents in Table A-19.

Table A-19
Modeling Assumptions for Distribution of Stage 2 Shortages[1]

Entity	Percentage of Total Lower Basin Shortage	Calculation
Arizona	15-20%	▪ The percentage changes as Arizona's 4th priority use schedule changes and ranges between 15 and 20% ▪ Computed as a ratio of Arizona's apportionment less the amount of shortage applied to Arizona under Stage 1, to the total apportionments of the Lower Division states and Mexico less the total amount shorted to users under Stage 1 ▪ Calculated as: (2.8 – AZ Stage 1 shortage) / (9.0 – total Stage 1 shortage)
California	60-65%	▪ California shortage sharing percentage changes as Arizona's 4th priority use schedule changes and ranges between 60 and 65% ▪ Computed assuming that California takes the remaining amount of the additional shortage ▪ Calculated as: 1.0 – 0.1667 – 0.0333 – Arizona's Stage 2 percentage expressed as a fraction

Table A-19
Modeling Assumptions for Distribution of Stage 2 Shortages[1]

Entity	Percentage of Total Lower Basin Shortage	Calculation
Nevada	3.33%	▪ Computed as a ratio of Nevada's apportionment less the amount of shortage applied to Nevada under Stage 1, to the total apportionments of the Lower Division states and Mexico less the amount shorted to users under Stage 1 ▪ Calculated as: (0.3 – NV Stage 1 shortage) / (9.0 – total Stage 1 shortage) = 0.0333 or 3.33%
Mexico	16.67%	▪ Computed as a ratio of Mexico's apportionment less the amount of shortage applied to Mexico under Stage 1, to the total apportionments of the Lower Division states and Mexico less the total amount shorted to users under Stage 1 ▪ Calculated as: (1.5 – Mexico Stage 1 shortage) / (9.0 – total Stage 1 shortage) = 0.1667 or 16.67%

1. These modeling assumptions do not reflect policy decisions and are not intended to constitute an interpretation or application of the 1944 Treaty. They have been developed for comparison of the alternatives.

The maximum amount of Stage 2 shortage that can be applied is dictated by MWD demand. If the amount of Stage 2 required is greater than MWD demand, than the Stage 2 shortage amount becomes,

$$TotalStage2Short_{Constrained} = \frac{MWD_{norm}}{100\% - (3.33\% + 16.67\% + AZP2and3Short\%)}$$

In the event that a Stage 2 shortage is constrained and not fully allocated, Lake Mead will drop below 1,000 feet msl. If Lake Mead goes below 1,000 feet msl, SNWA is reduced to zero (due to physical limitations) for the current month and the other users maintain their shortage amounts as if SNWA had not been completely reduced.

A.6.3.2 Basin States Alternative

The Basin States Alternative provides discrete stepped levels of shortage associated with specific Lake Mead elevations. These shortage amounts and the corresponding elevations are provided in the summary Table A-22, located in Section A.10. The maximum shortage is 600 kaf below elevation 1,025 feet msl. The shortage determination is based on comparing the January 1 Lake Mead elevation to the specific Lake Mead trigger elevations. If Lake Mead's elevation at the beginning of the year is less than the trigger elevation, a shortage of the corresponding amount is declared and certain Lower Basin depletions are reduced. The shortage remains in effect for that calendar year. The shortage is allocated according to the percents used under a Stage 1 shortage in the No Action Alternative provided in Table A-19. As in the No Alternative, SNWA is reduced to zero for the current month if, in the previous month the Lake Mead elevation is below 1,000 feet msl.

A.6.3.3 Conservation Before Shortage Alternative

The shortage strategy under the Conservation Before Shortage Alternative is identical to the Level 2 shortage protection in the No Action Alternative. The Level 1 shortage protection in the No Action Alternative is replaced with various levels of voluntary conservation in the Conservation Before Shortage Alternative. Modeling assumptions regarding the voluntary conservation portion of this alternative are located in Appendix M. The amounts of voluntary conservation and the corresponding elevations are identical to the shortage amounts and corresponding elevations under the Basin States Alternative.

A.6.3.4 Water Supply Alternative

There is no shortage strategy in place in the Water Supply Alternative. The only reduction in use occurs when, in the previous month the Lake Mead elevation is below 1,000 feet msl. In this event SNWA is reduced to zero for the current month.

A.6.3.5 Reservoir Storage Alternative

Like the Basin States Alternative, the Reservoir Storage Alternative provides discrete stepped levels of shortage associated with specific Lake Mead elevations. These shortage amounts and the corresponding elevations are provided in the summary Table A-22, located in Section A.10. The maximum shortage is 1,200 kaf below elevation 1,025 feet msl. Shortage determination and allocation occurs in the same way as the Basin States Alternative.

A.6.4 Lake Mead Storage & Delivery of Conserved System & Non-system Water

Detailed modeling assumptions regarding the Lake Mead storage and delivery mechanism for conserved system and non-system water as part of the Basin States, Conservation Before Shortage and Reservoir Storage alternatives is provided in Appendix M.

A.7 Summary of Lake Powell and Lake Mead Operation

A summary comparison of the Lake Powell and Lake Mead operations for each alternative is provided in Attachment 1-1 (Tables A-21 and A-22, respectively).

A.8 Lakes Mohave and Havasu Operation

Lake Mohave and Lake Havasu are operated to meet user-specified target storages at the end of each month. This operation remained consistent for all alternatives. The storage targets and the corresponding elevations are presented in Tables B-4 and B-5 of Appendix B.

A.9 Energy Generation

RiverWare™ includes a variety of methods that can be chosen to compute power generation. All methods used compute power and energy on a monthly basis. The following sections describe the methods used to compute power at Glen Canyon, Hoover, Davis and Parker Dams.

A.9.1 Glen Canyon Dam

The computation of power and energy generated at Glen Canyon Dam is based on the turbine release for the current month and a power coefficient which is a function of the turbine release and operating head. Turbine release is the lesser value of the maximum power release or the result of outflow minus spill. The power coefficient is computed through table interpolation given the operating head. The table used for interpolation is chosen based on the turbine release and can represent either flow through the turbine for most efficient power generation or the maximum flow through the turbine. The power coefficient may also be an intermediate value, computed through interpolation of both tables, if the turbine release is between the most efficient for power generation and the maximum flow through the turbine.

Once the power coefficient is computed, power generated for the current month is computed as,

$$Power = PowerCoefficient * TurbineRelease$$

Energy is calculated as the power multiplied by the length of the month in hours.

If the previous month's elevation is less than 3,490 feet msl, there is no power or energy generated for the current month. This elevation reflects the minimum power pool elevation at Lake Powell.

A.9.2 Hoover Dam

The method that computes power and energy generated at the Hoover Dam assumes two levels of power generation. The lower level of generation occurs at base flow while the upper level occurs at peak flow. The method computes the fraction of the month that the powerplant is operated at peak flow and base flow. The peaking flow is the most efficient flow through the turbines for the current operating head while the baseflow represents the minimum flow through the turbines to produce energy.

The base flow and corresponding power generation is based on the outflow for the current month. The peak flow must be computed through an iterative procedure using operating head, tailwater elevation and turbine release. The initial turbine release is assumed to be that corresponding to maximum power production. Tailwater elevation at Hoover Dam is computed as function of the elevation at Lake Mohave and Hoover Dam release.

The monthly release volume at base flow is computed by applying the base flow over the month. The monthly release volume at peak flow is computed as,

$$PeakFlowVolume = TurbineReleaseVolume - BaseFlowVolume$$

Next, the number of hours required for operation at base and peak flows are then computed as,

$$PeakHours = \frac{PeakFlowVolume}{(PeakFlow - BaseFlow) * 3600}$$

$$BaseHours = \frac{SecondsInMonth}{3600} - PeakHours$$

where, 3600 is the amount of seconds per hour. If peak hours is greater than the length of the month, peak hours is set equal to the length of the month and base hours is set to zero. The peak and base hours are then multiplied by the powerplant capacity at each level and added together to obtain the total energy produced for the month. Power is computed as the energy divided by the length of the month in hours.

The algorithm described here allows generation at elevations below 1,050 feet msl, the minimum power pool at Lake Mead. According to the algorithm, power is generated as long as the minimum operating head of 360 feet is available, corresponding to an elevation of about 1,011 feet msl. Because there is no operating experience at these levels, it is impossible to verify if CRSS mimics reality at such low heads. It is therefore critical then to view energy results from CRSS in a relative manner and not a strict numeric sense.

A.9.3 Davis Dam

The method that computes power and energy generation at Davis Dam is the same method used for Hoover Dam.

A.9.4 Parker Dam

The method that computes power and energy generation at Parker Dam is the same method used for Hoover Dam.

A.10 Model Input and Simulation

CRSS is used to simulate the future conditions of the Colorado River system on a monthly time step. Output data include reservoir storage, releases from dams, hydroelectric generation, etc. Input data for the model includes monthly natural flow at 29 nodes throughout the Colorado River system. Input data also includes physical parameters (such as individual reservoir storage capacity, evaporation rates, reservoir release capabilities, etc.), initial reservoir conditions, and the diversion and depletion schedules for entities in the Basin States and Mexico. Operating rules for current or proposed operating policies are considered input.

Although several methods are available for ascertaining the range of possible future inflows, Reclamation utilized the existing historical record of natural flows to create several distinct and synthetic hydrologic sequences that are then used in a series of simulations. For this process, Reclamation used a particular technique for sampling from the historical record known as the Indexed Sequential Method, or ISM (USBR, 1985; Ouarda, et al., 1997). Each future hydrologic sequence is generated from the historical natural flow record by “cycling” through the record. This method produces the “n” possible flow sequences, where n corresponds to the number of years in the flow data set. Using the historical natural flow data from 1906 through 2004 results with ISM results in a set of 99 separate simulations referred to as “traces.” This enables an evaluation of proposed criteria over a broad range of possible future hydrologic conditions. Evaluations typically include all 99 traces using statistical techniques.

A.11 Model Uncertainty

Using ISM, CRSS generates a wide range of hydrologic possibilities which include periods of extreme drought and periods of much above average flow, allowing evaluation of proposed federal actions under a wide range of future flow. It is possible; however, that future flows may include periods of wet or dry conditions that are outside of all the possible sequences seen in the historical record. See Appendix N for an evaluation of alternative hydrologic possibilities.

Model output is also sensitive to input diversion and depletion schedules. The best available data for future diversions and depletions are input to CRSS. Actual future depletion schedules, especially when simulating system conditions far into the future (beyond about 20 years from the present) may differ.

A.12 References

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Attachment 1

Summary Comparison of Lake Powell and Lake Mead Operations Under No Action and Action Alternatives

Table A-20

Comparison of Alternatives – Lake Powell

Lake Powell Elevation (feet msl)	No Action Alternative	Basin States Alternative	Conservation Before Shortage Alternative	Water Supply Alternative	Reservoir Storage Alternative	Lake Powell Storage (maf)
3,700	Equalize or Release 8.23 maf	Equalize or Release 8.23 maf	Equalize or Release 8.23 maf	Equalize or Release 8.23 maf	Equalize or Release 8.23 maf	**24.3**
Equalization	**602(a)**	**Upper Equalization Line**	**Upper Equalization Line**	**602(a)**	**602(a)**	**Equalization**
	Release 8.23 maf	Release 8.23 maf; if Lake Mead < 1,075 feet msl, balance contents with a min/max release of 7.0 and 9.0 maf	Release 8.23 maf; if Lake Mead < 1,075 feet msl, balance contents with a min/max release of 7.0 and 9.0 maf	Release 8.23 maf; if Lake Mead < 1,075 feet msl, balance contents with a min/max release of 7.0 and 9.5 maf	Release 8.23 maf	
3,595					Release 7.8 maf	**11.3**
3,575		Release 7.48 maf; if Lake Mead < 1,025 feet msl, release 8.23 maf	Release 7.48 maf; if Lake Mead < 1,025 feet msl, release 8.23 maf	Balance contents with a min/max release of 7.0 and 9.5 maf		**9.5**
3,560					Balance contents with a min/max release of 7.8 and 9.5 maf	**8.3**
3,525		Balance contents with a min/max release of 7.0 and 9.5 maf	Balance contents with a min/max release of 7.0 and 9.5 maf			**5.9**
3,490						**4.0**
3,370						**0**

1

Table A-21

Comparison of Alternatives – Lake Mead

Lake Mead Elevation (feet msl)	No Action Alternative	Basin States Alternative	Conservation Before Shortage Alternative	Water Supply Alternative	Reservoir Storage Alternative	Lake Mead Storage (maf)
1,220	Flood Control Surplus	Flood Control Surplus	Flood Control Surplus	Flood Control Surplus	Flood Control Surplus	25.9
1,200	Full Domestic Surplus (through 2016)	Full Domestic Surplus	Full Domestic Surplus	Full Domestic Surplus	Normal Operations	22.9
1,145	Partial Domestic Surplus (through 2016)	Normal Operations	Normal Operations	Partial Domestic Surplus		15.9
1,125	Normal Operations			Normal Operations		13.9
1,100					Shortage 600 kaf	11.5
1,075	Shortage 80 Percent Protection of elevation 1,050 feet msl	Shortage 400 kaf	Voluntary Conservation		Shortage 800 kaf	9.4
1,050		Shortage 500 kaf			Shortage 1,000 kaf	7.5
1,025		Shortage 600 kaf and Reconsultation			Shortage 1,200 kaf	5.8
1,000	Shortage Absolute Protection of elevation 1,000 feet msl		Shortage Absolute Protection of elevation 1,000 feet msl			4.3
895						0

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Appendix B

Colorado River System Facilities and Current River System Operations, From Lake Powell to SIB

This appendix describes the dams, reservoirs and river reaches on the mainstream of the Colorado River from Lake Powell to the SIB with Mexico. This appendix also describes the historical and current operation of those facilities.

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B.1 Natural Runoff and Storage of Water

The Colorado River serves as a source of water for irrigation, domestic and other uses in the States of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming and in Mexico. The Colorado River also serves as a source of water for a variety of recreational and environmental benefits. The Colorado River Basin is located in the southwestern United States and occupies a total area of approximately 250,000 square miles. The Colorado River is approximately 1,400 miles in length and originates along the Continental Divide in Rocky Mountain National Park in Colorado. Elevations in the Colorado River Basin range from sea level to over 14,000 feet msl in the mountainous headwaters.

Climate varies significantly throughout the Colorado River Basin. Most of the Colorado River Basin is comprised of desert or semi-arid rangelands, which generally receive less than 10 inches of precipitation per year. In contrast, many of the mountainous areas that rim the northern portion of the Colorado River Basin receive, on average, over 40 inches of precipitation per year. Most of the total annual flow in the Colorado River Basin results from natural runoff from mountain snowmelt. Because of this, natural flow is very high in the late spring and early summer, diminishing rapidly by mid-summer. While flows in late summer through autumn sometimes increase following rain events, natural flow in the late summer through winter is generally low.

Due to variability in climatic conditions, the natural flow in the Colorado River system is highly variable from year to year. In any case, the natural flow of the river represents an estimate of runoff flows that would exist in a natural setting, without storage, alteration or depletion by man. About 86 percent of the Colorado River System annual runoff originates in only 15 percent of the watershed—in the mountains of Colorado, Utah, Wyoming and New Mexico. While the average annual natural flow at Lees Ferry is calculated at approximately 15.1 maf, annual flows in excess of 23 maf and as little as 5 maf have occurred.

The flow in the Colorado River above Lake Powell reaches its annual maximum during the April through July period. During the summer and fall, thunderstorms occasionally produce additional peaks in the river. However, these flows are usually smaller in volume than the snowmelt peaks and of much shorter duration.

Flows immediately below Glen Canyon Dam consist almost entirely of water released from Lake Powell. Downstream of Glen Canyon Dam, the annual river gains from tributaries, groundwater discharge and occasional flash floods from side canyons average 900,000 af.

Immediately downstream of Hoover Dam, the river flows consist almost entirely of water released from Lake Mead. Downstream of Hoover Dam, the river gains additional water from tributaries such as the Bill Williams River and the Gila River, groundwater discharge, and return flows.

Total storage capacity in the Colorado River system is nearly four times the river's average natural flow or about 60 maf. However, the two largest reservoirs in the system, Lake Powell and Lake Mead account for approximately 50 maf of this storage capacity. The various reservoirs that provide storage, their respective capacities and modes of operation, along with the respective river reaches have been identified for discussion within the Colorado River system.

Annually, approximately 9 maf are released from Lake Mead to meet the delivery orders of water entitlement holders in the U.S. and for 1944 Treaty water deliveries to Mexico. Of this amount, some 7.5 maf are entitlements for the Lower Division states (Nevada, Arizona, and California), while the remaining 1.5 maf is delivered to Mexico.

Figure B-1 presents an overview of the historical natural flow calculated at Lees Ferry for calendar years 1906 through 2004. The natural flow represents an estimate of the flows that would originate or exist above Lees Ferry without storage, alteration or depletion by man. This is different than the recorded or historical stream flows that represent actual measured flows. Figure B-2 presents an overview of the historical flows recorded at Lees Ferry for the period 1922 through 2005 (calendar year).

Figure B-1
Natural Flow of the Colorado River at Lees Ferry, AZ
Calendar Year 1906-2004

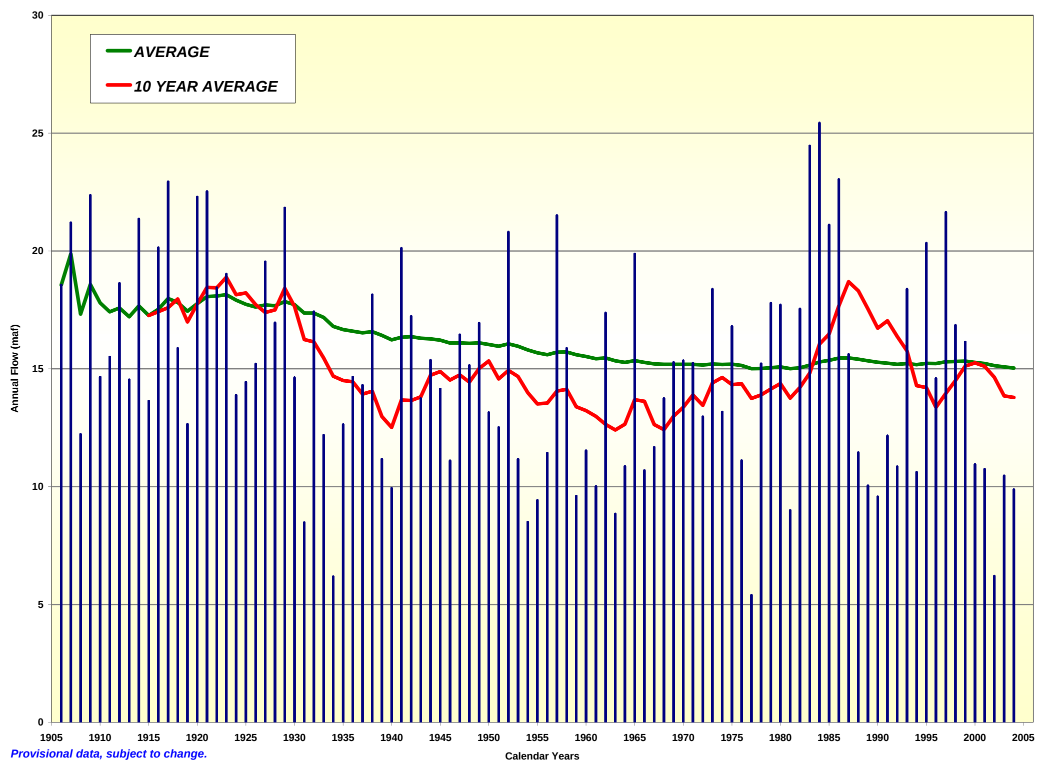
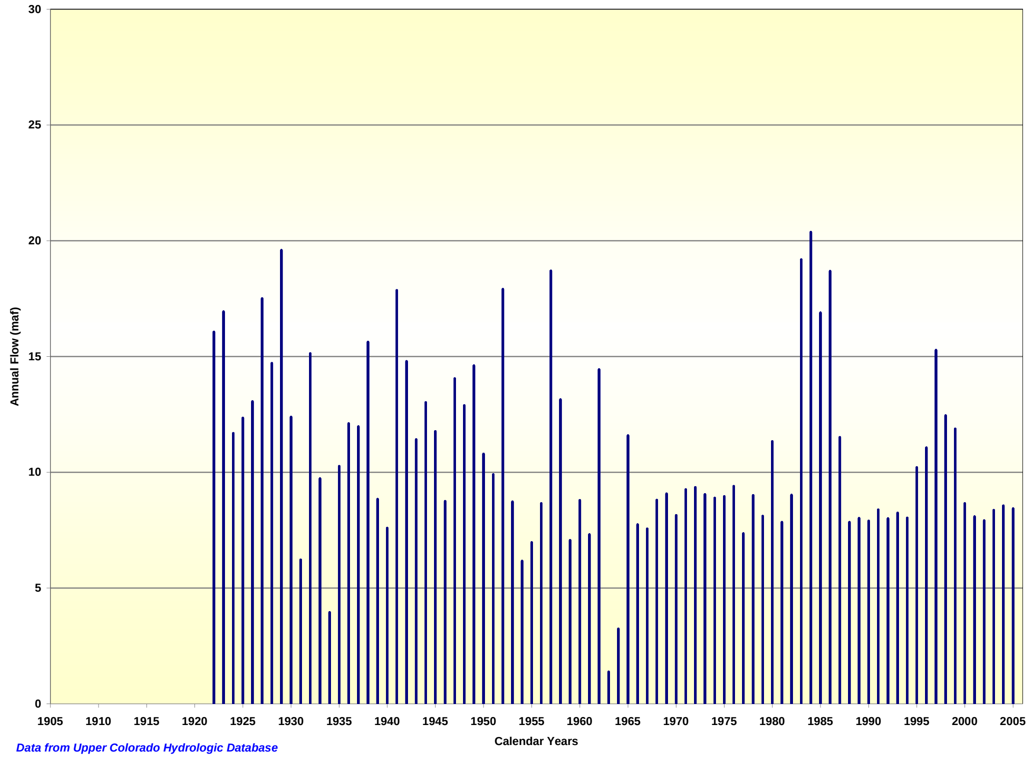


Figure B-2
Historic Annual Flow of the Colorado River at Lees Ferry, AZ Stream Gage
Calendar Year 1922-2005



B.2 Operation of the Colorado River System

The Secretary of the United States Department of the Interior (Secretary), acting through the United States Bureau of Reclamation (Reclamation), is vested with the responsibility of managing the mainstream waters of the lower Colorado River pursuant to applicable federal law. This responsibility is carried out consistent with a collection of documents known as the *Law of the River*, which includes a combination of federal and state statutes, interstate compacts, court decisions and decrees, an international treaty, contracts with the Secretary, operating criteria, regulations and administrative decisions.

Operation of the Colorado River system and delivery of Colorado River water to the seven Basin States and Mexico are conducted in accordance with the *Law of the River*. Water cannot be released from storage unless there is a reasonable beneficial use for the water. The exceptions to this are releases required for flood control, river regulation or dam safety. In the Lower Basin, water is released from the system to satisfy water delivery orders and to satisfy other purposes set forth in the Decree. The principal facilities that were built to manage the water in the Colorado River System include Glen Canyon Dam and Hoover Dam.

The Colorado River system is operated by Reclamation pursuant to LROC and the AOP. The AOP is required by the CRBPA. The AOP is formulated for the upcoming year under a variety of potential scenarios or conditions. The plan is developed based on projected demands, existing storage conditions and probable inflows. The AOP is prepared by Reclamation, acting on behalf of the Secretary, in consultation with the Basin States, the Upper Colorado River Commission, Indian tribes, appropriate federal agencies, representatives of the academic and scientific communities, environmental organizations, the recreation industry, water delivery contractors, contractors for the purpose of federal power, others interested in Colorado River operations, and the general public.

Prior to the beginning of the calendar year, Lower Basin diversion schedules are requested from water users entitled to Colorado River water. These schedules are estimated monthly diversions and return flows that allow Reclamation to determine a tentative schedule of monthly releases through the Hoover Powerplant. Actual monthly releases are determined by the demand for water downstream of Hoover, Davis and Parker Dams. Daily changes in water orders are made to accommodate emergencies, temperature and weather for downstream water orders below Parker Dam.

A minimum of 1.5 maf is delivered annually to Mexico in accordance with the 1944 Treaty. The 1944 Treaty contains provisions for delivery of up to 200,000 af above the 1.5 maf when there exists water in excess of that necessary to satisfy the uses in the United States and the guaranteed quantity of 1.5 maf to Mexico. Additionally, excess flows above the 200,000 af may become available to Mexico coincident with Lake Mead flood control releases and Gila River flood flows provided that the reasonable beneficial uses of the Lower Division states have been satisfied.

The Colorado River from Hoover Dam to the SIB is contained within the shallow Colorado River Valley in which Lake Mohave, Lake Havasu and other smaller diversion reservoirs are located. Within this segment, especially along river reaches below Parker Dam, the Colorado River is fringed with riparian vegetation and marshy backwaters, and contains a number of diversion dams and a system of levees. The northern reach of this segment, including Lake Mohave, lies within the LMNRA. The lower reach is bordered by a combination of federal, Tribal and private land. The last 23.7 miles is along the international border with Mexico. Reclamation retains authority and discretion for river operations in the reaches of this segment.

Under the BCPA and the Decree, releases from Hoover Dam are governed by orders for downstream water deliveries to Arizona, California, Nevada and Mexico. However, releases may exceed orders when flood releases are required under the USACE' flood control criteria, or for other purposes consistent with the BCPA and the Decree.

B.2.1 Lake Powell and Glen Canyon Dam

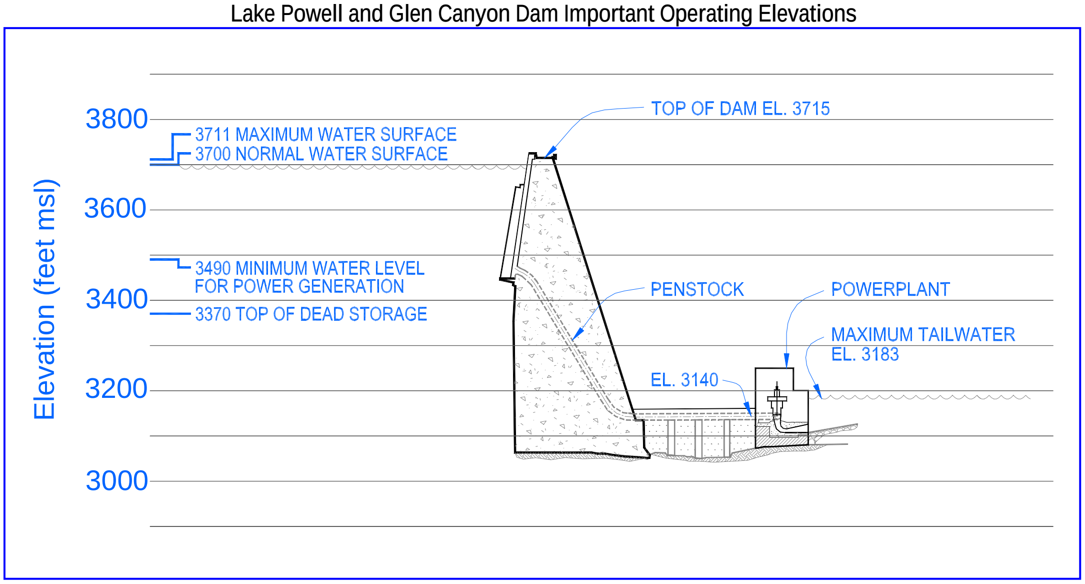
Lake Powell is a large reservoir on the Colorado River formed by Glen Canyon Dam. The reservoir is narrow and long (over 100 miles). Lake Powell provides water storage for use in meeting delivery requirements of the Upper Basin to the Lower Basin.

The normal operating range of Lake Powell is between elevations 3490 and 3700 feet msl. Elevation 3490 feet msl corresponds to minimum power pool. (Releases from Glen Canyon Dam can be made below 3490 feet msl down to elevation 3370 feet msl via the river bypass tubes.) Elevation 3700 feet msl corresponds to the top of the spillway radial gates. During floods, the elevation of Lake Powell can go above 3700 feet msl by raising the radial spillway gates, resulting in spillway releases. In 1983, Lake Powell reached a high elevation of 3708.34 feet msl Lake Powell is located within the GCNRA, which is administered by the NPS. Reclamation retains authority and discretion for the operation of Glen Canyon Dam and Lake Powell.

B.2.1.1 Dam and Reservoir Configuration

Glen Canyon Dam is a concrete arch dam rising approximately 700 feet above the level of the Colorado River streambed. A profile of the dam is depicted on Figure B-3. Except during flood conditions, the "full reservoir" water level is 3700 feet msl, corresponding to the top of the spillway gates. Under normal operating conditions, releases from Glen Canyon Dam are made through the Glen Canyon Powerplant by means of gates on the upstream face of the dam. The minimum water level at which hydropower can be generated is elevation 3490 feet msl. Releases in excess of the powerplant capacity may be made when flood conditions are caused by high runoff in the Colorado River Basin, or when needed to provide Beach/Habitat Building Flows (BHBF) downstream of the dam.

Figure B-3
Lake Powell and Glen Canyon Dam Important Operating Elevations



There are four river outlets at Glen Canyon Dam (96" diameter steel pipes with hollow-jet values for regulation), each with a capacity of 3,750 cfs. The release rate is controlled by the hollow-jet valves from elevation 3,500 feet to 3,700 feet. At elevation 3,700 feet a hollow-jet valve opening of 79 percent produces the 3,750 cfs. At elevation 3,500 feet, the hollow-jet valve must be fully opened to achieve 3,750 cfs.

At elevations below 3,500 feet with the hollow-jet valve fully opened, the flow is reduced below 3,750 cfs as the head is lowered. At elevation 3,490 feet, for instance, one river outlet with the hollow-jet valve fully opened will release about 3,660 cfs. At elevation 3,460 feet, one river outlet will release about 3,380 cfs. An annual release of 8.23 maf a equates to a continuous release of 11,368 cfs. With all four river outlets in service, this release can be achieved down to about elevation 3,440 feet. At this elevation the release capacity from the four river outlets is approximately 11,440 cfs (2,860 cfs per unit).

B.2.1.2 Operation of Glen Canyon Dam

Flows below Glen Canyon Dam are influenced by storage and release decisions that are scheduled and implemented on an annual, monthly and hourly basis from Glen Canyon Dam.

The annual volume of water released from Glen Canyon Dam is made according to the provisions of the LROC that includes a minimum objective release of 8.23 maf, storage equalization between Lake Powell and Lake Mead under prescribed conditions and the avoidance of spills. Annual releases from Lake Powell greater than the minimum occur if Upper Basin storage is greater than the storage required by Section 602(a) of the CRBPA, and if the storage in Lake Powell is greater than the storage in Lake Mead. Annual release volumes greater than the minimum objective of 8.23 maf are also made to avoid anticipated spills.

Monthly operational decisions are generally intermediate targets needed to systematically achieve the annual operating requirements. The actual volume of water released from Lake Powell each month depends on the forecast inflow, storage targets and annual release requirements described above. Demand for energy is also considered and accommodated as long as the annual release and storage requirements are not affected.

The National Weather Service's Colorado Basin River Forecast Center (CBRFC) provides the monthly forecasts of expected inflow into Lake Powell and other Upper Basin reservoirs. The CBRFC uses a satellite-telemetered network of hundreds of data collection points within the Upper Colorado River Basin that gather data on snow water content, precipitation, temperature and streamflow. Telemetry data is input into regression and real-time conceptual computer models to derive an inflow forecast Reclamation future release volumes are based on these derived forecasts. Particular attention is paid to April through July forecast which historically has the most impact on the hydrology of the region. Due to the variability in climatic conditions, modeling and data errors, these forecasts are based, in part, on large uncertainties. The greatest period of uncertainty occurs in early winter and decreases as the snow accumulation period progresses into the snowmelt season, often forcing modifications to the monthly schedule of releases.

An objective in the operation of Glen Canyon Dam is to attempt to safely fill Lake Powell each summer. When carryover storage from the previous year in combination with forecast inflow allows, Lake Powell is targeted to reach a storage of about 23.8 maf in July (0.5 maf from full pool). In years when Lake Powell fills or nearly fills in the summer, releases in the late summer and early winter are generally made to draw the reservoir level down, so that there is at least 2.4 maf of vacant space in Lake Powell on January 1. Storage targets are always reached in a manner consistent with the LROC.

Glen Canyon Dam is also operated consistent with the 1996 ROD on the Operation of Glen Canyon Dam developed as directed under the Grand Canyon Protection Act of 1992. The ROD describes criteria and plans for dam operations and includes other measures to ensure Glen Canyon Dam is operated in a manner consistent with the Grand Canyon Protection Act of 1992. Among these are an Adaptive Management Program, beach/habitat-building flows (BHBFs), beach/habitat-maintenance flows, and further study of temperature control.

Scheduling of BHBF releases from Glen Canyon Dam are discussed in Section B.3.2.

Daily and hourly releases are made according to the parameters of the ROD for the Operation of Glen Canyon Dam Final Environmental Impact Statement and published in the Glen Canyon Dam Operating Criteria (62 C.F.R. pt. 9447, Mar. 3, 1997), as shown in Table B-1.

Table B-1
Glen Canyon Dam Release Restrictions

Parameter	Flow Rate (cfs)	Conditions
Maximum Flow[1]	25,000	
Minimum Flow	5,000	Nighttime
	8,000	7:00 a.m. to 7:00 p.m.
Ramp Rates		
Ascending	4,000	Per hour
Descending	1,500	Per hour
Daily Fluctuations[2]	5,000 to 8,000	

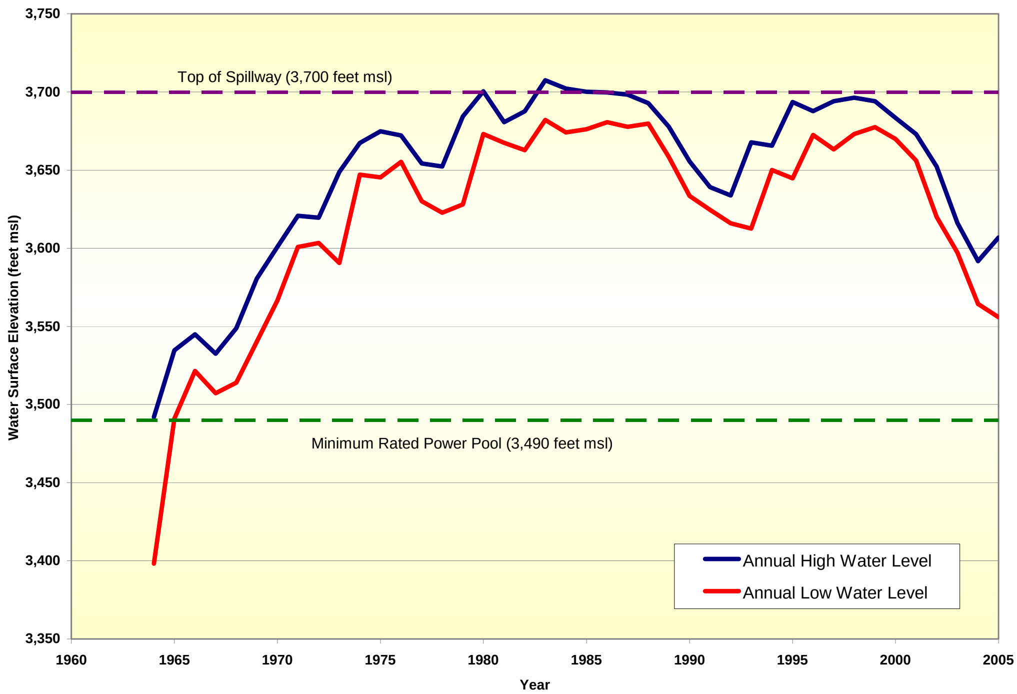
[1] To be evaluated and potentially increased as necessary and in years when delivery to the Lower Basin exceeds 8.23 maf.

[2] Daily fluctuation limit is 5,000 cfs for months with release volumes less than 0.6 maf; 6,000 cfs for monthly release volumes of 0.6 maf to 0.8 maf; and 8,000 cfs for monthly volumes over 0.8 maf.

B.2.1.3Historic Lake Powell Water Levels

Glen Canyon Dam and Lake Powell were designed to operate from a normal maximum elevation of 3700 feet msl to a minimum elevation of 3490 feet msl, the minimum for hydropower production. During flood conditions, the elevation of Lake Powell can exceed 3700 feet msl by raising and adding additional supported panels to the spillway radial gates. Since first reaching equalization storage with Lake Mead in 1974, the reservoir water level has fluctuated from a high of 3708 feet msl to a low of approximately 3555 feet msl, as shown on Figure B-4.

Figure B-4
Historic Lake Powell Water Levels
(Annual Highs and Lows)



B.2.2 Glen Canyon Dam to Lake Mead

The segment of the Colorado River between Glen Canyon Dam and Lake Mead is comprised of a narrow river corridor through the Grand Canyon that is administered primarily by the Grand Canyon National Park [1]. Flows within this reach of the river consist primarily of releases from Glen Canyon Dam as discussed in Section B.3.1.

[1] The 15.9 mile reach between Glen Canyon Dam and Lees Ferry is managed by the Glen Canyon National Recreation Area.

Issues that may need to be reconsidered within this segment of the river are those associated with a revised program of low steady summer flows and Beach/Habitat-Building Flow (BHBF) releases, as well as the temperature control studies that are ongoing.

B.2.2.1 River Flows between Glen Canyon Dam and Lake Mead

The river flows between Glen Canyon Dam and Lake Mead result from controlled releases from Glen Canyon Dam (Lake Powell) and include gains from tributaries in this reach of the river. Releases from Glen Canyon Dam are managed as previously discussed in Sections B.3.1. The most significant gains from perennial streams include inflow from the Little Colorado River (approximately 315 miles long) that provides the principal drainage way for the Painted Desert and the Paria River (approximately 75 miles long) that drains the rugged and arid region northwest of the Colorado River. However, inflow from these streams is concentrated over very short periods of time, and on average, make up approximately two percent of the total annual flow in this reach of the river.

B.2.2.2 Glen Canyon Dam Releases and the Adaptive Management Program

A function of the Glen Canyon Dam operations is to maximize power generation. However, this was having a negative impact on downstream resources. Realizing the impacts, the Secretary determined in July 1989 that an Environmental Impact Statement (EIS) should be prepared. The *Operation of Glen Canyon Dam EIS* developed and analyzed alternative operation scenarios that met statutory responsibilities for protecting downstream resources and achieving other authorized purposes, while protecting Native American interests. A final EIS was completed in March 1995, and the Secretary signed a ROD on October 8, 1996. Reclamation also consulted with the United States Fish and Wildlife Service (Service) under the ESA and incorporated the Service's recommendations into the ROD. As described in Section B.3.1 the operation of Glen Canyon Dam operates under the ROD.

The Adaptive Management Program (AMP) provides a process for assessing the effects of current operations of Glen Canyon Dam on downstream resources and using the results to develop recommendations for modifying operating criteria and other resource management actions. This is accomplished through the Adaptive Management Work Group (AMWG), a federal advisory committee. The AMWG consists of stakeholders that are federal and state resource management agencies, representatives of the seven Basin States, Indian Tribes, hydroelectric power marketers, environmental and conservation organizations and recreational and other interest groups. The duties of the AMWG are in an advisory capacity only. Coupled with this advisory role are long-term monitoring and research activities that provide a continual record of resource conditions and new information to evaluate the effectiveness of the operational modifications.

Beach/Habitat Building Flow and Beach/Habitat Maintenance Flow (BHBF) releases are scheduled high releases of short duration that are in excess of power plant capacity required for dam safety purposes and are made according to certain specific criteria. These BHBFs are designed to rebuild high elevation sandbars, deposit nutrients, restore backwater channels, and provide some of the dynamics of a natural system. The first test of a BHBF was conducted in the spring of 1996.

Beach/habitat-maintenance flow releases are releases at or near power plant capacity, which are intended to maintain favorable beach and habitat conditions for recreation and fish and wildlife, and to protect Tribal interests. Beach/habitat-maintenance flow releases can be made in years when no BHBF releases are made.

Both beach/habitat-building and beach/habitat-maintenance flows, along with the testing and evaluation of other types of releases under the AMP, were recommended by the Service to verify a program of flows that would improve habitat conditions for endangered fish. The proposed shortage guidelines and action alternatives could affect the range of storage conditions in Lake Powell and alter the flexibility to schedule and conduct such releases or to test other flow patterns.

In 1994, the Service issued a *Biological Opinion on the Operation of Glen Canyon Dam*. One of the elements of the reasonable and prudent alternative in the Biological Opinion, also a common element in the Glen Canyon Dam EIS, was the evaluation of methods to control release temperatures and, if viable, implement controls. Reclamation agreed with this recommendation and included it in the *Operation of Glen Canyon Dam Final Environmental Impact Statement* and subsequent ROD.

Reclamation has also recently initiated planning activities that will consider the possible modifications to Controls and Downstream Temperatures. The investigations associated with these planning activities are very preliminary and significant information is currently available to report on this planning process.

In addition, on September 1, 2006, Reclamation and the Center for Biological Diversity, Arizona Wildlife Federation, Living Rivers, Sierra Club – Grand Canyon Chapter and Glen Canyon Institute entered into a settlement agreement whereby Reclamation agreed to assess the impacts of current and modified operations of Glen Canyon Dam on the Humpback Chub, Bonytail Chub, Razorback Sucker and Colorado Pikeminnow. Reclamation plans to conduct further environmental studies related and anticipates that it will prepare a supplemental environmental impact statement by October 15, 2008.

B.2.3 Lake Mead and Hoover Dam

Lake Mead is a large reservoir on the Colorado River formed by Hoover Dam. The reservoir provides water storage for use in regulating the water supply and meeting delivery requirements in the Lower Basin. The normal operating range of the reservoir is between elevations 1219.61 and 1050 msl. Elevation 1050 msl corresponds to the minimum power pool (releases can be made from Hoover Dam below 1050 msl down to 895 feel msl via the intake towers). During floods, the elevation of Lake Mead can go above 1219.61 msl. The top of the raised spillway gates is at 1221.0 msl. Since its initial filling in the late 1930s, the reservoir water level has fluctuated from a high of 1225.85 feet msl (as occurred in July, 1983) to a low of 1083.21 feet msl (as occurred in April, 1956).

The reservoir is located within the LMNRA, which is administered by the NPS. However, Reclamation retains authority and discretion for the operation of Hoover Dam and Lake Mead.

The Las Vegas Wash is the primary channel through which the Las Vegas Valley's excess water returns to Lake Mead. The water flowing through the wash comprises less than 2 percent of the water in Lake Mead and consists of urban runoff, shallow groundwater, stormwater and releases from the valley's three water reclamation facilities.

The lower wash stretches 12 miles from the southeast part of the Las Vegas Valley to Lake Mead, entering the lake at Las Vegas Bay. Its once-plentiful wetlands helped polish urban flows on their way to Lake Mead. However, erosion in the wash has reduced wetlands acreage from a peak of approximately 2,000 acres to about 200 acres.

B.2.3.1 Dam and Reservoir Configuration

Hoover Dam and Lake Mead are operated with the following three main priorities:

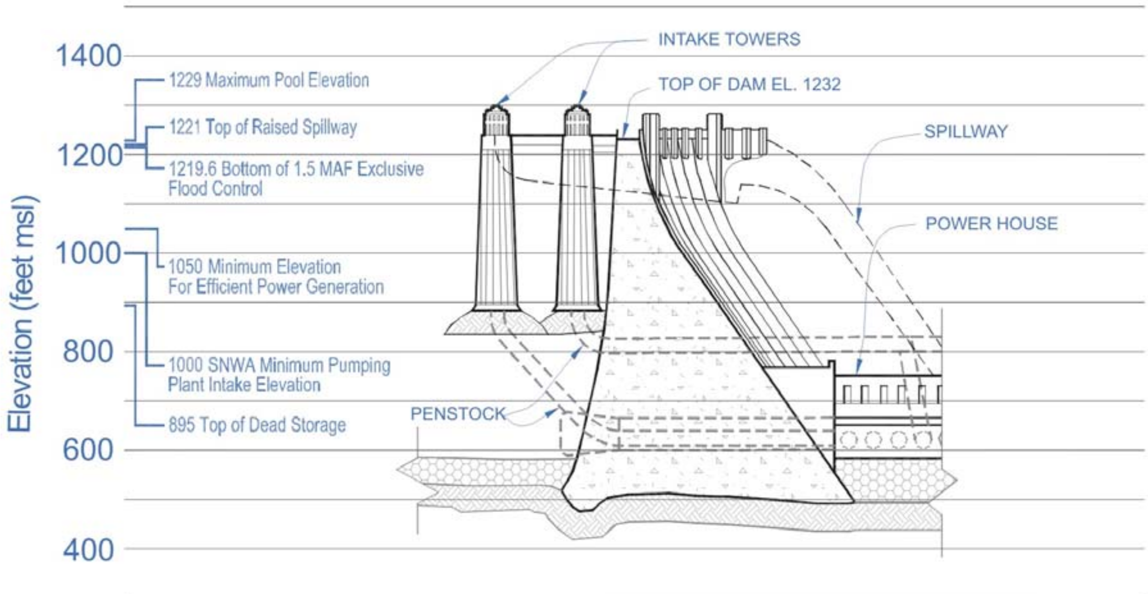
1) river regulation, improvement of navigation, and flood control,
2) irrigation and domestic uses, including the satisfaction of present perfected water rights, and
3) power.

The Boulder Canyon Project Act of 1928 specified flood control as the project purpose having first priority for operation of Hoover Dam and Lake Mead.

Hoover Dam is the northernmost Reclamation facility on the Lower Colorado River and is located approximately 345 miles upstream of SIB (342.2 river miles) downstream of Lee Ferry (687.2 river miles). Hoover Dam provides flood control protection and Lake Mead provides the majority of the storage capacity for the Lower Basin as well as significant recreation opportunities. Lake Mead storage capacity is currently estimated to 27.38 maf at a maximum elevation of 1229.0 feet msl. At this elevation, Lake Mead’s water surface area would equal 163,000 acres. The dam’s four intake towers draw water from the reservoir at elevations above 895 feet to drive 17 generators within the dam’s powerplant. The minimum elevation for effective power generation is 1050 feet msl.

Flood control regulations for Lake Mead were established to manage potential flood events arising from rain and snowmelt. Lake Mead’s uppermost 1.5 maf of storage capacity, between elevations 1219.61 and 1229.0 feet, is defined as exclusive flood control. Within this capacity allocation, 1.218 maf of flood storage is above elevation 1221.40 feet, the top of the raised spillway gates. Figure B-5 illustrates some of the important Hoover Dam and Lake Mead elevations that are referenced in subsequent sections.

Figure B-5
Lake Mead and Hoover Dam Important Operating Elevations



Lake Mead usually is at its maximum water level in November and December. If required, system storage space-building is achieved between the period of August 1 to January 1. Hoover Dam storage space-building releases are limited to 28,000 cfs, while the mean daily releases to meet the water delivery orders of Colorado River water entitlement holders and power users normally range between 8,000 cfs to 18,000 cfs.

In addition to controlled releases from Lake Mead to meet water supply and power requirements, water is also diverted from Lake Mead at the Southern Nevada Water Authority (SNWA) Saddle Island intake facilities, Boulder City's Hoover Dam intake, and the Basic Management, Inc.'s (BMI) intake facility for use in the Las Vegas area for domestic purposes by SNWA, BMI and other users.

The diversions by SNWA at its Saddle Island intake facilities entail pumping the water from the intake to SNWA's water transmission facilities for treatment and further conveyance to the greater Las Vegas area and Boulder City. SNWA has low intake facilities. The elevation of the original SNWA intake is approximately 1000 feet msl. However, the minimum required Lake Mead water level necessary to operate the pumping units at SNWA's original intake facility is 1050 feet msl. A second SNWA intake was constructed more recently and it has a second pumping plant with an intake elevation of 950 feet msl. The minimum required Lake Mead water level necessary to operate the pumping units at SNWA's second intake facility is 1000 feet msl. The second SNWA intake provides only a portion of the capacity required by SNWA to meet its Lake Mead water supply needs. Therefore, the intake elevation of SNWA's original pumping plant is critical to its ability to divert its full Colorado River water entitlement.

B.2.3.2 Operation of Hoover Dam

Hoover Dam is managed to provide at least 7.5 maf annually for consumptive use by the Lower Division states plus the United States' Colorado River water supply obligation to Mexico pursuant to the 1944 Treaty. Hoover Dam releases are managed on an hourly basis to maximize the value of generated power by providing peaking during high-demand periods. This results in fluctuating flows below Hoover Dam that can range from 1,000 cfs to 49,000 cfs. The upper value is the maximum flow-through capacity through the powerplant at Hoover Dam (49,000 cfs). However, because these flows enter Lake Mohave downstream, the affected zone of fluctuation is only a few miles.

Releases of water from Hoover Dam may also be affected by the Secretary's determinations relating to normal, surplus or shortage water supply conditions, as discussed in Section 4.4.4. Another type of release includes flood control releases. For Hoover Dam, flood control releases are defined in this Draft EIS as releases in excess of the downstream demands.

Flood control was specified as a primary project purpose by the BCPA, the act authorizing Hoover Dam. The U.S. Army Corps of Engineers (USACE) is responsible for developing the flood control operation plan for Hoover Dam and Lake Mead as indicated in 33 C.F.R. pt. 208.11. The plan is the result of a coordinated effort by the USACE and Reclamation. However, the USACE is responsible for providing the flood control regulations and has authority for final approval of the plan. Any deviations from the flood control operating instructions provided by the plan must be authorized by the USACE. The Secretary is responsible for operating Hoover Dam in accordance with these regulations.

Lake Mead's uppermost 1.5 maf of storage capacity, between elevations 1219.61 and 1229.0 feet msl, is defined as exclusive flood control space. Within this capacity allocation, 1.218 maf of flood storage is above elevation 1221.0 feet msl, which is the top of the raised spillway gates.

Flood control regulations specify that once Lake Mead flood releases exceed 40,000 cfs, the releases shall be maintained at the highest rate until the reservoir drops to elevation 1221.0 feet msl. Releases may then be gradually reduced to 40,000 cfs until the prescribed seasonal storage space is available.

The regulations set forth two primary criteria for flood control operations related to snowmelt: 1) preparatory reservoir space requirements, and 2) application of runoff forecasts to determine releases.

In preparation for each annual season of snow accumulation and associated runoff, progressive expansion of total Colorado River system reservoir space is required during the latter half of each year. Minimum available flood control space increases from 1.5 maf on August 1 to a system storage space of 5.35 maf on January 1. Required flood storage space can be accumulated within Lake Mead and in specified upstream reservoirs: Powell, Navajo, Blue Mesa, Flaming Gorge and Fontenelle. The minimum required to be reserved exclusively for flood control storage in Lake Mead is 1.5 maf. Table B-2 presents the amount of required flood storage space within the Colorado River system by date:

Table B-2
Minimum Required Colorado River System Storage Space

Date	Storage Volume (maf)
August 1	1.50
September 1	2.27
October 1	3.04
November 1	3.81
December 1	4.58
January 1	5.35

Normal space-building releases from Lake Mead to meet the required August 1 to January 1 flood control space are limited to a maximum of 28,000 cfs. Releases in any month based on water entitlement holders' demand are much less than 28,000 cfs (on the order of 20,000 cfs or less).

Between January 1 and July 31, flood control releases, based on forecast inflow, may be required to prevent filling of Lake Mead beyond its 1.5 maf minimum space requirement. Beginning on January 1 and continuing through July, the CBRFC issues monthly runoff forecasts. These forecasts are used by Reclamation in estimating releases from Hoover Dam. The release schedule contained in the USACE' regulations is based on increasing releases in six steps as shown on Table B-3.

Table B-3
Minimum Flood Control Releases at Hoover Dam

Step	Flow Rate (cfs)
Step 1	0
Step 2	19,000
Step 3	28,000
Step 4	35,000
Step 5	40,000
Step 6	73,000

The lowest step, zero cfs, corresponds to times when the regulations do not require flood control releases. Hoover Dam releases are then made to meet water and power objectives. The second step, 19,000 cfs, is based on the powerplant capacity of Parker Dam. The third step, 28,000 cfs, corresponds to the Davis Dam Powerplant capacity. In recent years both Parker and Davis power plant facilities have under gone a up rating program to improve the efficiency of individual power plant units. The current maximum releases are slightly higher for both Parker and Davis powerplant outputs and are as follows 22,000 cfs and 31,000 cfs respectively. The fourth step in the USACE release schedule is 35,000 cfs. This flow corresponds to the powerplant flow-through capacity of Hoover Dam in 1987. However, the present powerplant flow-through capacity at Hoover Dam is 49,000 cfs. At the time Hoover Dam was completed, 40,000 cfs was the approximate maximum flow from the dam considered to be non-damaging to the downstream streambed. The 40,000 cfs flow now forms the fifth step. Releases of 40,000 cfs and greater would result from low-probability hydrologic events. The sixth and final step in the series (73,000 cfs) is the maximum controlled release from Hoover Dam that can occur without spillway flow.

Flood control releases are required when forecast inflow exceeds downstream demands, available storage space at Lake Mead and Lake Powell and allowable space in other Upper Basin reservoirs. This includes accounting for projected bank storage and evaporation losses at both lakes, plus net withdrawal from Lake Mead by the SNWA. The USACE regulations set the procedures for releasing the volume that cannot be impounded, as discussed above.

Average monthly Hoover Dam releases are determined early in each month and apply only to the current month. The releases are progressively revised in response to updated runoff forecasts and changing reservoir storage levels during each subsequent month throughout the January 1–July 31 runoff period. If the reservoirs are full, drawdown is accomplished to vacate flood control space as required. Unless flood control is necessary, Hoover Dam is operated to meet downstream demands.

During non-flood operations, Lake Mead elevations fluctuate as releases increase and decrease due to downstream water uses, Glen Canyon Dam releases and 1944 Treaty deliveries to Mexico. Lake Mead’s elevations will fluctuate through out the year to both met the end-of-month target elevations for Lake Mohave and Lake Havasu and release for downstream requirements. Normally, Lake Mead elevations decline with increasing irrigation deliveries through June or later and then begin to rise again. Lake Mead’s storage capacity provides for the majority of Colorado River regulation from Glen Canyon Dam to the border with Mexico.

Each month our Water Operations Personnel send to Western Area Power Administration a monthly Hoover energy target that is based upon our most current daily operational data. In order to achieve downstream water orders below Hoover Dam a monthly energy target is set based on water demands below Parker and Davis Dams. The energy target for Hoover is broken down into weekly schedules but often it is the monthly target that drives the release at Hoover Dam. Because Hoover Dam is a peaking power plant, releases will often vary significantly to meet the energy demand. Monitoring of Hoover releases is checked each day for both hourly and daily values.

Hoover power plant turbines are fed by four penstocks which in turn are fed by four intake towers. The elevations that water may be feed into the penstocks are elevations 1045 feet msl and 895 feet msl for each intake tower. Eight cylinder gate valves are located at the eight respective intake locations (two for each penstock). The cylinder gate valves are 75 years old, being part of the original construction of Hoover Dam. Because of their age, each gate valve is operated as 1) completely open or 2) completely shut. This is necessary to avoid perturbations associated with partially opening the valves. Wicket gates --located upstream of each turbine--control real-time flow and peak power generation.

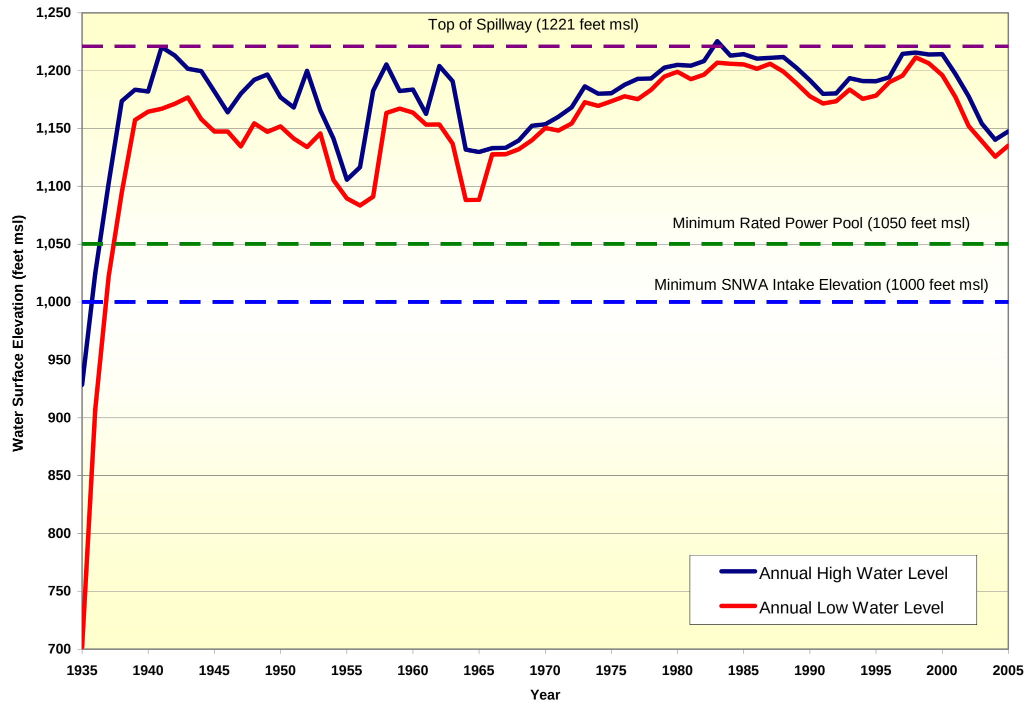
B.2.3.3 Historic Lake Mead Water Levels

Figure B-6 shows the historic annual water levels (annual maximum and minimum) of Lake Mead. As noted in Figure B-6, the annual change in elevations of Lake Mead has ranged from less than ten feet to as much as 75 feet msl. The decrease in the range of the elevations within a year observed after the mid-1960s can be attributed to the regulation provided by Lake Powell.

Historic Lake Mead low water levels have dropped down to an elevation of about 1083 feet msl during two periods (1954 to 1957 and 1965 to 1966). The maximum Lake Mead elevation of approximately 1225.6 feet msl occurred once, in 1983.

Three Lake Mead elevations of interest are shown in Figure B-5. The first elevation is 1221 feet msl, the top of the spillway gates. The second elevation is 1050 feet msl, the minimum elevation for the effective generation of power. The third elevation is 1000 feet msl, the minimum elevation required for the operation of SNWA’s lower intake.

Figure B-6
Historic Lake Mead Water Levels
(Annual Highs and Lows)



B.2.4 Hoover Dam to Davis Dam

This reach extends from Hoover Dam to Davis Dam and includes Lake Mohave up to its full-pool elevation. The approximately 67-mile length if this reach generally comprises of Lake Mohave. Lake Mohave is formed by Davis Dam and is bounded for most of its 67 mile length by the steep walls of Pyramid, El Dorado, and Black Canyons. The lake is relatively narrow, not more than four miles across at its widest point, but provides significant recreation opportunities and habitat for fish and wildlife. The lake also captures and delays flash flood discharge from the side washes below Hoover Dam. Typical flow time from Hoover Dam to Lake Mohave is four to six hours. The lake has a storage capacity of approximately 1.818 maf. Davis Dam and Davis Power Plant are located 67 miles downstream from Hoover Dam, and approximately two miles upstream from Laughlin, Nevada, and Bullhead City, Arizona.

B.2.4.1 River Flows between Hoover Dam and Davis Dam

The flows in the river reach between Hoover Dam and Davis Dam is comprised almost entirely from releases from Hoover Dam. The reservoir's primary purpose is to re-regulate Hoover Dam releases and aid in the delivery of water supplies to downstream United States entitlement holders and to Mexico. Located on the Arizona side of the river, the Davis Dam Powerplant has five generating units, with a generating capacity of 255,000 kW, and with a combined hydraulic capacity of 31,000 cfs. The power is marketed by Western.

Reclamation, as provided in the ISG ROD, will continue existing operations in Lake Mohave that benefit native fish through the effective period of the Interim Surplus Guidelines and will explore additional ways to provide benefits to native fish. The normal filling pattern of these two reservoirs coincides well with the fishery spawning period. Since lake elevations will be typical of previous years, normal conditions are expected for boating and other recreational uses.

Reclamation is the lead agency in the Native Fish Work Group, a multi-agency group of scientists attempting to augment the ageing stock of the endangered razorback sucker in Lake Mohave. Larval razorback suckers are captured by hand in and around spawning areas in late winter and early spring for rearing at Willow Beach Fish Hatchery below Hoover Dam. The following year, 1-year old razorback suckers are placed into predator-free, lake-side backwaters for rearing through the spring and summer. When the lake is normally drawn down during August through October, these fish are harvested from these rearing areas and then released to the lake. The razorback suckers grow very quickly, usually exceeding 10 inches in length by September. In 2004, 17,266 razorback suckers (300 mm minimum size) were repatriated into Lake Mohave from all sources. In 2005, 12,200 wild larvae were captured from natural spawning congregations on Lake Mohave and delivered to Willow Beach Hatchery.

Under normal water supply conditions, the flows in this river reach comprise of the water deliveries to Colorado River water users that divert water from this reach and others located downstream of Parker Dam.

Historical daily river flows since 1963 in this river reach have ranged between 590 cfs to 50,800 cfs. The higher flow rates have been associated with flood flows. Releases since 1963 from Davis Dam have ranged between 1,200 cfs to 44,106 cfs.

B.2.4.2 Historic Lake Mohave Water Levels

Hoover Dam flood control releases are passed through Davis Dam. Flood control requirements for Davis Dam were developed through the monthly target elevations developed for Lake Mohave. Flood control releases (from Hoover Dam), as well as side wash inflows, were considered in the development of the target elevations.

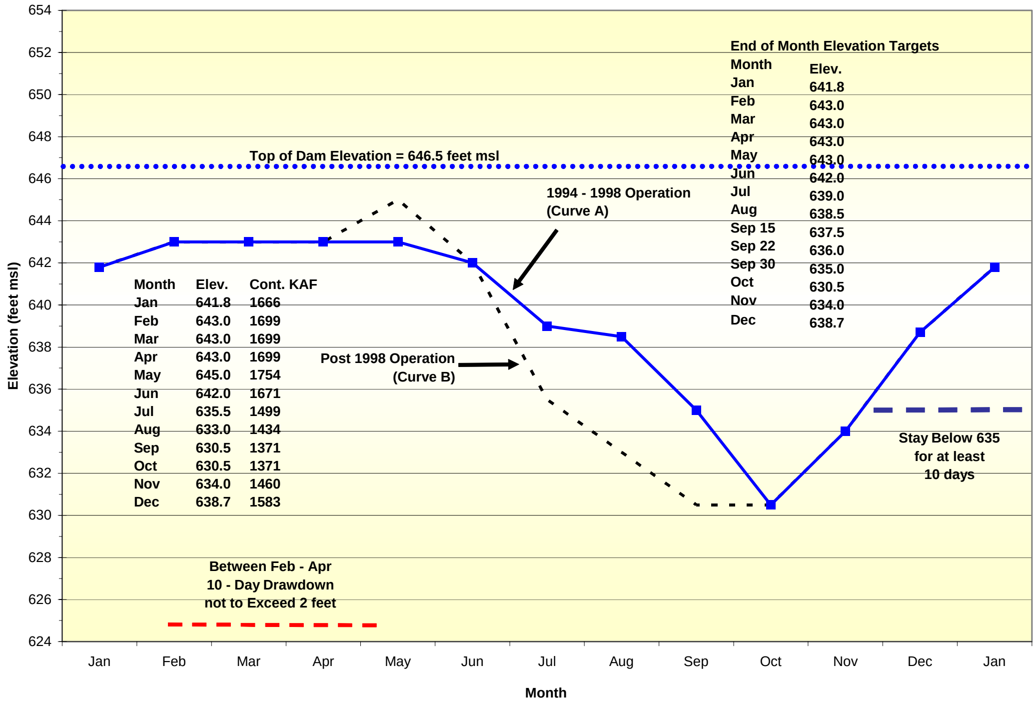
Reclamation has discretion to develop and manage Lake Mohave’s target elevations and allocated flood control reserved capacity that changes throughout the year by making releases through Davis Dam. This flood control reserved capacity is considered and taken into account in the Davis Dam release calculation. Specifically, the operators use a rule curve with “target water surface elevations” that coincide with respective vacant storage capacity. The target elevations that are used to assure that sufficient flood control storage capacity is allocated for Lake Mohave are shown in Table B-4 and Figure B-7 below.

Table B-4
Lake Mohave Monthly Target Elevation

Month	Mohave Target Elevation (feet msl)	Mohave Target Storage (kaf)
January	641.8	1,666
February	643.0	1,699
March	643.0	1,699
April	643.0	1,699
May	645.0	1,754
June	642.0	1,671
July	635.5	1,499
August	633.0	1,434
September	630.5	1,371
October	630.5	1,371
November	634.0	1,460
December	638.7	1,583

The razorback sucker backcove rearing program that began in 1994 can also limit the drawdown to no more than two feet in a ten-day period during the razorback sucker spawning season. Further, the program also requires that the Lake Mohave elevation be maintained above elevation 640 feet msl between the period between March 15 and June 15 to provide sufficient depth for the backcove rearing areas. These limitations require closer coordination of Lake Mohave with that of Lake Havasu as well as adjustment to the Hoover Dam hourly water release and energy production schedules. The operators take all these factors into account in the management of the Lake Mohave daily water surface levels.

Figure B-7
Lake Mohave Monthly Target Elevation



As shown on Figure B-7, Lake Mohave generally reaches its maximum elevation in the spring and its minimum elevation in the fall. Reclamation generally lowers the lake level in the fall to provide flood control storage space for runoff that results from large hurricane-type storms coming up river from Mexico. However, it needs to be noted that these are target elevations only. The actual elevations will sometimes differ from the target elevations with the regulation of Hoover releases and the balancing of arriving flows with downstream water demands.

As with releases from Hoover Dam, factors that must be considered when making the Davis Dam releases include the need to meet downstream water requirements throughout the month and the objective to maintain non-damaging flow levels downstream.

B.2.4.3 Operation of Davis Dam

The primary purpose of Davis Dam is to re-regulate Hoover Dam releases and aide in the delivery of water supplies to downstream United States entitlement holders and the annual delivery of 1.5 maf to Mexico. Other benefits provided by Davis Dam and Lake Mohave include flood control protection, navigation, recreation, and power production.

Water schedulers collect and compile water delivery orders from CAP, Metropolitan, and other Colorado River entitlement holders that divert water between Davis Dam and Parker Dam. The hourly release schedule for the Davis Dam is then integrated with the Parker Dam scheduled water releases and other objectives to coordinate the maximum release through the power facilities at the time of the peak usage of electricity; to the extent such release is compatible with the timing of the water deliveries and other constraints.

Since 1980, annual release from Davis Dam has varied from a low of 7.3 maf to a high of 21.7 maf (USBR 2000d). The maximum instantaneous release for Davis Dam is approximately 44,000 cfs and the minimum instantaneous release that can be expected under other than normal operating conditions is about 1,000 cfs. The minimum amount represents approximately one half of the release needed to turn one of the Davis Dam Power Plant's turbines. Such low flows are usually associated with downstream flooding, construction, search and rescue, or other emergency conditions.

The Davis Dam generating units are capable of providing moment-to-moment dynamic control. However, there is minimal use of this dynamic capability. If there are changes to hourly flows, the schedule change usually begins ten minutes to the hour and is fully implemented ten minutes after the hour. These flow changes are computer controlled and the changes to the unit releases are programmed well in advance.

The minimum elevation of Lake Mohave without resetting the intake stops is at about elevation 630 feet msl. The maximum elevation is 646.5 feet msl, where wave action begins to leak into the Dam's inspection gallery. The daily releases are coordinated such that the end of month target elevations are achieved.

B.2.5 Davis Dam to Parker Dam

This reach extends from Davis Dam to Parker Dam and includes Lake Havasu up to its full-pool elevation. Parker dam is located approximately 155 miles downstream from Hoover Dam and approximately 88 miles downstream from Davis Dam. The lower portion of this reach comprises Lake Havasu. Lake Havasu, formed by Parker Dam, is about 45 miles long and can store nearly 648,000 acre-feet (af) of water. At its maximum elevation of 450.5 feet msl, the lake has a surface area of approximately 20,390 acres.

Lake Havasu provides a forebay and desilting basin from which water is pumped into the Colorado River Aqueduct (California) by the Metropolitan Water District of Southern California and the Central Arizona Project (CAP) Aqueduct. The pumping plant that pumps water into the Colorado River Aqueduct is located on the west side of the river and is operated by The Metropolitan Water District of Southern California (Metropolitan). The pumping plant that pumps water into the CAP Aqueduct is located on the east side of the river and is operated by the CAWCD.

B.2.5.1 River Flows between Davis Dam and Parker Dam

The majority of the flows in this river reach are from releases from Hoover Dam and that get passed through Lake Mohave and Davis Dam. There are also some minor gains in this river reach that come from tributaries such as the Bill Williams River, groundwater discharge, and return flows from agriculture.

Under normal water supply conditions, the flows in this river reach comprise of the water deliveries to Colorado River water users that divert water from this reach and others located downstream of Parker Dam.

Historical river flows since 1963 in this river reach have ranged between1,200 cfs to 44,106 cfs. The higher flow rates have been associated with flood flows.

B.2.5.2 Operation of Parker Dam

Parker Dam’s primary purpose is to regulate the storage and releases from Lake Havasu. Parker Dam also has a power plant function and may provide a minimal amount of flood control, capturing and delaying flash floods into the river from tributaries below Davis Dam.

Releases at Parker Dam are scheduled on a daily basis to meet the short-term demands of Colorado River water users located downstream. The hourly release profile may be adjusted to meet electric service customer requirements.

The Parker Dam Power Plant is located on the California side of the Colorado River immediately below the dam. It houses four hydroelectric generating units. The installed generating capacity is 120,000 kW, but due to high tailrace elevation, the generation production is approximately 108,000 kW. Four 22-foot diameter penstocks carry up to 5,500 cfs each to feed the generating units. About 50 percent of the plant's power output is reserved in perpetuity by Metropolitan for pumping water along the Colorado River Aqueduct to the Southern California Coastal area. The remaining power is marketed by Western.

B.2.5.3 Historic Lake Havasu Water Levels

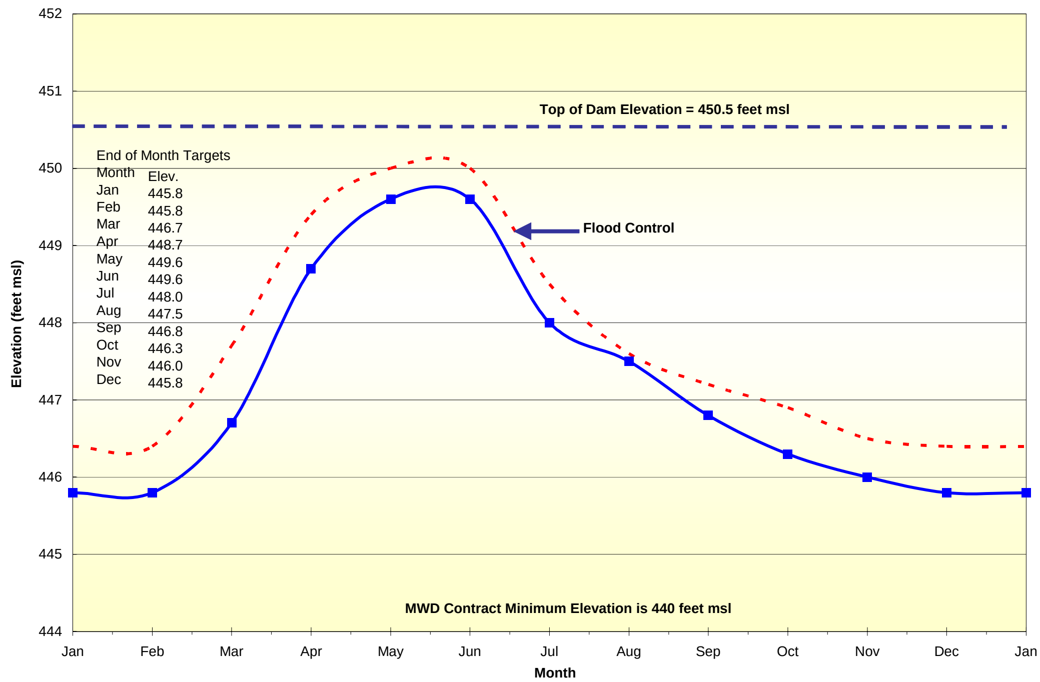
Hoover Dam flood control releases also are passed through Parker Dam after deliveries are made to the CAP and Metropolitan diversion facilities at Lake Havasu, and other users upstream of Parker Dam. Flood control requirements for Parker Dam were developed through the monthly target elevations developed for Lake Havasu. System flood control releases from Hoover Dam, as well as side wash inflows and flood flows on the Bill Williams River, were considered in those target elevations. Reclamation has discretion to develop and manage the target elevations of Lake Havasu by making releases through Parker Dam. Lakes Havasu is operated to meet a user-specified target storage at the end of each month. These storage targets are given in the following Table B-5.

Table B-5
Lake Havasu Monthly Target Elevations

Month	Havasu Target Elevations (feet msl)	Havasu Target Storage (kaf)
January	445.8	539.1
February	445.8	539.1
March	446.7	557.4
April	448.7	593.6
May	449.6	611.4
June	449.6	611.4
July	448.0	580.0
August	447.5	561.1
September	446.8	557.4
October	446.3	548.2
November	446.0	542.7
December	445.8	539.1

Lake Havasu generally reaches its maximum elevation in the spring and its minimum elevation in the winter. Reclamation generally lowers the lake level during the winter months to provide flood control storage space for runoff that results from large storms coming up river from Baja California, Mexico. The actual elevations will sometimes differ from the target elevations (Figure B-8) with the regulation of Hoover Dam and Parker Dam releases and the balancing of arriving flows with downstream water demands.

Figure B-8
Lake Havasu Monthly Target Elevations
Used to Provide Flood Control Reserve Capacity



The average, maximum, and minimum monthly elevations of Lake Havasu (elevations measured at midnight on last day of month) for the non-flood control years. The maximum average of approximately 448.7 feet msl occurs in May and the minimum average of about 446.0 feet msl occurs in February. The minimum target elevation for marina operators is 445.8 feet msl. Reclamation attempts to accommodate this minimum target elevation when other higher priority uses are not compromised. The maximum Lake Havasu elevation is 450.5 feet msl.

B.2.6 Parker Dam to Imperial Dam

Parker Dam is the last major dam on the lower Colorado River and provides the last opportunity for Reclamation to provide any significant regulation of river flows. Once water is released from Parker Dam, the water flows relatively unregulated until it reaches Imperial Dam. The transit time between Parker Dam and Imperial Dam is approximately 3 days.

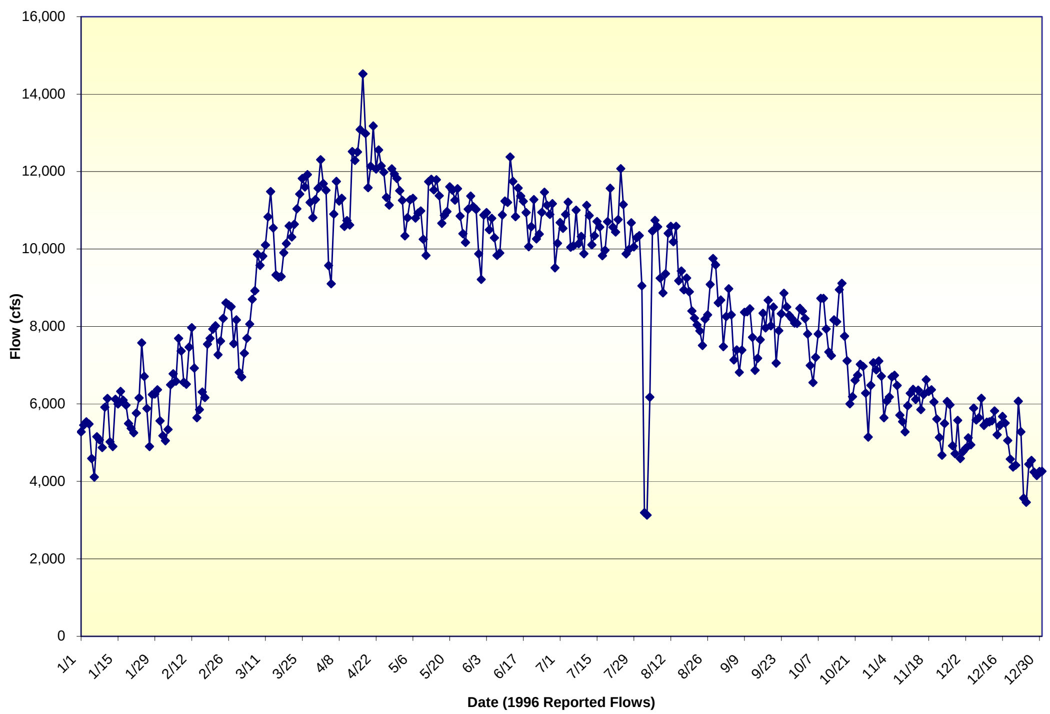
B.2.6.1 River Flows between Parker Dam and Imperial Dam

The flow of the Colorado River between Parker Dam and Imperial Dam is normally set at the amount needed to meet the United States consumptive use requirements downstream of the Parker Dam plus deliveries to Mexico below Morelos Diversion Dam. The scheduling and subsequent release of water through Parker Dam creates short-term fluctuations in river flows, depths, and elevations downstream of Parker Dam. These fluctuations of elevations in the river are most noticeable in the section of the river located immediately downstream of Parker Dam and lessen as the downstream distance increases.

Several features located downstream of Parker Dam are also used to manage the flows in the river and make deliveries to the Colorado River water users that divert water downstream of Parker Dam. This includes the Headgate Rock Dam, Palo Verde Diversion Dam, Senator Wash Dam, Imperial Diversion Dam and Laguna Dam. These are discussed in detail below.

Historical river flows since 1963 in this river reach have ranged between 30 cfs to 40,000 cfs. The higher flow rates have been associated with flood flows. An example of the daily fluctuation in flows in this river reach is shown on Figure B-9.

Figure B-9
Variation of Daily Flows Arriving at Imperial Dam
(reported 1996 daily river flow measurements at Cibola Stream Gage, RM 87.3)



Historical diversions since 1963 from this river reach have ranged between 0 af and 152,496 af.

Future flows in this reach are expected to be affected by the proposed water transfers and exchanges between the California agricultural water agencies and Metropolitan, which change the point of diversion. For example, under a potential transfer between IID and MWD (or SDCWA), the water that would normally be diverted at Imperial Dam would now be diverted above Parker Dam. The proposed California intrastate transfers are included in the simulation of the baseline conditions and surplus alternatives. The intrastate transfers proposed by California and any potential environmental effects that would occur as a result of those actions were previously addressed in the *Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions EIS* (USBR, October 2002).

B.2.6.2 Operation of Headgate Rock Dam

Headgate Rock Dam was completed in 1941and forms Lake Moovalya which serves as a diversion dam for the Colorado River Indian Irrigation Project (CRIIP). It controls the elevation of a 16-mile stretch of the river, reaching almost to the tail water of Parker Dam minus the diversion by the CRIIP. There is very little daily fluctuation in the water levels upstream of Headgate Rock Dam. Downstream levels reflect the releases from Parker Dam. Irrigation water is diverted from above the dam almost 12 months out of the year. When water is being diverted, the upstream elevation is kept at or around 364.4 feet msl. When water is not being diverted, the upstream lake can be lowered by opening the spillway gates, and the water level is kept at or around 363.4 feet msl and possibly lower if needed.

When the power plant is operational, power is generated through up to three 6.5-megawatt turbine units depending on water release through Parker Dam. The power is used for the irrigation project, BIA s needs, power sales, and exchanges off reservation.

CRIIP’s main canal is 18 miles long and includes six major control or diversion structures, as well as minor delivery, drainage, and highway structures. CRIIP operates the diversion on a demand basis. Water users must place their order at least 48 hours in advance, and the irrigation office usually provides that water within 48 hours from the posted end-of-order time each day. Accumulated daily water orders are relayed to the dam, so that gates on the dam and main canal intake structure are raised or lowered to divert the correct quantity into the irrigation system.

The CRIIP Irrigation Office prepares and submits an annual report that provides the annual projected water use to the River Operations Branch of Reclamation. This report estimates the monthly flow to be diverted for CRIIP use in the next crop year.

B.2.6.3 Operation of Palo Verde Diversion Dam

Palo Verde Diversion Dam is the intake for California's PVID. Flows between Palo Verde Diversion Dam and Imperial Dam are set by downstream demands and required deliveries to Mexico.

Palo Verde Diversion Dam is operated by PVID. The diversion dam maintains a constant elevation at the PVID canal intake during periods of normal riverflow. Except during periods of high river discharge, this forebay elevation is maintained at 283.5 feet.

B.2.6.4 Operation of Senator Wash Dam

Senator Wash Dam and Regulating Reservoir is located 20 miles northeast of the city of Yuma, Arizona, on the California side of the Colorado River approximately two miles upstream from Imperial Dam. This strategic off-stream water storage reservoir was constructed by Reclamation to facilitate water scheduling and to help in balancing the river flows and supply with demands. This is achieved by storing part of the Colorado River flow when excess flows are available above Imperial Dam and releasing the water in storage back to the river for downstream use when needed.

Senator Wash Reservoir was designed to have a water surface area of about 470 acres at a maximum operating elevation of 251 feet msl. At this elevation, the design storage capacity is approximately 13,840 af. The reservoir has inactive (dead) storage below elevation 210 feet msl which has an estimated capacity of about 1,577 af. The design active storage is located between elevations 210 feet msl and 251 feet msl and is estimated to be about 12,259 af.

Current operational restrictions limit the use of the full storage capacity available at Senator Wash Reservoir. The operational restriction of Senator Wash Reservoir is associated with Safety of Dams concerns. Previous structural evaluation, studies of the dam, and related facilities have shown evidence of potential piping through and around the foundation of the dam (transportation of dam embankment foundation material caused by seepage that could lead to failure of the dam or dikes). There is a potential for failure of the foundation or embankment which could result from liquefaction during an earthquake. The maximum operating elevation of Senator Wash Reservoir was previously restricted to 235 feet msl with temporary incursions up to 240 feet msl. However, with the recent installation of a geomembrane liner along the bottom of a portion of the reservoir, the maximum unrestricted operating elevation has been raised to 240 feet msl.

B.2.7 Imperial Dam to NIB

This reach extends from Imperial Dam to the NIB between the United States and Mexico. The entire extent of the channel is bound by a system of levees. Several features are located between Imperial Dam and NIB and are used to manage river flows and make deliveries to the Colorado River water users that divert water at and downstream of Imperial Dam. This includes Imperial Dam, Laguna Dam, Laguna Desilting Basin, Morelos Diversion Dam, California Wasteway, and Pilot Knob Wasteway. Other features include water conveyance system components (levees, bypass channels, wasteways, etc.), access roads, farmlands, and vegetation. Mittry Lake is also located on the Arizona side of the Colorado River.

The All-American Canal system diverts water from the California side of Imperial Dam and serves IID, Coachella Valley Water District (CVWD), the Yuma Project in Arizona and California, and the City of Yuma.

The Gila Gravity Main Canal system diverts water from the Arizona side of Imperial Dam and serves the north and south Gila Valley, Yuma Mesa, and Wellton-Mohawk area. Imperial Dam is also used to regulate deliveries to Mexico.

The All-American Canal Desilting Works, which is located adjacent to the All-American Canal diversion structure, is used to remove most of the sediment carried by the Colorado River prior to the water entering the AAC. The Imperial NWR is located mostly on the Arizona side of the Colorado River. Martinez Lake is a small water cove formed by the impoundment and backwater area located above Imperial Dam.

B.2.7.1 Operation of Imperial Dam

Imperial Dam and the impoundment that it forms upstream of the dam is used to raise the water surface of the river flows by approximately 25 feet msl to provide controlled gravity flow of water into the All-American Canal and the Gila Gravity Main Canal. Imperial Dam is situated on the Colorado River some 18 miles northeast of Yuma, Arizona.

The flows arriving at Imperial Dam normally range from a high of about 14,400 cfs (usually occurring in late spring to summer) to a low of about 2,500 cfs. The low flow period usually occurring after heavy rainfall occurs in the area below Imperial Dam (usually November, December, and January). During these wet weather periods, the rain saturates the farm fields, and the farmers and respective water agencies adjust or cancel their water delivery orders. Mexico's water order is required to be delivered regardless of wet weather or excess rainfall conditions.

The reservoir created by Imperial Dam initially had a capacity of 83,000 af. This storage capacity was not considered a project feature and, as anticipated, the reservoir quickly filled with sediment. The reservoir capacity is now considered to be approximately 1,000 af and intermittent dredging is required to maintain the required diversion capacity at the All-American Canal and Gila Gravity Main Canal Headworks.

The normal operating range for the Imperial Reservoir is between 180 feet msl and 180.85 feet msl. However, if the amount of water arriving at Imperial Dam is less than the demands, and pulling water out of Senator Wash cannot keep the elevation of Imperial Reservoir from continuing to fall, diversions at elevations below elevation 180.0 feet msl can be made to the All-American Canal or the Gila Gravity Main Canal. Under certain conditions, it is possible to draw down Imperial Reservoir elevations as low as 178.5 feet msl.

Imperial Dam is operated primarily as a diversion dam, providing water to the All-American and the Gila Gravity Main Canals to meet the beneficial use requirements of entitlement holders in California and Arizona. Releases may also be made to meet a portion of the 1944 Treaty deliveries to Mexico. Occasionally (two to three times per month), water is released through the sluice gates at Imperial Dam to move accumulated sediment to the Laguna Desilting Basin which is located about two miles downstream from Imperial Dam. The Laguna Desilting Basin, located within the Colorado River channel, is used to decant the water that is released or that passes Imperial Dam.

B.2.7.2 River Flows between Imperial Dam and NIB

The flows in the Colorado River below Imperial Dam are primarily comprised of the water delivered to Mexico in accordance with the 1944 Treaty. Mexico's principal diversion is at Morelos Diversion Dam, which is located, approximately nine miles southwest of Yuma, Arizona. Mexico owns, operates, and maintains Morelos Diversion Dam.

Much of the water that is delivered to Mexico at NIB is diverted at Imperial Dam into the All-American Canal (AAC) where it is returned to the bed of the Colorado River through Siphon Drop and Pilot Knob Powerplants. A portion of the NIB deliveries remains in the river, passing through Imperial and Laguna Dams to Morelos Diversion Dam.

Under normal operating conditions and when there is no runoff from the Gila River System, the delivery of scheduled water to Mexico at the NIB comes from two principal sources: 1) drainage return flows that occur downstream of Imperial Dam, and 2) the diversion of flows to Mexico from Imperial Dam. The drainage return flows are nearly constant throughout the year and from year to year and comprise both gravity and pumped drainage flows.

Water may be delivered to Mexico at the NIB via one or a combination of three routes. Figure B-10 presents a schematic that shows these routes. The following provides an explanation of these three flow routing methods:

1) The water scheduled to be delivered to Mexico is diverted at Imperial Dam, conveyed through the All-American Canal to the Pilot Knob Check, and at a point above the Pilot Knob Check, the flows are diverted from the All-American Canal through the Pilot Knob Power Plant and Wasteway back into the Colorado River. The Pilot Knob Wasteway channel discharges to the Colorado River at a point located approximately 2.1 miles upstream of NIB.

2) The water scheduled to be delivered to Mexico is diverted at Imperial Dam, conveyed through the AAC to the Siphon Drop, and at a point above the Siphon Drop, the flows are diverted from the AAC through the Siphon Drop Wasteway and into the Yuma Main Canal. The water is then conveyed some 3.5 miles within the Yuma Main Canal and then is diverted and discharged back into the Colorado River via the Yuma Main Canal Wasteway. The Yuma Main Canal Wasteway discharges to the Colorado River at a point located approximately 7.6 miles upstream of NIB.

3) The water scheduled to be delivered to Mexico is delivered directly to NIB via the Colorado River. Under this method, water is passed through Imperial and Laguna Dams and is allowed to flow via the river channel to NIB. These flows are in addition to the base flows in the riverbed downstream of Laguna Dam. The base flows are generally consistent throughout the year and result from gate leakage at Imperial Dam, returns to the river below Imperial Dam from the All-American Canal Desilting Basin, and drainage flows from downstream sources. These base flows normally range from 600 cfs to 800 cfs.

Another intermittent water source that is available for delivery to Mexico at the NIB is the Gila River. When releases from Painted Rock Dam occur, these flows are used to satisfy a portion of Mexico's delivery, depending on the amount of flow from the Gila River that enters the Colorado River upstream of the NIB.

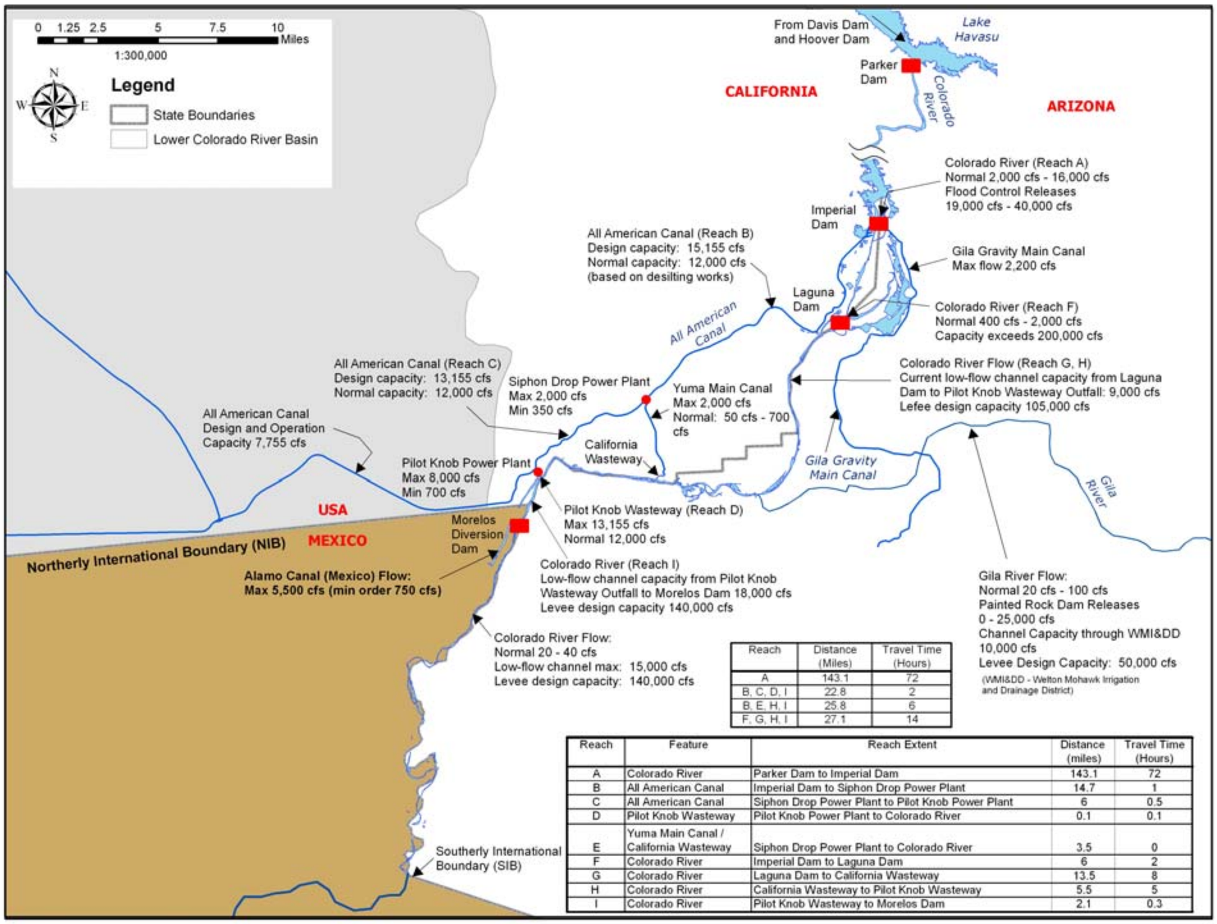
B.2.7.3 Operation of Laguna Dam

Laguna Dam is located on the Colorado River some 13 miles northeast of Yuma, Arizona, and about five miles downstream from Imperial Dam. The original purpose of this dam was to divert Colorado River water to the Yuma Project area. Laguna Dam now serves as a regulating structure for Colorado River water, for regulating sluicing flows from Imperial Dam, and for downstream toe protection for Imperial Dam. The reservoir created by Laguna Dam is commonly referred to as Laguna Reservoir.

Water can be stored in Laguna Reservoir between elevations 142 feet msl to 151.3 feet msl. The top of the overflow weir at Laguna Dam is at 151.3 feet msl. A small amount of additional storage can be obtained by forcing water into surcharge above the weir. The current estimate of the available storage capacity at Laguna Reservoir, between elevation 142 feet msl and 151.3 feet msl, is about 400 af.

The flows that occur below Imperial Dam and that flow into the Colorado River channel and Laguna Reservoir typically range from about 250 cfs to 350 cfs and comprise principally of return flows from the All-American desilting basins and gate leakage from the California sluiceway gates at Imperial Dam. Occasionally, sluicing flows are released to remove sediment accumulated from the desilting basins in the sluiceway channel. These flows occur two to three times per month, may range from 8,000 cfs to 12,000 cfs, and the duration may be up to 20 minutes. These flows carry the sediment to the Laguna Desilting Basin located about two miles downstream from Imperial Dam.

Figure B-10
Water Routing from Imperial Dam to NIB
Deliveries to Mexico Pursuant to 1944 Water Treaty



Reach	Distance (Miles)	Travel Time (Hours)
A	143.1	72
B, C, D, I	22.8	2
B, E, H, I	25.8	6
F, G, H, I	27.1	14

Reach	Feature	Reach Extent	Distance (miles)	Travel Time (Hours)
A	Colorado River	Parker Dam to Imperial Dam	143.1	72
B	All American Canal	Imperial Dam to Siphon Drop Power Plant	14.7	1
C	All American Canal	Siphon Drop Power Plant to Pilot Knob Power Plant	6	0.5
D	Pilot Knob Wasteway	Pilot Knob Power Plant to Colorado River	0.1	0.1
E	Yuma Main Canal / California Wasteway	Siphon Drop Power Plant to Colorado River	3.5	0
F	Colorado River	Imperial Dam to Laguna Dam	6	2
G	Colorado River	Laguna Dam to California Wasteway	13.5	8
H	Colorado River	California Wasteway to Pilot Knob Wasteway	5.5	5
I	Colorado River	Pilot Knob Wasteway to Morelos Dam	2.1	0.3

Flow releases from Laguna Dam typically range between 300 and 500 cfs. Occasionally, flows up to 4,000 cfs or higher may occur coincident with or following heavy rainfall.

Laguna Dam is operated to regulate river flows and to temporarily store water used in sluicing operations at Imperial Dam. Any water that is captured and temporarily stored at Laguna Reservoir is released to meet a portion of the 1944 Treaty deliveries to Mexico.

B.2.7.4 Mittry Lake

Mittry Lake is located on the east side of the Colorado River between Laguna Dam and Imperial Dam. The Mittry Lake Wildlife Area generally surrounds and includes Mittry Lake and includes approximately 600 acres of water surface and 2,400 acres of marsh or upland. Numerous serpentine waterways connect to the main lake body. The Mittry Lake Wildlife Area is jointly managed by the U.S. Bureau of Land Management, Reclamation, and the Arizona Game and Fish Department.

B.2.8 NIB to SIB

This reach extends from the NIB to the SIB between the United States and Mexico and is approximately 25 miles long. This section of the Colorado River serves as the international boundary between the United States and Mexico. This segment of the Colorado River has been highly altered and has levees on both sides.

Located approximately 1.1 miles downstream of the NIB is Morelos Diversion Dam. This dam functions as a diversion control structure for the Alamo Canal, which conveys water to Mexico. The Morelos Diversion Dam and the limitrophe section of the Colorado River channel, including the floodplain, are designed to convey a maximum flow of 140,000 cfs. Other major features located within this reach include water conveyance system components (levee, bypass channel, wasteways, etc.), access roads, farmlands, and vegetation.

B.2.8.1 Operation of Morelos Diversion Dam

In accordance with the 1944 Treaty and Minute 242, up to 140,000 af y of Mexico's treaty allocation of 1.5 mafy may be delivered at the SIB. Consequently, Mexico diverts the majority (approximately 1.36 mafy) of its 1944 Treaty allocation at Morelos Diversion Dam.

B.2.8.2River Flows between NIB to SIB

Flows in this reach of the river vary. At times the lower part of this reach is dry. Cohen and Henges-Jeck (2000) reported average total flows in this reach of 22,000 af in non-flood years and 2.12 maf in flood years.

The flows that are observed in this river reach typically are result of seepage from Morelos Diversion Dam, flow releases from Morelos Diversion Dam (flood flows and excess water not diverted by Mexico), irrigation return flows from Mexico and canal wasteways in the United States, and groundwater accumulation from both the United States and Mexico.

The reach of river between NIB and the SIB is commonly referred to by Reclamation as the Limitrophe Reach. Reclamation's authority in this division is limited to maintaining the bankline road, the levee, various drains to the river, and the U.S. Bypass drain that carries agricultural drainage water to the Cienega de Santa Clara in Mexico. The USIBWC is obligated to maintain the river channel within this division although Reclamation provides assistance to the USIBWC, when requested, for maintenance needs in this reach of the river.

Under current practice, Mexico is allowed to schedule up to 200 kaf pursuant to the 1944 Treaty during flood control years when water supplies exceed those required for use in the United States. Often, the flood control releases are greater than the surplus uses in both the United States and Mexico and water in excess of Mexico's water schedule (termed "excess flows") arrive at the NIB. Excess flows may also arrive at the NIB due to flooding on the Gila River and from operational activities upstream (i.e., cancelled water orders in the United States, maintenance activities, etc.). Mexico has the ability to divert the excess flows that arrive at Morelos Diversion Dam. Excess flows that are of magnitudes greater than what can be used by Mexico are passed through Morelos Diversion Dam and flow through the Limitrophe Reach to the Colorado River Delta.

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Appendix C

Upper Basin State Depletion Schedules

This appendix consists of a table displaying the schedule of projected Colorado River system depletions for Upper Basin states. These depletions were used to model the operation of the Colorado River system under the No Action Alternative and the action alternatives. Shown in the table are projected depletions of the Upper Division states (Colorado, Utah, Wyoming, and New Mexico) and Arizona's apportionment of water from the Upper Basin. The depletion schedule was developed by the Upper Basin states and was compiled and provided by the Upper Colorado River Commission in December, 1999.

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Table C-1
Upper Basin Depletion Schedule (kaf)

Calendar Year	Colorado	Utah	Wyoming	New Mexico	Arizona	Total Upper Basin
2008	2,517	940	512	529	45	4,543
2009	2,524	953	514	539	45	4,575
2010	2,580	1,009	517	548	50	4,704
2011	2,583	1,013	519	552	50	4,717
2012	2,586	1,017	520	557	50	4,729
2013	2,588	1,020	522	561	50	4,742
2014	2,591	1,024	524	565	50	4,754
2015	2,594	1,028	526	570	50	4,767
2016	2,597	1,032	527	573	50	4,779
2017	2,600	1,036	529	576	50	4,791
2018	2,603	1,041	531	579	50	4,804
2019	2,606	1,045	532	583	50	4,816
2020	2,626	1,055	535	589	50	4,855
2021	2,629	1,062	537	590	50	4,869
2022	2,633	1,069	540	591	50	4,883
2023	2,636	1,077	542	593	50	4,897
2024	2,639	1,084	544	594	50	4,911
2025	2,643	1,091	547	595	50	4,925
2026	2,646	1,099	549	597	50	4,940
2027	2,649	1,107	551	599	50	4,955
2028	2,652	1,114	553	600	50	4,971
2029	2,656	1,122	556	602	50	4,986
2030	2,675	1,129	571	604	50	5,029
2031	2,677	1,134	575	604	50	5,040
2032	2,679	1,139	580	604	50	5,052
2033	2,680	1,145	584	604	50	5,063
2034	2,682	1,150	588	604	50	5,075
2035	2,684	1,155	593	605	50	5,086
2036	2,686	1,160	597	605	50	5,097
2037	2,688	1,165	601	605	50	5,109
2038	2,689	1,171	605	605	50	5,120
2039	2,691	1,176	610	605	50	5,132
2040	2,703	1,177	615	605	50	5,150
2041	2,708	1,180	622	605	50	5,165
2042	2,712	1,184	629	605	50	5,180
2043	2,717	1,187	637	605	50	5,195
2044	2,721	1,190	644	605	50	5,210
2045	2,726	1,194	651	605	50	5,226
2046	2,731	1,197	658	605	50	5,241
2047	2,735	1,200	665	605	50	5,256
2048	2,740	1,203	673	605	50	5,271
2049	2,744	1,207	680	605	50	5,286
2050	2,776	1,207	687	605	50	5,325
2051	2,776	1,209	694	605	50	5,335
2052	2,777	1,212	701	605	50	5,344
2053	2,777	1,214	708	605	50	5,354
2054	2,777	1,216	715	605	50	5,363
2055	2,778	1,219	722	605	50	5,373
2056	2,778	1,221	729	605	50	5,383
2057	2,778	1,223	736	605	50	5,392
2058	2,778	1,225	743	605	50	5,402
2059	2,779	1,228	750	605	50	5,411
2060	2,784	1,230	760	605	50	5,429

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Appendix D

Lower Basin
State Depletion Schedules

This appendix contains schedules of projected Colorado River system depletions by the Lower Division States (Arizona, California, and Nevada). These depletion schedules were used to model the operation of the river system under the No Action Alternative and the action alternatives. The depletion schedules were developed by the Lower Division States and submitted to Reclamation in 2006. Depletions are presented in Tables D-1a through D-1j for Arizona, Tables D-2a through D-2b for California, and Table D-3 for Nevada.

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Table D-1a
State of Arizona Users (af)

Calendar Year	CAP	Mohave Valley IDD Ag. Portion	Mohave Valley IDD M&I Portion	Curtis, Armon	Curtis Family Trust	Jessen Family LTD	Ogram Boys Enterprises	Ogram
2008	1,382,421.1	20,005	4,126.8	225.6	1,579.2	1,080.0	694.6	361.2
2009	1,368,604.8	20,005	4,228.4	226.8	1,587.6	1,080.0	698.3	363.1
2010	1,354,788.4	20,005	4,330.0	228.0	1,596.0	1,080.0	702.0	365.0
2011	1,344,368.0	19,518	4,429.0	228.0	1,596.0	1,080.0	702.0	365.0
2012	1,333,947.6	19,030	4,528.0	228.0	1,596.0	1,080.0	702.0	365.0
2013	1,323,527.2	18,543	4,627.0	228.0	1,596.0	1,080.0	702.0	365.0
2014	1,313,106.8	18,055	4,726.0	228.0	1,596.0	1,080.0	702.0	365.0
2015	1,302,686.4	17,568	4,825.0	228.0	1,596.0	1,080.0	702.0	365.0
2016	1,302,066.0	17,080	4,924.0	228.0	1,596.0	1,080.0	702.0	365.0
2017	1,301,445.6	16,593	5,023.0	228.0	1,596.0	1,080.0	702.0	365.0
2018	1,300,825.2	16,105	5,122.0	228.0	1,596.0	1,080.0	702.0	365.0
2019	1,300,204.8	15,618	5,221.0	228.0	1,596.0	1,080.0	702.0	365.0
2020	1,299,584.4	15,130	5,320.0	228.0	1,596.0	1,080.0	702.0	365.0
2021	1,298,606.2	15,130	5,385.0	229.5	1,606.5	1,080.0	706.6	367.4
2022	1,297,627.9	15,130	5,450.0	231.0	1,617.0	1,080.0	711.2	369.8
2023	1,296,649.7	15,130	5,515.0	232.5	1,627.5	1,080.0	715.8	372.2
2024	1,295,671.5	15,130	5,580.0	234.0	1,638.0	1,080.0	720.4	374.6
2025	1,294,693.8	15,130	5,645.0	235.5	1,648.5	1,080.0	725.0	377.0
2026	1,293,718.5	15,130	5,710.0	237.0	1,659.0	1,080.0	729.6	379.4
2027	1,292,743.2	15,130	5,775.0	238.5	1,669.5	1,080.0	734.2	381.8
2028	1,291,767.9	15,130	5,840.0	240.0	1,680.0	1,080.0	738.8	384.2
2029	1,290,792.6	15,130	5,905.0	241.5	1,690.5	1,080.0	743.4	386.6
2030	1,289,817.2	15,130	5,970.0	243.0	1,701.0	1,080.0	748.0	389.0
2031	1,288,748.8	15,130	6,003.0	243.0	1,701.0	1,080.0	748.0	389.0
2032	1,287,680.3	15,130	6,036.0	243.0	1,701.0	1,080.0	748.0	389.0
2033	1,286,611.8	15,130	6,069.0	243.0	1,701.0	1,080.0	748.0	389.0
2034	1,285,543.4	15,130	6,102.0	243.0	1,701.0	1,080.0	748.0	389.0
2035	1,284,474.9	15,130	6,135.0	243.0	1,701.0	1,080.0	748.0	389.0
2036	1,283,406.4	15,130	6,168.0	243.0	1,701.0	1,080.0	748.0	389.0
2037	1,282,338.0	15,130	6,201.0	243.0	1,701.0	1,080.0	748.0	389.0
2038	1,281,269.5	15,130	6,234.0	243.0	1,701.0	1,080.0	748.0	389.0
2039	1,280,201.0	15,130	6,267.0	243.0	1,701.0	1,080.0	748.0	389.0
2040	1,279,132.5	15,130	6,300.0	243.0	1,701.0	1,080.0	748.0	389.0
2041	1,278,593.2	15,130	6,338.7	243.0	1,701.0	1,080.0	748.0	389.0
2042	1,278,053.9	15,130	6,377.4	243.0	1,701.0	1,080.0	748.0	389.0
2043	1,277,514.5	15,130	6,416.1	243.0	1,701.0	1,080.0	748.0	389.0
2044	1,276,975.2	15,130	6,454.8	243.0	1,701.0	1,080.0	748.0	389.0
2045	1,276,435.8	15,130	6,493.5	243.0	1,701.0	1,080.0	748.0	389.0
2046	1,275,896.5	15,130	6,532.2	243.0	1,701.0	1,080.0	748.0	389.0
2047	1,275,357.2	15,130	6,570.9	243.0	1,701.0	1,080.0	748.0	389.0
2048	1,274,817.8	15,130	6,609.6	243.0	1,701.0	1,080.0	748.0	389.0
2049	1,274,278.5	15,130	6,648.3	243.0	1,701.0	1,080.0	748.0	389.0
2050	1,273,739.1	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2051	1,273,490.2	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2052	1,273,241.3	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2053	1,272,992.4	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2054	1,272,743.5	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2055	1,272,494.6	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2056	1,272,245.7	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2057	1,271,996.8	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2058	1,271,747.9	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2059	1,271,499.0	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0
2060	1,271,250.1	15,130	6,687.0	243.0	1,701.0	1,080.0	748.0	389.0

Table D-1b
State of Arizona Users (af)

Calendar Year	Peach, John	Phillips, Milton & Jean	Beattie Farms Southwest	Pasquinelli, Gary & Barbara	Edward, Roy P.	Somerton	AZ State Land Dept Ag.	Smucker Park
2008	437.4	18.0	721.5	383.8	1.0	495.0	5,230.6	0.0
2009	439.7	18.0	721.5	385.9	1.0	495.0	5,263.8	0.0
2010	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2011	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2012	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2013	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2014	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2015	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2016	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2017	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2018	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2019	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2020	442.0	18.0	721.5	388.0	1.0	495.0	5,297.0	0.0
2021	444.9	18.0	721.5	390.5	1.0	495.0	5,327.3	0.0
2022	447.8	18.0	721.5	393.0	1.0	495.0	5,357.6	0.0
2023	450.7	18.0	721.5	395.5	1.0	495.0	5,387.9	0.0
2024	453.6	18.0	721.5	398.0	1.0	495.0	5,418.2	0.0
2025	456.0	18.0	721.5	400.5	1.0	495.0	5,448.5	0.0
2026	456.0	18.0	721.5	403.0	1.0	495.0	5,478.8	0.0
2027	456.0	18.0	721.5	405.5	1.0	495.0	5,509.1	0.0
2028	456.0	18.0	721.5	408.0	1.0	495.0	5,539.4	0.0
2029	456.0	18.0	721.5	410.5	1.0	495.0	5,569.7	0.0
2030	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2031	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2032	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2033	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2034	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2035	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2036	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2037	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2038	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2039	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2040	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2041	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2042	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2043	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2044	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2045	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2046	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2047	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2048	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2049	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2050	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2051	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2052	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2053	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2054	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2055	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2056	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2057	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2058	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2059	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0
2060	456.0	18.0	721.5	413.0	1.0	495.0	5,600.0	0.0

Table D-1c
State of Arizona Users (af)

Calendar Year	Cocopah Ind. Res.	Hopi Tribe	North Baja LLC	Rayner Ranches	Brooke Water LLC	Ehrenberg Impr. Assn	Fisher Landing	Martinez Lake Sites
2008	9,137.2	3,833.9	361.2	3,380.0	291.2	325.8	34.5	15.0
2009	9,137.2	3,833.9	363.1	3,395.0	293.1	331.4	34.5	15.0
2010	9,137.2	3,833.9	365.0	3,410.0	295.0	337.0	34.5	15.0
2011	9,137.2	3,833.9	365.0	3,410.0	297.2	343.0	34.5	15.0
2012	9,137.2	3,833.9	365.0	3,410.0	299.4	349.0	34.5	15.0
2013	9,137.2	3,833.9	365.0	3,410.0	301.6	355.0	34.5	15.0
2014	9,137.2	3,833.9	365.0	3,410.0	303.8	361.0	34.5	15.0
2015	9,137.2	3,833.9	365.0	3,410.0	306.0	367.0	34.5	15.0
2016	9,137.2	3,833.9	365.0	3,410.0	308.2	373.0	34.5	15.0
2017	9,137.2	3,833.9	365.0	3,410.0	310.4	379.0	34.5	15.0
2018	9,137.2	3,833.9	365.0	3,410.0	312.6	385.0	34.5	15.0
2019	9,137.2	3,833.9	365.0	3,410.0	314.8	391.0	34.5	15.0
2020	9,137.2	3,833.9	365.0	3,410.0	317.0	397.0	34.5	15.0
2021	9,137.2	3,833.9	367.4	3,431.3	317.4	402.1	34.5	15.0
2022	9,137.2	3,833.9	369.8	3,452.6	317.8	407.2	34.5	15.0
2023	9,137.2	3,833.9	372.2	3,473.9	318.2	412.3	34.5	15.0
2024	9,137.2	3,833.9	374.6	3,495.2	318.6	417.4	34.5	15.0
2025	9,137.2	3,833.9	377.0	3,516.5	319.0	422.5	34.5	15.0
2026	9,137.2	3,833.9	379.4	3,537.8	319.4	427.6	34.5	15.0
2027	9,137.2	3,833.9	381.8	3,559.1	319.8	432.7	34.5	15.0
2028	9,137.2	3,833.9	384.2	3,580.4	320.2	437.8	34.5	15.0
2029	9,137.2	3,833.9	386.6	3,601.7	320.6	442.9	34.5	15.0
2030	9,137.2	3,833.9	389.0	3,623.0	321.0	448.0	34.5	15.0
2031	9,137.2	3,833.9	389.0	3,623.0	321.3	448.0	34.5	15.0
2032	9,137.2	3,833.9	389.0	3,623.0	321.6	448.0	34.5	15.0
2033	9,137.2	3,833.9	389.0	3,623.0	321.9	448.0	34.5	15.0
2034	9,137.2	3,833.9	389.0	3,623.0	322.2	448.0	34.5	15.0
2035	9,137.2	3,833.9	389.0	3,623.0	322.5	448.0	34.5	15.0
2036	9,137.2	3,833.9	389.0	3,623.0	322.8	448.0	34.5	15.0
2037	9,137.2	3,833.9	389.0	3,623.0	323.1	448.0	34.5	15.0
2038	9,137.2	3,833.9	389.0	3,623.0	323.4	448.0	34.5	15.0
2039	9,137.2	3,833.9	389.0	3,623.0	323.7	448.0	34.5	15.0
2040	9,137.2	3,833.9	389.0	3,623.0	324.0	448.0	34.5	15.0
2041	9,137.2	3,833.9	389.0	3,623.0	324.2	448.0	34.5	15.0
2042	9,137.2	3,833.9	389.0	3,623.0	324.4	448.0	34.5	15.0
2043	9,137.2	3,833.9	389.0	3,623.0	324.6	448.0	34.5	15.0
2044	9,137.2	3,833.9	389.0	3,623.0	324.8	448.0	34.5	15.0
2045	9,137.2	3,833.9	389.0	3,623.0	325.0	448.0	34.5	15.0
2046	9,137.2	3,833.9	389.0	3,623.0	325.2	448.0	34.5	15.0
2047	9,137.2	3,833.9	389.0	3,623.0	325.4	448.0	34.5	15.0
2048	9,137.2	3,833.9	389.0	3,623.0	325.6	448.0	34.5	15.0
2049	9,137.2	3,833.9	389.0	3,623.0	325.8	448.0	34.5	15.0
2050	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2051	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2052	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2053	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2054	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2055	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2056	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2057	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2058	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2059	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0
2060	9,137.2	3,833.9	389.0	3,623.0	326.0	448.0	34.5	15.0

Table D-1d
State of Arizona Users (af)

Calendar Year	Hillcrest Water Co	Quartzsite	Shepard Water Co.	Verizon	Cibola Valley IDD	Mohave County WA	Mohave Water Cons. Dist.	AZ American Water Co.
2008	24.9	287.6	32.5	1.0	7,752.2	3,833.9	499.8	289.4
2009	25.7	299.3	32.5	1.0	7,752.2	3,833.9	513.0	290.7
2010	26.4	311.0	32.5	1.0	7,752.2	3,833.9	526.2	292.0
2011	27.8	325.0	32.5	1.0	7,752.2	3,833.9	539.9	293.2
2012	29.2	339.0	32.5	1.0	7,752.2	3,833.9	553.5	294.4
2013	30.7	353.0	32.5	1.0	7,752.2	3,833.9	567.2	295.6
2014	32.1	367.0	32.5	1.0	7,752.2	3,833.9	580.9	296.8
2015	33.5	381.0	32.5	1.0	7,752.2	3,833.9	594.6	298.0
2016	35.0	395.0	32.5	1.0	7,752.2	3,833.9	608.3	299.2
2017	36.4	409.0	32.5	1.0	7,752.2	3,833.9	621.9	300.4
2018	37.8	423.0	32.5	1.0	7,752.2	3,833.9	635.6	301.6
2019	39.2	437.0	32.5	1.0	7,752.2	3,833.9	649.3	302.8
2020	40.7	451.0	32.5	1.0	7,752.2	3,833.9	663.0	304.0
2021	41.3	457.9	32.5	1.0	7,752.2	3,833.9	671.8	304.7
2022	41.9	464.8	32.5	1.0	7,752.2	3,833.9	680.5	305.4
2023	42.6	471.7	32.5	1.0	7,752.2	3,833.9	689.3	306.1
2024	43.2	478.6	32.5	1.0	7,752.2	3,833.9	698.1	306.8
2025	43.8	485.5	32.5	1.0	7,752.2	3,833.9	706.9	307.5
2026	44.5	492.4	32.5	1.0	7,752.2	3,833.9	715.7	308.2
2027	45.1	499.3	32.5	1.0	7,752.2	3,833.9	724.4	308.9
2028	45.7	506.2	32.5	1.0	7,752.2	3,833.9	733.2	309.6
2029	46.4	513.1	32.5	1.0	7,752.2	3,833.9	742.0	310.3
2030	47.0	520.0	32.5	1.0	7,752.2	3,833.9	750.8	311.0
2031	47.1	522.4	32.5	1.0	7,752.2	3,833.9	754.5	311.2
2032	47.1	524.8	32.5	1.0	7,752.2	3,833.9	758.2	311.4
2033	47.2	527.2	32.5	1.0	7,752.2	3,833.9	761.9	311.6
2034	47.3	529.6	32.5	1.0	7,752.2	3,833.9	765.6	311.8
2035	47.4	532.0	32.5	1.0	7,752.2	3,833.9	769.3	312.0
2036	47.5	534.4	32.5	1.0	7,752.2	3,833.9	772.9	312.2
2037	47.5	536.8	32.5	1.0	7,752.2	3,833.9	776.6	312.4
2038	47.6	539.2	32.5	1.0	7,752.2	3,833.9	780.3	312.6
2039	47.7	541.6	32.5	1.0	7,752.2	3,833.9	784.0	312.8
2040	47.8	544.0	32.5	1.0	7,752.2	3,833.9	787.7	313.0
2041	47.9	545.2	32.5	1.0	7,752.2	3,833.9	792.4	313.5
2042	48.0	546.4	32.5	1.0	7,752.2	3,833.9	797.2	314.0
2043	48.1	547.6	32.5	1.0	7,752.2	3,833.9	801.9	314.5
2044	48.2	548.8	32.5	1.0	7,752.2	3,833.9	806.6	315.0
2045	48.3	550.0	32.5	1.0	7,752.2	3,833.9	811.3	315.5
2046	48.5	551.2	32.5	1.0	7,752.2	3,833.9	816.1	316.0
2047	48.6	552.4	32.5	1.0	7,752.2	3,833.9	820.8	316.5
2048	48.7	553.6	32.5	1.0	7,752.2	3,833.9	825.5	317.0
2049	48.8	554.8	32.5	1.0	7,752.2	3,833.9	830.2	317.5
2050	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2051	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2052	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2053	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2054	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2055	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2056	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2057	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2058	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2059	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0
2060	48.9	556.0	32.5	1.0	7,752.2	3,833.9	835.0	318.0

Table D-1e
State of Arizona Users (af)

Calendar Year	AZ State Land Dept. M&I	AZ State Parks Contact Point	AZ State Parks Windsor Beach	Bullhead City	Bureau Land Mgmt	Crystal Beach WCD	Gold Dome Mining Co.	Gold Standard Mines Corp.
2008	290.0	13.0	20.2	7,012.2	850.9	60.0	0.0	0.0
2009	295.0	13.0	20.2	7,197.1	850.9	61.0	0.0	0.0
2010	300.0	13.0	20.2	7,382.0	850.9	62.0	0.0	0.0
2011	333.0	13.0	20.2	7,573.9	850.9	63.0	0.0	0.0
2012	366.0	13.0	20.2	7,765.8	850.9	64.0	0.0	0.0
2013	399.0	13.0	20.2	7,957.7	850.9	65.0	0.0	0.0
2014	432.0	13.0	20.2	8,149.6	850.9	66.0	0.0	0.0
2015	465.0	13.0	20.2	8,341.5	850.9	67.0	0.0	0.0
2016	498.0	13.0	20.2	8,533.4	850.9	68.0	0.0	0.0
2017	531.0	13.0	20.2	8,725.3	850.9	69.0	0.0	0.0
2018	564.0	13.0	20.2	8,917.2	850.9	70.0	0.0	0.0
2019	597.0	13.0	20.2	9,109.1	850.9	71.0	0.0	0.0
2020	630.0	13.0	20.2	9,301.0	850.9	72.0	0.0	0.0
2021	639.0	13.0	20.2	9,424.2	850.9	72.6	0.0	0.0
2022	648.0	13.0	20.2	9,547.4	850.9	73.2	0.0	0.0
2023	657.0	13.0	20.2	9,670.6	850.9	73.8	0.0	0.0
2024	666.0	13.0	20.2	9,793.8	850.9	74.4	0.0	0.0
2025	675.0	13.0	20.2	9,917.0	850.9	75.0	0.0	0.0
2026	684.0	13.0	20.2	10,040.2	850.9	75.6	0.0	0.0
2027	693.0	13.0	20.2	10,163.4	850.9	76.2	0.0	0.0
2028	702.0	13.0	20.2	10,286.6	850.9	76.8	0.0	0.0
2029	711.0	13.0	20.2	10,409.8	850.9	77.4	0.0	0.0
2030	720.0	13.0	20.2	10,533.0	850.9	78.0	0.0	0.0
2031	726.0	13.0	20.2	10,584.8	850.9	78.3	0.0	0.0
2032	732.0	13.0	20.2	10,636.6	850.9	78.6	0.0	0.0
2033	738.0	13.0	20.2	10,688.4	850.9	78.9	0.0	0.0
2034	744.0	13.0	20.2	10,740.2	850.9	79.2	0.0	0.0
2035	750.0	13.0	20.2	10,792.0	850.9	79.5	0.0	0.0
2036	756.0	13.0	20.2	10,843.8	850.9	79.8	0.0	0.0
2037	762.0	13.0	20.2	10,895.6	850.9	80.1	0.0	0.0
2038	768.0	13.0	20.2	10,947.4	850.9	80.4	0.0	0.0
2039	774.0	13.0	20.2	10,999.2	850.9	80.7	0.0	0.0
2040	780.0	13.0	20.2	11,051.0	850.9	81.0	0.0	0.0
2041	780.0	13.0	20.2	11,117.3	850.9	81.1	0.0	0.0
2042	780.0	13.0	20.2	11,183.6	850.9	81.2	0.0	0.0
2043	780.0	13.0	20.2	11,249.9	850.9	81.3	0.0	0.0
2044	780.0	13.0	20.2	11,316.2	850.9	81.4	0.0	0.0
2045	780.0	13.0	20.2	11,382.5	850.9	81.5	0.0	0.0
2046	780.0	13.0	20.2	11,448.8	850.9	81.6	0.0	0.0
2047	780.0	13.0	20.2	11,515.1	850.9	81.7	0.0	0.0
2048	780.0	13.0	20.2	11,581.4	850.9	81.8	0.0	0.0
2049	780.0	13.0	20.2	11,647.7	850.9	81.9	0.0	0.0
2050	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2051	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2052	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2053	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2054	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2055	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2056	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2057	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2058	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2059	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0
2060	780.0	13.0	20.2	11,714.0	850.9	82.0	0.0	0.0

Table D-1f
State of Arizona Users (af)

Calendar Year	Golden Shores WCD	Lake Havasu City	McAlister, Maurice L.	Unallocated Priority 4	Marble Canyon Company	Lake Mead NRA	Imperial NWR	Cibola NWR
2008	428.8	12,322.4	3.9	0.0	15.6	738	3,618	7,655
2009	437.9	12,975.7	3.9	0.0	15.6	738	3,618	8,080
2010	447.0	13,629.0	3.9	0.0	15.6	738	3,618	8,505
2011	455.7	13,831.0	3.9	0.0	15.6	738	3,618	8,505
2012	464.4	14,033.0	3.9	0.0	15.6	738	3,618	8,505
2013	473.1	14,235.0	3.9	0.0	15.6	738	3,618	8,505
2014	481.8	14,437.0	3.9	0.0	15.6	738	3,618	8,505
2015	490.5	14,639.0	3.9	0.0	15.6	738	3,618	8,505
2016	499.2	14,841.0	3.9	0.0	15.6	738	3,618	8,505
2017	507.9	15,043.0	3.9	0.0	15.6	738	3,618	8,505
2018	516.6	15,245.0	3.9	0.0	15.6	738	3,618	8,505
2019	525.3	15,447.0	3.9	0.0	15.6	738	3,618	8,505
2020	534.0	15,649.0	3.9	0.0	15.6	738	3,618	8,505
2021	536.9	15,826.2	3.9	0.0	15.6	738	3,618	9,356
2022	539.8	16,003.4	3.9	0.0	15.6	738	3,618	10,206
2023	542.7	16,180.6	3.9	0.0	15.6	738	3,618	11,057
2024	545.6	16,357.8	3.9	0.0	15.6	738	3,618	11,907
2025	548.5	16,535.0	3.9	0.0	15.6	738	3,618	12,758
2026	551.4	16,712.2	3.9	0.0	15.6	738	3,618	13,608
2027	554.3	16,889.4	3.9	0.0	15.6	738	3,618	14,459
2028	557.2	17,066.6	3.9	0.0	15.6	738	3,618	15,309
2029	560.1	17,243.8	3.9	0.0	15.6	738	3,618	16,160
2030	563.0	17,421.0	3.9	0.0	15.6	738	3,618	17,010
2031	565.9	17,542.9	3.9	248.9	15.6	738	3,618	17,010
2032	568.8	17,664.8	3.9	497.8	15.6	738	3,618	17,010
2033	571.7	17,786.7	3.9	746.7	15.6	738	3,618	17,010
2034	574.6	17,908.6	3.9	995.6	15.6	738	3,618	17,010
2035	577.5	18,030.5	3.9	1,244.5	15.6	738	3,618	17,010
2036	580.4	18,152.4	3.9	1,493.4	15.6	738	3,618	17,010
2037	583.3	18,274.3	3.9	1,742.3	15.6	738	3,618	17,010
2038	586.2	18,396.2	3.9	1,991.2	15.6	738	3,618	17,010
2039	589.1	18,518.1	3.9	2,240.1	15.6	738	3,618	17,010
2040	592.0	18,640.0	3.9	2,489.0	15.6	738	3,618	17,010
2041	595.5	18,813.8	3.9	2,737.9	15.6	738	3,618	17,010
2042	599.0	18,987.6	3.9	2,986.8	15.6	738	3,618	17,010
2043	602.5	19,161.4	3.9	3,235.7	15.6	738	3,618	17,010
2044	606.0	19,335.2	3.9	3,484.6	15.6	738	3,618	17,010
2045	609.5	19,509.0	3.9	3,733.5	15.6	738	3,618	17,010
2046	613.0	19,682.8	3.9	3,982.4	15.6	738	3,618	17,010
2047	616.5	19,856.6	3.9	4,231.3	15.6	738	3,618	17,010
2048	620.0	20,030.4	3.9	4,480.2	15.6	738	3,618	17,010
2049	623.5	20,204.2	3.9	4,729.1	15.6	738	3,618	17,010
2050	627.0	20,378.0	3.9	4,978.0	15.6	738	3,618	17,010
2051	627.0	20,378.0	3.9	5,226.9	15.6	738	3,618	17,010
2052	627.0	20,378.0	3.9	5,475.8	15.6	738	3,618	17,010
2053	627.0	20,378.0	3.9	5,724.7	15.6	738	3,618	17,010
2054	627.0	20,378.0	3.9	5,973.6	15.6	738	3,618	17,010
2055	627.0	20,378.0	3.9	6,222.5	15.6	738	3,618	17,010
2056	627.0	20,378.0	3.9	6,471.4	15.6	738	3,618	17,010
2057	627.0	20,378.0	3.9	6,720.3	15.6	738	3,618	17,010
2058	627.0	20,378.0	3.9	6,969.2	15.6	738	3,618	17,010
2059	627.0	20,378.0	3.9	7,218.1	15.6	738	3,618	17,010
2060	627.0	20,378.0	3.9	7,467.0	15.6	738	3,618	17,010

Table D-1g
State of Arizona Users (af)

Calendar Year	Ak-Chin Ind. Comm.	SRPMIC	Havasu NWR	Lower CO River Dam Project	Army Yuma Proving Ground	Navy Marine Corps Yuma Air Station	Univ. Of Arizona	Yuma Mesa Fruit Growers Assn
2008	50,000	22,000	4,841	1	760	2,129	840	12
2009	50,000	22,000	4,841	1	760	2,129	840	12
2010	50,000	22,000	4,841	1	760	2,129	840	12
2011	50,000	22,000	4,841	1	760	2,129	840	12
2012	50,000	22,000	4,841	1	760	2,129	840	12
2013	50,000	22,000	4,841	1	760	2,129	840	12
2014	50,000	22,000	4,841	1	760	2,129	840	12
2015	50,000	22,000	4,841	1	760	2,129	840	12
2016	50,000	22,000	4,841	1	760	2,129	840	12
2017	50,000	22,000	4,841	1	760	2,129	840	12
2018	50,000	22,000	4,841	1	760	2,129	840	12
2019	50,000	22,000	4,841	1	760	2,129	840	12
2020	50,000	22,000	4,841	1	760	2,129	840	12
2021	50,000	22,000	4,841	1	760	2,129	840	12
2022	50,000	22,000	4,841	1	760	2,129	840	12
2023	50,000	22,000	4,841	1	760	2,129	840	12
2024	50,000	22,000	4,841	1	760	2,129	840	12
2025	50,000	22,000	4,841	1	760	2,129	840	12
2026	50,000	22,000	4,841	1	760	2,129	840	12
2027	50,000	22,000	4,841	1	760	2,129	840	12
2028	50,000	22,000	4,841	1	760	2,129	840	12
2029	50,000	22,000	4,841	1	760	2,129	840	12
2030	50,000	22,000	4,841	1	760	2,129	840	12
2031	50,000	22,000	4,841	1	760	2,129	840	12
2032	50,000	22,000	4,841	1	760	2,129	840	12
2033	50,000	22,000	4,841	1	760	2,129	840	12
2034	50,000	22,000	4,841	1	760	2,129	840	12
2035	50,000	22,000	4,841	1	760	2,129	840	12
2036	50,000	22,000	4,841	1	760	2,129	840	12
2037	50,000	22,000	4,841	1	760	2,129	840	12
2038	50,000	22,000	4,841	1	760	2,129	840	12
2039	50,000	22,000	4,841	1	760	2,129	840	12
2040	50,000	22,000	4,841	1	760	2,129	840	12
2041	50,000	22,000	4,841	1	760	2,129	840	12
2042	50,000	22,000	4,841	1	760	2,129	840	12
2043	50,000	22,000	4,841	1	760	2,129	840	12
2044	50,000	22,000	4,841	1	760	2,129	840	12
2045	50,000	22,000	4,841	1	760	2,129	840	12
2046	50,000	22,000	4,841	1	760	2,129	840	12
2047	50,000	22,000	4,841	1	760	2,129	840	12
2048	50,000	22,000	4,841	1	760	2,129	840	12
2049	50,000	22,000	4,841	1	760	2,129	840	12
2050	50,000	22,000	4,841	1	760	2,129	840	12
2051	50,000	22,000	4,841	1	760	2,129	840	12
2052	50,000	22,000	4,841	1	760	2,129	840	12
2053	50,000	22,000	4,841	1	760	2,129	840	12
2054	50,000	22,000	4,841	1	760	2,129	840	12
2055	50,000	22,000	4,841	1	760	2,129	840	12
2056	50,000	22,000	4,841	1	760	2,129	840	12
2057	50,000	22,000	4,841	1	760	2,129	840	12
2058	50,000	22,000	4,841	1	760	2,129	840	12
2059	50,000	22,000	4,841	1	760	2,129	840	12
2060	50,000	22,000	4,841	1	760	2,129	840	12

Table D-1h
State of Arizona Users (af)

Calendar Year	Yuma Union High School	Yuma Cemetery	City Of Yuma	Yuma Irr. Dist.	Unit B IDD	Yuma Mesa IDD	Wellton Mohawk IDD	Kaman Inc.
2008	117	0	25,761	32,648	19,990	159,815	277,997	0
2009	117	0	26,240	32,754	19,882	159,585	277,997	0
2010	117	0	26,718	32,860	19,773	159,354	277,997	0
2011	117	0	27,236	32,860	19,773	159,354	277,997	0
2012	117	0	27,753	32,860	19,773	159,354	277,997	0
2013	117	0	28,271	32,860	19,773	159,354	277,997	0
2014	117	0	28,788	32,860	19,773	159,354	277,997	0
2015	117	0	29,306	32,860	19,773	159,354	277,997	0
2016	117	0	29,823	32,860	19,773	159,354	277,997	0
2017	117	0	30,341	32,860	19,773	159,354	277,997	0
2018	117	0	30,858	32,860	19,773	159,354	277,997	0
2019	117	0	31,376	32,860	19,773	159,354	277,997	0
2020	117	0	31,893	32,860	19,773	159,354	277,997	0
2021	117	0	32,463	32,966	19,686	159,047	277,997	0
2022	117	0	33,034	33,072	19,599	158,739	277,997	0
2023	117	0	33,604	33,178	19,512	158,432	277,997	0
2024	117	0	34,175	33,284	19,425	158,124	277,997	0
2025	117	0	34,745	33,390	19,339	157,817	277,997	0
2026	117	0	35,315	33,496	19,252	157,510	277,997	0
2027	117	0	35,886	33,602	19,165	157,202	277,997	0
2028	117	0	36,456	33,708	19,078	156,895	277,997	0
2029	117	0	37,027	33,814	18,991	156,587	277,997	0
2030	117	0	37,597	33,920	18,904	156,280	277,997	0
2031	117	0	38,193	33,920	18,904	156,280	277,997	0
2032	117	0	38,789	33,920	18,904	156,280	277,997	0
2033	117	0	39,385	33,920	18,904	156,280	277,997	0
2034	117	0	39,981	33,920	18,904	156,280	277,997	0
2035	117	0	40,578	33,920	18,904	156,280	277,997	0
2036	117	0	41,174	33,920	18,904	156,280	277,997	0
2037	117	0	41,770	33,920	18,904	156,280	277,997	0
2038	117	0	42,366	33,920	18,904	156,280	277,997	0
2039	117	0	42,962	33,920	18,904	156,280	277,997	0
2040	117	0	43,558	33,920	18,904	156,280	277,997	0
2041	117	0	43,558	33,920	18,904	156,280	277,997	0
2042	117	0	43,558	33,920	18,904	156,280	277,997	0
2043	117	0	43,558	33,920	18,904	156,280	277,997	0
2044	117	0	43,558	33,920	18,904	156,280	277,997	0
2045	117	0	43,558	33,920	18,904	156,280	277,997	0
2046	117	0	43,558	33,920	18,904	156,280	277,997	0
2047	117	0	43,558	33,920	18,904	156,280	277,997	0
2048	117	0	43,558	33,920	18,904	156,280	277,997	0
2049	117	0	43,558	33,920	18,904	156,280	277,997	0
2050	117	0	43,558	33,920	18,904	156,280	277,997	0
2051	117	0	43,558	33,920	18,904	156,280	277,997	0
2052	117	0	43,558	33,920	18,904	156,280	277,997	0
2053	117	0	43,558	33,920	18,904	156,280	277,997	0
2054	117	0	43,558	33,920	18,904	156,280	277,997	0
2055	117	0	43,558	33,920	18,904	156,280	277,997	0
2056	117	0	43,558	33,920	18,904	156,280	277,997	0
2057	117	0	43,558	33,920	18,904	156,280	277,997	0
2058	117	0	43,558	33,920	18,904	156,280	277,997	0
2059	117	0	43,558	33,920	18,904	156,280	277,997	0
2060	117	0	43,558	33,920	18,904	156,280	277,997	0

Table D-1i
State of Arizona Users (af)

Calendar Year	Gila Monster Farms	Desert Lawn Memorial Park	Alec, Camille	Union Pacific Co.	Ft Mohave Ind. Res.	Ft Yuma Res.	CO Riv. Ind. Res.	Mohave Valley IDD
2008	5,270	155	60	29	67,800	1,178	395,200	3,208
2009	5,270	155	60	29	70,400	1,178	404,600	3,208
2010	5,270	155	60	29	73,000	1,178	414,000	3,208
2011	5,270	155	60	29	73,000	1,178	423,800	3,208
2012	5,270	155	60	29	73,000	1,178	433,600	3,208
2013	5,270	155	60	29	73,000	1,178	443,400	3,208
2014	5,270	155	60	29	73,000	1,178	453,200	3,208
2015	5,270	155	60	29	73,000	1,178	463,000	3,208
2016	5,270	155	60	29	73,000	1,178	463,000	3,208
2017	5,270	155	60	29	73,000	1,178	463,000	3,208
2018	5,270	155	60	29	73,000	1,178	463,000	3,208
2019	5,270	155	60	29	73,000	1,178	463,000	3,208
2020	5,270	155	60	29	73,000	1,178	463,000	3,208
2021	5,270	155	60	29	73,000	1,178	463,000	3,208
2022	5,270	155	60	29	73,000	1,178	463,000	3,208
2023	5,270	155	60	29	73,000	1,178	463,000	3,208
2024	5,270	155	60	29	73,000	1,178	463,000	3,208
2025	5,270	155	60	29	73,000	1,178	463,000	3,208
2026	5,270	155	60	29	73,000	1,178	463,000	3,208
2027	5,270	155	60	29	73,000	1,178	463,000	3,208
2028	5,270	155	60	29	73,000	1,178	463,000	3,208
2029	5,270	155	60	29	73,000	1,178	463,000	3,208
2030	5,270	155	60	29	73,000	1,178	463,000	3,208
2031	5,270	155	60	29	73,000	1,178	463,000	3,208
2032	5,270	155	60	29	73,000	1,178	463,000	3,208
2033	5,270	155	60	29	73,000	1,178	463,000	3,208
2034	5,270	155	60	29	73,000	1,178	463,000	3,208
2035	5,270	155	60	29	73,000	1,178	463,000	3,208
2036	5,270	155	60	29	73,000	1,178	463,000	3,208
2037	5,270	155	60	29	73,000	1,178	463,000	3,208
2038	5,270	155	60	29	73,000	1,178	463,000	3,208
2039	5,270	155	60	29	73,000	1,178	463,000	3,208
2040	5,270	155	60	29	73,000	1,178	463,000	3,208
2041	5,270	155	60	29	73,000	1,178	463,000	3,208
2042	5,270	155	60	29	73,000	1,178	463,000	3,208
2043	5,270	155	60	29	73,000	1,178	463,000	3,208
2044	5,270	155	60	29	73,000	1,178	463,000	3,208
2045	5,270	155	60	29	73,000	1,178	463,000	3,208
2046	5,270	155	60	29	73,000	1,178	463,000	3,208
2047	5,270	155	60	29	73,000	1,178	463,000	3,208
2048	5,270	155	60	29	73,000	1,178	463,000	3,208
2049	5,270	155	60	29	73,000	1,178	463,000	3,208
2050	5,270	155	60	29	73,000	1,178	463,000	3,208
2051	5,270	155	60	29	73,000	1,178	463,000	3,208
2052	5,270	155	60	29	73,000	1,178	463,000	3,208
2053	5,270	155	60	29	73,000	1,178	463,000	3,208
2054	5,270	155	60	29	73,000	1,178	463,000	3,208
2055	5,270	155	60	29	73,000	1,178	463,000	3,208
2056	5,270	155	60	29	73,000	1,178	463,000	3,208
2057	5,270	155	60	29	73,000	1,178	463,000	3,208
2058	5,270	155	60	29	73,000	1,178	463,000	3,208
2059	5,270	155	60	29	73,000	1,178	463,000	3,208
2060	5,270	155	60	29	73,000	1,178	463,000	3,208

Table D-1j
State of Arizona Users (af)

Calendar Year	Parker	North Gila Valley IDD	Yuma County WUA	Powers	Molina	Total State of Arizona
2008	684	19,761	228,211	624	0	2,800,000
2009	693	19,761	228,290	624	0	2,800,000
2010	701	19,761	228,368	624	0	2,800,000
2011	717	19,761	228,368	624	0	2,800,000
2012	734	19,761	228,368	624	0	2,800,000
2013	750	19,761	228,368	624	0	2,800,000
2014	766	19,761	228,368	624	0	2,800,000
2015	783	19,761	228,368	624	0	2,800,000
2016	799	19,761	228,368	624	0	2,800,000
2017	815	19,761	228,368	624	0	2,800,000
2018	831	19,761	228,368	624	0	2,800,000
2019	848	19,761	228,368	624	0	2,800,000
2020	864	19,761	228,368	624	0	2,800,000
2021	871	19,827	227,662	624	0	2,800,000
2022	878	19,893	226,955	624	0	2,800,000
2023	886	19,959	226,249	624	0	2,800,000
2024	893	20,025	225,543	624	0	2,800,000
2025	900	20,091	224,837	624	0	2,800,000
2026	907	20,156	224,130	624	0	2,800,000
2027	914	20,222	223,424	624	0	2,800,000
2028	922	20,288	222,718	624	0	2,800,000
2029	929	20,354	222,011	624	0	2,800,000
2030	936	20,420	221,305	624	0	2,800,000
2031	937	20,420	221,305	624	0	2,800,000
2032	938	20,420	221,305	624	0	2,800,000
2033	939	20,420	221,305	624	0	2,800,000
2034	940	20,420	221,305	624	0	2,800,000
2035	941	20,420	221,305	624	0	2,800,000
2036	941	20,420	221,305	624	0	2,800,000
2037	942	20,420	221,305	624	0	2,800,000
2038	943	20,420	221,305	624	0	2,800,000
2039	944	20,420	221,305	624	0	2,800,000
2040	945	20,420	221,305	624	0	2,800,000
2041	946	20,420	221,305	624	0	2,800,000
2042	948	20,420	221,305	624	0	2,800,000
2043	949	20,420	221,305	624	0	2,800,000
2044	950	20,420	221,305	624	0	2,800,000
2045	952	20,420	221,305	624	0	2,800,000
2046	953	20,420	221,305	624	0	2,800,000
2047	954	20,420	221,305	624	0	2,800,000
2048	955	20,420	221,305	624	0	2,800,000
2049	957	20,420	221,305	624	0	2,800,000
2050	958	20,420	221,305	624	0	2,800,000
2051	958	20,420	221,305	624	0	2,800,000
2052	958	20,420	221,305	624	0	2,800,000
2053	958	20,420	221,305	624	0	2,800,000
2054	958	20,420	221,305	624	0	2,800,000
2055	958	20,420	221,305	624	0	2,800,000
2056	958	20,420	221,305	624	0	2,800,000
2057	958	20,420	221,305	624	0	2,800,000
2058	958	20,420	221,305	624	0	2,800,000
2059	958	20,420	221,305	624	0	2,800,000
2060	958	20,420	221,305	624	0	2,800,000

Table D-2a
State of California Users (af)

Calendar Year	MWD	IID	CVWD	PVID	Ft Mohave Ind. Res.	City Of Needles	Salton Sea	Havasu NWR	Chemehuevi Ind. Res.
2008	767,177	2,817,037	316,448	375,400	8,995	1,223	25,000	0	4,200
2009	739,777	2,812,800	364,000	374,200	8,995	1,223	30,000	0	4,600
2010	747,377	2,793,800	368,000	373,000	8,995	1,223	35,000	0	5,000
2011	752,777	2,774,800	372,000	371,600	8,995	1,223	40,000	0	5,600
2012	758,177	2,754,800	377,000	370,200	8,995	1,223	45,000	0	6,200
2013	763,577	2,714,800	382,000	368,800	8,995	1,223	70,000	0	6,800
2014	758,977	2,689,800	387,000	367,400	8,995	1,223	90,000	0	7,400
2015	754,377	2,664,800	392,000	366,000	8,995	1,223	110,000	0	8,000
2016	754,377	2,639,800	397,000	366,000	8,995	1,223	130,000	0	8,000
2017	754,377	2,615,800	401,000	366,000	8,995	1,223	150,000	0	8,000
2018	784,377	2,717,800	419,000	366,000	8,995	1,223	0	0	8,000
2019	814,377	2,682,800	424,000	366,000	8,995	1,223	0	0	8,000
2020	846,877	2,645,300	429,000	366,000	8,995	1,223	0	0	8,000
2021	859,377	2,627,800	434,000	366,000	8,995	1,223	0	0	8,000
2022	856,877	2,625,300	439,000	366,000	8,995	1,223	0	0	8,000
2023	854,377	2,622,800	444,000	366,000	8,995	1,223	0	0	8,000
2024	854,377	2,617,800	449,000	366,000	8,995	1,223	0	0	8,000
2025	854,377	2,612,800	454,000	366,000	8,995	1,223	0	0	8,000
2026	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2027	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2028	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2029	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2030	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2031	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2032	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2033	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2034	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2035	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2036	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2037	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2038	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2039	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2040	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2041	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2042	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2043	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2044	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2045	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2046	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2047	854,377	2,607,800	459,000	366,000	8,995	1,223	0	0	8,000
2048	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2049	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2050	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2051	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2052	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2053	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2054	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2055	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2056	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2057	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2058	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2059	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000
2060	854,377	2,610,800	456,000	366,000	8,995	1,223	0	0	8,000

Table D-2b
State of California Users (af)

Calendar Year	Others & Misc. PPRs	Imperial NWR	CO Riv. Ind. Res.	AAC Yuma Project Bard Unit	AAC Yuma Project Res. Unit Quechan	California Pumpers	Other Pumpers Below NIB	Total State of California
2008	1,605	0	15,000	18,000	26,600	0	0	4,376,685
2009	1,605	0	17,000	18,000	27,800	0	0	4,400,000
2010	1,605	0	19,000	18,000	29,000	0	0	4,400,000
2011	1,605	0	23,000	18,000	30,400	0	0	4,400,000
2012	1,605	0	27,000	18,000	31,800	0	0	4,400,000
2013	1,605	0	31,000	18,000	33,200	0	0	4,400,000
2014	1,605	0	35,000	18,000	34,600	0	0	4,400,000
2015	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2016	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2017	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2018	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2019	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2020	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2021	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2022	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2023	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2024	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2025	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2026	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2027	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2028	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2029	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2030	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2031	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2032	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2033	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2034	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2035	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2036	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2037	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2038	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2039	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2040	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2041	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2042	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2043	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2044	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2045	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2046	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2047	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2048	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2049	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2050	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2051	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2052	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2053	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2054	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2055	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2056	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2057	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2058	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2059	1,605	0	39,000	18,000	36,000	0	0	4,400,000
2060	1,605	0	39,000	18,000	36,000	0	0	4,400,000

Table D-3
State of Nevada Users (af)

Calendar Year	Laughlin M&I	Mohave Steam Plant	Ft Mohave Ind. Res.	Moapa Valley WQIP	Lower Virgin WQIP	SNWP	Total State of Nevada
2008	4,000	16,000	9,000	0	0	271,000	300,000
2009	4,000	16,000	9,000	0	0	271,000	300,000
2010	4,000	16,000	9,000	0	0	271,000	300,000
2011	4,000	16,000	9,000	0	0	271,000	300,000
2012	4,000	16,000	9,000	0	0	271,000	300,000
2013	4,000	16,000	9,000	0	0	271,000	300,000
2014	4,000	16,000	9,000	0	0	271,000	300,000
2015	4,000	16,000	9,000	0	0	271,000	300,000
2016	4,000	16,000	9,000	0	0	271,000	300,000
2017	4,000	16,000	9,000	0	0	271,000	300,000
2018	4,000	16,000	9,000	0	0	271,000	300,000
2019	4,000	16,000	9,000	0	0	271,000	300,000
2020	4,000	16,000	9,000	0	0	271,000	300,000
2021	4,000	16,000	9,000	0	0	271,000	300,000
2022	4,000	16,000	9,000	0	0	271,000	300,000
2023	4,000	16,000	9,000	0	0	271,000	300,000
2024	4,000	16,000	9,000	0	0	271,000	300,000
2025	4,000	16,000	9,000	0	0	271,000	300,000
2026	4,000	8,000	9,000	0	0	279,000	300,000
2027	4,000	0	9,000	0	0	287,000	300,000
2028	4,000	0	9,000	0	0	287,000	300,000
2029	4,000	0	9,000	0	0	287,000	300,000
2030	4,000	0	9,000	0	0	287,000	300,000
2031	4,000	0	9,000	0	0	287,000	300,000
2032	4,000	0	9,000	0	0	287,000	300,000
2033	4,000	0	9,000	0	0	287,000	300,000
2034	4,000	0	9,000	0	0	287,000	300,000
2035	4,000	0	9,000	0	0	287,000	300,000
2036	4,000	0	9,000	0	0	287,000	300,000
2037	4,000	0	9,000	0	0	287,000	300,000
2038	4,000	0	9,000	0	0	287,000	300,000
2039	4,000	0	9,000	0	0	287,000	300,000
2040	4,000	0	9,000	0	0	287,000	300,000
2041	4,000	0	9,000	0	0	287,000	300,000
2042	4,000	0	9,000	0	0	287,000	300,000
2043	4,000	0	9,000	0	0	287,000	300,000
2044	4,000	0	9,000	0	0	287,000	300,000
2045	4,000	0	9,000	0	0	287,000	300,000
2046	4,000	0	9,000	0	0	287,000	300,000
2047	4,000	0	9,000	0	0	287,000	300,000
2048	4,000	0	9,000	0	0	287,000	300,000
2049	4,000	0	9,000	0	0	287,000	300,000
2050	4,000	0	9,000	0	0	287,000	300,000
2051	4,000	0	9,000	0	0	287,000	300,000
2052	4,000	0	9,000	0	0	287,000	300,000
2053	4,000	0	9,000	0	0	287,000	300,000
2054	4,000	0	9,000	0	0	287,000	300,000
2055	4,000	0	9,000	0	0	287,000	300,000
2056	4,000	0	9,000	0	0	287,000	300,000
2057	4,000	0	9,000	0	0	287,000	300,000
2058	4,000	0	9,000	0	0	287,000	300,000
2059	4,000	0	9,000	0	0	287,000	300,000
2060	4,000	0	9,000	0	0	287,000	300,000

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Appendix E

Colorado River Water Entitlement Priority Systems within Arizona, California, and Nevada

This appendix contains tables that list the Colorado River water entitlement holders within Arizona, California, and Nevada. One table is provided for each state. The entitlement priority system for each of the three Lower Division states is also shown in each respective table. The priorities presented in this appendix are based on the contractual arrangements between each entity and Reclamation, as well as key provisions of the Law of the River, including the Consolidated Decree.

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Table E-1
State of Arizona Colorado River Water Entitlement Holders and Priorities

Priority	Entitlement Holder	Contract No.	Date	Use	Entitlement Diversion	Entitlement CU
Surplus	Cibola Valley Irrigation & Drainage District (CVIDD)	2-07-30-W0028	1983	6	2,000	
	Gila Monster Farms	6-07-30-W0337	1997	6	request	
	Hopi Tribe	04-XX-30-W0432	2004	6	1,000	
	Mohave County Water Authority (Acquired From CVIDD)	04-XX-30-W0431	2004	6	1,000	
	TOTAL				4,000	
Bank	Central Arizona Water Conservation District (CAP)	14-06-W-245	1972	bank	AZ Balance	
	TOTAL				AZ Balance	
5th – Unused Apportionment	Arizona Public Service Company (formerly Yucca Power Plant)	6-07-30-W0336	2000	5 or 6	1,500	
	Arizona State Land Department	4-07-30-W0317	1999	5 or 6	9,067.2	
	Cibola Valley Irrigation & Drainage District (CVIDD)	2-07-30-W0028	1983	5	1,500	
	Gila Monster Farms	6-07-30-W0337	1997	5	656	
	Hopi Tribe	04-XX-30-W0432	2004	5	750	
	Lake Havasu City	3-07-30-W0039	1995	5 or 6	not specified******	
	Marble Canyon Company, Inc.	5-07-30-W0322	1996	5 or 6	not specified******	
	Mohave County Water Authority (Acquired From CVIDD)	04-XX-30-W0431	2004	5	750	
	Mohave County Water Authority (3500 af of 5/6 priority recommended for 4th priority)	5-07-30-W0320	1995	5 or 6	3500 5/6 + upon request	
	Subcontract to Arizona-American (750 AF)**					
	Subcontract to MVIDD (600 AF)**					
	City of Parker	2-07-30-W0025	1998	5 or 6	2,000	
	TOTAL				16,223	0
4th	Arizona State Land Department	7-07-30-W0358	2004	M&I	1,534	
	Arizona State Land Department	4-07-30-W0317	1999	Ag	6,607	
	Arizona State Parks Board - Contact Point	(Recommendation)		M&I	20	
	Arizona State Parks Board - Windsor Beach	7-07-30-W0364	1998	M&I	90	
	Arizona-American Water Company	00-XX-30-W0391	2001	M&I	1,420	
	B&F Investment, LLC	06-XX-30-W0453	2006	M&I	60	
	Beattie Farms Southwest	06-XX-30-W0446	2006	Ag	1,110	
	Brooke Water Company (formerly Graham) (+ recommendation of 120 af)	4-07-30-W0042	1983	M&I	320	
	Bullhead City	2-07-30-W0273	1982	M&I	15,210	
	Bureau of Land Management	8-07-30-W0373	1973/81/87	M&I		4,010
	Central Arizona Water Conservation District (CAP)	14-06-W-245	1972	M&I/Ag/Ind.	1,490,000	
	ChaCha (Curtis Family Trust) (Auza Farm and West Farm)	(Recommendation)		Ag	2,100	
	Cibola Valley Irrigation & Drainage District (M&I: 300af)	2-07-30-W0028	1983	M&I/Ag	12,066	
	City of Somerton	03-XX-30-W0419	2006	M&I	750	
	City of Yuma (Smucker Park)	14-06-303-2702	1969	M&I	33	
	Cocopah Indian Reservation	1974 Decree	1974	Ind.	2,026	
	Crystal Beach Water Conservation District	6-07-30-W0352	1997	M&I	132	
	Curtis, Armon (Curry Family LTD)	3-07-30-W0037	1983	Ag	300	
	Desert Lawn Memorial Park Association, Inc.	14-06-300-2587	1975	M&I	360	
	Ehrenburg Improvement District	8-07-30-W0006	1977	M&I	500	

Table E-1
State of Arizona Colorado River Water Entitlement Holders and Priorities

Priority	Entitlement Holder	Contract No.	Date	Use	Entitlement Diversion	Entitlement CU
4th	Fisher's Landing Water and Sewer Works, LLC	(Recommendation)		M&I	53	
	Gila Monster Farms (formerly Sturges Farms Inc.)	6-07-30-W0337	1997	Ag	1,435	
	Gold Dome Mining Corporation	0-07-030-W0250	1990	M&I	7	
	Gold Standard Mines Corporation	3-07-30-W0038	1983	M&I	75	
	Golden Shores Water Conservation District	9-07-30-W0203	1989	M&I	2,000	
	Hillcrest Water Company	5-07-30-W0078	1985	M&I	84	
	Hopi Tribe	04-XX-30-W0432	2004	Ind.	5,997	
	Jessen Family Limited	(Recommendation)		Ag	1,080	
	Lake Havasu City	3-07-30-W0039	1995	M&I	19,180	
	Marble Canyon Company, Inc.	5-07-30-W0322	1996	M&I	70	
	Martinez Lake Cabin Sites	(Recommendation)		M&I	23	
	McAlister, Maurice L.	7-07-30-W0355	1998	M&I	40	
	Mohave County Water Authority (Aquired From Cibola)	04-XX-30-W0431	2004	Ag	5,997	
	Mohave County Water Authority (+ recommendation 3,500 of 5/6 priority, to be total of 18,500)	5-07-30-W0320	1968	M&I	15,000	
	Subcontract to Bullhead City (6,000 AF)**			M&I		
	Subcontract to Lake Havasu City (6,000 AF)**			M&I		
	Subcontract to Mohave Water Cons. Dist. (3,000 AF)**			M&I		
	Mohave Valley Irrigation and Drainage District (5,000af M&I)	14-06-W-204	1968	M&I/Ag	35,060	
	Mohave Water Conservation District	9-07-30-W0012	1968	M&I	1,800	
	North Baja LLC (formerly Jamar Produce) (72af M&I)	5-07-30-W0066	1984	M&I/Ag	480	
	Ogram Boys Enterprises	1-XX-30-W0402	2005	Ag	924	
	Ogram, George	01-XX-30-W0398	2003	Ag	480	
	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	5-07-30-W0065	1986	Ag	486	
	Peach, John	(Recommendation)		Ag	456	
	Phillips, Milton and Jean	(Recommendation)		Ag	18	
	Rayner Ranches	5-07-30-W0064	1984	Ag	4,500	
	Reserved Secretary Water for Indian Settlements				3,500	
	Roy, Edward P. & Anna R.	6-07-30-W0124	1986	M&I	1	
	Shepard Water Company	(Recommendation)		M&I	50	
	City of Parker	2-07-30-W0025	1998	M&I	1,030	
	Town of Quartzsite	7-07-30-W0353	1999	M&I	1,070	
	Verizon (formerly Continental Telephone)	14-06-300-2506	1974	M&I	1	
	Unallocated Priority 4 Water					
	TOTAL				1,635,535	4,010
2nd & 3rd (co-equal)	Cibola National Wildlife Refuge	Secretarial Res.	8/21/1964	M&I	34,500	16,793
	Yuma Irrigation District (5,000af M&I)	14-06-300-1270	1962	M&I/Ag		67,278
	National Park Service	1964 Decree	1961	M&I	unquantified******	
	Yuma Union High School	14-06-303-179	1960	M&I	200	
	Union Pacific Railroad (formerly Southern Pacific Co.)	14-06-303-1524	12/21/1959	M&I	48	
	Kaman, Inc.	14-06-303-1555	12/2/1959	M&I	2	
	City of Yuma	14-06-W-106	11/12/1959	M&I		48,522

Table E-1
State of Arizona Colorado River Water Entitlement Holders and Priorities

Priority	Entitlement Holder	Contract No.	Date	Use	Entitlement Diversion	Entitlement CU
2nd & 3rd (co-equal)	Department of Navy MCAS	14-06-300-937	1/1/1959	M&I	3,000	
	Yuma County Water Users' Association (14,701af M&I)	14-06-300-621 & Certificates	1957	M&I/Ag	unquantified******	
	Yuma Area Office (489.95af M&I Conversion)				490	
	City of Yuma (cemetary)	14-06-303-1078	11/12/1956	M&I	60	
	Yuma Mesa Fruit Growers	14-06-303-1196	10/1/1956	Ag	15	
	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	14-06-W102	5/26/1956	M&I/Ag		141,519
	Desert Lawn Memorial Park	14-06-300-1079	5/1/1956	M&I	200	
	Ak-Chin Indian Community****	AK-CHIN121180A	1/1/1956	Ind.	50,000	
	University of Arizona	14-06-300-144	1954	Ag	1,088	
	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	14-06-303-528	12/23/1953	Ag	120	
	North Gila Valley Irrigation District (2,500af M&I)	14-06-W-54	3/12/1953	M&I/Ag		41,203
	Yuma Auxiliary Project (Unit B)	14-06-300-44	12/22/1962	Ag	unquantified******	
	Wellton-Mohawk Irrigation and Drainage District (5,000af M&I)	1-07-30-W0021	3/4/1952	M&I/Ag		278,000
	Chandler (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	4,278	
	Gilbert (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	6,762	
	Glendale (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	3,000	
	Mesa (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	2,760	
	Phoenix (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	5,000	
	Scottsdale (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	100	
	Tempe (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	100	
	Gila Monster Farms (formerly Sturges)	6-07-30-W0337	1/1/1952	Ag	6,285	
	Sturges, Harold	I76R-733	1/1/1952	Ag	335	
	Sturges, Irma	I76R-735	1/1/1952	Ag	385	
	Department of Army - Yuma Proving Ground	I76r-696	1951	M&I	1,129	
	Bureau of Reclamation - Davis Dam	Secretarial Res.	4/26/1941	M&I	100	
	Imperial National Wildlife Refuge	1964 Decree	2/14/1941	M&I	28,000	23,000
	Havasu Lake National Wildlife Refuge	1964 Decree	1/22/1941	M&I	41,839	37,399
	TOTAL				189,796	653,714
1st (PPR's)****	Molina	PPR No. 15	1928	Ag	318	
	Gila Monster Farms (formerly Sturges)	PPR No. 16	1925	Ag	780	
	Cocopah Indian Reservation	PPR No. 1	9/27/1917	Ind.	7,681	
	Cocopah Indian Reservation	PPR No. 8	1915	Ind.	1,140	
	Powers (Power, R.E. & P.)	PPR No. 7	1915	Ag	960	
	Zozaya (in MVIDD)	PPR No. 17	1912	Ag	720	
	Fort Mohave Indian Reservation	PPR No. 3	2/2/1911	Ind.	75,566	
	Brooke Water Company (formerly Graham)	PPR No. 9	1910	M&I	360	
	North Gila Valley Irrigation District****	PPR No. 6	7/8/1905	Ag	24,500	
	Yuma Auxiliary Project (Unit B)	PPR No. 5 & Certificates	7/8/1905	Ag	6,800	
	City of Parker	PPR No. 20	1905	M&I	630	400
	Hoover (in MVIDD/formerly Hopal)	4-07-30-W0052/PPR 11	1902	Ag	1,050	

Table E-1
State of Arizona Colorado River Water Entitlement Holders and Priorities

Priority	Entitlement Holder	Contract No.	Date	Use	Entitlement	
					Diversion	CU
1st (PPR's)****	Hulet (in MVIDD)	PPR No. 10	1902	Ag	1,080	
	Miller (in MVIDD)	PPR No. 12	1902	M&I	240	
	McKellips and Granite Reef Farms (in MVIDD)	PPR No. 13	1902	Ag	810	
	Sherill & Lafollette (in MVIDD)	PPR No. 14	1902	Ag	1,080	
	Swan (in MVIDD)	PPR No 18	1902	M&I	960	
	Yuma County Water Users' Association	PPR No. 4 & Certificates	1901	Ag	254,200	
	Phillips, Milton and Jean	PPR No. 19	1900	Ag	42	
	City of Yuma	PPR No. 21	1893	M&I		1,478
	Fort Mohave Indian Reservation	PPR No. 3	9/18/1890	Ind.	27,969	
	Fort Yuma Indian Reservation	PPR No. 3a	1/9/1884	Ind.	6,350	
	Colorado River Indian Reservation	PPR No. 2	11/16/1874	Ind.	51,986	
	Colorado River Indian Reservation	PPR No. 2	11/22/1873	Ind.	252,016	
	Colorado River Indian Reservation	PPR No. 2	3/3/1865	Ind.	358,400	
	TOTAL				1,075,638	1,878

*Note: CU means Consumptive Use; all units are in AFY.
**Leases are displayed below the Entitlement Holder and indented five spaces.
***Salt River Exchange cities and the Ak-Chin Indian Community values are subjust to CAP conveyance losses which are assumed to be 5%.
****PPR's are reduced last in the region, in order of priority date, regardless of state lines.

Table E-2
State of California Colorado River Water Entitlement Holders and Priorities

Priority	Entitlement Holder	Contract No.	Date	Use	Entitlement	
					Diversion	CU
Surplus	Bureau of Land Management	8-07-30-W0374	1973	M&I	1,000	
	City of Needles	5-07-30-W0091	1985	M&I	10,000	
	Coachella Valley Water District	7-07-30-W0150	1987	M&I/Ag	100,000	
	Department of the Navy	6-07-30-W0351	1999	M&I	23	
	Metropolitan Water District	7-07-30-W0171	1987	M&I	180,000	
	TOTAL				291,023	
7th- Unused & Surplus	Coachella Valley Water District (6a)	I1r-781	1934	Ag		
	Imperial Irrigation District (6a)	I1r-747	1932	Ag		300,000
	Palo Verde Irrigation District (6b) - Mesa Lands	PVID20733C	1933	Ag		
	TOTAL					300,000
6th- Unused & Surplus	San Diego County Water Authority (5b) (transferred right to MET)	I1r-1151	1934	M&I		
	Metropolitan Water District (5a) (Annexed 5b's Entitlement)	I1r-645	1931	M&I		662,000
	TOTAL					662,000
5th	Metropolitan Water District (4)	I1r-645	1931	M&I		550,000
	TOTAL				0	550,000
4th	Palo Verde Irrigation District (3b) - Mesa Lands	PVID20733C_P5	1933	Ag	<16,000 acres	0
	Coachella Valley Water District (3a)	I1r-781	1934	Ag		347,000
	Imperial Irrigation Districts (3a)*	I1r-747	1932	Ag		561,159
	Metropolitan Water District	1988 Cons. Agreement	1988	M&I		90,000
	San Diego County Water Authority	SDCWA Transfer		M&I		30,000
	TOTAL					908,159
3rd	Yuma Project, Reservation Division (includes Bard, Indian, Island)	Water Certificates	1905	Ind./Ag	<25,000 acres	
	TOTAL				0	0
2nd	Palo Verde Irrigation District (1)	PVID20733C_P2	1933	Ag	unlimited	
	TOTAL				0	0
1st (PPR's)**	One Acre PPR's	PPR's 45-80	1895-1928	M&I	36	22
	Sonny Gowan (Grannis)	PPR 32 & 7-07-30-W0158	1928	Ag	180	
	Chagnon	PPR No. 41	1925	Ag	120	
	Stephenson	PPR No. 30	1923	Ag	240	
	Colorado River Sportsmen's League	PPR No. 36	1921	Ag	96	
	Andrade (AKA Andrade, Andrews, Bly, Brown, Carney, Daniel, Fairbanks, Glynn, Lindeman, Leon, Schroeder, Sherman, Perrett, Wetmore, Wetmore, Williams)	PPR No. 38	1921	M&I/Ag	66	
	Milpitas	PPR No. 34	1918	Ag	108	
	Lawrence	PPR No. 42	1915	Ag	120	
	Milpitas	PPR No. 37	1914	Ag	69	
	Morgan	PPR No. 33	1913	Ag	150	
	Chemehuevi Indian Reservation	PPR No. 22	2/2/1907	Ind.	11,340	
	Cooper	PPR No. 40	1905	Ag	60	
	Yuma Project, Reservation Division (includes non-Indian/Island)	PPR 28 & Water Cert.	1905	Ind./Ag	38,270	
	Reynolds	PPR No. 39	1904	Ag	36	

Table E-2
State of California Colorado River Water Entitlement Holders and Priorities

Priority	Entitlement Holder	Contract No.	Date	Use	Entitlement Diversion	Entitlement CU
1st (PPR's)**	Imperial Irrigation District (includes lands in CVWD)	PPR No. 27	1901	Ag	2,600,000	
	Atchison, Topeka, and Santa Fe Railway Co. (being assigned to Needles)	PPR No. 44	1896	M&I	1,260	273
	Picacho Development Corp and CA Dept of Parks and Rec	PPR 31 & 8-07-30-W0187	1893	Ag	120	
	Fort Mohave Indian Reservation	PPR No. 25	9/18/1890	Ind.	16,720	
	Simons	PPR No. 35	1889	Ag	60	
	City of Needles	PPR No. 43/5-XX-30-W0445	1885	M&I	1,500	950
	Fort Yuma Indian Reservation	PPR No. 23	1/9/1884	Ind.	71,616	
	Palo Verde Irrigation District	PPR No. 26	1877	Ag	219,780	
	Colorado River Indian Reservation	PPR No. 24	5/15/1876	Ind.	5,860	
	Colorado River Indian Reservation	PPR No. 24	11/16/1874	Ind.	40,241	
	Colorado River Indian Reservation	PPR No. 24	10/22/1873	Ind.	10,745	
	Yuma Associates LTD and Winterhaven Water District (262.8 M&I)	PPR 29 & 4-07-30-W0053	1856	M&I/Ag	780	
	TOTAL				3,019,573	1,245

Note: CU means Consumptive Use; all units are in AFY.
Leases are displayed below the Entitlement Holder and indented five spaces.
*IID's PPR protects 2,600,000 acre-feet of it's Seven Party 4th Priority Entitlement. Therefore the 4th priority entitlement is reduced the the PPR right and an 11,500af reduction agreed to in the QSA for the tribes. It is assumed that IID QSA agreements retain a 4th priority right. Of the 561,159af remaining 4th priority right, MWD receives 90,000af and San Diego receives 30,000 acre-feet.
**PPR's are reduced last in the region, in order of priority date, regardless of state lines.
These priorities are based on the California Seven Party Agreement, modified to include the PPR's identified by the Consolidated Decree

Table E-3
State of Nevada Colorado River Water Entitlement Holders and Priorities

Priority	Entitlement Holder	Contract No.	Date	Use	Entitlement Diversion	Entitlement CU
8th – Balance & Surplus	Southern Nevada Water Authority (includes banking)	2-07-30-W0266	1992	M&I	balance + surplus	
	TOTAL					
8th ***	Big Bend Water District	2-07-30-W0269	1992	M&I	10,000	
	Southern Nevada Water Authority (Griffith Project)	7-07-30-W0004	1992	M&I	304,000	
	Sub. to City of Boulder City (8,918af)			M&I		
	Sub. to City Henderson (27,021af)			M&I		
	Sub. to City of North Las Vegas (26635af)			M&I		
	Sub. to Las Vegas Valley Water District (232,426af)			M&I		
	TOTAL				314,000	0
7th	Boy Scouts of America (annexed by SNWA)	9-07-30-W0011	1978	M&I	10	
	Bureau of Reclamation (includes Sportsman Park)	Secretarial Res.	1998	M&I	300	
	Nevada Dept. of Fish & Game, & NV Dept. of Wildlife	14-06-300-2405	1972	M&I		25
	U.S. Air Force (4,000af) (Delivered by SNWA)				4,000	
	TOTAL				310	25
6th	Las Vegas Valley Water District	14-06-300-2130	1969	M&I	15,407	
	TOTAL				15,407	0
5th	Lakeview Company (Hacienda Casino)****	14-06-300-1523	1965	M&I	0	
	Pacific Coast Building Products, Inc. (PABCO)	5-07-30-W0089	1965	M&I	928	
	TOTAL				928	0
4th	Basic Management, Inc.	14-06-300-2083	1969	M&I	8,608	
	City of Henderson	0-07-30-W0246	1967	M&I	15,878	
	TOTAL				24,486	0
3rd	Boulder City	14-06-300-978	1931	M&I	5,876	
	TOTAL				5,876	0
2nd	Lake Mead National Recreation Area	1964 Decree	1930	M&I	unlimited	
	TOTAL				0	0
1st **	Lake Mead National Recreation Area	PPR 82/1979 Decree	1926	M&I	500	300
	Fort Mohave Indian Reservation	PPR 81	1890	Ind.	12,534	
	TOTAL				13,034	0

Note: CU means Consumptive Use. All units are in acre-feet per year.
Leases are displayed below the Entitlement Holder and indented five spaces.
*PPR's are reduced last in the region, in order of priority date, regardless of state lines.

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Appendix F

Water Quality Modeling Documentation

This appendix contains the documentation for the modeling and analyses performed to evaluate the potential effects on water quality constituents of concern. Three different models were used to evaluate different water quality parameters and each is described in this appendix. The salinity module of the CRSS RiverWare™ model was used to evaluate changes in salinity concentrations for all alternatives. The CRSS RiverWare™ model is described in Appendix A. The CE-QUAL-W2 model and the GEMSS model were used to evaluate potential changes in temperature and water quality corresponding with reservoir draw down and respective reservoir releases. The results of the modeling and evaluation of these water quality parameters are described in Section 4.5.

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F.1 Salinity Modeling Using the Salinity Module of the CRSS RiverWare™ Model - Model and Approach Description

F.1.1 Model Description (Salinity Module of the CRSS RiverWare™ Model)

Salinity is the only water quality parameter modeled in CRSS. It is modeled as a conservative substance; therefore, dissolution and precipitation are not modeled. As with the hydrology component, salinity is modeled at a monthly time step and both reservoir and reach objects are assumed fully mixed over the month; thereby, requiring no lagging algorithms to route salt.

Seven of the twelve reservoirs (Flaming Gorge, Starvation, Navajo, Powell, Mead, Mohave, Havasu) are represented in CRSS model salinity. The reservoirs Flaming Gorge, Navajo, Powell, Mead, and Mohave use a Huen or Predictor-Corrector numerical method to route salinity through the reservoirs. The reservoirs Starvation and Havasu use a weighting method developed by Reclamation that facilities routing salinity in a reservoir that has a small storage to inflow ratio. Under this scenario standard numeric methods, such as the Huen method, can become numerically unstable. Both methods assume the reservoirs are fully mixed at a monthly time step. Flaming Gorge, Powell, and Mead include salinity in their bank storage computation. Water flows into the bank at the current time step concentration and fully mixes with the “bank” water. Water flows out of the “bank” at the current time step “bank” concentration.

Salt can enter the river system from either a natural source, salt loading resulting from irrigated agriculture return flows, or from flows imported into the system. Salt can leave the system from flows exported out of the system. Additionally, water quality improvement projects represent salt prevented from entering the system as the result of salinity control measures.

F.1.2 Input data

The CRSS salinity component requires several salinity specific data inputs. These include natural salinity at 24 nodes throughout the Colorado River System, future levels of salt loading resulting from agriculture, the concentration of exported and imported flows, future levels of salinity control, and initial reservoir salinity concentrations.

Salinity associated with the available natural flow data (described in Section 3.3) is computed with a single site salinity model presented in Prairie et al. (2005). This model uses a nonparametric regression method based on local polynomial estimation, which describes the variability of salt mass as a function of flow. The model is defined as: natural salt mass = f(natural streamflow) The main feature is that the function f is estimated locally (Loader 1999). The implementation steps are as follows.

1) At any value of the streamflow, say x*, K-nearest neighbors (K-NN) are identified from the observations.

2) To the K-NN a polynomial of order p is fit.

3) The fitted polynomial is then used to estimate the salt mass corresponding to the streamflow x*.

The number of nearest neighbors (K) and the order of polynomial p are estimated for the observed data using objective criteria, Generalized Cross Validation (GCV). The local estimation of the function f provides the capability to capture any arbitrary features (linear or nonlinear) that might be present in the data; besides, this obviates making any assumptions as to the underlying form of the function f (linear in the case of traditional linear regression approach). Prairie et al. (2005) provides details on the methodology and its development for salinity modeling.

Natural salt mass, required in compute the flow-salt regressions, is computed by removing anthropogenic influences (upstream reservoir regulation, salt loading from agriculture return flows, and salt removed with exports) affecting salt from observed historic data. Natural salt mass data from 1971-1995 were used for the 15 Upper Basin gauges, matching the time period used in the 2005 Triennial Review. The 9 Lower Basin gauges were modeled based on 1971-2004 natural salt mass data. Once the monthly regression relationships were determined for each gauge the associated natural salt for the natural flows from 1906-2004 are computed.

Salt loading resulting from agriculture is available at an annual time step and disaggregated to monthly values for modeling purposes. The concentrations of exported and imported flows are developed from available historic data at each export location and held constant through time. Future levels of salinity control are estimated from hydro-salinity studies performed for each salinity control project. Initial reservoir salinity concentrations were set based on the latest historic values available. These are the December 2005 values reported by the USGS with the exception of Davis and Parker Dam, which were assumed to be equivalent to Mead concentration since a December 2005 value is not available.

F.1.3 Calibration

To ensure the regressions properly capture the flow-salt relationship the regressions used to determine natural salt based on the 1971-1995 natural flows is input in a CRSS based model. The model is run with historic data representing salt loading from agriculture, concentration of exported flows, levels of salinity control, and initial reservoir salinity concentrations for the time period 1971-1995. If the simulated historic salinity concentrations below Powell and above Imperial Dam compare well with the actual historic salinity at these locations the model is properly calibrated. An example of this is shown in Prairie and Callejo (2005).

F.1.4 Limitations

Since the regression relationship between flow and salt is based a post-1971 values future projections are limited to simulating the post-1971 flow and salt relationship. A changing relationship cannot be modeled.

Limited data is available describing the monthly salt loading resulting from agriculture. Annual estimates are disaggregated for modeling purposes and monthly salinity results are typically aggregated to an annual time step before analysis of results. The variability of annual salt loading resulting from agriculture is not well understood; therefore, the annual estimate is held constant over all years. This assumption forces the variability in agricultural salt loading to be back computed into the natural salt mass. Therefore, it is important to recognize that the natural salt mass, as well as the natural flow, is NOT only what would naturally have occurred throughout the basin without anthropogenic effects. It also incorporates the error in any assumptions or in the accuracy of our estimates of the anthropogenic effects that we removed from the historic gauge records.

Lastly, the CRSS salinity component is generally intended for long-term modeling (15-20 years) and reservoir salinity is highly sensitive to initial reservoir conditions for the first 10-12 years. More accurately determining initial reservoir conditions will greatly improve the accuracy of the first 10-12 years of results. After these first 10-12 years the initial conditions have minimal impact on model results.

F.2 Reservoir Modeling Using CE-QUAL-W2 Water Quality Model - Model and Approach Description

F.2.1 Model Description (CE-QUAL-W2 Model)

CE-QUAL-W2 is a two dimensional, longitudinal/vertical, hydrodynamic, and water quality model. Because the model assumes lateral homogeneity, it is best suited for relatively long and narrow waterbodies exhibiting longitudinal and vertical water quality gradients (Cole 2003). Development and evolution of CE-QUAL-W2 has spanned three decades. The U.S. Army Corp of Engineers (USACE), J.E. Edinger and Associates (Edinger), and Dr. Scott Wells at Portland State University working with Mr. Tom Cole (USACE) have been the major developers in recent years. J.E. Edinger and Associates were contracted by the Upper and Lower Regions of the U.S. Bureau of Reclamation to test the earliest version of this model (LARM) in 1980 on Lake Powell and Lake Mead. All of the above have been helpful and provided some insight on the development of this application.

F.2.2 Model Capabilities & Limitations

The CE-QUAL-W2 model is capable of predicting water surface elevations, velocities, temperatures, and a number of water quality constituents. Water is routed through cells in a computational grid where each cell acts as a completely mixed reactor for each time step. Geometrically complex waterbodies can be represented through multiple branches and cells. Multiple inflows and outflows to the waterbody are represented through point/nonpoint sources, branches, precipitation, and other methods. Tools for modeling hydraulic structures such as spillways and pipes are available. Output from the model provides options for detailed and convenient analyses.

The model uses several assumptions and approximations to simulate hydrodynamics, transport, and water quality processes. The model solves for gradients in the longitudinal and vertical directions and assumes lateral gradients are negligible. This assumption may be inappropriate for waterbodies with significant lateral variations. Turbulence is modeled through eddy coefficients of which the user must decide which scheme is most appropriate for an application. An algorithm for vertical momentum is not included and results may be inaccurate in waterbodies with significant vertical acceleration. Water quality processes are extremely complex and the model uses simplified approaches to reach solutions. Several water quality processes are not simulated including zooplankton, macrophytes, and a dynamic sediment oxygen demand.

F.2.3 Input Data

The model is limited by the quality and availability of input data. This includes meteorological, inflow and outflow, water temperature, water quality, and calibration data. These data most often determine the accuracy and usefulness of the application.

F.2.4 Bathymetry

The bathymetry file of a CE-QUAL-W2 model is the two-dimensional numeric representation of a waterbody and is also referred to as the computational grid. The two dimensions represented are the longitudinal and vertical dimensions, or the length and depth of a waterbody which are divided into longitudinal segments and vertical layers. The lateral dimension, or width, is not represented in the grid but an average width is computed and used to determine volume. Since the model grid is two-dimensional all modeled parameters such as temperature, velocity, and water quality constituents can only vary in the longitudinal and vertical directions. This assumes that modeled parameters do not vary significantly in the lateral direction. This assumption has been found appropriate in relatively long and narrow waterbodies.

The components of the grid are, from smallest to largest, cells, segments, branches, and waterbodies. The cell is a single vertical layer within a single segment. Segments consist of one or more cells, branches are one or more longitudinal segments, and a waterbody is one or more branches. Bathymetry files are dimensions from a single waterbody.

The volume of the grid is computed by multiplying a cell’s length, thickness, and width. The sum of all cells within the grid is then the total storage for the waterbody. The computational grid storage is compared to actual storage-capacity charts to verify the model bathymetry accuracy.

F.2.5 Model Calibration

Model calibration involves comparing observed data to modeled, or predicted, results. The observed values are typically vertical profile and reservoir discharge observations for temperature and other water quality parameters. Calibration statistics are generated by computing the absolute mean error (AME). This computation is the sum of the absolute value of the predicted value minus the observed value, which is then divided by the total number of observations. This describes, on average, the difference between predicted and observed values.

F.2.6 Code Modifications

The unique chemical fingerprinting in Lake Powell with the build up of saline water, reservoir turn over and routing of the salt presents a unique data base to test the mixing algorithms of various models. The original WRE one-dimensional model, LARM, and earlier versions of CE-QUAL-W2 all completely mixed the reservoir each year, and thus multi-year runs were not possible. These models all fairly represented temperatures of the releases from the dam to test selective withdrawal alternatives. The version of CE-QUAL-W2 being utilized for this analysis is 3.2; however, Reclamation has contracted Environmental Resources Management (ERM) to assist in peer review and in code modification specific to this system. Since hydrodynamic mixing is critical to maintaining long term salinity profiles in this reservoir, a modification in the code was made for this modeling to improve seasonal mixing. Evaporation is one of the primary variables affecting vertical mixing in the reservoir. The code has been modified to allow the evaporation coefficients to be changed to a fixed value at any frequency. For the Lake Powell application monthly coefficients are used. By setting monthly evaporation coefficients the model calibration has been significantly improved for the test period in both heat and salinity budgets. Evaporation totals were compared with Reclamation computed monthly evaporation values as a calibration check.

F.2.7 Lake Powell Model

F.2.7.1 General Description

The Lake Powell model simulates hydrodynamics, temperature, salinity, dissolved oxygen, phytoplankton and organic matter decay. The model uses a geometric, computational grid and various input data to simulate these processes. The grid is discussed below. Input data describe meteorological conditions, inflows, outflows, and water quality parameters. Meteorological data are collected from Page, Arizona and Hanksville, Utah. Inflow records are used for the Colorado River (combination of the Colorado, Green, and San Rafael Rivers), San Juan River, and the Dirty Devil River. For inflows where little or no data is available estimates are made. These include:

- North Wash
- Trachyte Creek
- Hansen Creek
- Bullfrog Creek
- Halls Creek
- Escalante River
- Cha Creek
- Rock Creek
- Last Chance Creek
- Warm Creek

- Navajo Canyon
- Wahweap Creek

Outflow is for all releases made through Glen Canyon dam. Data for water quality parameters are from major tributaries where available. These datasets have been collected from the Bureau of Reclamation, United States Geological Survey, National Climatic Data Center, and Utah and Arizona state and local agency records.

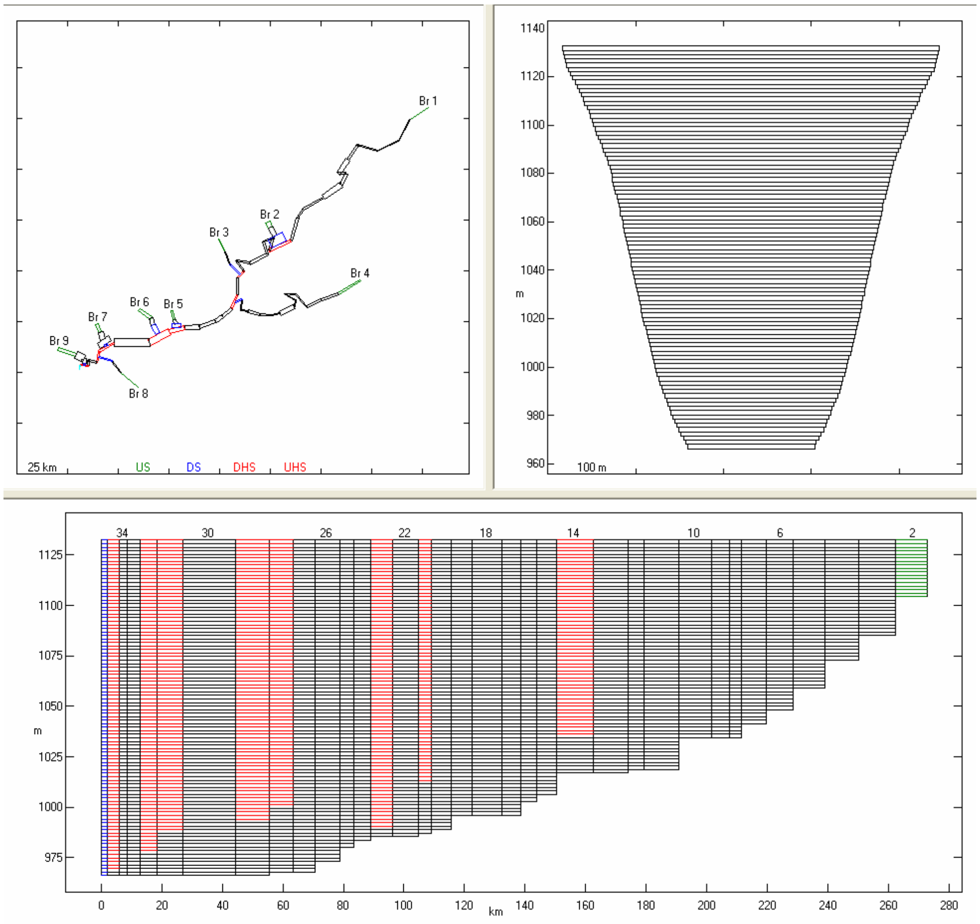
F.2.7.2 Lake Powell Bathymetry

The Lake Powell CE-QUAL-W2 bathymetry consists of 9 branches, 90 segments, and 97 layers. All layers are 1.75 meters thick. The branches represent the following channels and/or bays:

- Main (Colorado River) channel
- Bullfrog Bay
- Escalante River channel
- San Juan River channel
- Rock Creek Bay
- Last Chance Bay
- Warm Creek Bay
- Navajo Canyon
- Wahweap Bay

Figure F-1 is a diagram of the Lake Powell model bathymetry with top, front, and side views of the grid.

Figure F-1
Lake Powell Bathymetry



F.2.7.3 Lake Powell Model Assumptions

The input data used in the model are the best available and are assumed to be accurate representations of meteorology, flow, and water quality parameters. Additional assumptions, described below, may also affect model accuracy and reliability.

F.2.7.4 Meteorological Conditions

Meteorological conditions are represented in the model by one dataset. Data from the Page, Arizona airport is used to represent meteorological conditions on Lake Powell, mainly because it is the most complete dataset in the region. Page is located at the southernmost end of the reservoir and conditions there are not always representative of conditions on the rest of the lake, especially near the major inflows and northern end. The errors that result, however, are considered acceptable.

F.2.7.5 Water Balance

The model is calibrated to reproduce observed water surface elevations. An additional input referred to as the distributed tributary is created. This input includes flows that are required to balance the water budget, positive or negative. This represents precipitation, ungaged flow, bank storage, and other source/sinks. CE-QUAL-W2 distributes this flow evenly over the water surface in a simulation. Large flows can have water quality impacts. Reasonable assumptions are made for assigning water quality constituent concentrations to these flows.

F.2.7.6 Sediment Delta Interactions

Sediment deltas have built up near the mouth of major and minor inflows. Deposition and scour of these deltas creates interactions that impact several water quality parameters. The CE-QUAL-W2 model does not simulate sediment delta scouring, sediment digenesis of dissolved phosphorus, or chemical and biological oxygen demand release. This is on the edge of modeling and data gathering technology at this time. These processes are either not represented or an alternate approach is used to model them. The impact of these processes is not insignificant and until the approaches used are studied further the dissolved oxygen and nutrient calibrations are largely qualitative.

F.2.7.7 Lake Powell Model Calibration

The Lake Powell CE-QUAL-W2 model is considered calibrated for temperature and total dissolved solids for the period 1990-2005. Predicted results are compared to observed data from 13 locations including the tailwater. Calibration efforts for other water quality parameters such as dissolved oxygen, nutrients, and algae are ongoing and considered qualitative at this stage.

F.2.7.8 Temperature Calibration

Calibrations statistics for temperature are shown for each station in Table F-1. The number of profiles at each station is also given in the table. The AME of the temperature profiles is 0.8°C. The AME of the dam release temperatures is 0.45°C.

There are hundreds of individual profiles over the 15 year run period within the model. Three select vertical profiles with AME statistics are shown below for Wahweap (Figure F-2), Bullfrog (Figure F-3), and Cha (Figure F-4). A graph of the observed and predicted reservoir discharge temperatures is also shown (Figure F-5).

Table F-1
Lake Powell Temperature Calibration Statistics

Station	Years	AME	# of Profiles
Hite	91-05	1.39	52
Good Hope	92-05	1.11	52
Bullfrog	91-05	0.84	53
Escalante Confluence	91-05	0.69	54
San Juan Confluence	95-05	0.59	38
Oak Canyon	91-05	0.62	58
Crossing of the Fathers	91-05	0.58	60
Lower Zahn	91-03	1.21	38
Upper Piute	91-05	0.97	49
Lower Piute	91-05	0.80	44
Cha Canyon	91-05	0.69	51
Wahweap	91-05	0.65	179
Release Temperature	90-05	0.45	
Average		0.80	

Figure F-2
Temperature Profile at Wahweap Station, 2.4 kilometers from Glen Canyon Dam (AME = 0.39°C)

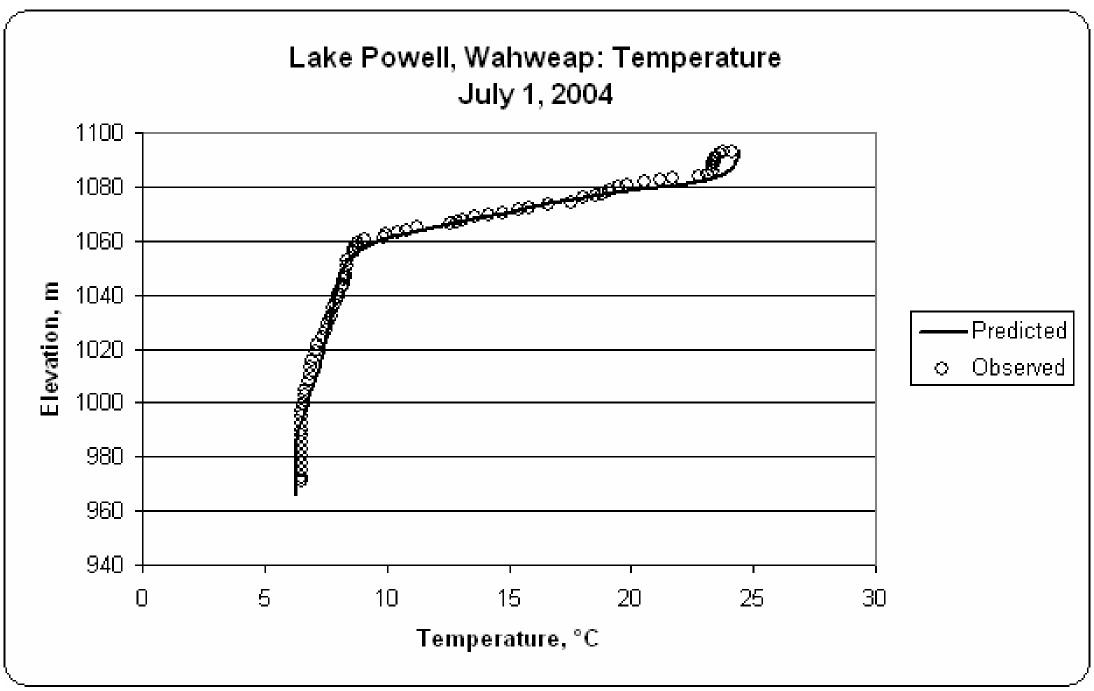


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Figure F-3
Temperature Profile at Bullfrog Station, 169.2 kilometers from Glen Canyon Dam

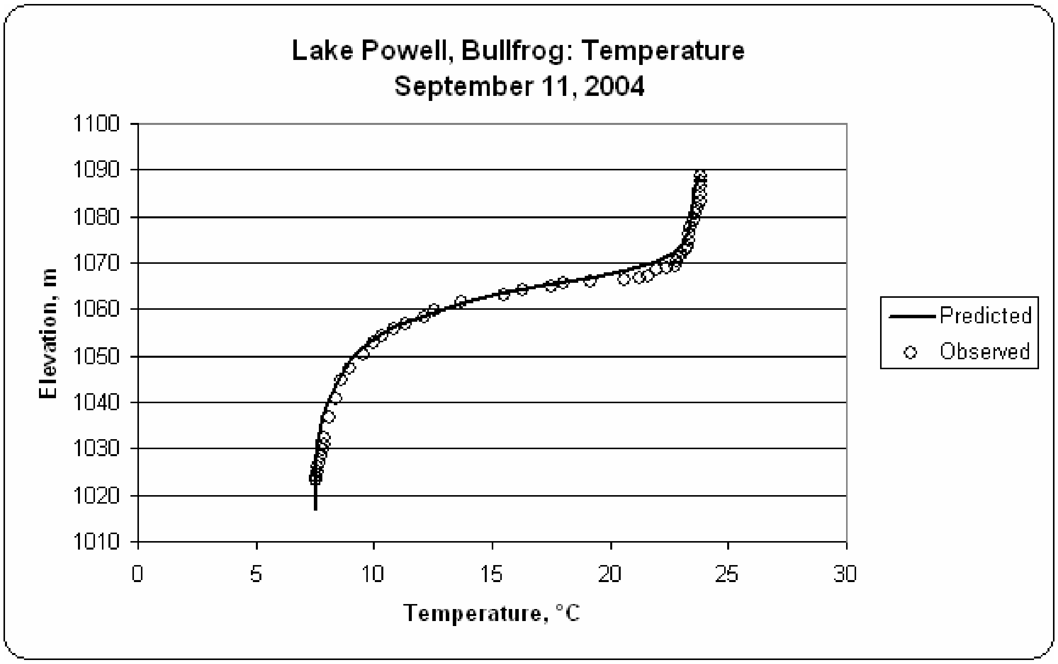


Figure F-4
Temperature Profile at Cha Station, 19.3 kilometers from the Confluence of the
San Juan River and Colorado River Channels (AME = 0.32°C)

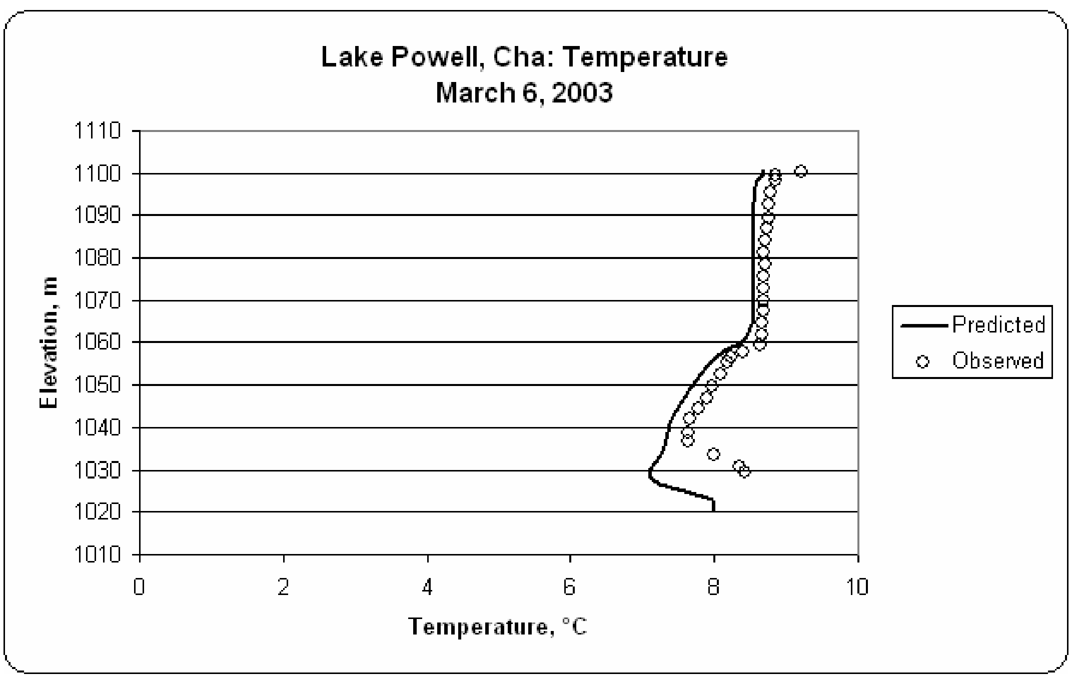
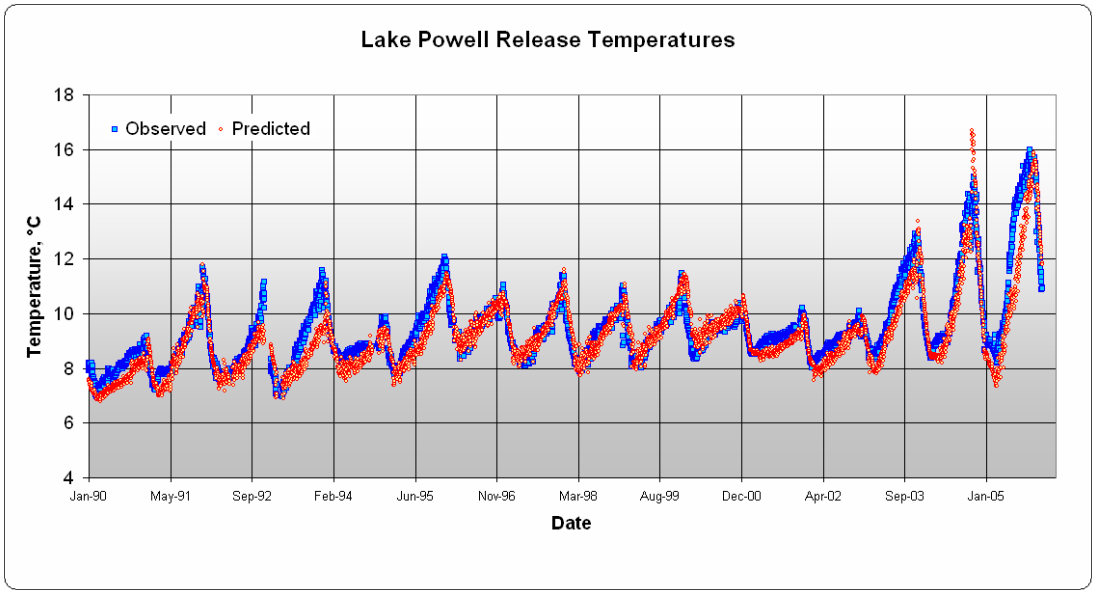


Figure F-5
Glen Canyon Dam Discharge Temperature Calibration



F.2.7.9 Total Dissolved Solids Calibration

Total dissolved solids, or TDS, are assumed to be a conservative parameter and, therefore, act as a tracer and help verify the hydrodynamic calibration. Calibration statistics and the number of profiles for TDS at each station are shown in Table F-2. The AME of the TDS profiles is 32.6 mg/L. The AME of the tailwater TDS is 14.1 mg/L.

Table F-2
Lake Powell TDS Calibration Statistics

Station	Years	AME	# of Profiles
Hite	91-05	54.98	52
Good Hope	92-05	41.61	42
Bullfrog	91-05	31.04	53
Escalante Confluence	91-05	27.88	54
San Juan Confluence	95-05	26.65	38
Oak Canyon	91-05	25.99	58
Crossing of the Fathers	91-05	25.42	60
Lower Zahn	91-03	40.43	38
Upper Piute	91-05	29.22	49
Lower Piute	91-05	24.25	44
Cha Canyon	91-05	27.01	51
Wahweap	91-94	34.71	179
Release TDS	90-05	14.1	
Average		32.63	

Three TDS vertical profiles with AME statistics, for the same stations and dates as the temperature profiles, are shown in Figure F-6, Figure F-7, Figure F-8, and Figure F-9.

Figure F-6
TDS Profile at Wahweap Station, 2.4 kilometers from Glen Canyon Dam (AME = 19.5 mg/L)

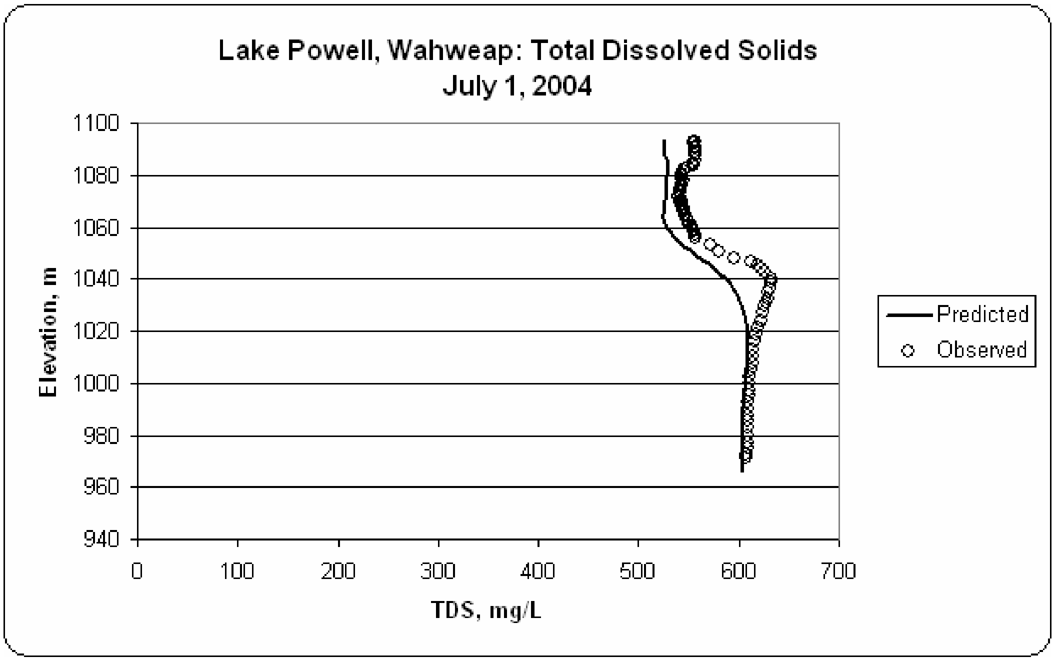


Figure F-7
TDS Profile at Bullfrog Station, 169.2 kilometers from Glen Canyon Dam (AME = 30.2 mg/L)

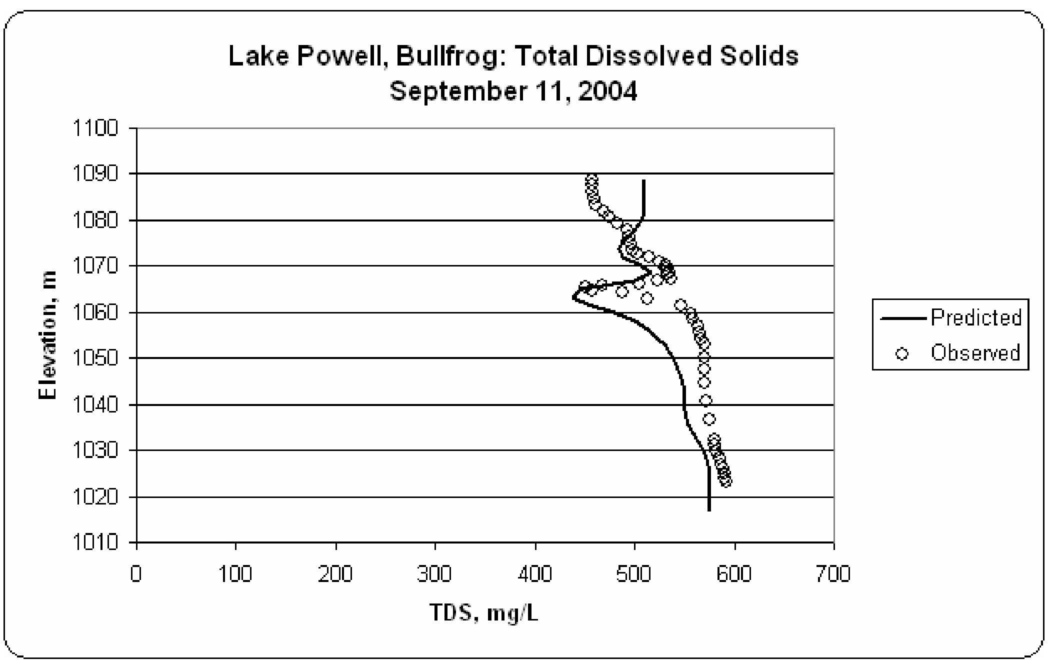


Figure F-8
TDS Profile at Cha Station, 19.3 kilometers from the Confluence of the San Juan River and Colorado River Channels (AME = 30.8 mg/L)

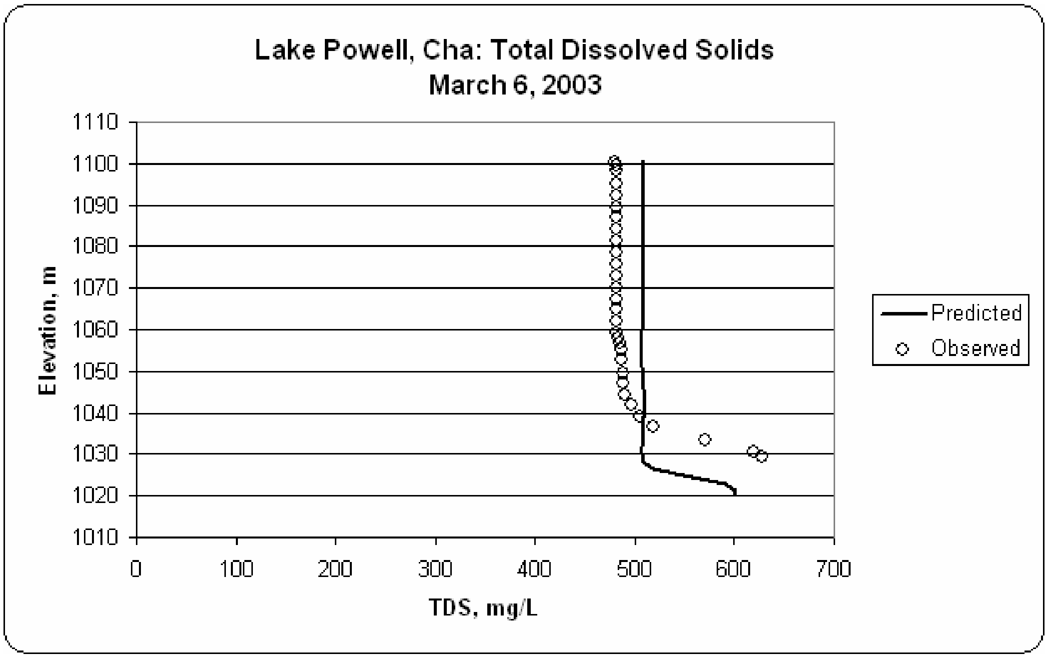
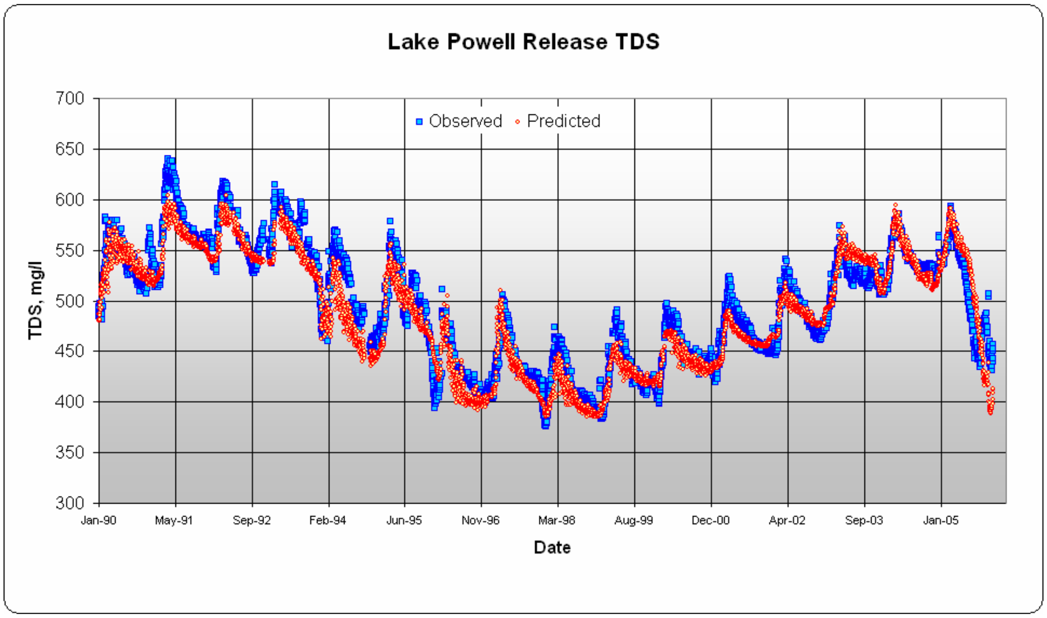


Figure F-9
Glen Canyon Dam Discharge TDS Calibration



F.2.7.10 Dissolved Oxygen Calibration

The dissolved oxygen calibration is still in its initial stages of development. It is affected by temperature, wind and wave mixing, plankton production and respiration, organic matter decay, and other chemical and biological oxygen demands. Many of these are complex and not extensively monitored. A qualitative/semi-quantitative analysis using an empirical method is being developed, a summary of which is given below.

Dissolved oxygen trends and cycles appear to be related to hydrology and reservoir drawdown. Based on these two parameters two CBOD compartments in the CE-QUAL-W2 model are being utilized to represent the sum total oxygen demand. They are loaded as part of the parameters in the inflow constituent file. The loading values in these two inflow CBOD boxes are being calculated by a set of rules and relationships based on changes in reservoir elevation, inflow volume, and water temperature. One box is used to represent chemical oxygen demand processes predominating cold water inflow conditions, while the other is used more to represent summer time carbonate biological oxygen demand processes associated with bacteriological decay of organic matter. Calibration is accomplished by iterative runs (trial and error) and comparison with downstream segment oxygen, phosphorus, carbon, and phytoplankton profile numbers. The overall DO calibration has an AME of 1.2 mg/L for vertical profiles and 0.9 mg/L for reservoir discharge DO (see Table F-3). Vertical profiles of the dissolved oxygen calibration at Wahweap (Figure F-10 and Figure F-11), Bullfrog (Figure F-12), and Cha (Figure F-13) are shown below as well as the discharge concentrations (Figure F-14). Calibration is expected to be further improved with additional iterative runs and refinement to the method.

Table F-3
Lake Powell DO Calibration Statistics

Station	Years	AME	# of Profiles
Hite	91-05	1.11	52
Good Hope	92-05	0.96	51
Bullfrog	91-05	1.00	54
Escalante Confluence	91-05	1.04	54
San Juan Confluence	95-05	1.13	38
Oak Canyon	91-05	1.00	58
Crossing of the Fathers	91-05	1.21	60
Lower Zahn	91-03	1.45	38
Upper Piute	91-05	1.23	49
Lower Piute	91-05	1.11	44
Cha Canyon	91-05	1.19	51
Wahweap	91-94	1.40	182
Release DO	90-05	0.86	
Average		1.19	

Figure F-10
DO Profile at Wahweap Station, 2.4 kilometers from Glen Canyon Dam (AME = 1.3 mg/L)

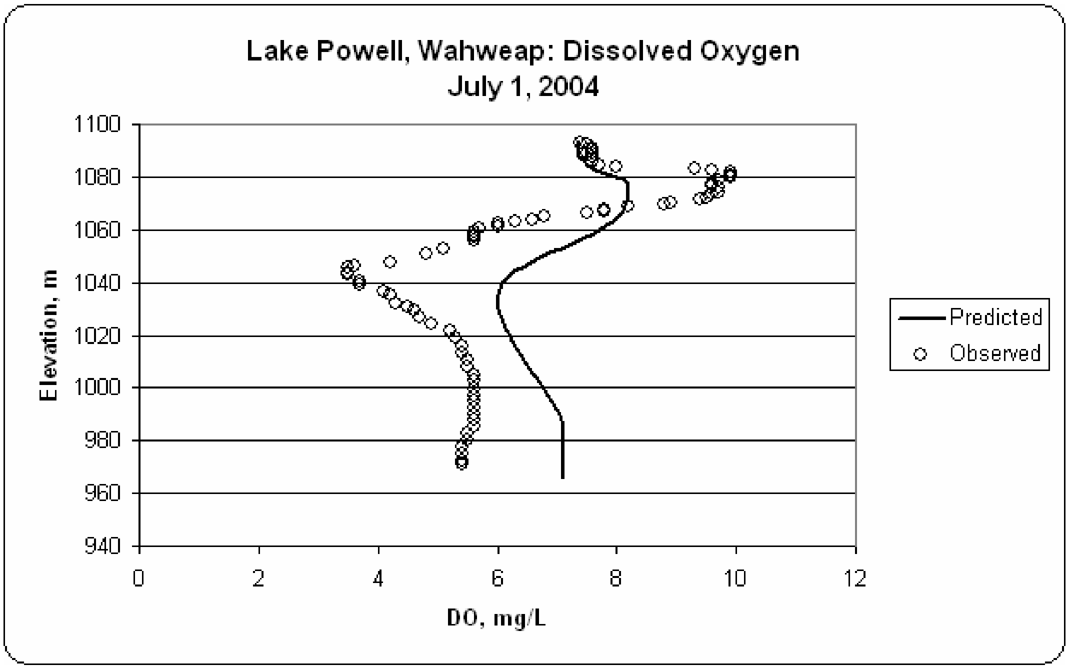


Figure F-11
DO Profile at Wahweap Station, 2.4 kilometers from Glen Canyon Dam (AME = 0.6 mg/L)

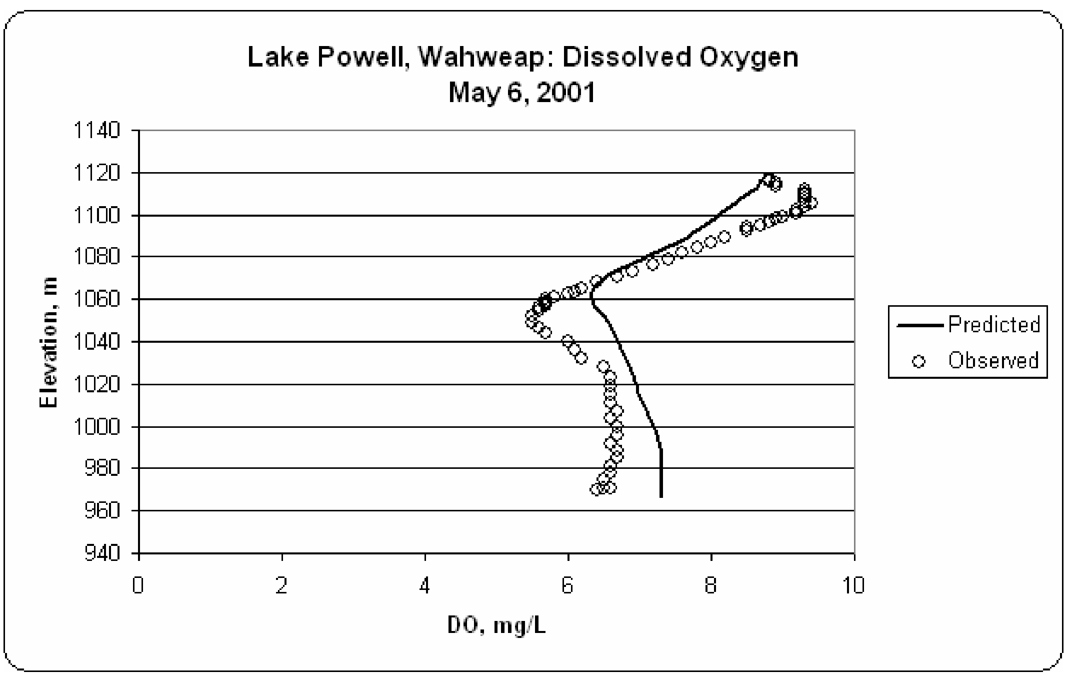


Figure F-12
DO Profile at Bullfrog Station, 169.2 kilometers from Glen Canyon Dam (AME = 0.9 mg/L)

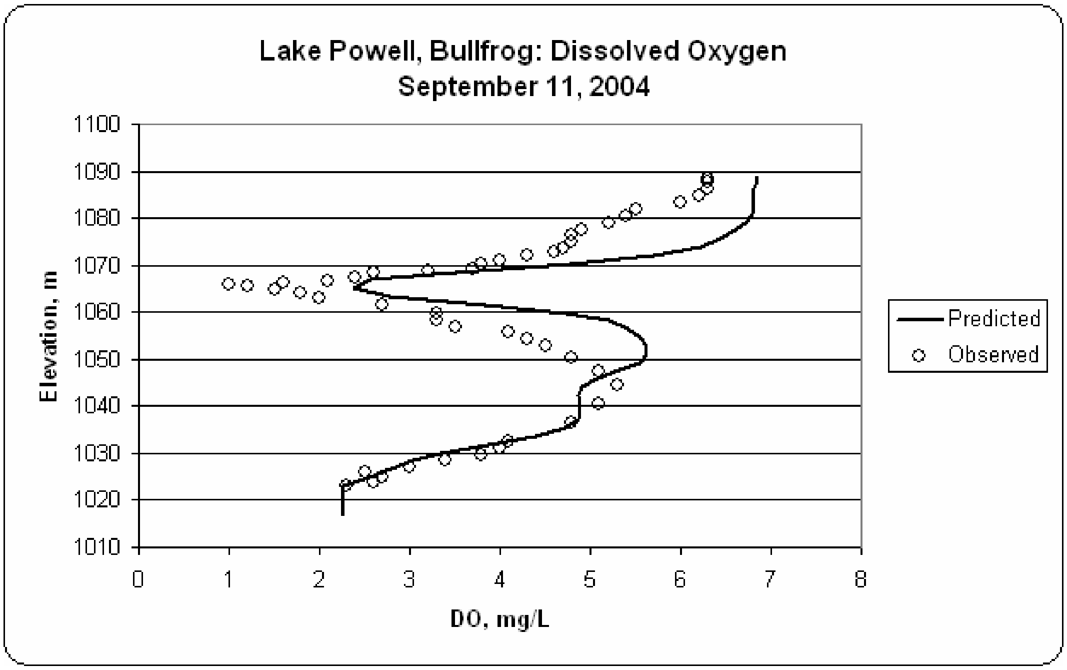


Figure F-13
DO Profile at Cha Station, 19.3 kilometers from the Confluence of the
San Juan River and Colorado River Channels (AME = 0.8 mg/L)

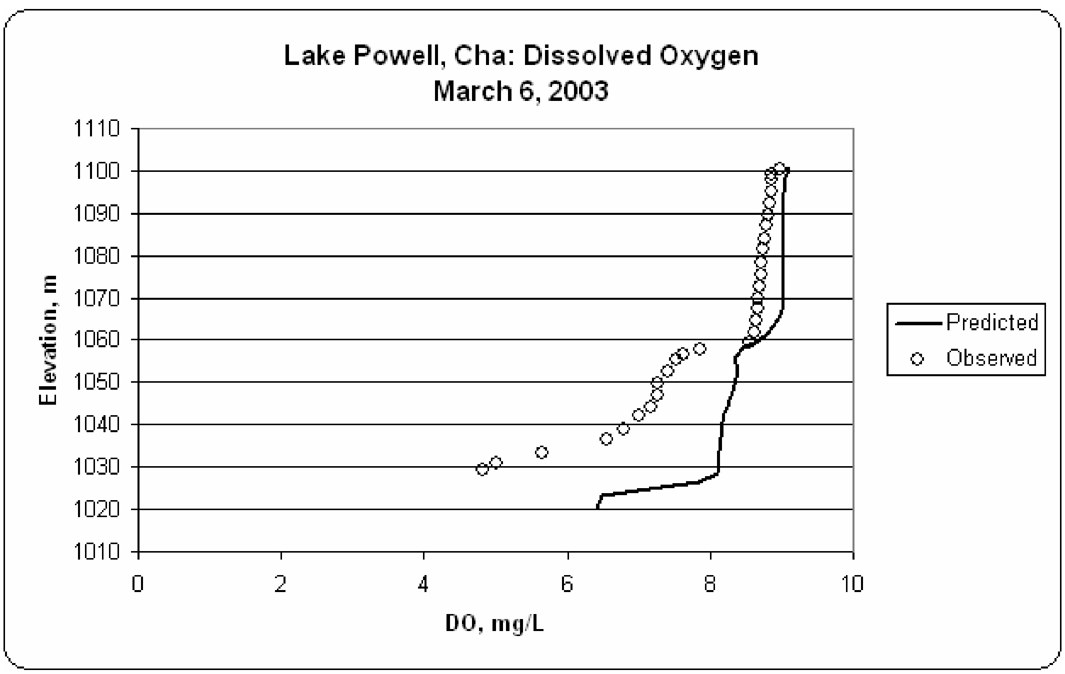
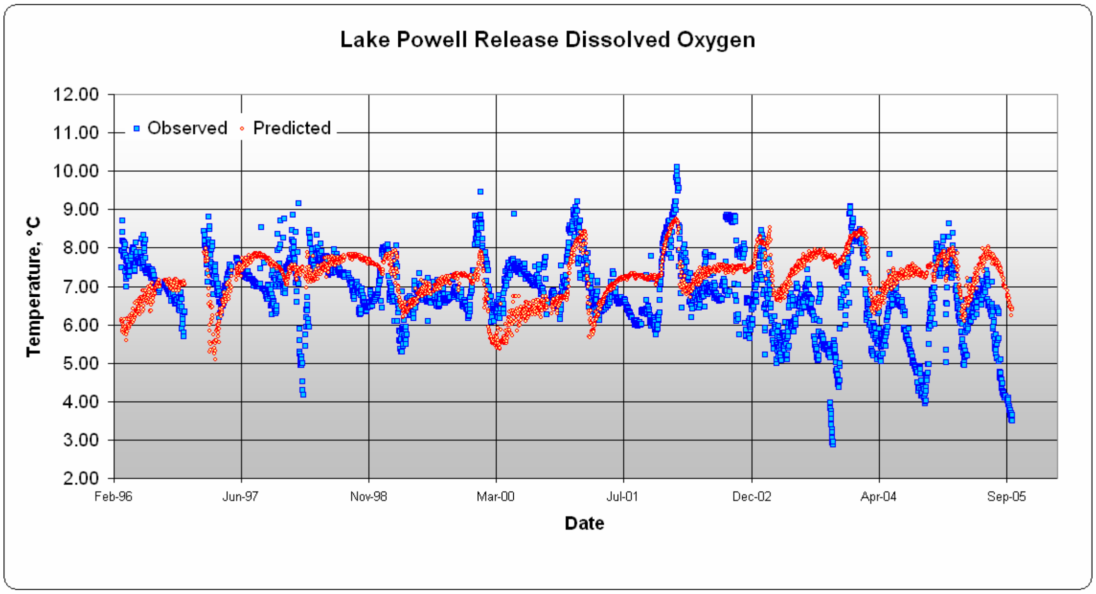


Figure F-14
Glen Canyon Dam Discharge DO Calibration



F.3 Temperature Modeling of Colorado River Flows Between Glen Canyon Dam and Lake Mead Using the GEMSS Water Quality Model - Model and Approach Description

F.3.1 Model Description (GEMSS Model)

The 1-D hydrodynamic and water quality model GEMSS was developed by J. E. Edinger Associates, Inc. (Wayne, PA). The transport equations for this model were similar to W2 which was based on the Generalized Longitudinal Hydrodynamic and Transport (GLHT) computation derived from the three-dimensional equations of fluid motion and continuity (Edinger and Buchak 1980). This model was selected because of its successful applications of the 1-D water quality/hydrodynamic module in TMDL studies. Like the CE-QUAL-W2 model it can model numerous water quality parameters; however, only water temperature was modeled for this study.

F.3.2 Model Geometry

The model's geometry data below Glen Canyon Dam to the Inflow of Lake Mead was based upon GIS spatial information and river cross sections available from USGS Grand Canyon Monitoring and Research Center (GCMRC). This information was used to generate a simplified geometry grid covering 280 miles of the Colorado River using 102 segments with averaged length of 7,000 m (23,000 ft) each and 234 slope points.

F.3.3 Model Time-varying Data

The model's time-varying data sets included flow rates, water temperatures, downstream water surface elevation, and meteorological data which were used to compute surface heat exchange. The boundary hydrology included daily average release data from Lake Powell and daily inflows of an average year (1947-2004) from the Little Colorado River. These data came from USGS gauging stations and Reclamation database. The water temperature boundary conditions included daily measured temperatures at Lees Ferry and daily temperature of an average year from the Little Colorado River. Meteorological data from Page, AZ was required to compute surface wind shear and heat exchange and consisted of hourly air and dew point temperature, wind speed, wind direction, cloud cover, solar radiation, and atmospheric pressure.

F.3.4 Temperature Calibrations

The GEMSS model was calibrated to observed Diamond Creek hydrology and observed water temperature at three locations (Lees Ferry, Little Colorado River confluence, and Diamond Creek) that were provided by GCMRC. The calibration period was based on the same period used in CE-QUAL-W2 (1990 to 2005); however observed data for these three locations were sporadic for this time period.

To verify the mass balance calculation of the model, the modeled flows were compared with actual flows at Diamond Creek. The modeled flows at Diamond Creek were consistently lower than observed flows by about 6% due to limited tributary inflows and constant average daily flows of a year from the Little Colorado River. The average errors for comparison between modeled and observed water temperatures were -0.08 °C at Lees Ferry, 0.09 °C below the Little Colorado River, and -1.1 °C at Diamond Creek (Figures F-15, F-16, and F-17 respectively). The modeled water temperatures at the Diamond Creek station were consistently lower than the observed data. This was likely caused by the difference in meteorological data between Diamond Creek and Page.

Figure F-15
GEMSS Modeled and Observed Temperatures at Lees Ferry (a sample period of 1995 to 2002)

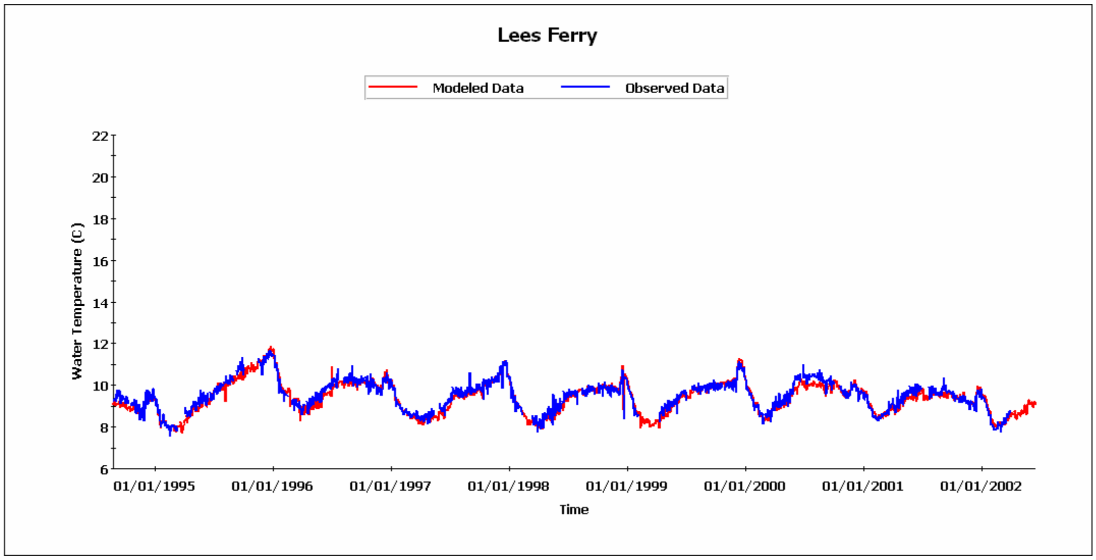


Figure F-16
GEMSS Modeled and Observed Temperatures at Diamond Creek (a sample period of 1999 to 2002)

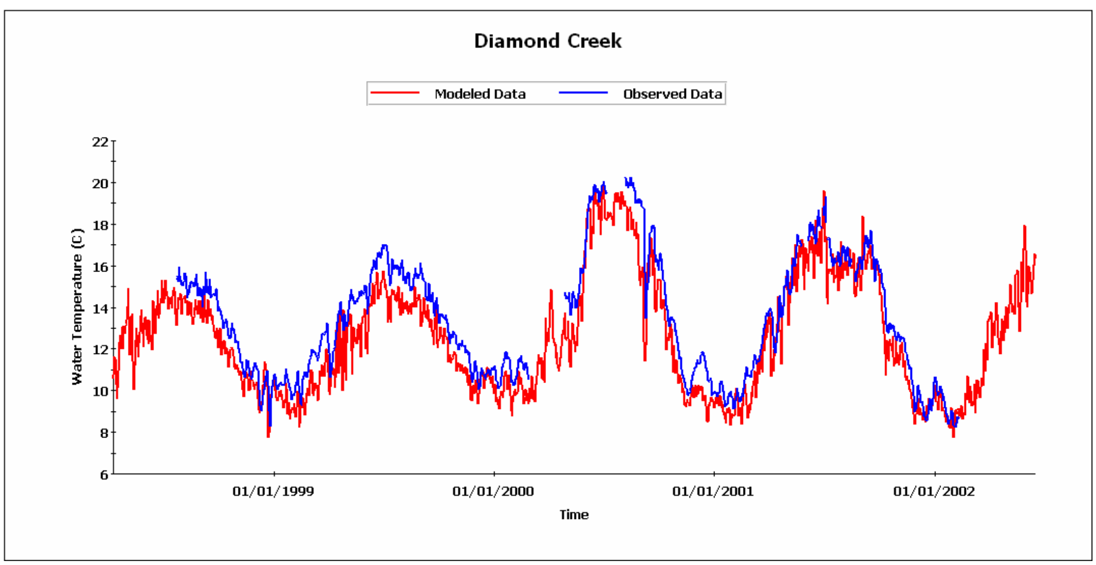
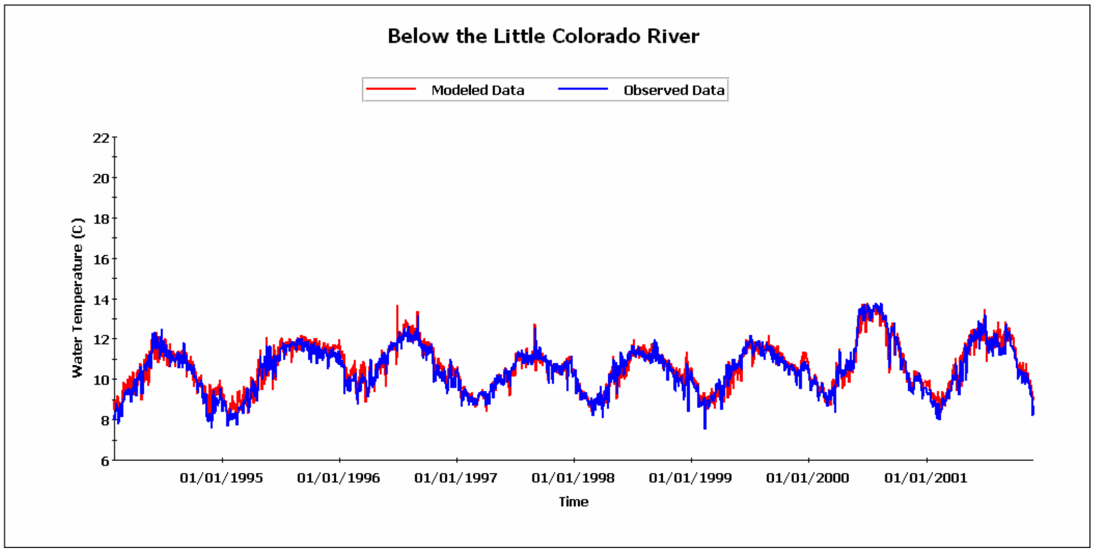


Figure F-17
GEMSS Modeled and Observed Temperatures for Below the Little Colorado River (a sample period of 1994 to 2002)



F.3.5 Analysis of Alternatives

The calibrated GEMSS model was used to analyze downstream temperature regimes for the Shortage alternatives. Release water temperatures from the CE-QUAL-W2 model and the flows from the CRSS model were used as inputs to the GEMSS model. The following assumptions were made in analyzing water temperatures downstream of Glen Canyon Dam:

- Monthly average reservoir release volumes were used for each of the CRSS 90th, 50th, and 10th percentile Powell elevations.
- Minimum and maximum release volumes based on each of the alternatives (including No Action) were used for each of the CRSS percentiles as mentioned in number one.
- Minimum and maximum release temperatures from CE-QUAL-W2 for all Shortage alternatives were used for each of the CRSS percentiles.
- A warm and a cool meteorological year (i.e. warmer or cooler air and dew point temperatures) were applied across alternatives and CRSS percentiles.
- The Basin States Alternative and Conservation Before Shortage Alternative were analysis as one alternative.

The outcome from combination of variable release volume, temperature, and meteorological conditions resulted in a range of temperatures at any given location and time of year.

F.4 References

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Appendix G

Shortage Allocation Model Documentation

This appendix describes the model (Shortage Allocation Model) and assumptions that were used to allocate shortages to water users in the states of Arizona, Nevada, and California (Lower Division States) as part of the analysis of water deliveries in this Draft EIS.

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Table of Contents

Attachments

List of Tables

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G.1 Introduction

In order to assess the potential effects of the alternatives, specific modeling assumptions were made and are documented in this appendix. In particular, it was assumed that Mexico would share proportionately in Lower Basin shortages. The proposed federal action is for the purpose of adopting additional operational strategies to improve the Department's annual management and operation of key Colorado River reservoirs for an interim period through 2026. However, in order to assess the potential effects of the proposed federal action in this Draft EIS, certain modeling assumptions are used that display projected water deliveries to Mexico. Reclamation's modeling assumptions are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico.

The United States will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Treaty with Mexico through the IBWC in consultation with the Department of State.

G.2 Background and Purpose

The Shortage Allocation Model was created to calculate the quantity of Colorado River water that would be available to water entitlement holders under shortage conditions on the mainstream of the lower Colorado River. A shortage condition would exist during a year when the Secretary, as part of the AOP, determines that there is less than 7.5 maf of water available to the Lower Division States.

The Shortage Allocation Model simulates shortage allocations and adjusts deliveries of Colorado River water in accordance with the apportionment to the Lower Division States prescribed in the Boulder Canyon Project Act of 1928 as confirmed by the Consolidated Decree. Certain modeling assumptions were made with regard to how shortages may be allocated. Reclamation acknowledges that there may be other interpretations of how shortages should be distributed. Reclamation's modeling assumptions are not intended to represent current or future policy with respect to shortage sharing or to limit Secretarial discretion to distribute shortages.

The Shortage Allocation Model simulates shortage allocations to individual Colorado River entitlement holders within each state. Entitlement holders are all persons or entities authorized to beneficially use Colorado River water pursuant to: 1) a right decreed by the United States Supreme Court, 2) a contract for the delivery of Colorado River water through the Secretary of the Interior (Secretary), or 3) a Secretarial reservation. For a list of each State's Colorado River water entitlement holders, please see Attachment 1, Tables G-15, G-17, and G-18.

Under the Colorado River Basin Project Act (*Sec-301(b)*), the Central Arizona Project (CAP) incurs most of any initial shortage to the Lower Division States. Consequently, there is a great deal of interest in how shortages are allocated among the individual CAP users. The distribution of CAP water during a time of shortage is complicated, and the Shortage Allocation Model has been developed to accommodate the unique shortage provisions of the Arizona Water Settlements Act (Public Law 108-451 dated December 10, 2004) and the CAP shortage framework as defined in various CAP water delivery contracts.

G.3 Description of the Shortage Allocation Model

The Shortage Allocation Model was developed as worksheets in Microsoft Office 2003 Excel software using the Excel Visual Basic Editor. Hyperlinks were created to show shortage impacts geographically using the GIS interface Arc Reader. The Shortage Allocation Model contains 21 worksheets, which are summarized briefly in the below Table G-1.

Table G-1
Relationship Between Worksheets in the Shortage Allocation Model

	Worksheet	Function	Retrieves Data from:	Sends Data to:
1	Region Worksheet	Calculates Stage I and Stage II Shortages to Nevada, California, Arizona, and Mexico	Arizona worksheets & Projected Use Schedules	AZ, NV, & CA worksheets
2	Nevada Worksheet	Calculates shortages to Nevada Entitlement Holders	Region Worksheet	
3	California Worksheet	Calculates shortages to California Entitlement Holders	Region Worksheet & QSA Worksheet	
4	Arizona Worksheet	Calculates shortages to Arizona Entitlement Holders	Region Worksheet & Arizona Projected Consumptive Use (CU) Schedules	CAP Worksheet
5	CAP Worksheet	Calculates shortages to CAP Entitlement Holders	Arizona Worksheet & CAP Projected CU Schedules	CAP Summary Worksheet
6	CAP Summary Worksheet	Displays all CAP Entitlements, Scheduled CU, Adjusted Delivery, and Reductions	CAP Worksheet & CAP Projected CU Schedules	
7	PPR Worksheet	Displays PPR's in date order regardless of state lines		
8	QSA Worksheet	Displays Exhibit B of the QSA		CA Worksheet
9	Arizona CU Schedules for Priorities 1-3	Projected Consumptive Use Schedules Provided to model Stage I and II Shortages and shortages to Arizona Entitlement Holders		Arizona and Region Worksheet
10	Arizona CU Schedules for Fourth Priority	Projected Consumptive Use Schedules Provided to model Stage I and II Shortages and shortages to Arizona Entitlement Holders		Arizona and Region Worksheet
11	Summary of Arizona State and CAP Schedules	Shows that all Arizona Projected CU does not exceed 2.8 maf		CAP NIA and Excess Agricultural Schedules

Table G-1
Relationship Between Worksheets in the Shortage Allocation Model

Worksheet	Function	Retrieves Data from:	Sends Data to:
CAP M&I, Tribal, NIA, and Excess Agricultural Schedules	Used to show CAP water availability and capture simulated shortage impacts in future years		CAP Worksheet
Decree Worksheets	Show how Diversion and CU ratios are calculated to estimate full CU Entitlements in Nevada and California		
Map Worksheets	Used to format shortage impacts to be interpreted by Arc Reader and produce Maps	Arizona, Nevada, and California Worksheets	GIS Arc Reader

The purpose and/or function of each of the worksheets is/are described as follows.

The Region worksheet (shown below) is the key worksheet for operating the Shortage Allocation Model. In the Region worksheet the Shortage Allocation Model is triggered by inputting the total Lower Basin shortage, in af, in the yellow box. Once the total shortage is entered, the Shortage Allocation Model calculates the amount of Stage I and Stage II Shortages (to be discussed in the next section), and the amount of the shortage to each of the Lower Division States as a whole, and Mexico. Each State's available water supply, shown on the Region worksheet, is linked to the State worksheets in Attachment 1 (Tables G-15, G-17, and G-18) and the CAP worksheets in Attachment 1 (Table G-16). The user may also select the shortage year on the Region worksheet, and, if desired, any of the three State maps, or the regional map, to view geographical impacts. The links from the Region worksheet to the State worksheets operate the Shortage Allocation Model.

Table G-2
Region Worksheet

	Assumed Distribution of Shortage	Consumptive Use Entitlement	Deliverable Consumptive Use	Consumptive Use Reduction
Stage I Shortage		1,729,907	1,329,907	400,000
Mexico	16.67%	288,318	221,651	66,667
United States				
Arizona	80.00%	1,383,925	2,063,925	320,000
Nevada	3.33%	57,664	44,330	13,333
California	0.00%	0	0	0

Table G-2
Region Worksheet

	Assumed Distribution of Shortage	Consumptive Use Entitlement	Deliverable Consumptive Use	Consumptive Use Reduction
Stage II Shortage (When AZ 4th=0)		7,270,093	7,270,093	0
Mexico	16.67%	1,211,682	1,211,682	0
United States				
Arizona	19.48%	1,416,075	1,416,075	0
Nevada	3.33%	242,336	242,336	0
California	60.52%	4,400,000	4,400,00	0
Stage I & II Total		9,000,000	8,600,000	400,000
Run Mode			Total Reduction	400,000
Arizona			2,480,000	320,000
Nevada			286,667	13,333
California			4,400,000	0
Mexico			1,433,333	66,667

The Shortage Allocation Model contains three State worksheets (see Tables G-15, G-17, and G-18 in Attachment 1). Given any shortage volume, the State worksheets calculate the reduced delivery quantity and shortage amount to the individual entitlement holders within each State. On the Arizona state worksheet, the adjusted delivery is calculated as a reduction to the scheduled use for each entitlement holder provided by the Arizona Department of Water Resources (ADWR). On the California and Nevada state worksheets the reduced delivery is calculated based upon an estimated full entitlement use schedule from 2004 water accounting data.

The Arizona State worksheet calculates the aggregate quantity of fourth priority water available to CAP. This quantity is imported to the CAP worksheet, which distributes available water to CAP entitlement holders. The results of the CAP worksheet are displayed in the CAP Summary Worksheet in Attachment 1, Table G-16.

Seven consumptive use schedules were provided by ADWR for use in the Shortage Allocation Model, for the period 2008 through 2060. The consumptive use schedules are listed below:

1) Arizona first through third priorities

2) Arizona fourth priority

3) Summary of Arizona State schedules

4) CAP municipal and industrial (M&I) priority user schedules (only provided to year 2035)

5) CAP Tribal schedules

6) CAP non-Indian agricultural priority (NIA) user schedules

7) CAP excess water schedules (only provided to year 2030)

The ADWR consumptive use schedules are shown in Attachment 8, Tables G-55 - G-58, and Appendix D.

When a shortage year is selected on the Region worksheet, the Shortage Allocation Model is programmed to calculate the Stage I and II Shortages based on the Arizona schedules and to inserts the consumptive use schedule for each entitlement holder on the Arizona worksheet under the “scheduled use” column (see table G-15). Each state page is organized in the same manner. The scheduled use is adjusted by the distributed shortage amount that was entered on the Region worksheet. The last column in the State worksheets show the simulated shortage allocated to each entitlement holder (see Tables G-15, G-17, and G-18).

The Shortage Allocation Model also includes two supporting worksheets including Exhibit B of the Quantification Settlement Agreement (QSA) and a full list of Present Perfected Rights (PPR’s). The QSA worksheet is linked to the California State worksheet. The QSA worksheet (Table G-59 in Attachment 8) displays the quantification of certain Colorado River water entitlements and transfers of Colorado River water in the State of California in thousands of acre-feet. The PPR worksheet displays a complete list of the PPR’s in the Lower Division States in date order from lowest to highest priority without regard to State lines in acre-feet (Table G-60 in Attachment 8). PPR diversion entitlements amount to approximately 4.1 maf and an estimated consumptive use entitlement of 3.4 maf in the Lower Basin. In the event of a severe shortage, where there is insufficient Colorado River water to satisfy the needs of the PPR entitlement holders, the PPR worksheet shows the order in which the limited water supply would be delivered to the PPR holders.

Finally, the Shortage Allocation Model allows the user to view impacts geographically in Arizona, Nevada, California, or the lower Colorado Region as a whole by selecting hyperlinks to maps on the Region worksheet (in dark blue).

Overall, the Shortage Allocation Model may be used to simulate any future shortage allocation for any year based on projected use, water orders, historical use, or average historical use. In a normal year, the Shortage Allocation Model may be used to simulate the amount of excess water that may be available for banking in any state. A benefit of the Shortage Allocation Model is that it relatively easy to modify for different scenarios, it is only 1.5 megabytes, and it computes all results in less than a few minutes.

G.4 Assumptions in the Shortage Allocation Model

G.4.1 Introduction

In accordance with Section II (B)(3) of the Consolidated Decree and Section 301(b) of the Colorado River Basin Project Act, the Secretary has the authority to declare and allocate shortages to the Lower Division States. Although some guidance is given with regard to how shortages would be allocated (i.e., PPR's must be met first without regard to State lines and California does not incur shortages until water use under Arizona post-1968 water delivery contracts are eliminated), no further guidance exists for the Secretary's shortage allocation decisions.

To determine the hydrologic impacts of the shortage alternatives, assumptions were made with regard to how shortages might be shared. These assumptions are made to facilitate analysis of the full range of potential impacts of each alternative and are not intended to represent current or future policy with respect to shortage sharing.

G.4.2 Stage I and II Assumptions

In the Shortage Allocation Model, shortages in the Lower Basin are categorized as Stage I and II Shortages. Shortages are first imposed under Stage I and would be applied to the most junior users within Arizona (those with post-1968 water rights, i.e., 4th and 5th priority rights within Arizona) and Nevada (primarily the SNWA). Stage I shortages continue until the deliveries to the post-1968 water rights holders in Arizona (including the CAP) are reduced to zero. The maximum amount of Stage I shortages during the period of analysis is dependent on the scheduled depletions for the post-1968 water rights holders and decreases over time from approximately 1.8 maf in 2008 to 1.7 maf in 2060.

After deliveries to the 4th and 5th priority rights within Arizona are reduced to zero, additional reductions are applied to Arizona, California, and Nevada. These shortages, referred to as Stage II shortages, continue to the shortage amount determined by the alternative.

The shortage sharing percentages are computed as follows:

- Shortage sharing for Stage I: Arizona, Nevada, and Mexico take a water supply reduction.
  - Mexico: 16.67 % reduction of the total shortage
    - Computed as a ratio of Mexico's Treaty allotment to the sum of the apportionments of the Lower Division States and Mexico's Treaty allotment
    - 1.5 maf / 9.0 maf = 0.1667
  - Nevada: 3.33% reduction of the total shortage
    - Computed as a ratio of Nevada's apportionment to the sum of the apportionments of the Lower Division States and Mexico's Treaty allotment
    - 0.3 maf / 9.0 maf = 0.0333
  - Arizona: 80% of the total shortage

- Computed assuming that Arizona takes the remaining amount of shortage
- 1.0 - 0.1667 - 0.0333 = 0.80

- ♦ Shortage Sharing for Stage II Reductions (severe shortage where Arizona fourth priority use is eliminated and California shares in remaining shortage)
  - Mexico: 16.67 % of the Stage II Shortage in addition to Stage I reductions
    - Computed as a ratio of Mexico's Treaty allotment less the amount of shortage applied to Mexico under Stage I, to the sum of the apportionments of the Lower Division States and Mexico's Treaty allotment less the total amount shorted to users under Stage I
    - (1.5 maf - Mexico Stage I shortage) / (9.0 maf – total Stage I shortage) = 0.1667
  - Nevada: 3.33 % of the Stage II Shortage in addition to Stage I Shortages
    - Computed as a ratio of Nevada's apportionment less the amount of shortage applied to Nevada under Stage I, to the sum of the apportionments of the Lower Division States and Mexico's Treaty allotment less the total amount shorted to users under Stage I Shortage
    - (0.3 maf - NV Stage I Shortage) / (9.0 maf – total Stage I Shortage) = 0.0333
  - Arizona: Arizona's Stage II shortage is approximately 20% and varies due to Arizona's one through three priority scheduled use
    - Computed as a ratio of Arizona's apportionment less the amount of shortage applied to Arizona under Stage I, to the sum of the apportionments of the Lower Division States and Mexico's Treaty allotment less the total amount shorted to users under Stage I Shortage
    - (2.8 maf - AZ Stage I Shortage) / (9.0 maf – total Stage I Shortage)
  - California: California's Stage II Shortage is approximately 60% and varies due to Arizona's priority one through three scheduled use
    - Computed assuming that California takes the remaining amount of the additional shortage
    - 1.0 - 0.1667 – 0.0333 – Arizona's Stage II Shortage expressed as a fraction

G.4.2 Operations of Stage I and II Shortages

The Region worksheet, also seen in Attachment 1, Table G-14, displays the calculations discussed above.

- Listed along the left side of Attachment 1, Table G-14 are Stage I and II Shortages, the respective entities: Mexico, Arizona, Nevada, and California, consumptive use apportionments to each state and the Treaty allotment to Mexico, and their respective shortages.

- The shaded blue region in the center of Attachment 1, Table G-14 shows, under a selected shortage volume, the adjusted amount of water available for consumptive use by the Lower Division States and available delivery to Mexico, and the shortage distribution in the last blue column.

- In 2008 the potential Stage I Shortage to Lower Division States and Mexico is 1,729,907 af, and the additional potential Stage II Shortage is 7,270,093 af. The potential shortage volumes are based on Arizona priorities one through three projected use of 1,416,075 af in 2008, as seen in the consumptive use column under a Stage II Shortage. The remainder of Arizona's apportionment, 1,383,925 af, is subject to a Stage I shortage.

- As Arizona priority one through three use increases over time to full entitlement use, the potential Stage I shortage decreases.

- In 2040, when Arizona reaches full entitlement use, priorities one through three are projected to use 1,428,510 af. The remainder of the State's apportionment, 1,371,490 af, is subject to a Stage I shortage. The potential Stage I shortage to the Lower Division States and Mexico is 1,714,362 af, and the additional potential Stage II shortage is 7,285,638 af.

- In 2017, as seen in Attachment 1, Table G-14, a simulated shortage of 400,000 af was not large enough to trigger a Stage II Shortage; therefore there are no Stage II shortages in the "Consumptive Use Reduction" column. In this situation, consumptive use in Arizona is reduced by 320,000 af, consumptive use in Nevada is reduced by of 13,333 af, and the delivery to Mexico is reduced by of 66,667 af.

G.4.3 General State Assumptions

- Each State is assumed to be using its entire apportionment each year.

- Entitlement holders with multiple priorities divert water by their highest (oldest) priority first.

- The Shortage Allocation Model uses the quantity of water projected to be ordered in a shortage year as a basis for distributing the available water supply to individual users.

- With exception of PPR's, all entitlement holders within a priority class share in shortage on a pro rata basis. Therefore, within any priority class other then PPRs, the Shortage Allocation Model does not consider entitlement dates.

- PPR water use is not always under contract with the Secretary or reported to Reclamation, therefore PPR holders are assumed to be diverting their full entitlement.

- The Shortage Allocation Model does not address current and future paybacks of overruns or underruns under the Inadvertent Overrun and Payback Policy.

G.4.4 Arizona Assumptions

- All Arizona projected water use schedules in the Shortage Allocation Model were supplied by ADWR (see Attachment 8 Tables 55-58, and Appendix D). Upon ADWR concurrence, some of the original schedules were adjusted. The agreed upon changes are as follows:

- The original CAP projected water use schedules exceeded the available water for CAP on Arizona schedules, so the CAP projected water use schedules were reduced to keep Arizona within its 2.8 maf apportionment. The following entitlement holders were affected: the Arizona Water Bank Authority (AWBA), excess agricultural water users, and the NIA Priority (consisting of Indian, M&I, and Agricultural entitlement holders).

- The Cibola Valley Irrigation and Drainage District water contract has recently been split into three separate contracts: Hopi Tribe, Mohave County Water Authority, and Cibola Valley Irrigation and Drainage District. Reclamation developed a separate schedule for each of the three entities rather than showing one schedule for the district.

- A projected water use schedule for Fort Yuma Indian Reservation in Arizona was added to allow for first priority use in accordance with the Consolidated Decree.

- Some projected water use schedules for entitlement holders were divided among their more specific contract entitlements or water rights.

- Lake Havasu City's entitlement and its 6,000 af of subcontracted water from Mohave County Water Authority are separated so that they may be applied under the appropriate Colorado River entitlement or subcontract.

G.4.5 CAP Framework and Assumptions:

The Shortage Allocation Model considers five priorities within CAP. Within the Shortage Allocation Model, the most senior CAP priorities are the Ak-Chin Indian Community and several central Arizona cities who receive water secured by the Salt River Pima-Maricopa Indian Community Water Rights Settlement Act of 1988. The second CAP priority is Municipal and Industrial (M&I) and Indian priority water. Next in priority within the CAP is non-Indian Agriculture (NIA) priority water, which is available to specific M&I, Agricultural, and Indian entitlement holders. CAP excess water that is available to non-Indian agricultural entitlement holders is the next priority. The lowest priority within CAP (and Arizona) is AWBA which receives the balance of unused water in Arizona. A diagram of CAP entitlement classes, quantified in units of acre-feet, follows:

Table G-3
CAP Priorities Before and After 2044

<table>
<tr><th colspan="5">Cap Priorities Before 2044 (After Losses)</th><th>Total Entitelment by Priority</th></tr>
<tr><td>CAP 5</td><td colspan="4">Arizona Water Bank: Balance of State's Unused Apportionment</td><td>Balance</td></tr>
<tr><td>CAP 4</td><td colspan="4">Excess Agriculture: Available CAP Water</td><td>Available</td></tr>
<tr><td>CAP 3</td><td>M&I: 148,598af</td><td colspan="3">Indian: 216,100af</td><td>364,698</td></tr>
<tr><td rowspan="4">CAP 2</td><td rowspan="4">M&I: 638,823af</td><td rowspan="4">Indian: 343,097af</td><td>Indian: 32,770af</td><td>GRIC: 31,970af
Tohono O'Odham Nation: 800af</td><td rowspan="4">981,902</td></tr>
<tr><td colspan="2">11.305 GRIC</td></tr>
<tr><td colspan="2">7,340 San Carlos, Salt River</td></tr>
<tr><td colspan="2">291,574 Indian</td></tr>
<tr><td>CAP 1</td><td>Salt River Exchange Cities: 20,900af</td><td colspan="3">Ak-Chin: 47,500af</td><td>68,400</td></tr>
<tr><td colspan="5">TOTAL</td><td>1,415,000</td></tr>
</table>

<table>
<tr><th colspan="5">Cap Priorities After 2044 (After Losses)</th><th>Total Entitelment by Priority</th></tr>
<tr><td>CAP 5</td><td colspan="4">Arizona Water Bank: Balance of State's Unused Apportionment</td><td>Balance</td></tr>
<tr><td>CAP 4</td><td colspan="4">Excess Agriculture: Available CAP Water</td><td>Available</td></tr>
<tr><td>CAP 3</td><td>M&I: 101,295af</td><td colspan="3">Indian: 216,100af</td><td>317,395</td></tr>
<tr><td rowspan="4">CAP 2</td><td rowspan="4">M&I: 686,126af</td><td rowspan="4">Indian: 343,097af</td><td>Indian: 32,770af</td><td>GRIC: 31,970af
Tohono O'Odham Nation: 800af</td><td rowspan="4">1,029,205</td></tr>
<tr><td colspan="2">11.305 GRIC</td></tr>
<tr><td colspan="2">7,340 San Carlos, Salt River</td></tr>
<tr><td colspan="2">291,574 Indian</td></tr>
<tr><td>CAP 1</td><td>Salt River Exchange Cities: 20,900af</td><td colspan="3">Ak-Chin: 47,500af</td><td>68,400</td></tr>
<tr><td colspan="5">TOTAL</td><td>1,415,000</td></tr>
</table>

It is noted that the water contracting framework for CAP is based on an assumption that at least 1,415,000 af will be available for diversion from the CAP aqueduct in a normal year. This quantity assumes that there is a five percent conveyance loss in the CAP aqueduct; therefore 1,490,000 af is required to be available at the CAP pumping plant on the Colorado River. In the event that the priority one, two, and three consumptive use within Arizona (excluding the 68,400 af of priority three water that is included within the CAP supply) exceeds 1,310,000 af of consumptive use in any year, the CAP entitlement holders would receive less than 1,415,000 af and the impact would be absorbed by the excess and NIA priority users. For a list of specific entitlement holders within each CAP priority, please see the following spreadsheet on the next page.

Table G-4
Snapshot of Attached Table G-16 Showing CAP Entitlements

Year 2017	Entitlement					
Table 5 Lower Basin Shortage: 500,000	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL
Bank					Balance	0
Relinquished Agricultural Contracts				Available		0
Ak-Chin Indian Community	47,500	27,500				75,000
Fort McDowell		18,233				18,233
Gila River		191,200	120,600			311,800
TON-Chui Chu		8,000				8,000
TON-San Xavier		27,000	23,000			50,000
TON-Schuk Toak		10,800	5,200			16,000
Pasqua Yaqui		500				500
Salt River		13,300				13,300
San Carlos Apache		43,500				43,500
Tonto Apache		128				128
Yavapai Apache (Camp Verde)		1,200				1,200
Unallocated HVD		1,218				1,218
Reserved Federal			67,300			67,300
Indian Subtotal	47,500	343,079	216,100	0	0	606,679
Apache Junction (AZ Water Co)		6,000				6,000
Avra Coop		808				808
AZ-American (Agua Fria)		11,093				11,093
AZ-American (Paradise Valley)		3,231				3,231
AZ-American (Sun City)		4,189				4,189
AZ-American (Sun City West)		2,372				2,372
AZ State Land Dept.		32,076	9,026			41,102
ASARCO (Ray Mine)		21,000				21,000
Avondale		5,416				5,416
Bernell Water Co (Cave Creek)		200				200
Buckeye		25				25
Carefree Water Co		1,300				1,300
Casa Grande (AZ Water Co)		8,884				8,884
Cave Creek Water Co		2,406				2,406
CAGRD		7,746				7,746
Chandler*	4,064	8,654	3,924			16,642
Chandler Heights Citrus ID		315				315

Table G-4
Snapshot of Attached Table G-16 Showing CAP Entitlements

Year 2017	Entitlement					
Table 5 Lower Basin Shortage: 500,000	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL
Chaparral City Water Co		8,909				8,909
Circle City Water Co		3,932				3,932
Comm. Water Co (Green Valley)		2,858				2,858
Coolidge (AZ Water Co)		2,000				2,000
El Mirage		508				508
Eloy		2,171				2,171
Florence		2,048				2,048
Flowing Wells ID		4,354				4,354
Gilbert	6,424	7,235	1,537			15,196
Glendale	2,850	17,236	682			20,768
Goodyear		10,742				10,742
Green Valley DWID		1,900				1,900
H20 Water Co		147				147
Marana		47				47
Maricopa County Parks & Rec		665				665
Mesa*	2,622	43,503	5,552			51,677
MDWID		13,460				13,460
Oro Valley		10,305				10,305
Peroria		25,236				25,236
Phelps Dodge Miami		2,906				2,906
Phoenix*	4,750	122,120	37,280			164,150
Phoenix Memorial Park		84				84
Pine Water Co		161				161
Queen Creek Water Co		348				348
Rio Verde Utilities		812				812
San Tan ID		236				236
Scottsdale*	95	52,810	3,308			56,211
Spanish Trail Water Co		3,037				3,037
Superior		285				285
Surprise		10,249				10,249
Tempe	95	4,315	23			4,433
Tonto Hills Utility Co		71				71
Tuscon		144,172				144,172
Vail Water Co		1,857				1,857
Valley Utilities Water Co		250				250
Water Utilities Comm. Fac. Dist. (AJ)		2,919				2,919

Table G-4
Snapshot of Attached Table G-16 Showing CAP Entitlements

Year 2017	Entitlement					
Table 5 Lower Basin Shortage: 500,000	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL
Water Util. Greater Buckeye		43				43
Water Util. Greater Tonopah		64				64
White Tank Sys. (AZ Water Co.)		968				968
San Carlos (Phelps Dodge/Globe)		18,145				18,145
State Reserved			87,268			87,268
M&I Subtotal	20,900	638,823	148,598	0	0	808,321
TOTAL	68,400	981,902	364,698	Available	Balance	1,415,000

*47,303af NIA Priority water converts to M&I Priority on January 1, 2044 and 2,952af is distributed to Chandler, 4,924af to Mesa, 36,144af to Phoenix, and 3,283af to Scottsdale.

G.4.6 CAP Shortage Assumptions:

The Shortage Allocation Model uses the following assumptions to allocate available CAP water. These assumptions are based on Reclamation staff interpretation of the CAP shortage compromise that was incorporated as part of the Arizona Water Settlements Act (AWSA).

Step I. Under the AWSA, a CAP shortage exists if,

- Prior to January 1, 2044, there is not enough Arizona fourth priority water to meet the CAP second priority scheduled water use up to 981,902 af for CAP M&I priority water (638,823 af) and Indian priority water (343,079 af) or
- After January 1, 2044, there is not enough Arizona fourth priority water to meet the CAP second priority scheduled water use up to 1,029,205 af for CAP M&I priority water (686,126 af) and Indian priority water (343,079 af).

Step II. If there is a shortage based on Step I above, the available CAP water is allocated between the CAP M&I and Indian entitlement holders (CAP second priority) as follows:

- If the Available CAP water is less than 853,079 af, then 36.37518 of the available CAP water supply percent is allocated to the Indian priority and the remainder is allocated to the M&I priority water.
- If the Available CAP water supply is greater than 853,079 af, then the water is allocated as follows:
  - Prior to January 1, 2044, the water allocated to the Indian priority is equal to 93,303 af plus 25.438 percent of the available CAP water. The remainder is allocated to the M&I priority.

- After January 1, 2044, the water allocated to the Indian priority is equal to 151,691 af plus 18.59354 percent of the available CAP water. The remainder is allocated to the M&I priority.

Step III. Distribute the available CAP water to the individual entitlement holders within the M&I Priority and Indian Priority.

♦ Within the M&I priority, the quantity of the available CAP water (determined above) is allocated to each entitlement holder based on each entitlement holder's proportionate share of the total quantity of scheduled M&I priority water. For example, if entitlement holder X showed a scheduled use of 50,000 af from the M&I priority, then, under a shortage, entitlement holder X would receive an amount of water equal to the total amount of water available to the M&I priority in the shortage year multiplied by the ratio obtained by dividing 50,000 af by 638,823 af.

♦ Within the Indian priority, if the amount of Indian priority water is less than 343,079 af,

- The first 32,770 af of shortage to the Indian priority is borne jointly by the Gila River Indian Community (GRIC) and the Tohono O'Odham Nation (31,970 af by GRIC and 800 af by Tohono).

- The next 18,735 af of shortage to the Indian priority is borne as follows:

  ▪ First, 11,305 af of shortage is borne by the GRIC. The rational for the GRIC's to bear this increment of the shortage next is based on the language in the AWSA contracts with the GRIC's and Tohono O'dham Nation that assures that the other Tribes sharing this block of water are to be made no worse off by the AWSA.

  ▪ Second, the next 7,430 af of shortage is borne jointly by:

San Carlos Tribe (excess Ak-Chin water)	5,830af	78.47%
Salt River Tribe	1,330af	17.90%
San Carlos Tribe	270af	3.63%
	7,430af	100.00%

- Lastly, the 291,574 af of water available to the Indian priority is shorted. The remaining available amount of water is pro-rated to each Tribe or Nation based on each Tribe or Nation's percentage of scheduled Indian priority use.

G.4.7 General CAP Assumptions

♦ Some of the Tribes or Nations lease their CAP water to cities. The Shortage Allocation Model does not address the shortage to the lessee, and assumes that it is up to the Tribe or Nation to administer the terms and conditions of its lease to determine the amount of water available to the lessee in the shortage year.

- In the projected water use schedules:

- ADWR projected CAP M&I water use to year 2035, at which point almost all entitlement holders were using their full entitlement. With ADWR's concurrence, Reclamation adjusted the 2035 projected water use schedule to show full entitlement use by entitlement holders and extended 2035's projected water use schedules to later years for which a projected water use schedule had not been not available.

- The projected water use schedule of the NIA Priority for the Maricopa-Stanfield Irrigation and Drainage District and Central Arizona Irrigation and Drainage District was adjusted from a combined total of 12,000 af to 9,026 for the Arizona State Land Department to reflect the desire of that entity to subcontract for 9,026 af of NIA priority water for irrigation use. All other NIA priority water has been relinquished by the original subcontractors as part of the AWSA.

- Under the AWSA for the Salt River Pima Maricopa Indian Community Water Rights Settlement Act of 1988, there is a formula in the Agreement that provides for the distribution of the 20,900 af of acquired Priority 3 water among all M&I users during a time of shortage. In non-shortage years, this water is made available only to four Phoenix area cities. Reclamation has been informed that the present formula is inoperable and that a technical correction to the formula will have to be developed and agreed to by the appropriate parties. The Shortage Allocation Model does not attempt to model this element of the Salt River Pima Maricopa Indian Community Water Rights Settlement Agreement.

G.4.8 Nevada Assumptions

- Very few assumptions are made in the Shortage Allocation Model for Nevada, however the following concepts are included:

- The Shortage Allocation Model reflects that Nevada has eight water delivery priorities (see Table G-17 in Attachment 1), as established in the Robert B. Griffith Water Project Contract No. 7-07-30-W0004 for delivery of Colorado River water signed by the United States and State of Nevada.

- In the above contract, it is stated that SNWA is entitled to divert the balance of any remaining un-allocated, unused, and surplus water in Nevada.

G.4.9 California Assumptions

- For modeling purposes, the PPR's within California are displayed as having a first priority relative to the priorities contained in the Seven Party Agreement. The priorities within the Seven Party Agreement do not consider PPR's in California's allocation of 4.4 maf. Reclamation recognizes that the QSA helps California parties to meet the water needs of PPR's by agreeing that certain parties to the Seven Party

Agreement would make water available to satisfy the requirements of the PPR holders while keeping the priorities within the Seven Party Agreement intact. In addition the QSA helped quantify entitlements in the Seven Party Agreement, which is necessary to model shortages.

- Those M&I parties which receive water under the Seven Party Agreement 3(a) by water transfers from Imperial Irrigation District (IID) under the QSA, are considered to have a Seven Party Agreement 3(a) priority water entitlement.
- Although the Metropolitan Water District of Southern California (MWD) shows a Seven Party Agreement entitlement of 550,000 af in the Shortage Allocation Model, MWD's "Full Entitlement Use" is assumed to be the calculated entitlement resulting from the balance of California's State apportionment and full entitlement use of higher priorities. However due to the Palo Verde Irrigation District's forbearance agreement with MWD, during times of shortage a minimum of 25,000 af of water will become available for MWD, which is reflected in the Shortage Allocation Model.
- To see the estimated entitlements associated with each California entitlement holder, please see G-18 in Attachment 1. It is important to note that shortages to California only impact MWD.

G.5 Operation of the Shortage Allocation Model

G.5.1 Operation of Regional and State Shortages

The Shortage Allocation Model is designed to allocate Colorado River water under normal and shortage conditions on the mainstream of the Lower Colorado River. The model is operated by entering any shortage volume in the "yellow box" as shown below. Following the yellow box is a brown list-box in which any year between 2008 and 2060 may be selected (see below).

Table G-5
Snapshot from Regional Worksheet Showing Operational Inputs

Run Mode	Total Reduction	500,000	PROCESS	
Arizona	2,400,000	400,000		Region Shortage Maps
Nevada	283,333	16,667		NV Shortage Maps
California	4,400,000	0		AZ Shortage Maps
Mexico	1,416,667	83,333		CA Shortage Maps

Once the year is selected, the Shortage Allocation Model will collect the projected water use schedules for each Arizona user and determine the point at which a Stage I and II Shortages will occur as discussed in the Assumptions section above.

If a shortage is so severe that Arizona fourth priority users are reduced to a zero acre-foot water delivery, California shares in shortage via the Stage II Shortage. In the example below reflecting a 500,000 acre-foot shortage in 2017, the simulated shortage is not sufficient to cause a Stage II Shortage. Therefore Arizona, Nevada, and Mexico take simulated reductions, as seen in the far right hand column below, according to Stage I shortage sharing ratios.

In the following example, a simulated and highly unlikely shortage of 1.8 maf in 2017 produces a Stage II Shortage, distributed as seen in the far right hand column below:

Table G-6
Snapshot from Regional Worksheet Showing a 500,000 acre-foot Shortage

	Shortage Distribution	Consumptive Use Entitlement	Deliverable Consumptive Use	Consumptive Use Reduction
Stage I Shortage		1,729,907	1,229,907	500,000
Mexico	16.67%	288,318	204,984	83,333
United States				
Arizona	80.00%	1,383,925	983,925	400,000
Nevada	3.33%	57,664	40,997	16,667
California	0.00%	0	0	0
Stage II Shortage (When AZ 4th=0)		7,270,093	7,270,093	0
Mexico	16.67%	1,211,682	1,211,682	0
United States				
Arizona	19.48%	1,416,075	1,416,075	0
Nevada	3.33%	242,336	242,336	0
California	60.52%	4,400,000	4,400,00	0
Stage I & II Total		9,000,000	8,500,000	500,000

Table G-7
Snapshot from Regional Worksheet Showing a 1.8 million acre-foot Shortage

	Shortage Distribution	Consumptive Use Entitlement	Deliverable Consumptive Use	Consumptive Use Reduction
Stage I Shortage		1,729,907	0	1,729,907
Mexico	16.67%	288,318	0	288,318
United States				
Arizona	80.00%	1,383,925	0	1,383,925
Nevada	3.33%	57,664	0	57,664
California	0.00%	0	0	0

Table G-7
Snapshot from Regional Worksheet Showing a 1.8 million acre-foot Shortage

	Shortage Distribution	Consumptive Use Entitlement	Deliverable Consumptive Use	Consumptive Use Reduction
Stage II Shortage (When AZ 4th=0)		7,270,093	7,270,000	70,093
Mexico	16.67%	1,211,682	1,200,000	11,682
United States				
Arizona	19.48%	1,416,075	1,402,422	13,653
Nevada	3.33%	242,336	240,000	2,336
California	60.52%	4,400,000	4,357,578	42,422
Stage I & II Total		9,000,000	7,200,000	1,800,000

The "consumptive use entitlement" column above shows the potential Stage I and II Shortages for each state and Mexico. The adjusted delivery, given a shortage volume, is shown in the first blue column and the shortage volume is shown in the second blue column. The adjusted delivery and shortage from Stage I and II are transported to each State worksheet. Each state worksheet provides priority and entitlement information, as well as the selected year's schedules. As seen in attached Tables G-15, G-17, and G-18 of the State worksheets, the last two columns show the adjusted delivery and shortage volume for each entitlement holder in each state. Arizona entitlement holders are reduced from their scheduled use for the selected year. California and Nevada entitlement holders are reduced from full entitlement use, as projected use schedules were not programmed for these States. Shortages are equally shared pro-rata by all the users except PPR's of an impacted priority.

Each State page is strung with formulas to calculate the adjusted delivery to each priority For each state the corresponding shortages are simply calculated by subtracting the adjusted delivery from the full entitlement or projected consumptive use schedules. In CAP the formulas are highly complicated and some even require programming due to time dependent changes expressed in the AWSA.

G.5.2 Operation of CAP

In 2017, a simulated shortage of 500,000 af to the Lower Division States and Mexico, reduces Arizona 400,000 af, thus reducing deliveries to the AWBA and Arizona fifth priorities. Next, Arizona fourth priority (non-CAP and CAP) are both reduced 29%. The available fourth priority CAP water from the Arizona worksheet, minus 5% losses, is inserted into the CAP worksheet. Table G.8 shows the remaining delivery to CAP is 877,437 af (71%). The CAP worksheet distributes shortages to CAP entitlement holders, by satisfying the highest CAP entitlement holders first.

The share of the available CAP water from Arizona fourth priority is first allocated to the M&I (560,931af) and Indian (316,505) priorities *(to see a detailed description of Tribes impacted by the assumed Indian shortage sharing scheme, please see "CAP Shortage Assumptions")*. Based on the process described in the "CAP Shortage Assumptions", the following formulas were created to allocate the proper volume of water to the Indian priority under shortage conditions, where B6 is the available water for CAP:

=IF(B6>981902,343079,IF(B6>853079,(0.25438*B6+93303),(0.3637518*B6)))

This formula is read: If the available water supply to CAP is greater than 981,902 af, allocate to the Indian priority the full entitlement of 343,079 af. If the available water supply is greater than 853,079 af, allocate to the Indian priority 25.438% of the available water supply plus an additional 93,303 af. If the available water supply is less than 853,079 af, allocate to the Indian priority 36.37518% of the available water supply to the CAP.

After 2044, the formula to calculate the CAP Indian priority adjusted entitlement is below, followed by a description:

=IF(B6>981902,343079,IF(B6>853079,(0.1859354*B6+151691),(0.3637518*B6)))

If the available water supply to CAP fourth priority is greater than 981,902 af, allocate to the Indian priority the full entitlement of 343,079 af. If the available water supply is greater than 853,079 af, allocate to the Indian priority 18.59354% of the available water supply plus an additional 151,691af. If the available water supply is less than 853,079 af, allocate to the Indian priority 36.37518% of the water available to the CAP.

The adjusted delivery to the M&I priority is the difference between available water to CAP and the delivery to the Indian priority, up to the M&I entitlement, or desired scheduled use if less. The NIA priority and then the excess water users receive the remaining available water, which would be “0” in this example, however NIA and excess water users are entitled to unused water from the M&I and Indian priority. Before the unused water is available to NIA and excess water users, M&I and Indian entitlement holders are permitted to use the other’s unused water during a shortage. This concept is called “cross-over”.

Table G-8 shows that the M&I priority creates cross over water, since M&I scheduled use (512,767 af) is less than the M&I entitlements (560,931 af) under the shortage condition. Therefore, 48,165 af of cross-over is available for Indian entitlement holders in the below example. The Indian priority needs to use 16,481 af of the cross over to meet projected water schedules for 2017. The remaining 31,684 af is available to the NIA priority (consisting of Indian and Non-Indian entitlement holders). In this shortage scenario, CAP water is not available to excess water users.

Table G-8
2017 CAP Worksheet Shortage Allocation

Fourth Priority Water Available to CAP	877,437	2017			
Excess Water for Agricultural Users	0	0			
				Non-Indian Portion	Indian Portion
NIA Priority	0	31,684	→	25,303	6,380
	Allowed Use	Adj. Delivery	Scheduled Use	Unused (cross over)	
M&I Priority	560,931	512,767	512,767	48,165	
Indian Priority	316,505	332,986	332,986	0	

The above 31,684 af of water allocated to the NIA priority users is distributed in Table G-9. Shortages to all NIA entitlement holders are shown in the last column.

Table G-9
2017 Allocation of NIA Priority Water from CAP Worksheet

	Entitlement	Scheduled Use	Adjusted Delivery	Shortage Allocation
Non-Indian Portion				
Chandler	3,924	3,924	1,075	2,849
Gilbert	1,537	1,537	421	1,116
Glendale	682	682	187	495
Mesa	5,551	5,552	1,520	4,032
Phoenix	37,280	37,280	10,209	27,071
Scottsdale	3,306	3,306	905	2,401
Tempe	23	23	6	17
ASLD (Agriculture)	9,026	9,026	2,472	6,554
State Reserved	87,269	31,072	8,509	22,563
Total	148,598	92,402	25,303	67,099
Indian Portion				
Gila River	120,600	0	0	0
TON-San Xavier	23,000	8,972	2,457	6,515
TON-Schuk Toak	5,200	2,028	555	1,473
Reserved Federal	67,300	12,300	3,368	8,932
Total	216,100	23,300	6,380	16,920

The shortage to the M&I priority under a 500,000 acre-foot basin-wide shortage simulated for the year 2017 is distributed in the last column as follows:

Table G-10
2017 CAP M&I Shortage Allocation from CAP Worksheet

M&I Priority Distribution	Entitlement	Scheduled Use	Adjusted Delivery	Shortage Allocation
Apache Junction (AZ Water Co)	6,000	6,000	6,000	0
Avra Coop	808	0	0	0
AZ-American (Agua Fria)	11,093	11,093	11,093	0
AZ-American (Paradise Valley)	3,321	3,321	3,321	0
AZ-American (Sun City)	4,189	4,189	4,189	0
AZ-American (Sun City West)	2,372	2,372	2,372	0
AZ State Land Dept.	32,076	700	700	0
ASARCO (Ray Mine)	21,000	0	0	0
Avondale	5,416	4,746	4,746	0
Bernell Water Co (Cave Creek)	200	0	0	0
Buckeye	25	0	0	0
Carefree Water Co	1,300	400	400	0
Casa Grande (AZ Water Co)	8,884	2,000	2,000	0
Cave Creek Water Co	2,406	2,048	2,048	0
CAGRD	7,746	7,746	7,746	0
Chandler*	8,654	8,654	8,654	0
Chandler Heights Citrus ID	315	0	0	0
Chaparral City Water Co	8,909	5,705	5,705	0
Circle City Water Co	3,932	0	0	0
Comm. Water Co (Green Valley)	2,858	0	0	0
Coolidge (AZ Water Co)	2,000	0	0	0
El Mirage	508	0	0	0
Eloy	2,171	2,171	2,171	0
Florence	2,048	2,048	2,048	0
Flowing Wells ID	4,354	0	0	0
Gilbert	7,235	7,235	7,235	0
Glendale	17,236	14,183	14,183	0
Goodyear	10,742	10,742	10,742	0
Green Valley DWID	1,900	0	0	0
H20 Water Co	147	0	0	0
Marana	47	0	0	0
Maricopa County Parks & Rec	665	645	645	0
Mesa*	43,503	30,029	30,029	0
MDWID	13,460	10,613	10,613	0
Oro Valley	10,305	10,305	10,305	0

Table G-10
2017 CAP M&I Shortage Allocation from CAP Worksheet

M&I Priority Distribution	Entitlement	Scheduled Use	Adjusted Delivery	Shortage Allocation
Peroria	25,236	19,067	19,067	0
Phelps Dodge Miami	2,906	0	0	0
Phoenix*	122,120	134,120	134,120	0
Phoenix Memorial Park	84	0	0	0
Pine Water Co	161	0	0	0
Queen Creek Water Co	348	348	348	0
Rio Verde Utilities	812	812	812	0
San Tan ID	236	0	0	0
Scottsdale*	52,810	52,810	52,810	0
Spanish Trail Water Co	3,037	0	0	0
Superior	285	0	0	0
Surprise	10,249	10,249	10,249	0
Tempe	4,315	4,315	4,315	0
Tonto Hills Utility Co	71	0	0	0
Tuscon	144,172	142,672	142,672	0
Vail Water Co	1,857	0	0	0
Valley Utilities Water Co	250	0	0	0
Water Utilities Comm. Fac. Dist. (AJ)	2,919	50	50	0
Water Util. Greater Buckeye	43	0	0	0
Water Util. Greater Tonopah	64	0	0	0
White Tank Sys. (AZ Water Co.)	968	968	968	0
Subtotal	620,678	512,767	512,767	0
San Carlos Apache Tribe Phelps Dodge/Globe	18,145	0	0	0
Total	638,823	512,767	512,767	0

*47,303af NIA Priority water converts to M&I Priority on January 1, 2044 and 2,952af is distributed to Chandler, 4,924af to Mesa, 36,144af to Phoenix, and 3,283af to Scottsdale.

The shortage to the Indian priority under a 500,000 acre-foot basin-wide shortage simulated for the year 2017 is distributed as follows:

Table G-11
2017 CAP Indian Shortage Allocation from CAP Worksheet

AWSA Indian Priority Distribution	Entitlement				
	Indian 1	Indian 2	Indian 3	Indian 4	Total
AK-Chin Allocation	27,500	0	0	0	27,500
Fort McDowell	18,233	0	0	0	18,233
Gila River	147,925	0	11,305	31,970	191,200
TON-Chui Chu	7,200	0	0	800	8,000
TON-San Xavier	27,000	0	0	0	27,000
TON-Schuk Toak	10,800	0	0	0	10,800
Pasqua Yaqui	500	0	0	0	500
Salt River	11,970	1,330	0	0	13,300
San Carlos Apache	37,400	6,100	0	0	43,500
Tonto Apache	128	0	0	0	128
Yavapai Apache (Camp Verde)	1,200	0	0	0	1,200
Yavapai Prescott	500	0	0	0	500
Unallocated HVID	1,218	0	0	0	1,218
Total	291,574	7,430	11,305	32,770	332,986

AWSA Indian Priority Distribution	Scheduled Use				
	Indian 1	Indian 2	Indian 3	Indian 4	Total
AK-Chin Allocation	27,500	0	0	0	27,500
Fort McDowell	8,140	0	0	0	8,140
Gila River	147,925	0	11,305	31,970	191,200
TON-Chui Chu	7,200	0	0	800	8,000
TON-San Xavier	27,000	0	0	0	27,000
TON-Schuk Toak	10,800	0	0	0	10,800
Pasqua Yaqui	500	0	0	0	500
Salt River	11,970	1,330	0	0	13,300
San Carlos Apache	37,400	6,100	0	0	43,500
Tonto Apache	128	0	0	0	128
Yavapai Apache (Camp Verde)	1,200	0	0	0	1,200
Yavapai Prescott	500	0	0	0	500
Unallocated HVID	1,218	0	0	0	1,218
Total	281,481	7,430	11,305	32,770	332,986

AWSA Indian Priority Distribution	Adjusted Delivery				
	Indian 1	Indian 2	Indian 3	Indian 4	Total
AK-Chin Allocation	27,500	0	0	0	27,500

Table G-11
2017 CAP Indian Shortage Allocation from CAP Worksheet

Fort McDowell	8,140	0	0	0	8,140
Gila River	147,925	0	11,305	31,970	191,200
TON-Chui Chu	7,200	0	0	800	8,000
TON-San Xavier	27,000	0	0	0	27,000
TON-Schuk Toak	10,800	0	0	0	10,800
Pasqua Yaqui	500	0	0	0	500
Salt River	11,970	1,330	0	0	13,300
San Carlos Apache	37,400	6,100	0	0	43,500
Tonto Apache	128	0	0	0	128
Yavapai Apache (Camp Verde)	1,200	0	0	0	1,200
Yavapai Prescott	500	0	0	0	500
Unallocated HVID	1,218	0	0	0	0
Total	281,481	7,430	11,305	32,770	332,986

AWSA Indian Priority Distribution	Shortage Allocation***				
	Indian 1	Indian 2	Indian 3	Indian 4	Total
AK-Chin Allocation	0	0	0	0	0
Fort McDowell	0	0	0	0	0
Gila River	0	0	0	0	0
TON-Chui Chu	0	0	0	0	0
TON-San Xavier	0	0	0	0	0
TON-Schuk Toak	0	0	0	0	0
Pasqua Yaqui	0	0	0	0	0
Salt River	0	0	0	0	0
San Carlos Apache	0	0	0	0	0
Tonto Apache	0	0	0	0	0
Yavapai Apache (Camp Verde)	0	0	0	0	0
Yavapai Prescott	0	0	0	0	0
Unallocated HVID	0	0	0	0	0
Total	0	0	0	0	0

G.5.3 Shortage Allocation Model Results

A summary of the above CAP shortages is displayed in the attached Table G-16. Additionally, the first table of each Attachment 2-8 summarizes all Lower Colorado River simulated shortages to the Lower Division States and Mexico, which was used in the Water Delivery section 4.4 of this Draft Environmental Impact Study (Draft EIS). Following the first table in Attachments 2-8 are Arizona and CAP shortages to entitlement holders by classification of water use: Indian priority entitlement holders (in Consumptive Use and Diversion amounts), M&I priority entitlement holders (Diversion only), and agricultural entitlement holders (Consumptive Use and Diversion). For example, the below output table shows reductions in consumptive use to Arizona agriculture from a 500,000 af lower basin shortage. The bottom of the output worksheets collects impacts by county in Arizona, which was used to analyze socio-economic impacts in this Draft EIS (see Attachments 2-8).

Table G-12.
Arizona (CU) Agricultural Summary Output Worksheet

2017								
Region		400,000	500,000	600,000	800,000	1,000,000	2,000,000	2,500,000
CAP	Agricultural Relinquished Water Contracts Under AWSA	272,691	272,691	272,691	272,691	272,691	272,691	272,691
CAP	Arizona State Land Department	989	6,554	9,026	9,026	9,026	9,026	9,026
4	Arizona State Land Department	1,225	1,531	1,837	2,450	3,062	5,297	5,297
4	Beattie Farms Southwest (new contract)(2004 over use of 263af)	187	209	250	334	417	722	722
4	ChaCha (Curtis Family Trust)(Auza Farm and Farm West)(over 13af)	369	461	554	738	923	1,596	1,596
4	Cibola Resources	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	1,723	2,154	2,585	3,446	4,308	7,452	7,452
4	Curtis, Armon (Curry Family LTD)	53	66	79	105	132	228	228
4	Gila Monster Farms (formerly Sturges Farms Inc.)	206	257	309	411	514	890	890
4	Jessen Family Limited (new contract)(2004 over use of 4,984af)	250	312	375	499	624	1,080	1,080
4	Mohave County Water Authority(new entitlement)	886	1,108	1,330	1,773	2,216	3,834	3,834
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	3,384	4,803	5,763	7,684	9,605	16,616	16,616
4	North Baja LLC (formerly Jamar Produce)(72af M&I)	68	85	102	135	169	293	293
4	Ogram Boys Enterprises (new contract)	162	203	243	325	406	702	702
4	Ogram, George	84	105	127	169	211	365	365
4	Pasquinelli, Gary and Barbara(formerly Ansel Hall)	90	112	135	179	224	388	388
4	Peach, John (2004 over use of 45af)	102	128	153	204	256	442	442
4	Phillips, Milton and Jean	4	5	6	8	10	18	18
4	Rayner Ranches	788	986	1,183	1,577	1,971	3,410	3,410
2	Yuma Irrigation District (5,000af M&I)	0	0	0	0	0	2,405	6,857
2	Yuma County Water Users' Association (14,701af M&I)	0	0	0	0	0	0	0
2	Yuma Area Office (489.95af M&I Conversion)	0	0	0	0	0	0	0
2	Yuma Mesa Fruit Growers	0	0	0	0	0	1	3
2	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	0	0	0	0	0	12,893	36,761
2	University of Arizona	0	0	0	0	0	73	207
2	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	0	0	0	0	0	5	15
2	North Gila Valley Irrigation District (2,500af M&I)	0	0	0	0	0	0	0

Table G-12.
Arizona (CU) Agricultural Summary Output Worksheet

2017								
Region		400,000	500,000	600,000	800,000	1,000,000	2,000,000	2,500,000
2	Yuma Auxiliary Project (Unit B)	0	0	0	0	0	1,120	3,193
2	Welton-Mohawk Irrigation and Drainage District (5,000af M&I)	0	0	0	0	0	23,567	67,193
2	Gila Monster Farms (formerly Sturges)	0	0	0	0	0	311	886
2	Sturges, Harold (not taking water)	0	0	0	0	0	0	0
2	Sturges, Irma (not taking water)	0	0	0	0	0	0	0
1	Molina	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	0	0	0	0	0	0	0
1	Zozaya (in MVIDD)	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	0	0	0	0	0	0	0
1	Yuma Auxiliary Project (Unit B)	0	0	0	0	0	0	0
1	Hulet (in MVIDD)	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler)	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD)	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD)	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	0	0	0	0	0	0	0
1	Phillips, Milton and Jean	0	0	0	0	0	0	0
	Arizona Total	10,020	12,524	15,029	20,039	25,049	83,706	158,447
	Ag by County							
	Coconino County	0	0	0	0	0	0	0
	La Paz County	2,677	3,347	4,016	5,355	6,693	11,579	11,579
	Maricopa County	62,719	62,719	62,719	62,719	62,719	62,719	62,719
	Mohave County	3,842	4,803	5,763	7,684	9,605	16,616	16,616
	Pinal County	210,916	216,256	218,998	218,998	218,998	218,998	218,998
	Yuma County	3,500	4,375	5,250	7,000	8,750	55,511	130,252
	Total Ag by County	283,699	291,769	296,746	301,756	306,765	365,423	440,164

Some of Arizona entitlements are split between agricultural and M&I entitlement holders. Thus, for such entitlement holders, the reduction in agricultural consumptive use is a proportion of the ratio of agricultural use to M&I use permitted in the entitlement holder's contract. For unquantified contract entitlements, the specified M&I amount in the contract was subtracted from the scheduled use for the selected year.

G.6 Relationship between CRSS & the Shortage Allocation Model

The Colorado River Simulation System (CRSS) model, as described in Appendix A, is used to determine a variety of river and reservoir parameters in the Colorado River Basin, including shortage amounts, reservoir elevations, and river flows. The Shortage Allocation Model provides a more detailed allocation of shortages in the Lower Basin by tracking the available water delivery and consumptive use down to the entitlement holder. The Shortage Allocation Model is capable of determining Stage I and II Shortage reductions, State reductions, and reductions to entitlement holders – including CAP entitlement holders.

In terms of the total amounts of Stage I and II Shortages, CRSS and the Shortage Allocation Model generate the same results. In terms of the breakdown of a Stage I Shortage amongst Arizona fourth priority entitlement holders, the models differ slightly. CRSS does not explicitly recognize and separate the AWBA and Arizona fifth priority water from CAP deliveries, while the Shortage Allocation Model recognizes these uses and reduces water available to the AWBA and fifth priority entitlement holders first, and then the quantity of fourth priority water available to Arizona CAP and non-CAP fourth priority entitlement holders are reduced proportionately. The result from the Shortage Allocation Model is a lesser impact to Arizona fourth priority and CAP entitlement holders when compared to CRSS. The total shortage to Arizona, however, remains the same.

At ADWR's request the recommended water delivery contracts were incorporated into CRSS and the Shortage Allocation Model since recommended contracts are likely to become permanent contracts (if the Secretary follows the recommendation of ADWR), and in most cases the water is already being used by the entity receiving the ADWR recommendation. The practice in Arizona is for ADWR to make a recommendation that an entity receive a water delivery contract, and the Secretary considers the recommendation and may contract with the entity. Some of the entities recommended for a contract by ADWR have not yet received a Colorado River water delivery contract. The recommended water delivery contract for Brooke Water Company (120 acre-feet) was inadvertently excluded by error in both models. In addition a recommended water delivery contract for the Mohave County Water Authority (MCWA) of 3,500 af was inadvertently excluded from CRSS. All recommended contracts will be incorporated into the analysis for the Final Environmental Impact Statement.

In Table G-373, shortage results generated in CRSS and the Shortage Allocation Model are provided. The difference in the results before 2020 is caused by CRSS not reducing the water deliveries to the AWBA before fourth priority. In year 2020 differences occur even after water is not being banked due to the excluded MCWA recommended contract.

Table G-13
Comparison of CRSS and Shortage Allocation Model Results

Year	User	Shortage Allocation Model	CRSS	Difference (Shortage Allocation Model - CRSS)
2010 (600,000 Acre-Foot Shortage)				
	AZ BANK	172,032	--------------	172,032
	CAP	287,885	453,275	-165,390
	RIVER	20,083	26,724	-6,641
	TOTAL	480,000	479,999	1
2012 (400,000 Acre-Foot Shortage)				
	AZ BANK	56,110	--------------	56,110
	CAP	247,755	301,633	-53,878
	RIVER	16,135	18,367	-2,232
	TOTAL	320,000	320,000	0
2020 (600,000 Acre-Foot Shortage)				
	AZ BANK	0	--------------	0
	CAP	450,439	451,300	-861
	RIVER	29,561	28,700	861
	TOTAL	480,000	480,000	0
2030 (1,757,939 Acre-Foot Shortage - 2nd/3rd Shortage of 7,061 Af)				
	AZ BANK	0	--------------	0
	CAP	1,287,473	1,289,817	-2,344
	RIVER	89,978	87,633	2,345
	TOTAL	1,377,451	1,377,450	1

One last difference between CRSS and the Shortage Allocation Model exists. In distributing the available water supply to individual users, CRSS models the quantity of water used by the individual entitlement holder in the previous year. The Shortage Allocation Model uses the quantity of water projected to be ordered in the shortage year as the basis for distributing the available water supply to individual users. In the example above, the Shortage Allocation Model results were computed based on the previous year’s use to produce the same results as CRSS.

A list of all output and attachments is provided in the table of contents.

Attachment 1: Operational Worksheets in the Shortage Allocation Model (Example: 2017, 400,000 acre-foot Shortage)

Table G-14
Shortage Allocation Model (Region Worksheet)

	U.S. & Mexico Shortage Sharing	Consumptive Use Entitlement	Deliverable Consumptive Use	Consumptive Use Reduction
Stage I Shortage:		1,729,907	1,329,907	400,000
Mexico	16.67%	288,318	221,651	66,667
United States:				
Arizona	80.00%	1,383,925	1,063,925	320,000
Nevada	3.33%	57,664	44,330	13,333
California	0.00%	0	0	0
Stage II Shortage (when AZ 4th = 0):		7,270,093	7,270,093	0
Mexico	16.67%	1,211,682	1,211,682	0
United States:				
Arizona	19.48%	1,416,075	1,416,075	0
Nevada	3.33%	242,336	242,336	0
California	60.52%	4,400,000	4,400,000	0
Stage I & II Total:		**9,000,000**	**8,600,000**	**400,000**

RUN MODE	-	-	- **TOTAL REDUCTION:**	**400,000**
Arizona			2,480,000	320,000
Nevada			286,667	13,333
California			4,400,000	0
Mexico			1,433,333	66,667

PROCESS

Region Shortage Maps
NV Shortage Maps
AZ Shortage Maps
CA Shortage Maps

Table G-15
State of Arizona

2017		**400,000**			ENTITLEMENT		SCHEDULED USE****		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
	State Consumptive Use							2,800,000		2,480,000		320,000
5th & Bank**	Central Arizona Water Conservation District (CAP)***	14-06-W-245	1972	bank	AZ Balance		0	0	0	0	0	0
	TOTAL				**AZ Balance**		**0**	**0**	**0**	**0**	**0**	**0**
	PERCENT									0%		0%
4th	Arizona State Land Department	7-07-30-W0358	2004	M&I	1,534		817	531	628	408	-189	-123
	Arizona State Land Department	4-07-30-W0317	1999	Ag	6,607		8,150	5,297	6,265	4,072	-1,884	-1,225
	Arizona State Parks Board - Contact Point	(Recommendation)		M&I	20		13	13	10	10	-3	-3
	Arizona State Parks Board - Windsor Beach	7-07-30-W0364	1998	M&I	90		31	20	24	15	-7	-5
	Arizona-American Water Company	00-XX-30-W0391	2001	M&I	1,420		463	300	356	231	-107	-69
	Beattie Farms Southwest (new contract)	06-XX-30-W0446	2006	Ag	1,110		1,110	722	853	555	-257	-167
	Brooke Water Company (formerly Graham) (recommended 120af not included)	4-07-30-W0042	1983	M&I	320		104	69	80	53	-24	-16
	Bullhead City	2-07-30-W0273	1982	M&I	15,210		13,025	8,725	10,014	6,708	-3,012	-2,018
	Bureau of Land Management	8-07-30-W0373	1973/81/87	M&I		4,010	1,309	851	1,007	654	-303	-197
	Central Arizona Water Conservation District (CAP)***	14-06-W-245	1972	M&I/Ag/Ind.	1,490,000		1,299,101	1,299,101	998,714	998,714	-300,386	-300,386
	ChaCha (Curtis Family Trust) (Auza Farm and West Farm)	(Recommendation)		Ag	2,100		2,456	1,596	1,888	1,227	-568	-369
	B&I Investment, LLC	06-XX-30-W0453	2006	M&I	60		0		0	0	0	0
	Cibola Valley Irrigation & Drainage District (M&I: 300af)	2-07-30-W0028	1983	M&I/Ag	12,066		10,842	7,752	8,335	5,960	-2,507	-1,793
	City of Somerton (new contract)	03-XX-30-W0419	2006	M&I	750		762	495	585	381	-176	-114
	City of Yuma (Smucker Park)	14-06-303-2702	1969	M&I	33		0	0	0	0	0	0

Table G-15
State of Arizona

2017		400,000			ENTITLEMENT		SCHEDULED USE****		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
	Cocopah Indian Reservation	1974 Decree	1974	Ind.	2,026		1,362	1,337	1,047	1,028	-315	-309
	Crystal Beach Water Conservation District	6-07-30-W0352	1997	M&I	132		106	69	82	53	-25	-16
	Curtis, Armon (Curry Family LTD)	3-07-30-W0037	1983	Ag	300		351	228	270	175	-81	-53
	Desert Lawn Memorial Park Association, Inc.	14-06-300-2587	1975	M&I	360		22	15	17	11	-5	-3
	Ehrenburg Improvement District	8-07-30-W0006	1977	M&I	500		529	379	407	291	-122	-88
	Fisher's Landing Water and Sewer Works, LLC	(Recommendation)		M&I	53		53	34	41	26	-12	-8
	Gila Monster Farms (formerly Sturges Farms Inc.)	6-07-30-W0337	1997	Ag	1,435		1,648	890	1,267	684	-381	-206
	Gold Dome Mining Corporation	0-07-030-W0250	1990	M&I	7		0	0	0	0	0	0
	Gold Standard Mines Corporation	3-07-30-W0038	1983	M&I	75		0	0	0	0	0	0
	Golden Shores Water Conservation District	9-07-30-W0203	1989	M&I	2,000		759	508	583	390	-175	-117
	Hillcrest Water Company	5-07-30-W0078	1985	M&I	84		56	36	43	28	-13	-8
	Hopi Tribe (new entitlement)	04-XX-30-W0432	2004	Ind.	5,997		5,898	3,834	4,534	2,947	-1,364	-886
	Jessen Family Limited (new contract)	(Recommendation)		Ag	1,080		1,662	1,080	1,277	830	-384	-250
	Lake Havasu City	3-07-30-W0039	1995	M&I	19,180		19,594	12,148	15,064	9,339	-4,531	-2,809
	Marble Canyon Company, Inc.	5-07-30-W0322	1996	M&I	70		24	16	19	12	-6	-4
	Martinez Lake Cabin Sites	(Recommendation)		M&I	23		23	15	18	11	-5	-3
	McAlister, Maurice L.	7-07-30-W0355	1998	M&I	40		6	4	5	3	-1	-1
	Mohave County Water Authority (new entitlement)	04-XX-30-W0431	2004	Ag	5,997		11,618	3,834	8,932	2,947	-2,686	-886
	Mohave County Water Authority (recommended 3,500af included)	5-07-30-W0320	1968	M&I	18,500		8,060	5,240	6,196	4,028	-1,864	-1,212
	Subcontract to Bullhead City (6,000 AF)			M&I								
	Subcontract to Lake Havasu City (6,000 AF)			M&I								

Table G-15
State of Arizona

2017		**400,000**			ENTITLEMENT		SCHEDULED USE****		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
	Subcontract to Mohave Water Cons. Dist. (3,000 AF)			M&I								
	Mohave Valley Irrigation and Drainage District (5,000af M&I)	14-06-W-204	1968	M&I/Ag	35,060		40,028	21,616	30,773	16,618	-9,256	-4,998
	Mohave Water Conservation District	9-07-30-W0012	1968	M&I	1,800		928	622	713	478	-215	-144
	North Baja LLC (formerly Jamar Produce) (72af M&I)	5-07-30-W0066	1984	M&I/Ag	480		520	365	399	281	-120	-84
	Ogram Boys Enterprises (new contract)	1-XX-30-W0402	2005	Ag	924		1,080	702	830	540	-250	-162
	Ogram, George	01-XX-30-W0398	2003	Ag	480		562	365	432	281	-130	-84
	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	5-07-30-W0065	1986	Ag	486		597	388	459	298	-138	-90
	Peach, John	(Recommendation)		Ag	456		680	442	523	340	-157	-102
	Phillips, Milton and Jean	(Recommendation)		Ag	18		28	18	21	14	-6	-4
	Rayner Ranches	5-07-30-W0064	1984	Ag	4,500		5,248	3,410	4,034	2,622	-1,213	-788
	Reserved Secretary Water for Indian Settlements				3,500		0		0	0	0	0
	Roy, Edward P. & Anna R.	6-07-30-W0124	1986	M&I	1		2	1	1	1	0	0
	Shepard Water Company	(Recommendation)		M&I	50		50	33	38	25	-12	-8
	City of Parker	2-07-30-W0025	1998	M&I	1,030		1,097	415	843	319	-254	-96
	Town of Quartzsite	7-07-30-W0353	1999	M&I	1,070		409	409	314	314	-95	-95
	Verizon (formerly Continental Telephone)	14-06-300-2506	1974	M&I	1		2	1	1	1	0	0
	Unallocated Priority 4 Water						0	0	0	0	0	0
	TOTAL				**1,639,035**	**4,010**	**1,441,182**	**1,383,925**	**1,107,943**	**1,063,925**	**-333,239**	**-320,000**
	PERCENT									77%		-23%

Table G-15
State of Arizona

2017		400,000			ENTITLEMENT		SCHEDULED USE****		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
2nd & 3rd (co-equal)	Cibola National Wildlife Refuge	Secretarial Res.	8/21/1964	M&I	34,500	16,793	13,692	8,505	13,692	8,505	0	0
	Yuma Irrigation District (5,000af M&I)	14-06-300-1270	1962	M&I/Ag		67,278	72,177	32,860	72,177	32,860	0	0
	National Park Service	1964 Decree	1961	M&I	unquantified****		738	738	738	738	0	0
	Yuma Union High School	14-06-303-179	1960	M&I	200		157	117	157	117	0	0
	Union Pacific Railroad (formerly Southern Pacific Co.)	14-06-303-1524	12/21/1959	M&I	48		59	29	59	29	0	0
	Kaman, Inc.	14-06-303-1555	12/2/1959	M&I	2		0	0	0	0	0	0
	City of Yuma	14-06-W-106	11/12/1959	M&I		48,522	43,445	28,852	43,445	28,852	0	0
	Department of Navy MCAS	14-06-300-937	1/1/1959	M&I	3,000		2,129	2,129	2,129	2,129	0	0
	Yuma County Water Users' Association (14,701af M&I)	14-06-300-621 & Certificates	1957	M&I/Ag	unquantified****		0		0	0	0	0
	Yuma Area Office (489.95af M&I Conversion)				490					0		
	City of Yuma (cemetary)	14-06-303-1078	11/12/1956	M&I	60		0	0	0	0	0	0
	Yuma Mesa Fruit Growers	14-06-303-1196	10/1/1956	Ag	15		12	12	12	12	0	0
	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	14-06-W102	5/26/1956	M&I/Ag		141,519	307,476	159,354	307,476	159,354	0	0
	Desert Lawn Memorial Park	14-06-300-1079	5/1/1956	M&I	200		207	140	207	140	0	0
	Ak-Chin Indian Community***	AK-CHIN121180A	1/1/1956	Ind.	50,000		50,000	50,000	50,000	50,000	0	0
	University of Arizona	14-06-300-144	1954	Ag	1,088		840	840	840	840	0	0
	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	14-06-303-528	12/23/1953	Ag	120		84	60	84	60	0	0
	North Gila Valley Irrigation District (2,500af M&I)	14-06-W-54	3/12/1953	M&I/Ag		41,203	0		0	0	0	0
	Yuma Auxiliary Project (Unit B)	14-06-300-44	12/22/1962	Ag	unquantified****		21,499	12,973	21,499	12,973	0	0
	Welton-Mohawk Irrigation and	1-07-30-W0021	3/4/1952	M&I/Ag		278,0	441,740	277,997	441,740	277,997	0	0

Table G-15
State of Arizona

2017		400,000			ENTITLEMENT		SCHEDULED USE****		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
	Drainage District (5,000af M&I)					00						
	Chandler (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	4,278		4,278	4,278	4,278	4,278	0	0
	Gilbert (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	6,762		6,762	6,762	6,762	6,762	0	0
	Glendale (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	3,000		3,000	3,000	3,000	3,000	0	0
	Mesa (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	2,760		2,760	2,760	2,760	2,760	0	0
	Phoenix (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	5,000		5,000	5,000	5,000	5,000	0	0
	Scottsdale (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	100		100	100	100	100	0	0
	Tempe (Salt River Pima-Maricopa Exchange)***	Salt River Settlement	3/4/1952	M&I	100		100	100	100	100	0	0
	Gila Monster Farms (formerly Sturges)	6-07-30-W0337	1/1/1952	Ag	6,285		6,670	3,600	6,670	3,600	0	0
	Sturges, Harold	I76R-733	1/1/1952	Ag	335		0		0	0	0	0
	Sturges, Irma	I76R-735	1/1/1952	Ag	385		0		0	0	0	0
	Department of Army - Yuma Proving Ground	I76r-696	1951	M&I	1,129		760	760	760	760	0	0
	Bureau of Reclamation - Davis Dam	Secretarial Res.	4/26/1941	M&I	100		1	1	1	1	0	0
	Imperial National Wildlife Refuge	1964 Decree	2/14/1941	M&I	28,000	23,000	5,831	3,618	5,831	3,618	0	0
	Havasu Lake National Wildlife Refuge	1964 Decree	1/22/1941	M&I	41,839	37,399	42,279	4,841	42,279	4,841	0	0
	TOTAL				**189,796**	**653,714**	**1,031,796**	**609,426**	**1,031,796**	**609,426**	**0**	**0**
	PERCENT									100%		0%

Table G-15
State of Arizona

2017		400,000			ENTITLEMENT		SCHEDULED USE****		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
1st (PPR's)*	Molina	PPR No. 15	1928	Ag	318		0	0	0	0	0	0
	Gila Monster Farms (formerly Sturges)	PPR No. 16	1925	Ag	780		1,445	780	1,445	780	0	0
	Cocopah Indian Reservation	PPR No. 1	9/27/1917	Ind.	7,681		6,950	6,792	6,950	6,792	0	0
	Cocopah Indian Reservation	PPR No. 8	1915	Ind.	1,140		1,031	1,008	1,031	1,008	0	0
	Powers (Power, R.E. & P.)	PPR No. 7	1915	Ag	960		960	624	960	624	0	0
	Zozaya (in MVIDD)	PPR No. 17	1912	Ag	720		720	389	720	389	0	0
	Fort Mohave Indian Reservation	PPR No. 3	2/2/1911	Ind.	75,566		98,653	53,280	98,653	53,280	0	0
	Brooke Water Company (formerly Graham)	PPR No. 9	1910	M&I	360		361	241	361	241	0	0
	North Gila Valley Irrigation District	PPR No. 6	7/8/1905	Ag	24,500		85,059	19,761	85,059	19,761	0	0
	Yuma Auxiliary Project (Unit B)	PPR No. 5 & Certificates	7/8/1905	Ag	6,800		11,269	6,800	11,269	6,800	0	0
	City of Parker	PPR No. 20	1905	M&I	630	400	1,057	400	1,057	400	0	0
	Hulet (in MVIDD)	PPR No. 10	1902	Ag	1,080		1,080	583	1,080	583	0	0
	Hoover (in MVIDD/formerly Hopal)	4-07-30-W0052/PPR 11	1902	Ag	1,050		1,050	567	1,050	567	0	0
	Miller (in MVIDD)	PPR No. 12	1902	M&I	240		240	130	240	130	0	0
	McKellips and Granite Reef Farms (in MVIDD)	PPR No. 13	1902	Ag	810		810	437	810	437	0	0
	Sherill & Lafollette (in MVIDD)	PPR No. 14	1902	Ag	1,080		1,080	583	1,080	583	0	0
	Swan (in MVIDD)	PPR No 18	1902	M&I	960		960	518	960	518	0	0
	Yuma County Water Users' Association	PPR No. 4 & Certificates	1901	Ag	254,200		357,227	228,368	357,227	228,368	0	0
	Phillips, Milton and Jean	PPR No. 19	1900	Ag	42		0	0	0	0	0	0
	City of Yuma	PPR No. 21	1893	M&I		1,478	2,350	1,489	2,350	1,489	0	0
	Fort Mohave Indian Reservation	PPR No. 3	9/18/1890	Ind.	27,969		36,514	19,720	36,514	19,720	0	0
	Fort Yuma Indian Reservation (new entitlement)	PPR No. 3a	1/9/1884	Ind.	6,350		1,812	1,178	1,812	1,178	0	0
	Colorado River Indian Reservation	PPR No. 2	11/16/18	Ind.	51,986		64,947	36,337	64,947	36,337	0	0

Table G-15
State of Arizona

2017		**400,000**			ENTITLEMENT		SCHEDULED USE****		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
			74									
	Colorado River Indian Reservation	PPR No. 2	11/22/1873	Ind.	252,016		314,848	176,152	314,848	176,152	0	0
	Colorado River Indian Reservation	PPR No. 2	3/3/1865	Ind.	358,400		447,755	250,511	447,755	250,511	0	0
	TOTAL				**1,075,638**	**1,878**	**1,438,179**	**806,649**	**1,438,179**	**806,649**	**0**	**0**
	PERCENT									100%		0%
	ARIZONA TOTALS						3,934,879	2,800,000	3,577,917	2,480,000	-333,239	-320,000
	ARIZONA TOTAL PERCENT									89%		-11%

Note: CU means Consumptive Use; all units are in AFY.
Subcontracts are displayed below the Entitlement Holder and indented five spaces.
*PPR's are reduced last regardless of state lines in order of priority date (see PPR Spreadsheet).
**Nevada banking is not included in the banked use.
***These CAP users are subjuct to CAP conveyance losses which are assumed to be 5%. The Secretary of the Interior has the discretion to reduce Ak Chin from 75kaf to 72kaf in times of shortage, which is not modeled.

****2004 Decree Accounting values and Diversion/CU conversion ratios were used to estimate not specified and unquantified entitlements.

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Table G-16
Central Arizona Project (CAP)

Year: 2017	Entitlement						Scheduled Use						Adjusted Delivery						Shortage Allocation					
Selected Shortage Volume: 400,000	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL
Bank						0					0	0					0	0					0	0
Relinquished Agricultural Contracts						0				272,691		272,691				0		0				272,691		272,691
Ak-Chin Indian Community	47,500	27,500				75,000	47,500	27,500				75,000	47,500	27,500				75,000	0	0				0
Fort McDowell		18,233				18,233		8,140				8,140		8,140				8,140		0				0
Gila River		191,200	120,600			311,800		191,200	0			191,200		191,200	0			191,200		0	0			0
TON-Chui Chu		8,000				8,000		8,000				8,000		8,000				8,000		0				0
TON-San Xavier		27,000	23,000			50,000		27,000	8,972			35,972		27,000	7,989			34,989		0	983			983
TON-Schuk Toak		10,800	5,200			16,000		10,800	2,028			12,828		10,800	1,806			12,606		0	222			222
Pasqua Yaqui		500				500		500				500		500				500		0				0
Salt River		13,300				13,300		13,300				13,300		13,300				13,300		0				0
San Carlos Apache		43,500				43,500		43,500				43,500		43,500				43,500		0				0
Tonto Apache		128				128		128				128		128				128		0				0
Yavapai Apache (Camp Verde)		1,200				1,200		1,200				1,200		1,200				1,200		0				0
Yavapai Prescott		500				500		500				500		500				500		0				0
Unallocated HVID		1,218				1,218		1,218				1,218		1,218				1,218		0				0
Reserved Federal			67,300			67,300			12,300			12,300			10,952			10,952			1,348			1,348
Indian Subtotal:	47,500	343,079	216,100	0	0	606,679	47,500	332,986	23,300	0	0	403,786	47,500	332,986	20,747	0	0	401,233	0	0	2,553	0	0	2,553
Apache Junction (AZ Water Co)		6,000				6,000		6,000				6,000		6,000				6,000		0				0
Avra Coop		808				808		0				0		0				0		0				0
AZ-American (Agua Fria)		11,093				11,093		11,093				11,093		11,093				11,093		0				0
AZ-American (Paradise Valley)		3,231				3,231		3,231				3,231		3,231				3,231		0				0
AZ-American (Sun City)		4,189				4,189		4,189				4,189		4,189				4,189		0				0
AZ-American (Sun City West)		2,372				2,372		2,372				2,372		2,372				2,372		0				0
AZ State Land Dept.		32,076	9,026			41,102		700	9,026			9,726		700	8,037			8,737		0	989			989
ASARCO (Ray Mine)		21,000				21,000		0				0		0				0		0				0
Avondale		5,416				5,416		4,746				4,746		4,746				4,746		0				0
Berneil Water Co (Cave Creek)		200				200		0				0		0				0		0				0
Buckeye		25				25		0				0		0				0		0				0
Carefree Water Co		1,300				1,300		400				400		400				400		0				0
Casa Grande (AZ Water Co)		8,884				8,884		2,000				2,000		2,000				2,000		0				0
Cave Creek Water Co		2,406				2,406		2,048				2,048		2,048				2,048		0				0
CAGRD		7,746				7,746		7,746				7,746		7,746				7,746		0				0
Chandler*	4,064	8,654	3,924			16,642	4,064	8,654	3,924			16,642	4,064	8,654	3,494			16,212	0	0	430			430
Chandler Heights Citrus ID		315				315		0				0		0				0		0				0

Table G-16
Central Arizona Project (CAP)

Year: 2017	Entitlement						Scheduled Use						Adjusted Delivery						Shortage Allocation					
Selected Shortage Volume: 400,000	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL
Chaparral City Water Co		8,909				8,909		5,705				5,705		5,705				5,705		0				0
Circle City Water Co		3,932				3,932		0				0		0				0		0				0
Comm. Water Co (Green Valley)		2,858				2,858		0				0		0				0		0				0
Coolidge (AZ Water Co)		2,000				2,000		0				0		0				0		0				0
El Mirage		508				508		0				0		0				0		0				0
Eloy		2,171				2,171		2,171				2,171		2,171				2,171		0				0
Florence		2,048				2,048		2,048				2,048		2,048				2,048		0				0
Flowing Wells ID		4,354				4,354		0				0		0				0		0				0
Gilbert	6,424	7,235	1,537			15,196	6,424	7,235	1,537			15,196	6,424	7,235	1,369			15,028	0	0	168			168
Glendale	2,850	17,236	682			20,768	2,850	14,183	682			17,715	2,850	14,183	607			17,640	0	0	75			75
Goodyear		10,742				10,742		10,742				10,742		10,742				10,742		0				0
Green Valley DWID		1,900				1,900		500				500		500				500		0				0
H2O Water Co		147				147		0				0		0				0		0				0
Marana		47				47		0				0		0				0		0				0
Maricopa County Parks & Rec		665				665		645				645		645				645		0				0
Mesa*	2,622	43,503	5,551			51,676	2,622	30,029	5,552			38,203	2,622	30,029	4,944			37,595	0	0	608			608
MDWID		13,460				13,460		10,613				10,613		10,613				10,613		0				0
Oro Valley		10,305				10,305		10,305				10,305		10,305				10,305		0				0
Peoria		25,236				25,236		19,067				19,067		19,067				19,067		0				0
Phelps Dodge Miami		2,906				2,906		0				0		0				0		0				0
Phoenix*	4,750	122,120	37,280			164,150	4,750	134,120	37,280			176,150	4,750	134,120	33,196			172,066	0	0	4,084			4,084
Phoenix Memorial Park		84				84		0				0		0				0		0				0
Pine Water Co		161				161		0				0		0				0		0				0
Queen Creek Water Co		348				348		348				348		348				348		0				0
Rio Verde Utilities		812				812		812				812		812				812		0				0
San Tan ID		236				236		0				0		0				0		0				0
Scottsdale*	95	52,810	3,306			56,211	95	52,810	3,306			56,211	95	52,810	2,944			55,849	0	0	362			362
Spanish Trail Water Co		3,037				3,037		0				0		0				0		0				0
Superior		285				285		0				0		0				0		0				0
Surprise		10,249				10,249		10,249				10,249		10,249				10,249		0				0
Tempe	95	4,315	23			4,433	95	4,315	23			4,433	95	4,315	20			4,430	0	0	3			3
Tonto Hills Utility Co		71				71		0				0		0				0		0				0
Tucson		144,172				144,172		142,672				142,672		142,672				142,672		0				0
Vail Water Co		1,857				1,857		0				0		0				0		0				0
Valley Utilities Water Co		250				250		0				0		0				0		0				0
Water Util. Comm. Fac. Dist. (AJ)		2,919				2,919		50				50		50				50		0				0
Water Util. Greater Buckeye		43				43		0				0		0				0		0				0
Water Util. Greater Tonopah		64				64		0				0		0				0		0				0
White Tank Sys. (AZ Water Co.)		968				968		968				968		968				968		0				0

Table G-16
Central Arizona Project (CAP)

Year: 2017	Entitlement						Scheduled Use						Adjusted Delivery						Shortage Allocation					
Selected Shortage Volume: 400,000	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL	CAP 1 (CR)	CAP 2 (M&I / Indian)	CAP 3 (NIA)	CAP 4 (Excess Water)	CAP 5 (Bank)	TOTAL
San Carlos (Phelps Dodge/Globe)		18,145				18,145		0				0		0				0		0				0
State Reserved			87,269			87,269			31,072			31,072			27,668			27,668			3,404			3,404
M&I Subtotal	20,900	638,823	148,598	0	0	808,321	20,900	512,767	92,402	0	0	626,069	20,900	512,767	82,278	0	0	615,945	0	0	10,124	0	0	10,124
TOTAL	68,400	981,902	364,698			1,415,000	68,400	845,753	115,702	272,691	0	1,302,546	68,400	845,753	103,026	0	0	1,017,179	0	0	12,676	272,691	0	285,367
PERCENT							100	86	32	100	0	92	100	100	89	0	0	78	0	0	11	100	0	22

*47,303af NIA Priority water converts to M&I Priority on January 1, 2044 and 2,952af is distributed to Chandler, 4,924af to Mesa, 36,144af to Phoenix, and 3,283af to Scottsdale.

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Table G-17
State of Nevada

2017		400,000				ENTITLEMENT		FULL ENTITLEMENT USE*		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	No.	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
		State Consumptive Use							300,000		286,667		-13,333
8th - Balance & Surplus	12	Southern Nevada Water Authority (includes banking)	2-07-30-W0266	1992	M&I	balance + surplus		116,918	70,914	94,935	57,581	-21,983	-13,333
		TOTAL						**116,918**	**70,914**	**94,935**	**57,581**	**-21,983**	**-13,333**
		PERCENT									**81%**		**-19%**

Table G-17
State of Nevada

2017		**400,000**				ENTITLEMENT		FULL ENTITLEMENT USE*		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	No.	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
8th	2	Big Bend Water District	2-07-30-W0269	1992	M&I	10,000		10,000	4,251	10,000	4,251	0	0
	12	Southern Nevada Water Authority (Griffith Project)	7-07-30-W0004	1992	M&I	304,000		304,000	172,070	304,000	172,070	0	0
		Sub. to City of Boulder City (8,918af)			M&I						0		
		Sub. to City Henderson (27,021af)			M&I						0		
		Sub. to City of North Las Vegas (26635af)			M&I						0		
		Sub. to Las Vegas Valley Water District (232,426af)			M&I						0		
		TOTAL				**314,000**	**0**	**314,000**	**176,322**	**314,000**	**176,322**	**0**	**0**
		PERCENT									**100%**		**0%**
7th	3	Boy Scouts of America (annexed by SNWA)	9-07-30-W0011	1978	M&I	10		10	6	10	6	0	0
	4	Bureau of Reclamation (includes Sportsman Park)	Secretarial Res.	1998	M&I	300		300	188	300	188	0	0
	10	Nevada Dept. of Fish & Game, & NV Dept. of Wildlife	14-06-300-2405	1972	M&I		25	1,082	25	1,082	25	0	0
		U.S. Air Force (4,000af) (Delivery from SNWA)				4,000		4,000	2,264	4,000	2,264	0	0
		TOTAL				**310**	**25**	**1,392**	**218**	**1,392**	**218**	**0**	**0**
		PERCENT									**100%**		**0%**
6th		Las Vegas Valley Water District	14-06-300-2130	1969	M&I	15,407		15,407	15,407	15,407	15,407	0	0
		TOTAL				**15,407**	**0**	**15,407**	**15,407**	**15,407**	**15,407**	**0**	**0**
		PERCENT									**100%**		
5th	9	Lakeview Company (Hacienda Casino)	14-06-300-1523	1965	M&I	0		0	0	0	0	0	0
	11	Pacific Coast Building Products, Inc.	5-07-30-W0089	1965	M&I	928		928	928	928	928	0	0
		TOTAL				**928**	**0**	**928**	**928**	**928**	**928**	**0**	**0**
		PERCENT									**100%**		**0%**

Table G-17
State of Nevada

2017		400,000				ENTITLEMENT		FULL ENTITLEMENT USE*		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	No.	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
4th	1	Basic Management, Inc.	14-06-300-2083	1969	M&I	8,608		8,608	8,608	8,608	8,608	0	0
	6	City of Henderson	0-07-30-W0246	1967	M&I	15,878		15,878	14,700	15,878	14,700	0	0
		TOTAL				**24,486**	**0**	**24,486**	**23,308**	**24,486**	**23,308**	**0**	**0**
		PERCENT									**100%**		**0%**
3rd	5	Boulder City	14-06-300-978	1931	M&I	5,876		5,876	3,326	5,876	3,326	0	0
		TOTAL				**5,876**	**0**	**5,876**	**3,326**	**5,876**	**3,326**	**0**	**0**
		PERCENT									**100%**		**0%**
2nd	8	Lake Mead National Recreation Area**	1964 Decree	1930	M&I	unlimited		679	679	679	679	0	0
		TOTAL				**0**	**0**	**679**	**679**	**679**	**679**	**0**	**0**
		PERCENT									**100%**		**0%**
1st***	8	Lake Mead National Recreation Area	PPR 82/1979 Decree	1926	M&I	500	300	500	500	500	500	0	0
	7	Fort Mohave Indian Reservation	PPR 81	1890	Ind.	12,534		12,534	8,398	12,534	8,398	0	0
		TOTAL				**13,034**	**0**	**13,034**	**8,898**	**12,534**	**8,898**	**0**	**0**
		PERCENT									**100%**		**0%**
NEVADA TOTALS						374,041	25	492,720	300,000	470,237	286,667	-21,983	-13,333
NEVADA PERCENT											96%		-4%

Note: CU means Consumptive Use. All units are in afy.

*2004 Decree Accounting values and Diversion/CU conversion ratios were used to estimate not specified and unquantified entitlements.
**This unlimited entitlement is estimated based on 2004 use.
***PPR's are reduced last in the region, in order of priority date, regardless of state lines. (see PPR Spreadsheet).

Subcontracts are displayed below the Entitlement Holder and indented five spaces

Table G-18
State of California

2017		**400,000**				ENTITLEMENT		FULL ENTITLEMENT USE*		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	No.	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
		State Consumptive Use							4,400,000		4,400,000		0
5th	15	Metropolitan Water District (4)	I1r-645	1931	M&I		550,000	547,535	486,872	547,535	486,872	0	0
		TOTAL				**0**	**550,000**	**547,535**	**486,872**	**547,535**	**486,872**	**0**	**0**
		PERCENT									100%		0%
4th	18	Palo Verde Irrigation District (3b) - Mesa Lands	PVID20733C_P5	1933	Ag	<16,000 acres	0	0	0	0	0	0	0
	6	Coachella Valley Water District (3a)	I1r-781	1934	Ag		347,000	336,973	327,000	336,973	327,000	0	0
	13	Imperial Irrigation Districts (3a)	I1r-747	1932	Ag		561,159	577,292	561,159	577,292	561,159	0	0
	15	Metropolitan Water District	1988 Cons. Agreement	1988	M&I		90,000	0	0				
	21	San Diego County Water Authority****	SDCWA Transfer		M&I		30,000	0	0				
		Lower Colorado Water Supply Project	2-07-30-W0280	1992	M&I		10,000	0	0				
		TOTAL					**1,028,159**	**914,264**	**888,159**	**914,264**	**888,159**	**0**	**0**
		PERCENT									100%		0%
3rd	26	Yuma Project, Reservation Division (includes Bard, Indian, Island)	Water Certificates	1905	Ind./Ag	<25,000 acres		13,644	7,545	13,644	7,545	0	0
		TOTAL	**3,863,169**			**0**	**0**	**13,644**	**7,545**	**13,644**	**7,545**	**0**	**0**
		PERCENT									100%		0%

Table G-18
State of California

2017		400,000				ENTITLEMENT		FULL ENTITLEMENT USE*		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	No.	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
2nd	18	Palo Verde Irrigation District (1)	PVID20733C_P2	1933	Ag	unlimited		690,559	294,099	690,559	294,099	0	0
		TOTAL				**0**	**0**	**690,559**	**294,099**	**690,559**	**294,099**	**0**	**0**
		PERCENT									100%		0%
1st (PPR's)***	27	One Acre PPR's	PPR's 45-80	1895-1928	M&I	36	22	36	22	36	22	0	0
	23	Sonny Gowan (Grannis)	PPR 32 & 7-07-30-W0158	1928	Ag	180		180	108	180	108	0	0
	3	Chagnon	PPR No. 41	1925	Ag	120		120	72	120	72	0	0
	24	Stephenson	PPR No. 30	1923	Ag	240		240	144	240	144	0	0
	8	Colorado River Sportsmen's League	PPR No. 36	1921	Ag	96		96	58	96	58	0	0
	1	Andrade	PPR No. 38	1921	M&I/Ag	66		66	47	66	47	0	0
		(AKA Andrade, Andrews, Bly, Brown, Carney, Daniel, Fairbanks, Glynn,											
		Lindeman, Leon, Schroeder, Sherman, Perrett, Wetmore, Wetmore, Williams)											
	16	Milpitas	PPR No. 34	1918	Ag	108		108	65	108	65	0	0
	14	Lawrence	PPR No. 42	1915	Ag	120		120	72	120	72	0	0
	16	Milpitas	PPR No. 37	1914	Ag	69		69	41	69	41	0	0
	17	Morgan	PPR No. 33	1913	Ag	150		150	90	150	90	0	0
	4	Chemehuevi Indian Reservation	PPR No. 22	1907	Ind.	11,340		11,340	6,094	11,340	6,094	0	0

Table G-18
State of California

2017		**400,000**				ENTITLEMENT		FULL ENTITLEMENT USE*		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	No.	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
	9	Cooper	PPR No. 40	1905	Ag	60		60	36	60	36	0	0
	26	Yuma Project, Reservation Division (includes non-Indian/Island)	PPR 28 & Water Cert.	1905	Ind./Ag	38,270		38,270	17,918	38,270	17,918	0	0
	20	Reynolds	PPR No. 39	1904	Ag	36		36	22	36	22	0	0
	13	Imperial Irrigation District (includes lands in CVWD)	PPR No. 27	1901	Ag	2,600,000		2,600,000	2,527,341	2,600,000	2,527,341	0	0
	5	Atchison, Topeka, and Santa Fe Railway Co. (being assigned to Needles)	PPR No. 44	1896	M&I	1,260	273	1,260	273	1,260	273	0	0
	19	Picacho Development Corp and CA Dept of Parks and Rec	PPR 31 & 8-07-30-W0187	1893	Ag	120		120	66	120	66	0	0
	11	Fort Mohave Indian Reservation	PPR No. 25	1890	Ind.	16,720		16,720	8,994	16,720	8,994	0	0
	22	Simons	PPR No. 35	1889	Ag	60		60	36	60	36	0	0
	5	City of Needles	PPR No. 43/5-XX-30-W0445	1885	M&I	1,500	950	1,500	950	1,500	950	0	0
	12	Fort Yuma Indian Reservation	PPR No. 23	1/9/1 884	Ind.	71,616		71,616	34,506	71,616	34,506	0	0
	18	Palo Verde Irrigation District	PPR No. 26	1877	Ag	219,780		219,780	93,601	219,780	93,601	0	0
	7	Colorado River Indian Reservation	PPR No. 24	1876	Ind.	5,860		5,860	3,324	5,860	3,324	0	0
	7	Colorado River Indian Reservation	PPR No. 24	1874	Ind.	40,241		40,241	22,823	40,241	22,823	0	0
	7	Colorado River Indian Reservation	PPR No. 24	1873	Ind.	10,745		10,745	6,094	10,745	6,094	0	0
	25	Yuma Associates LTD and Winterhaven Water District (262.8 M&I)	PPR 29 & 4-07-30-W0053	1856	M&I/Ag	780		780	528	780	528	0	0

Table G-18
State of California

2017		**400,000**				ENTITLEMENT		FULL ENTITLEMENT USE*		ADJUSTED DELIVERY		SHORTAGE ALLOCATION	
Priority	No.	Entitlement Holder	Contract No.	Date	Use	Diversion	CU	Diversion	CU	Diversion	CU	Diversion	CU
		TOTAL				**3,019,573**	**1,245**	**3,019,573**	**2,723,325**	**3,019,573**	**2,723,325**	**0**	**0**
		PERCENT									100%		0%
		CALIFORNIA TOTALS				3,310,596	2,541,403	6,378,066	5,646,423	5,185,576	4,400,000	-1,192,491	-1,246,422
		CALIFORNIA PERCENT									78%		-22%

Note: CU means Consumptive Use; all units are in AFY.

Exchange Agreements are displayed below the Entitlement Holder and indented five spaces.

*2004 Decree Accounting values and Diversion/CU conversion ratios were used to estimate not specified and unquantified entitlements.

***PPR's are reduced last in the region, in order of priority date, regardless of state lines. (see PPR Spreadsheet).

****Met's return credit ratio was used for this new user.

1

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Attachment 2: 2008 Summary Output of Shortages

Table G-19.
Lower Colorado River Shortage Summary

2008	Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Stage I Shortage:	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	1,827,557
Stage II Shortage:	0	0	0	0	0	0	0	672,443
Total U.S. & Mexican Shortage	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Mexico	33,333	66,667	83,333	100,000	133,333	200,000	300,000	416,667
Nevada	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Surplus Water – SNWA	0	0	0	0	0	0	0	0
8th Priority (SNWA - Balance & Unused)	6,667	13,333	16,667	20,000	26,667	40,000	60,000	70,914
8th Priority (SNWA & Big Bend)	0	0	0	0	0	0	0	12,419
7th Priority (Boy Scouts, BOR, NV Dept of…)	0	0	0	0	0	0	0	0
6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
5th Priority (PABCO & Lakeview Co.)	0	0	0	0	0	0	0	0
4th Priority (Henderson & Basic Management)	0	0	0	0	0	0	0	0
3rd Priority (Boulder City)	0	0	0	0	0	0	0	0
2nd Priority (Lake Mead National Rec Area)	0	0	0	0	0	0	0	0
1st Priority (PPR's: LMNRA & Fort Mohave)	0	0	0	0	0	0	0	0
SUBTOTAL	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Arizona	160,000	320,000	400,000	480,000	640,000	960,000	1,440,000	1,587,484
Surplus Contracts (Hopi Tribe, Mohave Co., Ag)	0	0	0	0	0	0	0	0
5th Priority & CAP Bank (unused)	160,000	320,000	342,985	342,985	342,985	342,985	342,985	342,985
4th Priority (River users and CAP)	0	0	57,015	137,015	297,015	617,015	1,097,015	1,119,061
CAP Excess Water for Agriculture*	0	0	50,299	120,876	262,029	400,000	400,000	400,000
CAP NIA Priority (M&I, Indian, and Agriculture)	0	0	0	0	0	66,304	66,304	66,304
CAP Indian Priority	0	0	0	0	0	2,000	2,000	11,857
CAP M&I Priority	0	0	0	0	0	142,334	440,784	457,496
2/3 Priority (includes some CAP entities)	0	0	0	0	0	0	0	125,438
1st Priority (PPR's)	0	0	0	0	0	0	0	0
SUBTOTAL	160,000	320,000	400,000	480,000	640,000	960,000	1,440,000	1,587,484
California	0	0	0	0	0	0	0	412,516
Surplus (BLM, Needles, Coachella, Navy, MET)	0	0	0	0	0	0	0	0
7th Priority (unused & surplus - CVWD, IID, PVID)	0	0	0	0	0	0	0	0
6th Priority (unused & surplus - MET)	0	0	0	0	0	0	0	0
5th Priority (MET)	0	0	0	0	0	0	0	412,516
4th Priority (PVID, CVWD, IDD - MET & San Diego)	0	0	0	0	0	0	0	0
3rd Priority (Reservation Division)	0	0	0	0	0	0	0	0
2nd Priority (PVID)	0	0	0	0	0	0	0	0
1st Priority (PPR's - include PVID & IID)	0	0	0	0	0	0	0	0
SUBTOTAL	0	0	0	0	0	0	0	412,516
TOTAL	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000

*Shortage allocation may be zero if excess water for agriculture is not available.

Table G-20
Arizona M&I Consumptive Use Shortages

2008			Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP M&I										
Apache Junction (AZ Water Co)	Pinal County		0	0	0	0	0	1,204	5,809	6,000
Avra Coop	Pima County		0	0	0	0	0	0	0	0
AZ-American (Agua Fria)	Maricopa County		0	0	0	0	0	2,187	10,553	10,900
AZ-American (Paradise Valley)	Maricopa County		0	0	0	0	0	648	3,128	3,231
AZ-American (Sun City)	Maricopa County		0	0	0	0	0	841	4,056	4,189
AZ-American (Sun City West)	Maricopa County		0	0	0	0	0	476	2,297	2,372
AZ State Land Dept.	Maricopa County		0	0	0	0	0	140	678	700
ASARCO (Ray Mine)	Pima County		0	0	0	0	0	0	0	0
Avondale	Maricopa County		0	0	0	0	0	952	4,595	4,746
Berneil Water Co (Cave Creek)	Maricopa County		0	0	0	0	0	0	0	0
Buckeye	Maricopa County		0	0	0	0	0	0	0	0
Carefree Water Co	Maricopa County		0	0	0	0	0	80	387	400
Casa Grande (AZ Water Co)	Pinal County		0	0	0	0	0	401	1,936	2,000
Cave Creek Water Co	Maricopa County		0	0	0	0	0	321	1,547	1,598
CAGRD	Maricopa County		0	0	0	0	0	1,554	7,500	7,746
Chandler*	Maricopa County		0	0	0	0	0	4,988	9,060	10,072
Chandler Heights Citrus ID	Maricopa County		0	0	0	0	0	0	0	0
Chaparral City Water Co	Maricopa County		0	0	0	0	0	955	4,610	4,761
Circle City Water Co	Maricopa County		0	0	0	0	0	0	0	0
Comm. Water Co (Green Valley)	Pima County		0	0	0	0	0	0	0	0
Coolidge (AZ Water Co)	Pinal County		0	0	0	0	0	0	0	0
El Mirage	Maricopa County		0	0	0	0	0	0	0	0
Eloy	Pinal County		0	0	0	0	0	436	2,102	2,171
Florence	Pinal County		0	0	0	0	0	411	1,983	2,048
Flowing Wells ID	Pima County		0	0	0	0	0	0	0	0
Gilbert	Maricopa County		0	0	0	0	0	2,989	8,542	10,105
Glendale	Maricopa County		0	0	0	0	0	3,528	14,414	15,456
Goodyear	Maricopa County		0	0	0	0	0	2,156	10,400	10,742
Green Valley DWID	Pima County		0	0	0	0	0	100	484	500
H2O Water Co	Maricopa County		0	0	0	0	0	0	0	0
Marana	Pima County		0	0	0	0	0	0	0	0
Maricopa County Parks & Rec	Maricopa County		0	0	0	0	0	126	610	630
Mesa*	Maricopa County		0	0	0	0	0	9,740	25,760	26,968
MDWID	Pima County		0	0	0	0	0	2,027	9,779	10,101
Oro Valley	Pima County		0	0	0	0	0	0	0	0
Peoria	Maricopa County		0	0	0	0	0	1,485	7,166	7,401
Phelps Dodge Miami	Gila County		0	0	0	0	0	0	0	0
Phoenix*	Maricopa County		0	0	0	0	0	60,901	151,249	155,981
Phoenix Memorial Park	Maricopa County		0	0	0	0	0	0	0	0
Pine Water Co	Gila County		0	0	0	0	0	0	0	0

Table G-20
Arizona M&I Consumptive Use Shortages

2008		County	M&I/Ag Ratio	Lower Colorado River Shortage Volumes in Annual Acre-Feet							
				200000	400000	500000	600000	800000	1200000	1800000	2500000
	Queen Creek Water Co	Maricopa County		0	0	0	0	0	70	337	348
	Rio Verde Utilities	Maricopa County		0	0	0	0	0	163	786	812
	San Tan ID	Maricopa County		0	0	0	0	0	0	0	0
	Scottsdale*	Maricopa County		0	0	0	0	0	12,629	48,288	49,786
	Spanish Trail Water Co	Pima County		0	0	0	0	0	0	0	0
	Superior	Pinal County		0	0	0	0	0	0	0	0
	Surprise	Maricopa County		0	0	0	0	0	924	4,459	4,606
	Tempe	Maricopa County		0	0	0	0	0	889	4,201	4,358
	Tonto Hills Utility Co	Maricopa County		0	0	0	0	0	0	0	0
	Tucson	Pima County		0	0	0	0	0	16,806	81,085	83,750
	Vail Water Co	Pima County		0	0	0	0	0	0	0	0
	Valley Utilities Water Co	Maricopa County		0	0	0	0	0	0	0	0
	Water Util. Comm. Fac. Dist. (AJ)	Pinal County		0	0	0	0	0	10	48	50
	Water Util. Greater Buckeye	Maricopa County		0	0	0	0	0	0	0	0
	Water Util. Greater Tonopah	Maricopa County		0	0	0	0	0	0	0	0
	White Tank Sys. (AZ Water Co.)	Maricopa County		0	0	0	0	0	194	937	968
	San Carlos (Phelps Dodge/Globe)	Gila County		0	0	0	0	0	0	0	0
	State Reserved	All Counties in CAP		0	0	0	0	0	2,974	2,974	2,974
M&I Subtotal				0	0	0	0	0	133,308	431,758	448,470
Arizona M&I											
4	Arizona State Land Department	Yuma County		0	0	15	36	77	160	284	290
4	Arizona State Parks Board - Contact Point	Mohave County		0	0	1	2	3	7	13	13
4	Arizona State Parks Board - Windsor Beach	Mohave County		0	0	1	2	5	11	20	20
4	Arizona-American Water Company	Mohave County		0	0	15	35	77	160	284	289
4	Brooke Water Company (formerly Graham)	La Paz County		0	0	3	6	13	28	49	50
4	Bullhead City	Mohave County		0	0	357	859	1,861	3,866	6,874	7,012
4	Bureau of Land Management	La Paz County		0	0	43	104	226	469	834	851
4	Cibola Valley Irrigation & Drainage District******* (M&I: 300af)	La Paz County	0.039	0	0	15	37	80	165	294	300
4	City of Somerton (new contract)	Yuma County		0	0	25	61	131	273	485	495
4	City of Yuma (Smucker Park)	Yuma County		0	0	0	0	0	0	0	0
4	Crystal Beach Water Conservation District	Mohave County		0	0	3	7	16	33	59	60
4	Desert Lawn Memorial Park Association, Inc.	Yuma County		0	0	1	2	4	8	14	15
4	Ehrenburg Improvement District	La Paz County		0	0	17	40	86	180	319	326
4	Fisher's Landing Water and Sewer Works, LLC	Yuma County		0	0	2	4	9	19	34	34
4	Gold Dome Mining Corporation	Yuma County		0	0	0	0	0	0	0	0
4	Gold Standard Mines Corporation	Mohave County		0	0	0	0	0	0	0	0
4	Golden Shores Water Conservation District	Mohave County		0	0	22	53	114	236	420	429
4	Hillcrest Water Company	La Paz County		0	0	1	3	7	14	24	25
4	Lake Havasu City	Mohave County		0	0	507	1,218	2,641	5,487	9,755	9,951
4	Marble Canyon Company, Inc.	Coconino County		0	0	1	2	4	9	15	16
4	Martinez Lake Cabin Sites (recommended)	Yuma County		0	0	1	2	4	8	15	15

Table G-20
Arizona M&I Consumptive Use Shortages

2008				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
		County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
4	McAlister, Maurice L.	Mohave County		0	0	0	0	1	2	4	4
4	Mohave County Water Authority (recommended 3,500af)	Mohave County		0	0	133	319	692	1,437	2,554	2,606
4	Subcontract to Bullhead City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Lake Havasu City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Mohave Water Cons. Dist. (3,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.240	0	0	255	612	1,327	2,757	4,901	5,000
4	Mohave Water Conservation District	Mohave County		0	0	25	61	133	276	490	500
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.190	0	0	4	9	19	40	71	72
4	Roy, Edward P. & Anna R.	Yuma County		0	0	0	0	0	1	1	1
4	Shepard Water Company	Yuma County		0	0	2	4	9	18	32	33
4	City of Parker	La Paz County		0	0	14	35	75	157	279	284
4	Town of Quartzsite	La Paz County		0	0	15	35	76	159	282	288
4	Verizon (formerly Continental Telephone)	La Paz County		0	0	0	0	0	1	1	1
2/3	Cibola National Wildlife Refuge	La Paz County		0	0	0	0	0	0	0	1,588
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.149	0	0	0	0	0	0	0	1,038
2/3	National Park Service	Mohave County		0	0	0	0	0	0	0	153
2/3	Yuma Union High School	Yuma County		0	0	0	0	0	0	0	24
2/3	Union Pacific Railroad (formerly Southern Pacific Co.)	Yuma County		0	0	0	0	0	0	0	6
2/3	Kaman, Inc.	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma	Yuma County		0	0	0	0	0	0	0	5,039
2/3	Department of Navy MCAS	Yuma County		0	0	0	0	0	0	0	442
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma (cemetary)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.063	0	0	0	0	0	0	0	2,075
2/3	Desert Lawn Memorial Park	Yuma County		0	0	0	0	0	0	0	29
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.018	0	0	0	0	0	0	0	1,038
2/3	Chandler (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	0	888
2/3	Gilbert (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	0	1,403
2/3	Glendale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	0	623
2/3	Mesa (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	0	573
2/3	Phoenix (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	0	1,038
2/3	Scottsdale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	0	21
2/3	Tempe (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	0	21
2/3	Department of Army - Yuma Proving Ground	Yuma County		0	0	0	0	0	0	0	158
2/3	Bureau of Reclamation - Davis Dam	Mohave County		0	0	0	0	0	0	0	0
2/3	Imperial National Wildlife Refuge	La Paz County		0	0	0	0	0	0	0	751
2/3	Havasu Lake National Wildlife Refuge (2004 over use of 7,777af)	Mohave County		0	0	0	0	0	0	0	1,005
1	Brooke Water Company (formerly Graham)	La Paz County		0	0	0	0	0	0	0	0
1	City of Parker	La Paz County		0	0	0	0	0	0	0	0
1	Miller (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	Swan (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0

Table G-20
Arizona M&I Consumptive Use Shortages

2008				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
		County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
1	City of Yuma	Yuma County		0	0	0	0	0	0	0	0
Total Arizona M&I:				0	0	1,476	3,548	7,691	15,978	28,408	46,890
M&I Summary by County		# of Tribes in the County									
	Coconino County	1		0	0	1	2	4	9	15	16
	Gila County	3		0	0	0	0	0	0	0	0
	La Paz County	13		0	0	112	269	583	1,211	2,153	4,536
	Maricopa County	36		0	0	0	0	0	108,939	325,558	338,876
	Mohave County	20		0	0	1,319	3,169	6,870	14,272	25,374	27,042
	Pima County	11		0	0	0	0	0	18,933	91,348	94,351
	Pinal County	7		0	0	0	0	0	2,462	11,879	12,269
	Yuma County	24		0	0	45	108	234	487	865	10,731
	All Counties in CAP	1		0	0	0	0	0	2,974	2,974	2,974
	(blank)	0		0	0	0	0	0	0	0	0
Total Arizona M&I:		116		0	0	1,476	3,548	7,691	149,286	460,166	490,794

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-21
Arizona Agricultural Diversion Shortages

2008				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima		0	0	50,299	120,876	262,029	400,000	400,000	400,000
CAP	Arizona State Land Department	Pinal County		0	0	0	0	0	9,026	9,026	9,026
4	Arizona State Land Department	Yuma County		0	0	410	985	2,136	4,437	7,889	8,048
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County		0	0	57	136	295	612	1,088	1,110
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County		0	0	124	297	645	1,340	2,382	2,430
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	0	0	531	1,276	2,766	5,747	10,217	10,423
4	Curtis, Armon (Curry Family LTD)	Yuma County		0	0	18	42	92	191	340	347
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		0	0	84	202	437	909	1,616	1,648
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		0	0	85	203	441	916	1,629	1,662
4	Mohave County Water Authority (new entitlement)	La Paz County		0	0	592	1,422	3,084	6,406	11,389	11,618

Table G-21
Arizona Agricultural Diversion Shortages

2008					Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio		200000	400000	500000	600000	800000	1200000	1800000	2500000
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.760		0	0	1,805	4,338	9,403	19,534	34,731	35,429
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.810		0	0	21	50	109	227	404	412
4	Ogram Boys Enterprises (new contract)	Yuma County			0	0	54	131	284	589	1,048	1,069
4	Ogram, George	Yuma County			0	0	28	68	147	306	545	556
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County			0	0	30	72	157	326	579	591
4	Peach, John (2004 over use of 45af)	Yuma County			0	0	34	82	179	371	660	673
4	Phillips, Milton and Jean	Yuma County			0	0	1	3	7	15	27	28
4	Rayner Ranches	Yuma County			0	0	265	637	1,381	2,868	5,099	5,202
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.851		0	0	0	0	0	0	0	12,602
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000		0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County			0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County			0	0	0	0	0	0	0	2
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.937		0	0	0	0	0	0	0	59,987
2/3	University of Arizona	Yuma County			0	0	0	0	0	0	0	174
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County			0	0	0	0	0	0	0	17
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000		0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County			0	0	0	0	0	0	0	4,536
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982		0	0	0	0	0	0	0	90,020
2/3	Gila Monster Farms (formerly Sturges)	Yuma County			0	0	0	0	0	0	0	1,384
2/3	Sturges, Harold (not taking water)	Yuma County			0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County			0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County			0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County			0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County			0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County			0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County			0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County			0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County			0	0	0	0	0	0	0	0

Table G-21
Arizona Agricultural Diversion Shortages

2008				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio		200000	400000	500000	600000	800000	1200000	1800000	2500000
Total Arizona Agricultural Diversion Shortages				0	0	4,139	9,947	21,563	44,795	79,642	249,966
Agricultural Diversion Shortage by County	# of Tribes in the County										
Coconino County	0			0	0	0	0	0	0	0	0
La Paz County	4			0	0	1,144	2,749	5,959	12,379	22,010	22,452
Maricopa County	0			0	0	11,569	27,801	60,267	92,000	92,000	92,000
Mohave County	6			0	0	1,805	4,338	9,403	19,534	34,731	35,429
Pinal County	1			0	0	38,730	93,074	201,762	317,026	317,026	317,026
Yuma County	32			0	0	1,190	2,860	6,201	12,881	22,901	192,085
Total Agricultural Diversion Shortage by County	43			0	0	54,438	130,823	283,592	453,821	488,668	658,992

Notes:

1 means Priority One in Arizona

2/3 means Priority Two/Three in Arizona

4 means Priority Four in Arizona

Table G-22
Arizona Agricultural Consumptive Use Shortages

2008				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages	County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima		0	0	50,299	120,876	262,029	400,000	400,000	400,000
CAP	Arizona State Land Department	Pinal County		0	0	0	0	0	9,026	9,026	9,026
4	Arizona State Land Department	Yuma County		0	0	266	640	1,388	2,884	5,128	5,231
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County		0	0	37	88	191	398	707	722
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County		0	0	80	193	419	871	1,548	1,579
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	0	0	380	912	1,978	4,109	7,305	7,452
4	Curtis, Armon (Curry Family LTD)	Yuma County		0	0	11	28	60	124	221	226
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		0	0	45	109	236	491	872	890
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		0	0	55	132	287	595	1,059	1,080
4	Mohave County Water Authority (new entitlement)	La Paz County		0	0	195	469	1,018	2,114	3,758	3,834
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.760	0	0	975	2,343	5,078	10,549	18,755	19,132
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.810	0	0	15	35	77	159	284	289
4	Ogram Boys Enterprises (new contract)	Yuma County		0	0	35	85	184	383	681	695
4	Ogram, George	Yuma County		0	0	18	44	96	199	354	361
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County		0	0	20	47	102	212	376	384
4	Peach, John (2004 over use of 45af)	Yuma County		0	0	22	54	116	241	429	437
4	Phillips, Milton and Jean	Yuma County		0	0	1	2	5	10	18	18

Table G-22
Arizona Agricultural Consumptive Use Shortages

	2008 Arizona Agricultural Consumptive Use Shortages	County	Ratio	Lower Colorado River Shortage Volumes in Annual Acre-Feet 200000	400000	500000	600000	800000	1200000	1800000	2500000
4	Rayner Ranches	Yuma County		0	0	172	414	897	1,864	3,313	3,380
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.851	0	0	0	0	0	0	0	5,737
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County		0	0	0	0	0	0	0	2
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.937	0	0	0	0	0	0	0	31,089
2/3	University of Arizona	Yuma County		0	0	0	0	0	0	0	174
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County		0	0	0	0	0	0	0	12
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	2,737
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982	0	0	0	0	0	0	0	56,652
2/3	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	747
2/3	Sturges, Harold (not taking water)	Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Consumptive Use Shortages			0	0	2,329	5,597	12,132	25,203	44,809	142,861
	Agricultural Consumptive Use Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		0	0	590	1,417	3,072	6,382	11,347	11,575
	Maricopa County	0		0	0	11,569	27,801	60,267	92,000	92,000	92,000
	Mohave County	6		0	0	975	2,343	5,078	10,549	18,755	19,132
	Pinal County	1		0	0	38,730	93,074	201,762	317,026	317,026	317,026
	Yuma County	32		0	0	764	1,837	3,982	8,271	14,706	112,153
	Total Agricultural Consumptive Use Shortage by County	43		0	0	52,628	126,472	274,160	434,229	453,835	551,887

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-23
Arizona Tribal Diversion Shortages

2008		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	0	0	0	0	9,857
Fort McDowell	Maricopa County	0	0	0	0	0	0	0	0
Gila River	Maricopa and Pinal County	0	0	0	0	0	0	0	0
TON-Chui Chu	Pinal County	0	0	0	0	0	0	0	0
TON-San Xavier	Pima County	0	0	0	0	0	1,631	1,631	1,631
TON-Schuk Toak	Pima County	0	0	0	0	0	369	369	369
Pasqua Yaqui	Pima County	0	0	0	0	0	0	0	0
Salt River	Maricopa County	0	0	0	0	0	0	0	0
San Carlos Apache	Gila County	0	0	0	0	0	0	0	0
Tonto Apache	Gila County	0	0	0	0	0	0	0	0
Yavapai Apache (Camp Verde)	Gila County	0	0	0	0	0	0	0	0
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	0	0	0	0	0
Unallocated HVID	Maricopa County	0	0	0	0	0	0	0	0
Reserved Federal	---	0	0	0	0	0	0	0	0
Total CAP Tribal Diversion Shortages		0	0	0	0	0	2,000	2,000	11,857
Non-CAP Arizona Tribal Diversion Shortages									
Cocopah Indian Reservation	Yuma County	0	0	69	167	362	751	1,335	1,362
Hopi Tribe (new entitlement)	La Paz County	0	0	301	722	1,565	3,252	5,782	5,898
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Diversion Shortages		0	0	370	889	1,927	4,003	7,117	7,261
Tribal Diversion Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	0	0	0	0	0
La Paz County	2	0	0	301	722	1,565	3,252	5,782	5,898
Maricopa County	3	0	0	0	0	0	0	0	0
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	0	0	0	0	0	2,000	2,000	2,000
Pinal County	2	0	0	0	0	0	0	0	9,857
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	0	0	0	0	0
Yuma County	2	0	0	69	167	362	751	1,335	1,362
---	1	0	0	0	0	0	0	0	0
Total Tribal Diversion Shortages by County	18	0	0	370	889	1,927	6,003	9,117	19,118

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

Table G-24
Arizona Tribal Consumptive Use Shortages

2008		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	0	0	0	0	9,857
Fort McDowell	Maricopa County	0	0	0	0	0	0	0	0
Gila River	Maricopa and Pinal County	0	0	0	0	0	0	0	0
TON-Chui Chu	Pinal County	0	0	0	0	0	0	0	0
TON-San Xavier	Pima County	0	0	0	0	0	1,631	1,631	1,631
TON-Schuk Toak	Pima County	0	0	0	0	0	369	369	369
Pasqua Yaqui	Pima County	0	0	0	0	0	0	0	0
Salt River	Maricopa County	0	0	0	0	0	0	0	0
San Carlos Apache	Gila County	0	0	0	0	0	0	0	0
Tonto Apache	Gila County	0	0	0	0	0	0	0	0
Yavapai Apache (Camp Verde)	Gila County	0	0	0	0	0	0	0	0
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	0	0	0	0	0
Unallocated HVID	Maricopa County	0	0	0	0	0	0	0	0
Reserved Federal	---	0	0	0	0	0	0	0	0
Total CAP Tribal Consumptive Use Shortages		0	0	0	0	0	2,000	2,000	11,857
Non-CAP Arizona Tribal Consumptive Use Shortages									
Cocopah Indian Reservation	Yuma County	0	0	68	164	355	737	1,311	1,337
Hopi Tribe (new entitlement)	La Paz County	0	0	195	469	1,018	2,114	3,758	3,834
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Consumptive Use Shortages		0	0	263	633	1,372	2,851	5,069	5,171
Tribal Consumptive Use Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	0	0	0	0	0
La Paz County	2	0	0	195	469	1,018	2,114	3,758	3,834
Maricopa County	3	0	0	0	0	0	0	0	0
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	0	0	0	0	0	2,000	2,000	2,000
Pinal County	2	0	0	0	0	0	0	0	9,857
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	0	0	0	0	0
Yuma County	2	0	0	68	164	355	737	1,311	1,337
---	1	0	0	0	0	0	0	0	0
Total Tribal Consumptive Use Shortages by County	18	0	0	263	633	1,372	4,851	7,069	17,028

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

Attachment 3: 2017 Summary Output of Shortages

Table G-25
Lower Colorado River Shortage Summary

2017	Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Stage I Shortage:	200,000	400,000	500,000	600,000	800,000	1,200,000	1,729,907	1,729,907
Stage II Shortage:	0	0	0	0	0	0	70,093	770,093
Total U.S. & Mexican Shortage	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Mexico	33,333	66,667	83,333	100,000	133,333	200,000	300,000	416,667
Nevada	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Surplus Water – SNWA	0	0	0	0	0	0	0	0
8th Priority (SNWA - Balance & Unused)	6,667	13,333	16,667	20,000	26,667	40,000	60,000	70,914
8th Priority (SNWA & Big Bend)	0	0	0	0	0	0	0	12,419
7th Priority (Boy Scouts, BOR, NV Dept of…)	0	0	0	0	0	0	0	0
6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
5th Priority (PABCO & Lakeview Co.)	0	0	0	0	0	0	0	0
4th Priority (Henderson & Basic Management)	0	0	0	0	0	0	0	0
3rd Priority (Boulder City)	0	0	0	0	0	0	0	0
2nd Priority (Lake Mead National Rec Area)	0	0	0	0	0	0	0	0
1st Priority (PPR's: LMNRA & Fort Mohave)	0	0	0	0	0	0	0	0
SUBTOTAL	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Arizona	160,000	320,000	400,000	480,000	640,000	960,000	1,397,578	1,533,925
Surplus Contracts (Hopi Tribe, Mohave Co., Ag)	0	0	0	0	0	0	0	0
5th Priority & CAP Bank (unused)	0	0	0	0	0	0	0	0
4th Priority (River users and CAP)	160,000	320,000	400,000	480,000	640,000	960,000	1,383,925	1,383,925
CAP Excess Water for Agriculture*	142,684	272,691	272,691	272,691	272,691	272,691	272,691	272,691
CAP NIA Priority (M&I, Indian, and Agriculture)	0	12,676	84,018	115,702	115,702	115,702	115,702	115,702
CAP Indian Priority	0	2,553	16,920	62,958	114,969	218,772	357,350	367,977
CAP M&I Priority	0	10,124	67,099	92,402	183,074	364,639	605,637	610,313
2/3 Priority (includes some CAP entities)	0	0	0	0	0	0	13,653	149,999
1st Priority (PPR's)	0	0	0	0	0	0	0	0
SUBTOTAL	160,000	320,000	400,000	480,000	640,000	960,000	1,397,578	1,533,925
California	0	0	0	0	0	0	42,422	466,075
Surplus (BLM, Needles, Coachella, Navy, MET)	0	0	0	0	0	0	0	0
7th Priority (unused & surplus - CVWD, IID, PVID)	0	0	0	0	0	0	0	0
6th Priority (unused & surplus - MET)	0	0	0	0	0	0	0	0
5th Priority (MET)	0	0	0	0	0	0	42,422	466,075
4th Priority (PVID, CVWD, IDD - MET & San Diego)	0	0	0	0	0	0	0	0
3rd Priority (Reservation Division)	0	0	0	0	0	0	0	0
2nd Priority (PVID)	0	0	0	0	0	0	0	0
1st Priority (PPR's - include PVID & IID)	0	0	0	0	0	0	0	0
SUBTOTAL	0	0	0	0	0	0	42,421	466,075
TOTAL	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000

*Shortage allocation may be zero if excess water for agriculture is not available.

Table G-26
Arizona M&I Consumptive Use Shortages

2017			Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
Apache Junction (AZ Water Co)	Pinal County		0	0	0	0	1,061	3,186	6,000	6,000
Avra Coop	Pima County		0	0	0	0	0	0	0	0
AZ-American (Agua Fria)	Maricopa County		0	0	0	0	1,962	5,889	11,093	11,093
AZ-American (Paradise Valley)	Maricopa County		0	0	0	0	571	1,715	3,231	3,231
AZ-American (Sun City)	Maricopa County		0	0	0	0	741	2,224	4,189	4,189
AZ-American (Sun City West)	Maricopa County		0	0	0	0	419	1,259	2,372	2,372
AZ State Land Dept.	Maricopa County		0	0	0	0	124	372	700	700
ASARCO (Ray Mine)	Pima County		0	0	0	0	0	0	0	0
Avondale	Maricopa County		0	0	0	0	839	2,520	4,746	4,746
Berneil Water Co (Cave Creek)	Maricopa County		0	0	0	0	0	0	0	0
Buckeye	Maricopa County		0	0	0	0	0	0	0	0
Carefree Water Co	Maricopa County		0	0	0	0	71	212	400	400
Casa Grande (AZ Water Co)	Pinal County		0	0	0	0	354	1,062	2,000	2,000
Cave Creek Water Co	Maricopa County		0	0	0	0	362	1,087	2,048	2,048
CAGRD	Maricopa County		0	0	0	0	1,370	4,112	7,746	7,746
Chandler*	Maricopa County		0	430	2,849	3,924	5,454	8,519	12,669	13,578
Chandler Heights Citrus ID	Maricopa County		0	0	0	0	0	0	0	0
Chaparral City Water Co	Maricopa County		0	0	0	0	1,009	3,029	5,705	5,705
Circle City Water Co	Maricopa County		0	0	0	0	0	0	0	0
Comm. Water Co (Green Valley)	Pima County		0	0	0	0	0	0	0	0
Coolidge (AZ Water Co)	Pinal County		0	0	0	0	0	0	0	0
El Mirage	Maricopa County		0	0	0	0	0	0	0	0
Eloy	Pinal County		0	0	0	0	384	1,153	2,171	2,171
Florence	Pinal County		0	0	0	0	362	1,087	2,048	2,048
Flowing Wells ID	Pima County		0	0	0	0	0	0	0	0
Gilbert	Maricopa County		0	168	1,116	1,537	2,816	5,378	8,916	10,353
Glendale	Maricopa County		0	75	495	682	3,190	8,212	14,929	15,566
Goodyear	Maricopa County		0	0	0	0	1,900	5,703	10,742	10,742
Green Valley DWID	Pima County		0	0	0	0	88	265	500	500
H2O Water Co	Maricopa County		0	0	0	0	0	0	0	0
Marana	Pima County		0	0	0	0	0	0	0	0
Maricopa County Parks & Rec	Maricopa County		0	0	0	0	114	342	645	645
Mesa*	Maricopa County		0	608	4,032	5,552	10,862	21,495	35,640	36,227
MDWID	Pima County		0	0	0	0	1,877	5,635	10,613	10,613
Oro Valley	Pima County		0	0	0	0	1,822	5,471	10,305	10,305
Peoria	Maricopa County		0	0	0	0	3,372	10,123	19,067	19,067
Phelps Dodge Miami	Gila County		0	0	0	0	0	0	0	0
Phoenix*	Maricopa County		0	4,084	27,071	37,280	60,996	108,487	171,506	172,569
Phoenix Memorial Park	Maricopa County		0	0	0	0	0	0	0	0
Pine Water Co	Gila County		0	0	0	0	0	0	0	0
Queen Creek Water Co	Maricopa County		0	0	0	0	62	185	348	348
Rio Verde Utilities	Maricopa County		0	0	0	0	144	431	812	812
San Tan ID	Maricopa County		0	0	0	0	0	0	0	0
Scottsdale*	Maricopa County		0	362	2,401	3,306	12,644	31,344	56,118	56,139
Spanish Trail Water Co	Pima County		0	0	0	0	0	0	0	0
Superior	Pinal County		0	0	0	0	0	0	0	0
Surprise	Maricopa County		0	0	0	0	1,812	5,441	10,249	10,249
Tempe	Maricopa County		0	3	17	23	786	2,314	4,340	4,361
Tonto Hills Utility Co	Maricopa County		0	0	0	0	0	0	0	0
Tucson	Pima County		0	0	0	0	25,229	75,747	142,672	142,672

Table G-26
Arizona M&I Consumptive Use Shortages

2017				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
	Vail Water Co	Pima County		0	0	0	0	0	0	0	0
	Valley Utilities Water Co	Maricopa County		0	0	0	0	0	0	0	0
	Water Util. Comm. Fac. Dist. (AJ)	Pinal County		0	0	0	0	9	27	50	50
	Water Util. Greater Buckeye	Maricopa County		0	0	0	0	0	0	0	0
	Water Util. Greater Tonopah	Maricopa County		0	0	0	0	0	0	0	0
	White Tank Sys. (AZ Water Co.)	Maricopa County		0	0	0	0	171	514	968	968
	San Carlos (Phelps Dodge/Globe)	Gila County		0	0	0	0	0	0	0	0
	State Reserved	All Counties in CAP		0	3,404	22,563	31,072	31,072	31,072	31,072	31,072
M&I Subtotal				0	9,135	60,544	83,376	174,048	355,613	596,611	601,287
Arizona M&I											
4	Arizona State Land Department	Yuma County		61	123	153	184	246	368	531	531
4	Arizona State Parks Board - Contact Point	Mohave County		2	3	4	5	6	9	13	13
4	Arizona State Parks Board - Windsor Beach	Mohave County		2	5	6	7	9	14	20	20
4	Arizona-American Water Company	Mohave County		35	69	87	104	139	208	300	300
4	Brooke Water Company (formerly Graham)	La Paz County		8	16	20	24	32	48	69	69
4	Bullhead City	Mohave County		1,009	2,018	2,522	3,026	4,035	6,053	8,725	8,725
4	Bureau of Land Management	La Paz County		98	197	246	295	393	590	851	851
4	Cibola Valley Irrigation & Drainage District******* (M&I: 300af)	La Paz County	0.039	35	69	87	104	139	208	300	300
4	City of Somerton (new contract)	Yuma County		57	114	143	172	229	343	495	495
4	City of Yuma (Smucker Park)	Yuma County		0	0	0	0	0	0	0	0
4	Crystal Beach Water Conservation District	Mohave County		8	16	20	24	32	48	69	69
4	Desert Lawn Memorial Park Association, Inc.	Yuma County		2	3	4	5	7	10	15	15
4	Ehrenburg Improvement District	La Paz County		44	88	110	131	175	263	379	379
4	Fisher's Landing Water and Sewer Works, LLC	Yuma County		4	8	10	12	16	24	34	34
4	Gold Dome Mining Corporation	Yuma County		0	0	0	0	0	0	0	0
4	Gold Standard Mines Corporation	Mohave County		0	0	0	0	0	0	0	0
4	Golden Shores Water Conservation District	Mohave County		59	117	147	176	235	352	508	508
4	Hillcrest Water Company	La Paz County		4	8	11	13	17	25	36	36
4	Lake Havasu City	Mohave County		1,404	2,809	3,511	4,213	5,618	8,427	12,148	12,148
4	Marble Canyon Company, Inc.	Coconino County		2	4	5	5	7	11	16	16
4	Martinez Lake Cabin Sites (recommended)	Yuma County		2	3	4	5	7	10	15	15
4	McAlister, Maurice L.	Mohave County		0	1	1	1	2	3	4	4
4	Mohave County Water Authority (recommended 3,500af)	Mohave County		606	1,212	1,514	1,817	2,423	3,635	5,240	5,240
4	Subcontract to Bullhead City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Lake Havasu City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Mohave Water Cons. Dist. (3,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.240	578	1,156	1,445	1,734	2,312	3,468	5,000	5,000
4	Mohave Water Conservation District	Mohave County		72	144	180	216	288	431	622	622
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.190	8	17	21	25	33	50	72	72
4	Roy, Edward P. & Anna R.	Yuma County		0	0	0	0	0	1	1	1
4	Shepard Water Company	Yuma County		4	8	9	11	15	23	33	33
4	City of Parker	La Paz County		48	96	120	144	192	288	415	415
4	Town of Quartzsite	La Paz County		47	95	118	142	189	284	409	409
4	Verizon (formerly Continental Telephone)	La Paz County		0	0	0	0	0	1	1	1
2/3	Cibola National Wildlife Refuge	La Paz County		0	0	0	0	0	0	191	2,093
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.149	0	0	0	0	0	0	112	1,231
2/3	National Park Service	Mohave County		0	0	0	0	0	0	17	182
2/3	Yuma Union High School	Yuma County		0	0	0	0	0	0	3	29
2/3	Union Pacific Railroad (formerly Southern Pacific Co.)	Yuma County		0	0	0	0	0	0	1	7
2/3	Kaman, Inc.	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma	Yuma County		0	0	0	0	0	0	646	7,101
2/3	Department of Navy MCAS	Yuma County		0	0	0	0	0	0	48	524

Table G-26
Arizona M&I Consumptive Use Shortages

2017				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma (cemetary)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.063	0	0	0	0	0	0	224	2,461
2/3	Desert Lawn Memorial Park	Yuma County		0	0	0	0	0	0	3	34
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.018	0	0	0	0	0	0	112	1,231
2/3	Chandler (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	96	1,053
2/3	Gilbert (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	151	1,664
2/3	Glendale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	67	738
2/3	Mesa (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	62	679
2/3	Phoenix (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	112	1,231
2/3	Scottsdale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	2	25
2/3	Tempe (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	2	25
2/3	Department of Army - Yuma Proving Ground	Yuma County		0	0	0	0	0	0	17	187
2/3	Bureau of Reclamation - Davis Dam	Mohave County		0	0	0	0	0	0	0	0
2/3	Imperial National Wildlife Refuge	La Paz County		0	0	0	0	0	0	81	891
2/3	Havasu Lake National Wildlife Refuge (2004 over use of 7,777af)	Mohave County		0	0	0	0	0	0	108	1,192
1	Brooke Water Company (formerly Graham)	La Paz County		0	0	0	0	0	0	0	0
1	City of Parker	La Paz County		0	0	0	0	0	0	0	0
1	Miller (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	Swan (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	City of Yuma	Yuma County		0	0	0	0	0	0	0	0
Total Arizona M&I:				4,199	8,398	10,498	12,598	16,797	25,195	38,376	58,899
M&I Summary by County		# of Tribes in the County									
	Coconino County	1		2	4	5	5	7	11	16	16
	Gila County	3		0	0	0	0	0	0	0	0
	La Paz County	13		293	586	732	878	1,171	1,757	2,804	5,516
	Maricopa County	36		0	5,730	37,981	52,304	111,791	230,909	389,180	393,856
	Mohave County	20		3,775	7,549	9,437	11,324	15,099	22,648	32,775	34,023
	Pima County	11		0	0	0	0	29,016	87,118	164,090	164,090
	Pinal County	7		0	0	0	0	2,170	6,514	12,269	12,269
	Yuma County	24		130	260	325	390	520	779	2,289	13,929
	All Counties in CAP	1		0	3,404	22,563	31,072	31,072	31,072	31,072	31,072
	(blank)	0		0	0	0	0	0	0	0	0
Total Arizona M&I:		116		4,199	17,533	71,042	95,974	190,845	380,808	634,495	654,771

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-27
Arizona Agricultural Diversion Shortages

2017				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima		142,684	272,691	272,691	272,691	272,691	272,691	272,691	272,691
CAP	Arizona State Land Department	Pinal County		0	989	6,554	9,026	9,026	9,026	9,026	9,026
4	Arizona State Land Department	Yuma County		942	1,884	2,356	2,827	3,769	5,653	8,150	8,150
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County		128	257	321	385	513	770	1,110	1,110
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County		284	568	710	852	1,136	1,703	2,456	2,456
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	1,205	2,410	3,012	3,615	4,820	7,230	10,423	10,423
4	Curtis, Armon (Curry Family LTD)	Yuma County		41	81	101	122	162	243	351	351
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		191	381	476	572	762	1,143	1,648	1,648
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		192	384	480	576	768	1,153	1,662	1,662
4	Mohave County Water Authority (new entitlement)	La Paz County		1,343	2,686	3,358	4,030	5,373	8,059	11,618	11,618
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.760	3,557	7,115	8,893	10,672	14,229	21,344	30,769	30,769
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.810	48	96	121	145	193	289	417	417
4	Ogram Boys Enterprises (new contract)	Yuma County		125	250	312	375	499	749	1,080	1,080
4	Ogram, George	Yuma County		65	130	162	195	260	390	562	562
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County		69	138	173	207	276	414	597	597
4	Peach, John (2004 over use of 45af)	Yuma County		79	157	197	236	314	472	680	680
4	Phillips, Milton and Jean	Yuma County		3	6	8	10	13	19	28	28
4	Rayner Ranches	Yuma County		607	1,213	1,517	1,820	2,427	3,640	5,248	5,248
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.851	0	0	0	0	0	0	1,371	15,062
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.937	0	0	0	0	0	0	6,456	70,931
2/3	University of Arizona	Yuma County		0	0	0	0	0	0	19	207
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County		0	0	0	0	0	0	2	21
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	482	5,292
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982	0	0	0	0	0	0	9,718	106,771
2/3	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	149	1,642
2/3	Sturges, Harold (not taking water)	Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Diversion Shortages			8,879	17,758	22,197	26,636	35,515	53,273	94,994	276,724
	Agricultural Diversion Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		2,596	5,193	6,491	7,789	10,386	15,578	22,458	22,458
	Maricopa County	0		32,817	62,719	62,719	62,719	62,719	62,719	62,719	62,719
	Mohave County	6		3,557	7,115	8,893	10,672	14,229	21,344	30,769	30,769

Table G-27
Arizona Agricultural Diversion Shortages

	2017				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages		County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
	Pinal County		1		109,866	210,961	216,526	218,998	218,998	218,998	218,998	218,998
	Yuma County		32		2,725	5,450	6,813	8,175	10,900	16,350	41,768	223,498
	Total Agricultural Diversion Shortage by County		43		151,562	291,437	301,442	308,353	317,232	334,989	376,711	558,441

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-28
Arizona Agricultural Consumptive Use Shortages

	2017				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages		County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA		Maricopa/Pinal/Pima		0	272,691	272,691	272,691	272,691	272,691	272,691	272,691
CAP	Arizona State Land Department		Pinal County		0	989	6,554	9,026	9,026	9,026	9,026	9,026
4	Arizona State Land Department		Yuma County		612	1,225	1,531	1,837	2,450	3,674	5,297	5,297
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)		Yuma County		83	167	209	250	334	500	722	722
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)		Yuma County		185	369	461	554	738	1,107	1,596	1,596
4	Cibola Resources		La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)		La Paz County	0.961	862	1,723	2,154	2,585	3,446	5,169	7,452	7,452
4	Curtis, Armon (Curry Family LTD)		Yuma County		26	53	66	79	105	158	228	228
4	Gila Monster Farms (formerly Sturges Farms Inc.)		Yuma County		103	206	257	309	411	617	890	890
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)		Yuma County		125	250	312	375	499	749	1,080	1,080
4	Mohave County Water Authority (new entitlement)		La Paz County		443	886	1,108	1,330	1,773	2,659	3,834	3,834
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)		Mohave County	0.760	1,921	3,842	4,803	5,763	7,684	11,526	16,616	16,616
4	North Baja LLC (formerly Jamar Produce) (72af M&I)		La Paz County	0.810	34	68	85	102	135	203	293	293
4	Ogram Boys Enterprises (new contract)		Yuma County		81	162	203	243	325	487	702	702
4	Ogram, George		Yuma County		42	84	105	127	169	253	365	365
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)		Yuma County		45	90	112	135	179	269	388	388
4	Peach, John (2004 over use of 45af)		Yuma County		51	102	128	153	204	307	442	442
4	Phillips, Milton and Jean		Yuma County		2	4	5	6	8	12	18	18
4	Rayner Ranches		Yuma County		394	788	986	1,183	1,577	2,365	3,410	3,410
2/3	Yuma Irrigation District (5,000af M&I)		Yuma County	0.851	0	0	0	0	0	0	624	6,857
2/3	Yuma County Water Users' Association (14,701af M&I)		Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)		Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers		Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)		Yuma County	0.937	0	0	0	0	0	0	3,346	36,761
2/3	University of Arizona		Yuma County		0	0	0	0	0	0	19	207
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)		Yuma County		0	0	0	0	0	0	1	15
2/3	North Gila Valley Irrigation District (2,500af M&I)		Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)		Yuma County		0	0	0	0	0	0	291	3,193
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)		Yuma County	0.982	0	0	0	0	0	0	6,116	67,193
2/3	Gila Monster Farms (formerly Sturges)		Yuma County		0	0	0	0	0	0	81	886
2/3	Sturges, Harold (not taking water)		Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)		Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)		Yuma County		0	0	0	0	0	0	0	0

Table G-28
Arizona Agricultural Consumptive Use Shortages

2017				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages	County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Consumptive Use Shortages			5,010	10,020	12,524	15,029	20,039	30,059	53,810	158,447
	Agricultural Consumptive Use Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		1,339	2,677	3,347	4,016	5,355	8,032	11,579	11,579
	Maricopa County	0		32,817	62,719	62,719	62,719	62,719	62,719	62,719	62,719
	Mohave County	6		1,921	3,842	4,803	5,763	7,684	11,526	16,616	16,616
	Pinal County	1		109,866	210,961	216,526	218,998	218,998	218,998	218,998	218,998
	Yuma County	32		1,750	3,500	4,375	5,250	7,000	10,500	25,615	130,252
	Total Agricultural Consumptive Use Shortage by County	43		147,693	283,699	291,769	296,746	301,756	311,775	335,526	440,164

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-29
Arizona Tribal Diversion Shortages

2017		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	0	3,924	14,065	28,564	39,191
Fort McDowell	Maricopa County	0	0	0	0	1,162	4,163	8,140	8,140
Gila River	Maricopa and Pinal County	0	0	0	38,858	64,382	118,933	191,200	191,200
TON-Chui Chu	Pinal County	0	0	0	800	1,827	4,483	8,000	8,000
TON-San Xavier	Pima County	0	983	6,515	8,972	12,824	22,781	35,972	35,972
TON-Schuk Toak	Pima County	0	222	1,473	2,028	3,569	7,552	12,828	12,828
Pasqua Yaqui	Pima County	0	0	0	0	71	256	500	500
Salt River	Maricopa County	0	0	0	0	3,038	7,452	13,300	13,300
San Carlos Apache	Gila County	0	0	0	0	11,437	25,229	43,500	43,500
Tonto Apache	Gila County	0	0	0	0	18	65	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	0	171	614	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	0	71	256	500	500
Unallocated HVID	Maricopa County	0	0	0	0	174	623	1,218	1,218
Reserved Federal	---	0	1,348	8,932	12,300	12,300	12,300	12,300	12,300
Total CAP Tribal Diversion Shortages		0	2,553	16,920	62,958	114,969	218,772	357,350	367,977
Non-CAP Arizona Tribal Diversion Shortages									

Table G-29
Arizona Tribal Diversion Shortages

2017		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Cocopah Indian Reservation	Yuma County	157	315	394	472	630	945	1,362	1,362
Hopi Tribe (new entitlement)	La Paz County	682	1,364	1,705	2,046	2,728	4,092	5,898	5,898
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Diversion Shortages		839	1,679	2,099	2,518	3,358	5,036	7,261	7,261
Tribal Diversion Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	0	11,626	25,908	44,828	44,828
La Paz County	2	682	1,364	1,705	2,046	2,728	4,092	5,898	5,898
Maricopa County	3	0	0	0	11,657	23,688	47,918	80,018	80,018
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	0	1,205	7,988	11,000	16,465	30,589	49,300	49,300
Pinal County	2	0	0	0	28,001	50,819	101,801	170,404	181,031
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	0	71	256	500	500
Yuma County	2	157	315	394	472	630	945	1,362	1,362
---	1	0	1,348	8,932	12,300	12,300	12,300	12,300	12,300
Total Tribal Diversion Shortages by County	18	839	4,232	19,018	65,476	118,327	223,808	364,611	375,238

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

Table G-30
Arizona Tribal Consumptive Use Shortages

2017		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	0	3,924	14,065	28,564	39,191
Fort McDowell	Maricopa County	0	0	0	0	1,162	4,163	8,140	8,140
Gila River	Maricopa and Pinal County	0	0	0	38,858	64,382	118,933	191,200	191,200
TON-Chui Chu	Pinal County	0	0	0	800	1,827	4,483	8,000	8,000
TON-San Xavier	Pima County	0	983	6,515	8,972	12,824	22,781	35,972	35,972
TON-Schuk Toak	Pima County	0	222	1,473	2,028	3,569	7,552	12,828	12,828
Pasqua Yaqui	Pima County	0	0	0	0	71	256	500	500
Salt River	Maricopa County	0	0	0	0	3,038	7,452	13,300	13,300
San Carlos Apache	Gila County	0	0	0	0	11,437	25,229	43,500	43,500
Tonto Apache	Gila County	0	0	0	0	18	65	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	0	171	614	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	0	71	256	500	500
Unallocated HVID	Maricopa County	0	0	0	0	174	623	1,218	1,218

Table G-30
Arizona Tribal Consumptive Use Shortages

2017		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Reserved Federal	---	0	1,348	8,932	12,300	12,300	12,300	12,300	12,300
Total CAP Tribal Consumptive Use Shortages		0	2,553	16,920	62,958	114,969	218,772	357,350	367,977
Non-CAP Arizona Tribal Consumptive Use Shortages									
Cocopah Indian Reservation	Yuma County	155	309	386	464	618	928	1,337	1,337
Hopi Tribe (new entitlement)	La Paz County	443	886	1,108	1,330	1,773	2,659	3,834	3,834
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Consumptive Use Shortages		598	1,196	1,495	1,794	2,391	3,587	5,171	5,171
Tribal Consumptive Use Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	0	11,626	25,908	44,828	44,828
La Paz County	2	443	886	1,108	1,330	1,773	2,659	3,834	3,834
Maricopa County	3	0	0	0	11,657	23,688	47,918	80,018	80,018
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	0	1,205	7,988	11,000	16,465	30,589	49,300	49,300
Pinal County	2	0	0	0	28,001	50,819	101,801	170,404	181,031
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	0	71	256	500	500
Yuma County	2	155	309	386	464	618	928	1,337	1,337
---	1	0	1,348	8,932	12,300	12,300	12,300	12,300	12,300
Total Tribal Consumptive Use Shortages by County	18	598	3,748	18,414	64,752	117,360	222,359	362,521	373,149

Notes:

1 means Priority One in Arizona

2/3 means Priority Two/Three in Arizona

4 means Priority Four in Arizona

*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

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Attachment 4: 2026 Summary Output of Shortages

Table G-31
Lower Colorado River Shortage Summary

2026	Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Stage I Shortage:	200,000	400,000	500,000	600,000	800,000	1,200,000	1,724,274	1,724,274
Stage II Shortage:	0	0	0	0	0	0	75,726	775,726
Total U.S. & Mexican Shortage	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Mexico	33,333	66,667	83,333	100,000	133,333	200,000	300,000	416,667
Nevada	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Surplus Water – SNWA	0	0	0	0	0	0	0	0
8th Priority (SNWA - Balance & Unused)	6,667	13,333	16,667	20,000	26,667	40,000	60,000	70,914
8th Priority (SNWA & Big Bend)	0	0	0	0	0	0	0	12,419
7th Priority (Boy Scouts, BOR, NV Dept of…)	0	0	0	0	0	0	0	0
6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
5th Priority (PABCO & Lakeview Co.)	0	0	0	0	0	0	0	0
4th Priority (Henderson & Basic Management)	0	0	0	0	0	0	0	0
3rd Priority (Boulder City)	0	0	0	0	0	0	0	0
2nd Priority (Lake Mead National Rec Area)	0	0	0	0	0	0	0	0
1st Priority (PPR's: LMNRA & Fort Mohave)	0	0	0	0	0	0	0	0
SUBTOTAL	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Arizona	160,000	320,000	400,000	480,000	640,000	960,000	1,394,205	1,530,879
Surplus Contracts (Hopi Tribe, Mohave Co., Ag)	0	0	0	0	0	0	0	0
5th Priority & CAP Bank (unused)	0	0	0	0	0	0	0	0
4th Priority (River users and CAP)	160,000	320,000	400,000	480,000	640,000	960,000	1,379,420	1,379,420
CAP Excess Water for Agriculture*	65,979	65,979	65,979	65,979	65,979	65,979	65,979	65,979
CAP NIA Priority (M&I, Indian, and Agriculture)	76,319	218,617	246,041	246,041	246,041	246,041	246,041	246,041
CAP Indian Priority	38,941	111,547	151,901	175,815	227,576	331,099	467,921	478,430
CAP M&I Priority	37,378	107,070	137,866	185,101	275,637	456,711	694,543	699,167
2/3 Priority (includes some CAP entities)	0	0	0	0	0	0	14,785	151,460
1st Priority (PPR's)	0	0	0	0	0	0	0	0
SUBTOTAL	160,000	320,000	400,000	480,000	640,000	960,000	1,394,205	1,530,879
California	0	0	0	0	0	0	45,795	469,121
Surplus (BLM, Needles, Coachella, Navy, MET)	0	0	0	0	0	0	0	0
7th Priority (unused & surplus - CVWD, IID, PVID)	0	0	0	0	0	0	0	0
6th Priority (unused & surplus - MET)	0	0	0	0	0	0	0	0
5th Priority (MET)	0	0	0	0	0	0	45,795	469,120
4th Priority (PVID, CVWD, IDD - MET & San Diego)	0	0	0	0	0	0	0	0
3rd Priority (Reservation Division)	0	0	0	0	0	0	0	0
2nd Priority (PVID)	0	0	0	0	0	0	0	0
1st Priority (PPR's - include PVID & IID)	0	0	0	0	0	0	0	0
SUBTOTAL	0	0	0	0	0	0	45,795	469,120
TOTAL	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000

*Shortage allocation may be zero if excess water for agriculture is not available.

Table G-32
Arizona M&I Consumptive Use Shortages

2026			Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
Apache Junction (AZ Water Co)	Pinal County		0	0	182	676	1,623	3,517	6,000	6,000
Avra Coop	Pima County		0	0	11	40	96	207	354	354
AZ-American (Agua Fria)	Maricopa County		0	0	336	1,249	3,001	6,503	11,093	11,093
AZ-American (Paradise Valley)	Maricopa County		0	0	98	364	874	1,894	3,231	3,231
AZ-American (Sun City)	Maricopa County		0	0	127	472	1,133	2,456	4,189	4,189
AZ-American (Sun City West)	Maricopa County		0	0	72	267	642	1,390	2,372	2,372
AZ State Land Dept.	Maricopa County		0	0	278	1,034	2,482	5,380	9,177	9,177
ASARCO (Ray Mine)	Pima County		0	0	278	1,035	2,485	5,386	9,188	9,188
Avondale	Maricopa County		0	0	153	568	1,363	2,954	5,039	5,039
Berneil Water Co (Cave Creek)	Maricopa County		0	0	3	10	24	51	88	88
Buckeye	Maricopa County		0	0	0	1	3	6	11	11
Carefree Water Co	Maricopa County		0	0	24	89	215	465	794	794
Casa Grande (AZ Water Co)	Pinal County		0	0	152	564	1,356	2,938	5,012	5,012
Cave Creek Water Co	Maricopa County		0	0	73	271	651	1,410	2,406	2,406
CAGRD	Maricopa County		0	0	235	872	2,095	4,541	7,746	7,746
Chandler*	Maricopa County		1,217	3,487	4,186	4,899	6,265	8,997	12,675	13,574
Chandler Heights Citrus ID	Maricopa County		0	0	4	16	37	81	138	138
Chaparral City Water Co	Maricopa County		0	0	219	815	1,957	4,241	7,235	7,235
Circle City Water Co	Maricopa County		0	0	52	194	465	1,008	1,720	1,720
Comm. Water Co (Green Valley)	Pima County		0	0	38	141	338	733	1,250	1,250
Coolidge (AZ Water Co)	Pinal County		0	0	26	99	237	513	875	875
El Mirage	Maricopa County		0	0	7	25	60	130	222	222
Eloy	Pinal County		0	0	66	245	587	1,273	2,171	2,171
Florence	Pinal County		0	0	62	231	554	1,201	2,048	2,048
Flowing Wells ID	Pima County		0	0	58	215	515	1,117	1,905	1,905
Gilbert	Maricopa County		477	1,366	1,756	2,352	3,494	5,778	8,926	10,347
Glendale	Maricopa County		212	606	1,152	2,430	4,880	9,779	16,269	16,899
Goodyear	Maricopa County		0	0	325	1,210	2,906	6,297	10,742	10,742
Green Valley DWID	Pima County		0	0	34	125	301	652	1,113	1,113
H2O Water Co	Maricopa County		0	0	2	7	17	38	64	64
Marana	Pima County		0	0	1	2	6	12	21	21
Maricopa County Parks & Rec	Maricopa County		0	0	20	74	179	387	660	660
Mesa*	Maricopa County		1,722	4,933	6,693	9,796	15,744	27,639	43,293	43,873
MDWID	Pima County		0	0	361	1,343	3,225	6,990	11,924	11,924
Oro Valley	Pima County		0	0	312	1,161	2,787	6,041	10,305	10,305
Peoria	Maricopa County		0	0	764	2,842	6,826	14,793	25,236	25,236
Phelps Dodge Miami	Gila County		0	0	38	143	344	745	1,271	1,271
Phoenix*	Maricopa County		11,564	33,125	41,341	52,386	73,558	115,901	171,514	172,565
Phoenix Memorial Park	Maricopa County		0	0	1	4	10	22	37	37
Pine Water Co	Gila County		0	0	2	8	19	41	70	70
Queen Creek Water Co	Maricopa County		0	0	11	39	94	204	348	348
Rio Verde Utilities	Maricopa County		0	0	25	91	220	476	812	812
San Tan ID	Maricopa County		0	0	3	12	28	61	103	103
Scottsdale*	Maricopa County		1,025	2,938	4,905	9,254	17,591	34,263	56,118	56,139
Spanish Trail Water Co	Pima County		0	0	40	150	359	779	1,329	1,329
Superior	Pinal County		0	0	4	14	34	73	125	125
Surprise	Maricopa County		0	0	310	1,154	2,772	6,008	10,249	10,249
Tempe	Maricopa County		7	20	154	509	1,190	2,552	4,340	4,361
Tonto Hills Utility Co	Maricopa County		0	0	1	3	8	18	31	31

Table G-32
Arizona M&I Consumptive Use Shortages

2026					Lower Colorado River Shortage Volumes in Annual Acre-Feet							
		CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
		Tucson	Pima County		0	0	4,339	16,143	38,769	84,019	143,328	143,328
		Vail Water Co	Pima County		0	0	25	92	220	476	812	812
		Valley Utilities Water Co	Maricopa County		0	0	3	12	30	64	109	109
		Water Util. Comm. Fac. Dist. (AJ)	Pinal County		0	0	40	147	353	765	1,305	1,305
		Water Util. Greater Buckeye	Maricopa County		0	0	1	2	5	11	19	19
		Water Util. Greater Tonopah	Maricopa County		0	0	1	3	8	16	28	28
		White Tank Sys. (AZ Water Co.)	Maricopa County		0	0	29	109	262	567	968	968
		San Carlos (Phelps Dodge/Globe)	Gila County		0	0	240	894	2,147	4,654	7,938	7,938
		State Reserved	All Counties in CAP		18,354	52,576	59,171	59,171	59,171	59,171	59,171	59,171
	M&I Subtotal				34,578	99,050	128,840	176,075	266,611	447,685	685,517	690,141
	Arizona M&I											
	4	Arizona State Land Department	Yuma County		79	159	198	238	317	476	684	684
	4	Arizona State Parks Board - Contact Point	Mohave County		2	3	4	5	6	9	13	13
	4	Arizona State Parks Board - Windsor Beach	Mohave County		2	5	6	7	9	14	20	20
	4	Arizona-American Water Company	Mohave County		36	71	89	107	143	214	308	308
	4	Brooke Water Company (formerly Graham)	La Paz County		9	18	23	27	36	54	78	78
	4	Bullhead City	Mohave County		1,165	2,329	2,911	3,494	4,658	6,987	10,040	10,040
	4	Bureau of Land Management	La Paz County		99	197	247	296	395	592	851	851
	4	Cibola Valley Irrigation & Drainage District******* (M&I: 300af)	La Paz County	0.039	35	70	87	104	139	209	300	300
	4	City of Somerton (new contract)	Yuma County		57	115	144	172	230	344	495	495
	4	City of Yuma (Smucker Park)	Yuma County		0	0	0	0	0	0	0	0
	4	Crystal Beach Water Conservation District	Mohave County		9	18	22	26	35	53	76	76
	4	Desert Lawn Memorial Park Association, Inc.	Yuma County		2	3	4	5	7	10	15	15
	4	Ehrenburg Improvement District	La Paz County		50	99	124	149	198	298	428	428
	4	Fisher's Landing Water and Sewer Works, LLC	Yuma County		4	8	10	12	16	24	34	34
	4	Gold Dome Mining Corporation	Yuma County		0	0	0	0	0	0	0	0
	4	Gold Standard Mines Corporation	Mohave County		0	0	0	0	0	0	0	0
	4	Golden Shores Water Conservation District	Mohave County		64	128	160	192	256	384	551	551
	4	Hillcrest Water Company	La Paz County		5	10	13	15	21	31	44	44
	4	Lake Havasu City	Mohave County		1,565	3,131	3,914	4,696	6,262	9,393	13,496	13,496
	4	Marble Canyon Company, Inc.	Coconino County		2	4	5	5	7	11	16	16
	4	Martinez Lake Cabin Sites (recommended)	Yuma County		2	3	4	5	7	10	15	15
	4	McAlister, Maurice L.	Mohave County		0	1	1	1	2	3	4	4
	4	Mohave County Water Authority (recommended 3,500af)	Mohave County		645	1,290	1,613	1,935	2,580	3,870	5,561	5,561
	4	Subcontract to Bullhead City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
	4	Subcontract to Lake Havasu City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
	4	Subcontract to Mohave Water Cons. Dist. (3,000 AF)	Mohave County		0	0	0	0	0	0	0	0
	4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.240	580	1,160	1,450	1,740	2,320	3,480	5,000	5,000
	4	Mohave Water Conservation District	Mohave County		83	166	208	249	332	498	716	716
	4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.190	8	17	21	25	33	50	72	72
	4	Roy, Edward P. & Anna R.	Yuma County		0	0	0	0	0	1	1	1
	4	Shepard Water Company	Yuma County		4	8	9	11	15	23	33	33
	4	City of Parker	La Paz County		59	118	147	176	235	353	507	507
	4	Town of Quartzsite	La Paz County		57	114	143	171	228	343	492	492
	4	Verizon (formerly Continental Telephone)	La Paz County		0	0	0	0	0	1	1	1
	2/3	Cibola National Wildlife Refuge	La Paz County		0	0	0	0	0	0	326	3,336
	2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.149	0	0	0	0	0	0	120	1,226
	2/3	National Park Service	Mohave County		0	0	0	0	0	0	18	181
	2/3	Yuma Union High School	Yuma County		0	0	0	0	0	0	3	29
	2/3	Union Pacific Railroad (formerly Southern Pacific Co.)	Yuma County		0	0	0	0	0	0	1	7
	2/3	Kaman, Inc.	Yuma County		0	0	0	0	0	0	0	0
	2/3	City of Yuma	Yuma County		0	0	0	0	0	0	809	8,291

Table G-32
Arizona M&I Consumptive Use Shortages

2026				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
2/3	Department of Navy MCAS	Yuma County		0	0	0	0	0	0	51	522
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma (cemetary)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.063	0	0	0	0	0	0	239	2,452
2/3	Desert Lawn Memorial Park	Yuma County		0	0	0	0	0	0	3	34
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.018	0	0	0	0	0	0	120	1,226
2/3	Chandler (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	102	1,049
2/3	Gilbert (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	162	1,658
2/3	Glendale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	72	736
2/3	Mesa (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	66	677
2/3	Phoenix (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	120	1,226
2/3	Scottsdale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	2	25
2/3	Tempe (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	2	25
2/3	Department of Army - Yuma Proving Ground	Yuma County		0	0	0	0	0	0	18	186
2/3	Bureau of Reclamation - Davis Dam	Mohave County		0	0	0	0	0	0	0	0
2/3	Imperial National Wildlife Refuge	La Paz County		0	0	0	0	0	0	87	887
2/3	Havasu Lake National Wildlife Refuge (2004 over use of 7,777af)	Mohave County		0	0	0	0	0	0	116	1,187
1	Brooke Water Company (formerly Graham)	La Paz County		0	0	0	0	0	0	0	0
1	City of Parker	La Paz County		0	0	0	0	0	0	0	0
1	Miller (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	Swan (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	City of Yuma	Yuma County		0	0	0	0	0	0	0	0
Total Arizona M&I:				4,622	9,245	11,556	13,867	18,490	27,734	42,288	64,810
M&I Summary by County		# of Tribes in the County									
	Coconino County	1		2	4	5	5	7	11	16	16
	Gila County	3		0	0	281	1,045	2,510	5,440	9,280	9,280
	La Paz County	13		322	643	804	965	1,287	1,930	3,186	6,997
	Maricopa County	36		16,224	46,474	63,361	93,437	151,086	266,383	418,002	422,626
	Mohave County	20		4,151	8,302	10,377	12,452	16,603	24,905	35,919	37,153
	Pima County	11		0	0	5,496	20,446	49,101	106,412	181,528	181,528
	Pinal County	7		0	0	531	1,975	4,743	10,279	17,536	17,536
	Yuma County	24		148	296	370	444	592	888	2,641	15,250
	All Counties in CAP	1		18,354	52,576	59,171	59,171	59,171	59,171	59,171	59,171
	(blank)	0		0	0	0	0	0	0	0	0
Total Arizona M&I:		116		39,201	108,295	140,396	189,942	285,101	475,420	727,278	749,556

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

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Table G-33
Arizona Agricultural Diversion Shortages

2026				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima		65,979	65,979	65,979	65,979	65,979	65,979	65,979	65,979
CAP	Arizona State Land Department	Pinal County		2,800	8,020	9,026	9,026	9,026	9,026	9,026	9,026
4	Arizona State Land Department	Yuma County		978	1,956	2,444	2,933	3,911	5,867	8,430	8,430
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County		129	257	322	386	515	772	1,110	1,110
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County		296	592	740	888	1,184	1,776	2,553	2,553
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	1,209	2,418	3,022	3,627	4,836	7,254	10,423	10,423
4	Curtis, Armon (Curry Family LTD)	Yuma County		42	85	106	127	169	254	365	365
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		191	382	478	574	765	1,147	1,648	1,648
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		193	385	482	578	771	1,156	1,662	1,662
4	Mohave County Water Authority (new entitlement)	La Paz County		1,348	2,695	3,369	4,043	5,390	8,085	11,618	11,618
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.760	3,402	6,805	8,506	10,207	13,609	20,414	29,332	29,332
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.810	51	102	127	152	203	305	438	438
4	Ogram Boys Enterprises (new contract)	Yuma County		130	260	325	391	521	781	1,122	1,122
4	Ogram, George	Yuma County		68	135	169	203	271	406	584	584
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County		72	144	180	216	288	432	620	620
4	Peach, John (2004 over use of 45af)	Yuma County		81	163	203	244	325	488	702	702
4	Phillips, Milton and Jean	Yuma County		3	6	8	10	13	19	28	28
4	Rayner Ranches	Yuma County		632	1,263	1,579	1,895	2,526	3,789	5,444	5,444
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.851	0	0	0	0	0	0	1,498	15,346
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.937	0	0	0	0	0	0	6,812	69,782
2/3	University of Arizona	Yuma County		0	0	0	0	0	0	20	206
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County		0	0	0	0	0	0	2	21
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	494	5,059
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982	0	0	0	0	0	0	10,382	106,355
2/3	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	160	1,635
2/3	Sturges, Harold (not taking water)	Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0

Table G-33
Arizona Agricultural Diversion Shortages

2026				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Diversion Shortages			8,824	17,648	22,061	26,473	35,297	52,945	95,445	274,484
	Agricultural Diversion Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		2,607	5,215	6,518	7,822	10,429	15,644	22,478	22,478
	Maricopa County	0		15,175	15,175	15,175	15,175	15,175	15,175	15,175	15,175
	Mohave County	6		3,402	6,805	8,506	10,207	13,609	20,414	29,332	29,332
	Pinal County	1		53,604	58,824	59,830	59,830	59,830	59,830	59,830	59,830
	Yuma County	32		2,815	5,629	7,037	8,444	11,259	16,888	43,635	222,674
	Total Agricultural Diversion Shortage by County	43		77,603	91,647	97,066	101,478	110,302	127,950	170,450	349,489

Notes:

1 means Priority One in Arizona

2/3 means Priority Two/Three in Arizona

4 means Priority Four in Arizona

Table G-34
Arizona Agricultural Consumptive Use Shortages

2026				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages	County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima		0	65,979	65,979	65,979	65,979	65,979	65,979	65,979
CAP	Arizona State Land Department	Pinal County		2,800	8,020	9,026	9,026	9,026	9,026	9,026	9,026
4	Arizona State Land Department	Yuma County		635	1,271	1,589	1,906	2,542	3,813	5,479	5,479
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County		84	167	209	251	335	502	722	722
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County		192	385	481	577	770	1,155	1,659	1,659
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	864	1,729	2,161	2,593	3,458	5,186	7,452	7,452
4	Curtis, Armon (Curry Family LTD)	Yuma County		27	55	69	82	110	165	237	237
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		103	206	258	310	413	619	890	890
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		125	251	313	376	501	752	1,080	1,080
4	Mohave County Water Authority (new entitlement)	La Paz County		445	889	1,112	1,334	1,779	2,668	3,834	3,834
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.760	1,837	3,675	4,593	5,512	7,349	11,024	15,840	15,840
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.810	36	71	89	107	143	214	307	307
4	Ogram Boys Enterprises (new contract)	Yuma County		85	169	212	254	339	508	730	730
4	Ogram, George	Yuma County		44	88	110	132	176	264	379	379
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County		47	93	117	140	187	280	403	403
4	Peach, John (2004 over use of 45af)	Yuma County		53	106	132	159	212	317	456	456
4	Phillips, Milton and Jean	Yuma County		2	4	5	6	8	13	18	18
4	Rayner Ranches	Yuma County		410	821	1,026	1,231	1,641	2,462	3,538	3,538
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.851	0	0	0	0	0	0	682	6,986
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0

Table G-34
Arizona Agricultural Consumptive Use Shortages

2026				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages	County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.937	0	0	0	0	0	0	3,530	36,165
2/3	University of Arizona	Yuma County		0	0	0	0	0	0	20	206
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County		0	0	0	0	0	0	1	15
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	298	3,053
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982	0	0	0	0	0	0	6,534	66,932
2/3	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	86	883
2/3	Sturges, Harold (not taking water)	Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Consumptive Use Shortages			4,990	9,981	12,476	14,971	19,961	29,942	54,176	157,266
	Agricultural Consumptive Use Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		1,345	2,689	3,362	4,034	5,379	8,068	11,593	11,593
	Maricopa County	0		15,175	15,175	15,175	15,175	15,175	15,175	15,175	15,175
	Mohave County	6		1,837	3,675	4,593	5,512	7,349	11,024	15,840	15,840
	Pinal County	1		53,604	58,824	59,830	59,830	59,830	59,830	59,830	59,830
	Yuma County	32		1,808	3,617	4,521	5,425	7,233	10,850	26,742	129,833
	Total Agricultural Consumptive Use Shortage by County	43		73,769	83,980	87,481	89,976	94,966	104,947	129,181	232,271

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

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Table G-35
Arizona Tribal Diversion Shortages

2026		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	0	4,796	14,622	28,637	39,146
Fort McDowell	Maricopa County	0	0	0	0	2,860	8,719	16,398	16,398
Gila River	Maricopa and Pinal County	14,964	42,863	73,957	91,515	117,313	170,166	239,440	239,440
TON-Chui Chu	Pinal County	0	0	644	800	2,056	4,628	8,000	8,000
TON-San Xavier	Pima County	5,060	14,494	16,312	16,312	21,021	30,668	43,312	43,312
TON-Schuk Toak	Pima County	1,144	3,277	3,688	3,688	5,571	9,430	14,488	14,488
Pasqua Yaqui	Pima County	0	0	0	0	87	266	500	500
Salt River	Maricopa County	0	0	0	1,110	3,418	7,694	13,300	13,300
San Carlos Apache	Gila County	0	0	0	5,090	12,623	25,985	43,500	43,500
Tonto Apache	Gila County	0	0	0	0	22	68	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	0	209	638	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	0	87	266	500	500
Unallocated HVID	Maricopa County	0	0	0	0	212	648	1,218	1,218
Reserved Federal	---	17,774	50,913	57,300	57,300	57,300	57,300	57,300	57,300
Total CAP Tribal Diversion Shortages		38,941	111,547	151,901	175,815	227,576	331,099	467,921	478,430
Non-CAP Arizona Tribal Diversion Shortages									
Cocopah Indian Reservation	Yuma County	158	316	395	474	632	948	1,362	1,362
Hopi Tribe (new entitlement)	La Paz County	684	1,368	1,710	2,052	2,737	4,105	5,898	5,898
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Diversion Shortages		842	1,684	2,105	2,526	3,369	5,053	7,261	7,261
Tribal Diversion Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	5,090	12,854	26,692	44,828	44,828
La Paz County	2	684	1,368	1,710	2,052	2,737	4,105	5,898	5,898
Maricopa County	3	4,489	12,859	22,187	28,564	41,684	68,111	102,748	102,748
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	6,204	17,771	20,000	20,000	26,680	40,364	58,300	58,300
Pinal County	2	10,474	30,004	52,414	64,861	88,971	138,366	204,245	214,754
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	0	87	266	500	500
Yuma County	2	158	316	395	474	632	948	1,362	1,362
---	1	17,774	50,913	57,300	57,300	57,300	57,300	57,300	57,300
Total Tribal Diversion Shortages by County	18	39,783	113,232	154,006	178,341	230,945	336,151	475,181	485,690

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

Table G-36
Arizona Tribal Consumptive Use Shortages

2026		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	0	4,796	14,622	28,637	39,146
Fort McDowell	Maricopa County	0	0	0	0	2,860	8,719	16,398	16,398
Gila River	Maricopa and Pinal County	14,964	42,863	73,957	91,515	117,313	170,166	239,440	239,440
TON-Chui Chu	Pinal County	0	0	644	800	2,056	4,628	8,000	8,000
TON-San Xavier	Pima County	5,060	14,494	16,312	16,312	21,021	30,668	43,312	43,312
TON-Schuk Toak	Pima County	1,144	3,277	3,688	3,688	5,571	9,430	14,488	14,488
Pasqua Yaqui	Pima County	0	0	0	0	87	266	500	500
Salt River	Maricopa County	0	0	0	1,110	3,418	7,694	13,300	13,300
San Carlos Apache	Gila County	0	0	0	5,090	12,623	25,985	43,500	43,500
Tonto Apache	Gila County	0	0	0	0	22	68	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	0	209	638	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	0	87	266	500	500
Unallocated HVID	Maricopa County	0	0	0	0	212	648	1,218	1,218
Reserved Federal	---	17,774	50,913	57,300	57,300	57,300	57,300	57,300	57,300
Total CAP Tribal Consumptive Use Shortages		38,941	111,547	151,901	175,815	227,576	331,099	467,921	478,430
Non-CAP Arizona Tribal Consumptive Use Shortages									
Cocopah Indian Reservation	Yuma County	155	310	388	465	620	931	1,337	1,337
Hopi Tribe (new entitlement)	La Paz County	445	889	1,112	1,334	1,779	2,668	3,834	3,834
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Consumptive Use Shortages		600	1,200	1,499	1,799	2,399	3,599	5,171	5,171
Tribal Consumptive Use Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	5,090	12,854	26,692	44,828	44,828
La Paz County	2	445	889	1,112	1,334	1,779	2,668	3,834	3,834
Maricopa County	3	4,489	12,859	22,187	28,564	41,684	68,111	102,748	102,748
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	6,204	17,771	20,000	20,000	26,680	40,364	58,300	58,300
Pinal County	2	10,474	30,004	52,414	64,861	88,971	138,366	204,245	214,754
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	0	87	266	500	500
Yuma County	2	155	310	388	465	620	931	1,337	1,337
---	1	17,774	50,913	57,300	57,300	57,300	57,300	57,300	57,300
Total Tribal Consumptive Use Shortages by County	18	39,541	112,747	153,400	177,614	229,975	334,697	473,092	483,601

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

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Attachment 5: 2027 Summary Output of Shortages

Table G-37
Lower Colorado River Shortage Summary

2027	Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Stage I Shortage:	200,000	400,000	500,000	600,000	800,000	1,200,000	1,723,659	1,723,659
Stage II Shortage:	0	0	0	0	0	0	76,341	776,341
Total U.S. & Mexican Shortage	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Mexico	33,333	66,667	83,333	100,000	133,333	200,000	300,000	416,667
Nevada	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Surplus Water - SNWA	0	0	0	0	0	0	0	0
8th Priority (SNWA - Balance & Unused)	6,667	13,333	16,667	20,000	26,667	40,000	60,000	70,914
8th Priority (SNWA & Big Bend)	0	0	0	0	0	0	0	12,419
7th Priority (Boy Scouts, BOR, NV Dept of…)	0	0	0	0	0	0	0	0
6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
5th Priority (PABCO & Lakeview Co.)	0	0	0	0	0	0	0	0
4th Priority (Henderson & Basic Management)	0	0	0	0	0	0	0	0
3rd Priority (Boulder City)	0	0	0	0	0	0	0	0
2nd Priority (Lake Mead National Rec Area)	0	0	0	0	0	0	0	0
1st Priority (PPR's: LMNRA & Fort Mohave)	0	0	0	0	0	0	0	0
SUBTOTAL	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Arizona	160,000	320,000	400,000	480,000	640,000	960,000	1,393,837	1,530,547
Surplus Contracts (Hopi Tribe, Mohave Co., Ag)	0	0	0	0	0	0	0	0
5th Priority & CAP Bank (unused)	0	0	0	0	0	0	0	0
4th Priority (River users and CAP)	160,000	320,000	400,000	480,000	640,000	960,000	1,378,927	1,378,927
CAP Excess Water for Agriculture*	31,869	31,869	31,869	31,869	31,869	31,869	31,869	31,869
CAP NIA Priority (M&I, Indian, and Agriculture)	110,373	252,614	271,041	271,041	271,041	271,041	271,041	271,041
CAP Indian Priority	61,303	140,306	178,018	202,008	253,748	357,229	493,846	504,338
CAP M&I Priority	49,070	112,309	145,717	192,848	283,349	464,351	701,812	706,429
2/3 Priority (includes some CAP entities)	0	0	0	0	0	0	14,909	151,620
1st Priority (PPR's)	0	0	0	0	0	0	0	0
SUBTOTAL	160,000	320,000	400,000	480,000	640,000	960,000	1,393,837	1,530,547
California	0	0	0	0	0	0	46,163	469,453
Surplus (BLM, Needles, Coachella, Navy, MET)	0	0	0	0	0	0	0	0
7th Priority (unused & surplus - CVWD, IID, PVID)	0	0	0	0	0	0	0	0
6th Priority (unused & surplus - MET)	0	0	0	0	0	0	0	0
5th Priority (MET)	0	0	0	0	0	0	46,163	469,453
4th Priority (PVID, CVWD, IDD - MET & San Diego)	0	0	0	0	0	0	0	0
3rd Priority (Reservation Division)	0	0	0	0	0	0	0	0
2nd Priority (PVID)	0	0	0	0	0	0	0	0
1st Priority (PPR's - include PVID & IID)	0	0	0	0	0	0	0	0
SUBTOTAL	0	0	0	0	0	0	46,163	469,452
TOTAL	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000

*Shortage allocation may be zero if excess water for agriculture is not available.

Table G-38
Arizona M&I Consumptive Use Shortages

2027			Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
Apache Junction (AZ Water Co)	Pinal County		0	0	260	747	1,682	3,552	6,000	6,000
Avra Coop	Pima County		0	0	18	50	113	239	404	404
AZ-American (Agua Fria)	Maricopa County		0	0	482	1,382	3,110	6,567	11,093	11,093
AZ-American (Paradise Valley)	Maricopa County		0	0	140	402	906	1,913	3,231	3,231
AZ-American (Sun City)	Maricopa County		0	0	182	522	1,175	2,480	4,189	4,189
AZ-American (Sun City West)	Maricopa County		0	0	103	295	665	1,404	2,372	2,372
AZ State Land Dept.	Maricopa County		0	0	451	1,294	2,913	6,150	10,388	10,388
ASARCO (Ray Mine)	Pima County		0	0	456	1,308	2,944	6,216	10,500	10,500
Avondale	Maricopa County		0	0	221	633	1,425	3,008	5,081	5,081
Berneil Water Co (Cave Creek)	Maricopa County		0	0	4	12	28	59	100	100
Buckeye	Maricopa County		0	0	1	2	4	7	13	13
Carefree Water Co	Maricopa County		0	0	37	106	238	503	850	850
Casa Grande (AZ Water Co)	Pinal County		0	0	236	678	1,526	3,222	5,442	5,442
Cave Creek Water Co	Maricopa County		0	0	104	300	675	1,424	2,406	2,406
CAGRD	Maricopa County		0	0	336	965	2,172	4,586	7,746	7,746
Chandler*	Maricopa County		1,598	3,657	4,300	5,002	6,350	9,047	12,676	13,574
Chandler Heights Citrus ID	Maricopa County		0	0	7	20	44	93	158	158
Chaparral City Water Co	Maricopa County		0	0	322	924	2,081	4,393	7,421	7,421
Circle City Water Co	Maricopa County		0	0	85	245	551	1,164	1,966	1,966
Comm. Water Co (Green Valley)	Pima County		0	0	62	178	401	846	1,429	1,429
Coolidge (AZ Water Co)	Pinal County		0	0	43	125	280	592	1,000	1,000
El Mirage	Maricopa County		0	0	11	32	71	150	254	254
Eloy	Pinal County		0	0	94	270	609	1,285	2,171	2,171
Florence	Pinal County		0	0	89	255	574	1,212	2,048	2,048
Flowing Wells ID	Pima County		0	0	95	271	610	1,289	2,177	2,177
Gilbert	Maricopa County		626	1,433	1,851	2,438	3,566	5,820	8,927	10,346
Glendale	Maricopa County		278	636	1,364	2,639	5,087	9,982	16,460	17,090
Goodyear	Maricopa County		0	0	466	1,338	3,012	6,359	10,742	10,742
Green Valley DWID	Pima County		0	0	52	149	336	710	1,200	1,200
H2O Water Co	Maricopa County		0	0	3	9	21	44	74	74
Marana	Pima County		0	0	1	3	7	14	24	24
Maricopa County Parks & Rec	Maricopa County		0	0	29	82	185	391	660	660
Mesa*	Maricopa County		2,261	5,175	7,216	10,328	16,301	28,249	43,954	44,533
MDWID	Pima County		0	0	525	1,507	3,391	7,160	12,095	12,095
Oro Valley	Pima County		0	0	447	1,284	2,889	6,101	10,305	10,305
Peoria	Maricopa County		0	0	1,096	3,143	7,076	14,940	25,236	25,236
Phelps Dodge Miami	Gila County		0	0	63	181	407	860	1,453	1,453
Phoenix*	Maricopa County		15,181	34,746	43,103	53,986	74,885	116,682	171,514	172,564
Phoenix Memorial Park	Maricopa County		0	0	2	5	12	25	42	42
Pine Water Co	Gila County		0	0	3	10	23	48	81	81
Queen Creek Water Co	Maricopa County		0	0	15	43	98	206	348	348
Rio Verde Utilities	Maricopa County		0	0	35	101	228	481	812	812
San Tan ID	Maricopa County		0	0	5	15	33	70	118	118
Scottsdale*	Maricopa County		1,346	3,081	5,599	9,884	18,113	34,571	56,118	56,139
Spanish Trail Water Co	Pima County		0	0	66	189	426	899	1,519	1,519
Superior	Pinal County		0	0	6	18	40	84	143	143
Surprise	Maricopa County		0	0	445	1,277	2,874	6,068	10,249	10,249
Tempe	Maricopa County		9	21	210	560	1,233	2,578	4,340	4,361
Tonto Hills Utility Co	Maricopa County		0	0	2	4	10	21	36	36

Table G-38
Arizona M&I Consumptive Use Shortages

2027				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
	Tucson	Pima County		0	0	6,227	17,865	40,213	84,909	143,422	143,422
	Vail Water Co	Pima County		0	0	40	116	260	550	929	929
	Valley Utilities Water Co	Maricopa County		0	0	5	16	35	74	125	125
	Water Util. Comm. Fac. Dist. (AJ)	Pinal County		0	0	64	185	416	879	1,485	1,485
	Water Util. Greater Buckeye	Maricopa County		0	0	1	3	6	13	22	22
	Water Util. Greater Tonopah	Maricopa County		0	0	1	4	9	19	32	32
	White Tank Sys. (AZ Water Co.)	Maricopa County		0	0	42	121	271	573	968	968
	San Carlos (Phelps Dodge/Globe)	Gila County		0	0	394	1,130	2,544	5,371	9,073	9,073
	State Reserved	All Counties in CAP		24,096	55,148	59,171	59,171	59,171	59,171	59,171	59,171
M&I Subtotal				45,395	103,896	136,691	183,822	274,323	455,325	692,786	697,403
Arizona M&I											
4	Arizona State Land Department	Yuma County		80	161	201	241	322	482	693	693
4	Arizona State Parks Board - Contact Point	Mohave County		2	3	4	5	6	9	13	13
4	Arizona State Parks Board - Windsor Beach	Mohave County		2	5	6	7	9	14	20	20
4	Arizona-American Water Company	Mohave County		36	72	90	108	143	215	309	309
4	Brooke Water Company (formerly Graham)	La Paz County		9	18	23	27	36	55	79	79
4	Bullhead City	Mohave County		1,179	2,359	2,948	3,538	4,717	7,076	10,163	10,163
4	Bureau of Land Management	La Paz County		99	197	247	296	395	592	851	851
4	Cibola Valley Irrigation & Drainage District******* (M&I: 300af)	La Paz County	0.039	35	70	87	104	139	209	300	300
4	City of Somerton (new contract)	Yuma County		57	115	144	172	230	345	495	495
4	City of Yuma (Smucker Park)	Yuma County		0	0	0	0	0	0	0	0
4	Crystal Beach Water Conservation District	Mohave County		9	18	22	27	35	53	76	76
4	Desert Lawn Memorial Park Association, Inc.	Yuma County		2	3	4	5	7	10	15	15
4	Ehrenburg Improvement District	La Paz County		50	100	126	151	201	301	433	433
4	Fisher's Landing Water and Sewer Works, LLC	Yuma County		4	8	10	12	16	24	34	34
4	Gold Dome Mining Corporation	Yuma County		0	0	0	0	0	0	0	0
4	Gold Standard Mines Corporation	Mohave County		0	0	0	0	0	0	0	0
4	Golden Shores Water Conservation District	Mohave County		64	129	161	193	257	386	554	554
4	Hillcrest Water Company	La Paz County		5	10	13	16	21	31	45	45
4	Lake Havasu City	Mohave County		1,583	3,165	3,957	4,748	6,330	9,496	13,639	13,639
4	Marble Canyon Company, Inc.	Coconino County		2	4	5	5	7	11	16	16
4	Martinez Lake Cabin Sites (recommended)	Yuma County		2	3	4	5	7	10	15	15
4	McAlister, Maurice L.	Mohave County		0	1	1	1	2	3	4	4
4	Mohave County Water Authority (recommended 3,500af)	Mohave County		649	1,298	1,623	1,948	2,597	3,895	5,595	5,595
4	Subcontract to Bullhead City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Lake Havasu City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Mohave Water Cons. Dist. (3,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.239	580	1,160	1,450	1,740	2,321	3,481	5,000	5,000
4	Mohave Water Conservation District	Mohave County		84	168	210	252	336	504	724	724
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.189	8	17	21	25	33	50	72	72
4	Roy, Edward P. & Anna R.	Yuma County		0	0	0	0	0	1	1	1
4	Shepard Water Company	Yuma County		4	8	9	11	15	23	33	33
4	City of Parker	La Paz County		60	119	149	179	239	358	514	514
4	Town of Quartzsite	La Paz County		58	116	145	174	232	348	499	499
4	Verizon (formerly Continental Telephone)	La Paz County		0	0	0	0	0	1	1	1
2/3	Cibola National Wildlife Refuge	La Paz County		0	0	0	0	0	0	348	3,542
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.149	0	0	0	0	0	0	120	1,225
2/3	National Park Service	Mohave County		0	0	0	0	0	0	18	181
2/3	Yuma Union High School	Yuma County		0	0	0	0	0	0	3	29
2/3	Union Pacific Railroad (formerly Southern Pacific Co.)	Yuma County		0	0	0	0	0	0	1	7
2/3	Kaman, Inc.	Yuma County		0	0	0	0	0	0	0	0

Table G-38
Arizona M&I Consumptive Use Shortages

2027				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
2/3	City of Yuma	Yuma County		0	0	0	0	0	0	828	8,424
2/3	Department of Navy MCAS	Yuma County		0	0	0	0	0	0	51	522
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma (cemetary)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.064	0	0	0	0	0	0	241	2,450
2/3	Desert Lawn Memorial Park	Yuma County		0	0	0	0	0	0	3	34
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.018	0	0	0	0	0	0	120	1,225
2/3	Chandler (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	103	1,048
2/3	Gilbert (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	163	1,657
2/3	Glendale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	72	735
2/3	Mesa (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	66	676
2/3	Phoenix (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	120	1,225
2/3	Scottsdale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	2	24
2/3	Tempe (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	2	24
2/3	Department of Army - Yuma Proving Ground	Yuma County		0	0	0	0	0	0	18	186
2/3	Bureau of Reclamation - Davis Dam	Mohave County		0	0	0	0	0	0	0	0
2/3	Imperial National Wildlife Refuge	La Paz County		0	0	0	0	0	0	87	886
2/3	Havasu Lake National Wildlife Refuge (2004 over use of 7,777af)	Mohave County		0	0	0	0	0	0	117	1,186
1	Brooke Water Company (formerly Graham)	La Paz County		0	0	0	0	0	0	0	0
1	City of Parker	La Paz County		0	0	0	0	0	0	0	0
1	Miller (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	Swan (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	City of Yuma	Yuma County		0	0	0	0	0	0	0	0
Total Arizona M&I:				4,664	9,328	11,659	13,991	18,655	27,983	42,680	65,481
M&I Summary by County		# of Tribes in the County									
	Coconino County	1		2	4	5	5	7	11	16	16
	Gila County	3		0	0	460	1,321	2,974	6,279	10,606	10,606
	La Paz County	13		324	648	810	973	1,297	1,945	3,229	7,222
	Maricopa County	36		21,299	48,748	68,277	98,132	155,460	270,115	420,719	425,336
	Mohave County	20		4,189	8,377	10,472	12,566	16,754	25,132	36,233	37,466
	Pima County	11		0	0	7,989	22,920	51,591	108,933	184,002	184,002
	Pinal County	7		0	0	794	2,278	5,128	10,827	18,288	18,288
	Yuma County	24		149	298	373	448	597	895	2,672	15,387
	All Counties in CAP	1		24,096	55,148	59,171	59,171	59,171	59,171	59,171	59,171
	(blank)	0		0	0	0	0	0	0	0	0
Total Arizona M&I:		116		50,058	113,224	148,351	197,813	292,978	483,307	734,937	757,494

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

1

Table G-39
Arizona Agricultural Diversion Shortages

2027					Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio		200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima			31,869	31,869	31,869	31,869	31,869	31,869	31,869	31,869
CAP	Arizona State Land Department	Pinal County			3,676	8,412	9,026	9,026	9,026	9,026	9,026	9,026
4	Arizona State Land Department	Yuma County			984	1,967	2,459	2,951	3,934	5,901	8,476	8,476
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County			129	258	322	386	515	773	1,110	1,110
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County			298	596	745	894	1,192	1,788	2,569	2,569
4	Cibola Resources	La Paz County			0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961		1,209	2,419	3,023	3,628	4,837	7,256	10,423	10,423
4	Curtis, Armon (Curry Family LTD)	Yuma County			43	85	106	128	170	255	367	367
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County			191	383	478	574	765	1,148	1,648	1,648
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County			193	386	482	578	771	1,157	1,662	1,662
4	Mohave County Water Authority (new entitlement)	La Paz County			1,348	2,696	3,370	4,044	5,392	8,088	11,618	11,618
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.761		3,417	6,835	8,544	10,252	13,670	20,505	29,453	29,453
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.811		51	102	128	154	205	307	441	441
4	Ogram Boys Enterprises (new contract)	Yuma County			131	262	328	393	524	786	1,130	1,130
4	Ogram, George	Yuma County			68	136	170	204	273	409	587	587
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County			72	145	181	217	290	434	624	624
4	Peach, John (2004 over use of 45af)	Yuma County			81	163	204	244	326	488	702	702
4	Phillips, Milton and Jean	Yuma County			3	6	8	10	13	19	28	28
4	Rayner Ranches	Yuma County			636	1,271	1,589	1,907	2,542	3,813	5,477	5,477
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.851		0	0	0	0	0	0	1,513	15,391
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000		0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County			0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County			0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.936		0	0	0	0	0	0	6,842	69,583
2/3	University of Arizona	Yuma County			0	0	0	0	0	0	20	206
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County			0	0	0	0	0	0	2	21
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000		0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County			0	0	0	0	0	0	494	5,020
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982		0	0	0	0	0	0	10,450	106,273
2/3	Gila Monster Farms (formerly Sturges)	Yuma County			0	0	0	0	0	0	161	1,634
2/3	Sturges, Harold (not taking water)	Yuma County			0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County			0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County			0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County			0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County			0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County			0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County			0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County			0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County			0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County			0	0	0	0	0	0	0	0
	Total Arizona Agricultural Diversion Shortages				8,855	17,710	22,137	26,564	35,419	53,129	95,796	274,443
	Agricultural Diversion Shortage by County	# of Tribes in the County										
	Coconino County	0			0	0	0	0	0	0	0	0
	La Paz County	4			2,609	5,217	6,521	7,826	10,434	15,652	22,482	22,482
	Maricopa County	0			7,330	7,330	7,330	7,330	7,330	7,330	7,330	7,330
	Mohave County	6			3,417	6,835	8,544	10,252	13,670	20,505	29,453	29,453

Table G-39
Arizona Agricultural Diversion Shortages

2027					Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages		County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
	Pinal County		1		28,214	32,951	33,565	33,565	33,565	33,565	33,565	33,565
	Yuma County		32		2,829	5,658	7,072	8,486	11,315	16,973	43,862	222,509
	Total Agricultural Diversion Shortage by County		43		44,399	57,991	63,032	67,459	76,314	94,023	136,691	315,338

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-40
Arizona Agricultural Consumptive Use Shortages

2027					Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages		County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA		Maricopa/Pinal/Pima			31,869	31,869	31,869	31,869	31,869	31,869	31,869
CAP	Arizona State Land Department		Pinal County		3,676	8,412	9,026	9,026	9,026	9,026	9,026	9,026
4	Arizona State Land Department		Yuma County		639	1,278	1,598	1,918	2,557	3,835	5,509	5,509
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)		Yuma County		84	167	209	251	335	502	722	722
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)		Yuma County		194	387	484	581	775	1,162	1,670	1,670
4	Cibola Resources		La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)		La Paz County	0.961	865	1,729	2,162	2,594	3,459	5,188	7,452	7,452
4	Curtis, Armon (Curry Family LTD)		Yuma County		28	55	69	83	111	166	239	239
4	Gila Monster Farms (formerly Sturges Farms Inc.)		Yuma County		103	206	258	310	413	619	890	890
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)		Yuma County		125	251	313	376	501	752	1,080	1,080
4	Mohave County Water Authority (new entitlement)		La Paz County		445	890	1,112	1,335	1,779	2,669	3,834	3,834
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)		Mohave County	0.761	1,845	3,691	4,614	5,536	7,382	11,073	15,905	15,905
4	North Baja LLC (formerly Jamar Produce) (72af M&I)		La Paz County	0.811	36	72	90	108	144	216	310	310
4	Ogram Boys Enterprises (new contract)		Yuma County		85	170	213	256	341	511	734	734
4	Ogram, George		Yuma County		44	89	111	133	177	266	382	382
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)		Yuma County		47	94	118	141	188	282	406	406
4	Peach, John (2004 over use of 45af)		Yuma County		53	106	132	159	212	317	456	456
4	Phillips, Milton and Jean		Yuma County		2	4	5	6	8	13	18	18
4	Rayner Ranches		Yuma County		413	826	1,032	1,239	1,652	2,478	3,559	3,559
2/3	Yuma Irrigation District (5,000af M&I)		Yuma County	0.851	0	0	0	0	0	0	689	7,007
2/3	Yuma County Water Users' Association (14,701af M&I)		Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)		Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers		Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)		Yuma County	0.936	0	0	0	0	0	0	3,546	36,062
2/3	University of Arizona		Yuma County		0	0	0	0	0	0	20	206
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)		Yuma County		0	0	0	0	0	0	1	15
2/3	North Gila Valley Irrigation District (2,500af M&I)		Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)		Yuma County		0	0	0	0	0	0	298	3,029
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)		Yuma County	0.982	0	0	0	0	0	0	6,577	66,880
2/3	Gila Monster Farms (formerly Sturges)		Yuma County		0	0	0	0	0	0	87	882
2/3	Sturges, Harold (not taking water)		Yuma County		0	0	0	0	0	0	0	0

Table G-40
Arizona Agricultural Consumptive Use Shortages

2027				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages	County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Consumptive Use Shortages			5,008	10,017	12,521	15,025	20,034	30,050	54,382	157,247
	Agricultural Consumptive Use Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		1,345	2,691	3,364	4,036	5,382	8,073	11,596	11,596
	Maricopa County	0		7,330	7,330	7,330	7,330	7,330	7,330	7,330	7,330
	Mohave County	6		1,845	3,691	4,614	5,536	7,382	11,073	15,905	15,905
	Pinal County	1		28,214	32,951	33,565	33,565	33,565	33,565	33,565	33,565
	Yuma County	32		1,817	3,635	4,544	5,452	7,270	10,904	26,881	129,746
	Total Agricultural Consumptive Use Shortage by County	43		40,553	50,298	53,416	55,920	60,928	70,945	95,277	198,142

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-41
Arizona Tribal Diversion Shortages

		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	0	4,892	14,683	28,644	39,137
Fort McDowell	Maricopa County	0	0	0	0	3,080	9,245	17,315	17,315
Gila River	Maricopa and Pinal County	27,381	62,669	94,047	110,515	136,829	189,494	258,440	258,440
TON-Chui Chu	Pinal County	0	0	671	800	2,081	4,644	8,000	8,000
TON-San Xavier	Pima County	6,975	15,963	17,128	17,128	21,931	31,543	44,128	44,128
TON-Schuk Toak	Pima County	1,577	3,609	3,872	3,872	5,793	9,639	14,672	14,672
Pasqua Yaqui	Pima County	0	0	0	0	89	267	500	500
Salt River	Maricopa County	0	0	0	1,323	3,459	7,721	13,300	13,300
San Carlos Apache	Gila County	0	0	0	6,069	12,753	26,068	43,500	43,500
Tonto Apache	Gila County	0	0	0	0	23	68	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	0	213	641	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	0	89	267	500	500
Unallocated HVID	Maricopa County	0	0	0	0	217	650	1,218	1,218

Table G-41
Arizona Tribal Diversion Shortages

		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Reserved Federal	---	25,370	58,065	62,300	62,300	62,300	62,300	62,300	62,300
Total CAP Tribal Diversion Shortages		61,303	140,306	178,018	202,008	253,748	357,229	493,846	504,338
Non-CAP Arizona Tribal Diversion Shortages									
Cocopah Indian Reservation	Yuma County	158	316	395	474	632	948	1,362	1,362
Hopi Tribe (new entitlement)	La Paz County	684	1,369	1,711	2,053	2,738	4,106	5,898	5,898
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Diversion Shortages		842	1,685	2,106	2,527	3,370	5,055	7,261	7,261
Tribal Diversion Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	6,069	12,989	26,777	44,828	44,828
La Paz County	2	684	1,369	1,711	2,053	2,738	4,106	5,898	5,898
Maricopa County	3	8,214	18,801	28,214	34,478	47,805	74,464	109,365	109,365
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	8,552	19,572	21,000	21,000	27,813	41,449	59,300	59,300
Pinal County	2	19,167	43,868	66,504	78,161	102,753	151,972	217,552	228,045
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	0	89	267	500	500
Yuma County	2	158	316	395	474	632	948	1,362	1,362
---	1	25,370	58,065	62,300	62,300	62,300	62,300	62,300	62,300
Total Tribal Diversion Shortages by County	18	62,145	141,990	180,124	204,535	257,118	362,284	501,106	511,599

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

Table G-42
Arizona Tribal Consumptive Use Shortages

		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	0	4,892	14,683	28,644	39,137
Fort McDowell	Maricopa County	0	0	0	0	3,080	9,245	17,315	17,315
Gila River	Maricopa and Pinal County	27,381	62,669	94,047	110,515	136,829	189,494	258,440	258,440
TON-Chui Chu	Pinal County	0	0	671	800	2,081	4,644	8,000	8,000
TON-San Xavier	Pima County	6,975	15,963	17,128	17,128	21,931	31,543	44,128	44,128
TON-Schuk Toak	Pima County	1,577	3,609	3,872	3,872	5,793	9,639	14,672	14,672
Pasqua Yaqui	Pima County	0	0	0	0	89	267	500	500
Salt River	Maricopa County	0	0	0	1,323	3,459	7,721	13,300	13,300
San Carlos Apache	Gila County	0	0	0	6,069	12,753	26,068	43,500	43,500

Table G-42
Arizona Tribal Consumptive Use Shortages

		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Tonto Apache	Gila County	0	0	0	0	23	68	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	0	213	641	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	0	89	267	500	500
Unallocated HVID	Maricopa County	0	0	0	0	217	650	1,218	1,218
Reserved Federal	---	25,370	58,065	62,300	62,300	62,300	62,300	62,300	62,300
Total CAP Tribal Consumptive Use Shortages		61,303	140,306	178,018	202,008	253,748	357,229	493,846	504,338
Non-CAP Arizona Tribal Consumptive Use Shortages									
Cocopah Indian Reservation	Yuma County	155	310	388	465	621	931	1,337	1,337
Hopi Tribe (new entitlement)	La Paz County	445	890	1,112	1,335	1,779	2,669	3,834	3,834
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Consumptive Use Shortages		600	1,200	1,500	1,800	2,400	3,600	5,171	5,171
Tribal Consumptive Use Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	6,069	12,989	26,777	44,828	44,828
La Paz County	2	445	890	1,112	1,335	1,779	2,669	3,834	3,834
Maricopa County	3	8,214	18,801	28,214	34,478	47,805	74,464	109,365	109,365
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	8,552	19,572	21,000	21,000	27,813	41,449	59,300	59,300
Pinal County	2	19,167	43,868	66,504	78,161	102,753	151,972	217,552	228,045
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	0	89	267	500	500
Yuma County	2	155	310	388	465	621	931	1,337	1,337
---	1	25,370	58,065	62,300	62,300	62,300	62,300	62,300	62,300
Total Tribal Consumptive Use Shortages by County	18	61,903	141,506	179,518	203,808	256,148	360,829	499,017	509,509

Notes:

1 means Priority One in Arizona

2/3 means Priority Two/Three in Arizona

4 means Priority Four in Arizona

*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

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Attachment 6: 2040 Summary Output of Shortages

Table G-43
Lower Colorado River Shortage Summary

2040	Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Stage I Shortage:	200,000	400,000	500,000	600,000	800,000	1,200,000	1,714,362	1,714,362
Stage II Shortage:	0	0	0	0	0	0	85,638	785,638
Total U.S. & Mexican Shortage	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Mexico	33,333	66,667	83,333	100,000	133,333	200,000	300,000	416,667
Nevada	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Surplus Water - SNWA	0	0	0	0	0	0	0	0
8th Priority (SNWA - Balance & Unused)	6,667	13,333	16,667	20,000	26,667	40,000	60,000	70,914
8th Priority (SNWA & Big Bend)	0	0	0	0	0	0	0	12,419
7th Priority (Boy Scouts, BOR, NV Dept of…)	0	0	0	0	0	0	0	0
6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
5th Priority (PABCO & Lakeview Co.)	0	0	0	0	0	0	0	0
4th Priority (Henderson & Basic Management)	0	0	0	0	0	0	0	0
3rd Priority (Boulder City)	0	0	0	0	0	0	0	0
2nd Priority (Lake Mead National Rec Area)	0	0	0	0	0	0	0	0
1st Priority (PPR's: LMNRA & Fort Mohave)	0	0	0	0	0	0	0	0
SUBTOTAL	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Arizona	160,000	320,000	400,000	480,000	640,000	960,000	1,388,281	1,525,531
Surplus Contracts (Hopi Tribe, Mohave Co., Ag)	0	0	0	0	0	0	0	0
5th Priority & CAP Bank (unused)	0	0	0	0	0	0	0	0
4th Priority (River users and CAP)	160,000	320,000	400,000	480,000	640,000	960,000	1,371,490	1,371,490
CAP Excess Water for Agriculture*	0	0	0	0	0	0	0	0
CAP NIA Priority (M&I, Indian, and Agriculture)	129,898	219,440	219,440	219,440	219,440	219,440	219,440	219,440
CAP Indian Priority	74,171	138,517	156,515	181,583	233,056	336,001	469,648	480,025
CAP M&I Priority	55,727	132,886	185,640	231,324	321,356	501,419	733,523	738,089
2/3 Priority (includes some CAP entities)	0	0	0	0	0	0	16,791	154,042
1st Priority (PPR's)	0	0	0	0	0	0	0	0
SUBTOTAL	160,000	320,000	400,000	480,000	640,000	960,000	1,388,281	1,525,531
California	0	0	0	0	0	0	51,719	474,469
Surplus (BLM, Needles, Coachella, Navy, MET)	0	0	0	0	0	0	0	0
7th Priority (unused & surplus - CVWD, IID, PVID)	0	0	0	0	0	0	0	0
6th Priority (unused & surplus - MET)	0	0	0	0	0	0	0	0
5th Priority (MET)	0	0	0	0	0	0	51,719	474,468
4th Priority (PVID, CVWD, IDD - MET & San Diego)	0	0	0	0	0	0	0	0
3rd Priority (Reservation Division)	0	0	0	0	0	0	0	0
2nd Priority (PVID)	0	0	0	0	0	0	0	0
1st Priority (PPR's - include PVID & IID)	0	0	0	0	0	0	0	0
SUBTOTAL	0	0	0	0	0	0	51,719	474,468
TOTAL	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000

*Shortage allocation may be zero if excess water for agriculture is not available.

Table G-44
Arizona M&I Consumptive Use Shortages

2040			Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
Apache Junction (AZ Water Co)	Pinal County		0	364	859	1,288	2,134	3,825	6,000	6,000
Avra Coop	Pima County		0	49	116	174	287	515	808	808
AZ-American (Agua Fria)	Maricopa County		0	673	1,589	2,382	3,946	7,072	11,093	11,093
AZ-American (Paradise Valley)	Maricopa County		0	196	463	694	1,149	2,060	3,231	3,231
AZ-American (Sun City)	Maricopa County		0	254	600	900	1,490	2,671	4,189	4,189
AZ-American (Sun City West)	Maricopa County		0	144	340	509	844	1,512	2,372	2,372
AZ State Land Dept.	Maricopa County		0	1,218	2,875	4,311	7,141	12,799	20,076	20,076
ASARCO (Ray Mine)	Pima County		0	1,274	3,008	4,510	7,469	13,388	21,000	21,000
Avondale	Maricopa County		0	328	776	1,163	1,926	3,453	5,416	5,416
Berneil Water Co (Cave Creek)	Maricopa County		0	12	29	43	71	128	200	200
Buckeye	Maricopa County		0	2	4	5	9	16	25	25
Carefree Water Co	Maricopa County		0	79	186	279	462	829	1,300	1,300
Casa Grande (AZ Water Co)	Pinal County		0	539	1,272	1,908	3,160	5,664	8,884	8,884
Cave Creek Water Co	Maricopa County		0	146	345	517	856	1,534	2,406	2,406
CAGRD	Maricopa County		0	470	1,109	1,663	2,755	4,938	7,746	7,746
Chandler*	Maricopa County		1,472	3,011	3,725	4,344	5,564	8,003	11,249	12,136
Chandler Heights Citrus ID	Maricopa County		0	19	45	68	112	201	315	315
Chaparral City Water Co	Maricopa County		0	540	1,276	1,913	3,169	5,680	8,909	8,909
Circle City Water Co	Maricopa County		0	238	563	844	1,399	2,507	3,932	3,932
Comm. Water Co (Green Valley)	Pima County		0	173	409	614	1,017	1,822	2,858	2,858
Coolidge (AZ Water Co)	Pinal County		0	121	286	429	711	1,275	2,000	2,000
El Mirage	Maricopa County		0	31	73	109	181	324	508	508
Eloy	Pinal County		0	132	311	466	772	1,384	2,171	2,171
Florence	Pinal County		0	124	293	440	728	1,306	2,048	2,048
Flowing Wells ID	Pima County		0	264	624	935	1,549	2,776	4,354	4,354
Gilbert	Maricopa County		576	1,413	2,010	2,527	3,547	5,586	8,380	9,784
Glendale	Maricopa County		256	1,477	2,901	4,133	6,563	11,421	17,744	18,367
Goodyear	Maricopa County		0	651	1,539	2,307	3,821	6,849	10,742	10,742
Green Valley DWID	Pima County		0	115	272	408	676	1,211	1,900	1,900
H2O Water Co	Maricopa County		0	9	21	32	52	94	147	147
Marana	Pima County		0	3	7	10	17	30	47	47
Maricopa County Parks & Rec	Maricopa County		0	40	95	143	237	424	665	665
Mesa*	Maricopa County		2,082	6,156	9,748	12,859	18,990	31,253	47,091	47,664
MDWID	Pima County		0	816	1,928	2,890	4,787	8,581	13,460	13,460
Oro Valley	Pima County		0	625	1,476	2,213	3,665	6,570	10,305	10,305
Peoria	Maricopa County		0	1,531	3,615	5,419	8,976	16,089	25,236	25,236
Phelps Dodge Miami	Gila County		0	176	416	624	1,034	1,853	2,906	2,906
Phoenix*	Maricopa County		13,981	31,752	42,828	52,419	71,321	109,125	157,865	158,903
Phoenix Memorial Park	Maricopa County		0	5	12	18	30	54	84	84
Pine Water Co	Gila County		0	10	23	35	57	103	161	161
Queen Creek Water Co	Maricopa County		0	21	50	75	124	222	348	348
Rio Verde Utilities	Maricopa County		0	49	116	174	289	518	812	812
San Tan ID	Maricopa County		0	14	34	51	84	150	236	236
Scottsdale*	Maricopa County		1,240	5,297	9,658	13,435	20,878	35,763	54,907	54,928
Spanish Trail Water Co	Pima County		0	184	435	652	1,080	1,936	3,037	3,037
Superior	Pinal County		0	17	41	61	101	182	285	285
Surprise	Maricopa County		0	622	1,468	2,201	3,645	6,534	10,249	10,249
Tempe	Maricopa County		9	276	633	941	1,549	2,766	4,332	4,353
Tonto Hills Utility Co	Maricopa County		0	4	10	15	25	45	71	71
Tucson	Pima County		0	8,744	20,650	30,960	51,279	91,916	144,172	144,172

Table G-44
Arizona M&I Consumptive Use Shortages

2040				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
	Vail Water Co	Pima County		0	113	266	399	660	1,184	1,857	1,857
	Valley Utilities Water Co	Maricopa County		0	15	36	54	89	159	250	250
	Water Util. Comm. Fac. Dist. (AJ)	Pinal County		0	177	418	627	1,038	1,861	2,919	2,919
	Water Util. Greater Buckeye	Maricopa County		0	3	6	9	15	27	43	43
	Water Util. Greater Tonopah	Maricopa County		0	4	9	14	23	41	64	64
	White Tank Sys. (AZ Water Co.)	Maricopa County		0	59	139	208	344	617	968	968
	San Carlos (Phelps Dodge/Globe)	Gila County		0	1,100	2,599	3,896	6,454	11,568	18,145	18,145
	State Reserved	All Counties in CAP		32,727	55,287	55,287	55,287	55,287	55,287	55,287	55,287
M&I Subtotal				52,342	127,167	179,922	225,606	315,637	495,701	727,805	732,371
Arizona M&I											
4	Arizona State Land Department	Yuma County		91	182	227	273	364	546	780	780
4	Arizona State Parks Board - Contact Point	Mohave County		2	3	4	5	6	9	13	13
4	Arizona State Parks Board - Windsor Beach	Mohave County		2	5	6	7	9	14	20	20
4	Arizona-American Water Company	Mohave County		37	73	91	110	146	219	313	313
4	Brooke Water Company (formerly Graham)	La Paz County		10	19	24	29	39	58	83	83
4	Bullhead City	Mohave County		1,289	2,578	3,223	3,868	5,157	7,735	11,051	11,051
4	Bureau of Land Management	La Paz County		99	199	248	298	397	596	851	851
4	Cibola Valley Irrigation & Drainage District******* (M&I: 300af)	La Paz County	0.039	35	70	87	105	140	210	300	300
4	City of Somerton (new contract)	Yuma County		58	115	144	173	231	346	495	495
4	City of Yuma (Smucker Park)	Yuma County		0	0	0	0	0	0	0	0
4	Crystal Beach Water Conservation District	Mohave County		9	19	24	28	38	57	81	81
4	Desert Lawn Memorial Park Association, Inc.	Yuma County		2	3	4	5	7	10	15	15
4	Ehrenburg Improvement District	La Paz County		52	105	131	157	209	314	448	448
4	Fisher's Landing Water and Sewer Works, LLC	Yuma County		4	8	10	12	16	24	34	34
4	Gold Dome Mining Corporation	Yuma County		0	0	0	0	0	0	0	0
4	Gold Standard Mines Corporation	Mohave County		0	0	0	0	0	0	0	0
4	Golden Shores Water Conservation District	Mohave County		69	138	173	207	276	414	592	592
4	Hillcrest Water Company	La Paz County		6	11	14	17	22	33	48	48
4	Lake Havasu City	Mohave County		1,756	3,512	4,390	5,268	7,024	10,537	15,053	15,053
4	Marble Canyon Company, Inc.	Coconino County		2	4	5	5	7	11	16	16
4	Martinez Lake Cabin Sites (recommended)	Yuma County		2	3	4	5	7	10	15	15
4	McAlister, Maurice L.	Mohave County		0	1	1	1	2	3	4	4
4	Mohave County Water Authority (recommended 3,500af)	Mohave County		692	1,384	1,730	2,076	2,768	4,152	5,932	5,932
4	Subcontract to Bullhead City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Lake Havasu City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Mohave Water Cons. Dist. (3,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.233	583	1,167	1,458	1,750	2,333	3,500	5,000	5,000
4	Mohave Water Conservation District	Mohave County		92	184	230	276	368	551	788	788
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.185	8	17	21	25	34	50	72	72
4	Roy, Edward P. & Anna R.	Yuma County		0	0	0	0	0	1	1	1
4	Shepard Water Company	Yuma County		4	8	9	11	15	23	33	33
4	City of Parker	La Paz County		64	127	159	191	254	381	545	545
4	Town of Quartzsite	La Paz County		63	127	159	190	254	381	544	544
4	Verizon (formerly Continental Telephone)	La Paz County		0	0	0	0	0	1	1	1
2/3	Cibola National Wildlife Refuge	La Paz County		0	0	0	0	0	0	455	4,171
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.147	0	0	0	0	0	0	134	1,226
2/3	National Park Service	Mohave County		0	0	0	0	0	0	20	181
2/3	Yuma Union High School	Yuma County		0	0	0	0	0	0	3	29
2/3	Union Pacific Railroad (formerly Southern Pacific Co.)	Yuma County		0	0	0	0	0	0	1	7
2/3	Kaman, Inc.	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma	Yuma County		0	0	0	0	0	0	1,124	10,309
2/3	Department of Navy MCAS	Yuma County		0	0	0	0	0	0	57	522

Table G-44
Arizona M&I Consumptive Use Shortages

2040				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP M&I		County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma (cemetary)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.064	0	0	0	0	0	0	267	2,452
2/3	Desert Lawn Memorial Park	Yuma County		0	0	0	0	0	0	4	34
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.018	0	0	0	0	0	0	134	1,226
2/3	Chandler (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	114	1,049
2/3	Gilbert (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	181	1,658
2/3	Glendale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	80	736
2/3	Mesa (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	74	677
2/3	Phoenix (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	134	1,226
2/3	Scottsdale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	3	25
2/3	Tempe (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	3	25
2/3	Department of Army - Yuma Proving Ground	Yuma County		0	0	0	0	0	0	20	186
2/3	Bureau of Reclamation - Davis Dam	Mohave County		0	0	0	0	0	0	0	0
2/3	Imperial National Wildlife Refuge	La Paz County		0	0	0	0	0	0	97	887
2/3	Havasu Lake National Wildlife Refuge (2004 over use of 7,777af)	Mohave County		0	0	0	0	0	0	129	1,187
1	Brooke Water Company (formerly Graham)	La Paz County		0	0	0	0	0	0	0	0
1	City of Parker	La Paz County		0	0	0	0	0	0	0	0
1	Miller (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	Swan (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	City of Yuma	Yuma County		0	0	0	0	0	0	0	0
Total Arizona M&I:				5,031	10,062	12,578	15,094	20,125	30,187	46,158	70,939
M&I Summary by County		# of Tribes in the County									
	Coconino County	1		2	4	5	5	7	11	16	16
	Gila County	3		0	1,286	3,038	4,555	7,545	13,524	21,212	21,212
	La Paz County	13		337	675	843	1,012	1,349	2,024	3,443	7,949
	Maricopa County	36		19,615	56,759	88,925	116,779	171,674	281,464	423,201	427,767
	Mohave County	20		4,532	9,064	11,330	13,596	18,128	27,192	38,996	40,215
	Pima County	11		0	12,360	29,190	43,764	72,486	129,930	203,798	203,798
	Pinal County	7		0	1,474	3,481	5,220	8,645	15,497	24,307	24,307
	Yuma County	24		160	320	400	480	641	961	3,116	17,364
	All Counties in CAP	1		32,727	55,287	55,287	55,287	55,287	55,287	55,287	55,287
	(blank)	0		0	0	0	0	0	0	0	0
Total Arizona M&I:		116		57,373	137,230	192,500	240,699	335,762	525,888	773,375	797,915

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

1

Table G-45
Arizona Agricultural Diversion Shortages

2040				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima		0	0	0	0	0	0	0	0
CAP	Arizona State Land Department	Pinal County		3,385	5,718	5,718	5,718	5,718	5,718	5,718	5,718
4	Arizona State Land Department	Yuma County		1,005	2,010	2,513	3,016	4,021	6,031	8,616	8,616
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County		129	259	324	388	518	777	1,110	1,110
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County		305	611	763	916	1,221	1,832	2,617	2,617
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	1,216	2,432	3,040	3,648	4,864	7,296	10,423	10,423
4	Curtis, Armon (Curry Family LTD)	Yuma County		44	87	109	131	174	262	374	374
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		192	385	481	577	769	1,154	1,648	1,648
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		194	388	485	582	775	1,163	1,662	1,662
4	Mohave County Water Authority (new entitlement)	La Paz County		1,355	2,711	3,388	4,066	5,421	8,132	11,618	11,618
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.767	3,549	7,099	8,874	10,648	14,198	21,296	30,425	30,425
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.815	53	105	132	158	211	316	451	451
4	Ogram Boys Enterprises (new contract)	Yuma County		134	269	336	403	537	806	1,151	1,151
4	Ogram, George	Yuma County		70	140	175	209	279	419	598	598
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County		74	148	185	222	297	445	635	635
4	Peach, John (2004 over use of 45af)	Yuma County		82	164	205	246	327	491	702	702
4	Phillips, Milton and Jean	Yuma County		3	6	8	10	13	19	28	28
4	Rayner Ranches	Yuma County		650	1,301	1,626	1,951	2,602	3,903	5,576	5,576
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.853	0	0	0	0	0	0	1,698	15,575
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.936	0	0	0	0	0	0	7,544	69,206
2/3	University of Arizona	Yuma County		0	0	0	0	0	0	22	206
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County		0	0	0	0	0	0	2	21
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	536	4,918
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982	0	0	0	0	0	0	11,594	106,364
2/3	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	178	1,635
2/3	Sturges, Harold (not taking water)	Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Diversion Shortages			9,057	18,114	22,642	27,170	36,227	54,341	99,208	275,562

Table G-45
Arizona Agricultural Diversion Shortages

2040			Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
Agricultural Diversion Shortage by County	# of Tribes in the County									
Coconino County	0		0	0	0	0	0	0	0	0
La Paz County	4		2,624	5,248	6,560	7,872	10,496	15,744	22,492	22,492
Maricopa County	0		0	0	0	0	0	0	0	0
Mohave County	6		3,549	7,099	8,874	10,648	14,198	21,296	30,425	30,425
Pinal County	1		3,385	5,718	5,718	5,718	5,718	5,718	5,718	5,718
Yuma County	32		2,883	5,767	7,209	8,650	11,534	17,301	46,292	222,646
Total Agricultural Diversion Shortage by County	43		12,442	23,832	28,360	32,889	41,945	60,059	104,927	281,281

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-46
Arizona Agricultural Consumptive Use Shortages

2040				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages	County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima			0	0	0	0	0	0	0
CAP	Arizona State Land Department	Pinal County		3,385	5,718	5,718	5,718	5,718	5,718	5,718	5,718
4	Arizona State Land Department	Yuma County		653	1,307	1,633	1,960	2,613	3,920	5,600	5,600
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County		84	168	210	253	337	505	722	722
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County		198	397	496	595	794	1,191	1,701	1,701
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	869	1,739	2,173	2,608	3,478	5,216	7,452	7,452
4	Curtis, Armon (Curry Family LTD)	Yuma County		28	57	71	85	113	170	243	243
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		104	208	259	311	415	623	890	890
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		126	252	315	378	504	756	1,080	1,080
4	Mohave County Water Authority (new entitlement)	La Paz County		447	895	1,118	1,342	1,789	2,684	3,834	3,834
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.767	1,917	3,833	4,792	5,750	7,667	11,500	16,430	16,430
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.815	37	74	92	111	148	222	317	317
4	Ogram Boys Enterprises (new contract)	Yuma County		87	175	218	262	349	524	748	748
4	Ogram, George	Yuma County		45	91	113	136	182	272	389	389
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County		48	96	120	145	193	289	413	413
4	Peach, John (2004 over use of 45af)	Yuma County		53	106	133	160	213	319	456	456
4	Phillips, Milton and Jean	Yuma County		2	4	5	6	8	13	18	18
4	Rayner Ranches	Yuma County		423	845	1,057	1,268	1,691	2,536	3,623	3,623
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.853	0	0	0	0	0	0	773	7,091
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.936	0	0	0	0	0	0	3,910	35,867
2/3	University of Arizona	Yuma County		0	0	0	0	0	0	22	206

Table G-46
Arizona Agricultural Consumptive Use Shortages

2040				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages	County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County		0	0	0	0	0	0	2	15
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	324	2,968
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982	0	0	0	0	0	0	7,296	66,937
2/3	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	96	883
2/3	Sturges, Harold (not taking water)	Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Consumptive Use Shortages			5,123	10,246	12,808	15,370	20,493	30,739	56,338	157,885
	Agricultural Consumptive Use Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		1,354	2,707	3,384	4,061	5,415	8,122	11,603	11,603
	Maricopa County	0		0	0	0	0	0	0	0	0
	Mohave County	6		1,917	3,833	4,792	5,750	7,667	11,500	16,430	16,430
	Pinal County	1		3,385	5,718	5,718	5,718	5,718	5,718	5,718	5,718
	Yuma County	32		1,853	3,706	4,632	5,559	7,411	11,117	28,305	129,852
	Total Agricultural Consumptive Use Shortage by County	43		8,508	15,965	18,526	21,088	26,211	36,458	62,057	163,603

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-47
Arizona Tribal Diversion Shortages

2040		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	451	5,305	15,015	28,770	39,147
Fort McDowell	Maricopa County	0	0	0	299	3,518	9,955	18,233	18,233
Gila River	Maricopa and Pinal County	36,182	74,018	91,576	106,822	132,936	185,163	252,323	252,323
TON-Chui Chu	Pinal County	0	323	762	918	2,189	4,731	8,000	8,000
TON-San Xavier	Pima County	10,399	17,568	17,568	18,011	22,777	32,310	44,568	44,568
TON-Schuk Toak	Pima County	2,351	3,972	3,972	4,149	6,055	9,869	14,772	14,772
Pasqua Yaqui	Pima County	0	0	0	8	96	273	500	500

Table G-47
Arizona Tribal Diversion Shortages

2040		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Salt River	Maricopa County	0	0	0	1,526	3,639	7,866	13,300	13,300
San Carlos Apache	Gila County	0	0	0	6,713	13,315	26,520	43,500	43,500
Tonto Apache	Gila County	0	0	0	2	25	70	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	20	232	655	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	8	96	273	500	500
Unallocated HVID	Maricopa County	0	0	0	20	235	665	1,218	1,218
Reserved Federal	---	25,239	42,636	42,636	42,636	42,636	42,636	42,636	42,636
Total CAP Tribal Diversion Shortages		74,171	138,517	156,515	181,583	233,056	336,001	469,648	480,025
Non-CAP Arizona Tribal Diversion Shortages									
Cocopah Indian Reservation	Yuma County	159	318	397	477	636	954	1,362	1,362
Hopi Tribe (new entitlement)	La Paz County	688	1,376	1,720	2,064	2,752	4,129	5,898	5,898
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Diversion Shortages		847	1,694	2,118	2,541	3,388	5,082	7,261	7,261
Tribal Diversion Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	6,735	13,572	27,245	44,828	44,828
La Paz County	2	688	1,376	1,720	2,064	2,752	4,129	5,898	5,898
Maricopa County	3	10,855	22,205	27,473	33,892	47,273	74,035	108,448	108,448
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	12,751	21,540	21,540	22,168	28,929	42,451	59,840	59,840
Pinal County	2	25,327	52,135	64,866	76,144	100,550	149,360	213,395	223,773
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	8	96	273	500	500
Yuma County	2	159	318	397	477	636	954	1,362	1,362
---	1	25,239	42,636	42,636	42,636	42,636	42,636	42,636	42,636
Total Tribal Diversion Shortages by County	18	75,018	140,211	158,632	184,124	236,444	341,083	476,908	487,285

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

Table G-48
Arizona Tribal Consumptive Use Shortages

2040		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	451	5,305	15,015	28,770	39,147
Fort McDowell	Maricopa County	0	0	0	299	3,518	9,955	18,233	18,233
Gila River	Maricopa and Pinal County	36,182	74,018	91,576	106,822	132,936	185,163	252,323	252,323
TON-Chui Chu	Pinal County	0	323	762	918	2,189	4,731	8,000	8,000
TON-San Xavier	Pima County	10,399	17,568	17,568	18,011	22,777	32,310	44,568	44,568
TON-Schuk Toak	Pima County	2,351	3,972	3,972	4,149	6,055	9,869	14,772	14,772
Pasqua Yaqui	Pima County	0	0	0	8	96	273	500	500

Table G-48
Arizona Tribal Consumptive Use Shortages

2040		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Salt River	Maricopa County	0	0	0	1,526	3,639	7,866	13,300	13,300
San Carlos Apache	Gila County	0	0	0	6,713	13,315	26,520	43,500	43,500
Tonto Apache	Gila County	0	0	0	2	25	70	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	20	232	655	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	8	96	273	500	500
Unallocated HVID	Maricopa County	0	0	0	20	235	665	1,218	1,218
Reserved Federal	---	25,239	42,636	42,636	42,636	42,636	42,636	42,636	42,636
Total CAP Tribal Consumptive Use Shortages		74,171	138,517	156,515	181,583	233,056	336,001	469,648	480,025
Non-CAP Arizona Tribal Consumptive Use Shortages									
Cocopah Indian Reservation	Yuma County	156	312	390	468	624	936	1,337	1,337
Hopi Tribe (new entitlement)	La Paz County	447	895	1,118	1,342	1,789	2,684	3,834	3,834
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Consumptive Use Shortages		603	1,207	1,508	1,810	2,413	3,620	5,171	5,171
Tribal Consumptive Use Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	6,735	13,572	27,245	44,828	44,828
La Paz County	2	447	895	1,118	1,342	1,789	2,684	3,834	3,834
Maricopa County	3	10,855	22,205	27,473	33,892	47,273	74,035	108,448	108,448
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	12,751	21,540	21,540	22,168	28,929	42,451	59,840	59,840
Pinal County	2	25,327	52,135	64,866	76,144	100,550	149,360	213,395	223,773
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	8	96	273	500	500
Yuma County	2	156	312	390	468	624	936	1,337	1,337
---	1	25,239	42,636	42,636	42,636	42,636	42,636	42,636	42,636
Total Tribal Consumptive Use Shortages by County	18	74,774	139,723	158,023	183,393	235,469	339,620	474,819	485,196

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

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Attachment 7: 2060 Summary Output of Shortages

Table G-49
Lower Colorado River Shortage Summary

2060	Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Stage I Shortage:	200,000	400,000	500,000	600,000	800,000	1,200,000	1,714,362	1,714,362
Stage II Shortage:	0	0	0	0	0	0	85,638	785,638
Total U.S. & Mexican Shortage	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000
Mexico	33,333	66,667	83,333	100,000	133,333	200,000	300,000	416,667
Nevada	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Surplus Water - SNWA	0	0	0	0	0	0	0	0
8th Priority (SNWA - Balance & Unused)	6,667	13,333	16,667	20,000	26,667	40,000	60,000	70,914
8th Priority (SNWA & Big Bend)	0	0	0	0	0	0	0	12,419
7th Priority (Boy Scouts, BOR, NV Dept of…)	0	0	0	0	0	0	0	0
6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
5th Priority (PABCO & Lakeview Co.)	0	0	0	0	0	0	0	0
4th Priority (Henderson & Basic Management)	0	0	0	0	0	0	0	0
3rd Priority (Boulder City)	0	0	0	0	0	0	0	0
2nd Priority (Lake Mead National Rec Area)	0	0	0	0	0	0	0	0
1st Priority (PPR's: LMNRA & Fort Mohave)	0	0	0	0	0	0	0	0
SUBTOTAL	6,667	13,333	16,667	20,000	26,667	40,000	60,000	83,333
Arizona	160,000	320,000	400,000	480,000	640,000	960,000	1,388,281	1,525,531
Surplus Contracts (Hopi Tribe, Mohave Co., Ag)	0	0	0	0	0	0	0	0
5th Priority & CAP Bank (unused)	0	0	0	0	0	0	0	0
4th Priority (River users and CAP)	160,000	320,000	400,000	480,000	640,000	960,000	1,371,490	1,371,490
CAP Excess Water for Agriculture[1]	0	0	0	0	0	0	0	0
CAP NIA Priority (M&I, Indian, and Agriculture)[2]	222,436	258,060	258,060	258,060	258,060	258,060	258,060	258,060
CAP Indian Priority	132,218	172,941	186,015	211,449	262,604	364,913	497,743	508,120
CAP M&I Priority	90,217	190,126	247,367	292,248	381,725	560,677	791,351	795,917
2/3 Priority (includes some CAP entities)	0	0	0	0	0	0	16,791	154,042
1st Priority (PPR's)	0	0	0	0	0	0	0	0
SUBTOTAL	160,000	320,000	400,000	480,000	640,000	960,000	1,388,281	1,525,531
California	0	0	0	0	0	0	51,719	474,469
Surplus (BLM, Needles, Coachella, Navy, MET)	0	0	0	0	0	0	0	0
7th Priority (unused & surplus - CVWD, IID, PVID)	0	0	0	0	0	0	0	0
6th Priority (unused & surplus - MET)	0	0	0	0	0	0	0	0
5th Priority (MET)	0	0	0	0	0	0	51,719	474,468
4th Priority (PVID, CVWD, IDD - MET & San Diego)	0	0	0	0	0	0	0	0
3rd Priority (Reservation Division)	0	0	0	0	0	0	0	0
2nd Priority (PVID)	0	0	0	0	0	0	0	0
1st Priority (PPR's - include PVID & IID)	0	0	0	0	0	0	0	0
SUBTOTAL	0	0	0	0	0	0	51,719	474,468
TOTAL	200,000	400,000	500,000	600,000	800,000	1,200,000	1,800,000	2,500,000

[1]Shortage allocation may be zero if excess water for agriculture is not available.
[2] It is important to note that the schedules were inadvertently not adjusted after year 2044 to account for the M&I transfer in the AWSA, therefore impacts are over stated to the NIA priority in year 2060. This error will be fixed for the Final EIS.

Table G-50
Arizona M&I Consumptive Use Shortages

2060			Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
Apache Junction (AZ Water Co)	Pinal County		0	747	1,248	1,640	2,423	3,988	6,000	6,000
Avra Coop	Pima County		0	101	168	221	326	537	808	808
AZ-American (Agua Fria)	Maricopa County		0	1,382	2,307	3,033	4,479	7,373	11,093	11,093
AZ-American (Paradise Valley)	Maricopa County		0	402	672	883	1,305	2,147	3,231	3,231
AZ-American (Sun City)	Maricopa County		0	522	871	1,145	1,692	2,784	4,189	4,189
AZ-American (Sun City West)	Maricopa County		0	295	493	648	958	1,576	2,372	2,372
AZ State Land Dept.	Maricopa County		0	2,501	4,175	5,489	8,107	13,343	20,076	20,076
ASARCO (Ray Mine)	Pima County		0	2,616	4,368	5,741	8,480	13,957	21,000	21,000
Avondale	Maricopa County		0	675	1,126	1,481	2,187	3,600	5,416	5,416
Berneil Water Co (Cave Creek)	Maricopa County		0	25	42	55	81	133	200	200
Buckeye	Maricopa County		0	3	5	7	10	17	25	25
Carefree Water Co	Maricopa County		0	162	270	355	525	864	1,300	1,300
Casa Grande (AZ Water Co)	Pinal County		0	1,107	1,848	2,429	3,587	5,904	8,884	8,884
Cave Creek Water Co	Maricopa County		0	300	500	658	972	1,599	2,406	2,406
CAGRD	Maricopa County		0	965	1,611	2,118	3,128	5,148	7,746	7,746
Chandler*	Maricopa County		2,382	4,209	5,178	5,937	7,450	10,477	14,479	15,366
Chandler Heights Citrus ID	Maricopa County		0	39	66	86	127	209	315	315
Chaparral City Water Co	Maricopa County		0	1,110	1,853	2,436	3,597	5,921	8,909	8,909
Circle City Water Co	Maricopa County		0	490	818	1,075	1,588	2,613	3,932	3,932
Comm. Water Co (Green Valley)	Pima County		0	356	594	781	1,154	1,899	2,858	2,858
Coolidge (AZ Water Co)	Pinal County		0	249	416	547	808	1,329	2,000	2,000
El Mirage	Maricopa County		0	63	106	139	205	338	508	508
Eloy	Pinal County		0	270	452	594	877	1,443	2,171	2,171
Florence	Pinal County		0	255	426	560	827	1,361	2,048	2,048
Flowing Wells ID	Pima County		0	542	906	1,190	1,758	2,894	4,354	4,354
Gilbert	Maricopa County		933	1,984	2,587	3,061	4,004	5,891	8,489	9,893
Glendale	Maricopa County		414	2,627	4,065	5,193	7,440	11,936	17,793	18,415
Goodyear	Maricopa County		0	1,338	2,234	2,937	4,338	7,139	10,742	10,742
Green Valley DWID	Pima County		0	237	395	519	767	1,263	1,900	1,900
H2O Water Co	Maricopa County		0	18	31	40	59	98	147	147
Marana	Pima County		0	6	10	13	19	31	47	47
Maricopa County Parks & Rec	Maricopa County		0	83	138	182	269	442	665	665
Mesa*	Maricopa County		3,371	9,942	13,982	17,150	23,466	36,096	52,408	52,981
MDWID	Pima County		0	1,676	2,799	3,680	5,435	8,946	13,460	13,460
Oro Valley	Pima County		0	1,284	2,143	2,817	4,161	6,849	10,305	10,305
Peoria	Maricopa County		0	3,143	5,249	6,899	10,190	16,772	25,236	25,236
Phelps Dodge Miami	Gila County		0	362	604	794	1,173	1,931	2,906	2,906
Phoenix*	Maricopa County		22,633	47,465	61,670	72,807	95,011	139,419	196,649	197,687
Phoenix Memorial Park	Maricopa County		0	10	17	23	34	56	84	84
Pine Water Co	Gila County		0	20	33	44	65	107	161	161
Queen Creek Water Co	Maricopa County		0	43	72	95	141	231	348	348
Rio Verde Utilities	Maricopa County		0	101	169	222	328	540	812	812
San Tan ID	Maricopa County		0	29	49	65	95	157	236	236
Scottsdale*	Maricopa County		2,007	9,315	13,995	17,664	24,979	39,609	58,424	58,445
Spanish Trail Water Co	Pima County		0	378	632	830	1,226	2,018	3,037	3,037
Superior	Pinal County		0	35	59	78	115	189	285	285
Surprise	Maricopa County		0	1,277	2,132	2,802	4,139	6,812	10,249	10,249
Tempe	Maricopa County		14	554	914	1,196	1,759	2,884	4,334	4,354
Tonto Hills Utility Co	Maricopa County		0	9	15	19	29	47	71	71
Tucson	Pima County		0	17,957	29,985	39,416	58,217	95,819	144,172	144,172
Vail Water Co	Pima County		0	231	386	508	750	1,234	1,857	1,857
Valley Utilities Water Co	Maricopa County		0	31	52	68	101	166	250	250

Table G-50
Arizona M&I Consumptive Use Shortages

2060				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
	Water Util. Comm. Fac. Dist. (AJ)	Pinal County		0	364	607	798	1,179	1,940	2,919	2,919
	Water Util. Greater Buckeye	Maricopa County		0	5	9	12	17	29	43	43
	Water Util. Greater Tonopah	Maricopa County		0	8	13	17	26	43	64	64
	White Tank Sys. (AZ Water Co.)	Maricopa County		0	121	201	265	391	643	968	968
	San Carlos (Phelps Dodge/Globe)	Gila County		0	2,260	3,774	4,961	7,327	12,059	18,145	18,145
	State Reserved	All Counties in CAP		52,983	61,468	61,468	61,468	61,468	61,468	61,468	61,468
M&I Subtotal				84,737	183,768	241,009	285,891	375,367	554,319	784,993	789,559
Arizona M&I											
4	Arizona State Land Department	Yuma County		91	182	227	273	364	546	780	780
4	Arizona State Parks Board - Contact Point	Mohave County		2	3	4	5	6	9	13	13
4	Arizona State Parks Board - Windsor Beach	Mohave County		2	5	6	7	9	14	20	20
4	Arizona-American Water Company	Mohave County		37	74	93	111	148	223	318	318
4	Brooke Water Company (formerly Graham)	La Paz County		10	20	25	30	40	59	85	85
4	Bullhead City	Mohave County		1,367	2,733	3,416	4,100	5,466	8,199	11,714	11,714
4	Bureau of Land Management	La Paz County		99	199	248	298	397	596	851	851
4	Cibola Valley Irrigation & Drainage District******* (M&I: 300af)	La Paz County	0.039	35	70	87	105	140	210	300	300
4	City of Somerton (new contract)	Yuma County		58	115	144	173	231	346	495	495
4	City of Yuma (Smucker Park)	Yuma County		0	0	0	0	0	0	0	0
4	Crystal Beach Water Conservation District	Mohave County		10	19	24	29	38	57	82	82
4	Desert Lawn Memorial Park Association, Inc.	Yuma County		2	3	4	5	7	10	15	15
4	Ehrenburg Improvement District	La Paz County		52	105	131	157	209	314	448	448
4	Fisher's Landing Water and Sewer Works, LLC	Yuma County		4	8	10	12	16	24	34	34
4	Gold Dome Mining Corporation	Yuma County		0	0	0	0	0	0	0	0
4	Gold Standard Mines Corporation	Mohave County		0	0	0	0	0	0	0	0
4	Golden Shores Water Conservation District	Mohave County		73	146	183	219	293	439	627	627
4	Hillcrest Water Company	La Paz County		6	11	14	17	23	34	49	49
4	Lake Havasu City	Mohave County		1,920	3,840	4,800	5,760	7,679	11,519	16,457	16,457
4	Marble Canyon Company, Inc.	Coconino County		2	4	5	5	7	11	16	16
4	Martinez Lake Cabin Sites (recommended)	Yuma County		2	3	4	5	7	10	15	15
4	McAlister, Maurice L.	Mohave County		0	1	1	1	2	3	4	4
4	Mohave County Water Authority (recommended 3,500af)	Mohave County		731	1,462	1,828	2,193	2,924	4,386	6,266	6,266
4	Subcontract to Bullhead City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Lake Havasu City (6,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Subcontract to Mohave Water Cons. Dist. (3,000 AF)	Mohave County		0	0	0	0	0	0	0	0
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.229	583	1,167	1,458	1,750	2,333	3,500	5,000	5,000
4	Mohave Water Conservation District	Mohave County		97	195	244	292	390	584	835	835
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.185	8	17	21	25	34	50	72	72
4	Roy, Edward P. & Anna R.	Yuma County		0	0	0	0	0	1	1	1
4	Shepard Water Company	Yuma County		4	8	9	11	15	23	33	33
4	City of Parker	La Paz County		65	130	163	195	260	391	558	558
4	Town of Quartzsite	La Paz County		65	130	162	195	259	389	556	556
4	Verizon (formerly Continental Telephone)	La Paz County		0	0	0	0	0	1	1	1
2/3	Cibola National Wildlife Refuge	La Paz County		0	0	0	0	0	0	455	4,171
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.147	0	0	0	0	0	0	134	1,226
2/3	National Park Service	Mohave County		0	0	0	0	0	0	20	181
2/3	Yuma Union High School	Yuma County		0	0	0	0	0	0	3	29
2/3	Union Pacific Railroad (formerly Southern Pacific Co.)	Yuma County		0	0	0	0	0	0	1	7
2/3	Kaman, Inc.	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma	Yuma County		0	0	0	0	0	0	1,123	10,305
2/3	Department of Navy MCAS	Yuma County		0	0	0	0	0	0	57	522
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	City of Yuma (cemetary)	Yuma County		0	0	0	0	0	0	0	0

Table G-50
Arizona M&I Consumptive Use Shortages

2060				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	CAP M&I	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.064	0	0	0	0	0	0	267	2,452
2/3	Desert Lawn Memorial Park	Yuma County		0	0	0	0	0	0	4	34
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.018	0	0	0	0	0	0	134	1,226
2/3	Chandler (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	114	1,049
2/3	Gilbert (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	181	1,658
2/3	Glendale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	80	736
2/3	Mesa (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	74	677
2/3	Phoenix (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	134	1,226
2/3	Scottsdale (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	3	25
2/3	Tempe (Salt River Pima-Maricopa Exchange)****	Maricopa		0	0	0	0	0	0	3	25
2/3	Department of Army - Yuma Proving Ground	Yuma County		0	0	0	0	0	0	20	186
2/3	Bureau of Reclamation - Davis Dam	Mohave County		0	0	0	0	0	0	0	0
2/3	Imperial National Wildlife Refuge	La Paz County		0	0	0	0	0	0	97	887
2/3	Havasu Lake National Wildlife Refuge (2004 over use of 7,777af)	Mohave County		0	0	0	0	0	0	129	1,187
1	Brooke Water Company (formerly Graham)	La Paz County		0	0	0	0	0	0	0	0
1	City of Parker	La Paz County		0	0	0	0	0	0	0	0
1	Miller (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	Swan (in MVIDD)	Mohave County		0	0	0	0	0	0	0	0
1	City of Yuma	Yuma County		0	0	0	0	0	0	0	0
Total Arizona M&I:				5,325	10,650	13,312	15,975	21,299	31,949	48,675	73,452
M&I Summary by County		# of Tribes in the County									
	Coconino County	1		2	4	5	5	7	11	16	16
	Gila County	3		0	2,642	4,412	5,799	8,565	14,098	21,212	21,212
	La Paz County	13		341	681	852	1,022	1,362	2,044	3,471	7,978
	Maricopa County	36		31,755	91,247	127,688	156,261	213,224	327,151	474,208	478,775
	Mohave County	20		4,822	9,645	12,056	14,467	19,289	28,934	41,485	42,704
	Pima County	11		0	25,384	42,386	55,717	82,294	135,447	203,798	203,798
	Pinal County	7		0	3,028	5,055	6,645	9,815	16,155	24,307	24,307
	Yuma County	24		160	320	400	480	641	961	3,115	17,360
	All Counties in CAP	1		52,983	61,468	61,468	61,468	61,468	61,468	61,468	61,468
	(blank)	0		0	0	0	0	0	0	0	0
Total Arizona M&I:		116		90,062	194,418	254,322	301,866	396,667	586,268	833,080	857,617

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-51
Arizona Agricultural Diversion Shortages

2060					Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages		County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA		Maricopa/Pinal/Pima		0	0	0	0	0	0	0	0
CAP	Arizona State Land Department		Pinal County		5,480	6,357	6,357	6,357	6,357	6,357	6,357	6,357
4	Arizona State Land Department		Yuma County		1,005	2,010	2,513	3,016	4,021	6,031	8,616	8,616
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)		Yuma County		129	259	324	388	518	777	1,110	1,110
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)		Yuma County		305	611	763	916	1,221	1,832	2,617	2,617

Table G-51
Arizona Agricultural Diversion Shortages

2060				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Diversion Shortages	County	M&I/Ag Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	1,216	2,432	3,040	3,648	4,864	7,296	10,423	10,423
4	Curtis, Armon (Curry Family LTD)	Yuma County		44	87	109	131	174	262	374	374
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		192	385	481	577	769	1,154	1,648	1,648
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		194	388	485	582	775	1,163	1,662	1,662
4	Mohave County Water Authority (new entitlement)	La Paz County		1,355	2,711	3,388	4,066	5,421	8,132	11,618	11,618
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.771	3,633	7,266	9,083	10,899	14,532	21,798	31,142	31,142
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.815	53	105	132	158	211	316	451	451
4	Ogram Boys Enterprises (new contract)	Yuma County		134	269	336	403	537	806	1,151	1,151
4	Ogram, George	Yuma County		70	140	175	209	279	419	598	598
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County		74	148	185	222	297	445	635	635
4	Peach, John (2004 over use of 45af)	Yuma County		82	164	205	246	327	491	702	702
4	Phillips, Milton and Jean	Yuma County		3	6	8	10	13	19	28	28
4	Rayner Ranches	Yuma County		650	1,301	1,626	1,951	2,602	3,903	5,576	5,576
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.853	0	0	0	0	0	0	1,698	15,576
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.936	0	0	0	0	0	0	7,544	69,208
2/3	University of Arizona	Yuma County		0	0	0	0	0	0	22	206
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County		0	0	0	0	0	0	2	21
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	536	4,918
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982	0	0	0	0	0	0	11,595	106,368
2/3	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	178	1,636
2/3	Sturges, Harold (not taking water)	Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Diversion Shortages			9,140	18,281	22,851	27,421	36,562	54,842	99,926	276,285
	Agricultural Diversion Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		2,624	5,248	6,560	7,872	10,496	15,744	22,492	22,492
	Maricopa County	0		0	0	0	0	0	0	0	0
	Mohave County	6		3,633	7,266	9,083	10,899	14,532	21,798	31,142	31,142
	Pinal County	1		5,480	6,357	6,357	6,357	6,357	6,357	6,357	6,357
	Yuma County	32		2,883	5,767	7,209	8,650	11,534	17,301	46,292	222,652
	Total Agricultural Diversion Shortage by County	43		14,620	24,638	29,209	33,779	42,919	61,200	106,283	282,643

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-52
Arizona Agricultural Consumptive Use Shortages

2060				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
	Arizona Agricultural Consumptive Use Shortages	County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
CAP	Agricultural Relinquished Water Contracts under AWSA	Maricopa/Pinal/Pima			0	0	0	0	0	0	0
CAP	Arizona State Land Department	Pinal County		5,480	6,357	6,357	6,357	6,357	6,357	6,357	6,357
4	Arizona State Land Department	Yuma County		653	1,307	1,633	1,960	2,613	3,920	5,600	5,600
4	Beattie Farms Southwest (new contract) (2004 over use of 263af)	Yuma County		84	168	210	253	337	505	722	722
4	ChaCha (Curtis Family Trust) (Auza Farm and West Farm) (over 13af)	Yuma County		198	397	496	595	794	1,191	1,701	1,701
4	Cibola Resources	La Paz County		0	0	0	0	0	0	0	0
4	Cibola Valley Irrigation & Drainage District (M&I: 300af)	La Paz County	0.961	869	1,739	2,173	2,608	3,478	5,216	7,452	7,452
4	Curtis, Armon (Curry Family LTD)	Yuma County		28	57	71	85	113	170	243	243
4	Gila Monster Farms (formerly Sturges Farms Inc.)	Yuma County		104	208	259	311	415	623	890	890
4	Jessen Family Limited (new contract) (2004 over use of 4,984af)	Yuma County		126	252	315	378	504	756	1,080	1,080
4	Mohave County Water Authority (new entitlement)	La Paz County		447	895	1,118	1,342	1,789	2,684	3,834	3,834
4	Mohave Valley Irrigation and Drainage District (5,000af M&I)	Mohave County	0.771	1,962	3,924	4,905	5,886	7,848	11,771	16,817	16,817
4	North Baja LLC (formerly Jamar Produce) (72af M&I)	La Paz County	0.815	37	74	92	111	148	222	317	317
4	Ogram Boys Enterprises (new contract)	Yuma County		87	175	218	262	349	524	748	748
4	Ogram, George	Yuma County		45	91	113	136	182	272	389	389
4	Pasquinelli, Gary and Barbara (formerly Ansel Hall)	Yuma County		48	96	120	145	193	289	413	413
4	Peach, John (2004 over use of 45af)	Yuma County		53	106	133	160	213	319	456	456
4	Phillips, Milton and Jean	Yuma County		2	4	5	6	8	13	18	18
4	Rayner Ranches	Yuma County		423	845	1,057	1,268	1,691	2,536	3,623	3,623
2/3	Yuma Irrigation District (5,000af M&I)	Yuma County	0.853	0	0	0	0	0	0	773	7,091
2/3	Yuma County Water Users' Association (14,701af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Area Office (489.95af M&I Conversion)	Yuma County		0	0	0	0	0	0	0	0
2/3	Yuma Mesa Fruit Growers	Yuma County		0	0	0	0	0	0	0	3
2/3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)	Yuma County	0.936	0	0	0	0	0	0	3,910	35,868
2/3	University of Arizona	Yuma County		0	0	0	0	0	0	22	206
2/3	Yuma Mesa Grapefruit Company (Camille Allec Jr.)	Yuma County		0	0	0	0	0	0	2	15
2/3	North Gila Valley Irrigation District (2,500af M&I)	Yuma County	0.000	0	0	0	0	0	0	0	0
2/3	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	324	2,968
2/3	Welton-Mohawk Irriation and Drainage District (5,000af M&I)	Yuma County	0.982	0	0	0	0	0	0	7,297	66,939
2/3	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	96	883
2/3	Sturges, Harold (not taking water)	Yuma County		0	0	0	0	0	0	0	0
2/3	Sturges, Irma (not taking water)	Yuma County		0	0	0	0	0	0	0	0
1	Molina (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
1	Gila Monster Farms (formerly Sturges)	Yuma County		0	0	0	0	0	0	0	0
1	Powers (Power, R.E. & P.) (2004 use 384af over entitlement)	Yuma County		0	0	0	0	0	0	0	0
1	Zozaya (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	North Gila Valley Irrigation District****	Yuma County		0	0	0	0	0	0	0	0
1	Yuma Axiliary Project (Unit B)	Yuma County		0	0	0	0	0	0	0	0
1	Hulet (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Holpal (in MVIDD/formerly Hurschler) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	McKellips and Granite Reef Farms (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Sherill & Lafollette (in MVIDD) (Water Use Not Reported)	Mohave County		0	0	0	0	0	0	0	0
1	Yuma County Water Users' Association	Yuma County		0	0	0	0	0	0	0	0
1	Phillips, Milton and Jean (Water Use Not Reported)	Yuma County		0	0	0	0	0	0	0	0
	Total Arizona Agricultural Consumptive Use Shortages			5,168	10,337	12,921	15,505	20,673	31,010	56,726	158,276
	Agricultural Consumptive Use Shortage by County	# of Tribes in the County									
	Coconino County	0		0	0	0	0	0	0	0	0
	La Paz County	4		1,354	2,707	3,384	4,061	5,415	8,122	11,603	11,603
	Maricopa County	0		0	0	0	0	0	0	0	0

Table G-52
Arizona Agricultural Consumptive Use Shortages

2060				Lower Colorado River Shortage Volumes in Annual Acre-Feet							
Arizona Agricultural Consumptive Use Shortages		County	Ratio	200000	400000	500000	600000	800000	1200000	1800000	2500000
Mohave County		6		1,962	3,924	4,905	5,886	7,848	11,771	16,817	16,817
Pinal County		1		5,480	6,357	6,357	6,357	6,357	6,357	6,357	6,357
Yuma County		32		1,853	3,706	4,632	5,559	7,411	11,117	28,306	129,855
Total Agricultural Consumptive Use Shortage by County		43		10,648	16,694	19,278	21,863	27,031	37,368	63,083	164,633

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona

Table G-53
Arizona Tribal Diversion Shortages

2060		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	618	5,442	15,092	28,770	39,147
Fort McDowell	Maricopa County	0	0	0	410	3,608	10,006	18,233	18,233
Gila River	Maricopa and Pinal County	58,575	87,026	99,781	114,554	140,506	192,411	259,156	259,156
TON-Chui Chu	Pinal County	0	477	796	962	2,225	4,751	8,000	8,000
TON-San Xavier	Pima County	26,739	31,022	31,022	31,628	36,365	45,839	58,022	58,022
TON-Schuk Toak	Pima County	6,045	7,014	7,014	7,256	9,151	12,941	17,814	17,814
Pasqua Yaqui	Pima County	0	0	0	11	99	274	500	500
Salt River	Maricopa County	0	0	0	1,599	3,699	7,899	13,300	13,300
San Carlos Apache	Gila County	0	0	0	6,940	13,502	26,625	43,500	43,500
Tonto Apache	Gila County	0	0	0	3	25	70	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	27	237	659	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	11	99	274	500	500
Unallocated HVID	Maricopa County	0	0	0	27	241	668	1,218	1,218
Reserved Federal	---	40,859	47,403	47,403	47,403	47,403	47,403	47,403	47,403
Total CAP Tribal Diversion Shortages		132,218	172,941	186,015	211,449	262,604	364,913	497,743	508,120
Non-CAP Arizona Tribal Diversion Shortages									
Cocopah Indian Reservation	Yuma County	159	318	397	477	636	954	1,362	1,362
Hopi Tribe (new entitlement)	La Paz County	688	1,376	1,720	2,064	2,752	4,129	5,898	5,898
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Diversion Shortages		847	1,694	2,118	2,541	3,388	5,082	7,261	7,261
Tribal Diversion Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	6,970	13,765	27,354	44,828	44,828
La Paz County	2	688	1,376	1,720	2,064	2,752	4,129	5,898	5,898
Maricopa County	3	17,572	26,108	29,934	36,402	49,700	76,297	110,498	110,498
Mohave County	1	0	0	0	0	0	0	0	0

Table G-53
Arizona Tribal Diversion Shortages

2060		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Diversion Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Pima County	3	32,784	38,035	38,035	38,895	45,615	59,054	76,335	76,335
Pinal County	2	41,002	61,395	70,643	81,767	106,022	154,531	218,179	228,556
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	11	99	274	500	500
Yuma County	2	159	318	397	477	636	954	1,362	1,362
---	1	40,859	47,403	47,403	47,403	47,403	47,403	47,403	47,403
Total Tribal Diversion Shortages by County	18	133,066	174,635	188,133	213,990	265,992	369,995	505,003	515,381

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

Table G-54
Arizona Tribal Consumptive Use Shortages

2060		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Ak-Chin Indian Community	Pinal County	0	0	0	618	5,442	15,092	28,770	39,147
Fort McDowell	Maricopa County	0	0	0	410	3,608	10,006	18,233	18,233
Gila River	Maricopa and Pinal County	58,575	87,026	99,781	114,554	140,506	192,411	259,156	259,156
TON-Chui Chu	Pinal County	0	477	796	962	2,225	4,751	8,000	8,000
TON-San Xavier	Pima County	26,739	31,022	31,022	31,628	36,365	45,839	58,022	58,022
TON-Schuk Toak	Pima County	6,045	7,014	7,014	7,256	9,151	12,941	17,814	17,814
Pasqua Yaqui	Pima County	0	0	0	11	99	274	500	500
Salt River	Maricopa County	0	0	0	1,599	3,699	7,899	13,300	13,300
San Carlos Apache	Gila County	0	0	0	6,940	13,502	26,625	43,500	43,500
Tonto Apache	Gila County	0	0	0	3	25	70	128	128
Yavapai Apache (Camp Verde)	Gila County	0	0	0	27	237	659	1,200	1,200
Yavapai Prescott	Yavapai County (Reassignment to Scottsdale)*	0	0	0	11	99	274	500	500
Unallocated HVID	Maricopa County	0	0	0	27	241	668	1,218	1,218
Reserved Federal	---	40,859	47,403	47,403	47,403	47,403	47,403	47,403	47,403
Total CAP Tribal Consumptive Use Shortages		132,218	172,941	186,015	211,449	262,604	364,913	497,743	508,120
Non-CAP Arizona Tribal Consumptive Use Shortages									
Cocopah Indian Reservation	Yuma County	156	312	390	468	624	936	1,337	1,337
Hopi Tribe (new entitlement)	La Paz County	447	895	1,118	1,342	1,789	2,684	3,834	3,834
Fort Mohave Indian Reservation	Mohave County	0	0	0	0	0	0	0	0
Fort Yuma Indian Reservation (new entitlement)	Yuma County	0	0	0	0	0	0	0	0
Colorado River Indian Reservation	La Paz County	0	0	0	0	0	0	0	0
Total Non-CAP Arizona Tribal Consumptive Use Shortages		603	1,207	1,508	1,810	2,413	3,620	5,171	5,171

Table G-54
Arizona Tribal Consumptive Use Shortages

2060		Lower Colorado River Shortage Volumes in Annual Acre-Feet							
CAP Tribal Consumptive Use Shortages	County	200000	400000	500000	600000	800000	1200000	1800000	2500000
Tribal Consumptive Use Shortages by County	Number of Tribes in the County								
Gila County	3	0	0	0	6,970	13,765	27,354	44,828	44,828
La Paz County	2	447	895	1,118	1,342	1,789	2,684	3,834	3,834
Maricopa County	3	17,572	26,108	29,934	36,402	49,700	76,297	110,498	110,498
Mohave County	1	0	0	0	0	0	0	0	0
Pima County	3	32,784	38,035	38,035	38,895	45,615	59,054	76,335	76,335
Pinal County	2	41,002	61,395	70,643	81,767	106,022	154,531	218,179	228,556
Yavapai County (Reassignment to Scottsdale)*	1	0	0	0	11	99	274	500	500
Yuma County	2	156	312	390	468	624	936	1,337	1,337
---	1	40,859	47,403	47,403	47,403	47,403	47,403	47,403	47,403
Total Tribal Consumptive Use Shortages by County	18	132,822	174,147	187,523	213,259	265,017	368,533	502,914	513,291

Notes:
1 means Priority One in Arizona
2/3 means Priority Two/Three in Arizona
4 means Priority Four in Arizona
*Yavapai, 500AF was re-assigned to Scottsdale (1994 Act, PL 103-434)

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Attachment 8: Supporting Worksheets in the Shortage Allocation Model

Table G-55
Arizona and CAP Summary Schedules

						Adjusted by Reclamation					Provided by ADWR		
Year	Priority 1 - Priority 3 Mainstem Total with Ten Tribes Partnership Schedule	Priority 4 Mainstem Total	Priority 1 - Priority 4 Mainstem Total	Central Arizona Project Schedule before losses	Central Arizona Project Schedule after losses	CAP M&I & Indian Schedule (after losses)	CAP NIA Priority Schedule (after losses)	Excess Water (after losses)	CAP Bank & 5th		CAP M&I & Indian Schedule	CAP NIA Priority Schedule	Excess Water
2008	1,337,954	79,859	1,417,813	1,382,187	1,313,077	520,938	66,304	400,000	325,835		520,938	66,304	400,000
2009	1,350,703	81,161	1,431,864	1,368,136	1,299,729	568,355	67,304	400,000	264,070		568,355	67,304	400,000
2010	1,363,452	82,463	1,445,915	1,354,085	1,286,381	626,548	96,402	400,000	163,430		626,548	96,402	400,000
2011	1,373,770	82,800	1,456,570	1,343,430	1,276,259	673,296	97,402	400,000	105,560		673,296	97,402	400,000
2012	1,384,087	83,138	1,467,225	1,332,775	1,266,136	714,429	98,402	400,000	53,305		714,429	98,402	400,000
2013	1,394,405	83,475	1,477,880	1,322,120	1,256,014	750,424	99,402	400,000	6,188		750,424	99,402	400,000
2014	1,404,722	83,812	1,488,535	1,311,465	1,245,892	779,002	100,402	366,488	0		779,002	100,402	400,000
2015	1,415,040	84,150	1,499,190	1,300,810	1,235,770	808,019	103,702	324,049	0		808,019	103,702	400,000
2016	1,415,557	84,487	1,500,044	1,299,956	1,234,958	833,480	109,702	291,776	0		833,480	109,702	400,000
2017	1,416,075	84,825	1,500,899	1,299,101	1,234,146	845,753	115,702	272,691	0		845,753	115,702	300,000
2018	1,416,592	85,415	1,502,007	1,297,993	1,233,093	849,457	121,702	261,934	0		849,457	121,702	300,000
2019	1,417,110	86,005	1,503,115	1,296,885	1,232,041	853,161	127,702	251,178	0		853,161	127,702	300,000
2020	1,417,627	85,133	1,502,760	1,297,240	1,232,378	863,860	161,801	206,717	0		863,860	161,801	300,000
2021	1,418,119	85,619	1,503,738	1,296,262	1,231,449	873,758	167,801	189,889	0		873,758	167,801	300,000
2022	1,418,612	86,105	1,504,717	1,295,283	1,230,519	881,977	173,801	174,741	0		881,977	173,801	300,000
2023	1,419,104	86,591	1,505,695	1,294,305	1,229,590	890,201	179,801	159,588	0		890,201	179,801	300,000
2024	1,419,596	87,077	1,506,673	1,293,327	1,228,661	898,420	185,801	144,440	0		898,420	185,801	225,000
2025	1,420,088	87,562	1,507,651	1,292,349	1,227,732	906,596	215,921	105,215	0		906,596	215,921	225,000
2026	1,420,580	88,046	1,508,626	1,291,374	1,226,805	914,785	246,041	65,979	0		914,785	246,041	225,000
2027	1,421,073	88,529	1,509,601	1,290,399	1,225,879	922,969	271,041	31,869	0		922,969	271,041	225,000
2028	1,421,565	89,012	1,510,577	1,289,423	1,224,952	931,152	293,800	0	0		931,152	306,281	225,000
2029	1,422,057	89,495	1,511,552	1,288,448	1,224,026	938,423	285,602	0	0		938,423	331,401	225,000
2030	1,422,549	89,978	1,512,527	1,287,473	1,223,099	945,689	277,410	0	0		945,689	360,499	225,000
2031	1,423,145	90,450	1,513,596	1,286,404	1,222,084	952,932	269,152	0	0		952,932	361,499	0
2032	1,423,741	90,923	1,514,664	1,285,336	1,221,069	960,174	260,895	0	0		960,174	362,499	0
2033	1,424,338	91,395	1,515,733	1,284,267	1,220,054	967,417	252,637	0	0		967,417	363,499	0
2034	1,424,934	91,868	1,516,801	1,283,199	1,219,039	974,660	244,379	0	0		974,660	364,699	0
2035	1,425,530	92,340	1,517,870	1,282,130	1,218,024	981,902	236,122	0	0		981,902	364,699	0
2036	1,426,126	92,812	1,518,938	1,281,062	1,217,009	981,902	235,107	0	0		981,902	364,699	0
2037	1,426,722	93,285	1,520,007	1,279,993	1,215,994	981,902	234,092	0	0		981,902	364,699	0
2038	1,427,318	93,757	1,521,075	1,278,925	1,214,979	981,902	233,077	0	0		981,902	364,699	0
2039	1,427,914	94,229	1,522,144	1,277,856	1,213,964	981,902	232,062	0	0		981,902	364,699	0
2040	1,428,510	94,702	1,523,212	1,276,788	1,212,949	981,902	231,047	0	0		981,902	364,699	0
2041	1,428,510	95,241	1,523,751	1,276,249	1,212,436	981,902	230,534	0	0		981,902	364,699	0
2042	1,428,510	95,780	1,524,291	1,275,709	1,211,924	981,902	230,022	0	0		981,902	364,699	0
2043	1,428,510	96,320	1,524,830	1,275,170	1,211,412	981,902	229,510	0	0		981,902	364,699	0
2044	1,428,510	96,859	1,525,369	1,274,631	1,210,899	981,902	228,997	0	0		981,902	317,395	0

Table G-55
Arizona and CAP Summary Schedules

						Adjusted by Reclamation					Provided by ADWR		
Year	Priority 1 - Priority 3 Mainstem Total with Ten Tribes Partnership Schedule	Priority 4 Mainstem Total	Priority 1 - Priority 4 Mainstem Total	Central Arizona Project Schedule before losses	Central Arizona Project Schedule after losses	CAP M&I & Indian Schedule (after losses)	CAP NIA Priority Schedule (after losses)	Excess Water (after losses)	CAP Bank & 5th		CAP M&I & Indian Schedule	CAP NIA Priority Schedule	Excess Water
2045	1,428,510	97,398	1,525,909	1,274,091	1,210,387	981,902	228,485	0	0		981,902	317,395	0
2046	1,428,510	97,938	1,526,448	1,273,552	1,209,874	981,902	227,972	0	0		981,902	317,395	0
2047	1,428,510	98,477	1,526,987	1,273,013	1,209,362	981,902	227,460	0	0		981,902	317,395	0
2048	1,428,510	99,016	1,527,527	1,272,473	1,208,850	981,902	226,948	0	0		981,902	317,395	0
2049	1,428,510	99,556	1,528,066	1,271,934	1,208,337	981,902	226,435	0	0		981,902	317,395	0
2050	1,428,510	100,095	1,528,605	1,271,395	1,207,825	981,902	225,923	0	0		981,902	317,395	0
2051	1,428,510	100,344	1,528,854	1,271,146	1,207,588	981,902	225,686	0	0		981,902	317,395	0
2052	1,428,510	100,593	1,529,103	1,270,897	1,207,352	981,902	225,450	0	0		981,902	317,395	0
2053	1,428,510	100,842	1,529,352	1,270,648	1,207,116	981,902	225,214	0	0		981,902	317,395	0
2054	1,428,510	101,091	1,529,601	1,270,399	1,206,879	981,902	224,977	0	0		981,902	317,395	0
2055	1,428,510	101,340	1,529,850	1,270,150	1,206,643	981,902	224,741	0	0		981,902	317,395	0
2056	1,428,510	101,589	1,530,099	1,269,901	1,206,406	981,902	224,504	0	0		981,902	317,395	0
2057	1,428,510	101,837	1,530,348	1,269,652	1,206,170	981,902	224,268	0	0		981,902	317,395	0
2058	1,428,510	102,086	1,530,597	1,269,403	1,205,933	981,902	224,031	0	0		981,902	317,395	0
2059	1,428,510	102,335	1,530,845	1,269,155	1,205,697	981,902	223,795	0	0		981,902	317,395	0
2060	1,428,510	102,584	1,531,094	1,268,906	1,205,460	981,902	223,558	0	0		981,902	317,395	0

Table G-56A
CAP M&I Projected Use Schedules

Users	M&I Subcontract	M&I Subcontract Reallocation	M&I Subcontract Other	Total Entitlement	Hohokam Pre-GRIC	Hohokam Post-GRIC	Indian Lease / Assignment	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Apache Junction - Arizona Water Company	6,000			6,000				6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Arizona-American Water Company - Agua Fria	11,093			11,093				10,900	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093
Arizona-American Water Company - Paradise Valley	3,231			3,231				3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231
Arizona-American Water Company - Sun City	4,189			4,189				4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189
Arizona-American Water Company - Sun City West	2,372			2,372				2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372
Arizona State Land Department	20,076			20,076				700	700	700	700	700	700	700	700	700	700	700	700	1,911	3,122	4,333	5,544
ASARCO - Hayden/Ray Mine	21,000			21,000				0	0	0	0	0	0	0	0	0	0	0	0	1,313	2,625	3,938	5,250
Avondale, City of	5,416			5,416				4,746	4,746	4,746	4,746	4,746	4,746	4,746	4,746	4,746	4,746	4,746	4,746	4,788	4,830	4,872	4,914
Avra Water Corporation		808		808				0	0	0	0	0	0	0	0	0	0	0	0	51	101	152	202
Berneil Water Company	200			200				0	0	0	0	0	0	0	0	0	0	0	0	13	25	38	50
Buckeye, Town of	25			25				0	0	0	0	0	0	0	0	0	0	0	0	2	3	5	6
Carefree, Town of	1,300			1,300				400	400	400	400	400	400	400	400	400	400	400	400	456	513	569	625

Table G-56A
CAP M&I Projected Use Schedules

Users	M&I Subcontract	M&I Subcontract Reallocation	M&I Subcontract Other	Total Entitlement	Hohokam Pre-GRIC	Hohokam Post-GRIC	Indian Lease / Assignment	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Casa Grande - Arizona Water Company	8,884			8,884				2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,430	2,861	3,291	3,721
Cave Creek Water Company	1,600	806		2,406				1,598	1,648	1,698	1,748	1,798	1,848	1,898	1,948	1,998	2,048	2,098	2,148	2,198	2,248	2,298	2,348
Central Arizona Groundwater Replenishment District	7,746			7,746				7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746
Chandler, City of	3,668	4,986		8,654				5,305	6,592	7,880	8,289	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654
Chandler Heights Citrus Irrigation District	315			315				0	0	0	0	0	0	0	0	0	0	0	0	20	39	59	79
Chaparral City Water Company	6,978	1,931		8,909				4,761	4,838	4,915	5,018	5,120	5,223	5,325	5,428	5,566	5,705	5,844	5,982	6,121	6,306	6,492	6,677
Circle City Water Company	3,932			3,932				0	0	0	0	0	0	0	0	0	0	0	0	246	492	737	983
Coolidge - Arizona Water Company	2,000			2,000				0	0	0	0	0	0	0	0	0	0	0	0	125	250	375	500
Community Water Company of Green Valley	1,337	1,521		2,858				0	0	0	0	0	0	0	0	0	0	0	0	179	357	536	715
El Mirage, City of		508		508				0	0	0	0	0	0	0	0	0	0	0	0	32	64	95	127
Eloy, City of	2,171			2,171				2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171
Florence, Town of	2,048			2,048				2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048
Flowing Wells Irrigation District	4,354			4,354				0	0	0	0	0	0	0	0	0	0	0	0	272	544	816	1,089
Gilbert, Town of	7,235			7,235				7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235
Glendale, City of	14,183	3,053		17,236				14,183	14,183	14,183	14,183	14,183	14,183	14,183	14,183	14,183	14,183	14,183	14,183	14,374	14,565	14,755	14,946
Goodyear, City of	3,531	7,211		10,742				10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742
Green Valley Water Company	1,900			1,900				500	500	500	500	500	500	500	500	500	500	500	500	588	675	763	850
H20 Water Company, Inc.		147		147				0	0	0	0	0	0	0	0	0	0	0	0	9	18	28	37
Marana, Town of	47			47				0	0	0	0	0	0	0	0	0	0	0	0	3	6	9	12
Maricopa County Parks	665			665				630	630	630	635	635	635	640	640	640	645	645	645	650	650	650	655
Mesa, City of	36,388	7,115		43,503				20,872	21,794	22,716	23,761	24,807	25,853	26,898	27,944	28,987	30,029	31,072	32,115	33,787	34,433	35,080	35,726
Metropolitan Domestic Water Improvement District	8,858	4,602		13,460				10,101	10,152	10,204	10,263	10,321	10,379	10,438	10,496	10,555	10,613	10,671	10,730	10,901	11,071	11,242	11,412
Oro Valley, Town of	6,748	3,557		10,305				0	0	9,541	9,668	9,795	9,922	10,049	10,176	10,303	10,305	10,305	10,305	10,305	10,305	10,305	10,305
Peoria, City of	19,709	5,527		25,236				7,401	7,992	8,583	10,081	11,580	13,078	14,577	16,075	17,571	19,067	20,564	22,060	23,556	25,236	25,236	25,236
Phelps-Dodge Miami	2,906			2,906				0	0	0	0	0	0	0	0	0	0	0	0	182	363	545	727
Phoenix, City of	113,914	8,206	12,000	134,120				117,715	121,416	125,129	131,441	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120
Phoenix Memorial Park	84			84				0	0	0	0	0	0	0	0	0	0	0	0	5	11	16	21
Pine Water Company	161			161				0	0	0	0	0	0	0	0	0	0	0	0	10	20	30	40
Queen Creek Water Company	348			348				348	348	348	348	348	348	348	348	348	348	348	348	348	348	348	348
Rio Verde Utilities, Inc.	812			812				812	812	812	812	812	812	812	812	812	812	812	812	812	812	812	812
San Carlos Apache M & I	18,145			18,145				0	0	0	0	0	0	0	0	0	0	0	0	1,134	2,268	3,402	4,536
San Tan Irrigation District	236			236				0	0	0	0	0	0	0	0	0	0	0	0	15	30	44	59
Scottsdale, City of	49,829	2,981		52,810				46,460	47,724	48,989	50,353	51,718	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810
Spanish Trail Water Company	3,037			3,037				0	0	0	0	0	0	0	0	0	0	0	0	190	380	569	759
Superior - Arizona Water Company		285		285				0	0	0	0	0	0	0	0	0	0	0	0	18	36	53	71
Surprise, City of	7,373	2,876		10,249				4,606	5,061	5,516	6,049	6,582	7,115	7,648	8,181	9,908	10,249	10,249	10,249	10,249	10,249	10,249	10,249
Tempe, City of	4,315			4,315				4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315
Tonto Hills Utility Company	71			71				0	0	0	0	0	0	0	0	0	0	0	0	4	9	13	18
Tucson, City of	135,966	8,206		144,172				83,750	90,000	96,250	102,500	109,100	116,096	123,512	131,372	134,450	142,672	142,672	142,672	142,766	142,860	142,953	143,047
Vail Water Company	786	1,071		1,857				0	0	0	0	0	0	0	0	0	0	0	0	116	232	348	464

Table G-56A
CAP M&I Projected Use Schedules

Users	M&I Subcontract	M&I Subcontract Reallocation	M&I Subcontract Other	Total Entitlement	Hohokam Pre-GRIC	Hohokam Post-GRIC	Indian Lease / Assignment	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Valley Utility Water Company, Inc.		250		250				0	0	0	0	0	0	0	0	0	0	0	0	16	31	47	63
Water Utilities Community Facilities District	2,919			2,919				50	50	50	50	50	50	50	50	50	50	50	50	229	409	588	767
Water Utility of Greater Buckeye, Inc.	43			43				0	0	0	0	0	0	0	0	0	0	0	0	3	5	8	11
Water Utility of Greater Tonopah, Inc.	64			64				0	0	0	0	0	0	0	0	0	0	0	0	4	8	12	16
White Tanks - Arizona Water Company	968			968				968	968	968	968	968	968	968	968	968	968	968	968	968	968	968	968
CAP M&I TOTAL								388,855	403,697	427,899	445,655	460,078	471,581	482,417	493,693	501,412	512,767	515,553	518,339	528,121	537,102	544,403	551,709

Table G-56B
CAP M&I Projected Use Schedules

Users	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Apache Junction - Arizona Water Company	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Arizona-American Water Company - Agua Fria	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093	11,093
Arizona-American Water Company - Paradise Valley	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231	3,231
Arizona-American Water Company - Sun City	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189	4,189
Arizona-American Water Company - Sun City West	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372	2,372
Arizona State Land Department	6,755	7,966	9,177	10,388	11,599	12,810	14,021	15,232	16,443	17,654	18,865	20,076
ASARCO - Hayden/Ray Mine	6,563	7,875	9,188	10,500	11,813	13,125	14,438	15,750	17,063	18,375	19,688	21,000
Avondale, City of	4,955	4,997	5,039	5,081	5,123	5,165	5,207	5,249	5,290	5,332	5,374	5,416
Avra Water Corporation	253	303	354	404	455	505	556	606	657	707	758	808
Berneil Water Company	63	75	88	100	113	125	138	150	163	175	188	200
Buckeye, Town of	8	9	11	13	14	16	17	19	20	22	23	25
Carefree, Town of	681	738	794	850	906	963	1,019	1,075	1,131	1,188	1,244	1,300
Casa Grande - Arizona Water Company	4,151	4,582	5,012	5,442	5,872	6,303	6,733	7,163	7,593	8,024	8,454	8,884
Cave Creek Water Company	2,398	2,406	2,406	2,406	2,406	2,406	2,406	2,406	2,406	2,406	2,406	2,406
Central Arizona Groundwater Replenishment District	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746	7,746
Chandler, City of	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654	8,654
Chandler Heights Citrus Irrigation District	98	118	138	158	177	197	217	236	256	276	295	315

Table G-56B
CAP M&I Projected Use Schedules

Users	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Chaparral City Water Company	6,863	7,048	7,235	7,421	7,606	7,793	7,979	8,166	8,351	8,537	8,724	8,909
Circle City Water Company	1,229	1,475	1,720	1,966	2,212	2,458	2,703	2,949	3,195	3,441	3,686	3,932
Coolidge - Arizona Water Company	625	750	875	1,000	1,125	1,250	1,375	1,500	1,625	1,750	1,875	2,000
Community Water Company of Green Valley	893	1,072	1,250	1,429	1,608	1,786	1,965	2,144	2,322	2,501	2,679	2,858
El Mirage, City of	159	191	222	254	286	318	349	381	413	445	476	508
Eloy, City of	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171	2,171
Florence, Town of	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048	2,048
Flowing Wells Irrigation District	1,361	1,633	1,905	2,177	2,449	2,721	2,993	3,266	3,538	3,810	4,082	4,354
Gilbert, Town of	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235	7,235
Glendale, City of	15,137	15,328	15,519	15,710	15,900	16,091	16,282	16,473	16,664	16,854	17,045	17,236
Goodyear, City of	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742	10,742
Green Valley Water Company	938	1,025	1,113	1,200	1,288	1,375	1,463	1,550	1,638	1,725	1,813	1,900
H20 Water Company, Inc.	46	55	64	74	83	92	101	110	119	129	138	147
Marana, Town of	15	18	21	24	26	29	32	35	38	41	44	47
Maricopa County Parks	655	655	660	660	660	665	665	665	665	665	665	665
Mesa, City of	36,372	37,018	37,678	38,338	38,999	39,659	40,319	40,956	41,593	42,230	42,866	43,503
Metropolitan Domestic Water Improvement District	11,583	11,754	11,924	12,095	12,265	12,436	12,607	12,777	12,948	13,118	13,289	13,460
Oro Valley, Town of	10,305	10,305	10,305	10,305	10,305	10,305	10,305	10,305	10,305	10,305	10,305	10,305
Peoria, City	25,236	25,236	25,236	25,236	25,236	25,236	25,236	25,236	25,236	25,236	25,236	25,236
Phelps-Dodge Miami	908	1,090	1,271	1,453	1,635	1,816	1,998	2,180	2,361	2,543	2,724	2,906
Phoenix, City of	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120	134,120
Phoenix Memorial Park	26	32	37	42	47	53	58	63	68	74	79	84
Pine Water Company	50	60	70	81	91	101	111	121	131	141	151	161
Queen Creek Water Company	348	348	348	348	348	348	348	348	348	348	348	348
Rio Verde Utilities, Inc.	812	812	812	812	812	812	812	812	812	812	812	812
San Carlos Apache M & I	5,670	6,804	7,938	9,073	10,207	11,341	12,475	13,609	14,743	15,877	17,011	18,145
San Tan Irrigation District	74	89	103	118	133	148	162	177	192	207	221	236
Scottsdale, City of	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810	52,810
Spanish Trail Water Company	949	1,139	1,329	1,519	1,708	1,898	2,088	2,278	2,468	2,657	2,847	3,037
Superior - Arizona Water Company	89	107	125	143	160	178	196	214	232	249	267	285
Surprise, City of	10,249	10,249	10,249	10,249	10,249	10,249	10,249	10,249	10,249	10,249	10,249	10,249
Tempe, City of	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315	4,315
Tonto Hills Utility Company	22	27	31	36	40	44	49	53	58	62	67	71
Tucson, City of	143,141	143,235	143,328	143,422	143,516	143,610	143,703	143,797	143,891	143,985	144,078	144,172
Vail Water Company	580	696	812	929	1,045	1,161	1,277	1,393	1,509	1,625	1,741	1,857
Valley Utility Water Company, Inc.	78	94	109	125	141	156	172	188	203	219	234	250
Water Utilities Community Facilities District	947	1,126	1,305	1,485	1,664	1,843	2,022	2,202	2,381	2,560	2,740	2,919
Water Utility of Greater Buckeye, Inc.	13	16	19	22	24	27	30	32	35	38	40	43
Water Utility of Greater Tonopah, Inc.	20	24	28	32	36	40	44	48	52	56	60	64
White Tanks - Arizona Water Company	968	968	968	968	968	968	968	968	968	968	968	968
CAP M&I TOTAL	559,011	566,270	573,541	580,808	588,073	595,344	602,610	609,853	617,095	624,338	631,581	638,823

Table G-56B
CAP M&I Projected Use Schedules

Users	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035

Table G-57
CAP Tribal (On Reservation) Projected Use Schedules

Year	Camp Verde	Tonto Apache	Fort McDowell	San Carlos Apache	Salt River Pima-Maricopa	Gila River	Ak-Chin	Chui-Chu	Shuk Toak (1)	Pasua-Yaqui	San Xavier (2)	Yavapai-Prescott	Future Indian Settlements	Total Indian On-Reservation Use
2008		128		9,750	13,300	56,605	27,500	2,000	10,800	500	11,000	500		132,083
2009	1,200	128	800	16,500	13,300	73,430	27,500	4,000	10,800	500	16,000	500		164,658
2010	1,200	128	1,718	23,250	13,300	90,254	27,500	6,000	10,800	500	23,500	500		198,649
2011	1,200	128	2,635	30,000	13,300	107,078	27,500	8,000	10,800	500	26,000	500		227,641
2012	1,200	128	3,553	36,750	13,300	123,903	27,500	8,000	10,800	500	27,000	500	1,218	254,351
2013	1,200	128	4,470	43,500	13,300	140,727	27,500	8,000	10,800	500	27,000	500	1,218	278,843
2014	1,200	128	5,388	43,500	13,300	157,551	27,500	8,000	10,800	500	27,000	500	1,218	296,585
2015	1,200	128	6,305	43,500	13,300	174,376	27,500	8,000	10,800	500	27,000	500	1,218	314,327
2016	1,200	128	7,223	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	332,069
2017	1,200	128	8,140	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	332,986
2018	1,200	128	9,058	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	333,904
2019	1,200	128	9,975	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	334,821
2020	1,200	128	10,893	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	335,739
2021	1,200	128	11,810	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	336,656
2022	1,200	128	12,728	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	337,574
2023	1,200	128	13,645	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	338,491
2024	1,200	128	14,563	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	339,409
2025	1,200	128	15,480	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	340,326
2026	1,200	128	16,398	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	341,244
2027	1,200	128	17,315	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	342,161
2028	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2029	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2030	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2031	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2032	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2033	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2034	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2035	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2036	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2037	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2038	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2039	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2040	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2041	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2042	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2043	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2044	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2045	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2046	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2047	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2048	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2049	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2050	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2051	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2052	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2053	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2054	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2055	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079

Table G-56B
CAP M&I Projected Use Schedules

Users		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
2056	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2057	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2058	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2059	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079
2060	1,200	128	18,233	43,500	13,300	191,200	27,500	8,000	10,800	500	27,000	500	1,218	343,079

Table G-58
CAP NIA Priority Projected Use Schedules

Year	ASLD	Chandler	Glendale	Scottsdale	Tempe	Mesa	Phoenix	Gilbert	GRIC	San Xavier	Schuk Toak	Federal	Re-Allocation	Total
2008	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	1,631	369		2,974	66,304
2009	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	2,447	553		2,974	67,304
2010	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	3,262	738		31,072	96,402
2011	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	4,078	922		31,072	97,402
2012	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	4,894	1,106		31,072	98,402
2013	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	5,709	1,291		31,072	99,402
2014	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	6,525	1,475		31,072	100,402
2015	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	7,340	1,660	2,300	31,072	103,702
2016	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	8,156	1,844	7,300	31,072	109,702
2017	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	8,972	2,028	12,300	31,072	115,702
2018	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	9,787	2,213	17,300	31,072	121,702
2019	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	10,603	2,397	22,300	31,072	127,702
2020	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	11,418	2,582	27,300	59,171	161,801
2021	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	12,234	2,766	32,300	59,171	167,801
2022	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	13,050	2,950	37,300	59,171	173,801
2023	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	13,865	3,135	42,300	59,171	179,801
2024	9,026	3,924	682	3,306	23	5,552	37,280	1,537	0	14,681	3,319	47,300	59,171	185,801
2025	9,026	3,924	682	3,306	23	5,552	37,280	1,537	24,120	15,496	3,504	52,300	59,171	215,921
2026	9,026	3,924	682	3,306	23	5,552	37,280	1,537	48,240	16,312	3,688	57,300	59,171	246,041
2027	9,026	3,924	682	3,306	23	5,552	37,280	1,537	67,240	17,128	3,872	62,300	59,171	271,041
2028	8,658	3,764	654	3,171	22	5,326	35,761	1,474	92,549	17,212	3,891	64,558	56,760	293,800
2029	7,779	3,382	588	2,849	20	4,785	32,128	1,325	83,147	16,166	3,655	57,999	50,994	264,816
2030	6,946	3,020	525	2,544	18	4,272	28,688	1,183	74,243	15,063	3,406	51,788	67,155	258,849
2031	6,720	2,922	508	2,461	17	4,134	27,757	1,144	71,834	15,181	3,432	50,108	64,976	251,193
2032	6,496	2,824	491	2,379	17	3,996	26,831	1,106	69,438	15,262	3,451	48,437	62,809	243,535
2033	6,273	2,727	474	2,298	16	3,859	25,910	1,068	67,055	15,305	3,460	46,774	60,653	235,873
2034	6,048	2,629	457	2,215	15	3,720	24,981	1,030	64,650	15,303	3,460	45,097	58,478	228,082
2035	5,844	2,541	442	2,140	15	3,595	24,137	995	62,465	15,314	3,462	43,573	56,502	221,024
2036	5,819	2,530	440	2,131	15	3,579	24,033	991	62,197	15,774	3,566	43,386	56,259	220,718
2037	5,794	2,519	438	2,122	15	3,564	23,929	987	61,928	16,229	3,669	43,198	56,016	220,407
2038	5,768	2,508	436	2,113	15	3,548	23,825	982	61,660	16,680	3,771	43,011	55,773	220,090
2039	5,743	2,497	434	2,104	15	3,533	23,722	978	61,391	17,126	3,872	42,824	55,530	219,768
2040	5,718	2,486	432	2,094	15	3,517	23,618	974	61,123	17,568	3,972	42,636	55,287	219,440
2041	5,706	2,480	431	2,090	15	3,510	23,566	972	60,987	18,045	4,080	42,542	55,165	219,586
2042	5,693	2,475	430	2,085	15	3,502	23,513	969	60,852	18,519	4,187	42,447	55,042	219,729
2043	5,680	2,469	429	2,081	14	3,494	23,461	967	60,716	18,991	4,294	42,353	54,919	219,868
2044	6,512	2,831	492	2,385	17	4,006	26,897	1,109	69,609	22,361	5,056	48,556	62,964	252,795
2045	6,498	2,825	491	2,380	17	3,997	26,837	1,106	69,454	22,898	5,177	48,448	62,823	252,949
2046	6,483	2,818	490	2,375	17	3,988	26,777	1,104	69,298	23,433	5,298	48,339	62,682	253,100

Table G-58
CAP NIA Priority Projected Use Schedules

Year	ASLD	Chandler	Glendale	Scottsdale	Tempe	Mesa	Phoenix	Gilbert	GRIC	San Xavier	Schuk Toak	Federal	Re-Allocation	Total
2047	6,468	2,812	489	2,369	16	3,979	26,717	1,101	69,142	23,964	5,418	48,230	62,541	253,248
2048	6,454	2,806	488	2,364	16	3,970	26,656	1,099	68,986	24,494	5,538	48,122	62,400	253,392
2049	6,439	2,799	487	2,359	16	3,961	26,596	1,097	68,831	25,020	5,657	48,013	62,259	253,534
2050	6,425	2,793	485	2,353	16	3,952	26,536	1,094	68,675	25,544	5,775	47,904	62,118	253,672
2051	6,418	2,790	485	2,351	16	3,948	26,508	1,093	68,603	26,097	5,900	47,854	62,053	254,117
2052	6,411	2,787	484	2,348	16	3,944	26,480	1,092	68,531	26,649	6,025	47,804	61,988	254,562
2053	6,405	2,784	484	2,346	16	3,940	26,453	1,091	68,459	27,200	6,150	47,754	61,923	255,004
2054	6,398	2,781	483	2,343	16	3,935	26,425	1,089	68,387	27,750	6,274	47,704	61,858	255,445
2055	6,391	2,779	483	2,341	16	3,931	26,397	1,088	68,315	28,298	6,398	47,654	61,793	255,885
2056	6,384	2,776	482	2,338	16	3,927	26,369	1,087	68,244	28,845	6,522	47,604	61,728	256,323
2057	6,378	2,773	482	2,336	16	3,923	26,342	1,086	68,172	29,391	6,645	47,553	61,663	256,760
2058	6,371	2,770	481	2,334	16	3,919	26,314	1,085	68,100	29,936	6,768	47,503	61,598	257,195
2059	6,364	2,767	481	2,331	16	3,915	26,286	1,084	68,028	30,479	6,891	47,453	61,533	257,628
2060	6,357	2,764	480	2,329	16	3,911	26,258	1,083	67,956	31,022	7,014	47,403	61,468	258,060

Table G-59
Exhibit B of the QSA

In Thousands of Acre-feet																						
		IID Priority 3a											CVWD Priority 3a									
			Reductions											Reductions			Additions					
Calendar Year	2 Priority 1, 2 and 3b	IID Priority 3a Quantified Amount	3 IID Reduction: MWD 1988 Agreement Transfer	IID Reduction: SDCWA Transfer	4 IID Reduction: AAC Lining IID, SDCWA & SLR	5,6IID Reduction: SDCWA Mitigation Transfer	7Intra-Priority 3 Transfer IID/CVWD	6 IID Reduction: MWD Transfer with Salton Sea Restoration	8IID Reduction: Conditional ISG Backfill	9IID Reduction: Misc. PPRs	IID Reductions: Total Amount (sum of columns 4 through 11)	10 IID Net Consumptive Use Amount (difference between column 3 and column 12)	CVWD Priority 3a Quantified Amount	4 CVWD Reduction: CC Lining, SDCWA & SLR	9 CVWD Reduction: Misc. PPRs	11 CVWD Reductions: Total Amount (sum of columns 15 + 16)	7 Intra-Priority 3 Transfer IID / CVWD	3 Intra-Priority 3 Transfer MWD / CVWD	CVWD Net Consumptive Use Amount (columns 14 - 17 plus columns 18 + 19)	Total Priority 1-3 Use Plus PPR Consumptive Use (sum of columns 2+13+20 plus 11+16)	12 ISG Bench-marks	12 Annual Targets
2003	420	3,100	110	10	0	5	0	0	0	11.5	136.5	2,963.5	330	0	3	3	0	20	347	3,745.0	3,740	3,740
2004	420	3,100	110	20	0	10	0	0	0	11.5	151.5	2,948.5	330	0	3	3	0	20	347	3,730.0		3,707
2005	420	3,100	110	30	0	15	0	0	0	11.5	166.5	2,933.5	330	0	3	3	0	20	347	3,715.0		3,674
2006	420	3,100	110	40	0	20	0	0	9	11.5	190.5	2,909.5	330	26	3	29	0	20	321	3,665.0	3,640	3,640
2007	420	3,100	110	50	0	25	0	0	0	11.5	196.5	2,903.5	330	26	3	29	0	20	321	3,659.0		3,603
2008	420	3,100	110	50	67.7	25	4	20	0	11.5	288.2	2,811.8	330	26	3	29	4	20	325	3,571.3		3,566
2009	420	3,100	110	60	67.7	30	8	40	0	11.5	327.2	2,772.8	330	26	3	29	8	20	329	3,536.3	3,530	3,530
2010	420	3,100	110	70	67.7	35	12	60	0	11.5	366.2	2,733.8	330	26	3	29	12	20	333	3,501.3		3,510
2011	420	3,100	110	80	67.7	40	16	80	0	11.5	405.2	2,694.8	330	26	3	29	16	20	337	3,466.3		3,490
2012	420	3,100	110	90	67.7	45	21	100	0	11.5	445.2	2,654.8	330	26	3	29	21	20	342	3,431.3	3,470	3,470
2013	420	3,100	110	100	67.7	70	26	100	0	11.5	485.2	2,614.8	330	26	3	29	26	20	347	3,396.3		3,462
2014	420	3,100	110	100	67.7	90	31	100	0	11.5	510.2	2,589.8	330	26	3	29	31	20	352	3,376.3		3,455
2015	420	3,100	110	100	67.7	110	36	100	0	11.5	535.2	2,564.8	330	26	3	29	36	20	357	3,356.3		3,448
2016	420	3,100	110	100	67.7	130	41	100	0	11.5	560.2	2,539.8	330	26	3	29	41	20	362	3,336.3		3,440
2017	420	3,100	110	100	67.7	150	45	91	0	11.5	575.2	2,524.8	330	26	3	29	45	20	366	3,325.3		

Table G-59
Exhibit B of the QSA

In Thousands of Acre-feet

Calendar Year	2 Priority 1, 2 and 3b	IID Priority 3a											CVWD Priority 3a							Total Priority 1-3 Use Plus PPR Consumptive Use (sum of columns 2+13+20 plus 11+16)	12 ISG Bench-marks	12 Annual Targets
			Reductions											Reductions			Additions					
		IID Priority 3a Quantified Amount	3 IID Reduction: MWD 1988 Agreement Transfer	IID Reduction: SDCWA Transfer	4 IID Reduction: AAC Lining IID, SDCWA & SLR	5,6IID Reduction: SDCWA Mitigation Transfer	7Intra-Priority 3 Transfer IID/CVWD	6 IID Reduction: MWD Transfer with Salton Sea Restoration	8IID Reduction: Conditional ISG Backfill	9IID Reduction: Misc. PPRs	IID Reductions: Total Amount (sum of columns 4 through 11)	10 IID Net Consumptive Use Amount (difference between column 3 and column 12)	CVWD Priority 3a Quantified Amount	4 CVWD Reduction: CC Lining, SDCWA & SLR	9 CVWD Reduction: Misc. PPRs	11 CVWD Reductions: Total Amount (sum of columns 15 + 16)	7 Intra-Priority 3 Transfer IID / CVWD	3 Intra-Priority 3 Transfer MWD / CVWD	CVWD Net Consumptive Use Amount (columns 14 - 17 plus columns 18 + 19)			
2018	420	3,100	110	130	67.7	0	63	0	0	11.5	382.2	2,717.8	330	26	3	29	63	20	384	3,536.3		
2019	420	3,100	110	160	67.7	0	68	0	0	11.5	417.2	2,682.8	330	26	3	29	68	20	389	3,506.3		
2020	420	3,100	110	193	67.7	0	73	0	0	11.5	454.7	2,645.3	330	26	3	29	73	20	394	3,473.8		
2021	420	3,100	110	205	67.7	0	78	0	0	11.5	472.2	2,627.8	330	26	3	29	78	20	399	3,461.3		
2022	420	3,100	110	203	67.7	0	83	0	0	11.5	474.7	2,625.3	330	26	3	29	83	20	404	3,463.8		
2023	420	3,100	110	200	67.7	0	88	0	0	11.5	477.2	2,622.8	330	26	3	29	88	20	409	3,466.3		
2024	420	3,100	110	200	67.7	0	93	0	0	11.5	482.2	2,617.8	330	26	3	29	93	20	414	3,466.3		
2025	420	3,100	110	200	67.7	0	98	0	0	11.5	487.2	2,612.8	330	26	3	29	98	20	419	3,466.3		
2026	420	3,100	110	200	67.7	0	103	0	0	11.5	492.2	2,607.8	330	26	3	29	103	20	424	3,466.3		
2027	420	3,100	110	200	67.7	0	103	0	0	11.5	492.2	2,607.8	330	26	3	29	103	20	424	3,466.3		
2028	420	3,100	110	200	67.7	0	103	0	0	11.5	492.2	2,607.8	330	26	3	29	103	20	424	3,466.3		
2029-2037	420	3,100	110	200	67.7	0	103	0	0	11.5	492.2	2,607.8	330	26	3	29	103	20	424	3,466.3		
2038-2047	420	3,100	110	200	67.7	0	103	0	0	11.5	492.2	2,607.8	330	26	3	29	103	20	424	3,466.3		
2048-2077	420	3,100	110	200	67.7	0	100	0	0	11.5	489.2	2,610.8	330	26	3	29	100	20	421	3,466.3		

1Exhibit B is independent of increases and reductions as allowed under the Inadvertent Overrun and Payback Policy.

2Any higher use covered by MWD, any lesser use will produce water for MWD and help satisfy ISG Benchmarks and Annual Targets.

3IID/MWD 1988 Conservation Program conserves up to 110,000 AFY and the amount is based upon periodic verification. Of amount conserved, up to 20,000 AFY to CVWD (column 19), which does not count toward ISG Benchmarks and Annual Targets, and remainder to MWD.

4Ramp-up amounts may vary based upon construction progress, and final amounts will be determined by the Secretary pursuant to the Allocation Agreement.

5Any amount identified in Exhibit B for mitigation purposes will only be from non-Colorado River sources and these amounts may be provided by exchange for Colorado River water.

6Water would be transferred to MWD subject to satisfaction of certain conditions and to appropriate Federal approvals. These transfers may also be subject to state approvals. Schedules are subject to adjustments with mutual consent. After 2006, these quantities will count toward the ISG Benchmarks (column 22) and Annual Targets (column 23) only if and to the extent that water is transferred into the Colorado River Aqueduct for use by MWD and/or SDCWA.

7MWD can acquire if CVWD declines the water. Any water obtained by MWD will be counted as additional agricultural reduction to help satisfy the ISG Benchmarks and Annual Targets. MWD will provide CVWD 50,000 AFY of the 100,000 AFY starting in year 46.

8IID has agreed to provide transfer amounts to meet the minimum ISG benchmarks, not to exceed a cumulative total of 145,000 AF. Maximum transfer amounts are 25,000 AF in 2006, 50,000 AF plus the unused amount from 2006 in 2009, and 70,000 AF plus the unused amounts from 2006 and 2009 in 2012. In addition to the maximum transfer amounts IID has also committed that no more than 72,500 AF of reduced inflow to the Salton Sea would result from these additional transfers.

9Up to the amount shown, as agreed upon reduction to IID or CVWD to cover collectively the sum of individual Miscellaneous PPRs, Federal reserved rights and Decreed rights. This is a reduction that counts towards ISG Benchmarks and Annual Targets.

10For purposes of Subparagraph 8(b)(2)(i) and (ii) and 8(c)(1) and (4) the Secretary will take into account: (i) the satisfaction of necessary conditions to certain transfers (columns 7 and 9) not within IID's control: (ii) the amounts of conserved water as determined, where such amounts may vary (columns 4, 6, 9 and 10); and (iii) with respect to column 7, reductions by IID will be considered in determining IID's compliance regardless of whether the conserved water is diverted into the Colorado River Aqueduct.

11For purposes of Subparagraph 8(c)(1) and (4) the Secretary will take into account: (i) the satisfaction of necessary conditions to certain transfers (columns 15 and 16) not within CVWD's control; and (ii) the amounts of conserved water as determined, where such amounts may vary (column 15).

12All consumptive use of priorities 1 through 3 plus 14,500 AF of PPRs must be within 25,000 AF of the amount stated.

13Assumes SDCWA does not elect termination in year 35.

14Assumes SDCWA and IID mutually consent to renewal term of 30 years.

Notes:

Substitute transfers can be made provided the total volume of water to be transferred remains equal or greater than amounts shown consistent with applicable Federal approvals.

The shaded columns represent amounts of water that may vary.

Table G-60
Present Perfected Right Holders

	Priority Date	PPR Number	State	Diversion Entitlement	CU Entitlement
Lake Mead National Recreation Area	5/3/1929	82	NV	500	
Molina	1928	15	AZ	318	
Sonny Gowan (Grannis)	1928	32	CA	180	
Diehl*	1928	59	CA	1	0.6
Stallard*	1928	66	CA	1	0.6
Estrada*	1928	77	CA	1	0.6
Corrington*	1928	79	CA	1	0.6
Tolliver*	1928	80	CA	1	0.6
Randolph*	1926	65	CA	1	0.6
Keefe*	1926	67	CA	1	0.6
Gila Monster Farms (formerly Sturges)	1925	16	AZ	780	
Chagnon	1925	41	CA	120	
Faubion*	1925	48	CA	1	0.6
Earle*	1925	58	CA	1	0.6
Whittle*	1925	78	CA	1	0.6
Beauchamp*	1924	51	CA	1	0.6
McGee*	1924	63	CA	1	0.6
Stallard*	1924	64	CA	1	0.6
Hadlock*	1924	72	CA	1	0.6
Stephenson	1923	30	CA	240	
Draper, G.*	1923	46	CA	1	0.6
Dudley*	1922	49	CA	1	0.6
Colorado River Sportsmen's League	1921	36	CA	96	
Andrade	1921	38	CA	66	
Conger*	1921	45	CA	1	0.6
Vaulin*	1920	70	CA	1	0.6
Salisbury*	1920	71	CA	1	0.6
McDonough*	1919	47	CA	1	0.6
Cate*	1919	62	CA	1	0.6
Milpitas	1918	34	CA	108	
Cocopah Indian Reservation	9/27/1917	1	AZ	7,681	
Schneider*	1917	56	CA	1	0.6
Douglas*	1916	50	CA	1	0.6
Clark*	1916	52	CA	1	0.6
Graham*	1916	61	CA	1	0.6
Cocopah Indian Reservation	1915	8	AZ	1,140	
Powers (Power, R.E. & P.)	1915	7	AZ	960	
Lawrence	1915	42	CA	120	
Lawrence*	1915	53	CA	1	0.6
Milpitas	1914	37	CA	69	
Graham, J.*	1914	54	CA	1	0.6
Morgan	1913	33	CA	150	
Zozaya	1912	17	AZ	720	
Reid*	1912	60	CA	1	0.6
Fitz*	1912	75	CA	1	0.6
Fort Mohave Indian Reservation	2/2/1911	3	AZ	75,566	
Brooke Water Company (formerly Graham)	1910	9	AZ	360	
Geiger*	1910	55	CA	1	0.6
Williams*	1909	76	CA	1	0.6
Chemehuevi Indian Reservation	2/2/1907	22	CA	11,340	
North Gila Valley Unit	7/8/1905	6	AZ	24,500	

Table G-60
Present Perfected Right Holders

	Priority Date	PPR Number	State	Diversion Entitlement	CU Entitlement
Yuma Axiliary Project (Unit B)	7/8/1905	5	AZ	6,800	
City of Parker	1905	20	AZ	630	400
Cooper	1905	40	CA	60	
Reservation Division/Yuma Project (non-Indian portion)	1905	28	CA	38,270	
Reynolds	1904	39	CA	36	
Ferguson, C.*	1903	68	CA	1	0.6
Ferguson, W.*	1903	69	CA	1	0.6
Streeter*	1903	73	CA	1	0.6
Draper, J.*	1903	74	CA	1	0.6
Hulet	1902	10	AZ	1,080	
Holpal (formerly Hurschler)	1902	11	AZ	1,050	
Miller	1902	12	AZ	240	
McKellips and Granite Reef Farms	1902	13	AZ	810	
Sherill & Lafollette	1902	14	AZ	1,080	
Swan	1902	18	AZ	960	
Yuma County Water Users' Association	1901	4	AZ	254,200	
Imperial Irrigation District & CVWD lands	1901	27	CA	2,600,000	
Milton and Jean Phillips	1900	19	AZ	42	
Atchison, Topeka, and Santa Fe Railway Co.	1896	44	CA	1,260	273
Martinez*	1895	57	CA	1	0.6
City of Yuma	1893	21	AZ	2,333	1,478
Picacho Development Corp and CA Dept of Parks and Rec	1893	31	CA	120	
Fort Mohave Indian Reservation	9/18/1890	3	AZ	27,969	
Fort Mohave Indian Reservation	9/18/1890	25	CA	16,720	
Fort Mohave Indian Reservation	9/18/1890	81	NV	12,534	
Simons	1889	35	CA	60	
City of Needles (includes Parker Dam & Gov Camp)	1885	43	CA	1,500	950
Fort Yuma Indian Reservation	1/9/1884	23	CA	71,616	
Fort Yuma Indian Reservation	1/9/1884	3	AZ	6,350	
Palo Verde Irrigation District	1877	26	CA	219,780	
Colorado River Indian Reservation	5/15/1876	24	CA	5,860	
Colorado River Indian Reservation	11/16/1874	24	CA	40,241	
Colorado River Indian Reservation	11/16/1874	2	AZ	51,986	
Colorado River Indian Reservation	11/22/1873	2	AZ	252,016	
Colorado River Indian Reservation	10/22/1873	24	CA	10,745	
Colorado River Indian Reservation	3/3/1865	2	AZ	358,400	
Yuma Associates LTD and Winterhaven Water District (formerly Wavers)	1856	29	CA	780	
California Total				3,019,575	
Arizona Total				1,077,971	
Nevada Total				13,034	
TOTAL PPR's in Region				4,110,580	

Source: Consolidated Decree. Supreme Court of the United States. 2006
*One Acre-Foot PPR's

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Appendix H

Socioeconomics Data

This appendix includes detailed information that was used to assess changes in employment, income, and tax revenues and that supports the analysis contained in Section 4.14 “Socioeconomics”. This includes information on Arizona agricultural cropping patterns; budgets for crops included in the analysis; and a detailed breakdown of estimated changes in employment, income, and tax revenues for each county, shortage amount, and year evaluated.

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List of Tables

H.1 Irrigation Districts and Indian Communities

Central Arizona Project Irrigation Districts and Indian Communities Included in the Assessment of Effects on Arizona Agricultural Production.

By county, the CAP irrigation districts and Indian communities are:

- Pinal: Maricopa-Stanfield Irrigation & Drainage District (MSIDD)
  Central Arizona Irrigation and Drainage District (CAIDD)
  San Carlos Irrigation and Drainage District (SCIDD)
  Hohokam Irrigation and Drainage District (HIDD)
  New Magma Irrigation and Drainage District (NMIDD)
  Tohono O'odham Nation (TON) - Chuichu District
  Gila River Indian Community (GRIC)
- Maricopa: Queen Creek Irrigation District (QCIDD)
  Harquahala Valley Irrigation District (HVDD)
  Tonopah Irrigation District (TIDD)
  Roosevelt Irrigation District (RID)
- Pima: Tohono O'odham Nation
  Schuk Toak District
  San Xavier District

H.2 Arizona Cropping Patterns

Table H-1
Cropping Patterns for Shortage Analysis

Irrigation Districts	Cotton	Grains	Forage	Vegetables	Trees	Totals
MSIDD	27,862	18,154	8,711	3,106	3,886	61,719
CAIDD	28,546	22,823	2,957	3,116	2,281	59,723
HIDD	12,817	8,627	3,632	632	0	25,708
NMIDD	9,042	5,107	5,449	1,808	1,855	23,261
QCIDD	5,258	3,847	2,532	2,632	368	14,637
HVIDD	13,419	3,109	3,709	3,709	505	24,451
TIDD	2,453	22	546	0	0	3,021
Totals	99,397	61,689	27,536	15,003	8,895	212,520

H.3 Crop Budgets for Arizona Counties

H.3.1 Partial Crop Budgeting and Impacts Upon Crop Selection due to Water Cost and Water Shortages

This analysis is referred to as partial crop budgeting for two reasons. The first reason is that only total costs and returns are presented for each crop, with essentially no detail regarding the composition of the values. Secondly, as explained below, not all costs of production are taken into consideration; the emphasis is primarily on variable or cash costs. Partial crop budget tables are located at the end of this text.

Partial crop budgets were generated for upland cotton, alfalfa hay, and durum wheat. This analysis focuses on upland cotton, alfalfa hay, and durum wheat because these crops are historically the most sensitive to water costs. Such crops may be subject to elimination from a crop rotation as the cost and availability of irrigation water changes.

Theoretical economic production assumptions were applied in developing the partial budgets. The first assumption is that farmers will continue to produce a particular crop only as long as the returns from the crop cover all variable costs and contribute something toward fixed costs. For the partial crop budget analysis, the intent is to identify only the variable production costs or only those costs which a farmer in Arizona is assumed to include when making the decision whether to continue to produce a particular crop in the face of declining profitability. The goal of the partial crop budget analysis is to estimate a set of cost and return values that represent a typical farm although it is recognized that each farmer is faced with unique production costs, realized yields, and crop prices. The partial crop budgets provide what is assumed to be the average costs and returns faced by a range of farmers in the counties included in this analysis. The outcome provided by the partial budgets is identification of the cost of irrigation water at which farmers, on the average, would decide to fallow fields of a particular crop because the returns failed to cover the variable costs of production. It is assumed that, if each farmer's production costs and prices were used, on the average, the impacts would be similar to those resulting from this analysis.

University of Arizona 1998 crop enterprise budgets were used as the starting point for the partial crop budget analysis. Costs of farming inputs (equipment maintenance, fertilizer application, fuel, etc.) were adjusted to reflect 2005 costs using cost indices available from the National Agricultural Statistics Service. Average commodity prices and yields over a five-year period, from 2001 to 2005, were the basis for gross revenues. The total cash cost for land preparation and growing expenses including irrigation water costs, and total harvest and post-harvest costs developed by the University of Arizona were used in this analysis. Costs which were specifically excluded from the analysis include farm pickup use costs for a particular crop, taxes, housing, insurance on farm equipment, capital replacement on machinery and vehicles, interest on equity in machinery and vehicles, property taxes, opportunity interest on land, water assessment, returns to management, and profit.

The values derived are not indicative of the profitability of a particular crop. The values are intended to represent a marginal analysis relative to farmers' growing decisions. For example, the crop profitability decision value for wheat in Maricopa County is shown to be $59.55 per acre. The $59.55 represents the revenues above variable expenses that contribute to payment of fixed costs of the farming operation. To the $59.55 is added the current estimated irrigation water cost. Total estimated irrigation water cost plus the profitability decision value is then divided by the af of water applied per acre to calculate the threshold value. The threshold value for wheat in Maricopa County is $23.96. The threshold value is the maximum amount a farmer would pay for water to irrigate wheat. In this study, a farmer is assumed not to consider all economic costs when deciding whether to grow a particular crop. This assumption is based on historic agricultural production practices and decision making in the Lower Basin States. In addition, the economic costs associated with total farm production are unique to each farm operation. The values used in this analysis represent average conditions for farms in the counties included in this study.

Tables H-3 through H-20 show the partial budgeting results. In summary, the estimated maximum average amount a farmer would pay for irrigation water per af is shown in Table H-2, below.

Table H-2
Estimated Maximum Average Amount a Farmer Would Pay for Irrigation Water

Crop	County	Max Amount Paid for Irrigation Water ($/af)
Wheat	Pinal	$25.84
	Maricopa	$23.96
	Pima[1]	$25.84
	La Paz	$10.98
	Mojave	$44.88
	Yuma	$16.77

Table H-2
Estimated Maximum Average Amount a Farmer Would Pay for Irrigation Water

Crop	County	Max Amount Paid for Irrigation Water ($/af)
Cotton	Pinal	$70.48
	Maricopa	$40.56
	Pima[1]	$70.48
	La Paz	($42.23)
	Mojave	$54.84
	Yuma	($46.43)
Alfalfa Hay	Pinal	$66.55
	Maricopa	$40.35
	Pima[1]	$66.55
	La Paz	$56.83
	Mojave	$32.70
	Yuma	$69.37

[1] Partial farm budget information not available for Pima County. Assumed maximum amount paid for irrigation water would be similar to that of Pinal County.

The differences in the wheat estimates between counties are due mainly to yield differences and required water assumptions. For cotton, the differences in estimates between counties are also due to yield differences and required water assumptions. In Pinal County, the first crop projected to drop out of production is wheat, followed by alfalfa, and then cotton, given increasing irrigation water costs and assuming that all other variables remained unchanged.

Table H-3
Hay and Forage Production Profitability in Maricopa County—Partial Budget

	Total
Crops sales revenues—Alfalfa Hay (yield in tons = 8.3, price per ton = $102.20)	$850.30
Total cash growing costs (includes $112.50 for irrigation water)	$319.62
Cash harvest costs	$207.97
Interest on operating costs at 10%	$15.98
Total cash expenses	$543.56
General and office overhead—5% of operating expenses	$27.18
General farm maintenance—3% of operating expense	$16.31
Share of stand establishment	$73.13
Total variable costs	$660.18
Crop returns over variable costs	$190.13
Annual crop water use— 90 acre-inches or 7.50 af	
Returns to crop and water over variable costs	$302.63
Maximum average amount a farmer would pay for irrigation water per af	$40.35

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-4
Food and Feed Grain Production Profitability in Maricopa County—Partial Budget

	Total
Crops sales revenues—Durum Wheat (yield in pounds = 5,578, price per pound = $0.071)	$396.04
Total cash growing costs (includes $8.33 for irrigation water)	$220.70
Cash harvest costs	$79.83
Interest on operating costs at 10%	$11.03
Total cash expenses	$311.57
General and office overhead—5% of operating expenses	$15.58
General farm maintenance—3% of operating expense	$9.35
Total variable costs	$336.49
Crop returns over variable costs	$59.55
Annual crop water use— 34 acre-inches or 2.83 af	
Returns to crop and water over variable costs	$67.88
Maximum average amount a farmer would pay for irrigation water per af	$23.96

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-5
Upland Cotton Production Profitability in Maricopa County—Partial Budget

	Total
Crops sales revenues—Cotton Lint (yield in pounds = 1,298, price per pound = $0.636)	$825.53
Crops sales revenues—Cottonseed (yield in tons = 1.14, price per ton = $142.00)	$161.88
Total revenues	$987.41
Total cash growing costs (includes $30.00 for irrigation water)	$453.41
Cash harvest costs	$275.07
Interest on operating costs at 10%	$22.67
Total cash expenses	$751.15
General and office overhead—5% of operating expenses	$37.56
General farm maintenance—3% of operating expense	$22.53
Total variable costs	$811.24
Crop returns over variable costs	$176.17
Annual crop water use— 61 acre-inches or 5.08 af	
Returns to crop and water over variable costs	$206.17
Maximum average amount a farmer would pay for irrigation water per af	$40.56

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-6
Hay and Forage Production Profitability in Pinal County—Partial Budget

	Total
Crops sales revenues—Alfalfa Hay (yield in tons = 8.86, price per ton = $102.20)	$905.49
(grazing = 250 hd, cents per hd = $0.13)	$32.50
Total revenues	$937.99
Total cash growing costs (includes $237.00 for irrigation water)	$354.89
Cash harvest costs	$231.87
Interest on operating costs at 10%	$17.74
Total cash expenses	$604.51
General and office overhead—5% of operating expenses	$30.23
General farm maintenance—3% of operating expense	$18.14
Share of stand establishment	$84.22
Total variable costs	$737.09
Crop returns over variable costs	$200.90
Annual crop water use— 79 acre-inches or 6.58 af	
Returns to crop and water over variable costs	$437.90
Maximum average amount a farmer would pay for irrigation water per af	$66.55

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-7
Food and Feed Grain Production Profitability in Pinal County—Partial Budget

	Total
Crops sales revenues—Durum Wheat (yield in pounds = 5,812, price per pound = $0.071)	$412.65
Total cash growing costs (includes $96.00 for irrigation water)	$317.06
Cash harvest costs	$74.26
Interest on operating costs at 10%	$15.85
Total cash expenses	$407.18
General and office overhead—5% of operating expenses	$20.36
General farm maintenance—3% of operating expense	$12.22
Total variable costs	$439.75
Crop returns over variable costs	$27.10
Annual crop water use— 32 acre-inches or 2.67 af	
Returns to crop and water over variable costs	$68.90
Maximum average amount a farmer would pay for irrigation water per af	$25.84

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-8
Upland Cotton Production Profitability in Pinal County—Partial Budget

	Total
Crops sales revenues—Cotton Lint (yield in pounds = 1,361, price per pound = $0.636)	$865.60
Crops sales revenues—Cottonseed (yield in tons = 1.2, price per ton = $142.00)	$170.40
Total revenues	$1,036.00
Total cash growing costs (includes $30.00 for irrigation water)	$519.23
Cash harvest costs	$280.94
Interest on operating costs at 10%	$25.96
Total cash expenses	$826.13
General and office overhead—5% of operating expenses	$41.31
General farm maintenance—3% of operating expense	$24.78
Total variable costs	$892.22
Crop returns over variable costs	$143.78
Annual crop water use— 49 acre-inches or 4.08 af	
Returns to crop and water over variable costs	$287.78
Maximum average amount a farmer would pay for irrigation water per af	$70.48

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-9
Hay and Forage Production Profitability in Cochise County—Partial Budget

	Total
Crops sales revenues—Alfalfa Hay (yield in tons = 7.84, price per ton = $102.20)	$801.25
(grazing = 250 hd, cents per hd = $0.13)	$32.50
Total revenues	$833.75
Total cash growing costs (includes $243.63 for irrigation water)	$585.30
Cash harvest costs	$102.67
Interest on operating costs at 10%	$29.26
Total cash expenses	$717.23
General and office overhead—5% of operating expenses	$35.86
General farm maintenance—3% of operating expense	$21.52
Share of stand establishment	$84.22
Total variable costs	$858.83
Crop returns over variable costs	($25.08)
Annual crop water use— 68 acre-inches or 5.67 af	
Returns to crop and water over variable costs	$218.55
Maximum average amount a farmer would pay for irrigation water per af	$38.57

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-10
Food and Feed Grain Production Profitability in Cochise County—Partial Budget

	Total
Crops sales revenues—Durum Wheat (yield in pounds = 6,210, price per pound = $0.071)	$440.91
Total cash growing costs (includes $107.04 for irrigation water)	$427.90
Cash harvest costs	$68.57
Interest on operating costs at 10%	$21.39
Total cash expenses	$517.87
General and office overhead—5% of operating expenses	$25.89
General farm maintenance—3% of operating expense	$15.54
Total variable costs	$559.29
Crop returns over variable costs	$118.38
Annual crop water use— 28 acre-inches or 2.33 af	
Returns to crop and water over variable costs	$11.34
Maximum average amount a farmer would pay for irrigation water per af	$4.86

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-11
Upland Cotton Production Profitability in Cochise County—Partial Budget

	Total
Crops sales revenues—Cotton Lint (yield in pounds = 1,032, price per pound = $0.636)	$656.35
Crops sales revenues—Cottonseed (yield in tons = 0.91, price per ton = $142.00)	$129.22
Total revenues	$785.57
Total cash growing costs (includes $132.57 for irrigation water)	$527.74
Cash harvest costs	$183.44
Interest on operating costs at 10%	$26.39
Total cash expenses	$737.57
General and office overhead—5% of operating expenses	$36.88
General farm maintenance—3% of operating expense	$22.13
Total variable costs	$796.57
Crop returns over variable costs	($11.00)
Annual crop water use— 37 acre-inches or 3.08 af	
Returns to crop and water over variable costs	$121.57
Maximum average amount a farmer would pay for irrigation water per af	$39.43

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-12
Hay and Forage Production Profitability in La Paz County—Partial Budget

	Total
Crops sales revenues—Alfalfa Hay (yield in tons = 7.9, price per ton = $102.20)	$804.31
(grazing = 250 hd, cents per hd = $0.13)	$32.50
Total revenues	$836.81
Total cash growing costs (includes $243.63 for irrigation water)	$187.67
Cash harvest costs	$171.67
Interest on operating costs at 10%	$9.38
Total cash expenses	$368.73
General and office overhead—5% of operating expenses	$18.44
General farm maintenance—3% of operating expense	$11.06
Share of stand establishment	$84.22
Total variable costs	$482.44
Crop returns over variable costs	$354.37
Annual crop water use— 79 acre-inches or 6.58 af	
Returns to crop and water over variable costs	$374.16
Maximum average amount a farmer would pay for irrigation water per af	$56.83

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-13
Food and Feed Grain Production Profitability in La Paz County—Partial Budget

	Total
Crops sales revenues—Durum Wheat (yield in pounds = 5,642, price per pound = $0.071)	$400.58
Total cash growing costs (includes $0 for irrigation water)	$266.05
Cash harvest costs	$61.90
Interest on operating costs at 10%	$13.30
Total cash expenses	$341.26
General and office overhead—5% of operating expenses	$17.06
General farm maintenance—3% of operating expense	$10.24
Total variable costs	$268.56
Crop returns over variable costs	$32.03
Annual crop water use— 35 acre-inches or 2.92 af	
Returns to crop and water over variable costs	$32.03
Maximum average amount a farmer would pay for irrigation water per af	$10.98

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-15
Hay and Forage Production Profitability in Yuma County—Partial Budget

	Total
Crops sales revenues—Alfalfa Hay (yield in tons = 9.1, price per ton = $102.20)	$933.09
(grazing = 250 hd, cents per hd = $0.13)	$32.50
Total revenues	$965.59
Total cash growing costs (includes $25.83 for irrigation water)	$153.29
Cash harvest costs	$224.07
Interest on operating costs at 10%	$7.66
Total cash expenses	$385.02
General and office overhead—5% of operating expenses	$19.25
General farm maintenance—3% of operating expense	$11.55
Share of stand establishment	$84.22
Total variable costs	$500.04
Crop returns over variable costs	$465.54
Annual crop water use— 85 acre-inches or 7.08 af	
Returns to crop and water over variable costs	$491.37
Maximum average amount a farmer would pay for irrigation water per af	$69.37

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-16
Food and Feed Grain Production Profitability in Yuma County—Partial Budget

	Total
Crops sales revenues—Durum Wheat (yield in pounds = 5,976, price per pound = $0.071)	$424.30
Total cash growing costs (includes $0 for irrigation water)	$246.97
Cash harvest costs	$83.09
Interest on operating costs at 10%	$12.35
Total cash expenses	$342.41
General and office overhead—5% of operating expenses	$17.12
General farm maintenance—3% of operating expense	$10.27
Total variable costs	$369.80
Crop returns over variable costs	$54.49
Annual crop water use— 39 acre-inches or 3.25 af	
Returns to crop and water over variable costs	$54.49
Maximum average amount a farmer would pay for irrigation water per af	$16.77

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-17
Upland Cotton Production Profitability in Yuma County—Partial Budget

	Total
Crops sales revenues—Cotton Lint (yield in pounds = 1,286, price per pound = $0.636)	$817.90
Crops sales revenues—Cottonseed (yield in tons = 1.13, price per ton = $142.00)	$160.46
Total revenues	$978.36
Total cash growing costs (includes $0 for irrigation water)	$684.90
Cash harvest costs	$337.21
Interest on operating costs at 10%	$34.24
Total cash expenses	$1056.35
General and office overhead—5% of operating expenses	$52.82
General farm maintenance—3% of operating expense	$31.69
Total variable costs	$1,140.85
Crop returns over variable costs	($162.50)
Annual crop water use— 42 acre-inches or 3.50 af	
Returns to crop and water over variable costs	($162.50)
Maximum average amount a farmer would pay for irrigation water per af	($46.43)

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-18
Hay and Forage Production Profitability in Mohave County—Partial Budget

	Total
Crops sales revenues—Alfalfa Hay (yield in tons = 7.9, price per ton = $102.20)	$804.31
(grazing = 200 hd, cents per hd = $0.13)	$26.00
Total revenues	$830.31
Total cash growing costs (includes $21.33 for irrigation water)	$307.84
Cash harvest costs	$172.90
Interest on operating costs at 10%	$15.39
Total cash expenses	$496.13
General and office overhead—5% of operating expenses	$24.81
General farm maintenance—3% of operating expense	$14.88
Share of stand establishment	$84.22
Total variable costs	$620.04
Crop returns over variable costs	$210.27
Annual crop water use— 85 acre-inches or 7.08 af	
Returns to crop and water over variable costs	$231.60
Maximum average amount a farmer would pay for irrigation water per af	$32.70

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-19
Food and Feed Grain Production Profitability in Mohave County—Partial Budget

	Total
Crops sales revenues—Durum Wheat (yield in pounds = 5,642, price per pound = $0.071)	$400.58
Total cash growing costs (includes $10.46 for irrigation water)	$185.19
Cash harvest costs	$51.09
Interest on operating costs at 10%	$9.26
Total cash expenses	$245.54
General and office overhead—5% of operating expenses	$12.28
General farm maintenance—3% of operating expense	$7.37
Total variable costs	$265.18
Crop returns over variable costs	$135.40
Annual crop water use— 39 acre-inches or 3.25 af	
Returns to crop and water over variable costs	$145.86
Maximum average amount a farmer would pay for irrigation water per af	$44.88

Note: Dollar values are on a per acre basis. Information is for October 2006.

Table H-20
Upland Cotton Production Profitability in Mohave County—Partial Budget

	Total
Crops sales revenues—Cotton Lint (yield in pounds = 1,354, price per pound = $0.636)	$861.14
Crops sales revenues—Cottonseed (yield in tons = 1.19, price per ton = $142.00)	$168.98
Total revenues	$1,030.12
Total cash growing costs (includes $15.06 for irrigation water)	$441.54
Cash harvest costs	$250.24
Interest on operating costs at 10%	$22.08
Total cash expenses	$713.85
General and office overhead—5% of operating expenses	$35.69
General farm maintenance—3% of operating expense	$21.42
Total variable costs	$770.96
Crop returns over variable costs	$259.16
Annual crop water use— 60 acre-inches or 5.00 af	
Returns to crop and water over variable costs	$274.22
Maximum average amount a farmer would pay for irrigation water per af	$54.84

Note: Dollar values are on a per acre basis. Information is for October 2006.

H.4 County Level Changes in Employment and Personal Income

H.4.1 Summary Table

Table H-21
Estimated Changes in Employment as a Result of Shortages to
Non-Indian Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
400,000	(526.9)	(168.0)	–[1]	–	–
500,000	(47.1)	(46.7)	(111.8)	(41.5)	(49.2)
600,000	(59.7)	(59.5)	(59.7)	(61.6)	(62.4)
800,000	(87.5)	(87.2)	(87.8)	(90.3)	(91.3)
1,000,000	(271.3)	(111.7)	(112.0)	(114.1)	(107.7)
1,200,000	–	–	(134.0)	(137.1)	(137.5)
1,800,000	–	(239.6)	(240.6)	(179.9)	(219.7)
2,500,000	–	–	(533.8)	–	–

Note: [1] “-“ indicates no shortage occurring.

Table H-22
Estimated Changes in Personal Income as a Result of Shortages to
Non-Indian Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
400,000	(21,017,759)	(4,963,670)	–	–	–
500,000	(1,331,323)	(1,333,635)	(3,245,248)	(1,050,702)	(1,383,456)
600,000	(1,637,503)	(1,648,493)	(1,655,837)	(1,696,714)	(1,708,852)
800,000	(2,345,847)	(2,362,478)	(2,372,533)	(2,429,973)	(2,446,125)
1,000,000	(7,989,042)	(3,050,150)	(3,061,767)	(2,268,426)	(2,994,889)
1,200,000	–	–	(3,777,330)	(3,873,907)	(3,917,884)
1,800,000	–	(6,704,853)	(6,728,486)	(6,950,566)	(6,519,349)
2,500,000	–	–	(12,963,221)	–	–

Table H-23
Estimated Changes in Employment as a Result of Shortages to
Indian Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
400,000	(7.1)	(148.0)	–	–	–
500,000	(29.8)	(224.8)	(249.0)	(179.4)	(304.8)
600,000	(154.8)	(204.1)	(235.2)	(290.8)	(325.2)

Table H-23
Estimated Changes in Employment as a Result of Shortages to
Indian Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
800,000	(272.4)	(339.9)	(362.1)	(363.7)	(483.1)
1,000,000	(323.4)	(410.5)	(457.3)	(457.2)	(524.4)
1,200,000	–	–	(580.8)	(577.7)	(559.7)
1,800,000	–	(790.6)	(898.1)	(886.0)	(944.5)
2,500,000	–	–	(385.3)	–	–

Table H-24
Estimated Changes in Personal Income as a Result of Shortages to
Indian Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
400,000	(162,640)	(3,815,682)	–	–	–
500,000	(610,510)	(6,079,360)	(6,855,157)	(4,662,385)	(9,159,432)
600,000	(3,347,690)	(6,007,816)	(7,213,788)	(8,502,279)	(9,867,649)
800,000	(7,008,795)	(10,434,090)	(10,063,182)	(11,756,529)	(16,772,539)
1,000,000	(9,641,094)	(14,100,960)	(16,168,483)	(16,152,867)	(18,803,150)
1,200,000	–	–	(21,505,787)	(21,343,879)	(23,972,184)
1,800,000	–	(30,522,085)	(35,237,258)	(34,690,039)	(36,386,782)
2,500,000	–	–	(17,465,930)	–	–

Table H-25
Estimated Changes in Employment as a Result of Shortages to
Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
400,000	(534.0)	(316.0)	–	–	–
500,000	(76.9)	(271.5)	(360.8)	(220.9)	(354.0)
600,000	(214.5)	(263.6)	(294.9)	(352.4)	(387.6)
800,000	(359.9)	(427.1)	(449.9)	(454.0)	(574.4)
1,000,000	(594.7)	(522.2)	(569.3)	(571.3)	(632.1)
1,200,000	–	–	(714.8)	(714.8)	(697.2)
1,800,000	–	(1,030.2)	(1,138.7)	(1,065.9)	(1,164.2)
2,500,000	–	–	(919.1)	–	–

Table H-26
Estimated Changes in Personal Income as a Result of Shortages to Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
400,000	(21,180,399)	(8,779,352)	–	–	–
500,000	(1,941,833)	(7,412,995)	(10,100,405)	(5,713,087)	(10,542,888)
600,000	(4,985,193)	(7,656,309)	(8,869,625)	(10,198,993)	(11,576,501)
800,000	(9,354,642)	(12,796,568)	(12,435,715)	(14,186,502)	(19,218,664)
1,000,000	(17,630,136)	(17,151,110)	(19,230,250)	(18,421,293)	(21,798,039)
1,200,000	–	–	(25,283,117)	(25,217,786)	(27,890,068)
1,800,000	–	(37,226,938)	(41,965,744)	(41,640,605)	(42,906,131)
2,500,000	–	–	(30,429,151)	–	–

H.4.2 2017 Tables

Table H-27
Estimated Change In Employment and Income as a Result of a 400,000 af shortage to Non-Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(108.3)	(49.7)	(158.0)	(3,101,689)	(1,778,334)	(4,880,023)
Pinal	(168.0)	(166.6)	(334.7)	(9,811,282)	(5,312,141)	(15,123,423)
Mohave	(7.0)	(3.3)	(10.3)	(280,882)	(99,347)	(380,229)
La Paz	(6.1)	(3.2)	(9.4)	(191,206)	(72,685)	(263,892)
Yuma	(8.4)	(6.1)	(14.5)	(210,015)	(160,177)	(370,192)
Total			(526.9)			(21,017,759)

Table H-28
Estimated Change In Employment and Income as a Result of a 500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(11.3)	(4.1)	(15.4)	(343,917)	(122,296)	(466,213)
La Paz	(7.7)	(4.0)	(11.7)	(238,999)	(90,853)	(329,852)
Yuma	(10.2)	(9.8)	(20.0)	(284,031)	(251,227)	(535,258)
Total			(47.1)			(1,331,323)

Table H-29
Estimated Change In Employment and Income as a Result of a
600,000 af shortage to Non-Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(15.6)	(4.9)	(20.5)	(406,988)	(145,258)	(552,246)
La Paz	(9.2)	(4.9)	(14.1)	(286,791)	(109,021)	(395,812)
Yuma	(11.8)	(13.3)	(25.1)	(353,170)	(336,275)	(689,445)
Total			(59.7)			(1,637,503)

Table H-30
Estimated Change In Employment and Income as a Result of a
800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(24.2)	(6.5)	(30.7)	(533,094)	(191,168)	(724,262)
La Paz	(11.7)	(9.3)	(21.0)	(407,739)	(202,256)	(609,995)
Yuma	(15.3)	(20.6)	(35.8)	(497,622)	(513,968)	(1,011,590)
Total			(87.5)			(2,345,847)

Table H-31
Estimated Change In Employment and Income as a Result of a
1,000,000 af shortage to Non-Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(108.6)	(49.9)	(158.5)	(3,115,126)	(1,786,783)	(4,901,910)
Pinal	–	–	–	–	–	–
Mohave	(31.6)	(8.7)	(40.3)	(698,739)	(255,697)	(954,435)
La Paz	(13.8)	(15.2)	(29.0)	(540,297)	(321,637)	(861,934)
Yuma	(17.8)	(25.7)	(43.5)	(627,805)	(642,957)	(1,270,763)
Total			(271.3)			(7,989,042)

Table H-32
Estimated Change In Employment and Income as a Result of a
1,200,000 af shortage to Non-Indian Agricultural Lands in Arizona—2017

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	–	–	–		–	–	–
La Paz	–	–	–		–	–	–
Yuma	–	–	–		–	–	–
Total			–				–

Table H-33
Estimated Change In Employment and Income as a Result of a
1,800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2017

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	–	–	–		–	–	–
La Paz	–	–	–		–	–	–
Yuma	–	–	–		–	–	–
Total			–				–

Table H-34
Estimated Change In Employment and Income as a Result of a
2,500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2017

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	–	–	–		–	–	–
La Paz	–	–	–		–	–	–
Yuma	–	–	–		–	–	–
Total			–				–

Table H-35
Estimated Change In Employment and Income as a Result of a
400,000 af Shortage to Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa						
Pinal	(0.3)	(0.2)	(0.4)	(9,313)	(3,726)	(13,039)
Pima	(2.9)	(0.5)	(3.5)	(43,533)	(19,130)	(62,663)
Mohave	–	–	–	–	–	–
La Paz	(1.6)	(0.9)	(2.5)	(50,222)	(19,092)	(69,314)
Yuma	(0.5)	(0.2)	(0.7)	(11,020)	(6,604)	(17,624)
Graham	–	–	–	–	–	–
Total			(7.1)			(162,640)

Table H-36
Estimated Change In Employment and Income as a Result of a
500,000 af Shortage to Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	(1.8)	(0.8)	(2.6)	(61,795)	(24,718)	(86,513)
Pima	(19.5)	(3.7)	(23.2)	(288,526)	(126,785)	(415,310)
Mohave	–	–	–	–	–	–
La Paz	(2.0)	(1.1)	(3.1)	(62,778)	(23,864)	(86,643)
Yuma	(0.6)	(0.3)	(0.9)	(13,783)	(8,260)	(22,044)
Graham	–	–	–	–	–	–
Total			(29.8)			(610,510)

Table H-37
Estimated Change In Employment and Income as a Result of a
600,000 af Shortage to Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(88.7)	(23.8)	(112.5)	(1,588,285)	(872,792)	(2,461,076)
Pinal	(3.5)	(1.5)	(5.0)	(118,640)	(47,455)	(166,096)
Pima	(26.9)	(5.1)	(32.0)	(397,337)	(174,599)	(571,936)
Mohave	–	–	–	–	–	–
La Paz	(2.3)	(1.8)	(4.1)	(79,608)	(38,262)	(117,870)
Yuma	(0.7)	(0.5)	(1.2)	(17,758)	(12,954)	(30,712)
Graham	–	–	–	–	–	–
Total			(154.8)			(3,347,690)

Table H-38
Estimated Change In Employment and Income as a Result of a
800,000 af Shortage to Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(99.8)	(26.7)	(126.5)	(1,787,165)	(982,079)	(2,769,244)
Pinal	(48.5)	(20.3)	(68.8)	(1,626,270)	(650,499)	(2,276,769)
Pima	(42.8)	(10.3)	(53.1)	(804,880)	(349,025)	(1,153,905)
Mohave	–	–	–	–	–	–
La Paz	(2.9)	(3.3)	(6.2)	(114,451)	(69,641)	(184,092)
Yuma	(0.9)	(0.9)	(1.8)	(26,134)	(23,257)	(49,390)
Graham	(11.0)	(5.0)	(16.0)	(450,369)	(125,026)	(575,395)
Total			(272.4)			(7,008,795)

Table H-39
Estimated Change In Employment and Income as a Result of a
1,000,000 af Shortage to Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(94.2)	(25.2)	(119.5)	(1,687,854)	(927,506)	(2,615,360)
Pinal	(73.2)	(37.1)	(110.3)	(3,068,969)	(1,196,272)	(4,265,241)
Pima	(47.3)	(13.5)	(60.9)	(1,068,924)	(459,691)	(1,528,615)
Mohave	–	–	–	–	–	–
La Paz	(3.5)	(4.9)	(8.3)	(149,275)	(101,004)	(250,279)
Yuma	(1.1)	(1.4)	(2.5)	(34,456)	(33,494)	(67,951)
Graham	(14.0)	(7.9)	(21.9)	(714,849)	(198,826)	(913,648)
Total			(323.4)			(9,641,094)

Table H-40
Estimated Change In Employment and Income as a Result of a
1,200,000 af Shortage to Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Graham	–	–	–	–	–	–
Total			–			–

Table H-41
Estimated Change In Employment and Income as a Result of a
1,800,000 af Shortage to Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Graham	–	–	–	–	–	–
Total			–			–

Table H-42
Estimated Change In Employment and Income as a Result of a
2,500,000 af Shortage to Indian Agricultural Lands in Arizona—2017

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Graham	–	–	–	–	–	–
Total			–			–

H.4.3 2026 Tables

Table H-43
Estimated Change In Employment and Income as a Result of a
400,000 af shortage to Non-Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(34.6)	(9.3)	(43.9)	(620,264)	(340,846)	(961,110)
Pinal	(63.6)	(26.6)	(90.2)	(2,131,330)	(852,521)	(2,983,851)
Mohave	(6.2)	(3.2)	(9.4)	(269,892)	(95,346)	(365,238)
La Paz	(6.2)	(3.2)	(9.4)	(192,016)	(72,994)	(265,010)
Yuma	(8.6)	(6.5)	(15.1)	(218,207)	(170,254)	(388,461)
Total			(168.0)			(4,963,670)

Table H-44
Estimated Change In Employment and Income as a Result of a
500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(10.4)	(3.9)	(14.3)	(330,197)	(117,301)	(447,498)
La Paz	(7.7)	(4.0)	(11.8)	(239,993)	(91,231)	(331,224)
Yuma	(10.4)	(10.2)	(20.6)	(292,845)	(262,068)	(554,913)
Total			(46.7)			(1,333,635)

Table H-45
Estimated Change In Employment and Income as a Result of a
600,000 af shortage to Non-Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(14.5)	(4.7)	(19.2)	(390,503)	(139,256)	(529,758)
La Paz	(9.2)	(4.9)	(14.1)	(288,006)	(109,483)	(397,489)
Yuma	(12.2)	(14.0)	(26.2)	(367,430)	(353,816)	(721,246)
Total			(59.5)			(1,648,493)

Table H-46
Estimated Change In Employment and Income as a Result of a
800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(22.7)	(6.2)	(28.9)	(511,113)	(183,166)	(694,279)
La Paz	(11.7)	(9.4)	(21.1)	(409,934)	(204,234)	(614,168)
Yuma	(15.7)	(21.5)	(37.2)	(516,653)	(537,378)	(1,054,031)
Total			(87.2)			(2,362,478)

Table H-47
Estimated Change In Employment and Income as a Result of a
1,000,000 af shortage to Non-Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(30.4)	(8.0)	(38.4)	(650,522)	(235,930)	(886,452)
La Paz	(13.9)	(15.3)	(29.2)	(543,054)	(324,120)	(867,175)
Yuma	(18.1)	(26.0)	(44.1)	(644,427)	(652,096)	(1,296,523)
Total			(111.7)			(3,050,150)

Table H-48
Estimated Change In Employment and Income as a Result of a
1,200,000 af shortage to Non-Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Total			–			–

Table H-49
Estimated Change In Employment and Income as a Result of a
1,800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(49.8)	(18.9)	(68.8)	(1,416,064)	(549,790)	(1,965,853)
La Paz	(219.0)	(36.3)	(58.2)	(1,025,185)	(758,328)	(1,783,512)
Yuma	(64.3)	(48.3)	(112.6)	(1,682,915)	(1,272,573)	(2,955,488)
Total			(239.6)			(6,704,853)

Table H-50
Estimated Change In Employment and Income as a Result of a
2,500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Total	–		–			–

Table H-51
Estimated Change In Employment and Income as a Result of a
400,000 af Shortage to Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(32.2)	(8.7)	(40.9)	(578,164)	(317,711)	(895,875)
Pinal	(36.0)	(15.0)	(51.0)	(1,204,778)	(481,905)	(1,686,683)
Pima	(42.7)	(10.2)	(52.9)	(799,258)	(346,668)	(1,145,927)
Mohave	–	–	–	–	–	–
La Paz	(1.6)	(0.9)	(2.5)	(50,370)	(19,147)	(69,517)
Yuma	(0.5)	(0.2)	(0.7)	(11,055)	(6,625)	(17,680)
Graham	–	–	–	–	–	–
Total			(148.0)			(3,815,682)

Table H-52
Estimated Change In Employment and Income as a Result of a
500,000 af Shortage to Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(55.7)	(15.0)	(70.6)	(997,573)	(548,184)	(1,545,757)
Pinal	(62.8)	(26.3)	(89.1)	(2,104,781)	(842,302)	(2,948,083)
Pima	(44.5)	(11.4)	(56.0)	(903,686)	(390,436)	(1,294,122)
Mohave	–	–	–	–	–	–
La Paz	(2.0)	(1.1)	(3.1)	(62,962)	(23,934)	(86,897)
Yuma	(0.6)	(0.3)	(0.9)	(13,819)	(8,281)	(22,100)
Graham	(3.5)	(1.6)	(5.1)	(142,768)	(39,633)	(182,401)
Total			(224.8)			(6,079,360)

Table H-53
Estimated Change In Employment and Income as a Result of a
600,000 af Shortage to Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(71.5)	(19.1)	(90.6)	(1,279,768)	(703,255)	(1,983,023)
Pinal	(69.3)	(31.9)	(101.2)	(2,598,267)	(1,025,350)	(3,623,617)
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	(2.3)	(1.8)	(4.1)	(79,931)	(38,554)	(118,487)
Yuma	(0.7)	(0.5)	(1.2)	(17,864)	(13,084)	(30,948)
Graham	(4.8)	(2.2)	(7.0)	(197,041)	(54,701)	(251,741)
Total			(204.1)			(6,007,816)

Table H-54
Estimated Change In Employment and Income as a Result of a
800,000 af Shortage to Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(100.7)	(27.6)	(128.4)	(1,854,237)	(1,015,546)	(2,869,783)
Pinal	(77.2)	(42.6)	(119.7)	(3,558,055)	(1,373,870)	(4,931,925)
Pima	(50.5)	(15.6)	(66.1)	(1,232,412)	(529,644)	(1,762,056)
Mohave	–	–	–	–	–	–
La Paz	(2.9)	(3.3)	(6.2)	(114,910)	(70,056)	(184,965)
Yuma	(0.9)	(0.9)	(1.8)	(26,240)	(23,387)	(49,627)
Graham	(12.2)	(5.5)	(17.7)	(497,597)	(138,136)	(635,734)
Total			(339.9)			(10,434,090)

Table H-55
Estimated Change In Employment and Income as a Result of a
1,000,000 af Shortage to Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(110.8)	(37.3)	(148.1)	(2,528,157)	(1,368,601)	(3,896,757)
Pinal	(86.6)	(56.1)	(142.7)	(4,585,532)	(1,812,065)	(6,397,598)
Pima	(63.8)	(22.6)	(86.4)	(1,757,954)	(768,251)	(2,526,205)
Mohave	–	–	–	–	–	–
La Paz	(3.5)	(4.9)	(8.3)	(149,837)	(101,511)	(251,347)
Yuma	(1.1)	(1.4)	(2.5)	(34,615)	(33,690)	(68,305)
Graham	(14.2)	(8.3)	(22.5)	(751,665)	(209,083)	(960,748)
Total			(410.5)			(14,100,960)

Table H-56
Estimated Change In Employment and Income as a Result of a
1,200,000 af Shortage to Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Graham	–	–	–	–	–	–
Total			–			–

Table H-57
Estimated Change In Employment and Income as a Result of a
1,800,000 af Shortage to Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(178.1)	(100.1)	(278.2)	(5,976,369)	(3,536,939)	(9,513,308)
Pinal	(158.3)	(176.3)	(334.5)	(9,546,502)	(5,601,698)	(15,148,200)
Pima	(112.3)	(47.8)	(160.1)	(3,660,900)	(1,632,231)	(5,293,131)
Mohave	–	–	–	–	–	–
La Paz	(5.1)	(8.7)	(13.7)	(262,217)	(182,464)	(444,681)
Yuma	(1.7)	(2.5)	(4.1)	(61,811)	(60,955)	(122,765)
Graham	–	–	–	–	–	–
Total			(790.6)			(30,522,085)

Table H-58
Estimated Change In Employment and Income as a Result of a
2,500,000 af Shortage to Indian Agricultural Lands in Arizona—2026

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Graham	–	–	–	–	–	–
Total			–			–

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Table H-59
Estimated Change In Employment and Income as a Result of a
400,000 af shortage to Non-Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Total			–			–

Table H-60
Estimated Change In Employment and Income as a Result of a
500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(16.7)	(4.4)	(21.2)	(299,607)	(164,639)	(464,247)
Pinal	(30.7)	(12.9)	(43.6)	(1,029,461)	(411,779)	(1,441,239)
Mohave	(10.4)	(3.9)	(14.4)	(331,544)	(117,791)	(449,336)
La Paz	(7.7)	(4.0)	(11.8)	(240,103)	(91,273)	(331,376)
Yuma	(10.4)	(10.4)	(20.8)	(294,700)	(264,350)	(559,050)
Total			(111.8)			(3,245,248)

Table H-61
Estimated Change In Employment and Income as a Result of a
600,000 af shortage to Non-Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(14.6)	(4.7)	(19.3)	(392,098)	(139,837)	(531,934)
La Paz	(9.2)	(4.9)	(14.1)	(288,153)	(109,539)	(397,692)
Yuma	(12.2)	(14.2)	(26.3)	(369,656)	(356,555)	(726,211)
Total			(59.7)			(1,655,837)

Table H-62
Estimated Change In Employment and Income as a Result of a
800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2027

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	(22.9)	(6.2)	(29.1)		(513,276)	(183,953)	(697,229)
La Paz	(11.7)	(9.4)	(21.2)		(410,190)	(204,464)	(614,653)
Yuma	(15.8)	(21.7)	(37.5)		(519,621)	(541,030)	(1,060,651)
Total			(87.8)				(2,372,533)

Table H-63
Estimated Change In Employment and Income as a Result of a
1,000,000 af shortage to Non-Indian Agricultural Lands in Arizona—2027

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	(30.5)	(8.1)	(38.6)		(655,245)	(237,866)	(893,110)
La Paz	(13.9)	(15.3)	(29.2)		(543,412)	(324,443)	(867,854)
Yuma	(18.1)	(26.1)	(44.2)		(647,189)	(653,614)	(1,300,803)
Total			(112.0)				(3,061,767)

Table H-64
Estimated Change In Employment and Income as a Result of a
1,200,000 af shortage to Non-Indian Agricultural Lands in Arizona—2027

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	(35.9)	(11.1)	(47.0)		(867,615)	(324,935)	(1,192,550)
La Paz	(16.1)	(21.2)	(37.2)		(676,633)	(444,422)	(1,121,055)
Yuma	(21.6)	(28.2)	(49.8)		(750,152)	(713,573)	(1,463,725)
Total			(134.0)				(3,777,330)

Table H-65
Estimated Change In Employment and Income as a Result of a
1,800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2027

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	(50.0)	(19.1)	(69.1)		(1,423,582)	(552,872)	(1,976,453)
La Paz	(21.9)	(36.3)	(58.3)		(1,025,389)	(758,511)	(1,783,900)
Yuma	(64.6)	(48.5)	(113.2)		(1,690,821)	(1,277,311)	(2,968,133)
Total			(240.6)				(6,728,486)

Table H-66
Estimated Change In Employment and Income as a Result of a
2,500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2027

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	–	–	–		–	–	–
La Paz	–	–	–		–	–	–
Yuma	(350.3)	(183.6)	(533.8)		(7,940,506)	(5,022,715)	(12,963,221)
Total			(533.8)				(12,963,221)

Table H-67
Estimated Change In Employment and Income as a Result of a
400,000 af Shortage to Indian Agricultural Lands in Arizona—2027

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Pima	–	–	–		–	–	–
Mohave	–	–	–		–	–	–
La Paz	–	–	–		–	–	–
Yuma	–	–	–		–	–	–
Graham	–	–	–		–	–	–
Total			–				–

Table H-68
Estimated Change In Employment and Income as a Result of a
500,000 af Shortage to Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(70.8)	(19.0)	(89.8)	(1,268,568)	(697,101)	(1,965,669)
Pinal	(69.9)	(32.7)	(102.5)	(2,662,713)	(1,048,751)	(3,711,465)
Pima	(39.5)	(7.9)	(47.4)	(610,090)	(267,384)	(877,474)
Mohave	–	–	–	–	–	–
La Paz	(2.0)	(1.1)	(3.1)	(62,999)	(23,949)	(86,947)
Yuma	(0.6)	(0.3)	(0.9)	(13,819)	(8,281)	(22,100)
Graham	(3.7)	(1.6)	(5.3)	(149,981)	(41,611)	(191,502)
Total			(249.0)			(6,855,157)

Table H-69
Estimated Change In Employment and Income as a Result of a
600,000 af Shortage to Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(86.3)	(23.1)	(109.1)	(1,544,754)	(848,870)	(2,393,624)
Pinal	(73.6)	(37.7)	(111.3)	(3,121,818)	(1,215,462)	(4,337,280)
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	(2.6)	(2.5)	(5.2)	(97,447)	(54,328)	(151,775)
Yuma	(0.7)	(0.5)	(1.2)	(17,864)	(13,084)	(30,948)
Graham	(5.7)	(2.6)	(8.4)	(234,940)	(65,221)	(300,161)
Total			(235.2)			(7,213,788)

Table H-70
Estimated Change In Employment and Income as a Result of a
800,000 af Shortage to Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(104.9)	(31.7)	(136.6)	(2,158,333)	(1,167,278)	(3,325,611)
Pinal	(81.6)	(48.6)	(130.2)	(4,100,771)	(1,570,942)	(5,671,713)
Pima	(52.7)	(16.8)	(69.4)	(1,319,597)	(569,221)	(188,818)
Mohave	–	–	–	–	–	–
La Paz	(2.9)	(3.3)	(6.2)	(114,961)	(70,101)	(185,062)
Yuma	(0.9)	(0.9)	(1.8)	(26,213)	(23,355)	(49,568)
Graham	(12.3)	(5.7)	(17.9)	(502,823)	(139,588)	(642,410)
Total			(362.1)			(10,063,182)

Table H-71
Estimated Change In Employment and Income as a Result of a
1,000,000 af Shortage to Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(119.9)	(45.8)	(165.8)	(2,997,031)	(1,663,444)	(4,660,475)
Pinal	(96.2)	(72.3)	(168.4)	(5,251,350)	(2,320,677)	(7,572,027)
Pima	(66.0)	(23.7)	(89.7)	(1,843,295)	(806,992)	(2,650,287)
Mohave	–	–	–	–	–	–
La Paz	(3.5)	(4.9)	(8.3)	(149,888)	(101,556)	(251,444)
Yuma	(1.1)	(1.4)	(2.5)	(34,615)	(33,690)	(68,305)
Graham	(14.2)	(8.4)	(22.6)	(755,727)	(210,218)	(965,945)
Total			(457.3)			(16,168,483)

Table H-72
Estimated Change In Employment and Income as a Result of a
1,200,000 af Shortage to Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(138.6)	(63.2)	(201.9)	(3,953,511)	(2,264,906)	(6,218,417)
Pinal	(116.8)	(106.7)	(223.5)	(6,674,508)	(3,407,811)	(10,082,320)
Pima	(79.3)	(30.6)	(110.0)	(2,366,916)	(1,044,728)	(3,411,644)
Mohave	–	–	–	–	–	–
La Paz	(4.1)	(6.3)	(10.4)	(184,815)	(133,011)	(317,825)
Yuma	(1.3)	(1.8)	(3.1)	(42,991)	(43,993)	(86,984)
Graham	(17.9)	(13.9)	(31.9)	(1,032,770)	(355,826)	(1,388,597)
Total			(580.8)			(21,505,787)

Table H-73
Estimated Change In Employment and Income as a Result of a
1,800,000 af Shortage to Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(187.7)	(108.9)	(296.7)	(6,464,153)	(3,843,671)	(10,307,825)
Pinal	(168.7)	(193.7)	(362.3)	(10,266,904)	(6,152,006)	(16,418,910)
Pima	(114.2)	(48.8)	(163.0)	(3,737,870)	(1,667,171)	(5,405,041)
Mohave	–	–	–	–	–	–
La Paz	(5.1)	(8.7)	(13.7)	(262,217)	(182,464)	(444,681)
Yuma	(1.7)	(2.5)	(4.1)	(61,811)	(60,955)	(122,765)
Graham	(28.4)	(29.9)	(58.3)	(1,768,847)	(769,189)	(2,538,036)
Total			(898.1)			(35,237,258)

Table H-74
Estimated Change In Employment and Income as a Result of a
2,500,000 af Shortage to Indian Agricultural Lands in Arizona—2027

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	(177.3)	(208.0)	(385.3)	(10,860,490)	(6,605,440)	(17,465,930)
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Graham	–	–	–	–	–	–
Total			(385.3)			(17,465,930)

H.4.5 2040 Tables

Table H-75
Estimated Change In Employment and Income as a Result of a
400,000 af shortage to Non-Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Total			–			–

Table H-76
Estimated Change In Employment and Income as a Result of a
500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(7.1)	(1.3)	(8.4)	(104,172)	(37,926)	(142,098)
La Paz	(7.7)	(4.1)	(11.8)	(241,539)	(91,819)	(333,358)
Yuma	(10.6)	(10.8)	(21.3)	(301,962)	(273,283)	(575,246)
Total			(41.5)			(1,050,702)

Table H-77
Estimated Change In Employment and Income as a Result of a
600,000 af shortage to Non-Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(15.6)	(4.9)	(20.4)	(406,137)	(144,948)	(551,085)
La Paz	(9.3)	(4.9)	(14.2)	(289,847)	(110,093)	(400,030)
Yuma	(12.4)	(14.6)	(27.0)	(378,350)	(367,249)	(745,599)
Total			(61.6)			(1,696,714)

Table H-78
Estimated Change In Employment and Income as a Result of a
800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(24.2)	(6.4)	(30.6)	(531,995)	(190,768)	(722,763)
La Paz	(11.8)	(9.6)	(21.4)	(413,356)	(207,314)	(620,670)
Yuma	(16.1)	(22.2)	(38.3)	(531,230)	(555,310)	(1,086,540)
Total			(90.3)			(2,429,973)

Table H-79
Estimated Change In Employment and Income as a Result of a
1,000,000 af shortage to Non-Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(31.6)	(8.7)	(40.2)	(696,252)	(254,679)	(950,931)
La Paz	(14.0)	(15.4)	(29.4)	(547,343)	(327,983)	
Yuma	(18.2)	(26.3)	(44.5)	(657,960)	(659,535)	(1,317,495)
Total			(114.1)			(2,268,426)

Table H-80
Estimated Change In Employment and Income as a Result of a
1,200,000 af shortage to Non-Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(37.1)	(11.8)	(49.0)	(916,762)	(345,084)	(1,261,847)
La Paz	(16.2)	(21.3)	(37.5)	(681,331)	(448,653)	(1,129,984)
Yuma	(22.2)	(28.4)	(50.6)	(761,626)	(720,450)	(1,482,076)
Total			(137.1)			(3,873,907)

Table H-81
Estimated Change In Employment and Income as a Result of a
1,800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(51.5)	(19.9)	(71.5)	(1,483,975)	(577,632)	(2,061,607)
La Paz	(21.9)	(28.9)	(7.5)	(1,025,900)	(758,971)	(1,784,871)
Yuma	(68.5)	(50.3)	(118.9)	(1,775,831)	(1,328,257)	(3,104,088)
Total			(197.9)			(6,950,566)

Table H-82
Estimated Change In Employment and Income as a Result of a
2,500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Total			–			–

Table H-83
Estimated Change In Employment and Income as a Result of a
400,000 af Shortage to Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Graham	–	–	–	–	–	–
Total			–			–

Table H-84
Estimated Change In Employment and Income as a Result of a
500,000 af Shortage to Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(69.0)	(18.5)	(87.5)	(1,235,215)	(678,772)	(1,913,987)
Pinal	(19.1)	(10.7)	(29.8)	(896,598)	(345,674)	(1,242,272)
Pima	(45.7)	(12.3)	(58.1)	(975,834)	(420,675)	(1,396,509)
Mohave	–	–	–	–	–	–
La Paz	(2.0)	(1.1)	(3.1)	(63,330)	(24,075)	(87,405)
Yuma	(0.6)	(0.3)	(0.9)	(13,888)	(8,324)	(22,212)
Graham	–	–	–	–	–	–
Total			(179.4)			(4,662,385)

Table H-85
Estimated Change In Employment and Income as a Result of a
600,000 af Shortage to Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(84.7)	(22.7)	(107.4)	(1,516,265)	(833,215)	(2,349,480)
Pinal	(73.0)	(36.8)	(109.8)	(3,043,470)	(1,187,012)	(4,230,483)
Pima	(46.2)	(12.7)	(59.0)	(1,005,255)	(433,006)	(1,438,262)
Mohave	–	–	–	–	–	–
La Paz	(2.3)	(1.8)	(4.1)	(80,545)	(39,106)	(119,651)
Yuma	(0.7)	(0.5)	(1.2)	(18,023)	(13,279)	(31,303)
Graham	(6.4)	(2.9)	(9.3)	(260,722)	(72,379)	(333,100)
Total			(290.8)			(8,502,279)

Table H-86
Estimated Change In Employment and Income as a Result of a
800,000 af Shortage to Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(104.5)	(31.3)	(135.8)	(2,128,862)	(1,152,573)	(3,281,435)
Pinal	(80.9)	(47.7)	(128.5)	(4,014,939)	(1,539,774)	(5,554,712)
Pima	(54.9)	(17.9)	(72.7)	(1,405,305)	(608,135)	(2,013,440)
Mohave	–	–	–	–	–	–
La Paz	(2.9)	(3.3)	(6.3)	(115,676)	(70,745)	(186,421)
Yuma	(0.9)	(1.0)	(1.9)	(26,452)	(23,648)	(50,099)
Graham	(12.6)	(5.9)	(18.5)	(524,732)	(145,689)	(670,422)
Total			(363.7)			(11,756,529)

Table H-87
Estimated Change In Employment and Income as a Result of a
1,000,000 af Shortage to Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(119.1)	(45.1)	(164.2)	(2,956,109)	(1,637,710)	(4,593,819)
Pinal	(95.4)	(71.0)	(166.4)	(5,197,954)	(2,279,888)	(7,477,842)
Pima	(68.1)	(24.8)	(92.8)	(1,924,626)	(843,918)	(2,768,544)
Mohave	–	–	–	–	–	–
La Paz	(3.5)	(4.9)	(8.4)	(150,858)	(102,430)	(253,288)
Yuma	(1.1)	(1.4)	(2.5)	(34,880)	(34,016)	(68,896)
Graham	(14.4)	(8.5)	(22.9)	(774,904)	(215,575)	(990,478)
Total			(457.2)			(16,152,867)

Table H-88
Estimated Change In Employment and Income as a Result of a
1,200,000 af Shortage to Indian Agricultural Lands in Arizona—2040

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(137.9)	(62.6)	(200.5)	(3,917,340)	(2,242,161)	(6,159,500)
Pinal	(114.7)	(103.3)	(218.0)	(6,534,059)	(3,300,524)	(9,834,583)
Pima	(81.3)	(31.7)	(113.0)	(2,443,947)	(1,079,701)	(3,523,648)
Mohave	–	–	–	–	–	–
La Paz	(4.1)	(6.5)	(10.5)	(185,989)	(134,069)	(320,058)
Yuma	(1.3)	(1.8)	(3.1)	(43,309)	(44,384)	(87,693)
Graham	(18.2)	(14.4)	(32.6)	(1,051,854)	(366,544)	(1,418,397)
Total			(577.7)			(21,343,879)

Table H-89
Estimated Change In Employment and Income as a Result of a
1,800,000 af Shortage to Indian Agricultural Lands in Arizona—2040

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	(186.2)	(107.6)	(293.7)		(6,387,059)	(3,795,193)	(10,182,252)
Pinal	(165.5)	(188.3)	(353.7)		(10,044,268)	(4,036,616)	(16,026,204)
Pima	(114.5)	(48.9)	(163.5)		(3,748,622)	(1,672,053)	(5,420,675)
Mohave	–	–	–		–	–	–
La Paz	(5.1)	(8.7)	(13.7)		(262,217)	(182,464)	(444,681)
Yuma	(1.7)	(2.5)	(4.1)		(61,811)	(60,955)	(122,765)
Graham	(28.0)	(29.3)	(57.3)		(1,740,302)	(753,159)	(2,493,462)
Total			(886.0)				(34,690,039)

Table H-90
Estimated Change In Employment and Income as a Result of a
2,500,000 af Shortage to Indian Agricultural Lands in Arizona—2040

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Pima	–	–	–		–	–	–
Mohave	–	–	–		–	–	–
La Paz	–	–	–		–	–	–
Yuma	–	–	–		–	–	–
Graham	–	–	–		–	–	–
Total			–				–

H.4.6 2060 Tables

Table H-91
Estimated Change In Employment and Income as a Result of a
400,000 af shortage to Non-Indian Agricultural Lands in Arizona—2060

	Employment				Income		
County	Direct	Indirect + Induced	Total		Direct	Indirect + Induced	Total
Maricopa	–	–	–		–	–	–
Pinal	–	–	–		–	–	–
Mohave	–	–	–		–	–	–
La Paz	–	–	–		–	–	–
Yuma	–	–	–		–	–	–
Total			–				–

Table H-92
Estimated Change In Employment and Income as a Result of a
500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(11.8)	(4.2)	(16.0)	(350,645)	(124,748)	(475,393)
La Paz	(7.7)	(4.1)	(11.8)	(241,539)	(91,279)	(332,818)
Yuma	(10.6)	(10.8)	(21.4)	(301,962)	(273,283)	(575,245)
Total			(49.2)			(1,383,456)

Table H-93
Estimated Change In Employment and Income as a Result of a
600,000 af shortage to Non-Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	(415,036)	(148,187)	(563,223)
Mohave	(16.2)	(5.0)	(21.2)	(289,847)	(110,183)	(400,030)
La Paz	(9.3)	(4.9)	(14.2)	(378,350)	(367,249)	(745,599)
Yuma	(12.4)	(14.6)	(27.0)	–	–	–
Total			(62.4)			(1,708,852)

Table H-94
Estimated Change In Employment and Income as a Result of a
800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(25.0)	(6.6)	(31.6)	(543,836)	(195,079)	(738,915)
La Paz	(11.8)	(9.6)	(21.4)	(413,356)	(207,314)	(620,670)
Yuma	(16.1)	(22.2)	(38.3)	(531,230)	(555,310)	(1,086,540)
Total			(91.3)			(2,446,125)

Table H-95
Estimated Change In Employment and Income as a Result of a
1,000,000 af shortage to Non-Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(32.2)	(9.0)	(41.2)	(722,224)	(265,327)	(987,551)
La Paz	(14.0)	(8.0)	(22.0)	(547,343)	(142,499)	(689,842)
Yuma	(18.2)	(26.3)	(44.5)	(657,960)	(659,536)	(1,317,496)
Total			(107.7)			(2,994,889)

Table H-96
Estimated Change In Employment and Income as a Result of a
1,200,000 af shortage to Non-Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(37.2)	(12.2)	(49.4)	(947,953)	(357,871)	(1,305,824)
La Paz	(16.2)	(21.3)	(37.5)	(681,331)	(448,653)	(1,129,984)
Yuma	(22.2)	(28.4)	(50.6)	(761,626)	(720,450)	(1,482,076)
Total			(137.5)			(3,917,884)

Table H-97
Estimated Change In Employment and Income as a Result of a
1,800,000 af shortage to Non-Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	(52.7)	(20.6)	(73.3)	(1,528,524.0)	(595,897.0)	(2,124,421.0)
La Paz	(21.9)	(36.4)	(58.3)	(1,025,900.0)	(758,971.0)	(1,784,871.0)
Yuma	(34.2)	(53.9)	(88.1)	(1,267,421.0)	(1,342,636.0)	(2,610,057.0)
Total			(219.7)			(6,519,349.0)

Table H-98
Estimated Change In Employment and Income as a Result of a
2,500,000 af shortage to Non-Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Total			–			–

Table H-99
Estimated Change In Employment and Income as a Result of a
400,000 af Shortage to Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Other	–	–	–	–	–	–
Total			–			–

Table H-100
Estimated Change In Employment and Income as a Result of a
500,000 af Shortage to Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(75.1)	(20.2)	(95.3)	(1,345,861)	(739,575)	(2,085,436)
Pinal	(71.2)	(34.4)	(105.6)	(2,825,865)	(1,107,996)	(3,933,861)
Pima	(72.7)	(27.2)	(99.9)	(2,104,798)	(925,720)	(3,030,518)
Mohave	–	–	–	–	–	–
La Paz	(2.0)	(1.1)	(3.1)	(63,330)	(24,075)	(87,405)
Yuma	(0.6)	(0.3)	(0.9)	(13,888)	(8,324)	(22,212)
Other	–	–	–	–	–	–
Total			(304.8)			(9,159,432)

Table H-101
Estimated Change In Employment and Income as a Result of a
600,000 af Shortage to Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(90.9)	(24.4)	(115.3)	(1,628,342)	(894,803)	(2,523,145)
Pinal	(74.8)	(39.3)	(114.1)	(3,265,146)	(1,267,508)	(4,532,654)
Pima	(60.2)	(20.6)	(80.8)	(1,613,510)	(702,664)	(2,316,174)
Mohave	–	–	–	–	–	–
La Paz	(2.3)	(1.8)	(4.1)	(80,545)	(39,106)	(119,651)
Yuma	(0.7)	(0.5)	(1.2)	(18,023)	(13,279)	(31,302)
Other	(6.6)	(3.1)	(9.7)	(269,819)	(74,904)	(344,723)
Total			(325.2)			(9,867,649)

Table H-102
Estimated Change In Employment and Income as a Result of a
800,000 af Shortage to Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(106.2)	(33.0)	(139.2)	(2,249,239)	(1,212,637)	(3,461,876)
Pinal	(103.9)	(85.2)	(189.1)	(5,787,580)	(2,730,297)	(8,517,877)
Pima	(87.5)	(34.8)	(122.3)	(2,686,864)	(1,189,991)	(3,876,855)
Mohave	–	–	–	–	–	–
La Paz	(2.9)	(3.3)	(6.2)	(115,676)	(70,745)	(186,421)
Yuma	(0.9)	(6.7)	(7.6)	(26,452)	(23,648)	(50,100)
Graham	(12.7)	(6.0)	(18.7)	(531,758)	(147,652)	(679,410)
Total			(483.1)			(16,772,539)

Table H-103
Estimated Change In Employment and Income as a Result of a
1,000,000 af Shortage to Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(122.6)	(48.3)	(170.9)	(3,132,285)	(1,748,494)	(4,880,779)
Pinal	(99.6)	(77.9)	(177.5)	(5,486,375)	(2,500,209)	(7,986,584)
Pima	(100.6)	(41.7)	(142.3)	(3,203,651)	(1,424,624)	(4,628,275)
Mohave	–	–	–	–	–	–
La Paz	(3.5)	(4.9)	(8.4)	(150,858)	(102,430)	(253,288)
Yuma	(1.1)	(1.4)	(2.5)	(34,880)	(34,016)	(68,896)
Graham	(14.3)	(8.5)	(22.8)	(770,878)	(214,450)	(985,328)
Total			(524.4)			(18,803,150)

Table H-104
Estimated Change In Employment and Income as a Result of a
1,200,000 af Shortage to Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(141.2)	(65.7)	(206.9)	(4,085,643)	(2,347,995)	(6,433,638)
Pinal	(118.8)	(25.5)	(144.3)	(6,814,222)	(3,514,537)	(10,328,759)
Pima	(113.7)	(48.5)	(162.2)	(3,718,977)	(1,658,594)	(5,377,571)
Mohave	–	–	–	–	–	–
La Paz	(4.1)	(6.4)	(10.5)	(185,529)	(133,655)	(319,184)
Yuma	(1.3)	(1.8)	(3.1)	(43,309)	(44,384)	(87,693)
Graham	(18.3)	(14.4)	(32.7)	(1,056,299)	(369,040)	(1,425,339)
Total			(559.7)			(23,972,184)

Table H-105
Estimated Change In Employment and Income as a Result of a
1,800,000 af Shortage to Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	(189.2)	(110.4)	(299.6)	(6,542,468)	(3,892,919)	(10,435,387)
Pinal	(165.9)	(189.0)	(354.9)	(10,073,907)	(6,004,577)	(16,078,484)
Pima	(147.5)	(66.2)	(213.7)	(5,046,232)	(1,721,196)	(6,767,428)
Mohave	–	–	–	–	–	–
La Paz	(5.1)	(8.7)	(13.8)	(262,217)	(182,464)	(444,681)
Yuma	(1.7)	(2.5)	(4.2)	(61,811)	(60,955)	(122,766)
Graham	(28.4)	(29.9)	(58.3)	(1,768,847)	(769,189)	(2,538,036)
Total			(944.5)			(36,386,782)

Table H-106
Estimated Change In Employment and Income as a Result of a
2,500,000 af Shortage to Indian Agricultural Lands in Arizona—2060

	Employment			Income		
County	Direct	Indirect + Induced	Total	Direct	Indirect + Induced	Total
Maricopa	–	–	–	–	–	–
Pinal	–	–	–	–	–	–
Pima	–	–	–	–	–	–
Mohave	–	–	–	–	–	–
La Paz	–	–	–	–	–	–
Yuma	–	–	–	–	–	–
Other	–	–	–	–	–	–
Total			–			–

H.5 County Level Changes in Tax Revenue

H.5.1 Summary Tables

Table H-107
Estimated Changes in Tax Impacts as a Result of Shortages to
Non-Indian Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
400,000	(7,213,564)	(1,722,361)	–	–	–
500,000	(437,924)	(438,154)	(1,110,476)	(344,954)	(455,037)
600,000	(538,788)	(541,687)	(544,095)	(557,703)	(561,917)
800,000	(771,551)	(776,056)	(779,352)	(798,450)	(804,058)
1,000,000	(2,654,659)	(1,001,855)	(1,005,597)	(1,031,937)	(1,043,631)
1,200,000	–	–	(1,237,258)	(1,268,309)	(1,282,352)
1,800,000	–	(2,188,778)	(2,196,425)	(2,268,392)	(2,118,131)
2,500,000	–	–	(4,231,429)	–	–

Table H-108
Estimated Changes in Tax Impacts as a Result of Shortages to
Indian Agricultural Lands for Selected Shortage Amounts and Years

Shortage Amount (af)	Year				
	2017	2026	2027	2040	2060
400,000	(55,469)	(1,338,754)	–	–	–
500,000	(213,626)	(2,131,417)	(2,408,201)	(1,632,162)	(3,174,113)
600,000	(1,180,482)	(2,107,217)	(2,527,297)	(2,143,983)	(3,434,743)
800,000	(2,457,060)	(3,639,707)	(4,091,848)	(2,937,735)	(5,783,285)
1,000,000	(3,366,673)	(4,876,591)	(5,564,650)	(3,987,999)	(6,432,090)
1,200,000	–	–	(7,356,110)	(5,236,042)	(8,167,047)
1,800,000	–	(10,318,168)	(11,968,736)	(8,446,512)	(12,514,450)
2,500,000	–	–	6,045,388	–	–

H.5.2 2017 Tables

Table H-109
Estimated Change In Tax Impact as a Result of a 400,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2017

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	(1,634,293)	–
Pinal	(5,245,667)	(4,579)
Mohave	(126,374)	–
La Paz	(87,118)	(22,882)
Yuma	(120,112)	(5,763)
Pima	–	(22,245)
Graham	–	–
Total	(7,213,564)	(55,469)

Table H-110
Estimated Change In Tax Impact as a Result of a 500,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2017

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	(30,382)
Mohave	(156,224)	–
La Paz	(108,893)	(28,603)
Yuma	(172,807)	(7,208)
Pima	–	(147,433)
Graham	–	–
Total	(437,924)	(213,626)

Table H-111
Estimated Change In Tax Impact as a Result of a 600,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2017

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(870,312)
Pinal	–	(58,330)
Mohave	(186,091)	–
La Paz	(130,668)	(38,827)
Yuma	(222,029)	(9,979)
Pima	–	(203,034)
Graham	–	–
Total	(538,788)	(1,180,482)

Table H-112
Estimated Change In Tax Impact as a Result of a 800,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2017

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(979,290)
Pinal	–	(799,566)
Mohave	(245,808)	–
La Paz	(200,875)	(60,497)
Yuma	(324,868)	(15,942)
Pima	–	(403,561)
Graham	–	(198,204)
Total	(771,551)	(2,457,060)

Table H-113
Estimated Change In Tax Impact as a Result of a 1,000,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2017

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	(1,641,195)	(924,872)
Pinal	–	(1,492,502)
Mohave	(322,103)	–
La Paz	(283,315)	(82,155)
Yuma	(408,046)	(21,867)
Pima	–	(529,597)
Graham	–	(315,680)
Total	(2,654,659)	(3,366,673)

Table H-114
Estimated Change In Tax Impact as a Result of a 1,200,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2017

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Pima	–	–
Graham	–	–
Total	–	–

Table H-115
Estimated Change In Tax Impact as a Result of a 1,800,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2017

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Pima	–	–
Graham	–	–
Total	–	–

Table H-116
Estimated Change In Tax Impact as a Result of a 2,500,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2017

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Pima	–	–
Graham	–	–
Total	–	–

H.5.3 2026 Tables

Table H-117
Estimated Change In Tax Impact as a Result of a 400,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2026

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	(339,878)	(316,809)
Pinal	(1,047,882)	(592,337)
Mohave	(121,169)	–
La Paz	(87,487)	(22,950)
Yuma	(125,945)	(5,781)
Pima	–	(400,877)
Graham	–	–
Total	(1,722,361)	(1,338,754)

Table H-118
Estimated Change In Tax Impact as a Result of a 500,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2026

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(546,627)
Pinal	–	(1,035,321)
Mohave	(149,727)	–
La Paz	(109,346)	(28,687)
Yuma	(179,081)	(7,227)
Pima	–	(450,724)
Graham	–	(62,831)
Total	(438,154)	(2,131,417)

Table H-119
Estimated Change In Tax Impact as a Result of a 600,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2026

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(701,258)
Pinal	–	(1,270,159)
Mohave	(178,284)	–
La Paz	(131,222)	(39,029)
Yuma	(232,181)	(10,055)
Pima	–	–
Graham	–	(86,716)
Total	(541,687)	(2,107,217)

Table H-120
Estimated Change In Tax Impact as a Result of a 800,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2026

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(1,012,808)
Pinal	–	(1,723,528)
Mohave	(235,399)	–
La Paz	(202,240)	(60,783)
Yuma	(338,417)	(16,018)
Pima	–	(607,581)
Graham	–	(218,989)
Total	(776,056)	(3,639,707)

Table H-121
Estimated Change In Tax Impact as a Result of a 1,000,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2026

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(1,351,393)
Pinal	–	(2,230,885)
Mohave	(300,395)	–
La Paz	(285,030)	(82,504)
Yuma	(416,430)	(21,981)
Pima	–	(857,748)
Graham	–	(332,080)
Total	(1,001,855)	(4,876,591)

Table H-122
Estimated Change In Tax Impact as a Result of a 1,200,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2026

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Pima	–	–
Graham	–	–
Total	–	–

Table H-123
Estimated Change In Tax Impact as a Result of a 1,800,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2026

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(3,122,636)
Pinal	–	(5,246,624)
Mohave	(645,068)	–
La Paz	(584,879)	(145,867)
Yuma	(958,831)	(39,454)
Pima	–	(1,763,587)
Graham	–	–
Total	(2,188,778)	(10,318,168)

Table H-124
Estimated Change In Tax Impact as a Result of a 2,500,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2026

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Pima	–	–
Graham	–	–
Total	–	–

H.5.4 2027 Tables

Table H-125
Estimated Change In Tax Impact as a Result of a 400,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2027

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Pima	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Graham	–	–
Total	–	–

Table H-126
Estimated Change In Tax Impact as a Result of a 500,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2027

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	(164,172)	(695,121)
Pinal	(506,141)	(1,300,601)
Pima	–	(310,582)
Mohave	(150,365)	–
La Paz	(109,396)	(28,704)
Yuma	(180,402)	(7,227)
Graham	–	(65,966)
Total	(1,110,476)	(2,408,201)

Table H-127
Estimated Change In Tax Impact as a Result of a 600,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2027

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(846,459)
Pinal	–	(1,517,466)
Pima	–	–
Mohave	(179,040)	–
La Paz	(131,289)	(49,922)
Yuma	(233,766)	(10,055)
Graham	–	(103,395)
Total	(544,095)	(2,527,297)

Table H-128
Estimated Change In Tax Impact as a Result of a 800,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2027

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(1,164,776)
Pinal	–	(1,979,888)
Pima	–	(649,082)
Mohave	(236,423)	–
La Paz	(202,399)	(60,814)
Yuma	(340,530)	(15,999)
Graham	–	(221,289)
Total	(779,352)	(4,091,848)

Table H-129
Estimated Change In Tax Impact as a Result of a 1,000,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2027

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(1,592,240)
Pinal	–	(2,635,631)
Pima	–	(898,373)
Mohave	(302,521)	–
La Paz	(285,253)	(82,536)
Yuma	(417,823)	(21,981)
Graham	–	(333,889)
Total	(1,005,597)	(5,564,650)

Table H-130
Estimated Change In Tax Impact as a Result of a 1,200,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2027

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(2,083,555)
Pinal	–	(3,500,758)
Pima	–	(1,147,626)
Mohave	(398,138)	–
La Paz	(368,106)	(104,258)
Yuma	(471,014)	(27,943)
Graham	–	(491,970)
Total	(1,237,258)	(7,356,110)

Table H-131
Estimated Change In Tax Impact as a Result of a 1,800,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2027

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(3,373,195)
Pinal	–	(5,684,551)
Pima	–	(1,800,226)
Mohave	(648,453)	–
La Paz	(585,006)	(145,867)
Yuma	(962,966)	(39,454)
Graham	–	(925,443)
Total	(2,196,425)	(11,968,736)

Table H-132
Estimated Change In Tax Impact as a Result of a 2,500,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2027

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	(6,045,388)
Pima	–	–
Mohave	–	–
La Paz	–	–
Yuma	(4,231,429)	–
Graham	–	–
Total	(4,231,429)	(6,045,388)

H.5.5 2040 Tables

Table H-133
Estimated Change In Tax Impact as a Result of a 400,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2040

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Pima	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Graham	–	–
Total	–	–

Table H-134
Estimated Change In Tax Impact as a Result of a 500,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2040

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(676,845)
Pinal	–	(434,037)
Pima	–	(485,162)
Mohave	(49,331)	–
La Paz	(110,050)	(28,855)
Yuma	(185,573)	(7,263)
Graham	–	–
Total	(344,954)	(1,632,162)

Table H-135
Estimated Change In Tax Impact as a Result of a 600,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2040

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(830,848)
Pinal	–	(1,480,457)
Pima	–	(499,206)
Mohave	(185,688)	–
La Paz	(132,060)	(39,410)
Yuma	(239,955)	(10,168)
Graham	–	(114,742)
Total	(557,703)	(2,143,983)

Table H-136
Estimated Change In Tax Impact as a Result of a 800,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2040

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(1,150,048)
Pinal	–	(1,939,434)
Pima	–	(689,881)
Mohave	(245,287)	–
La Paz	(204,368)	(61,259)
Yuma	(348,795)	(16,169)
Graham	–	(230,992)
Total	(798,450)	(2,937,735)

Table H-137
Estimated Change In Tax Impact as a Result of a 1,000,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2040

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(1,571,219)
Pinal	–	(2,603,172)
Pima	–	(937,088)
Mohave	(320,984)	–
La Paz	(287,698)	(83,139)
Yuma	(423,255)	(22,169)
Graham	–	(342,431)
Total	(1,031,937)	(3,987,999)

Table H-138
Estimated Change In Tax Impact as a Result of a 1,200,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2040

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(2,064,974)
Pinal	–	(3,415,381)
Pima	–	(1,184,294)
Mohave	(420,266)	–
La Paz	(371,028)	(104,988)
Yuma	(477,015)	(28,170)
Graham	–	(503,209)
Total	(1,268,309)	(5,236,042)

Table H-139
Estimated Change In Tax Impact as a Result of a 1,800,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2040

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(3,333,595)
Pinal	–	(5,549,212)
Pima	–	(1,805,345)
Mohave	(675,644)	–
La Paz	(585,324)	(145,867)
Yuma	(1,007,424)	(37,454)
Graham	–	(908,634)
Total	(2,268,392)	(8,446,512)

Table H-140
Estimated Change In Tax Impact as a Result of a 2,500,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2040

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Pima	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Graham	–	–
Total	–	–

H.5.6 2060 Tables

Table H-141
Estimated Change In Tax Impact as a Result of a 400,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2060

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pima	–	–
Pinal	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Graham	–	–
Total	–	–

Table H-142
Estimated Change In Tax Impact as a Result of a 500,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2060

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(737,474)
Pinal	–	(1,377,668)
Pima	–	(1,022,853)
Mohave	(159,414)	–
La Paz	(110,050)	(28,855)
Yuma	(185,573)	(7,263)
Graham	–	–
Total	(455,037)	(3,174,113)

Table H-143
estimated Change In Tax Impact as a Result of a 600,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2060

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(892,261)
Pinal	–	(1,585,169)
Pima	–	(788,990)
Mohave	(189,902)	–
La Paz	(132,060)	(39,410)
Yuma	(239,955)	(10,168)
Graham	–	(118,745)
Total	(561,917)	(3,434,743)

Table H-144
Estimated Change In Tax Impact as a Result of a 800,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2060

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(1,210,206)
Pinal	–	(2,961,601)
Pima	–	(1,299,928)
Mohave	(250,895)	–
La Paz	(204,368)	(61,259)
Yuma	(348,795)	(16,169)
Graham	–	(234,122)
Total	(804,058)	(5,783,285)

Table H-145
Estimated Change In Tax Impact as a Result of a 1,000,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2060

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(1,661,715)
Pinal	–	(2,778,501)
Pima	–	(1,545,928)
Mohave	(332,678)	–
La Paz	(287,698)	(83,139)
Yuma	(423,255)	(22,169)
Graham	–	(340,638)
Total	(1,043,631)	(6,432,090)

Table H-146
Estimated Change In Tax Impact as a Result of a 1,200,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2060

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(2,151,427)
Pinal	–	(3,585,689)
Pima	–	(1,791,233)
Mohave	(434,309)	–
La Paz	(371,028)	(104,702)
Yuma	(477,015)	(28,170)
Graham	–	(505,826)
Total	(1,282,352)	(8,167,047)

Table H-147
Estimated Change In Tax Impact as a Result of a 1,800,000 af shortage to Non-Indian and Indian Agricultural Lands in Arizona—2060

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	(3,413,424)
Pinal	–	(5,567,230)
Pima	–	(2,423,032)
Mohave	(695,702)	–
La Paz	(585,324)	(145,867)
Yuma	(837,105)	(39,454)
Graham	–	(925,443)
Total	(2,118,131)	(12,514,450)

Table H-148
Estimated Change In Tax Impact as a Result of a 2,500,000 af
shortage to Non-Indian and Indian Agricultural Lands in Arizona—2060

County	Non-Indian Agricultural Land Total	Indian Agricultural Lands Total
Maricopa	–	–
Pinal	–	–
Pima	–	–
Mohave	–	–
La Paz	–	–
Yuma	–	–
Graham	–	–
Total	–	–

Appendix I

Public Outreach, Coordination and Consultation Efforts

This appendix provides documentation of the public outreach, coordination, and consultation efforts undertaken by Reclamation with regard to the preparation of this Draft EIS and the proposed federal action. Reclamation discussed the development of the proposed federal action with various agencies and organizations at (1) agency/organization regular meetings, (2) public conferences and events sponsored by the agency/organizations, and (3) meetings sponsored by Reclamation. The entities included the Basin States' water resource departments, water agencies within these states, contractors and associations for federal hydropower, and non-governmental organizations. Reclamation also consulted with Indian tribes and Mexico. The coordination activities with each agency, entity or group are summarized in Chapter 6.

Table of Contents

List of Tables

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1 # I.1 Public Outreach, Coordination and Consultation Efforts

Table I-1
Consultation and Coordination Regarding the EIS

Agency or Organization Invited to or Requesting Meetings	Meeting Dates
Federal Agencies	
National Oceanographic and Atmospheric Administration	Various planning meetings
Bureau of Indian Affairs – Cooperating Agency	Various plan formulation and evaluation meetings
Fish and Wildlife Service– Cooperating Agency	Various plan formulation and evaluation meetings
National Park Service - Cooperating Agency	Various plan formulation and evaluation meetings
U.S. Department of State	Various planning meetings
U.S. Section of the International Boundary and Water Commission – Cooperating Agency	Various plan formulation and evaluation meetings;
Western Area Power Administration– Cooperating Agency	Various plan formulation and evaluation meetings
State And Local Water And Power Agencies	
Arizona Department of Water Resources	3/27/06, 4/13/06, 4/24/06, 5/15/06, 6/7/06, 6/16/06, 8/22/06, 10/31/06
California Department of Water Resources	3/27/06, 4/13/06
Coachella Valley Water District	3/27/06, 4/13/06
Colorado Department of Natural Resources	3/27/06, 4/13/06, 4/24/06, 5/15/06, 6/7/06, 6/16/06, 8/22/06, 10/31/06
Colorado River Board of California	3/27/06, 4/13/06, 4/24/06, 5/15/06, 6/7/06, 6/16/06, 8/22/06, 10/31/06
Colorado River Commission of Nevada	3/27/06, 4/13/06, 4/24/06, 5/15/06, 6/7/06, 6/16/06, 8/22/06, 10/31/06
Colorado River Energy Distributors Association	4/24/06, 5/15/06, 6/7/06, 6/16/06, 10/31/06
Colorado Water Conservation Board	3/27/06, 4/13/06, 8/22/06
Imperial Irrigation District	3/27/06, 4/13/06, 6/16/06
Las Vegas Valley Water District	3/27/06, 4/13/06, 4/24/06, 5/15/06, 6/7/06, 6/16/06, 8/22/06, 10/31/06
Metropolitan Water District, California	3/27/06, 4/13/06, 4/18/06, 4/24/06, 5/15/06, 6/7/06, 6/16/06, 8/22/06, 10/31/06
Nevada Department of Justice	6/16/06
New Mexico Interstate Stream Commission	3/27/06, 4/13/06, 4/24/06, 5/15/06, 8/22/06
Office of the State Engineer, Wyoming	3/27/06, 4/13/06, 4/24/06, 5/15/06, 6/7/06, 8/22/06, 10/31/06
Palo Verde Irrigation District	3/27/06, 4/13/06
San Diego County Water Authority	3/27/06, 4/13/06
Southern Nevada Water Authority	4/13/06, 6/16/06
Upper Colorado River Commission	3/27/06, 4/24/06, 5/15/06, 6/16/06
Utah Attorney General's Office	4/13/06
Utah Division of Water Resources	3/27/06,4/13/06, 4/24/06, 5/15/06, 6/7/06, 6/16/06, 8/22/06
Wyoming Water Association	6/7/06
Non-Governmental Environmental Organizations	
Defenders of Wildlife	5/8/06, 4/28/06, 6/9/06, 6/14/06, 6/16/06,10/19/06, 11/16/06, 11/19/06
Environmental Defense	5/8/06, 4/28/06, 6/9/06, 6/14/06, 6/16/06, 10/19/06, 11/16/06, 11/19/06

Table I-1
Consultation and Coordination Regarding the EIS

Agency or Organization Invited to or Requesting Meetings	Meeting Dates
Living Rivers	5/8/06, 4/28/06, 6/9/06, 6/14/06, 6/16/06, 11/16/06, 11/19/06
National Wildlife Federation	5/8/06, 4/28/06, 6/9/06, 6/14/06, 6/16/06, 10/19/06, 11/16/06, 11/19/06
Nature Conservancy in Arizona	5/8/06, 4/28/06, 6/9/06, 6/14/06, 6/18/06, 10/19/06, 11/16/06, 11/19/06
Pacific Institute	5/8/06, 4/28/06, 6/9/06, 6/14/06, 6/16/06, 10/19/06, 11/16/06, 11/19/06
Sierra Club	5/8/06, 4/28/06, 6/9/06, 6/14/06, 6/16/06
Sonoran Institute	11/19/06
Utah Water & Sierra Club Southwest Water Committee	10/19/06, 11/16/06, 11/19/06
United Mexican States Agencies	
National Water Commission	2/8/06, 6/23/06, 9/25-29/06
International Boundary and Water Commission, Mexican Section	2/8/06, 6/23/06, 9/25-29/06
Secretariat of Foreign Relations	2/8/06, 6/23/06

Table I-2
Conferences and Events Regarding the Draft EIS

Date	Event Name	Organizer	Purpose
March 25-26, 2006	Guides Training Seminar (GTS)	Grand Canyon River Guides (GCRG)	To give a presentation on Glen Canyon Dam operations and Colorado River Basin hydrology
May 3-5, 2006	APWA Spring Conference	Michele Ruemler	Provide a forum for the development and exchange of ideas, information and technology which enhances the delivery of public services
May 24-25, 2006	Glen Canyon Dam Technical Work Group Meeting	Linda Whetton	To inform, discuss and take possible action
June 20-21, 2006	Arizona Water Conference	CLE	Colorado River Issues
July 4-7, 2006	India Workshop	Balaji Rajagopalan	To share research experiences and expertise in laying a foundation for a sustained collaboration with India on a topic of water resources management
March 2005	RiverWare User Group Meeting		
June 2005	NRLC Conference		
July 22, 2005	Arizona Colorado River Shortage Sharing Stakeholder Workshop	Arizona Department of Water Resources	To discuss Shortage Implementation in Arizona, to develop recommendations to the Director regarding Colorado River Shortage implementation criteria
October 2005	Colorado River Symposium		
October 2005	CLE		
October 31, 2005	NRC		
January 23, 2006	Water Expo 2006	Pamela Justice	To address the issue of conservation with an emphasis on Colorado River shortage sharing
March 1, 2006	Water Education Foundation Tour		Highlight key points: 1922 Colorado River Compact, US water deliveries to Mexico, Reclamation's water quantity and quality requirements, shortage criteria negotiations, Quantification Settlement Agreement

Table I-2
Conferences and Events Regarding the Draft EIS

Date	Event Name	Organizer	Purpose
March 20, 2006	Imperial Briefing		
April 5, 2006	Colorado River Fish and Wildlife Council Annual Meeting	Rod Stone	Present a brief plot on Lake Mead elevation, lower basin status on snowpack, shortage project, Management Strategies EIS, Lower Colorado operations and conditions
April 6, 2006	Federal Interagency Hydrologic Modeling Conference	The JFIC Committee	
April 7, 2006	Southwestern Water Conservation District 24th Annual Water Seminar		
May 3-5, 2006	2006 Arizona Water and Pollution Control Association Annual Conference	AWPCA	Present the state of the Colorado River System
June 16, 2006	2007 AOP Consult Meeting		Present draft project alternatives
June 26, 2006	IID Board Meeting	IID	Water Department Workshop
July 3-4, 2006	Environmentally Sustainable Water Resources Management Methodologies	Institute of Science and Technology Jawaharlal Nehru Technological University	Talk about river basin management, reservoir operations and stakeholder participation in water management
August 10, 2006	Counsel of State Governments West Colorado River Basin Forum Keynote		
September 12, 2006	East Valley Water Forum Quarterly Meeting	East Valley Water Forum	Update on the Colorado River, the management plan, and the drought planning efforts
September 18, 2006	Imperial Dam Advisory Board Meeting	Imperial Dam Advisory Board	Board Meeting
December 5-7, 2006	Tribal Lands Climate Conference	the Cocopah Indian Tribe & the National Wildlife Federation	To collect first-hand, on-the-ground accounts about the natural resources that have sustained changes due to carbon emissions and climate change related events

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I.2 December 23, 2005 Letter to CAP Tribes

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
BCOO-1000
ENV-6.00

DEC 23 2005

Honorable Raphael Bear
President, Ft. McDowell Yavapai Nation
P.O. Box 17779
Fountain Hills, AZ 85269

Subject: Request to Initiate Consultation on the Development of Lower Colorado River Basin (Lower Basin) Shortage Guidelines and Coordinated Management Strategies

Dear President Bear:

The Secretary of the Department of the Interior has recently directed the Bureau of Reclamation to develop Lower Basin shortage guidelines and coordinated management strategies for Lake Powell and Lake Mead under low reservoir conditions. Reclamation, in accordance with National Environmental Policy Act (NEPA) and Council on Environmental Quality regulations, has begun to prepare an Environmental Impact Statement (EIS) to address the proposed guidelines and strategies. A notice was published in the Federal Register on September 30, 2005, that announced the start of the scoping process and the intent to prepare an EIS (70 Federal Register 57322).

On behalf of the Department, we would like to initiate government-to-government consultation with the Ft. McDowell Yavapai Nation, in concert with the initiation of our NEPA process for this proposed action, to identify and consider potential impacts to any tribal trust resources as a result of the proposed action.

Mr. Rick Gold, Regional Director, Upper Colorado Region, and I respectfully request an opportunity to consult with you on these planned actions and discuss your interest and involvement in the NEPA process for this proposed action. To that end, we have arranged a meeting at Two Arizona Center, 400 North 5th Street, 12th Floor Conference Room A & B in Phoenix, Arizona, on January 27, 2006, from 10:00 a.m. to 12:00 noon.

Our staff will call your office during the next few weeks regarding this request. You may call Ms. Nan Yoder at 702-293-8495 or contact her by email at nyoder@lc.usbr.gov to discuss the consultation process or to confirm your availability for the meeting.

Sincerely,

Robert W. Johnson
Regional Director

Identical Letter Sent To:

Continued on next page.

Identical Letter Sent To:

Honorable Terry O. Enos
Chairperson, Ak-Chin Indian Community
42507 West Peters and Nall Road
Maricopa, AZ 85239-3940

Honorable Richard P. Narcia
Governor, Gila River Indian Community
P.O. Box 97
Sacaton, AZ 85247

Honorable Robert Valencia
Chairman, Pascua Yaqui Tribe
7474 South Camino de Oeste
Tucson, AZ 85746

Honorable Joni M. Ramos
President, Salt River Pima-Maricopa Indian Community
10005 E. Osborn Rd.
Scottsdale, AZ 85256

Honorable Kathleen Wesley-Kitcheyan
Chairwoman, San Carlos Apache Indian Tribe
P.O. Box "0"
San Carlos, AZ 85550

Honorable Vivian Juan-Saunders
Chairwoman, Tohono O'odham Nation
P.O. Box 837
Sells, AZ 85634-0837

Honorable Ivan Smith
Chairman, Tonto Apache Tribal Council
Tonto Apache Reservation No. 30
Payson, AZ 85541

Honorable Jamie Fullmer
Chairman, Yavapai-Apache Nation
2400 W. Datsi Street
Camp Verde, AZ 86322

bc: Mr. Bryan Bowker
Acting Regional Director
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

LC-1000, LC-1100, BCOO-1000, BCOO-1003, PXAO-1000, NAOO-1100, UC-100, UC-105, UC-402, UC-438, UC-700, UC-720

BCOO-1000-Chrono Daily WBR:NYoder:ms:12/22/05:8495
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1 # I.3 December 23, 2005 Letter to Ten Tribes

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

BCOO-1000
ENV-6.00

DEC 23 2005

Honorable Charles Wood
Chairman, Chemehuevi Indian Tribe
P.O. Box 1976
Havasu Lake, CA 92363-1976

Subject: Request to Initiate Consultation on the Development of Lower Colorado River Basin (Lower Basin) Shortage Guidelines and Coordinated Management Strategies

Dear Chairman:

The Secretary of the Department of the Interior has recently directed the Bureau of Reclamation to develop Lower Basin shortage guidelines and coordinated management strategies for Lake Powell and Lake Mead under low reservoir conditions. Reclamation, in accordance with National Environmental Policy Act (NEPA) and Council on Environmental Quality regulations, has begun to prepare an Environmental Impact Statement (EIS) to address the proposed guidelines and strategies. A notice was published in the Federal Register on September 30, 2005, that announced the start of the scoping process and the intent to prepare an EIS (70 Federal Register 57322).

On behalf of the Department, we would like to initiate government-to-government consultation with the Chemehuevi Indian Tribe, in concert with the initiation of our NEPA process for this proposed action, to identify and consider potential impacts to any tribal trust resources as a result of the proposed action.

Mr. Rick Gold, Regional Director, Upper Colorado Region, and I respectfully request an opportunity to consult with you on these planned actions and discuss your interest and involvement in the NEPA process for this proposed action. To that end, we have arranged a meeting at McCarran Airport, Las Vegas, Nevada, Rooms 4 and 5, on January 19, 2006, from 10:00 a.m. to 12:00 noon.

Our staff will call your office during the next few weeks regarding this request. You may call Ms. Nan Yoder at 702-293-8495 or contact her by email at nyoder@lc.usbr.gov to discuss the consultation process or to confirm your availability for the meeting.

Sincerely,

Robert W. Johnson
Regional Director

Identical Letter Sent To:

Continued on next page.

2

2

Identical Letter Sent To:

Honorable Sherry Cordova
Chairwoman, Cocopah Indian Tribe
West Founth 15th and Avenue G
Somerton, AZ 85350

Honorable Nora McDowell
Chairperson, Fort Mojave Indian Tribe
500 Merriman Avenue
Needles, CA 92363

Honorable Mike Jackson, Sr.
President, Quechan Indian Tribe
P.O. Box 1899
Yuma, AZ 85366

Honorable Clement Frost
Chairman, Southern Ute Indian Tribe
P.O. Box 737
Ignacio, CO 81137

Honorable Levi Pesata
President, Jicarilla Apache Nation
P.O. Box 507
Dulce, NM 87528

Honorable Daniel Eddy, Jr.
Chairman, Colorado River Indian Tribes
Route 1, Box 23-B
Parker, AZ 85344-9704

Honorable Joe Shirley, Jr.
President, Navajo Nation
P.O. Box 9000
Window Rock, AZ 86515

Honorable Maxine Natchees
Business Committee Chairwoman
Northern Ute Indian Tribe
P.O. Box 190
Fort Duchesne, UT 84026

Honorable Selwyn Whiteskunk
Chairman, Ute Mountain Ute Tribe
P.O. Box 248
Towaoc, CO 81334

bc: Mr. Bryan Bowker
Acting Regional Director
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

LC-1000, LC-1100, BCOO-1000, BCOO-1003, PXAO-1000, NAOO-1100, UC-100, UC-105, UC-402, UC-438, UC-700, UC-720

BCOO-1000-Chrono Daily WBR:NYoder:ms:12/21/05:8495
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I.4 March 16, 2006 Letter to CAP Tribes

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE® IN AMERICA

IN REPLY REFER TO:
LC-2600
ENV-3.00

MAR 16 2006

CERTIFIED – RETURN RECEIPT REQUESTED

Honorable Delia Carlyle
Chairwoman, Ak-Chin Indian Community
42507 West Peters and Nall Road
Maricopa, AZ 85239-3940

Subject: Proposed Shortage Guidelines for the Lower Basin of the Colorado River and Coordinated Strategies for the Operation of Lake Powell and Lake Mead, Government-to-Government Consultation

Dear Chairwoman:

As you are aware, the Upper and Lower Colorado Regions of the Bureau of Reclamation are proposing to develop shortage guidelines for the Lower Basin of the Colorado River and coordinated strategies for the operation of Lake Powell and Lake Mead. A copy of the September 30, 2005 Federal Register notice initiating this process is enclosed. As part of this effort, Reclamation has already begun to engage your tribe in government-to-government consultations because of your participation in the Central Arizona Project water rights settlement.

In compliance with the National Historic Preservation Act (NHPA) and Executive Order 13007, regarding sacred sites, Reclamation is further seeking your assistance in identifying and evaluating historic properties, especially those of traditional religious or cultural importance, and what potential effects, if any, this proposed action might have on these properties.

A representative from Reclamation will be calling your office within two weeks to facilitate a government-to-government consultation regarding properties under NHPA and sacred site guidelines, or you may call Mr. John Jamrog, Environmental Compliance Group Manager for the Lower Colorado Region at 702-293-8675.

Sincerely,

William J. Liebhauser, Acting Director
Resources Management Office

Enclosure

cc: See next page.

2

cc: Mr. Allen J. Auspach
Acting Regional Director
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Cathy Wilson
Supervisory Water Rights Specialist
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Amy Heustein
Environmental Protection Officer
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

1

bc: Office of the Field Solicitor
U.S. Department of the Interior
Sandra Day O'Connor
U.S. Courthouse, Suite 404
Attention: Ms. Katherine Verburg
401 West Washington Street, SPC 44,
Phoenix, AZ 85003-2151

Office of the Field Solicitor
U.S. Department of the Interior
Sandra Day O'Connor
U.S. Courthouse, Suite 404
Attention: Mr. Bob Snow
401 West Washington Street, SPC 44,
Phoenix, AZ 85003-2151

BCOO-1000, BCOO-1003 (w/signed copy), LC-1000, LC-1100, LC-2000, LC-2010, LC- 2600, LC-2630, LC-2700, NAAO-1100, PXAO-1100, UC-100, UC-105, UC-402, UC-406, UC-438, UC-700, UC-720

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Daily
WBR:JJamrog:nr:03/15/06:293-8675
(Usr\COMM2000\COM2600\John Jamrog\Final ShortageEISmaillist2.CAPtribesculturalpropletter.DOC)

Identical Letter Sent To:

Ms. Nancy Nelson
Cultural Resources Manager
Ak-Chin Indian Community
47685 North Eco Museum Road
Maricopa, AZ 85239

Ms. Dezbah Hatathli
Acting Cultural Programs Supervisor
Salt River Pima-Maricopa Indian Community
Cultural & Environmental Services
10005 East Osborn Road
Scottsdale, AZ 85256

Honorable William R. Rhodes
Governor
Gila River Indian Community
P.O. Box 97
Sacaton, AZ 85746

Honorable Kathleen Wesley-Kitcheyan
Chairwoman, San Carlos Apache Indian Tribe
P.O. Box "0"
San Carlos, AZ 85550

Mr. Barnaby Lewis
Cultural Resources Program Specialist
Gila River Indian Community
P.O. Box 97
Sacaton, AZ 85746

Ms. Vernelda Grant
Tribal Archaeologist
San Carlos Apache Indian Tribe
P.O. Box "0"
San Carlos, AZ 85550

Honorable Herminia Frias
Chairwoman, Pascua Yaqui Tribe
7474 South Camino de Oeste
Tucson, AZ 85746

Honorable Vivian Juan-Saunders
Chairwoman, Tohono O'odham Nation
P.O. Box 837
Sells, AZ 85634-0837

Honorable Joni M. Ramos
President
Salt River Pima-Maricopa Indian Community
10005 East Osborn Road
Scottsdale, AZ 85256

Mr. Peter Steere
Project Manager
Cultural Resources Department
Tohono O'odham Nation
P. O. Box 837
Sells, AZ 85634-0834

1

Honorable Ivan Smith
Chairman, Tonto Apache Tribal Council
Tonto Apache Reservation No. 30
Payson, AZ 85541

Honorable Jamie Fullmer
Chairman, Yavapai-Apache Nation
2400 West Datsi Street
Camp Verde, AZ 86322

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or faxed comments should be submitted by October 17, 2005.

John W. Roberts,

Acting Chief, National Register/National Historic Landmarks Program.

ARKANSAS

Faulkner County

Lee, Carl and Esther, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 17493 US 65S, Damascus, 05001170

Tyler—Southerland House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 36 Southerland, Conway, 05001168

Ward, Earl and Mildred, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 1157 Mitchell St., Conway, 05001169

Webb, Joe and Nina, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 2945 Prince, Conway, 05001171

Washington County

Prairie Grove Battlefield (Boundary Increase II), N of US 62, E of Prairie Grove, Prairie Grove, 05001167

COLORADO

Montrose County

North Rim Road, Black Canyon of the Gunnison National Park, Black Canyon of the Gunnison National Park, Crawford, 05001181

GEORGIA

Bartow County

ATCO–Goodyear Mill and Mill Village Historic District, Roughly bounded by Sugar Valley Rd., Cassville rd. and Pettit Creek, Wingfoot Trail and Litchfield St., Cartersville, 05001172

MAINE

Androscoggin County

Keystone Mineral Springs, Keystone Rd., Poland, 05001175

Cumberland County

Battery Steele, Florida Ave., Peaks Island, Portland, 05001176

Lakeside Grange #63, Main St., jct. of Main St. and Lincoln St., Harrison, 05001173

Hancock County

Garland Farm, 1029 ME 3, Bar Harbor, 05001174

MINNESOTA

Cook County

Grand Portage National Monument, Off US 61 within the area of the Grand Portage Indian Reservation, Grand Portage, 05001180

MISSOURI

Madison County

St. Louis, Iron Mountain and Southern Railroad Depot, Allen St., 150 ft. No of Jct. of Allen and Kelly Sts., Fredericktown, 05001178

MONTANA

Park County

Hepburn, John, Place, 626 E. River Rd., Emigrant, 05001177

New Mexico

Santa Fe County

Kelly, Daniel T., House, (Buildings Designed by John Gaw Meem MPS) 531 E. Palace Ave., Santa Fe, 05001182

OREGON

Multnomah County

Harrison Court Apartments, 1834 SW. 5th Ave., Portland, 05001179

[FR Doc. 05–19526 Filed 9–29–05; 8:45 am]

BILLING CODE 4312–51–P

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Colorado River Reservoir Operations: Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead Under Low Reservoir Conditions

AGENCY: Bureau of Reclamation, Interior.

ACTION: Notice of intent to prepare an environmental impact statement (EIS) and notice to solicit comments and hold public scoping meetings on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions.

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA), the Bureau of Reclamation (Reclamation) proposes to conduct public scoping meetings and prepare an EIS for the development of Lower Colorado River Basin Shortage Guidelines and Coordinated Management Strategies for Operation of Lake Powell and Lake Mead Under Low Reservoir Conditions. The Secretary of the Interior (Secretary) has directed Reclamation to develop additional Colorado River management strategies to address operations of Lake Powell and Lake Mead under low reservoir conditions.

The proposed action is to develop these guidelines and strategies. Through the NEPA process initiated by this **Federal Register** notice, Reclamation is considering development of: (1) Specific guidelines that will identify those circumstances under which the Department of the Interior (Department) would reduce annual water deliveries from Lake Mead to the Lower Basin States below the 7.5 million acre-feet (maf) Lower Basin apportionment and the manner in which those deliveries would be reduced, and (2) coordinated management strategies for the operation of Lake Powell and Lake Mead.

Alternatives to be analyzed in the EIS have not been developed at this time and will be developed through the NEPA process, including through the upcoming EIS scoping meetings.

DATES AND ADDRESSES: Four public meetings will be held to solicit comments on the scope of specific shortage guidelines and other coordinated management strategies and the issues and alternatives that should be analyzed. Oral and written comments will be accepted at the public meetings to be held at the following locations:

- Tuesday, November 1, 2005—6 p.m. to 8 p.m., Hilton Salt Lake City Center, Topaz Room, 255 South West Temple, Salt Lake City, Utah.
- Wednesday, November 2, 2005—6 p.m. to 8 p.m., Adam's Mark Hotel, Tower Court D, 1550 Court Place, Denver, Colorado.
- Thursday, November 3, 2005—6 p.m. to 8 p.m., Arizona Department of Water Resources, Third Floor, Conference Rooms A&B, 500 North Third Street, Phoenix, Arizona.
- Tuesday, November 8, 2005—6 p.m. to 8 p.m., Henderson Convention Center, Grand Ballroom, 200 South Water Street, Henderson, Nevada.

Written comments on the proposed development of these strategies may be sent by close of business on *Wednesday, November 30, 2005*, to: Regional Director, Bureau of Reclamation, Lower Colorado Region, Attention: BCOO–1000, PO Box 61470, Boulder City, Nevada 89006–1470, faxogram at (702) 293–8156, or e-mail at *strategies@lc.usbr.gov*; and/or Regional Director, Bureau of Reclamation, Upper Colorado Region, Attention: UC–402, 125 South State Street, Salt Lake City, Utah 84318–1147, faxogram at (801) 524–3858, or e-mail at *strategies@uc.usbr.gov*.

FOR FURTHER INFORMATION CONTACT: Terrance J. Fulp, PhD., at (702) 293–8500 or e-mail at *strategies@lc.usbr.gov*; and/or Randall Peterson at (801) 524–3633 or e-mail at *strategies@uc.usbr.gov*. If special assistance is required regarding accommodations for attendance at any of the public meetings, please call Nan Yoder at (702) 293–8495, faxogram at (702) 293–8156, or e-mail at *nyoder@lc.usbr.gov* no less than 5 working days prior to the applicable meeting(s).

SUPPLEMENTARY INFORMATION: In recent years the Colorado River Basin experienced the worst five-year drought

1

Federal Register / Vol. 70, No. 189 / Friday, September 30, 2005 / Notices 57323

in recorded history. Drought in the Basin has impacted system storage, while demands for Colorado River water supplies have continued to increase. In the future, low reservoir conditions may not be limited to drought periods as additional development of Colorado River water occurs. The Colorado River is of strategic importance in the southwestern United States for water supply, hydropower production, recreation, fish and wildlife habitat, and other benefits. In addition, the Republic of Mexico has an allocation to the waters of the Colorado River pursuant to a 1944 treaty with the United States.

In 2001, the Department adopted Interim Surplus Guidelines (66 FR 7772) that are used by the Secretary in making annual determinations regarding "Normal" and "Surplus" conditions for the operation of Lake Mead. Since adoption, these Guidelines have, among other operational and management benefits, allowed the Department and entities in Arizona, California, and Nevada that rely on the Colorado River greater predictability in identifying when Colorado River water in excess of 7.5 maf will be available for use within these three States. In contrast, at this time the Department does not have detailed guidelines in place for annual determinations of releases from Lake Mead of less than 7.5 maf to water users in the three Lower Division States of Arizona, California, and Nevada (often referred to as a "shortage" condition on the lower Colorado River). Therefore, water users who rely on the Colorado River in these States are not currently able to identify particular reservoir conditions under which the Secretary would release less than 7.5 maf for use on an annual basis. Nor are these water users able to identify the amount of any potential future annual reductions in water deliveries.

Over the past year, the seven Colorado River Basin States have been proactively discussing strategies to address the recent period of system-wide drought in the Colorado River Basin. In addition, Reclamation has conducted detailed briefings for stakeholders in the Colorado River Basin and other interested entities regarding future scenarios for Colorado River operations.

Currently, each year, the Secretary establishes an Annual Operating Plan (AOP) for the Colorado River Reservoirs. The AOP describes how Reclamation will manage the reservoirs over a 12-month period, consistent with the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968 (Long-Range Operating Criteria), the Decree entered by the U.S. Supreme Court in the *Arizona* v. *California* litigation, and other provisions of applicable Federal law. Reclamation consults annually with the Colorado River Basin States, Indian tribes, and other interested parties in the development of the AOP. Further, as part of the AOP process, the Secretary makes annual determinations under the Long-Range Operating Criteria regarding the availability of Colorado River water for deliveries to the Lower Division States. To meet the consultation requirements of Federal law, Reclamation also consults with the Colorado River Basin States, Indian tribes, and other interested parties during the five-year periodic reviews of the Long-Range Operating Criteria.

During the mid-year review of the 2005 AOP conducted this past spring, the Department received conflicting recommendations from the Colorado River Basin States regarding operations of Glen Canyon Dam for the remainder of the 2005 water year. In a May 2, 2005, letter to the Governors of the Colorado River Basin States, issued to complete the 2005 AOP mid-year review, the Secretary directed Reclamation to develop additional strategies to improve coordinated management of the reservoirs in the Colorado River system. Pursuant to that direction, Reclamation conducted a public consultation workshop on May 26, 2005, in Henderson, Nevada; issued a **Federal Register** notice soliciting public comments on June 15, 2005; and conducted public meetings on July 26 and July 28, 2005, in Henderson, Nevada, and Salt Lake City, Utah, respectively. Reclamation received a broad range of public comments and suggestions from these discussions, not all of which can be addressed in this proposed process. In addition, some suggestions may be part of ongoing or future efforts.

In order to assure the continued productive management and use of the Colorado River into the future, Reclamation is now soliciting public comments on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions. Reclamation will utilize a public process pursuant to NEPA. By this notice, Reclamation provides notice of its intent to prepare an EIS on this action, and provides notice of its upcoming EIS scoping meetings. Reclamation invites all interested members of the general public, including the seven Colorado River Basin States, Indian tribes, water and power contractors, environmental organizations, representatives of academic and scientific communities, representatives of the recreation industry, and other organizations and agencies to present oral and written comments concerning the format and scope of specific shortage guidelines and coordinated management strategies, and the issues and alternatives to be considered during the development of these proposed guidelines and strategies. Reclamation anticipates publishing a "scoping report" after completion of the public scoping meetings identified in this **Federal Register** notice.

All comments received will be considered as Reclamation develops formal alternatives under NEPA. Similar to the surplus guidelines referenced above, it is likely that these shortage guidelines will be interim in nature. It is the Department's intent that these guidelines and coordinated management strategies will provide guidance to the Secretary's AOP decisions, and provide more predictability to water users and the public throughout the Colorado River Basin, particularly those in the Lower Division States. The Department does not intend to evaluate the decommissioning of Glen Canyon Dam.

Public Disclosure

Written comments, including names and home addresses of respondents, will be made available for public review. Individual respondents may request that their home address be withheld from public disclosure, which will be honored to the extent allowable by law. There may be circumstances in which respondents' identity may also be withheld from public disclosure, as allowable by law. If you wish to have your name and/or address withheld, you must state this prominently at the beginning of your comment. All submissions from organizations, business, and from individuals identifying themselves as representatives or officials of organizations or businesses, will be made available for public disclosure in their entirety.

Dated: September 22, 2005.

Rick L. Gold,

Regional Director—UC Region, Bureau of Reclamation.

Dated: September 22, 2005.

Jayne Harkins,

Deputy Regional Director—LC Region, Bureau of Reclamation.

[FR Doc. 05–19607 Filed 9–29–05; 8:45 am]

BILLING CODE 4310–MN–P

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I.5 March 16, 2006 Letter to Ten Tribes

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
LC-2600
ENV-3.00

MAR 16 2006

CERTIFIED – RETURN RECEIPT REQUESTED

The Honorable Charles Wood
Chairman, Chemehuevi Indian Tribe
P.O. Box 1976
Havasu Lake, CA 92363-1976

Subject: Proposed Shortage Guidelines for the Lower Basin of the Colorado River and Coordinated Strategies for the Operation of Lake Powell and Lake Mead, Government-to-Government Consultations

Dear Chairman:

As you are aware, the Upper and Lower Colorado Regions of the Bureau of Reclamation are proposing to develop shortage guidelines for the Lower Basin of the Colorado River and coordinated strategies for the operation of Lake Powell and Lake Mead. A copy of the September 30, 2005 Federal Register notice initiating this process is enclosed. As part of this effort, Reclamation has already begun to engage in government-to-government consultations with the Ten Tribes Partnership, of which your tribe is a member.

In compliance with the National Historic Preservation Act (NHPA) and Executive Order 13007, regarding sacred sites, Reclamation is further seeking your assistance in identifying and evaluating historic properties, especially those of traditional religious or cultural importance, and what potential effects, if any, this proposed action might have on these properties.

A representative from Reclamation will be calling your office within two weeks to facilitate a government-to-government consultation regarding properties under the NHPA and sacred site guidelines, or you may call Mr. John Jamrog, Environmental Compliance Group Manager for the Lower Colorado Region at 702-293-8675.

Sincerely,

William J. Liebhauser, Acting Director
Resources Management Office

Enclosure

cc: See next page.

cc: Mr. Allen J. Auspach
Acting Regional Director
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Amy Heustein
Supervisory Water Rights Specialist
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Cathy Wilson
Environmental Protection Officer
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

bc: Office of the Field Solicitor
U.S. Department of the Interior
Sandra Day O'Connor
U.S. Courthouse, Suite 404
Attention: Ms. Katherine Verburg
401 West Washington Street, SPC 44
Phoenix, AZ 85003-2151

Office of the Field Solicitor
U.S. Department of the Interior
Sandra Day O'Connor
U.S. Courthouse, Suite 404
Attention: Mr. Bob Snow
401 West Washington Street, SPC 44
Phoenix, AZ 85003-2151

BCOO-1000, BCOO-1003 (w/signed cpy), BCOO-4600, LC-1000, LC-1100, LC-2000, LC-2010, LC- 2600, LC-2630, LC-2700, NAAO-1100, PXAO-1100, UC-100, UC-105, UC-402, UC-406, UC-438, UC-700, UC-720

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Identical Letter Sent To:

Honorable Sherry Cordova
Chairwoman, Cocopah Indian Tribe
County 15th and Avenue G
Somerton, AZ 85350

Ms. Lisa Wanstall
Museum Director, Cocopah Indian Tribe
County 15th and Avenue G
Somerton, AZ 85350

Honorable Daniel Eddy, Jr.
Chairman, Colorado River Indian Tribes
Route 1, Box 23-B
Parker, AZ 85344-9704

Mr. Michael Tsosie
Museum Director
Colorado River Indian Tribes
Route 1, Box 23-B
Parker, AZ 85344-9704

Honorable Nora McDowell
Chairwoman, Fort Mojave Indian Tribe
500 Merriman Avenue
Needles, CA 92363

Ms. Linda Otero
Director, Ahamakav Cultural Society
Fort Mojave Indian Tribe
P.O. Box 5990
Mohave Valley, CA 86440

Honorable Joe Shirley, Jr.
President, Navajo Nation
Box 9000
Window Rock, AZ 86515

Dr. Alan Downer
Navajo Nation Historic Preservation Department
P.O. Box 4950
Window Rock, AZ 86515

Mr. Stephen Begay
NAGPRA Representative
Navajo Nation Historic Preservation Department
P.O. Box 4950
Window Rock, AZ 86515

1

Mr. Ron Maldonado
Navajo Nation Historic Preservation Office
P.O. Box 4950
Window Rock, AZ 86515

Honorable Michael Jackson, Sr.
President, Quechan Indian Tribe
P.O. Box 1899
Yuma, AZ 85366

Honorable Pauline Jose
Chairwoman, Quechan Culture Community
Fort Yuma Quechan Indian Tribe
P.O. Box 1899
Yuma, AZ 85366

Honorable Maxine Natchees
Business Committee Chairwoman
Northern Ute Indian Tribe
P.O. Box 190
Fort Duchesne, UT 84026

Honorable Clement J. Frost
Chairman, Southern Ute Indian Tribe
P.O. Box 737
Ignacio, CO 81137

Mr. Neil Cloud
NAGPRA Representative
Southern Ute Indian Tribe
P.O. Box 737
Ignacio, CO 81137

Mr. Terry O. Knight
NAGPRA Representative
Ute Mountain Ute Tribe
Box 53
Towaoc, CO 81334-0248

Honorable Levi Pesata
President, Jicarilla Apache Nation
P.O. Box 507
Dulce, NM 87528

Ms. Adelaide Paiz
Cultural Preservation Officer
Jicarilla Apache Nation
P.O. Box 507
Dulce, NM 87528

Honorable Manual Health
Chairman, Ute Mountain Ute Tribe
P.O. Box 248
Towaoc, CO 81334-0248

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or faxed comments should be submitted by October 17, 2005.

John W. Roberts,

Acting Chief, National Register/National Historic Landmarks Program.

ARKANSAS

Faulkner County

Lee, Carl and Esther, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 17493 US 65S, Damascus, 05001170

Tyler—Southerland House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 36 Southerland, Conway, 05001168

Ward, Earl and Mildred, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 1157 Mitchell St., Conway, 05001169

Webb, Joe and Nina, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 2945 Prince, Conway, 05001171

Washington County

Prairie Grove Battlefield (Boundary Increase II), N of US 62, E of Prairie Grove, Prairie Grove, 05001167

COLORADO

Montrose County

North Rim Road, Black Canyon of the Gunnison National Park, Black Canyon of the Gunnison National Park, Crawford, 05001181

GEORGIA

Bartow County

ATCO–Goodyear Mill and Mill Village Historic District, Roughly bounded by Sugar Valley Rd., Cassville rd. and Pettit Creek, Wingfoot Trail and Litchfield St., Cartersville, 05001172

MAINE

Androscoggin County

Keystone Mineral Springs, Keystone Rd., Poland, 05001175

Cumberland County

Battery Steele, Florida Ave., Peaks Island, Portland, 05001176

Lakeside Grange #63, Main St., jct. of Main St. and Lincoln St., Harrison, 05001173

Hancock County

Garland Farm, 1029 ME 3, Bar Harbor, 05001174

MINNESOTA

Cook County

Grand Portage National Monument, Off US 61 within the area of the Grand Portage Indian Reservation, Grand Portage, 05001180

MISSOURI

Madison County

St. Louis, Iron Mountain and Southern Railroad Depot, Allen St., 150 ft. No of Jct. of Allen and Kelly Sts., Fredericktown, 05001178

MONTANA

Park County

Hepburn, John, Place, 626 E. River Rd., Emigrant, 05001177

New Mexico

Santa Fe County

Kelly, Daniel T., House, (Buildings Designed by John Gaw Meem MPS) 531 E. Palace Ave., Santa Fe, 05001182

OREGON

Multnomah County

Harrison Court Apartments, 1834 SW. 5th Ave., Portland, 05001179

[FR Doc. 05–19526 Filed 9–29–05; 8:45 am]

BILLING CODE 4312–51–P

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Colorado River Reservoir Operations: Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead Under Low Reservoir Conditions

AGENCY: Bureau of Reclamation, Interior.

ACTION: Notice of intent to prepare an environmental impact statement (EIS) and notice to solicit comments and hold public scoping meetings on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions.

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA), the Bureau of Reclamation (Reclamation) proposes to conduct public scoping meetings and prepare an EIS for the development of Lower Colorado River Basin Shortage Guidelines and Coordinated Management Strategies for Operation of Lake Powell and Lake Mead Under Low Reservoir Conditions. The Secretary of the Interior (Secretary) has directed Reclamation to develop additional Colorado River management strategies to address operations of Lake Powell and Lake Mead under low reservoir conditions.

The proposed action is to develop these guidelines and strategies. Through the NEPA process initiated by this **Federal Register** notice, Reclamation is considering development of: (1) Specific guidelines that will identify those circumstances under which the Department of the Interior (Department) would reduce annual water deliveries from Lake Mead to the Lower Basin States below the 7.5 million acre-feet (maf) Lower Basin apportionment and the manner in which those deliveries would be reduced, and (2) coordinated management strategies for the operation of Lake Powell and Lake Mead.

Alternatives to be analyzed in the EIS have not been developed at this time and will be developed through the NEPA process, including through the upcoming EIS scoping meetings.

DATES AND ADDRESSES: Four public meetings will be held to solicit comments on the scope of specific shortage guidelines and other coordinated management strategies and the issues and alternatives that should be analyzed. Oral and written comments will be accepted at the public meetings to be held at the following locations:

• Tuesday, November 1, 2005—6 p.m. to 8 p.m., Hilton Salt Lake City Center, Topaz Room, 255 South West Temple, Salt Lake City, Utah.

• Wednesday, November 2, 2005—6 p.m. to 8 p.m., Adam's Mark Hotel, Tower Court D, 1550 Court Place, Denver, Colorado.

• Thursday, November 3, 2005—6 p.m. to 8 p.m., Arizona Department of Water Resources, Third Floor, Conference Rooms A&B, 500 North Third Street, Phoenix, Arizona.

• Tuesday, November 8, 2005—6 p.m. to 8 p.m., Henderson Convention Center, Grand Ballroom, 200 South Water Street, Henderson, Nevada.

Written comments on the proposed development of these strategies may be sent by close of business on *Wednesday, November 30, 2005*, to: Regional Director, Bureau of Reclamation, Lower Colorado Region, Attention: BCOO–1000, PO Box 61470, Boulder City, Nevada 89006–1470, faxogram at (702) 293–8156, or e-mail at *strategies@lc.usbr.gov*; and/or Regional Director, Bureau of Reclamation, Upper Colorado Region, Attention: UC–402, 125 South State Street, Salt Lake City, Utah 84318–1147, faxogram at (801) 524–3858, or e-mail at *strategies@uc.usbr.gov.*

FOR FURTHER INFORMATION CONTACT: Terrance J. Fulp, PhD., at (702) 293–8500 or e-mail at *strategies@lc.usbr.gov*; and/or Randall Peterson at (801) 524–3633 or e-mail at *strategies@uc.usbr.gov.* If special assistance is required regarding accommodations for attendance at any of the public meetings, please call Nan Yoder at (702) 293–8495, faxogram at (702) 293–8156, or e-mail at *nyoder@lc.usbr.gov* no less than 5 working days prior to the applicable meeting(s).

SUPPLEMENTARY INFORMATION: In recent years the Colorado River Basin experienced the worst five-year drought

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in recorded history. Drought in the Basin has impacted system storage, while demands for Colorado River water supplies have continued to increase. In the future, low reservoir conditions may not be limited to drought periods as additional development of Colorado River water occurs. The Colorado River is of strategic importance in the southwestern United States for water supply, hydropower production, recreation, fish and wildlife habitat, and other benefits. In addition, the Republic of Mexico has an allocation to the waters of the Colorado River pursuant to a 1944 treaty with the United States.

In 2001, the Department adopted Interim Surplus Guidelines (66 FR 7772) that are used by the Secretary in making annual determinations regarding "Normal" and "Surplus" conditions for the operation of Lake Mead. Since adoption, these Guidelines have, among other operational and management benefits, allowed the Department and entities in Arizona, California, and Nevada that rely on the Colorado River greater predictability in identifying when Colorado River water in excess of 7.5 maf will be available for use within these three States. In contrast, at this time the Department does not have detailed guidelines in place for annual determinations of releases from Lake Mead of less than 7.5 maf to water users in the three Lower Division States of Arizona, California, and Nevada (often referred to as a "shortage" condition on the lower Colorado River). Therefore, water users who rely on the Colorado River in these States are not currently able to identify particular reservoir conditions under which the Secretary would release less than 7.5 maf for use on an annual basis. Nor are these water users able to identify the amount of any potential future annual reductions in water deliveries.

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Written comments, including names and home addresses of respondents, will be made available for public review. Individual respondents may request that their home address be withheld from public disclosure, which will be honored to the extent allowable by law. There may be circumstances in which respondents' identity may also be withheld from public disclosure, as allowable by law. If you wish to have your name and/or address withheld, you must state this prominently at the beginning of your comment. All submissions from organizations, business, and from individuals identifying themselves as representatives or officials of organizations or businesses, will be made available for public disclosure in their entirety.

Dated: September 22, 2005.

Rick L. Gold,

Regional Director—UC Region, Bureau of Reclamation.

Dated: September 22, 2005.

Jayne Harkins,

Deputy Regional Director—LC Region, Bureau of Reclamation.

[FR Doc. 05–19607 Filed 9–29–05; 8:45 am]

BILLING CODE 4310–MN–P

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I.6 March 16, 2006 Letter to Other Tribes

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
LC-2600
ENV-3.00

MAR 16 2006

CERTIFIED – RETURN RECEIPT REQESTED

Mr. Leigh Kuwanwisiwma
Director, Cultural Preservation Office
Hopi Tribe of Arizona
P.O. Box 123
Kykotsmovi, AZ 86039

Subject: Proposed Shortage Guidelines for the Lower Basin of the Colorado River and Coordinated Strategies for the Operation of Lake Powell and Lake Mead, Government-to-Government Consultations

Dear Mr. Kuwanwisiwma:

The Upper and Lower Colorado Regions of the Bureau of Reclamation are proposing to develop Lower Basin shortage guidelines and coordinated reservoir operations strategies for Lake Powell and Lake Mead. A copy of the September 30, 2005 Federal Register notice initiating this process is enclosed.

Reclamation would like to enter into a government-to-government consultation regarding any concerns your tribe might have with our proposed action. In addition, in compliance with the National Historic Preservation Act and Executive Order 13007, regarding sacred sites, Reclamation is seeking your assistance in identifying and evaluating historic properties, especially those of traditional religious or cultural importance, and what potential effects, if any, this proposed action might have on these properties.

A representative from Reclamation will be calling your office within two weeks to facilitate a government-to-government consultation regarding this action, or you may call Mr. John Jamrog, Environmental Compliance Group Manager for the Lower Colorado Region at 702-293-8675.

Sincerely,

William J. Liebhauser, Acting Director
Resources Management Office

Enclosure

2

bc: BCOO-1000, BCOO-1003 (w/cpy signed letter), LC-1000, LC-1100, LC-2000, LC-2010, LC-2600, LC-2630, LC-2700, NAAO-1100, PXAO-1100, UC-100, UC-105, UC-402, UC-406, UC-438, UC-700, UC-720

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Daily
WBR:JJamrog:nr:03/13/06:293-8675
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Identical Letter Sent To:

Honorable Raphael Bear
President, Fort McDowell Yavapai Nation
P.O. Box 17770
Fountain Hills, AZ 85269

Ms. Karen Ray
Cultural Resource Representative
Fort McDowell Yavapai Nation
P.O. Box 17770
Fountain Hills, AZ 85269

Honorable Thomas Siyuja, Sr.
Chairman, Havasupai Tribe
P.O. Box 10
Supai, AZ 86435

Mr. Roland Manakaja
Cultural Representative
Havasupai Tribe
P.O. Box 10
Supai, AZ 86435

Honorable Wayne Taylor, Jr.
Chairman, Hopi Tribe
P.O. Box 123
Kykotsmovi, AZ 86029

Ms. Loretta Jackson
Tribal Historic Preservation Officer
Hualapai Tribe
215 Diamond Creek Road
Box 310
Peach Springs, AZ 86434

Honorable Charles Vaughn
Chairman, Hualapai Tribe
Box 179
Peach Springs, AZ 86434

Honorable Carmen Bradley
Chairwoman, Kaibab Band of Paiute Indians
HC65 Box 2
Fredonia, AZ 86022

Ms. Brenda Drye
Cultural Resource Representative
Kaibab Band of Paiute Indians
HC65 Box 2
Fredonia, AZ 86022

Honorable Alfreda Mitre
Chairwoman, Las Vegas Paiute Tribe
One Paiute Drive
Las Vegas, NV 89106

Mr. Kenny Anderson
Cultural Representative
Las Vegas Paiute Tribe
One Paiute Drive
Las Vegas, NV 89106

Honorable Phil Swain
Chairman, Moapa Paiute Tribe
P.O. Box 340
Moapa, NV 89025-0340

Ms. Lalovi Miller
Cultural Representative
Moapa Paiute Tribe
P.O. Box 391

1

3

Honorable Laura Tom
Chairwoman, Paiute Indian Tribe of Utah
440 No. Paiute Drive
Cedar City, UT 84720

Ms. Doreena Martineau
Cultural Resource Representative
Paiute Indian Tribe of Utah
440 No. Paiute Drive
Cedar City, UT 84720

Honorable Fred Vallo, Sr.
Governor, Pueblo of Acoma
Box 309
Acoma, NM 87034

Mr. Steven Concho
NAGPRA Representative
Pueblo of Acoma
Box 309
Acoma, NM 87304

Honorable Simon Suipa
Governor, Pueblo of Cochiti
Box 70
Cochiti Pueblo, NM 87072

Mr. Tony Herrera
NAGPRA Representative
Pueblo of Cochiti
Box 157
Cochiti, NM 87072

Mr. Jacob Pecos
Coordinator
Pueblo of Cochiti
Box 70
Cochiti, NM 87072

Honorable Raymond Lucero
Governor, Pueblo of Jemez
Box 100
Jemez Pueblo, NM 87024

Mr. Matthew Liebman
Cultural Resource Representative
Pueblo of Jemez
Box 100
Jemez Pueblo, NM 87024

Honorable Roland Johnson
Governor, Pueblo of Laguna
Box 194
Laguna Pueblo, NM 87026

Mr. Victor Sarracino
NAGPRA Representative
Pueblo of Laguna
Box 153
Laguna, NM 87026

Honorable Tom F. Talache, Jr.
Governor, Pueblo of Nambe
Route 1 Box 117-BB
Santa Fe, NM 87506

Mr. Ernest Mirabal
NAGPRA Representative
Pueblo of Nambe
Route 1 Box 117-A
Santa Fe, NM 87506

Mr. Charlie Tapia
NAGPRA Representative
Pueblo of Pojoaque
Route 11 Box 71
Santa Fe, NM 87501

Honorable Jacob Viarrial
Governor, Pueblo of Pojoaque
Route 11 Box 71
Santa Fe, NM 87501

Mr. Luke Duran
NAGPRA Representative
Pueblo of Pojoaque
Route 11 Box 71
Santa Fe, NM 87501

4

Mr. Herman Agoyo
NAGPRA Representative
Pueblo of San Juan
Box 1099
San Juan, NM 87566

Honorable Wilfred Garcia
Governor, Pueblo of San Juan
Box 1099
San Juan Pueblo, NM 87566

Ms. Jenny Holmes
Pueblo of Sandia
Box 6008
Bernalillo, NM 87004

Honorable Stuwart Paisano
Governor, Pueblo of Sandia
481 Sandia Loop
Bernalillo, NM 87004

Mr. Ben Robbins
Pueblo of Santa Ana
2 Dove Road
Santa Ana Pueblo, NM 87004

Honorable Myron Armijo
Governor, Pueblo of Santa Ana
2 Dove Road
Bernalillo, NM 87004

Honorable Denny Gutierrez
Governor, Pueblo of Santa Clara
Box 580
Espanola, NM 87532

Mr. Paul Baca
Pueblo of Santa Clara
Box 580
Bernalillo, NM 87532

Honorable Marvin Herrera
Governor, Pueblo of Tesuque
Route 42 Box 360-T
Santa Fe, NM 87506

Mr. Celestino Gauchupin
NAGPRA Representative
Pueblo of Zia
135 Capitol Square Drive
Zia Pueblo, NM 87053-6013

Honorable Peter Pino
Governor, Pueblo of Zia
135 Capitol Square Drive
Zia Pueblo, NM 87053-6013

Dr. Jonathan Damp
Pueblo of Zuni
Box 1149
Zuni Pueblo, NM 87327-0339

Honorable Arlen Quetawki, Sr.
Governor, Pueblo of Zuni
Box 339
Pueblo of Zuni, NM 87327-0339

Ms. Lorraine Swanick
Natural Resource Coordinator
Pueblo of San Felipe
Box 4339
San Felipe Pueblo, NM 87001

Honorable Lawrence Troncosa
Governor, Pueblo of San Felipe
Box 4339
San Felipe Pueblo, NM 87001

Honorable Ernest Jones Sr.
President, Yavapai-Prescott Indian Tribe
530 East Merritt Street
Prescott, AZ 86301-2038

Ms. Nancy Hayden
Director of Research
Yavapai-Prescott Indian Tribe
530 East Merritt Street
Prescott, AZ 86301-2038

5

Honorable Dallas Massey, Sr.
Chairman, White Mountain Apache
P.O. Box 700
White River, AZ 85941

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or faxed comments should be submitted by October 17, 2005.

John W. Roberts,

Acting Chief, National Register/National Historic Landmarks Program.

ARKANSAS

Faulkner County

Lee, Carl and Esther, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 17493 US 65S, Damascus, 05001170

Tyler—Southerland House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 36 Southerland, Conway, 05001168

Ward, Earl and Mildred, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 1157 Mitchell St., Conway, 05001169

Webb, Joe and Nina, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 2945 Prince, Conway, 05001171

Washington County

Prairie Grove Battlefield (Boundary Increase II), N of US 62, E of Prairie Grove, Prairie Grove, 05001167

COLORADO

Montrose County

North Rim Road, Black Canyon of the Gunnison National Park, Black Canyon of the Gunnison National Park, Crawford, 05001181

GEORGIA

Bartow County

ATCO–Goodyear Mill and Mill Village Historic District, Roughly bounded by Sugar Valley Rd., Cassville rd. and Pettit Creek, Wingfoot Trail and Litchfield St., Cartersville, 05001172

MAINE

Androscoggin County

Keystone Mineral Springs, Keystone Rd., Poland, 05001175

Cumberland County

Battery Steele, Florida Ave., Peaks Island, Portland, 05001176

Lakeside Grange #63, Main St., jct. of Main St. and Lincoln St., Harrison, 05001173

Hancock County

Garland Farm, 1029 ME 3, Bar Harbor, 05001174

MINNESOTA

Cook County

Grand Portage National Monument, Off US 61 within the area of the Grand Portage Indian Reservation, Grand Portage, 05001180

MISSOURI

Madison County

St. Louis, Iron Mountain and Southern Railroad Depot, Allen St., 150 ft. No of Jct. of Allen and Kelly Sts., Fredericktown, 05001178

MONTANA

Park County

Hepburn, John, Place, 626 E. River Rd., Emigrant, 05001177

New Mexico

Santa Fe County

Kelly, Daniel T., House, (Buildings Designed by John Gaw Meem MPS) 531 E. Palace Ave., Santa Fe, 05001182

OREGON

Multnomah County

Harrison Court Apartments, 1834 SW. 5th Ave., Portland, 05001179

[FR Doc. 05–19526 Filed 9–29–05; 8:45 am]

BILLING CODE 4312–51–P

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Colorado River Reservoir Operations: Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead Under Low Reservoir Conditions

AGENCY: Bureau of Reclamation, Interior.

ACTION: Notice of intent to prepare an environmental impact statement (EIS) and notice to solicit comments and hold public scoping meetings on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions.

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA), the Bureau of Reclamation (Reclamation) proposes to conduct public scoping meetings and prepare an EIS for the development of Lower Colorado River Basin Shortage Guidelines and Coordinated Management Strategies for Operation of Lake Powell and Lake Mead Under Low Reservoir Conditions. The Secretary of the Interior (Secretary) has directed Reclamation to develop additional Colorado River management strategies to address operations of Lake Powell and Lake Mead under low reservoir conditions.

The proposed action is to develop these guidelines and strategies. Through the NEPA process initiated by this **Federal Register** notice, Reclamation is considering development of: (1) Specific guidelines that will identify those circumstances under which the Department of the Interior (Department) would reduce annual water deliveries from Lake Mead to the Lower Basin States below the 7.5 million acre-feet (maf) Lower Basin apportionment and the manner in which those deliveries would be reduced, and (2) coordinated management strategies for the operation of Lake Powell and Lake Mead.

Alternatives to be analyzed in the EIS have not been developed at this time and will be developed through the NEPA process, including through the upcoming EIS scoping meetings.

DATES AND ADDRESSES: Four public meetings will be held to solicit comments on the scope of specific shortage guidelines and other coordinated management strategies and the issues and alternatives that should be analyzed. Oral and written comments will be accepted at the public meetings to be held at the following locations:

- Tuesday, November 1, 2005—6 p.m. to 8 p.m., Hilton Salt Lake City Center, Topaz Room, 255 South West Temple, Salt Lake City, Utah.
- Wednesday, November 2, 2005—6 p.m. to 8 p.m., Adam's Mark Hotel, Tower Court D, 1550 Court Place, Denver, Colorado.
- Thursday, November 3, 2005—6 p.m. to 8 p.m., Arizona Department of Water Resources, Third Floor, Conference Rooms A&B, 500 North Third Street, Phoenix, Arizona.
- Tuesday, November 8, 2005—6 p.m. to 8 p.m., Henderson Convention Center, Grand Ballroom, 200 South Water Street, Henderson, Nevada.

Written comments on the proposed development of these strategies may be sent by close of business on *Wednesday, November 30, 2005*, to: Regional Director, Bureau of Reclamation, Lower Colorado Region, Attention: BCOO–1000, PO Box 61470, Boulder City, Nevada 89006–1470, faxogram at (702) 293–8156, or e-mail at *strategies@lc.usbr.gov*; and/or Regional Director, Bureau of Reclamation, Upper Colorado Region, Attention: UC–402, 125 South State Street, Salt Lake City, Utah 84318–1147, faxogram at (801) 524–3858, or e-mail at *strategies@uc.usbr.gov*.

FOR FURTHER INFORMATION CONTACT: Terrance J. Fulp, PhD., at (702) 293–8500 or e-mail at *strategies@lc.usbr.gov*; and/or Randall Peterson at (801) 524–3633 or e-mail at *strategies@uc.usbr.gov*. If special assistance is required regarding accommodations for attendance at any of the public meetings, please call Nan Yoder at (702) 293–8495, faxogram at (702) 293–8156, or e-mail at *nyoder@lc.usbr.gov* no less than 5 working days prior to the applicable meeting(s).

SUPPLEMENTARY INFORMATION: In recent years the Colorado River Basin experienced the worst five-year drought

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in recorded history. Drought in the Basin has impacted system storage, while demands for Colorado River water supplies have continued to increase. In the future, low reservoir conditions may not be limited to drought periods as additional development of Colorado River water occurs. The Colorado River is of strategic importance in the southwestern United States for water supply, hydropower production, recreation, fish and wildlife habitat, and other benefits. In addition, the Republic of Mexico has an allocation to the waters of the Colorado River pursuant to a 1944 treaty with the United States.

In 2001, the Department adopted Interim Surplus Guidelines (66 FR 7772) that are used by the Secretary in making annual determinations regarding "Normal" and "Surplus" conditions for the operation of Lake Mead. Since adoption, these Guidelines have, among other operational and management benefits, allowed the Department and entities in Arizona, California, and Nevada that rely on the Colorado River greater predictability in identifying when Colorado River water in excess of 7.5 maf will be available for use within these three States. In contrast, at this time the Department does not have detailed guidelines in place for annual determinations of releases from Lake Mead of less than 7.5 maf to water users in the three Lower Division States of Arizona, California, and Nevada (often referred to as a "shortage" condition on the lower Colorado River). Therefore, water users who rely on the Colorado River in these States are not currently able to identify particular reservoir conditions under which the Secretary would release less than 7.5 maf for use on an annual basis. Nor are these water users able to identify the amount of any potential future annual reductions in water deliveries.

Over the past year, the seven Colorado River Basin States have been proactively discussing strategies to address the recent period of system-wide drought in the Colorado River Basin. In addition, Reclamation has conducted detailed briefings for stakeholders in the Colorado River Basin and other interested entities regarding future scenarios for Colorado River operations.

Currently, each year, the Secretary establishes an Annual Operating Plan (AOP) for the Colorado River Reservoirs. The AOP describes how Reclamation will manage the reservoirs over a 12-month period, consistent with the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968 (Long-Range Operating Criteria), the Decree entered by the U.S. Supreme Court in the *Arizona* v. *California* litigation, and other provisions of applicable Federal law. Reclamation consults annually with the Colorado River Basin States, Indian tribes, and other interested parties in the development of the AOP. Further, as part of the AOP process, the Secretary makes annual determinations under the Long-Range Operating Criteria regarding the availability of Colorado River water for deliveries to the Lower Division States. To meet the consultation requirements of Federal law, Reclamation also consults with the Colorado River Basin States, Indian tribes, and other interested parties during the five-year periodic reviews of the Long-Range Operating Criteria.

During the mid-year review of the 2005 AOP conducted this past spring, the Department received conflicting recommendations from the Colorado River Basin States regarding operations of Glen Canyon Dam for the remainder of the 2005 water year. In a May 2, 2005, letter to the Governors of the Colorado River Basin States, issued to complete the 2005 AOP mid-year review, the Secretary directed Reclamation to develop additional strategies to improve coordinated management of the reservoirs in the Colorado River system. Pursuant to that direction, Reclamation conducted a public consultation workshop on May 26, 2005, in Henderson, Nevada; issued a **Federal Register** notice soliciting public comments on June 15, 2005; and conducted public meetings on July 26 and July 28, 2005, in Henderson, Nevada, and Salt Lake City, Utah, respectively. Reclamation received a broad range of public comments and suggestions from these discussions, not all of which can be addressed in this proposed process. In addition, some suggestions may be part of ongoing or future efforts.

In order to assure the continued productive management and use of the Colorado River into the future, Reclamation is now soliciting public comments on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions. Reclamation will utilize a public process pursuant to NEPA. By this notice, Reclamation provides notice of its intent to prepare an EIS on this action, and provides notice of its upcoming EIS scoping meetings. Reclamation invites all interested members of the general public, including the seven Colorado River Basin States, Indian tribes, water and power contractors, environmental organizations, representatives of academic and scientific communities, representatives of the recreation industry, and other organizations and agencies to present oral and written comments concerning the format and scope of specific shortage guidelines and coordinated management strategies, and the issues and alternatives to be considered during the development of these proposed guidelines and strategies. Reclamation anticipates publishing a "scoping report" after completion of the public scoping meetings identified in this **Federal Register** notice.

All comments received will be considered as Reclamation develops formal alternatives under NEPA. Similar to the surplus guidelines referenced above, it is likely that these shortage guidelines will be interim in nature. It is the Department's intent that these guidelines and coordinated management strategies will provide guidance to the Secretary's AOP decisions, and provide more predictability to water users and the public throughout the Colorado River Basin, particularly those in the Lower Division States. The Department does not intend to evaluate the decommissioning of Glen Canyon Dam.

Public Disclosure

Written comments, including names and home addresses of respondents, will be made available for public review. Individual respondents may request that their home address be withheld from public disclosure, which will be honored to the extent allowable by law. There may be circumstances in which respondents' identity may also be withheld from public disclosure, as allowable by law. If you wish to have your name and/or address withheld, you must state this prominently at the beginning of your comment. All submissions from organizations, business, and from individuals identifying themselves as representatives or officials of organizations or businesses, will be made available for public disclosure in their entirety.

Dated: September 22, 2005.

Rick L. Gold,

Regional Director—UC Region, Bureau of Reclamation.

Dated: September 22, 2005.

Jayne Harkins,

Deputy Regional Director—LC Region, Bureau of Reclamation.

[FR Doc. 05–19607 Filed 9–29–05; 8:45 am]

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I.7 May 3, 2006 Letter to Tribes

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
LC-2600
ENV-3.00

MAY 3 2006

CERTIFIED – RETURN RECEIPT REQUESTED

Honorable Charles Wood
Chairman, Chemehuevi Indian Tribe
P.O. Box 1976
Havasu City, CA 92363-1976

Subject: Presentation of Draft Alternatives Being Considered for the Proposed Shortage Guidelines for the Lower Basin of the Colorado River and Coordinated Strategies for the Operation of Lake Powell and Lake Mead, Under Low Reservoir Conditions, Government-to-Government Consultations

Dear Chairman:

As part of continuing government-to-government consultations for the development of Lower Basin shortage guidelines and coordinated reservoir operations strategies for Lake Powell and Lake Mead, under low reservoir conditions, the Upper and Lower Colorado Regions of the Bureau of Reclamation request to meet with consulting tribes to present the draft alternatives currently being considered for analysis under the planned EIS.

During the meeting we will provide the tribal representatives with an update of progress on the project, a brief discussion of the recently published Scoping Summary Report, and a detailed presentation of the draft alternatives being considered for analysis, including preliminary results of modeling predictions of reservoir conditions as a result of each alternative being considered. A court reporter will be on hand to record the discussions at the meeting, including any input or suggestions you may have regarding the draft alternatives. The Definitions for Draft Alternatives and Elements/Options Matrix, and Draft Alternatives and Elements/Options Considered in Each Alternative, are enclosed for your review leading up to the meeting.

Although several tribal representatives have expressed interest in the potential impacts these alternatives may have on their reserved water rights, contracts, or operations, the analysis of those impacts has not yet been initiated. Therefore we will not be able to fully articulate these impacts with any certainty at this time. Our intention is to inform and engage tribal governments about the assumptions and proposals being considered for analysis at important stages of the EIS process. These impacts will be addressed through the EIS process in the future.

To accommodate the traveling distances of the majority of the consulting tribes, we are recommending a meeting in Phoenix, Arizona on one of the following days: May 22; May 23; or May 30, 2006. Please contact Mr. John Jamrog, Environmental Compliance Group Manager for the Lower Colorado Region, by phone at 702-293-8675, or via e-mail at jjamrog@lc.usbr.gov, to

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confirm which dates are best for you. A representative from Reclamation will also be calling your office within the week to confirm your availability and participation and to inform you of the exact location of the meeting facility in Phoenix.

Sincerely,

AMELIA C. PORTER

For
William J. Liebhauser, Director
Resources Management Office

Enclosures – 2

<u>Identical Letter Sent To:</u>

Honorable Sherry Cordova
Chairwoman, Cocopah Indian Tribe
County 15th and Avenue G
Somerton, AZ 85350

Honorable Daniel Eddy, Jr.
Chairman, Colorado River Indian Tribes
Route 1, Box 23-B
Parker, AZ 85344-9704

Honorable Michael Jackson, Sr.
President, Quechan Indian Tribe
P.O. Box 1899
Yuma, AZ 85366

Honorable Joe Shirley, Jr.
President, Navajo Nation
Box 9000
Window Rock, AZ 86515

Honorable Clement J. Frost
Chairman, Southern Ute Indian Tribe
P.O. Box 737
Ignacio, CO 81137

Honorable Levi Pesata
President, Jicarilla Apache Nation
P.O. Box 507
Dulce, NM 87528

Ms. Lisa Wanstall
Museum Director, Cocopah Indian Tribe
County 15th and Avenue G
Somerton, AZ 85350

Mr. Ron Maldonado
Navajo Nation Historic Preservation Office
P.O. Box 4950
Window Rock, AZ 86515

Honorable Nora McDowell
Chairwoman, Fort Mohave Indian Tribe
500 Merriman Avenue
Needles, CA 92363

Ms. Betsey Chapoose
Northern Ute Indian Tribe
P.O. Box 190
Fort Duchesne, UT 84026

Honorable Herminia Frias
Chairwoman, Pascua Yaqui Tribe
7474 South Camino de Oeste
Tucson, AZ 85746

Honorable Manual Health
Chairman, Ute Mountain Ute Tribe
P.O. Box 248
Towaoc, CO 81334-0248

3

Honorable Delia Carlyle
Chairwoman, Ak-Chin Indian Community
42507 West Peters and Nall Road
Maricopa, AZ 85239-3940

Honorable Kathleen Wesley-Kitcheyan
Chairwoman, San Carlos Apache Indian Tribe
P.O. Box "0"
San Carlos, AZ 85550

Honorable Vivian Juan-Saunders
Chairwoman, Tohono O'odham Nation
P.O. Box 837
Sells, AZ 85634-0837

Honorable Ivan Smith
Chairman, Tonto Apache Tribal Council
Tonto Apache Reservation No. 30
Payson, AZ 85541

Honorable Gary Tom
Chairman, Kaibab Band of Paiute Indians
HC65 Box 2
Fredonia, AZ 86022

Honorable Raphael Bear
President, Fort McDowell Yavapai Nation
P.O. Box 17770
Fountain Hills, AZ 85269

Honorable Phil Swain
Chairman, Moapa Paiute Tribe
P.O. Box 340
Moapa, NV 89025-0340

Honorable Laura Tom
Chairwoman, Paiute Indian Tribe of Utah
440 N. Paiute Drive
Cedar City, UT 84720

Honorable Tom F. Talache, Jr.
Governor, Pueblo of Nambe
Route 1, Box 117-BB
Santa Fe, NM 87506

Honorable Wayne Taylor, Jr.
Chairman, Hopi Tribe
Box 123
Kykotsmovi, AZ 86029

Mr. Leigh Kuwanwisiwma
Hopi Tribe
Box 123
Kykotsmovi, AZ 86029

Honorable Charles Vaughn
Chairman, Hualapai Tribe
Box 179
Peach Springs, AZ 86434

Honorable Alfreda Mitre
Chairwoman, Las Vegas Paiute Tribe
One Paiute Drive
Las Vegas, NV 89106

Honorable Jamie Fullmer
Chairman, Yavapai-Apache Nation
2400 West Datsi Street
Camp Verde, AZ 86322

Honorable Thomas Siyuja, Sr.
Chairman, Havasupai Tribe
P.O. Box 10
Supai, AZ 86435

Honorable Raymond Lucero
Governor, Pueblo of Jemez
Box 100
Jemez Pueblo, NM 87024

Cultural Resource Representative
Pueblo of Jemez
Box 100
Jemez Pueblo, NM 87024

Honorable Fred Vallo, Sr.
Governor, Pueblo of Acoma
Box 309
Acoma, NM 87034

4

Honorable Jacob Viarrial
Governor, Pueblo of Pojoaque
Route 11, Box 71
Santa Fe, NM 87501

Honorable Wilfred Garcia
Governor, Pueblo of San Juan
Box 1099
San Juan Pueblo, NM 87566

Honorable Stuwart Paisano
Governor, Pueblo of Sandia
481 Sandia Loop
Bernalillo, NM 87004

Mr. Ben Robbins
Pueblo of Santa Ana
2 Dove Road
Santa Ana Pueblo, NM 87004

Honorable Myron Armijo
Governor, Pueblo of Santa Ana
2 Dove Road
Bernalillo, NM 87004

Mrs. Jackie Gutierrez
Pueblo of Santa Clara
Box 580
Espanola, NM 87532

Honorable Ernest Jones, Sr.
President, Yavapai-Prescott Indian Tribe
530 East Merritt Street
Prescott, AZ 86301-2038

Mr. Mark Mitchell
Pueblo of Tesque
Route 42, Box 360-T
Santa Fe, NM 87506

Dr. Alan Downer
Navajo Nation Historic Preservation Department
P.O. Box 4950
Window Rock, AZ 86515

Honorable Simon Suipa
Governor, Pueblo of Cochiti
Box 70
Cochiti Puebloe, NM 87072

Honorable Peter Pino
Governor, Pueblo of Zia
135 Capitol Square Drive
Zia Pueblo, NM 87053-6013

Dr. Jonathan Damp
Pueblo of Zuni
Box 1149
Zuni Pueblo, NM 87327-0339

Honorable Arlen Quetawki, Sr.
Governor, Pueblo of Zuni
Box 339
Pueblo of Zuni, NM 87327-0339

Honorable Denny Gutierrez
Governor, Pueblo of Santa Clara
Box 580
Espanola, NM 87532

Honorable Lawrence Troncosa
Governor, Pueblo of San Felipe
Box 4339
San Felipe Pueblo, NM 87001

Honorable Gilbert Bigil
Governor, Pueblo of Tesuque
Route 42, Box 360-T
Santa Fe, NM 87506

Honorable Dallas Massey, Sr.
Chairman, White Mountain Apache
P.O. Box 700
White River, AZ 85941

Honorable William R. Rhodes
Governor, Gila River Indian Community
P.O. Box 97
Sacaton, AZ 85746

1

5

Mr. Michael Tsosie
Museum Director
Colorado River Indian Tribes
Route 1, Box 23-B
Parker, AZ 85344-9704

Ms. Linda Otero
Director, Ahamakav Cultural Society
Fort Mohave Indian Tribe
P.O. Box 5990
Mohave Valley, CA 86440

Mr. Neil Cloud
NAGPRA Representative
Southern Ute Indian Tribe
P.O. Box 737
Ignacio, CO 81137

Mr. Maria Reyes
Cultural Resource Representative
Pascua Yaqui Tribe
7474 South Camino de Oeste
Tucson, AZ 85746

Honorable Joni Ramos
President
Salt River Pima-Maricopa Indian Community
10005 East Osborn Road
Scottsdale, AZ 85356

Ms. Vernelda Grant
Tribal Archaeologist
San Carlos Apache Indian Tribe
P.O. Box "0"
San Carlos, AZ 85550

Mr. Roland Manakaja
Cultural Representative
Havasupai Tribe
P.O. Box 10
Supai, AZ 86435

Honorable Pauline Jose
Chairwoman, Quechan Culture Community
Fort Yuma Quechan Indian Tribe
P.O. Box 1899
Yuma, AZ 85366

Honorable Maxine Natchees
Business Committee Chairwoman
Northern Ute Indian Tribe
P.O. Box 190
Fort Duchesne, UT 84026

Mr. Terry O. Knight
NAGPRA Representative
Ute Mountain Ute Tribe
Box 53
Towaoc, CO 81334-0248

Ms. Lorene Willis
Cultural Preservation Officer
Jicarilla Apache Nation
P.O. Box 507
Dulce, NM 87528

Ms. Nancy Nelson
Cultural Resources Manager
Ak-Chin Indian Community
47685 North Eco Museum Road
Maricopa, AZ 85239

Mr. Barnaby Lewis
Cultural Resources Program Specialist
Gila River Indian Community
P.O. Box 97
Sacaton, AZ 85746

Mr. Wally Davis, Jr.
Cultural Resource Representative
Tonto Apache Tribal Council
Tonto Apache Reservation No. 30
Payson, AZ 85541

6

Mr. Chris Coder
Cultural Resource Representative
Yavapai-Apache Nation
2400 West Datsi Street
Camp Verde, AZ 86322

Mr. Kenny Anderson
Cultural Representative
Las Vegas Paiute Tribe
One Paiute Drive
Las Vegas, NV 89106

Ms. Lalovi Miller
Cultural Respresentative
Moapa Paiute Tribe
P.O. Box 391
Moapa, NV 89025-0391

Mr. Ernest Mirabal
NAGPRA Representative
Pueblo of Nambe
Route 1, Box 117-A
Santa Fe, NM 87506

Mr. Lee Suina
NAGPRA Representative
Pueblo of Cochiti
Box 157
Cochiti, NM 87072

Ms. Selic Lucero
Cultural Resource Representative
Pueblo of San Felipe
Box 4339
San Felipe Pueblo, NM 87001

Mr. Greg Glassco
Cultural Resource Representative
Yavapai-Prescott Indian Tribe
530 East Merritt Street
Prescott, AZ 86301-2038

Ms. Karen Ray
Cultural Resource Representative
Fort McDowell Yavapai Nation
P.O. Box 17770
Fountain Hills, AZ 85269

Mr. Jacob Pecos
Coordinator
Pueblo of Cochiti
Box 70
Cochiti, NM 87072

Ms. Doreena Martineau
Cultural Resource Representative
Paiute Indian Tribe of Utah
440 N. Paiute Drive
Cedar City, UT 84720

Mr. Todd Scissons
NAGPRA Representative
Pueblo of Acoma
Box 309
Acoma, NM 87304

Mr. Herman Agoyo
NAGPRA Representative
Pueblo of San Juan
Box 1099
San Juan, NM 87566

Ms. Nancy Hayden
Director of Research
Yavapai-Prescott Indian Tribe
530 East Merritt Street
Prescott, AZ 86301-2038

Mr. Celestino Gauchupin
NAGPRA Representative
Pueblo of Zia
135 Capitol Square Drive
Zia Pueblo, NM 87053-6013

7

Mr. Shane Anton
Acting Cultural Programs Supervisor
Salt River Pima-Maricopa Indian Community
Cultural & Environmental Services
10005 East Osborn Road
Scottsdale, AZ 85256

Ms. Loretta Jackson
Tribal Historic Preservation Officer
Hualapai Tribe
215 Diamond Creek Road
Box 310
Peach Springs, AZ 86434

Mr. Luke Duran
NAGPRA Representative, Pueblo of Pojoaque
C/O PPED
#5 W. Gutierrez, Suite B
Santa Fe, NM 87506

Mr. Stephen Begay
NAGPRA Representative, Navajo Nation
Historic Preservation Department
P.O. Box 4950
Window Rock, AZ 86515

Mr. Peter Steere
Project Manager
Cultural Resources Department
Tohono O'odham Nation
P.O. Box 837
Sells, AZ 85634-0834

cc: Mr. Allen J. Auspach
Acting Regional Director
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Amy Heustein
Environmental Protection Officer
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Cathy Wilson
Supervisory Water Rights Specialist
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001
(w/encls to each)

Mr. Sam Spiller
U.S. Fish and Wildlife Service
2321 West Royal Palm Road
Phoenix, AZ 85021

8

bc: Office of the Field Solicitor
U.S. Department of the Interior
Sandra Day O'Connor
U.S. Courthouse, Suite 404
Attention: Ms. Katherine Verburg
401 West Washington Street, SPC 44,
Phoenix, AZ 85003-2151

Office of the Field Solicitor
U.S. Department of the Interior
Sandra Day O'Connor
U.S. Courthouse, Suite 404
Attention: Mr. Bob Snow
401 West Washington Street, SPC 44,
Phoenix, AZ 85003-2151

LC-1000, LC-1100, LC-2000, LC-2001-Chrono, LC-2010, LC-2600, LC-2630, LC-2700, BCOO-1000, BCOO-1003, PXAO-1100, NAAO-1100, UC-100, UC-105, UC-402, UC-406, UC-438, UC-700, UC-720,
(w/encls to each)

Daily
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Definitions for Draft Alternatives and Elements/Options Matrix

(Working Draft: April 13, 2006 version)

- **Absolute protection of a specified reservoir elevation**
  - The reservoir release is reduced by the amount needed to keep the reservoir above the specified elevation (i.e., inflow = outflow)
  - Example: Absolute protection of elevation 3490' at Powell would reduce Powell's release below 8.23 MAF as Powell nears elevation 3490' and would result in additional water stored in Powell and less water in Mead
  - Example: Absolute protection of elevation 1000' in Mead would reduce Mead's release as Mead nears elevation 1000' and would result in shortages at whatever magnitude necessary

- **No protection of reservoir elevations**
  - The reservoir continues to make specified releases until there is no water above the dead pool; then inflow = outflow

- **Reservoir balancing**
  - Lake Powell's release is computed to keep it and Lake Mead at equal storage (or at the same percent full)

- **Modification of Lake Powell's annual release based on elevation**
  - The annual release changes each year depending upon where Lake Powell's elevation is at the beginning of the year (or can also be based on where the elevation is forecasted to be at the end of the year)

- **Proactive Shortage**
  - Shortages are applied at higher levels in the reservoir in order to reduce the chance of going below a lower, specified elevation
  - Results in more frequent shortages of smaller magnitudes than an absolute protection strategy
  - **Probabilistic protection -** shortages are taken at higher levels to approximate a specified chance

Draft Alternatives and Elements/Options Considered in Each Alternative

Working Draft: April 13, 2006 version

Alternatives		A Shortage Guidelines to reduce deliveries/releases from Lake Mead	B Coordinated Reservoir Operations (Lake Mead & Lake Powell)	C Lake Mead Storage and Delivery of Conserved and Non-system Water	D Interim Surplus Guidelines for deliveries/releases from Lake Mead
Alt. 1	No Action Alternative	• Two level shortage strategy - probabilistic protection of elevation 1050' at Lake Mead (80P1050) and absolute protection of elevation 1000' at Lake Mead.	• Minimum objective release of 8.23 MAF unless storage equalization releases are required. • Absolute protection of elevation 3490' at Lake Powell.	• No water management/accounting mechanism for storage and delivery of water conserved through extraordinary water conservation and/or water augmentation programs.	• No modification or extension of the Interim Surplus Guidelines which end in 2016. • Beginning in 2017, surplus declarations revert to the 70R strategy.
Alt. 2	Basin States Preliminary Alternative	• Stepped shortages up to 600 KAF. • Initiate efforts to develop additional guidelines for shortages if Lake Mead falls below elevation 1025' (Note: includes reconsultation with Basin States).	• Under low reservoir storage conditions, either reduce Lake Powell release or balance contents depending on projected Lake Mead and Lake Powell elevations. • No absolute protection of 3490' at Lake Powell.	• Storage/delivery water management/accounting program at Lake Mead for water conserved through extraordinary water conservation and/or water augmentation. • Maximum created storage credit of 625 KAF per year. • Maximum total additional Lake Mead storage through extraordinary conservation and/or augmentation of 2.1 MAF. • Maximum delivery from Lake Mead of water developed by extraordinary conservation and/or augmentation of 1.0 MAF per year.	• Modification of Interim Surplus Guidelines to eliminate Partial Domestic Surplus condition. • The modified guidelines are implemented from 2008 through 2025. • Beginning in 2026, surplus declarations revert to the 70R strategy.
Alt. 3	Conservation Before Shortage Alternative	• Absolute protection of SNWA intake (elevation 1000') at Lake Mead.	• Minimum objective release of 8.23 MAF unless storage equalization releases are required. • Absolute protection of elevation 3490' at Lake Powell.	• Conservation of different volumes of water tied to varying Lake Mead water levels prior to shortage.	• No modification or extension of the Interim Surplus Guidelines which end in 2016. • Beginning in 2017, surplus declarations revert to the 70R strategy.
Alt. 4	No Protections Alternative	• No protection of critical elevations. • Release full annual entitlement amounts until drawn down to top of dead pool: then outflow = inflow.	• Minimum objective release of 8.23 MAF unless storage equalization releases are required. • 8.23 MAF until drawn down to top of dead pool: then outflow = inflow	• No water management/accounting mechanism for storage and delivery of water conserved through extraordinary water conservation and/or water augmentation programs.	• No modification or extension of the Interim Surplus Guidelines which end in 2016. • Beginning in 2017, surplus declarations revert to the 70R strategy.
Alt. 5	Power Protection Alternative	• Absolute protection of minimum power pool elevation (1050') at Lake Mead.	• Minimum objective release of 8.23 MAF unless storage equalization releases are required. • Absolute protection of minimum power pool elevation (3490') at Lake Powell.	• No water management/accounting mechanism for storage and delivery of water conserved through extraordinary water conservation and/or water augmentation programs.	• No modification or extension of the Interim Surplus Guidelines which end in 2016. • Beginning in 2017, surplus declarations revert to the 70R strategy.

Common assumptions to ALL Alternatives:

1. First year of modeling under above-identified alternatives is 2008 and extends to 2060 (53 years) (Note: water elevation for January 1, 2008 will be projected using the May 2006 24-Month Study).
2. Future hydrologic sequences will be based on the 99-year natural flow record (1906-2004).
3. All alternatives revert to No Action modeling assumptions beginning in 2026.
4. Analysis of all alternatives will assume implementation of shortages to Mexico pursuant to Article 10 of 1944 Water Treaty with Mexico when Lower Basin shortage is declared.

- 1 -

5/2/2006, Pre-decisional

I.8 May 12, 2006 Letter to Tribes

copy.

United States Department of the Interior
BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:

LC-2600
ENV-3.00

MAY 1 2 2006

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Honorable Charles Vaughn
Chairman, Hualapai Tribe
P.O. Box 179
Peach Springs, AZ 86434

Subject: Response to Request for Consultation Meeting Regarding Shortage Guidelines EIS

Dear Chairman:

On April 6, 2006, Ms. Nancy Coulam, of the Bureau of Reclamation's Upper Colorado Region, spoke with you on the phone regarding government-to-government consultation between Reclamation and the Hualapai Tribe. This discussion was concerning Reclamation's proposal to develop Lower Basin shortage guidelines and coordinated reservoir operations strategies for Lake Powell and Lake Mead, under low reservoir conditions. An Environmental Impact Statement (EIS) is currently being prepared by Reclamation to analyze this proposal.

During that conversation, you expressed that the Hualapai Tribe had concerns about Lakes Powell and Mead, preserving a specific in-stream flow in the Colorado River, and protection of cultural resources if changes in the river level result in exposure or inundation of sites. You also stated an interest in having a face-to-face meeting to discuss the proposed action, as well as the concerns of the tribe. You should have already received a letter inviting you to a tribal consultation meeting scheduled for the end of this month regarding the alternatives being considered for analysis in the EIS. The meeting is planned to be in Phoenix, Arizona and will be hosted by Reclamation for all consulting tribes. In addition to that invitation, we would welcome the opportunity to meet with you personally, along with any staff or tribal members you wish to include, at our mutual convenience.

Please contact Mr. John Jamrog, Environmental Compliance Group Manager for the Lower Colorado Region at (702) 293-8675 or me to arrange a meeting with appropriate Reclamation management.

Sincerely,

William J. Liebhauser, Director
Resources Management Office

cc: See next page.

cc: Continued from previous page.

Mr. Allen J. Auspach
Acting Regional Director
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Cathy Wilson
Supervisory Water Rights Specialist
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Loretta Jackson
Tribal Historic Preservation Officer
Hualapai Tribe
215 Diamond Creek Road
Box 310
Peach Springs, AZ 86434

Ms. Amy Heustein
Environmental Protection Officer
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Mr. Sam Spiller
U.S. Fish and Wildlife Service
2321 West Royal Palm Road
Phoenix, AZ 85021

bc: Office of the Field Solicitor
U.S. Department of the Interior
Sandra Day O'Connor U.S. Courthouse
Attention: Ms. Katherine Verburg
401 W. Washington St., Suite 404, SPC 44
Phoenix, AZ 85003-2151

Office of the Field Solicitor
U.S. Department of the Interior
Sandra Day O'Connor U.S. Courthouse
Attention: Mr. Bob Snow
401 W. Washington St., Suite 404, SPC 44
Phoenix, AZ 85003-2151

BCOO-1000, BCOO-1003 (w/cpy signed letter)
LC-1000, LC-1100, LC-2000, LC-2010, LC-2600, LC-2630, LC-2700
UC-100, UC-105, UC-402, UC-406, UC-438, UC-700, UC-720
NAAO-1100
PXAO-1100

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(Usr\COMM2000\COM2600\John Jamrog:&Shortage Hualapaiconsultinviteletter.doc)

I.9 September 28, 2006 Letter to Hualapai Tribe

United States Department of the Interior
BUREAU OF RECLAMATION
Lower Colorado Regional Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
LC-2600
ENV-3.00

SEP 28 2006

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

Honorable Charles Vaughn
Chairman, Hualapai Tribal Council
P.O. Box 179
Peach Springs, AZ 86434

Subject: Request for Meeting Regarding for the Lower Colorado Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead

Dear Chairman:

Thank you for your letter dated August 28, 2006, regarding the Environmental Impact Statement (EIS) for the Lower Colorado Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead.

Since receipt of your letter, we have also been contacted by Mr. H. Scott Althouse, of Williams and Works P.A., who is representing the Hualapai Tribe. We have been working with him to establish a mutually acceptable date for a government-to-government consultation meeting. We will continue to work with you and Mr. Althouse to accomplish this goal. Given the current schedule for the EIS, we suggest scheduling our meeting as soon as possible.

We appreciate your assistance and willingness to consult with us regarding this important undertaking. Although we will continue to work with Mr. Althouse by phone, please feel free to contact Mr. John Jamrog, Environmental Compliance Group Manager for the Lower Colorado Region in Boulder City, NV, at (702) 293-8675, directly, at any time.

Sincerely,

William J. Liebhauser, Director
Resources Management Office

cc: See next page.

2

cc: Continued from previous page.

cc: Mr. Allen J. Auspach
Acting Regional Director
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Amy Heuslein
Environmental Protection Officer
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Cathy Wilson
Supervisory Water Rights Specialist
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Mr. Sam Spiller
U.S. Fish and Wildlife Service
2321 West Royal Palm Road
Phoenix, AZ 85021

Ms. Loretta Jackson
Tribal Historic Preservation Officer
Hualapai Tribe
Box 310
Peach Springs, AZ 86434

H. Scott Althouse, Esq.
Williams & Works, P.A.
1801 Hildebrand Lane NE, Suite 200
Bainbridge Island, WA 98110

bc: Ms. Katherine Verburg
Boulder City Solicitor
Department of the Interior
Native American Affairs Office
400 North 5th Street, Suite 1470
Phoenix, AZ 85004-3909

Department of the Interior
Office of the Solicitor
Attention: Mr. Bob Snow
1849 C Street, NW, MS-6412
Washington , DC 20240

BCOO-1000, BCOO-1003, LC-1000, LC-1100, LC-2000, LC-2600, LC-2630, LC-2700, NAAO-1100, PXAO-1100, UC-100, UC-105, UC-402,UC-406, UC-438, UC-700, UC-720

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Daily
WBR:JJamrog:llm:09/27/06:293-8675
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I.10 January 22, 2007 Letter to Tribal Representatives

United States Department of the Interior
BUREAU OF RECLAMATION
Boulder Canyon Operations Office
P.O. Box 61470
Boulder City, NV 89006-1470

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
BCOO-4452
ENV-3.00

JAN 2 2 2007

Interested Parties (See Enclosed List)

Subject: Government-to-Government Consultation on the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead

Dear Tribal Representatives:

As part of continuing government-to-government consultations on the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead, the Upper and Lower Colorado Regions of the Bureau of Reclamation request to meet with tribal representatives to discuss key aspects of the Draft Environmental Impact Statement (Draft EIS).

We invite you to meet from 12:00 p.m. to 3:00 p.m. Pacific Standard Time on February 22, 2007, in Mezzanine Room #3, McCarran International Airport, Las Vegas, Nevada. During the meeting, we will provide tribal representatives with an update of progress on the project and present information on key aspects of the Draft EIS that will be published on February 28, 2007. A court reporter will be present to record the discussions during the meeting. An agenda and power point presentation will be provided for you at the meeting.

If you are unable to attend, the following conference line is provided for your convenience: 1-866-830-3963 (code: 5142989).

Please contact Amber Cunningham at 702-293-8472 if you have any questions.

Sincerely,

Terrance J. Fulp, Ph.D.
Area Manager
Boulder Canyon Operations Office

Enclosure

cc: Mr. Allen J. Auspach
Acting Regional Director
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Amy Heuslein
Environmental Protection Officer
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Ms. Cathy Wilson
Supervisory Water Rights Specialist
Bureau of Indian Affairs
P.O. Box 10
Phoenix, AZ 85001

Mr. Sam Spiller
U.S. Fish and Wildlife Service
2321 West Royal Palm Road
Phoenix, AZ 85021

bc: Boulder City Field Unit of Field Solicitor
U.S. Department of the Interior
Native American Affairs Office
Attention: Ms. Katherine Verburg
400 North Fifth Street, Suite 1470
Phoenix, AZ 85004

Office of the Field Solicitor
U.S. Department of the Interior
Attention: Mr. Bob Snow
1849 C Street, NW #6352
Washington, DC 20240

3

Honorable Sherry Cordova
Chairwoman, Cocopah Indian Tribe
County 15th and Avenue G
Somerton, AZ 85350

Ms. Jill McCormick
Cultural Resources Manager
Cocopah Indian Tribe
County 15th and Avenue G
Somerton, AZ 85350

Honorable Daniel Eddy, Jr.
Chairman, Colorado River Indian Tribes
Route 1, Box 23-B
Parker, AZ 85344-9704

Mr. Michael Tsosie
Museum Director
Colorado River Indian Tribes
Route 1, Box 23-B
Parker, AZ 85344-9704

Honorable Nora McDowell
Chairwoman, Fort Mojave Indian Tribe
500 Merriman Avenue
Needles, CA 92363

Ms. Linda Otero
Director, Ahamakav Cultural Society
Fort Mojave Indian Tribe
P.O. Box 5990
Mohave Valley, CA 86440

Honorable Joe Shirley, Jr.
President, Navajo Nation
Box 9000
Window Rock, AZ 86515

Dr. Alan Downer
Navajo Nation Historic Preservation Department
P.O. Box 4950
Window Rock, AZ 86515

Mr. Stephen Begay
NAGPRA Representative
Navajo Nation Historic Preservation Department
P.O. Box 4950
Window Rock, AZ 86515

Mr. Ron Maldonado
Navajo Nation Historic Preservation Office
P.O. Box 4950
Window Rock, AZ 86515

Honorable Michael Jackson, Sr.
President, Quechan Indian Tribe
P.O. Box 1899
Yuma, AZ 85366

Honorable Pauline Jose
Chairwoman, Quechan Culture Community
Fort Yuma Quechan Indian Tribe
P.O. Box 1899
Yuma, AZ 85366

Honorable Maxine Natchees
Business Committee Chairwoman
Northern Ute Indian Tribe
P.O. Box 190
Fort Duchesne, UT 84026

Ms. Betsey Chapoose
Northern Ute Indian Tribe
P.O. Box 190
Fort Duchesne, UT 84026

Honorable Clement J. Frost
Chairman, Southern Ute Indian Tribe
P.O. Box 737
Ignacio, CO 81137

Mr. Neil Cloud
NAGPRA Representative
Southern Ute Indian Tribe
P.O. Box 737
Ignacio, CO 81137

1

4

Mr. Terry O. Knight
NAGPRA Representative
Ute Mountain Ute Tribe
Box 53
Towaoc, CO 81334-0248

Honorable Levi Pesata
President, Jicarilla Apache Nation
P.O. Box 507
Dulce, NM 87528

Ms. Lorene Willis
Cultural Preservation Officer
Jicarilla Apache Nation
P.O. Box 507
Dulce, NM 87528

Honorable Manual Health
Chairman, Ute Mountain Ute Tribe
P.O. Box 248
Towaoc, CO 81334-0248

Honorable Delia Carlyle
Chairwoman, Ak-Chin Indian Community
42275 West Peters and Nall Road
Maricopa, AZ 85239-3940

Ms. Nancy Nelson
Cultural Resources Manager
Ak-Chin Indian Community
47685 North Eco Museum Road
Maricopa, AZ 85239

Honorable William R. Rhodes
Governor
Gila River Indian Community
P.O. Box 97
Sacaton, AZ 85746

Mr. Barnaby Lewis
Cultural Resources Program Specialist
Gila River Indian Community
P.O. Box 97
Sacaton, AZ 85746

Honorable Herminia Frias
Chairwoman, Pascua Yaqui Tribe
7474 South Camino de Oeste
Tucson, AZ 85746

Mrs. Marian Reyes
Cultural Resources Program Specialist
Pascua Yaqui Tribe
7474 South Camino de Oeste
Tucson, AZ 85746

Honorable Joni Ramos
President
Salt River Pima-Maricopa Indian Community
10005 East Osborn Road
Scottsdale, AZ 85256

Mr. Shane Anton
Acting Cultural Programs Supervisor
Salt River Pima-Maricopa Indian Community
Cultural & Environmental Services
10005 East Osborn Road
Scottsdale, AZ 85256

Honorable Kathleen Wesley-Kitcheyan
Chairwoman, San Carlos Apache Indian Tribe
P.O. Box "0"
San Carlos, AZ 85550

Ms. Vernelda Grant
Tribal Archaeologist
San Carlos Apache Indian Tribe
P.O. Box "0"
San Carlos, AZ 85550

Honorable Vivian Juan-Saunders
Chairwoman, Tohono O'odham Nation
P.O. Box 837
Sells, AZ 85634-0837

1

Mr. Peter Steere
Project Manager
Cultural Resources Department
Tohono O'odham Nation
P. O. Box 837
Sells, AZ 85634-0837

Honorable Ivan Smith
Chairman, Tonto Apache Tribal Council
Tonto Apache Reservation No. 30
Payson, AZ 85541

Mr. Wally Davis, Jr.
Cultural Resources Program Specialist
Tonto Apache Tribal Council
Tonto Apache Reservation No. 30
Payson, AZ 85541

Honorable Jamie Fullmer
Chairman, Yavapai-Apache Nation
2400 West Datsi Street
Camp Verde, AZ 86322

Mr. Chris Coder
Cultural Resources Program Specialist
Yavapai-Apache Nation
2400 West Datsi Street
Camp Verde, AZ 86322

Honorable Raphael Bear
President, Fort McDowell Yavapai Nation
P.O. Box 17770
Fountain Hills, AZ 85269

Ms. Karen Ray
Cultural Resource Representative
Fort McDowell Yavapai Nation
P.O. Box 17770
Fountain Hills, AZ 85269

Honorable Thomas Siyuja, Sr.
Chairman, Havasupai Tribe
P.O. Box 10
Supai, AZ 86435

Mr. Roland Manakaja
Cultural Representative
Havasupai Tribe
P.O. Box 10
Supai, AZ 86435

Honorable Wayne Taylor, Jr.
Chairman, Hopi Tribe
Box 123
Kykotsmovi, AZ 86029

Mr. Leigh Kuwanwisiwma
Hopi Tribe
Box 123
Kykotsmovi, AZ 86029

Ms. Loretta Jackson
Tribal Historic Preservation Officer
Hualapai Tribe
215 Diamond Creek Road
Box 310
Peach Springs, AZ 86434

Honorable Charles Vaughn
Chairman, Hualapai Tribe
Box 179
Peach Springs, AZ 86434

Honorable Gary Tom
Chairman, Kaibab Band of Paiute Indians
HC65 Box 2
Fredonia, AZ 86022

Honorable Alfreda Mitre
Chairwoman, Las Vegas Paiute Tribe
One Paiute Drive
Las Vegas, NV 89106

Mr. Kenny Anderson
Cultural Representative
Las Vegas Paiute Tribe
One Paiute Drive
Las Vegas, NV 89106

6

Honorable Phil Swain
Chairman, Moapa Paiute Tribe
P.O. Box 340
Moapa, NV 89025-0340

Ms. Lalovi Miller
Cultural Representative
Moapa Paiute Tribe
P.O. Box 391
Moapa, NV 89025-0391

Honorable Laura Tom
Chairwoman, Paiute Indian Tribe of Utah
440 No. Paiute Drive
Cedar City, UT 84720

Ms. Doreena Martineau
Cultural Resource Representative
Paiute Indian Tribe of Utah
440 No. Paiute Drive
Cedar City, UT 84720

Honorable Fred Vallo, Sr.
Governor, Pueblo of Acoma
Box 309
Acoma, NM 87034

Mr. Todd Scissons
Director, Historic Preservation Office
Pueblo of Acoma
Box 309
Acoma, NM 87034

Honorable Simon Suipa
Governor, Pueblo of Cochiti
Box 70
Cochiti Pueblo, NM 87072

Mr. Lee Suina
NAGPRA Representative
Pueblo of Cochiti
Box 157
Cochiti, NM 87072

Mr. Jacob Pecos
Coordinator
Pueblo of Cochiti
Box 70
Cochiti, NM 87072

Honorable Raymond Lucero
Governor, Pueblo of Jemez
Box 100
Jemez Pueblo, NM 87024

Cultural Resource Representative
Pueblo of Jemez
Box 100
Jemez Pueblo, NM 87024

Honorable Tom F. Talache, Jr.
Governor, Pueblo of Nambe
Route 1, Box 117-BB
Santa Fe, NM 87506

Mr. Ernest Mirabal
NAGPRA Representative
Pueblo of Nambe
Route 1, Box 117-A
Santa Fe, NM 87506

Honorable George Rivera
Governor, Pueblo of Pojoaque
78 Cities of Gold Road
Santa Fe, NM 87506

Mr. Luke Duran
NAGPRA Representative
Pueblo of Pojoaque
C/O PPED
#5 W. Gutierrez, Suite 2B
Santa Fe, NM 87506

Mr. Herman Agoyo
NAGPRA Representative
Pueblo of San Juan
Box 1099
San Juan Pueblo, NM 87566

7

Honorable Wilfred Garcia
Governor, Pueblo of San Juan
Box 1099
San Juan Pueblo, NM 87566

Honorable Stuwart Paisano
Governor, Pueblo of Sandia
481 Sandia Loop
Bernalillo, NM 87004

Mr. Ben Robbins
Pueblo of Santa Ana
2 Dove Road
Bernalillo, NM 87004

Honorable Myron Armijo
Governor, Pueblo of Santa Ana
2 Dove Road
Bernalillo, NM 87004

Honorable Denny Gutierrez
Governor, Pueblo of Santa Clara
Box 580
Espanola, NM 87532

Mrs. Jackie Gutierrez
Pueblo of Santa Clara
Box 580
Espanola, NM 87532

Honorable Gilbert Bigil
Governor, Pueblo of Tesuque
Route 42 Box 360-T
Santa Fe, NM 87506

Mr. Mark Mitchell
Pueblo of Tesuque
Route 42, Box 360-T
Santa Fe, NM 87506

Mr. Celestino Gauchupin
NAGPRA Representative
Pueblo of Zia
135 Capitol Square Drive
Zia Pueblo, NM 87053-6013

Honorable Peter Pino
Governor, Pueblo of Zia
135 Capitol Square Drive
Zia Pueblo, NM 87053-6013

Dr. Jonathan Damp
Pueblo of Zuni
Box 1149
Zuni Pueblo, NM 87327-0339

Honorable Arlen Quetawki, Sr.
Governor, Pueblo of Zuni
Box 339
Pueblo of Zuni, NM 87327-0339

Ms. Selic Lucero
Cultural Resource Representative
Pueblo of San Felipe
Box 4339
San Felipe Pueblo, NM 87001

Honorable Lawrence Troncosa
Governor, Pueblo of San Felipe
Box 4339
San Felipe Pueblo, NM 87001

Honorable Ernest Jones, Sr.
President, Yavapai-Prescott Indian Tribe
530 East Merritt Street
Prescott, AZ 86301-2038

Ms. Nancy Hayden
Director of Research
Yavapai-Prescott Indian Tribe
530 East Merritt Street
Prescott, AZ 86301-2038

Mr. Greg Glassco
Cultural Resource Representative
Yavapai-Prescott Indian Tribe
530 East Merritt Street
Prescott, AZ 86301-2038

1

8

Honorable Dallas Massey, Sr.
Chairman, White Mountain Apache
P.O. Box 700
White River, AZ 85941

Honorable Roland E. Johnson
Governor, Pueblo of Laguna
P.O. Box 194
Laguna, NM 87026

Ms Lorraine Swanick
Natural Resource Coordinator
Pueblo of San Felipe
Box 4339
San Felipe Pueblo, NM 87001

Mr. Sam Montoya
Cultural Resource Representative
Pueblo of Sandia
Box 6008
Bernalillo, NM 87004

Mrs. Roni H. Polk
NAGPRA Coordinator
Pueblo of Acoma
Box 309
Acoma, NM 87034

Mr. Grant Buma
Colorado River Indian Tribes
Route 1, Box 23-B
Parker, AZ 85344

Ms. Brenna Clani
Navajo Nation DOJ
P.O. Box 2010
Window Rock, AZ 86515

Ms. Catherine Condon
Southern Ute Tribe
Greene, Moyer & McElroy
1007 Pearl, Suite 220
Boulder, CO 80304

Mr. Manuel Heart
Ute Mountain Ute Tribe
P.O. Box JJ
Towaoc, CO 81334

Navajo Nation
Box 3390
Window Rock, AZ 86515

Mr. Tim Pierson
Gila River Indian Community
5002 North Maricopa
Box 5090
Chandler, AZ 85226

Mr. Gary L. Parker
Gila River Indian Irrigation & Drainage
5002 N. Maricopa Road
Box 5005
Chandler, AZ 85226

Mr. Robert F. Palmgust
Strickland Firm for Ak-Chin
440 E. Broadway, Suite 700
Tucson, AZ 85711

Mr. Clarence Miquel
Tohono O'odham Nation
Route 2, Box 626
Casa Grande, AZ 85222

Ms. Gloria Thomas
Tohono O'odham Nation
Route 2, Box 601-A
Casa Grande, AZ 85222

Robyn Interpreter
Sparks, Tehan, and Ryky PC
7503 First Street
Scottsdale, AZ 85251

Honorable Charles Wood
Chairman, Chemehuevi Indian Tribe
P.O. Box 1976
Havasu Lake, CA 92363-1976

1

9

Dr. Carole Klopatek
Fort McDowell Yavapai Nation
P.O. Box 17779
Fountain Hills, AZ 85269-7779

Mr. H. Scott Althouse
Williams & Works, P.A.
1801 Hildebrand Lane NE, Suite 200
Bainbridge Island, WA 98110

Ms. Cyndy Cole
Arizona Daily Sun
1751 South Thompson
Flagstaff, AZ 86001

1

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Appendix J

Seven Basin States
Preliminary Proposal Regarding
Colorado River Interim Operations, February 3, 2006

The seven Colorado River Basin States developed and submitted a Preliminary Proposal Regarding Colorado River Interim Operations in a letter to the Secretary dated February 3, 2006. The full text of the seven Colorado River Basin States' proposal is provided in this Appendix. Included is the Seven Colorado River Basin States' proposal is the transmittal letter, preliminary proposal, and draft agreement.

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J.1 Letter to Secretary of the Interior

The States of Arizona, California, Colorado, Nevada,
New Mexico, Utah and Wyoming
Governor's Representatives on Colorado River Operations

February 3, 2006

Honorable Gale A. Norton, Secretary
Department of the Interior
1849 C. Street, NW
Washington, D.C. 20240

Re: Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for the Operation of Lake Mead and Lake Powell Under Low Reservoir Conditions

Dear Secretary Norton:

The materials attached to this letter contain descriptions of the programs that the seven Colorado River Basin States suggest be included within the scope of the environmental impact statement (EIS) for the proposed *Colorado River Reservoir Operations: Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead Under Low Reservoir Conditions* (70 Fed. Reg. 57322) (Sept. 30, 2005).

The Basin States, Bureau of Reclamation and others have consulted regularly since our previous correspondence on August 25, 2005 to further discuss and refine recommended management strategies for the Colorado River system. Subsequently, individual entities within the seven Basin States submitted oral and written comments to the Bureau of Reclamation on the above-referenced EIS process. Attachment A, "Seven Basin States' Preliminary Proposal Regarding Colorado River Interim Operations," is submitted as a consensus document on behalf of the seven Basin States. Please recognize that the States are still actively working on the matters addressed in this submission and anticipate further refinement.

Our recommendation is designed to provide input for the Department's consideration as it develops additional operational and water accounting procedures to: 1) delay the onset and minimize the extent and duration of shortages in the Lower Division States; 2) maximize the protection afforded the Upper Division States by storage in Lake Powell against possible curtailment of Upper Basin uses; 3) provide for more efficient, flexible, responsive and reliable operation of the system reservoirs for the benefit of both the Upper and Lower Basins by developing additional system water supplies through extraordinary conservation, system efficiency and augmentation projects; 4) allow the continued development and use of the Colorado River resource in both the Upper and Lower Basins; and 5) allow for development of dedicated water supplies through participation in improvements to system efficiency and clarification of how to proceed with development of non-system water reaching the Lower Basin

S-2006

The Honorable Gale A. Norton
February 3, 2006
Page 2 of 3

mainstream. It is our position that implementation of these operational and accounting procedures can be accomplished without modification of the Long Range Operating Criteria or other elements of the law of the river.

The States' attached proposal incorporates an approach to shortage management. Additionally, the proposal includes modification and extension of the Department's Interim Surplus Guidelines to incorporate operations for all reservoir conditions.

The attached proposal also addresses the States' recommended approach to implementation of shortages pursuant to the U.S.-Mexico Treaty of 1944. We request that the Department of the Interior initiate, at the earliest appropriate time, consultation with the U.S. Section of the International Boundary and Water Commission and the U.S. Department of State on implementation of Treaty shortages. We further request the opportunity to consult with Interior and State Department officials on this issue as the federal government formulates its approach to any bi-national consultation with Mexico.

An agreement between Basin State water managers and users will be necessary to put in place additional terms upon which they have reached common understanding. We intend that this agreement be finalized while Reclamation is preparing the draft EIS, and be executed as soon as practicable. We are including with this letter a draft version of the agreement (Attachment B), to memorialize our current understandings and to provide you the benefits of our thoughts at this time. As with Attachment A, please recognize that the parties are still actively working on the matters addressed in Attachment B, and contemplate additional development and refinement of the agreement. We recognize that timely execution of our agreement is necessary in order to allow funding of certain efficiency projects to go forward.

During the time Reclamation is preparing the draft EIS, the States will move forward with a package of other actions that include implementation of a demonstration program for extraordinary conservation in 2006, system efficiency projects, preparation of an action plan for system augmentation through weather modification, execution of a memorandum of understanding for preparing a Lower Division States interstate drought management plan, development of forbearance agreements among the Lower Division States and the initiation of a study for long-term augmentation of Colorado River system water supplies. The States have already begun the consultant procurement process to support the long-term augmentation study, and intend to complete a weather modification action plan and a memorandum of understanding for interstate drought planning as soon as practicable. The Basin States recognize that Reclamation is undertaking NEPA compliance separately to determine whether to construct a regulating reservoir near Drop 2 of the All-American Canal and urge swift completion of that process.

We appreciate the opportunity you have provided for the Colorado River Basin States to recommend to you a program of reservoir management that considers all their respective concerns and interests. The Basin States look forward to working with you and Reclamation in analyzing and addressing these matters.

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The Honorable Gale A. Norton
February 3, 2006
Page 3 of 3

Sincerely,

Herb Guenther
Director
Arizona Department of Water Resources

Gerald R. Zimmerman
~~Executive Director~~
Colorado River Board of California

Scott Balcomb
Governor's Representative
State of Colorado

Rod Kuharich
Director
Colorado Water Conservation Board

Richard Bunker
Chairman
Colorado River Commission of Nevada

Patricia Mulroy
General Manager
Southern Nevada Water Authority

John R. D'Antonio, Jr.
Governor's Representative
State of New Mexico

Patrick Tyrrell
State Engineer
State of Wyoming

D. Larry Anderson
Director
Utah Division of Water Resources

List of Attachments:

Attachment A: Seven Basin States' Preliminary Proposal Regarding Colorado River Interim Operations

Attachment B: Draft Agreement

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J.2 Attachment A: Preliminary Proposal Regarding Colorado River Interim Operations

ATTACHMENT A
Seven Basin States' Preliminary Proposa Regarding Colorado River Interim Operations

The Seven Basin States (States) have worked together to recommend interim operations to the Secretary that should minimize shortages in the Lower Basin and avoid the risk of curtailment in the Upper Basin through conservation, more efficient reservoir operations, and long-term alternatives to bring additional water into the Colorado River community.

The States' recommendation has three key elements. First, the States propose to manage the reservoirs to minimize shortages and avoid curtailments. Second, the States have identified actions in the Lower Basin to conserve water. Third, the States recommend a specific proposal for implementing shortages in the Lower Basin. Finally, the States recognize the need for additional water supplies to meet the current and future needs in the Basin.

Section 1. Allocation of Unused Basic Apportionment Water under Article II(B)(6)

A. Introduction

Article II(B)(6) of the 1964 Decree in *Arizona* v. *California* (Decree) allows the Secretary to allocate water that is apportioned to one Lower Division State, but is for any reason unused in that State, to another Lower Division State. This determination is made for one year only and no rights to recurrent use of the water accrue to the State that receives the allocated water.

B. Application of Unused Basic Apportionment

Before making a determination of a surplus condition under this proposal, the Secretary will determine the quantity of apportioned but unused water under Article II (B)(6), and will allocate such water in the following order of priority.

1. Meet the direct delivery domestic use requirements of the Metropolitan Water District of Southern California, (MWD) and the Southern Nevada Water Authority (SNWA), as allocated between them by agreement.

2. Meet the needs of off stream banking activities by MWD in California and SNWA in Nevada, as allocated between them by agreement.

3. Meet the other needs for water in California in accordance with the California Seven-Party Agreement as supplemented by the Quantification Settlement Agreement.

Section 2. Coordinated Operation of Lakes Powell and Mead

Figure 1 describes the operating strategy that has been agreed to by the Colorado River Basin States.

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Seven Basin States' Preliminary Proposa Regarding Colorado River Interim Operations

Powell Elevation (feet)	Powell Operation	Powell Live Storage (maf)
3700	Equalize or 8.23 maf	**24.32**
3636 - 3664 (see table below)	8.23 maf; if Mead < 1075 feet, balance contents with a min/max release of 7.0 and 9.0 maf	**15.54- 19.02** (2008 - 2025)
3575	7.48 maf 8.23 maf if Mead < 1025 f	**9.52**
3525	Balance contents with a min/max release of 7.0 and 9.5 maf	**5.93**
3370		**0**

Lake Powell Equalization Elevation Table

In each of the following years, the Lake Powell Equalization Elevation will be as follows:

Year	Elevation (feet)
2008	3636
2009	3639
2010	3642
2011	3643
2012	3645
2013	3646
2014	3648
2015	3649
2016	3651
2017	3652
2018	3654
2019	3655
2020	3657
2021	3659
2022	3660
2023	3662
2024	3663
2025	3664

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ATTACHMENT A
Seven Basin States' Preliminary Proposa Regarding Colorado River Interim Operations

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1. Equalization: In years when Lake Powell content is projected on January 1 to be at or above the elevation stated in the Lake Powell Equalization Elevation Table, an amount of water will be released from Lake Powell to Lake Mead at a rate greater than 8,230,000 acre-feet per year to the extent necessary to equalize storage in the two reservoirs, or otherwise to release 8,230,000 acre-feet from Lake Powell.

2. Upper Elevation Balancing: In years when Lake Powell content is projected on January 1 to be below the elevation stated in the Lake Powell Equalization Elevation Table and at or above 3575 ft., the Secretary shall release 8,230,000 acre-feet from Lake Powell if the projected elevation of Lake Mead is at or above 1075 ft. If the projected elevation of Lake Mead is below 1075 ft., the Secretary shall balance the contents of Lake Mead and Lake Powell, but shall release no more than 9,000,000 acre-feet and no less than 7,000,000 acre-feet from Lake Powell.

3. Mid-Elevation Releases: In years when Lake Powell content is projected on January 1 to be below 3575 ft. and at or above 3525 ft., the Secretary shall release 7,480,000 acre-feet from Lake Powell if the projected elevation of Lake Mead is at or above 1025 ft. If the projected elevation of Lake Mead is below 1025 ft., the Secretary shall release 8,230,000 acre-feet from Lake Powell.

4. Lower Elevation Balancing: In years when Lake Powell content is projected on January 1 to be below 3525 ft., the Secretary shall balance the contents of Lake Mead and Lake Powell, but shall release no more than 9,500,000 acre-feet and no less than 7,000,000 acre-feet from Lake Powell.

Coordinated Operation of Lakes Powell and Mead as described herein will be presumed to be consistent with the Section 602(a) storage requirement contained in the Colorado River Basin Project Act.

The objective of the operation of Lakes Powell and Mead as described herein is to avoid curtailment of uses in the Upper Basin, minimize shortages in the Lower Basin and not adversely affect the yield for development available in the Upper Basin.

The August 24-month study projections for the January 1 system storage and reservoir water surface elevations, for the following year, would be used to determine the applicability of the coordinated operation of Lakes Powell and Mead.

Section 3. Determination of Lake Mead Operation during the Interim Period

A. Interim Surplus Guidelines

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Seven Basin States' Preliminary Proposa Regarding Colorado River Interim Operations

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1. The Basin States recommend that the Secretary continue to implement the Interim Surplus Guidelines (ISG) except as modified by this proposal, including the following:
   a. Partial Domestic Surplus would be discontinued upon issuance of the Record Of Decision ("ROD"); and

   b. The ISG effective period would be extended through December 31, 2025.

2. During the years 2017 through 2025 the Secretary shall distribute Domestic Surplus water:

   a. For use by MWD, 250,000 acre-feet per year in addition to the amount of California's basic apportionment available to MWD.

   b. For use by SNWA, 100,000 acre-feet per year in addition to the amount of Nevada's basic apportionment available to SNWA.

   c. For use in Arizona, 100,000 acre-feet per year in addition to the amount of Arizona's basic apportionment available to Arizona contractors.

B. Flood Control Surplus

In years in which the Secretary makes space building or flood control releases pursuant to the Field Working Agreement, the Secretary shall determine a Flood Control Surplus for the remainder of that year or the subsequent year as specified in Section 7 of the ISG. In such years, releases will be made to satisfy all beneficial uses within the United States, including unlimited off-stream banking. Intentionally Created Surplus credits, as defined herein, would be reduced by the amount of any flood control release, if necessary until no credits are remaining. Under current practice, surplus declarations under the Treaty for Mexico are declared when flood control releases are made. Operation under a Flood Control Surplus does not establish any determination relating to implementation of the Treaty, including any potential changes in approach relating to surplus declarations under the Treaty. Such determinations must be addressed in a bilateral fashion with the Republic of Mexico.

C. Quantified Surplus
(70R Strategy)

In years when the Secretary determines that water should be released for beneficial consumptive use to reduce the risk of potential reservoir spills based on the 70R Strategy, the Secretary shall determine and allocate Quantified Surplus sequentially as follows:

1. Establish the volume of the Quantified Surplus. For the purpose of determining the existence, and establishing the volume, of Quantified

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Surplus, the Secretary would not consider the volume of Intentionally Created Surplus credits, as defined herein.

2. Allocate and distribute the Quantified Surplus 50% to California, 46% to Arizona and 4% to Nevada, subject to 3. through 5. that follow.

3. Distribute California's share first to meet basic apportionment demands and MWD's demands. Then distribute to California Priorities 6 and 7 and other surplus contracts. Distribute Nevada's share first to meet basic apportionment demands and SNWA's demands. Distribute Arizona's share to surplus demands in Arizona including off stream banking and interstate banking demands. Arizona, California and Nevada agree that Nevada would get first priority for interstate banking in Arizona.

4. Distribute any unused share of the Quantified Surplus in accordance with Section 1, Allocation of Unused Basic Apportionment Water Under Article II (B)(6).

5. Determine whether MWD, SNWA and Arizona have received the amount of water they would have received under Section 3 D of this proposal, Domestic Surplus, if a Quantified Surplus had not been declared. If they have not, then determine and meet all demands provided for in Section 3 D, Domestic Surplus.

D. Domestic Surplus

In years when Lake Mead elevation is projected on January 1 to be above 1145 ft and below 70R Strategy elevation determination, the Secretary would determine a Domestic Surplus in accordance with Section 2(B)(2) of the ISG between the effective date of the ROD and December 31, 2016 and in accordance with Section 3(A) (2) of this proposal between January 1, 2017 and December 31, 2025.

E. Normal Conditions

In years when Lake Mead elevation is projected on January 1 to be above elevation 1075 ft. and below 1145 ft., the Secretary would determine a normal operating condition. In any year when Lake Mead elevations are in this range, the Secretary may determine that Intentionally Created Surplus ("ICS") as described in Section 4 of this proposal is available. ICS credits may then be delivered pursuant to the provisions of Section 4.

F. Shortage Conditions

Shortages would be implemented in the Lower Division States and Mexico under the following conditions and in the following manner:

1. 400,000 acre foot shortage: In years when Lake Mead content is projected on January 1 to be at or below elevation 1075 ft. and at or above 1050 ft.,

ATTACHMENT A
Seven Basin States' Preliminary Proposa Regarding Colorado River Interim Operations

a quantity of 400,000 acre-feet shall not be released or delivered in the Lower Division States and Mexico.

2. 500,000 acre foot shortage: In years when Lake Mead content is projected on January 1 to be below elevation 1050 ft. and at or above 1025 ft. a quantity of 500,000 acre-feet shall not be released or delivered in the Lower Division States and Mexico.

3. 600,000 acre foot shortage: In years when Lake Mead content is projected on January 1 to be below 1025 ft., a quantity of 600,000 acre-feet shall not be released or delivered in the Lower Division States and Mexico.

4. The three conditions described above are illustrated in Figure 2.

Figure 2

Lake Mead Step Shortage		
Mead Elevation (ft)	Stepped Shortage	Mead Live Storage
1075 to 1050	400 kaf	9.37 to 7.47 maf
<1050 to 1025	500 kaf	7.47 to 5.80 maf
<1025 to 1000	600 kaf	5.80 to 4.33 maf
<1000	Increased reductions to be consistent with consultation(s)	<4.33 maf

5. The United States, through the appropriate mechanisms, should implement a shortage pursuant to Article 10 of the 1944 Treaty in any year in which the Secretary has declared that a shortage condition exists pursuant to Art. II(B)(3) of the Decree. The total quantity of water that will not be released or delivered to Mexico shall be based on Lower Basin water deliveries during normal water supply conditions. The proportion of the shortage that shall be borne by Mexico will be 17% (1.5 maf / 9 maf x 100% = 17%).

6. Arizona and Nevada will share shortages based on a shortage sharing agreement. In the event that no agreement has been reached, Arizona and Nevada will share shortages in accordance with the 1968 Colorado River Basin Project Act, the Decree, other existing law as applicable, and the Interstate Banking Agreement between Arizona and Nevada parties.

7. Whenever Lake Mead reaches elevation1025 ft., the Secretary will consult with the States to determine whether Colorado River hydrologic conditions, together with the delivery of 8.4 million acre-feet of Colorado River water to Lower Basin users and Mexico, will cause the elevation of Lake Mead to fall below 1000 ft. Upon such a determination, the

Secretary shall consult with the states to discuss further measures that may be undertaken to avoid or reduce further increases in shortage determinations. If increased reductions are required, the Secretary shall implement the reductions consistent with the law of the river.

8. The States will evaluate factors at critical elevations that may avoid shortage determinations as reservoir elevations approach critical thresholds. The States may provide operational recommendations surrounding the critical elevations at some later date.

Section 4. System Efficiency, Extraordinary Conservation and Augmentation Projects

The States propose that the Secretary develop a policy and accounting procedure concerning augmentation, extraordinary conservation, and system efficiency projects, including specific extraordinary conservation projects, tributary conservation projects, introduction of non-Colorado River System water, system efficiency improvements and exchange of non-Colorado River System water. The accounting and recovery process would be referred to as "Intentionally Created Surplus" consistent with the concept that the States will take actions to augment storage of water in the Lower Colorado River Basin. The water would be distributed pursuant to Section II(B)(2) of the Decree and forbearance agreements between the States. The ICS credits may not be created or released without such forbearance agreements.

A. The purposes of the Lake Mead Intentionally Created Surplus ("ICS") program are to:

1. Help avoid shortages to the Lower Basin. For the purposes of determining calendar year declarations of Domestic Surplus, Normal and Shortage conditions, any ICS credits would be considered system water;

2. Benefit both Lake Mead and Lake Powell; and

3. Increase the surface elevations of both Lakes Powell and Mead to higher levels than would have otherwise occurred.

B. Extraordinary Conservation Storage Credits

1. Users of Colorado River water may create ICS credits through extraordinary conservation under the following conditions:

a. A Boulder Canyon Project Act Section 5 Contractor ("Contractor") shall repay all outstanding system payback obligations before it can create ICS credits.

b. ICS credits can only be created if such water could have otherwise been beneficially used.

c. A Contractor notifies Reclamation by September 15 of the amount of ICS credits it wishes to create for the subsequent year.

2. ICS credits may be created only through extraordinary conservation activities. These activities include:

   a. Fallowing of land that currently is, historically was, and otherwise would have been in the next year, irrigated.

   b. Canal lining programs

   c. Desalination programs

   d. Extraordinary conservation programs existing as of January 1, 2006

   e. Other extraordinary conservation measures as agreed upon by the States

3. If conditions during the year change due to weather or other unforeseen circumstances, a Contractor may request a mid-year modification of its water order to reduce the amount of ICS credits created during that year. A Contractor cannot increase the amount of ICS credits it had previously scheduled to create during the year.

4. Any ICS credits would be used first to offset any overrun for that year or future year(s).

5. The maximum amount of ICS credits that can be created during any year through extraordinary conservation is limited to each state as listed below.

   a. California: 400,000 acre-feet per year

   b. Nevada: 125,000 acre-feet per year

   c. Arizona: 100,000 acre-feet per year

6. The maximum cumulative amount of ICS credits created through extraordinary conservation that would be available at any one time is:

   a. 1,500,000 acre-feet for California;

   b. 300,000 acre-feet for Nevada; and

   c. 300,000 acre-feet for Arizona.

7. No category of surplus water can be used to create ICS credits.

8. At the time the ICS credits are created by extraordinary conservation, the Contractor will dedicate 5% of the ICS credits to the system on a one-time basis to provide a water supply benefit to the system. Additionally, ICS credits will be subject to annual evaporation loss (estimated to be no more than 3% annually) during each year in which no shortage has been declared. The Secretary will not assess any other charge for creating ICS credits.

9. Contractors that have created ICS credits may recover them under the following conditions:

    a. A Contractor may request delivery of ICS credits it has created at the time it submits its annual water order for the following year. The ICS credits would be added to the Contractor's approved water order for that year upon approval by Reclamation.
    b. The amount of ICS credits that may be recovered by California in any one year is limited to 400,000 acre-feet, by Nevada 300,000 acre-feet and Arizona 300,000 acre-feet; provided that the May 1, 24-month study for that year does not indicate that a shortage condition would be declared in the current or succeeding year.

    c. If extraordinary weather conditions or water emergencies occur, a Contractor may request that Reclamation increase its use of ICS credits for that year.

    d. A Contractor may request to reduce its use of ICS credits during the year for any reason, including reduction in water demands.

    e. If Reclamation releases water for flood control purposes, ICS credits shall be reduced on a pro-rata basis among all holders of ICS credits-- if necessary until no credits remain. In determining the amount of Quantified Surplus, Reclamation shall not consider the volume of ICS credits that will be available.

10. Contractors may begin to create ICS through extraordinary conservation 1) beginning in 2006 as a pilot program (which may be lost if the Secretary does not adopt an extraordinary conservation program as part of the Coordinated Operation of Lakes Powell and Mead) or 2) after adoption of the Coordinated Operation for Lakes Powell and Mead until 2025. Any ICS credits under this program remaining at the end of the program would remain available for recovery for up to 10 years following termination of the Program.

C. Tributary Conservation

The Secretary should develop procedures in consultation with the States that would permit Contractors to purchase and fallow annual or permanent water rights on tributaries

ATTACHMENT A
Seven Basin States' Preliminary Proposa Regarding Colorado River Interim Operations

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within the Lower Division States that have been used for a significant period of years and were created prior to Congress' adoption of the Boulder Canyon Project Act that, when retired, and verified by the Secretary, contribute water to the Colorado River mainstream for diversion by the Contractor. The water recovered by the Contractor may be used for municipal and industrial purposes only. This water would be in addition to the State's basic apportionment and would be available during declared shortages.

It is intended that the water would be taken on a real-time basis and that not more than 95% of such water will be recovered; however, if storage were required, such stored water would be subject to all provisions applicable to ICS credits created through extraordinary conservation.

D. System Efficiency Projects

A Contractor may make contributions of capital to the Secretary for use in Secretarial projects designed to realize efficiencies that save water that would otherwise be lost from the Colorado River System in the United States. The Secretary in consultation with the States will identify system efficiency projects, terms for capital participation in such projects, and types and amounts of benefits the Secretary would provide in consideration of non-federal capital contributions to system efficiency projects, including a portion of the water saved by the project. Water made available to Contractors by the Secretary would be considered Intentionally Created Surplus. System efficiency projects are only intended to provide temporary water supplies and would not be available for permanent use.

Benefits to the total water available within the Colorado River System in the United States should be substantial, taking into account any benefit provided to any non-federal capital contributor. In those cases in which benefits are provided to a non-federal capital contributor in the form of a portion of the water saved by the system efficiency project, the water provided to the capital contributor should be characterized as Colorado River surplus water intentionally created by the system efficiency project. The ICS credits should be provided to the capital contributor pursuant to its BCPA § 5 surplus contract. The Secretary should first obtain the waiver or forbearance of any other BCPA § 5 surplus contractor(s) that may possess any right to the delivery of the same water, so that the Secretary may deliver it to the capital contributor pursuant to Article II (B)(6) of the Decree. The ICS credits should be provided to the capital contributor on a predetermined schedule of annual deliveries for a period of years as agreed by the Secretary and Contractor. The ICS credits would not be stored, and therefore would not spill from system reservoirs. Delivery of ICS credits during shortage conditions will be determined on a project-by-project basis.

E. Introduction and Recovery of Non-Colorado River System Water

The Secretary should develop procedures, in consultation with the States, that would prospectively allow non-Colorado River System water in a Lower Division State to be introduced into, conveyed through, and diverted from system reservoirs, or otherwise through the Colorado River System. The non-Colorado River System water may be introduced either (1) directly from the non-Colorado River System source, or (2) as effluent resulting from use of the non-Colorado River System water in the introducing entity's service area, assuming water quality concerns are adequately addressed by the Contractor introducing the water. This water is in addition to a state's basic apportionment and may be used during declared shortages.

Contractors proposing to introduce, convey and recover such non-Colorado River System water should make sufficient arrangements, contractual or otherwise, with the Secretary so as to guarantee that any such action causes no harm to the Secretary's management of the Colorado River System. Such arrangements would provide that the introduction, conveyance and recovery of such water be done pursuant to appropriate permits or other authorizations as required by state law, that the actual amount of water introduced, conveyed and recovered would be reported to the Secretary on an annual basis, and that no more than 95% of such water introduced will be recovered. The non-Colorado River System water would be intended to be taken on a real-time basis, and hence would not spill from system reservoirs. However, if storage were required such stored water would be subject to all provisions applicable to ICS created through extraordinary conservation. Any agreements made with the Secretary to introduce and recover this water will survive the termination of the Coordinated Operations of Lakes Powell and Mead.

Weather modification projects should be pursued as a means of augmenting Colorado River System water supplies. However, increases in water supply that result from weather modification projects are not included within the projects defined in this Section and would not create any additional supply for a Contractor or State that engages in a weather modification project.

Section 5. Non-Colorado River System Water Exchanges

Contractors in Arizona, California, or Nevada may secure an additional water supply by funding the development of a non-Colorado River System water supply in one Lower Division State for use in another State by exchange. The new water supply developed would be consumptively used in the State in which it was developed by a Contractor and that Contractor would intentionally reduce its consumptive use of Colorado River water. This would allow the Contractor(s) in the other Lower Division State(s) that provided the funding to consumptively use the Colorado River water that was intentionally unused through an agreement with the Secretary of the Interior. Through the cooperation of the International Boundary and Water Commission, United States and Mexico, similar agreements could be established by which non-Colorado River System water supplies in Mexico could be developed for use in the United States by exchange.

It could be necessary for a State or other lower priority Contractors in the State in which consumptive use was intentionally reduced to agree to forebear their use of such water depending on the then-existing priority system to use of Colorado River water, to avoid a claim against the water being delivered to the Contractor that funded the new water supply. As an alternative to forbearance, an offer by the Contractor developing the non-Colorado River System water to allow the lower priority Contractor to pay the cost of developing a portion or all of the non-

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Colorado River System water supplies to be developed, would be utilized to protect such a lower priority Contractor's position in the then-existing priority system. A refusal of an offer to pay the cost of developing a portion or all of the non-Colorado River System water supplies to be developed would constitute the lower-priority Contractor's waiver of a right to challenge the exchange.

Section 6. Accounting Mechanisms

The operating alternatives discussed in Sections 4 and 5 will require new or modified Colorado River accounting mechanisms. No specific accounting mechanism to allow these types of operations is proposed for evaluation in Reclamation's current NEPA process. However, the description and evaluation of such accounting mechanisms would provide Contractors with the assurance that if such accounting mechanism were adopted in the Record of Decision, funds spent to propose such an arrangement in the future would not be spent in vain.

Section 7. Effective Period

The proposed interim operations will be in effect 30 days from the publication of the Secretary's Record of Decision in the Federal Register. The proposed interim operations will, unless subsequently modified, remain in effect through December 31, 2025 (through preparation of the 2026 AOP), subject to a formal review of their effectiveness beginning no later than 2020.

J.3 Attachment B: Draft Agreement

AGREEMENT

The [name parties] hereby enter into this Agreement effective as of ______________.

RECITALS

A. Parties.

1. Arizona

a. The Arizona Department of Water Resources, through its Director, is the successor to the signatory agency of the State for the 1922 Colorado River Compact, and the 1944 Contract for Delivery of Water with the United States, both authorized and ratified by the Arizona Legislature, A.R.S. §§ 45-1301 and 1311. Pursuant to A.R.S. §§ 45-107, the Director is authorized and directed, subject to the limitations in A.R.S. §§ 45-106, for and on behalf of the State of Arizona, to consult, advise and cooperate with the Secretary of the Interior of the United States with respect to the exercise by the Secretary of Congressionally authorized authority relative to the waters of the Colorado River (including but not limited to the Boulder Canyon Project Act, 43 U.S.C. § 617, and the 1968 Colorado River Basin Project Act, 43 U.S.C. § 1501) and with respect to the development, negotiation and execution of interstate agreements. Additionally, under A.R.S. § 45-105(A)(9), the Director is authorized to "prosecute and defend all rights, claims and privileges of this state respecting interstate streams."

b. Under A.R.S. § 11-951 *et. seq.*, the Director is authorized to enter into Intergovernmental Agreements with other public agencies, which includes another state; departments, agencies, boards and commissions of another state; and political subdivisions of another state.

2. California. The chairman of the Colorado River Board of California, acting as the Colorado River Commissioner pursuant to California Water Code section 12525, has the authority to exercise on behalf of California every right and power granted to California by the Boulder Canyon Project Act, and to do and perform all other things necessary or expedient to carry out the purposes of the Colorado River Board.

3. Colorado

a. Section 24-1-109, Colorado Revised Statutes (2005) provides that "Interstate compacts authorized by law shall be administered under the direction of the office of the governor." This includes the Colorado River Compact and the Upper Colorado River Basin Compact. Section 37-60-109 provides that "the governor from time to time, with approval of the board, shall appoint a commissioner, who shall represent the state of Colorado upon joint commissions to be composed of commissioners representing the state of Colorado and another state or other states for the purpose of negotiating and entering into compacts or agreements between said states…" By Executive Order _____, issued __________, 2006, attached hereto as Exhibit _______ and incorporated herein by reference, the Governor appointed Upper Colorado River Commissioner Scott Balcomb to represent the State of Colorado.

b. Section 37-60-106, subsections (e) and (i), C.R.S. (2005), authorize the Colorado Water Conservation Board to "cooperate with the United States and the agencies thereof, and with other states for the purpose of bringing about the greater utilization of the water of the state of Colorado and the prevention of flood damages," and "to confer with and appear before the officers, representatives, boards, bureaus, committees, commissions, or other agencies of other states, or of the federal government, for the purpose of protecting and asserting the authority, interests, and rights of the state of Colorado and its citizens with respect to the waters of the interstate streams in this state." By resolution dated ______________, attached hereto as Exhibit __, and incorporated herein by reference, the Colorado Water Conservation Board authorized and directed its Director to negotiate with and enter into agreements with other state entities within the Colorado River Basin.

4. Nevada

a. The Colorado River Commission of the State of Nevada (CRCN) is an agency of the State of Nevada, authorized generally by N.R.S. §§ 538.041 and 538.251. CRCN is authorized by N.R.S. § 538.161 (6), (7) to enter into this Agreement. The CRCN, in furtherance of the State of Nevada's responsibility to promote the health and welfare of its people in Colorado River matters, makes this Agreement to supplement the supply of water in the Colorado River which is available for use in Nevada, augment the waters of the Colorado River, and facilitate the more flexible operation of dams and facilities by the Secretary of the Interior of the United States. The Chairman of the Commission, signatory hereto, serves as one of the Governor's representatives as contemplated by Section 602(b) of the 1968 Colorado River Basin Project Act, 43 U.S.C. § 1552(b) and the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act.

b. The Southern Nevada Water Authority (SNWA) is a Nevada joint powers agency and political subdivision of the State of Nevada, created by agreement dated July 25, 1991, as amended November 17,1994 and January 1,1996, pursuant to N.R.S. §§ 277.074 and 277.120. SNWA is authorized by N.R.S. § 538.186 to enter into this Agreement and, pursuant

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286 U.S. 494 (1922). *See Hinderlider v. La Plata River & Cherry Creek Ditch Co.,* 304 U.S. 92 (1938). In signing this Agreement, the State Engineer intends that this Agreement be mutually and equally binding between the Parties.

B. Background

1. Federal law and practice (including Section 602(b) of the 1968 Colorado River Basin Project Act, 43 U.S.C. § 1552(b), and the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act), contemplate that in the operation of Lakes Powell and Mead, the Secretary of the Interior consults with the States through Governors' Representatives, who represent the Governors and their respective States. Through this law and practice, the Governors' Representatives have in the past reached agreements among themselves and with the Secretary on various aspects of Colorado River reservoir operation. This Agreement is entered into in furtherance of this law and practice.

2. On January 16, 2001, the Secretary adopted Colorado River Interim Surplus Guidelines (ISG) based on an alternative prepared by the Colorado River Basin States, for the purposes of determining annually the conditions under which the Secretary would declare the availability of surplus water for use within the states of Arizona, California and Nevada in accordance with and under the authority of the Boulder Canyon Project Act of 1928 (45 Stat. 1057) and the Decree of the United States Supreme Court in *Arizona v. California*, 376 U.S. 340 (1964). The ISG are effective through calendar year 2015 (through preparation of the 2016 Annual Operating Plan).

3. In the years following the adoption of the ISG, drought conditions in the Colorado River Basin caused a significant reduction in storage levels in Lakes Powell and Mead, and precipitated discussions by and among the Parties, and between the Parties and the United States through the Department of the Interior and the Bureau of Reclamation. The Parties recognize that the Upper Division States have not yet developed their full apportionment under the Colorado River Compact. Although the Secretary has not imposed any shortage in the Lower Basin, the Parties also recognize that with additional Upper Basin development and in drought conditions, the Lower Division States may be required to suffer shortages in deliveries of water from Lake Mead. Therefore, these discussions focused on ways to improve the management of water in Lakes Powell and Mead so as to enhance the protection afforded to the Upper Basin by Lake Powell, and to delay the onset and minimize the extent and duration of shortages in the Lower Basin.

4. Shortages in the Lower Basin will also trigger shortages in the delivery of water to Mexico pursuant to the Mexican Water Treaty of 1944, February 3, 1944, U.S.-Mex., 59 Stat. 1219, T.S. 994, 3 U.N.T.S. 313.

286 U.S. 494 (1922). *See Hinderlider v. La Plata River & Cherry Creek Ditch Co.,* 304 U.S. 92 (1938). In signing this Agreement, the State Engineer intends that this Agreement be mutually and equally binding between the Parties.

B. <u>Background</u>

1. Federal law and practice (including Section 602(b) of the 1968 Colorado River Basin Project Act, 43 U.S.C. § 1552(b), and the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act), contemplate that in the operation of Lakes Powell and Mead, the Secretary of the Interior consults with the States through Governors' Representatives, who represent the Governors and their respective States. Through this law and practice, the Governors' Representatives have in the past reached agreements among themselves and with the Secretary on various aspects of Colorado River reservoir operation. This Agreement is entered into in furtherance of this law and practice.

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5. On May 2, 2005, the Secretary announced her intent to undertake a process to develop Lower Basin shortage guidelines and explore management options for the coordinated operation of Lakes Powell and Mead. On June 15, 2005, the Bureau of Reclamation published a notice in the *Federal Register*, announcing its intent to implement the Secretary's direction. The Bureau of Reclamation has proceeded to undertake scoping and develop alternatives pursuant to the National Environmental Policy Act (the NEPA Process), which the Parties anticipate will form the basis for a ROD to be issued by the Secretary by December 2007.

6. On August 25, 2005, the Governors' Representatives for the seven Colorado River Basin States wrote a letter to the Secretary expressing conceptual agreement in the development and implementation of three broad strategies for improved management and operation of the Colorado River: Coordinated Reservoir Management and Lower Basin Shortage Guidelines; System Efficiency and Management; and Augmentation of Supply.

7. On February 3, 2006, the Governors' Representatives transmitted to the Secretary their recommendation for the scope of the NEPA Process, which refined many of the elements outlined in the August 25, 2005 letter.

8. At the request of the Secretary, the Parties have continued their discussions relative to the areas of agreement outlined in the letters of August 25, 2005 and February 3, 2006.

9. In furtherance of the letters of August 25, 2005 and February 3, 2006, the Parties have reached agreement to take additional actions for their mutual benefit, which are designed to augment the supply of water available for use in the Colorado River System and improve the management of water in the Colorado River.

C. Purpose. The Parties intend that the actions by them contemplated in this Agreement will: improve cooperation and communication among them; provide additional security and certainty in the water supply of the Colorado River System for the benefit of the people served by water from the Colorado River System; and avoid circumstances which could otherwise form the basis for claims or controversies over interpretation or implementation of the Colorado River Compact and other applicable provisions of the law of the river.

AGREEMENT

In consideration of the above recitals and the mutual covenants contained herein, and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Parties agree as follows:

1. Recitals. The Recitals set forth above are material facts that are relevant to and form the basis for the agreements set forth herein.

2. Definitions. As used in this Agreement, the following terms have the following meanings:

A. Colorado River System. This term shall have the meaning as defined in the Colorado River Compact.

B. ISG. The Colorado River Interim Surplus Guidelines adopted by the Secretary on January 16, 2001.

C. NEPA Process. The decision-making process pursuant to the National Environmental Policy Act, 42 U.S.C. §§ 4321 through 47, beginning with the Bureau of Reclamation's Notice to SolicitComments and Hold Public Meetings, 70 Fed. Reg. 34794 (June 15, 2005) and culminating in a Record of Decision.

D. Party or Parties. Any party or parties to this Agreement.

E. Parties' Recommendation. The Seven Basin States' Preliminary Proposal Regarding Colorado River Interim Operations, a copy of which is attached hereto and incorporated herein by this reference, presented by the Parties to the Secretary in furtherance of the States' letters of August 25, 2005 and February 3, 2006, and any modification of the Parties' Recommendation adopted by the Parties pursuant to this Agreement.

F. ROD. The Record of Decision anticipated to be issued by the Secretary after completion of NEPA Process, pursuant to her letter of May 2, 2005, and the Notice published in the Federal Register on September 30. 2005, 70 Fed. Reg. 57322.

G. Secretary. The Secretary of the Interior or the Bureau of Reclamation, as applicable.

H. State or States. Any of the states of Arizona, California, Colorado, Nevada, New Mexico, Utah or Wyoming, as context requires.

3. Support for Parties' Recommendation. After considering a number of alternatives, each Party has determined that the Parties' Recommendation is in the best interests of that Party, and promotes the health and welfare of that Party and of the Colorado River Basin States. In the NEPA Process, the Parties shall support the Secretary's adoption of the Parties' Recommendation in a ROD. If during the course of the NEPA Process any new information becomes available which causes any Party, in its sole and absolute discretion, to reassess any provision of the Parties' Recommendation, that Party shall immediately notify all other Parties in writing. The Parties shall jointly confer and, if they agree to any modification of the Parties' Recommendation, shall consult with the Secretary to advise her of such modification and request the adoption thereof in the ROD. If after such conference and consultation it is apparent there is an

irreconcilable conflict between the Parties as to such modification, then any Party may upon written notice to the other Parties withdraw from this Agreement, and in such event this Agreement shall no longer be effective or binding upon such withdrawing Party. All withdrawing Parties hereby reserve all rights upon withdrawal from this Agreement to take such actions, including support of or challenges to the ROD, as they in their sole and absolute discretion deem necessary or appropriate. In the event of the withdrawal of any one or more Parties from this Agreement, this Agreement shall continue in full force and effect as to the remaining Parties. The remaining Parties may confer to determine whether to continue this Agreement in effect, to amend this Agreement, or to terminate this Agreement. In the event of termination, all Parties shall be relieved from the terms hereof, and this Agreement shall be of no further force or effect.

4. ROD Consistent with the Parties' Recommendation. In the event the Secretary adopts a ROD in substantial conformance with the Parties' Recommendation, the Parties shall take all necessary actions to implement the terms of the ROD, including the approval and execution of agreements necessary for such implementation.

5. ROD Inconsistent with the Parties' Recommendation. In the event the Secretary adopts a ROD that any Party, in its sole and absolute discretion, determines is not in substantial conformance with the Parties' Recommendation, such Party shall immediately notify all other Parties of such determination in writing. The Parties shall jointly confer, and consult with the Secretary as necessary, in order to determine whether the ROD is in substantial conformance with this Agreement, or whether any action, including the amendment of this Agreement, may resolve such concern. If after such conference and consultation it is apparent there is an irreconcilable conflict between the ROD and the concerns of such Party, then such Party may upon written notice to the other Parties withdraw from this Agreement, and in such event this Agreement shall no longer be effective or binding upon such withdrawing Party. All withdrawing Parties hereby reserve all rights upon withdrawal from this Agreement to take such actions, including support of or challenges to the ROD, as they in their sole and absolute discretion deem necessary or appropriate. In the event of the withdrawal of any one or more Parties from this Agreement, this Agreement shall continue in full force and effect as to the remaining Parties. The remaining Parties may confer to determine whether to continue this Agreement in effect, to amend this Agreement, or to terminate this Agreement. In the event of termination, all Parties shall be relieved from the terms hereof, and this Agreement shall be of no further force or effect.

6. Additions to the ROD. The Parties hereby request that the Secretary recognize the specific provisions of this Agreement as part of the NEPA Process and, if appropriate, include in the ROD specific provisions that reference this Agreement as a basis for the ROD. The Parties also hereby request that the Secretary include in the ROD specific provision that the Secretary will first consult with all the States, through their designated Governor's Representatives, before making any substantive modification to the ROD. Finally, the Parties hereby request that the Secretary include in the ROD specific provision that upon a request by any State for modification of the ROD, or upon any request by any State to resolve any claim or controversy arising under this Agreement or

under the operations of Lakes Powell and Mead pursuant to the ROD, the ISG, or any other applicable provision of federal law, regulation, criteria, policy, rule or guideline, the Secretary shall invite all of the Governors, or their designated representatives, to consult with the Secretary in an attempt to resolve such claim or controversy by mutual agreement.

7. Consultation on Operations. After the Secretary commences operating Lakes Powell and Mead pursuant to the ROD, the Parties shall confer among themselves as necessary, but at least annually, to assess such operations. Any Party may request consultation with the other Parties on a proposed adjustment or modification of such operations, based on changed circumstances, unanticipated conditions, or other factors. Upon such request, the Parties shall in good faith confer to resolve any such issues, and based thereon may request consultation by the States with the Secretary on adjustments to or modifications of operations under the ROD. In any event, the Parties shall confer before December 31, 2020, to determine whether to extend this Agreement and recommend that the Secretary continue operations under the ROD for an additional period, or modify this Agreement and recommend that the Secretary modify operations under the ROD, or terminate this Agreement and recommend that the Secretary not continue operations under the ROD after the expiration thereof.

8. Development of System Augmentation. The Parties agree to diligently pursue system augmentation within the Colorado River System including but not limited to the determination of the feasibility of projects to increase precipitation in the basin or to augment available supplies through desalination. Additionally, the Parties agree to cooperatively pursue an interim water supply of at least a cumulative amount of 280,000 acre-feet for use in Nevada while long-term augmentation projects are being pursued. It is anticipated that this interim water supply will be made available in return for Nevada's funding of the Drop 2 Reservoir currently proposed for construction by the Bureau of Reclamation. Annual recovery of this interim water supply by Nevada will not exceed 40,000 acre-feet. All water available to Nevada in consideration for funding the Drop 2 Reservoir would remain available during all shortage conditions declared by the Secretary.

In consideration of the Parties' diligent pursuit of long-term augmentation and the availability of the interim water supply, the Southern Nevada Water Authority (SNWA) agrees that it will withdraw right-of-way Application No. N-79203 filed with the Bureau of Land Management on October 1, 2004 for the purpose of developing Permit No. 58591 issued by the Nevada State Engineer in Ruling No. 4151.

The SNWA will not re-file such right-of-way application or otherwise seek to divert the water rights available under Permit No. 58591 from the Virgin River prior to 2014 so long as Nevada is allowed to utilize its pre-Boulder Canyon Project Act Virgin and Muddy River rights in accordance with section 4(C) of the Parties' Recommendation in the form forwarded to the Secretary on February 3, 2006, and the interim water supply made available to Nevada is reasonably certain to remain available. The SNWA will not re-file such right-of-way application or otherwise seek to divert the water rights available under Permit No. 58591 from the Virgin River after 2014 so long as diligent pursuit of system augmentation is proceeding to provide Nevada an annual supply of 75,000 acre-feet by the year 2020. Prior to re-filing any applications with the Bureau of Land Management, SNWA and Nevada will consult with the other Basin States.

This agreement is without prejudice to any Party's claims, rights or interests in the Virgin or Muddy River systems.

9. Consistency with Existing Law. The Parties' Recommendation is consistent with existing law. The Parties expressly agree that the storage of water in and release of water from Lakes Powell and Mead pursuant to a ROD issued by the Secretary in substantial conformance with the Parties' Recommendation and this Agreement, and any agreements, rules and regulations adopted by the Secretary or the parties to implement such ROD, shall not constitute a violation of Article III(a)-(e) inclusive of the Colorado River Compact, or Sections 601 and 602(a) of the Colorado River Basin Project Act of 1968 (43 U.S.C. §§ 1551 and 1552(a)), and all applicable rules and regulations promulgated thereunder.

10. Resolution of Claims or Controversies. The Parties recognize that litigation is not the preferred alternative to the resolution of claims or controversies concerning the law of the river. In furtherance of this Agreement, the Parties desire to avoid litigation, and agree to pursue a consultative approach to the resolution of any claim or controversy. In the event that any Party becomes concerned that there may be a claim or controversy under this Agreement, the ROD, Article III(a)-(e) inclusive of the Colorado River Compact, or Sections 601 and 602(a) of the Colorado River Basin Project Act of 1968 (43 U.S.C. §§ 1551 and 1552(a)), and all applicable rules and regulations promulgated thereunder, such Party shall notify all other Parties in writing, and the Parties shall in good faith meet in order to resolve such claim or controversy by mutual agreement prior to any litigation. No Party shall initiate any judicial or administrative proceeding against any other Party or against the Secretary under Article III(a)-(e) inclusive of the Colorado River Compact, or Sections 601 and 602(a) of the Colorado River Basin Project Act of 1968 (43 U.S.C. §§ 1551 and 1552(a)), or any other applicable provision of federal law, regulation, criteria, policy, rule or guideline, and no claim thereunder shall be ripe, until such conference has been completed. In addition, all States shall comply with any request by the Secretary for consultation in order to resolve any claim or controversy. In addition, any State may invoke the provisions of Article VI of the Colorado River Compact. Notwithstanding anything in this Agreement to the contrary, the terms of this Paragraph 10 shall survive for a period of five years following the termination or expiration of this Agreement, and shall apply to any withdrawing Party after withdrawal for such period.

11. Reservation of Rights. Notwithstanding the terms of this Agreement and the Parties' Recommendation, in the event that for any reason this Agreement is terminated, or that the term of this Agreement is not extended, or upon the withdrawal of any Party from this Agreement, the Parties reserve, and shall not be deemed to have waived, any and all rights, including any claims or defenses, they may have as of the date hereof or as

may accrue during the term hereof, under any existing federal or state law or administrative rule, regulation or guideline, including without limitation the Colorado River Compact, the Upper Colorado River Basin Compact, the Decree in *Arizona v. California*, the Colorado River Basin Project Act of 1968, and any other applicable provision of federal law, rule, regulation, or guideline.

12. No Third-Party Beneficiaries. This Agreement is made for the benefit of the Parties. No Party to this Agreement intends for this Agreement to confer any benefit upon any person or entity not a signatory upon a theory of third-party beneficiary or otherwise.

13. Joint Defense Against Third Party Claims. In the event the Secretary adopts a ROD in substantial conformance with the Parties' Recommendation as set forth herein, they will have certain common, closely parallel, or identical interests in supporting, preserving and defending the ROD and this Agreement. The nature of this interest and the relationship among the Parties present common legal and factual issues and a mutuality of interests. Because of these common interests, the Parties will mutually benefit from an exchange of information relating to the support, preservation and defense of the ROD and this Agreement, as well as from a coordinated investigation and preparation for discussion of such interests. In furtherance thereof, in the event of any challenge by a third party as to the ROD or this Agreement (including claims by any withdrawing Party), the Parties will cooperate to proceed with reasonable diligence and to use reasonable best efforts in the support, preservation and defense thereof, including any lawsuit or administrative proceeding challenging the legality, validity or enforceability of any term of the ROD or this Agreement, and will to the extent appropriate enter into such agreements, including joint defense or common interest agreements, as are necessary therefor. Each Party shall bear its own costs of participation and representation in any such defense.

14. Reaffirmation of Existing Law. Nothing in this Agreement or the Parties' Recommendation is intended to, nor shall this Agreement be construed so as to, diminish or modify the right of any Party under existing law, including without limitation the Colorado River Compact, the Upper Colorado River Basin Compact, or the Decree in *Arizona v. California*. The Parties hereby affirm the entitlement and right of each State under such existing law to use and develop the water of the Colorado River System.

15. Term. This Agreement shall be effective as of the date of the first two signatories hereto, and shall be effective as to any additional Party as of the date of execution by such Party. Unless earlier terminated, this Agreement shall be effective for so long as the ROD and the ISG are in effect, and shall terminate upon the termination of the ROD and the ISG.

16. Authority. The persons and entities executing this Agreement on behalf of the Parties are recognized by the Parties as representing the respective States in matters concerning the operation of Lakes Powell and Mead, and as those persons and entities authorized to bind the respective Parties to the terms hereof. Each person executing this

Agreement has the full power and authority to bind the respective Party to the terms of this Agreement. No Party shall challenge the authority of any person or Party to execute this Agreement and bind such Party to the terms hereof, and the Parties waive the right to challenge such authority.

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Appendix K

“Conservation Before Shortage II” Proposal, July 7, 2006

A consortium of environmental NGOs developed and submitted the Conservation Before Shortage II proposal in a letter dated July 7, 2006. This proposal supplemented the original proposal (Conservation Before Shortage proposal) submitted on July 18, 2005. The consortium includes Defenders of Wildlife, Environmental Defense, National Wildlife Federation, Pacific Institute, Sierra Club, the Nature Conservancy, Rivers Foundation of the Americas, and the Sonoran Institute. The full text of the Conservation Before Shortage II proposal and supplemental information submitted therein is provided in this Appendix.

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K.1 Conservation Before Shortage II: Proposal for Colorado River Operations

Defenders of Wildlife * Environmental Defense * National Wildlife Federation
The Nature Conservancy * Pacific Institute * Sierra Club * Sonoran Institute

July 7, 2006

The Honorable Dirk Kempthorne
Secretary, U.S. Department of the Interior
1849 C Street, NW
Washington, DC 20240

via email: strategies@lc.usbr.gov

Dear Secretary Kempthorne:

With this letter, we submit our proposal "Conservation Before Shortage II" for your consideration in the "Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead, Particularly Under Low Reservoir Conditions."

A year ago, we submitted our original proposal "Conservation Before Shortage" in anticipation of Reclamation's work to develop new shortage rules for the Colorado River. Since then, the Colorado River Basin States significantly changed the scope of Reclamation's deliberations with the submission of their own proposal. The new flexibility they propose with Intentionally Created Surplus (ICS), administered appropriately, could provide a framework for improving environmental conditions on the Colorado. We have therefore combined the ICS concept with a slightly modified version of our original proposal.

The original Conservation Before Shortage was a proposal to manage shortages in the Colorado River by asking water users to voluntarily engage in predictable, small-scale reductions in use – and receive compensation for those reductions – rather than face large-scale, involuntary, and uncompensated disruptions in water deliveries that could cut into municipal and agricultural water supplies and create unmitigated economic impacts. Conservation Before Shortage II combines such voluntary, market-based water conservation to protect against shortages on the Lower Colorado River with a voluntary, market-based mechanism to protect or enhance flow dependent environmental values.

With this letter, we submit a description of Conservation Before Shortage II (including relevant background, a description of the proposal itself, a rationale for the proposal, and the identification of several additional issues), as well as the original Conservation Before Shortage proposal, and an additional proposal to expand the ICS program to include Mexico.

We appreciate the effort Reclamation staff have made to help us understand the hydrologic impacts of our proposals through the use of their expertise in river operations modeling. We hope to continue this dialogue about management of Colorado River shortages with Interior and Reclamation, as well as the Colorado River Basin States, the International Boundary and Water Commission and representatives of the Republic of Mexico.

Thank you for your consideration, and please do not hesitate to contact any one of us if you have questions.

Sincerely,

Kara Gillon
Staff Attorney
Defenders of Wildlife
kgillon@defenders.org

Michael Cohen
Senior Associate
Pacific Institute
mcohen@pacinst.org

Jennifer Pitt
Scientist
Environmental Defense
jpitt@environmentaldefense.org

James Wechsler
Chair, Southwest Waters Committee
Sierra Club
jawex@aros.net

Garrit Voggesser
Manager, Tribal Lands Conservation Program
National Wildlife Federation
voggesser@nwf.org

Peter Culp and Francisco Zamora
Sonoran Institute
pculp@ssd.com and
francisco@sonoran.org

Robert Wigington
Western Water Policy Counsel
The Nature Conservancy
rwigington@tnc.org

Pamela Hyde
Chair
Rivers Foundation of the Americas
tapeats@aol.com

cc:
Herb Guenther, Arizona Department of Water Resources
Jerry Zimmerman, Colorado River Board of California
Pat Mulroy, Southern Nevada Water Authority.
Don Ostler, Upper Basin Colorado River Commission
Carlos Marin, International Boundary and Water Commission
Arturo Herrera, Comisión Internacional de Limites y Aguas

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July 7, 2006

Conservation Before Shortage II:

Proposal for Colorado River Operations

I. Background/Context

In August of 2005, various non-governmental conservation organizations introduced the "Conservation Before Shortage" proposal into the U.S. Bureau of Reclamation's (Reclamation) process for the "Development of Lower Colorado River Basin Shortage Guidelines and Coordinated Management Strategies for Lakes Powell and Mead Under Low Reservoir Conditions" (Shortage Guidelines). The "Conservation Before Shortage" proposal suggested an approach to the management of shortages in the Lower Colorado through the implementation of a tiered program of voluntary and compensated water conservation, tied to the surface elevation of Lake Mead.

Since the time of that proposal, the seven Basin States have reached agreement on a far-reaching proposal to transform management of Colorado River system water through conjunctive management of Lakes Mead and Powell, modification and extension of the existing Interim Surplus Criteria, and the adoption of shortage guidelines. Perhaps most significantly, the Basin States' proposal introduces a series of new mechanisms to increase flexibility within the Lower Basin delivery system and water allocations, including the creation of a new category of water: "Intentionally Created Surplus" (ICS). ICS can be generated through extraordinary conservation measures, funding of system efficiency improvements, and recognition of water exchanges.

As currently constituted, the Basin States' proposal is largely concerned with water deliveries between and among the Basin States, with ICS programs and related mechanisms confined to the states of the Lower Basin. While these programs will clearly benefit water management on the Colorado River system, we suggest that significant benefits for U.S. water users, Mexican water users, and the environment could be gained by expanding portions of the Basin States' proposal to include additional potential domestic water users, provide for direct federal participation, and leave the door open to potential international implementation of ICS programs.

In addition, we strongly suggest that there remain significant potential advantages to some of the concepts expressed in the original "Conservation Before Shortage" proposal, particularly the use of voluntary, market-based conservation as a method to mitigate involuntary shortages. By combining that proposal with an expanded ICS program we believe that "Conservation Before Shortage II" is a powerful tool for mitigating against shortages and helping to meet the federal government's bypass flow replacement obligations under the Colorado River Basin Salinity Control Act.

Conservation Before Shortage II meets the purposes identified in the Basin States' original proposal: delaying and minimizing the onset of shortage in the Lower Basin and the risk of curtailment in the Upper Basin through conservation, more efficient reservoir operations and water supply augmentation. It also meets multiple federal objectives on the Colorado River, including the watermaster's continued federal oversight and management of the river, the protection of important environmental resources, and replacement of the bypass flow.

Over the past several months, the conservation organizations that developed the original Conservation Before Shortage proposal have, with technical assistance from Reclamation's modeling staff, developed a revised version of the proposal (hereafter referred to as "CBS II"). This document describes the essential elements of the CBS II proposal, the rationale behind these elements, its relationship to the states' proposal, and the significant potential benefits associated with the CBS II approach.

II. Elements of Conservation Before Shortage II

A. Shortage Guidelines to Reduce Deliveries/Releases from Lake Mead

Shortage Conditions

At elevations below 1000 feet, the Secretary would impose involuntary shortage conditions to the extent necessary to maintain an elevation of 1000 feet (absolute protection of elevation 1000 feet).[1]

Conservation Conditions

In years when the August 24-month study projects the elevation of Lake Mead on January 1 will fall within the elevation ranges for "conservation conditions" identified below, on behalf of the Secretary of the Interior (Secretary), Reclamation will engage in a program to purchase ICS credits in the amounts corresponding to those ranges. To the extent permitted by law and through the appropriate authorities, Reclamation will also seek to generate such ICS credits by purchasing water from users in Mexico (temporarily reducing deliveries of Colorado River water to Mexico). Federal ICS creation requirements would follow identical triggers and reductions to the involuntary shortages proposed under the Basin States' alternative:

- Elevation greater than 1050 to 1075 feet: 400,000 acre-feet
- Elevation greater than 1025 to 1050 feet: 500,000 acre-feet
- Elevation greater than 1000 to 1025 feet: 600,000 acre-feet

Reclamation would maintain an accounting system to track cumulative Main Outlet Drain Extension bypass flow replacement obligations (to the extent not otherwise satisfied via other mechanisms) and banked federal ICS credits. ICS credits created when the elevation of Lake Mead is at or below 1075 feet would first be credited against the cumulative bypass flow "deficit." Federal ICS credits created in excess of this deficit would be credited to the federal ICS account up to the amount of the federal cap of 1.5 million acre feet (see below). Federal ICS credits created in excess of the federal cap would become system water.

[1] In the event that a shortage is declared when Lake Mead is at or below elevation 1000 feet, and a bi-lateral determination of an extraordinary drought is also made under the 1944 Treaty, deliveries to Mexico would be reduced in the same proportion as consumptive uses in the Lower Basin are reduced.

All funding for creation of federal ICS up to the amount of the 1.5 million acre foot cap would be provided by the federal government in recognition of the bypass flow replacement and environmental benefits. Thereafter, 50% of funding would be provided by the federal government, with the remaining 50% derived from fees assessed against Lower Basin water and power users using the mechanisms described in the original CBS proposal (see Attachment A).

B. Coordinated Reservoir Operations (Lake Mead and Lake Powell).

CBS II does not address coordinated reservoir operations. However, for the purpose of highlighting the differences between CBS II and the Basin States' alternative in Reclamation's modeling exercise, reservoir operations at Lakes Mead and Powell would be coordinated as described in the Basin States Alternative.

C. Lake Mead Storage and Delivery of Conserved and Non-system Water

ICS credits generated via extraordinary conservation activities, tributary conservation, system efficiency projects, and other mechanisms would be handled under rules identical to the Basin States Alternative, except as follows:

- ICS credits could be generated by entities that are not current Colorado River delivery contract holders (although a delivery contract with the Secretary would be required for the storage and delivery of ICS credits). Entities eligible for participation in the ICS program would include:
    - U.S. federal agencies
    - State agencies
    - Private entities, including U.S. non-governmental organizations
    - Mexican federal agencies
    - Mexican water users
- All participating entities would follow the Basin States rules for storage and withdrawal of ICS credits (including restrictions on creation and use of ICS credits during shortage and surplus conditions, 5% system set-aside for creation of ICS[2], and reductions to stored ICS to account for evaporation losses), except:

[2] The Basin States' proposal provides that at the time ICS credits are created by extraordinary conservation, the entity creating the credits will dedicate 5% of the ICS credits to the system on a one-time basis to provide a water supply benefit to the system, while 10% of the ICS credits would be set aside under the Reservoir Storage Alternative. Quite possibly, the set-aside rate of 10% may be too modest. We suggest that Reclamation analyze the benefits and costs of a larger set-aside.

- U.S. federal government would be permitted to purchase or create and bank ICS credits during Conservation Conditions (see below), but would be subject to the same rules for delivery and use of ICS credits as other users.

- Mexico would be permitted to create, bank, and deliver ICS credits during “Normal,” “Full Domestic Surplus,” and 70(r) surplus conditions but not during Conservation, Shortage or Flood Control Surplus conditions. Same-year ICS reallocations within Mexico that do not result in system storage would not be subject to the 5% system set-aside (as this would not alter Treaty deliveries). Water banked by Mexico in Lake Mead would be subject to the 5% system set-aside as well as evaporative loss charges. Mexico’s participation in the ICS program would operate under a Treaty minute reflecting procedures to alter delivery schedules to accommodate transfers of ICS within Mexico, as well as procedures for temporary reductions and corresponding increases in Treaty deliveries to allow for banking in Lake Mead.

- The maximum amount of ICS credits that could be created in any one year would be limited to 950,000 acre-feet per year, allocated among the participants as follows:
  - California contractors: 400,000 acre-feet per year (state proposal)
  - Nevada contractors: 125,000 acre-feet per year (state proposal)
  - Arizona contractors: 100,000 acre-feet per year (state proposal)
  - United States: 100,000 acre-feet per year (except during Conservation Conditions, see above) (potentially allowing use of water for environmental projects)
  - Mexico (government/users): 125,000 acre-feet per year (enough water to bank and deliver 200,000 acre-feet of a 250,000 acre-foot flood flow every 5 years with the last 50,000 acre-feet scheduled as part of Mexico’s annual delivery in the year of the flood flow release, plus allow for other environmental, municipal, industrial, and other uses, accounting for the 5% system set-aside and up to 5% annual evaporation loss for banked water)
  - All other users: 100,000 acre-feet per year

- The maximum cumulative amount of ICS credits that would available at any one time would be 4,200,000 acre-feet, allocated as follows:
  - California contractors: 1,500,000 acre-feet (state proposal)
  - Nevada contractors: 300,000 acre-feet (state proposal)
  - Arizona contractors: 300,000 acre-feet (state proposal)

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- United States: 1,500,000 acre-feet (3-5 years of Conservation Conditions acquisitions, 15 years of ICS recovery)
- Mexico: 400,000 acre-feet (enough water to bank 200,000 acre-feet of a 250,000 acre-foot flood flow every 5 years with the last 50,000 acre-feet scheduled as part of Mexico's annual delivery in the year of the flood flow release, plus approximately 2-3 years cumulative storage for other uses)
- All other: 200,000 acre-feet (2 years storage to allow for purchase and storage of water during cheaper market conditions)

- The maximum amount of ICS credits that could be recovered in any one year would be limited to 1.6 million acre-feet per year, allocated as follows:
  - California contractors: 400,000 acre-feet (state proposal)
  - Nevada contractors: 300,000 acre-feet (state proposal)
  - Arizona contractors: 300,000 acre-feet (state proposal)
  - United States: 100,000 acre-feet (maximum volume of federally-banked ICS that could be recovered each year for environmental use, including MSCP, at Mead elevations above 1075 feet) (10 years worth of recovery)
  - Mexico: 400,000 acre-feet (enough to provide for unlikely confluence of 250,000 acre-feet flood flow plus significant non-environmental use in one year)
  - All other: 100,000 acre-feet (enough to implement restoration in the limitrophe reach, plus water available for additional projects).
- During Conservation Conditions, the federal government is required to acquire ICS from U.S. and/or Mexican users pursuant to shortage guidelines in volumes of 400,000, 500,000, and 600,000 acre-feet (see II.*A*, above).

D. Interim Surplus Guidelines for deliveries/releases from Lake Mead and all other operation criteria

CBS II does not address the Interim Surplus Guidelines or other operating criteria. However, for the purpose of highlighting the differences between CBS II and the Basin States' alternative in Reclamation's modeling exercise, all other river operation criteria, including operation of the Interim Surplus Guidelines, would be the same as proposed in the Basin States Alternative.

III. Rationale for Conservation Before Shortage II

Conservation Before Shortage II is founded on the principle that the Secretary should take greater responsibility to operate the Colorado River in a manner that minimizes shortages in the Lower Basin and avoids the risk of curtailment in the Upper Basin through conservation, more efficient reservoir operations, and increased flexibility in the management of river resources, while protecting or enhancing environmental values associated with the Colorado River. Three elements of CBS II highlight this principle:

(1) voluntary, market-based water conservation as an alternative to and mitigation mechanism against involuntary, uncompensated shortages on the Lower Colorado River;

(2) voluntary, market-based mechanisms to protect or enhance flow dependent environmental values, in close alignment with applying such mechanisms to mitigate against involuntary, uncompensated shortages; and

(3) potential expansion of ICS programs (pending appropriate diplomatic consultations) to include water users in Mexico and to improve the management of Colorado River water supplies in both countries.

A. Voluntary, Market-Based Conservation as an Alternative to Involuntary Shortage

As discussed in the original Conservation Before Shortage proposal (see Attachment A), we believe that there are significant potential advantages to the use of voluntary, market-based conservation as an alternative to and as a means of mitigating against involuntary shortages.

- Based on extensive modeling performed for the Lower Basin states, reductions of 400,000, 500,000 and 600,000 acre-feet at Lake Mead elevations 1075 feet, 1050 feet and 1025 feet, respectively, appear to provide optimal results in preventing larger involuntary shortages that perform better than the 200,000, 400,000, and 600,000 acre-foot reductions proposed in the original CBS proposal.

- It is desirable to protect the elevation of Lake Mead at no less than 1000 feet under any condition to protect Southern Nevada Water Authority's lower intake structures, as well as the new minimum power pool if proposed low-pressure turbines are installed at Hoover Dam.

- It is preferable for Lower Basin water users to voluntarily engage in predictable, small-scale reductions in use – and receive compensation for those reductions – rather than face large-scale, involuntary and uncompensated disruptions in water deliveries that could cut into municipal and agricultural water supplies and create unmitigated economic impacts.

- There is a large volume of Colorado River water which could be temporarily conserved through voluntary, market-based mechanisms such as part-year fallowing or forbearance agreements, dry year options, or other similar arrangements to reduce Lower Basin consumptive use on an occasional, temporary basis as an alternative to involuntary shortages to low-priority users.[3]

- Users of Colorado River water in Mexico may wish to participate in short-term, voluntary and compensated conservation agreements, to reduce the probability of larger, uncompensated future reductions due to a declaration of shortage under the 1944 Treaty with Mexico.[4]

The ICS program suggested in the Basin States' proposal will likely result in the identification of numerous opportunities for extraordinary conservation activities that could be used to accomplish reductions in water use in the Lower Basin. These mechanisms could not be utilized by other water users when the elevation of Lake Mead is at or below 1075 feet, creating a readily available supply of ICS credit-eligible water that could instead be utilized by the federal government as a means of temporarily reducing water use on a voluntary, compensated basis.

CBS II would also create an obvious means of implementing a significant portion of the federal government's bypass flow replacement obligation. The recently published report led by the Central Arizona Water Conservancy District "Balancing Water Needs on the Lower Colorado River: Recommendations of the Yuma Desalting Plant/Cienega de Santa Clara Workgroup," includes recognition that replacement of the MODE bypass flow is primarily necessary during shortage conditions to ensure that accumulated system water deficits resulting from the bypass flow do not result in shortages to Lower Basin users. One of the primary recommendations in the report is the creation of a "shortage alleviation trust fund" which would be used, in combination with fallowing programs or other conservation mechanisms, to provide replacement water to compensate for accumulated bypass flow deficits during shortage conditions. The recommendations of the workgroup have been widely circulated among Lower Basin water users and have received significant support among both water users, water managers, and environmental interests.

Use of the ICS mechanism by the federal government when Lake Mead elevation is at or below 1075 feet would provide an ideal means of implementing this recommendation of the YDP/Cienega de Santa Clara workgroup. ICS credits that the federal government would be required to purchase when Lake Mead elevation is at or below 1075 feet could be retired for the benefit of the system to the extent necessary to eliminate any accumulated bypass flow replacement deficit; only after this deficit is extinguished would ICS credits accrue to the federal government for other uses.

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[3] Some 4.5 million acre-feet of Colorado River water are used to irrigate crops in the Lower Basin states, and more than 1 million acre-feet are used to irrigate crops in Mexico. Conservation of between 400,000 and 600,000 acre-feet through the use of part-year fallowing programs, dry year options, or other similar arrangements would constitute only 7-11% of total Lower Basin agricultural use in the United States and Mexico. (However, as even small-scale reductions in agricultural water use may have third-party impacts, provision should be made to support community economic development in affected areas.) Conversely, even under the Basin States' tiered shortage proposal, involuntary shortages could have significant economic consequences, disrupting water banking plans in Arizona and cutting low-priority municipal and agricultural use in the U.S. and Mexico (resulting in unpredictable loss of farm income, economic disruptions from municipal shortfalls, or requiring expensive municipal conservation efforts or efforts to secure agricultural water to support hardened municipal demand).

[4] Such an agreement would likely require a new Minute to the 1944 Treaty with Mexico. Fallowing agreements in Mexico would have to be administered by the appropriate authorities.

B. Voluntary, Market-Based Conservation to Protect or Enhance Environmental Flows.

This proposal suggests two mechanisms for protecting and enhancing environmental flows in close alignment with the mechanisms to mitigate involuntary and uncompensated shortages, although other mechanisms may also be appropriate for consideration. First, extending the ICS program to include a broader range of participants than current Colorado River contractors provides an opportunity to ensure that some portion of the water developed via extraordinary conservation activities could be dedicated to environmental uses, via the participation of interested parties (such as conservation organizations) in ICS creation. There are several proposed restoration efforts in the United States – such as a restoration proposal for the limitrophe reach of the Colorado River – which could potentially benefit from access to ICS water supplies during normal conditions.

Second, direct participation of the federal government in the ICS program could be an excellent mechanism for purchasing water for environmental purposes or other public benefit uses by the federal government. Although these credits would only be available for use when the elevation of Lake Mead is greater than 1075 feet, they could be used to provide "bridge" supplies for restoration projects, run pilot restoration projects, or meet other interim water supply needs.

C. ICS for Mexico

As discussed in detail in a draft proposal entitled *Taking ICS to Mexico: International Opportunities in the Seven States Agreement* (see Attachment B), ICS credits could be used to firm urban water supplies in both countries, implement long-studied environmental restoration projects in the Colorado River Delta, and increase flexibility in Mexico's agricultural sector – creating economic, environmental, and social benefits in both countries while offering the United States and Mexico a venue for cooperation in the otherwise contentious area of water management at the border. In addition, during shortage conditions, extension of the ICS program to include Mexico would expand the pool of participants who could provide voluntary, compensated reductions in water use as an alternative to involuntary shortages in the United States.

An extension of the ICS program to include Mexico would likely require the adoption of a new Minute to the Treaty of 1944, and would obviously require diplomatic discussions and negotiations likely to occur in a different venue than Reclamation's domestic process to develop Shortage Guidelines. However, we strongly suggest that the current federal process should leave the door open to the eventual approval of a binational extension of the ICS program, to limit the costs of future review of such a program and encourage the initiation of binational discussions about such a program. Since critical elements of the Basin States' proposal – most notably the proposed shortage policy and proposed policies for water exchanges – will already require consultation with Mexico and/or the adoption of a new Minute, these opportunities could be considered in the same diplomatic process

IV. Additional Issues

To characterize the impact that these concepts would have on river management outcomes, we have attempted to minimize the differences (and thus the number of modeling variables at play) between CBS II and the Basin States' proposal. While we do not necessarily agree with or endorse all of the approaches suggested in the Basin States' proposal, we have not attempted to alter many of its basic elements, including the proposed modification and extension of the Interim Surplus Guidelines, new conjunctive management of Lakes Mead and Powell, or the imposition of Shortage Criteria only through 2026. However, CBS II incorporates these elements of the Basin States' proposal for comparative and analytical purposes only.

We do not assume the various proposals under consideration, including CBS II and the Basin States' proposals, are consistent with the existing law. Reclamation should clarify, during the environmental review process, how or whether these proposals would function within existing laws.

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K.2 Attachment A: Original Conservation Before Shortage Proposal (Dated July 18, 2005)

Conservation Before Shortage

Proposed Shortage Criteria for
Colorado River Operations

I. Background/Context

The effects of a multi-year drought have had a tremendous impact on storage in the Colorado River basin. Although above-average precipitation in the Lower Basin has led to small recoveries in system storage over the winter of 2004-2005, total system storage on the Colorado River has decreased by more than 40% over the past several years. As a result, there is a real possibility that the Secretary of the Interior will declare an actual shortage on the lower Colorado River in the near future. A shortage declaration would reduce deliveries to the Central Arizona Project (CAP) and to southern Nevada (which are among the first in line for cuts in the event of a shortage).

The surface elevation of Lake Mead dropped more than 80 feet from the end of 2000 through the end of 2004; Lake Powell dropped by more than 115 feet in this period. The Bureau of Reclamation's (Reclamation's) Riverware model of the Colorado, based on historic flow records, projects that reservoir levels at Lake Powell could head quickly towards the minimum power pool if the drought continues, and reservoir levels at Lake Mead could fall below the elevation of southern Nevada's upper intakes or remain in a long-term decline that will be difficult to reverse until Powell begins to re-fill. In addition, the model predicts that even if precipitation levels returned to average today, it could take 10-20 years for the Colorado River reservoir system to recover fully (during which time continued development of water supplies in the Upper Basin will further shrink available supplies). As a result, it is time to begin a long-delayed discussion about the method for defining, mitigating, and sharing shortages on the Colorado River.

Although the Secretary of the Department of the Interior (Secretary) has the authority to declare a shortage on the Colorado River, thereby reducing deliveries to some Lower Colorado River contractors, to date no criteria exist for determining when such a shortage will be declared. In June 2005, the Department of the Interior (DOI) noticed its intent to begin a public scoping process for the development of "Lower Basin Shortage Guidelines," (70 Fed.Reg. 34794). In 2004, DOI initiated a series of technical meetings with the Colorado Basin states to discuss drought issues, and the seven Basin states met frequently among themselves throughout the winter of 2004-2005 to discuss potential shortage criteria. Non-governmental organizations (NGOs) were not invited to participate in these discussions; however, several NGOs with interest and expertise in Colorado River issues began meeting over the winter to develop an alternative shortage proposal. These organizations met with Reclamation staff to review the results of technical modeling runs developed in support of the states' discussions, and Reclamation has provided additional modeling data to these interested NGOs in response to their inquiries and to evaluate potential shortage criteria.

These meetings led to the development of this document, which proposes an approach to the management of shortages in the Lower Colorado through the implementation of a tiered conservation program that is tied to the surface elevation of Lake Mead.

II. Rationale for this Proposal

The basic rationale behind this "Conservation Before Shortage" proposal is that shortage criteria should attempt to maximize the reliability and predictability of water deliveries on the Lower Colorado by introducing increased flexibility into the management of river resources when shortage conditions are imminent.

Principles:

- It is desirable to protect the elevation of Lake Mead at 1050 feet (the current minimum power pool) to the extent feasible without implementing shortages that would involuntarily curtail deliveries to Lower Basin users.
- It is desirable to protect the elevation of Lake Mead at no less than 1000 feet under any condition in order to protect Southern Nevada Water Authority's lower intake structures, as well as the new minimum power pool if proposed low-pressure turbines are installed at Hoover Dam.
- It is desirable to avoid shortages in the Lower Basin above 500,000 acre-feet whenever possible (the approximate level at which shortages would cut into CAP's deliveries beyond those currently utilized for water banking).
- It is preferable for Lower Basin water users to voluntarily engage in predictable, small-scale reductions in use – and receive compensation for those reductions – rather than face large-scale, involuntary, and uncompensated disruptions in water deliveries that could cut into municipal and agricultural water supplies and create unmitigated economic impacts.
- Minimizing large, forced disruptions to normal deliveries as a result of shortage declarations will minimize the threat of unmitigated environmental impacts in the Lower Colorado River and Delta as a result of significantly decreased deliveries to low-priority users and corresponding return flows that support environmental values.
- Market-based programs, with low transaction costs and appropriate mitigation of third-party impacts, can offer a reasonable mechanism for minimizing the risk and impacts of shortage.[1]
- Users of Colorado River water in Mexico may wish to participate in short-term conservation agreements, to reduce the probability of larger, uncompensated future reductions due to a declaration of shortage under the 1944 Treaty with Mexico.
- Water can be obtained from agricultural users in the United States, and could be obtained in Mexico with an appropriate agreement,[2] through the use of voluntary, market-based forbearance programs. Economic studies of Lower Basin agricultural use, as well as recent leases of water from farmers in this area, suggest that there is a large volume of water in the basin that could be obtained for $20 - 100 per acre-foot (see Figure 9).

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[1] Some 4.5 million acre-feet of Colorado River water are used to irrigate crops in the Lower Basin states, and more than 1 million acre-feet are used to irrigate crops in Mexico. Conservation of between 200,000 and 600,000 acre-feet through the use of part-year fallowing programs, dry year options, or other similar arrangements would constitute only 4-11% of total Lower Basin agricultural use in the United States and Mexico. (However, as even small-scale reductions in agricultural water use may have third-party impacts, some portion of funds accrued for the purchase of water should be set aside to support community economic development in affected areas.) Conversely, without these small-scale reductions, water users would likely be faced with the need to curtail large amounts of water quite abruptly, with significant economic consequences. (Shortages of nearly 2 million acre-feet in a single year are predicted by Reclamation's model when the 1000 feet elevation is protected at Lake Mead without conservation measures).

[2] Such an agreement would likely require a new Minute to the 1944 Treaty with Mexico. Fallowing agreements in Mexico would have to be administered by the appropriate authorities.

III. Conservation Before Shortage Policy

The "Conservation Before Shortage" policy essentially consists of two sets of criteria tied to projected elevations at Lake Mead on January 1 of a given year, according to the Bureau of Reclamation's August 24-month study. These criteria consist of three "conservation triggers," which impose progressively increasing conservation goals as lake levels drop from 1100 feet to 1050 feet, and a "shortage trigger," which imposes involuntary shortages in the Lower Basin as are necessary to accomplish absolute protection of Lake Mead at a minimum elevation of 1000 feet.

(A) Normal Conditions

In years when the 24-month study projects the elevation of Lake Mead on January 1 will be at or above 1100 feet, the Secretary of the Interior (Secretary) shall determine a Normal or Surplus (as defined by the Interim Surplus Guidelines) year.

(B) Conservation Triggers

First Conservation Trigger: Below 1100 Feet at Lake Mead

In years when the 24-month study projects the elevation of Lake Mead on January 1 will be at or above 1075 feet but below 1100 feet, the Secretary will seek to conserve 200,000 acre-feet of water. On behalf of the Secretary, Reclamation will preferentially seek to achieve this 200,000 acre-feet of savings by means of voluntary conservation agreements (including forbearance agreements) with Lower Basin delivery-contract holders. Additionally, Reclamation will, to the extent permitted by law and through the appropriate authorities, seek forbearance or other such water conservation agreements with Colorado River users in Mexico. In the case of such agreements, U.S. deliveries of Colorado River water to Mexico at the Northerly International Boundary will be reduced by the total volume indicated by these binational agreements.

Second Conservation Trigger: Below 1075 Feet at Lake Mead

In years when the 24-month study projects that the elevation of Lake Mead on January 1 will be at or above 1050 feet but below 1075 feet, the Secretary will seek to conserve 400,000 acre-feet of water. Reclamation will preferentially seek to achieve this 400,000 acre-feet of savings by means of voluntary conservation agreements (including forbearance agreements) with Lower Basin delivery-contract holders. Additionally, Reclamation will, to the extent permitted by law and through the appropriate authorities, seek forbearance or other such water conservation agreements with Colorado River users in Mexico. In the case of such agreements, U.S. deliveries of Colorado River water to Mexico at the Northerly International Boundary will be reduced by the total volume indicated by these binational agreements.

Third Conservation Trigger: Below 1050 Feet at Lake Mead

In years when the 24-month study projects that the elevation of Lake Mead on January 1 will be below 1050 feet (minimum power pool absent the installation of low-pressure turbines), the Secretary will seek to conserve 600,000 acre-feet of water. Reclamation will preferentially seek to achieve this 600,000 acre-feet of savings by means of voluntary conservation agreements (including forbearance agreements) with Lower Basin delivery-contract holders. Additionally, Reclamation will, to the extent permitted by law and through the appropriate authorities, seek forbearance or other such water conservation agreements with Colorado River users in Mexico. In the case of such agreements, U.S. deliveries of Colorado River water to Mexico at the Northerly International Boundary will be reduced by the total volume indicated by these binational agreements.

(C) Shortage Trigger

Absolute Protection of Lake Mead Elevation 1000 Feet

The Secretary shall not permit the elevation of Lake Mead to drop below elevation 1000 feet (minimum low-pressure power pool and Southern Nevada Water Authority intakes) at any time. Shortages to Colorado River contractors shall be implemented in the Lower Basin and in Mexico[3] to the extent necessary to prevent such declines.

(D) Funding Mechanisms

In recognition of the federal government's continuing national obligation to replace the MODE bypass flow to Mexico, 43 U.S.C. § 1571(c), the federal government will assume responsibility for the cost of all conservation agreements up to the volume of the bypass flow that the Secretary has not otherwise replaced in the year that a conservation trigger becomes effective. Given the national interest in minimizing both environmental impacts and economic disruptions resulting from the involuntary curtailment of deliveries to Colorado River users, the federal government would also assume responsibility for half of the cost of any additional agreements required to generate conserved water for the "Conservation Before Shortage" policy, pursuant to the Secretary's authority under the Reclamation States Emergency Drought Relief Act of 1991 (Drought Relief Act),[4] conservation authorities in the Farm Bill, or other appropriate authority that may be granted by Congress.

To the extent that conservation of water is required beyond that to be funded by the federal government in the manner described above, conservation activities would be funded through one or both of the following:

Power Pool Protection Fund

The priority of water used for power generation is considered to be tertiary to that of irrigation and domestic use under the Law of the River. As a result, Hoover and Glen Canyon Dams are operated to maintain deliveries to water users regardless of the impact of declining reservoir levels on power production. However, one of the more significant corollary benefits of the conservation program described in this proposal, beyond the primary benefit of protecting water users from involuntary and uncompensated shortages, would be the preservation of power production at Hoover Dam at higher levels and for longer durations by reducing deliveries for irrigation, domestic use, and underground storage in a manner that would not otherwise occur under current practices.

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[3] In the event that a shortage is declared and is also considered to be an extraordinary drought under the 1944 Treaty, deliveries to Mexico will be reduced in the same proportion as consumptive uses in the United States are reduced.

[4] The Reclamation States Emergency Drought Relief Act of 1991, 43 U.S.C. §§ 2201 *et seq.*, provides the Secretary of Interior the authority to purchase water "from willing sellers, including, but not limited to, water made available by Federal Reclamation project contractors through conservation or other means with respect to which the seller has reduced the consumption of water." 43 U.S.C. § 2211(c).

Given the significant loss in generating capacity that has already occurred as a result of declines in power pool elevations,[5] and the even more significant impacts that would be associated with a total loss of generating capacity, the implementation of "Conservation Before Shortage" would clearly benefit power purchasers and consumers. As such, it would seem reasonable to derive a percentage of the funding for the proposed voluntary conservation program from a modest, conditional surcharge on power rates under existing or renewed contracts for hydropower produced at Hoover Dam as a means to mitigate against the loss of power head and stave off the complete loss of power production at Hoover Dam.[6] This surcharge could be imposed in years when Reclamation's August 24-month study projects that the storage in Lake Mead falls below fifty percent of its active capacity. The revenues generated by this surcharge could be collected in a "power pool protection fund," to be maintained by Reclamation for expenditure when and if lake elevations reach a conservation "trigger."

Temporary Cost Recovery/Delivery Surcharges

Pursuant to the Drought Relief Act, the Secretary of Interior is authorized to engage in water purchases from willing sellers and to seek cost recovery for water delivered from the users of that water under temporary contracts. 43 U.S.C. §2211(c), §2212(a),(c). Reclamation could utilize this authority to purchase water through temporary, part-year fallowing arrangements, dry-year options, or similar mechanisms, and would seek cost recovery from Colorado River users. In recognition of the Basin-wide interest in alleviating the impacts of drought and reducing uncertainty on the Lower Colorado, and in the interests of encouraging extraordinary conservation to minimize the likelihood of significant delivery interruptions, the cost of some portion of conservation agreements, including those with Colorado River users in Mexico, could be funded through a conservation surcharge imposed on a per-acre-foot basis on all Lower Basin contractors.

Anticipated Cost of Conservation

Current short-term leasing agreements between farmers and irrigation districts or municipal water agencies, as well as recent research on the net returns per acre-foot of irrigation water, suggest that "Conservation Before Shortage" water could be obtained for $20 - 100 per acre-foot. To ensure that such water remains available in times of increased scarcity (when market forces might otherwise increase the cost), the Secretary should be granted the authority to enter into "Conservation Before Shortage option agreements," similar to existing dry-year leasing agreements/interruptible supply agreements that have been enacted within the basin states.

[5] Largely as a result of declining reservoir elevations, power production at Hoover and Glen Canyon has declined steadily since the onset of drought conditions in the Colorado River Basin. Annual power production at Hoover fell from 5,697 gigawatt-hours (GWh) in 1998 to 4,094 GWh in 2003, according to Western Area Power Administration (WAPA) Annual Reports, 1998 – 2003. A portion of hydropower revenues currently supports the two Upper Basin endangered fish recovery programs, the Glen Canyon Adaptive Management Program, and the Colorado River Salinity Control Program; alternative sources of revenue should be identified and implemented to fully fund these recovery programs. The Department of the Interior should also work proactively with WAPA to identify alternative sources of power for those Indian tribes that have experienced power shortages, or drastic increases in power costs, due to the declining production associated with falling reservoir levels.
[6] The rates for power produced at Hoover Dam have increased as reservoir levels and power production have declined, but may still remain well below open market rates. Although annual revenues tend to vary from year to year, revenues from Hoover Dam power production have generally been in the range of $50 million annually.

IV. Analysis: Benefits of Conservation Before Shortage Policy

To date, actual shortage criteria for the Colorado River have not been defined. For the purposes of comparison, a 'baseline' was defined as the current operating conditions for the Colorado River, with the addition of a policy requiring the absolute protection of Lake Mead at 1000 feet (that is, Hoover Dam would not release any water to cause the elevation of Lake Mead to drop below 1000 feet). The baseline policy does *not* provide for the implementation of conservation measures. These 'baseline' conditions, reflecting current operating conditions, are depicted in the following figures.

Analysis of the "Conservation Before Shortage" policy suggests that this policy could produce significant benefits for Basin water users by:

- Consistently maintaining reservoir storage and power head above baseline conditions in average to low flow conditions, resulting in increased power production and improved power revenues;
- Significantly reducing the likelihood of involuntary, uncompensated shortages in the Lower Basin and corresponding, unmitigated economic impacts;
- Significantly reducing the likelihood of involuntary and uncompensated shortages in the Lower Basin at levels above 500,000 acre-feet (the approximate level at which a shortage imposed by the Secretary would cut into CAP deliveries, by exceeding the ability of the Arizona Water Bank to readily buffer the shortage); and
- Eliminating the risk that elevations at Lake Mead will drop below minimum power head, improving the reliability of power production and associated revenues.

The analyses below show the impacts of the "Conservation Before Shortage" (CBS) policy on reservoir operations based on historic flows in the Colorado River Basin.

Modeling Assumptions

The proposed "Conservation Before Shortage" policy was modeled using Reclamation's Riverware model, which is based on historical records of flows in the Colorado River Basin over approximately the past century. Conservation triggers, as described in Section III, were implemented at 1100 feet, 1075 feet and 1050 feet, with the assumption that required measures to reduce Lower Basin consumptive use by 200,000, 400,000, and 600,000 acre-feet, respectively, would be implemented in years when the January 1 elevation at Lake Mead is below the triggers. An absolute protection trigger was implemented at Lake Mead elevation 1000 feet, with releases from Lake Mead to meet delivery obligations to Lower Basin users reduced as necessary to maintain that level. To avoid even modestly under-predicting the elevations of Mead and Powell pools, particularly in the near term, this modeling has assumed that the schedule of Upper Basin depletions will effectively begin with the last reported actual level for CY 2000, will increase at a slower rate than projected by the Upper Colorado River Basin Commission through CY 2009, and will increase at the rate projected by the Commission thereafter.[7]

For purposes of the model, the minimum objective release out of Lake Powell was assumed to be 8.23 maf per year (reflecting current operating conditions).[8] Alternative scenarios for conjunctive management were not modeled, and the protection of a minimum power pool at Lake Powell was not incorporated into this proposal; either or both of these assumptions would affect the elevation of Lake Powell. Model runs used end-of-year 2004 elevations at Lake Mead and Lake Powell to establish initial conditions for 2005, and were run through year 2025.

Protection of Lake Mead

Figures 1 -3 show the potential value of implementing the CBS policy, under a range of average to extremely low flow conditions. **These and following figures show that the CBS policy would greatly benefit the elevation of Lake Mead.**

As shown in Figure 1 below, under average conditions, the CBS policy would maintain reservoir elevations at Mead approximately 30 feet above the baseline policy. As shown by Figures 2 and 3, the CBS policy would significantly reduce the rate of decline in the lower 25^{th} and in the very low 10^{th} percentile reservoir elevations for Mead and maintain even these lower reservoir elevations above the 1000 foot protection level. Model runs showed essentially no impact of the CBS on the higher 90^{th} percentile Mead elevations, so no figure is provided.

[7] *See* "Estimates of Future Depletions in the Upper Division States," Upper Colorado River Commission Memorandum, December 23, 1999. This schedule predicts a 440,000 acre-foot increase in Upper Basin depletions between 2000 and 2010 and a 542,000 acre-foot increase over actual CY2000 depletions, as reported in Reclamation's Consumptive Uses and Losses 1996-2000 report (see Tables UC-1 & UC-6). Actual increases in Upper Basin depletions water may not keep pace with this schedule, because water that would otherwise have been utilized has been and may continue to be physically unavailable for depletion in the Upper Basin due to drought conditions, and in other cases, projects that were proposed to have been constructed during this period may not yet have been or will not be completed through CY 2009. A slower rate of increase from 2000 to 2009 was modeled by subtracting four increments of 100,000 acre-feet from the Commission's schedule from CY 2005 to 2009. This and all other Riverware modeling exercises should be revised to reflect actual increases in Upper Basin depletions as soon as more current information becomes available.

[8] This assumption is not intended to endorse or reject the Secretary's current use of 8.23 maf as the minimum release objective for Powell, the protection of a minimum power pool at Powell, or proposals for the conjunctive management of the combined storage of Mead and Powell. Alternative release scenarios should be incorporated into the modeling for this proposal as they are developed. As a general matter, none of the assumptions used in this proposal should be construed as an interpretation of the 1922 Colorado River Compact, the 1944 Treaty with Mexico, or any other aspect of the Law of the River.

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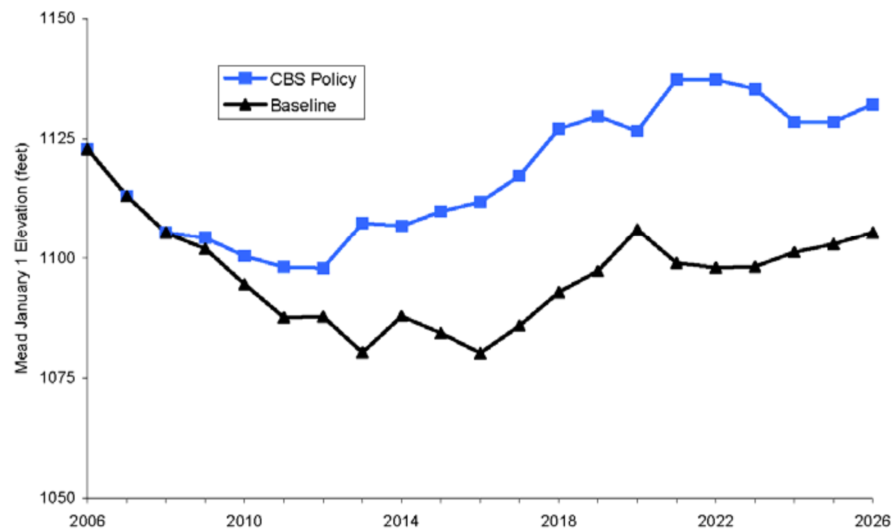

Figure 1. Impact of CBS policy on elevations at Lake Mead, at 50th percentile elevation.

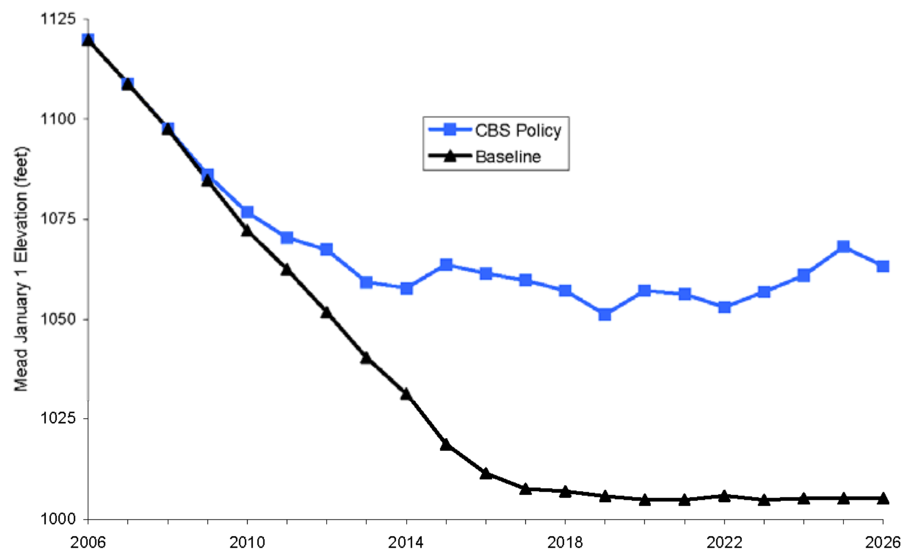

Figure 2. Impact of CBS policy on elevations at Lake Mead, at 25th percentile elevation.

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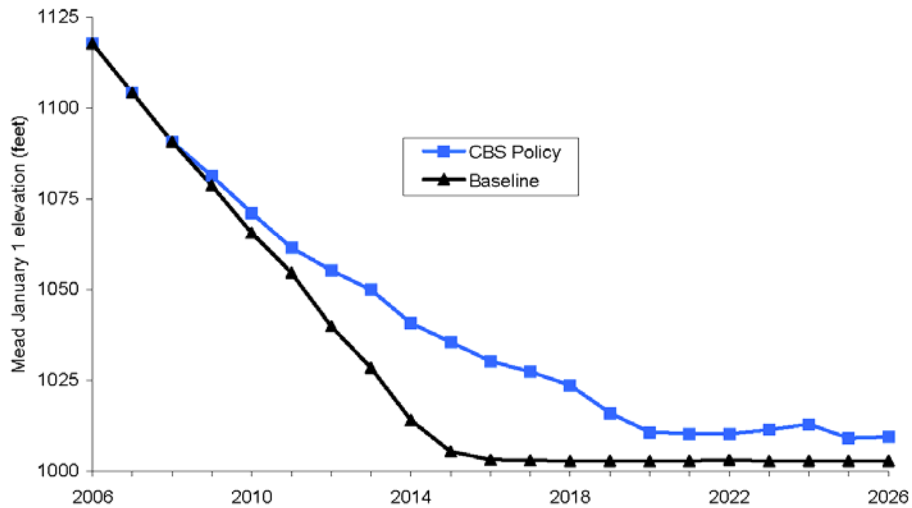

Figure 3. Impact of CBS policy on Lake Mead elevation, at 10th percentile elevation.

Probability of Shortages

As noted above, a primary goal of the CBS policy is to significantly reduce the probability of an involuntary, uncompensated shortage in excess of 500,000 acre-feet (the approximate level at which CAP deliveries would be reduced beyond that currently utilized for water banking). **As shown in Figure 4, below, the probability of shortages exceeding 500,000 acre-feet is reduced to 5% or less through the entire modeled period under the CBS policy. By contrast, the probability of shortage under the baseline policy rapidly approaches 30% during this same period. Furthermore, as shown in Figure 5, below, the CBS policy reduces the probability of any involuntary shortage by approximately 20% over the next 20 years.**

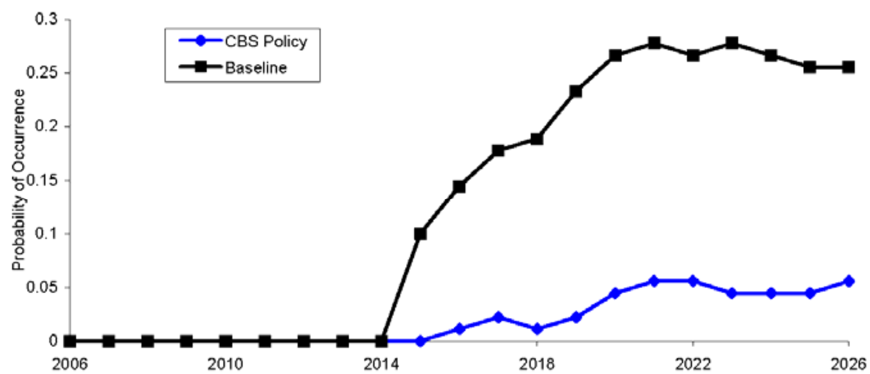

Figure 4. Impact of CBS policy on probability of involuntary Lower Basin shortage greater than 500,000 acre-feet.

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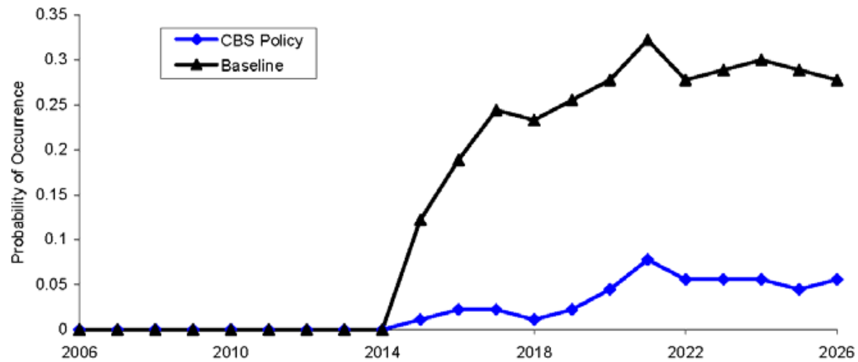

Figure 5. Impact of CBS policy on probability of any involuntary shortage in the Lower Basin.

Probability of Reaching Conservation Triggers

Figures 6 - 8, below, show the relative probability of reaching or exceeding any of the proposed conservation triggers at 1100 feet, 1075 feet and 1050 feet. As one might expect, the probability of reaching the first two triggers is highest in the earlier years of the modeled period, while the probability of reaching the third trigger is higher towards the end of the modeled period. However, the probability of reaching and continuing to remain below a given trigger for an extended period of time appears to be low because of the conservation measures tied to the triggers. For obvious reasons, trigger levels are most likely to be reached under low or very low flow conditions, and are rarely (if ever) reached under high flow conditions.

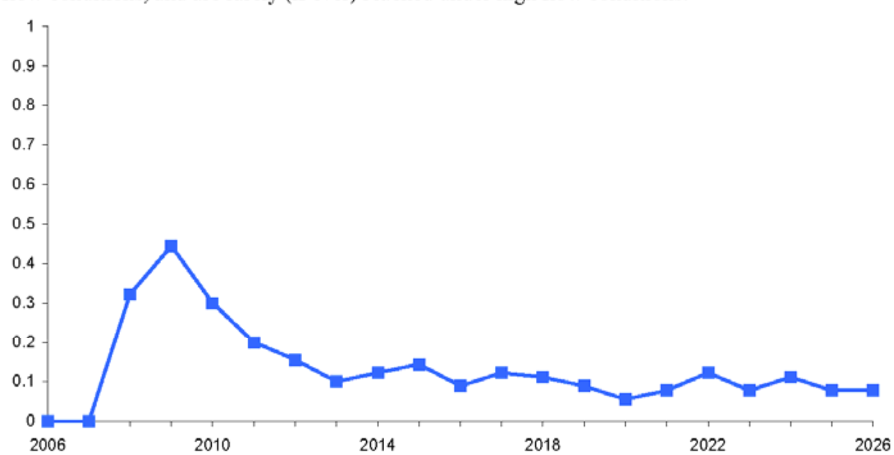

Figure 6. Probability of Lake Mead January 1 elevation occurring in a bounded range of 1100 feet to 1075 feet, with CBS policy in place.

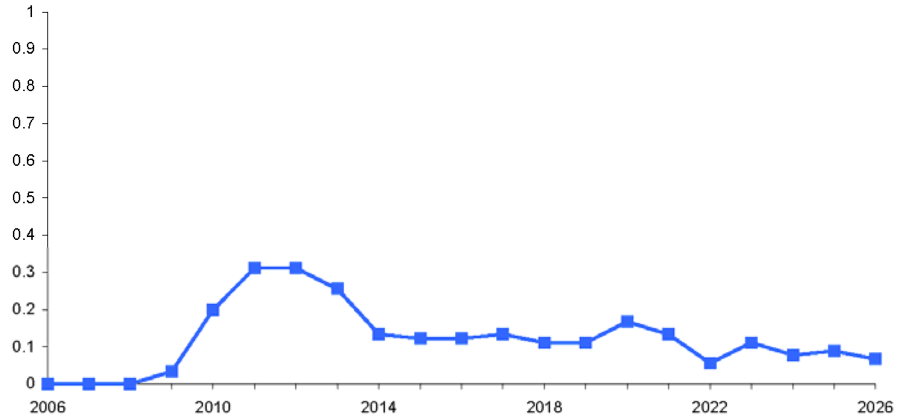

Figure 7. Probability of Lake Mead January 1 elevation occurring in a bounded range of 1075 feet to 1050 feet, with CBS policy in place.

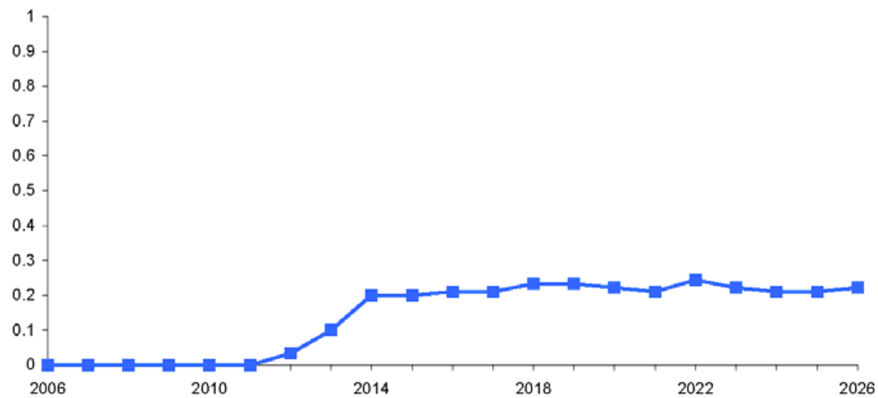

Figure 8. Probability of Lake Mead January 1 elevation occurring below 1050 feet, with CBS policy in place.

Cost of Implementing Conservation Triggers

The cost of implementing conservation triggers is directly related to the cost of obtaining water using the proposed voluntary, market-based conservation mechanisms. Recent purchases of water from farmers in the Lower Basin, as well as analysis of agricultural production in this area, suggest that there is a substantial volume of water used for irrigation which could potentially be obtained on a temporary basis for $20 - 100 per acre-foot. For example, in 2004, the Imperial Irrigation District acquired water from its farmers for less than $60 per acre-foot.

As shown in Figure 9, a recent economic study by Environmental Defense into the profits returned by field crops suggests that slightly more than 2.3 million acre-feet of agricultural water

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is being used by Lower Basin farmers in California and Arizona to produce profits of less than $100 per acre-foot; more than one million acre-feet of agricultural water is being used to produce profits of less than $20 per acre-foot. (Figures are based on the average volume of water applied to produce a crop unit and market rates for each crop, less costs of production.)

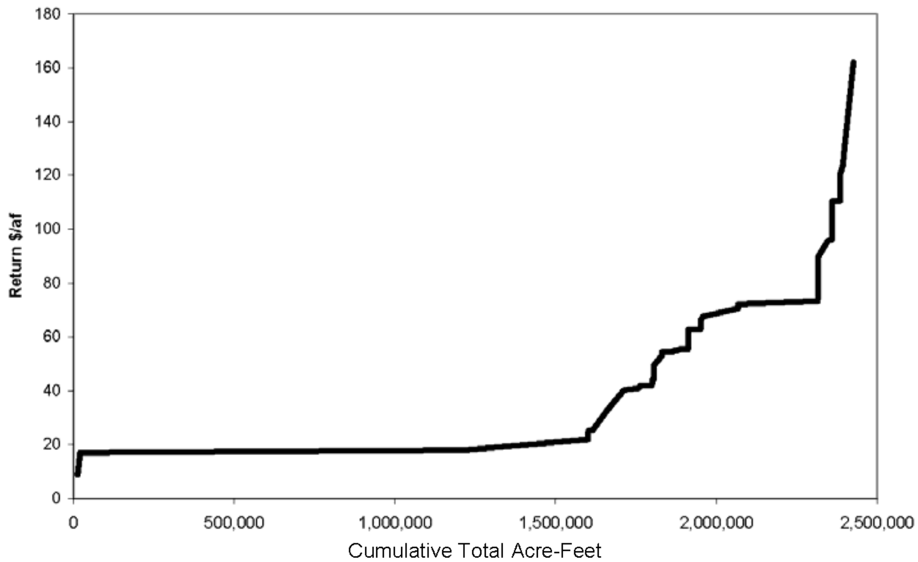

Figure 9. Profits per acre-foot returned on Colorado River water used in the production of selected crops in the Lower Colorado River Basin.[9]

While these figures do not necessarily reflect the amount at which any given water user would be willing to take part in a part-year fallowing program or agree to a dry-year option, they do suggest that if an open, market-based approach is used to identify potential participants, a number of water users in the Lower Basin would probably be willing to temporarily reduce or forgo the use of water for agricultural production in a price range between $20 and $100 per acre-foot (as the sale of water in this range would produce equal or greater monetary returns to the user than the use of water to irrigate crops).

In order to mitigate third-party impacts of fallowing, the federal government could establish a drought economic adjustment fund that would provide economic development grants to affected communities in the counties of origin. These funds preferentially would go to established county-based farm labor assistance programs to the extent that such programs exist, and could include lump sum payments to displaced workers based on a percentage of foregone annual income.

[9] This graph has not been published elsewhere. For methodology, please contact Jennifer Pitt at jpitt@environmentaldefense.org. A study using similar methodology, but limited to crop values in the Wellton-Mohawk Irrigation and Drainage District, has been published previously (Pitt et al., New Water for the Colorado River: Replacing the Bypass Flow, 6 U. Denver Water L. Rev. 68 (2002)). The study found a range of prices similar to that represented here for profits derived from water use in that area.

Using these assumptions for water acquisition costs, Table 1 suggests the approximate range of costs for implementing each of the conservation triggers under the CBS policy.

Table 1. Approximate federal and power/water user cost of implementation of CBS policy conservation trigger levels (assumes that water can be acquired temporarily for $20 - $100/acre-foot, and that the annual federal bypass obligation of 110,000 acre-feet has not otherwise been satisfied).

Trigger	Conservation required	Federal obligation (bypass + 50%)	Federal cost (millions)	Remaining Obligation	Water user cost (millions)	Power Surcharge (millions)	User cost per af (all Lower Basin users)
1075-1100	200,000 af	155,000 af	$3 - $15.4	45,000 af	$0.45 - $2.3	$0.45 - $2.3	$0.06 - $0.30
1050-1075	400,000 af	255,000 af	$5 - $25.4	145,000 af	$1.5 - $7.3	$1.5 - $7.3	$0.19 - $0.97
Below 1050	600,000 af	355,000 af	$7 - $35.4	245,000 af	$2.5 - $12.3	$2.5 - $12.3	$0.33 - $1.63

Cost of Not Implementing “Conservation Before Shortage” Policy

Although the “Conservation Before Shortage” policy would impose notable costs on water and power users, and on taxpayers generally, these costs should be compared with the much larger financial costs that would occur if the Secretary were to impose involuntary, uncompensated shortages, as well as the costs due to the lack of certainty and reliability that would exist without the CBS policy. The recent drought and decrease in power production at both Hoover Dam and Glen Canyon Dam point to the dramatic costs imposed by the loss of reservoir storage.

If Lake Mead falls to 1050 feet, power rates will need to be increased to an approximate composite rate of 2.31 cents/kWh, which is a 44.3% increase over current rates. Replacement power purchases would be (depending on the user) 2.9 to 3.7 times the Hoover rate. In FY03, replacement power may have cost customers an additional $24 million.

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K.3 Attachment B: Taking ICS to Mexico: International Opportunities in the Seven States Agreement

Taking ICS to Mexico:
International Opportunities in the Seven States Agreement

Introduction

The Seven Basin states recently reached agreement on a far-reaching proposal to improve the management of Colorado River system water through conjunctive management of Lakes Mead and Powell, modification and extension of the existing interim surplus guidelines, and the adoption of shortage guidelines. Perhaps most significantly, this agreement introduces of a series of new mechanisms to increase flexibility within the Lower Basin delivery system and water allocations, including the creation of a new category of water: "Intentionally Created Surplus," which can be generated through extraordinary conservation measures or the funding of system efficiency improvements, and the recognition of water exchanges.

At the present time, the states' proposal is largely concerned with operations between and among the Basin states, particularly the states of the Lower Basin, although some elements of the proposal (such as water exchanges) have apparently contemplated Mexican participation. However, it would appear that significant benefits for U.S. water users, Mexican water users, and the environment could also be derived from expressly extending portions of the proposed agreement to water users in Mexico – while helping Mexican users to more readily bear burdens that could otherwise be imposed by the alterations proposed in the states' accord.

In particular, an extension of proposed policies related to Intentionally Created Surplus (ICS), system efficiency improvements, and water exchanges to include water users in Mexico could provide significant assistance in resolving difficult issues related to urban, agricultural, and environmental water supplies in Mexico, while opening enormous opportunities for both U.S. and Mexican water users to obtain water supplies via funding of irrigation efficiency improvements, the construction of urban water infrastructure, water supply replacement or enhancement, desalination, and other projects. These credits could be used to firm up urban water supplies in both countries, engage in long-studied environmental restoration projects in the Delta, and increase flexibility in Mexico's agricultural sector – creating economic, environmental, and social benefits in both countries while offering the United States and Mexico a venue for cooperation in the otherwise contentious area of water management at the border.

These outcomes would meet all three of the purposes identified in the Basin States' original proposal: improving cooperation and communication, providing additional security and certainty in the water supply of the Colorado River System, and avoiding circumstances which could otherwise form the basis for claims or controversies over the Colorado River Compact and other applicable provisions of the Law of the River.

While an extension of this agreement to include Mexico would likely need to occur on a different timeframe than for the domestic implementation of the agreement, the domestic process should at least not close the door on an international program, and would preferably encourage the initiation of binational discussions on the issue. Since critical elements of the states' current proposal – most notably the proposed shortage policy and proposed policies for unilateral water exchanges – will already require consultation with Mexico and/or the adoption of a new Minute, these opportunities could be considered in the same diplomatic process.

Binational Challenges for the Seven States' Agreement

Mexico has no storage system for Colorado River water, and as such, is effectively dependent on the U.S. reservoir system to guarantee water deliveries to meet municipal and agricultural demands. In addition, although the Mexicali Valley has significant groundwater resources, Mexico does not currently operate a water bank or other shortage mitigation program comparable to those in place in the United States (e.g., the Arizona Water Bank). At the same time, the lack of storage in Mexico effectively prevents Mexico from accumulating reserve supplies that could be used to meet environmental needs in Mexico (such as pulse flooding the in Delta region, which has been identified as a necessary precondition to effective restoration of key riparian areas). In the face of a rapidly growing population, ongoing efficiency and water accounting issues in its agricultural sector, and increasing pressure to protect and restore critical environmental resources in the Delta, Mexico faces a uniquely challenging situation with regard to the management of its water resources.

Of particular concern for Mexico in the states' proposal could be the provisions related to the implementation of shortages on the Lower Colorado. Although the Treaty of 1944 provides that Mexico is to share "proportionately" with U.S. users in times of "extraordinary drought," the precise meaning of this provision remains unclear, and it has never been invoked since the time of the Treaty's execution. The states' agreement, for the first time, unilaterally and precisely defines a set of proposed parameters under which shortages would be implemented against the Mexican allocation. Because Mexico has no readily available mechanisms to reduce or mitigate against shortage impacts on its users (such as reservoir storage or water banking), the potential for shortages will cause understandable concern for Mexican water users – similar to those that have arisen among low-priority users in the U.S.

Similarly, although conjunctive management of Lakes Mead and Powell as proposed in the states' agreement will doubtless help to reduce the probability that such shortages will actually occur, this will potentially come at the cost of decreasing the probability of future spills from these reservoirs in the future, since reservoirs may be drawn down further in the event of drought, increasing available capacity to absorb flood events in the future. The states' proposal also appears likely to create incentives to further increase the efficiency of U.S. water delivery systems by providing opportunities to receive ICS credits for the funding of these projects (e.g., Southern Nevada Water Authority's proposed funding of the Drop 2 reservoir); these projects will further reduce normal-year deliveries to Mexico. Combined with gradually increasing efficiency in agricultural water use, this will continue to pose challenges for the maintenance of critical environmental values in the Delta, which receive virtually all of their current water supplies from agricultural return flows, excess deliveries, canal leakage, and occasional flood events.

However, the states' proposal also offers a potential opportunity to promote binational solutions to these concerns as well as a broader suite of water issues in the border region – particularly insofar as it could be used to promote improvements in agricultural efficiency, water infrastructure, and municipal water quality and supply in Mexico. A brief discussion of these opportunities is provided below, together with examples of how particular programs might work. Of course, any projects undertaken would require the review, approval, and continuing oversight of both countries. However, it is critical to note that each of these programs could be undertaken without altering Mexico's basic Treaty entitlement to Colorado River water; any decrease (or increase) in Treaty deliveries would be matched by a mutually agreed-to compensation program or a proportionate increase (or decrease) in water deliveries in a later year. None of these programs would change Mexico's right to Colorado River water deliveries under the 1944 Treaty.

Expanding Three Elements of the States' Proposal to Mexico: How It Could Work

Intentionally-Created Surplus (ICS)

Under the states' proposal, a contractor could generate "ICS credits" by engaging in extraordinary conservation activities that have the effect of reducing the use of Colorado River water. These activities could include land fallowing, canal lining, desalination, or other extraordinary conservation measures agreed to by the states, so long as they result in the savings of water that would otherwise have been beneficially used as a part of a state's basic entitlement (surplus water cannot be used), the contractor plans and identifies the intended savings in advance (by September 15 of the preceding year), and the credits are first used to offset any delivery overruns.

These ICS credits would then be stored in Lake Mead for use by the contractor at some future time, subject to annual reductions to account for storage losses to reservoir evaporation, and a 5% "system tax" that would accrue to the benefit of the river system as a whole.The remaining credits could then be used during any year with "normal" operating conditions. During shortage or surplus conditions, the credits could not be used, and they would be reduced on a pro-rata basis in the event of a spill. However, for the purposes of determining calendar year declarations of surplus, normal, and shortage conditions, stored water that is subject to ICS credits would be considered system water – helping to keep reservoir levels higher in Powell and Mead and avoid shortages in the Lower Basin.

ICS credits would be subject to both yearly and cumulative maximums for each state, with California limited to no more than 400,000 acre-feet per year and a total credit of 1.5 million acre-feet, and Arizona and Nevada to 100,000 and 125,000 acre-feet per year, respectively, and total credits of 300,000 acre-feet. Recovery of ICS credits is similarly

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limited to 400,000 acre-feet annually for California and 300,000 acre-feet annually for Arizona and Nevada.

- How it could work in Mexico:[1]
  - Mexican users could engage in extraordinary conservation activities in Mexico with the effect of reducing actual beneficial use such that deliveries to Mexico under the Treaty could be temporarily reduced below 1.5 million acre-feet in any one year. This would generate ICS credits that would be available for delivery to Mexico in later years, under the same rules applicable to U.S. users, resulting in temporary increases in deliveries above the 1.5 million acre-foot Treaty obligation.
    - Example: Pronatura Sonora pays to temporarily fallow low-productivity lands in the Mexicali Valley, saving 30,000 acre-feet of water a year over a period of years. Treaty deliveries in each year are accordingly reduced below 1.5 million acre-feet, resulting in increased storage in Lake Mead. Pronatura receives an ICS credit which it can deliver to Mexico in a future year as a pulse flow for a riparian restoration project (after reducing the ICS credit for reservoir evaporation and paying the 5% system tax).

System Efficiency Projects

In addition to creating ICS through extraordinary conservation activities for existing uses of Colorado River water, the states' proposal allows for Colorado River users to receive ICS credits in exchange for making capital contributions to projects that would increase the overall efficiency of the Colorado River delivery system. The credits would comprise a portion of the water saved through the efficiency project, and would not be stored, but would rather be provided to the user that developed the credit on a predetermined schedule for some period of years.

- How it could work in Mexico: Mexican or U.S water users could fund delivery system efficiency improvements and receive proportionate amounts of temporary ICS credits for their investments that could be used under the same rules applicable under the states' proposal. These temporary credits would have the effect of either increasing (if funded by a Mexican user) or reducing (if funded by a U.S. user) Treaty deliveries to Mexico for an agreed period of time. After the temporary ICS credits expired, the system efficiency improvement would accrue to the country in which the project was undertaken.
  - Example: Metropolitan Water District develops a cooperative program with CNA and the U.S. federal government to invest in upgrades to the Mexicali Valley irrigation system, including canal lining and water

[1] The legal mechanism for implementing the extension of ICS and water exchanges to Mexico is discussed below.

accounting infrastructure, resulting in significant savings of water that would otherwise have been lost in the delivery system while improving or at least maintaining agricultural productivity. MWD receives a fixed amount of ICS credits for a period of years that can be used as a "bridge" supply until permanent water transfers from U.S. agricultural sources are completed. After the expiration of that period, all ICS credits revert to Mexico. Mexico, in turn, commits to dedicate a portion of the water saved to natural habitat restoration in the Colorado River Delta. With the approval of the U.S. Fish and Wildlife Service and appropriate international agreements, this could even result in some partial credit under the Multi-Species Conservation Program. Mexico uses the bulk of efficiency savings from the program to improve urban and agricultural water supplies, including offsetting expected impacts from the lining of the All-American Canal.

Water Exchanges

Finally, the states' proposal allows Colorado River users in the Lower Basin to secure additional water supplies by funding the development of a non-Colorado River System water supply in one state for use in another state by exchange. The new water supply would be used in place of the Colorado River water supply, allowing the user that provided the funding to use the Colorado River water that is no longer used through and agreement with the Secretary of the Interior. The states' proposal expressly contemplates exchanges with Mexico, albeit only unilateral exchanges in which non-Colorado River System supplies would be developed in Mexico, with the savings used in the United States.

- How it could work in Mexico: This program could be extended to a bilateral program in which water could be exchanged in either direction, with exchanges resulting in commensurate increases or decreases in Treaty deliveries (indeed, it is unclear why Mexico would agree to a purely unilateral program as proposed by the states).

Opportunities in Mexico

The examples cited above suggest just a few of the opportunities which could be explored if the states' proposal could be extended to users in Mexico - opportunities that could help not only to offset the impacts of the states' proposal, but also to meaningfully improve the tools available to meet human and environmental needs in the border region.

Over the years, there have been a number of proposals suggesting means by which the United States and Mexico might cooperate to improve both agricultural efficiency and municipal water quality in the border region. Notably, in 1991, the United States Bureau of Reclamation (BOR) and the Comisón Nacional del Agua (CNA) released a joint proposal entitled "International Cooperative Water Conservation and Irrigation Efficiency Improvement Program between the Republic of Mexico and the United States of America" that was championed by Dennis Underwood. This proposal noted similarities between cropping patterns and irrigation methods in the Imperial and Mexicali Valleys, and based on the experience of municipal and industrial users in California with investment in efficiency improvements (that were otherwise beyond the means of farmers in the region), suggested that similar investments in the Mexicali Valley could produce significant short and long-term water supply benefits.

Observations of water management in the Mexicali Valley suggest that there remain significant opportunities for improving water delivery and use through system automation, operational changes to improve the timing and quantity of deliveries, conversion to high capacity farm turnouts, canal lining, spill interception, land leveling, installation of canal turnouts for rapid delivery, improved cropping patterns, changed field irrigation practices and adaptation to low water-use technologies, improvements to drainage, and improved maintenance procedures. Water conserved from these efforts could be beneficial in terms of providing replacement supplies in the face of shortages, reducing dependence of local farmers on groundwater supplies, and providing environmental benefits.

For example, the Mexicali Irrigation District (DDR 0014) reports approximately 645,000 af/yr (800 mcm/yr) in conveyance losses that are recoverable (as opposed to conveyance losses that recharge groundwater supply[2]). Based on some extremely rough estimates, of this total conveyance loss, approximately 150,000 af/yr (200 mcm/yr) may be attributable to seepage from major canals. Much of this latter seepage apparently occurs along approximately 70 kilometers of unlined canal sections, which could potentially be lined, by one estimate, for around $600 million pesos (US $56 million). These include the Reforma canal (28 km, estimated lining cost $150 million pesos or US $13.7 million), the Revolución canal (20 km, no lining estimate available), the Alimenta del Sur canal (5.5 km, no lining estimate available), and the Nuevo Delta canal (16 km, lining cost $300 million pesos or US$27.4 million).[3] None of these sections reportedly cross or recharge aquifers from which significant amounts of groundwater are recovered or that support river flows or wetlands. The total estimated costs of all of these lining projects would likely be comparable to the $80-$90 million construction cost for the Drop 2 storage reservoir, but could potentially produce a far larger quantity of savings at a much lower cost per acre-foot.

The opportunities associated with an international expansion of the seven states proposal are not limited to agricultural water use. Mexico is currently experiencing increasing risks of shortages to municipal and industrial water supplies in the Mexicali Valley and the major communities to the west of the Valley – as well as significant concerns related to water quality due to high water salinity in the Mexicali Valley region and water

[2] The extent to which the aquifers are interconnected and to which such losses are recoverable without impacting groundwater recharge that is pumped for irrigation or that supports river flows or wetlands should be verified by geo-hydrologic investigation, modeling, and monitoring.
[3] These figures are rough estimates based on informal discussions with a former employee of CONAGUA and are provided for illustrative purposes only. The estimated costs for lining the Nuevo Delta canal reach are apparently high due the location of this reach over a geologic fault.

pollution. These concerns create a significant opportunity for the use of tools such as ICS and system efficiency investments to improve these supplies – and perhaps just as significantly, opportunities to invest in desalination or other technologies to replace low-quality Colorado River supplies or otherwise improve water quality for municipal use.

Creating a Delta Water Supply

These proposals would necessarily require consideration of environmental needs in the Colorado River Delta. As numerous studies have pointed out, the remaining Delta ecosystem largely depends on "system inefficiencies" for its water supply – such as return flows from agriculture, effluent flows, canal leakage, and releases in excess of Treaty requirements from the U.S. These proposals would create inevitable incentives to reduce these inefficiencies in Mexico (just as the states' proposal creates incentives to reduce inefficiencies in the United States). As such, it is essential that any program in Mexico provide a mechanism for replacing (or improving) the Delta's water supplies while meeting critical agricultural and municipal needs.

To a certain extent, this issue could be addressed through implementation of an ICS mechanism in Mexico. Several recent studies, including a recent Packard Report, "Immediate Options for Augmenting Water Flows to the Colorado River Delta in Mexico," have investigated options related to taking existing, marginal agricultural lands in Mexico out of production and utilizing the water associated with those lands for environmental purposes. The Sonoran Institute and Pronatura Noroeste-Sonora, together with other NGO partners, are currently in the process of exploring just such an option, focusing on highly marginal lands in the southern portions of the Mexicali Valley where salt buildup and shallow groundwater create economic challenges for agricultural production. Although funding for these efforts has not yet been secured, mechanisms have been identified for holding water derived from these lands via water trusts, wheeling water to appropriate locations, and designating protected receiving areas in the riparian corridor to ensure that water is used for environmental benefit.

Nevertheless, reliance on non-governmental organizations alone will not guarantee the continued availability of water to support key ecosystem values in the Delta. To ensure the continued viability of the Delta ecosystem – and to avoid ongoing uncertainties for U.S. and Mexican water users associated with environmental challenges to water allocations – any international program should include a process for securing necessary environmental flows, such as the dedication of a portion of the proceeds of various water-saving programs to provide a permanent, reliable supply of water to replace current supplies and support environmental uses in the Delta.

Making a Binational Proposal Work: Changes to the States' Proposal and the Treaty of 1944

Implementation of a binational program for Intentionally-Created Surplus, efficiency improvements, and water exchanges would of course require an alteration to the current framework of the Treaty of 1944 between the United States and Mexico. Currently, the

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Treaty requires the delivery of 1.5 million acre-feet of water to Mexico annually, absent surplus or extraordinary drought.

It should be noted that none of the proposals discussed above would have the result of altering the basic entitlements of either the United States or Mexico under the Treaty; regardless of the program developed, Mexico would continue to have the same 1.5 million acre-foot entitlement to Colorado River water even if the precise timing (or the place) of the delivery of that entitlement was altered). As such, the implementation of such programs should not result in any conflict with other provisions of the Law of the River, and in particular the Colorado River Compact, since no change in position between the U.S. and Mexico would occur.

However, the implementation of the proposals discussed above would require temporary reductions or increases in deliveries above or below this basic number to the extent that water was stored or released from Lake Mead in response to programs generating ICS via extraordinary conservation or investment in system efficiency improvements, or else via water exchanges between parties in the U.S. and Mexico. As such, an appropriate alteration to the delivery rules under the Treaty would be required.

This could be effectively accomplished via the addition of a new Minute to the Treaty of 1944, adopted through the International Boundary and Water Commission (IBWC). Pursuant to the Treaty of 1944, IBWC is authorized to build and manage waterworks, to resolve problems and negotiate further agreements regarding international waters, and to settle treaty-interpretation disputes.[4] The Treaty grants broad jurisdiction to IBWC to "plan, build, and manage water works; to enter into further agreements regarding international waters," and to "settle all differences that may arise between the two Governments with respect to the interpretation or application of this Treaty, subject to the approval of the two Governments."[5] Assuming appropriate approvals could be obtained from the U.S. and Mexican federal governments, IBWC should thus have appropriate authority under the Treaty to implement a binational program for ICS, water efficiency improvements, and water exchanges based on the same rules applicable to the other Lower Basin states. In addition, any international agreement would need to address a number of technical issues that would be associated with these programs, including the development of appropriate accounting methods for water conservation, and the identification of conservation priorities and opportunities to which water generated for ecosystem use might be put.

Such a new Minute could be modeled after the new regulations or guidelines that would need to be adopted to implement the states' proposal in the U.S. As the shortage criteria for deliveries to Mexico and the states' existing proposal for unilateral water exchanges would also likely require implementation via a new Minute, these issues could be explored under the same diplomatic process.

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[4] *See* Mexico-U.S. Water Treaty of 1944, Art. 24, 59 Stat. at 1255-1257.
[5] *See* Mexico-U.S. Water Treaty of 1944, Art. 24(d).

Obviously, these proposals would require diplomatic discussions between the U.S. and Mexico before they could be appropriately implemented, which would place the implementation of an international ICS program on a different timeframe than that anticipated for the adoption of a domestic program. However, as the operation of such a program would likely require consideration of environmental concerns under the National Environmental Policy Act, as well as appropriate recognition in any guidelines that may be adopted by the Secretary to implement the states' agreement. For example, the rules used to guide the storage and release of ICS credit water would need to recognize the potential for delivery of ICS to Mexico pursuant to the Treaty of 1944, rather than solely by reference to Section II(B)(2) of the Decree and forbearance agreements between the states. Similarly, rules defining the maximum amount of ICS credits that could be generated in any one year, and the cumulative amount that could be subject to storage in Lake Mead, would also need to reference the potential for Mexican use of this system.

To ensure that a potential international program could be eventually implemented in conjunction with the states' proposed program, and assuming that there is interest among Mexican water users in such an international program, we suggest that the proposals discussed above should be appropriately considered as a part of the U.S. Bureau of Reclamation's ongoing public process for the "Development of Lower Colorado River Basin Shortage Guidelines and Coordinated Management Strategies for Lakes Powell and Mead Under Low Reservoir Conditions."

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Appendix L

Federal Register Notices

Three *Federal Register* notices have been issued to inform the public about the formulation of the interim operational guidelines and the preparation and availability of this Draft EIS. The full text of the *Federal Register Notices* is provided in this appendix.

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L.1 Federal Register Volume 70, Number 114

34794 Federal Register / Vol. 70, No. 114 / Wednesday, June 15, 2005 / Notices

Bureau of Land Management lands, inquiries may also be directed to Taylor Brelsford, Subsistence Coordinator, Alaska State Office, 222 West 7th Avenue, #13, Anchorage, Alaska 99513; phone (907) 271–5806.

SUPPLEMENTARY INFORMATION: Regional Council discussion during the meeting will be devoted to the review and recommendation of the East Alaska Draft Resource Management Plan and Environmental Impact Statement.

Dated: June 7, 2005.

Henri R. Bisson,

State Director.

[FR Doc. 05–11774 Filed 6–14–05; 8:45 am]

BILLING CODE 4310–JA–P

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Colorado River Reservoir Operations: Development of Management Strategies for Lake Powell and Lake Mead Under Low Reservoir Conditions

AGENCY: Bureau of Reclamation, Interior.

ACTION: Notice to solicit comments and hold public meetings on the development of management strategies for Lake Powell and Lake Mead, including Lower Basin shortage guidelines, under low reservoir conditions.

SUMMARY: The Secretary of the Interior (Secretary) has directed the Bureau of Reclamation (Reclamation) to develop additional Colorado River management strategies to address operations of Lake Powell and Lake Mead under low reservoir conditions. It is anticipated that, among other potential elements, these strategies could identify those circumstances under which the Department of the Interior (Department) would reduce annual water deliveries, and the manner in which annual operations would be modified.

DATES AND ADDRESSES: Two public meetings will be held to solicit comments on the content, format, mechanism, and analysis to be considered during the development of management strategies for Lake Powell and Lake Mead under low reservoir conditions. Oral and written comments will be accepted at the public meetings to be held at the following locations:

- *Tuesday, July 26, 2005*—10 a.m. to 12 noon, Henderson Convention Center, Grand Ballroom, 200 South Water Street, Henderson, Nevada.
- *Thursday, July 28, 2005*—10 a.m. to 12 noon, Hilton Salt Lake City Center, Topaz Room, 255 South West Temple, Salt Lake City, Utah.

Written comments on the proposed development of these strategies may be sent by close of business on *Wednesday, August 31, 2005,* to: Regional Director, Bureau of Reclamation, Lower Colorado Region, Attention: BCOO–1000, P.O. Box 61470, Boulder City, Nevada 89006–1470, fax at 702–293–8156, or e-mail at *strategies@lc.usbr.gov;* and/or Regional Director, Bureau of Reclamation, Upper Colorado Region, Attention: UC–402, 125 South State Street, Salt Lake City, Utah 84318–1147, fax at 801–524–3858, or e-mail at *strategies@uc.usbr.gov.*

FOR FURTHER INFORMATION CONTACT: Terrance J. Fulp, Ph.D., at 702–293–8500 or e-mail at *strategies@lc.usbr.gov;* and/or Randall Peterson at 801–524–3633 or e-mail at *strategies@uc.usbr.gov.* If special assistance is required regarding accommodations for attendance at either of the public meetings, please call Nan Yoder at 702–293–8495, fax at 702–293–8156, or e-mail at *nyoder@lc.usbr.gov* no less than 5 working days prior to the applicable meeting(s).

SUPPLEMENTARY INFORMATION: In recent years the Department has undertaken a number of initiatives to improve the efficient and coordinated operation and management of the Colorado River. For example, a number of Indian water rights settlements have been enacted and implemented, while additional settlements are under active negotiation. Important programs have been developed in the Upper and Lower Basins to address conservation of endangered species. Scientific investigations are proceeding under the framework of the Glen Canyon Adaptive Management Program to study the impacts to and improve the values for which the Grand Canyon National Park and the Glen Canyon National Recreation Area were established. In 2003, water users in California executed agreements that will assist California to limit its use of water from the Colorado River to its normal year apportionment of 4.4 million acre-feet (maf).

More recently a new management challenge has emerged on the Colorado River. The Colorado River Basin has experienced the worst five-year drought in recorded history. Drought in the Basin has impacted system storage, while demands for Colorado River water supplies have continued to increase. During the period from October 1, 1999, to October 1, 2004, storage in Colorado River reservoirs fell from 55.7 maf to 29.7 maf.

In the future, low reservoir conditions may not be limited to drought periods as additional development of Colorado River water occurs. The Colorado River is of strategic importance in the southwestern United States for water supply, hydropower production, recreation, fish and wildlife habitat, and other benefits. In addition, the Republic of Mexico has an allocation to the waters of the Colorado River pursuant to a 1944 treaty with the United States.

In a May 2, 2005, letter to the Governors of the Colorado River Basin States, issued in the context of the 2005 Annual Operating Plan mid-year review, the Secretary directed Reclamation to develop additional strategies to improve coordinated management of the reservoirs in the Colorado River system. Pursuant to that direction, Reclamation conducted a public consultation workshop on May 26, 2005, in Henderson, Nevada, and has prepared this **Federal Register** notice. In order to assure the continued productive use of the Colorado River into the future, Reclamation is soliciting public comments on, at a minimum, the development of management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions.

It is the Department's intent that the development of additional management strategies, including Lower Basin Shortage Guidelines, will provide guidance to the Secretary's Annual Operating Plan decisions, and provide more predictability to water users throughout the Basin, particularly those in the Lower Division States of Arizona, California, and Nevada. For example, in 2001 the Department adopted Interim Surplus Guidelines (66 FR 7772) that are used by the Secretary in making annual determinations regarding "Normal" and "Surplus" conditions for the operation of Lake Mead. Among other provisions, these Guidelines have allowed the Department and entities in Arizona, California, and Nevada that rely on the Colorado River greater predictability in identifying when Colorado River water in excess of 7.5 maf will be available for use within these three states. In contrast, at this time the Department does not have detailed guidelines in place for annual determinations of releases from Lake Mead of less than 7.5 maf to water users in the three Lower Division States (often referred to as a "shortage" condition on the lower Colorado River). Therefore, water users who rely on the Colorado River in these states are not currently able to identify particular reservoir conditions under which the Secretary would release less than 7.5 maf for use

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on an annual basis. Nor are these water users able to identify the amount of any potential future annual reductions in water deliveries. By developing additional management strategies, these users would be better able to plan for periods of less than full water deliveries. Additional operational tools may also facilitate conservation of reservoir storage, thereby minimizing the adverse effects of long-term drought or low-reservoir conditions in the Colorado River Basin.

Over the past year, the seven Colorado River Basin States have been proactively discussing strategies to address the current system-wide drought in the Colorado River Basin. In addition, Reclamation has conducted detailed briefings for stakeholders in the Colorado River Basin and other interested entities regarding future scenarios for Colorado River operations. Reclamation will integrate available technical information in the upcoming development of additional management strategies for Colorado River operations.

Reclamation intends to utilize a public process during the development of management strategies for Lake Powell and Lake Mead under low reservoir conditions. By this notice, Reclamation invites all interested members of the general public, including the seven Colorado River Basin States, Indian Tribes, water and power contractors, environmental organizations, representatives of academic and scientific communities, representatives of the recreation industry, and other organizations and agencies to present oral and written comments concerning the content, format, mechanism, and analysis to be considered during the development of these proposed strategies.

Reclamation has not yet determined the appropriate level of National Environmental Policy Act (NEPA) documentation for the upcoming development of additional management strategies. However, to ensure timely consideration of technical information and public comment, Reclamation is proceeding, at this time, as if the development of additional management strategies would require preparation of an Environmental Impact Statement. Information received by Reclamation pursuant to this **Federal Register** notice and the upcoming public meetings will be analyzed in order to define the nature of any proposed federal actions, the level of appropriate NEPA documentation, and the need, if any, for additional scoping activities. In addition to NEPA documentation, other compliance activities, as appropriate, will be undertaken pursuant to applicable Federal law.

Public Disclosure

Written comments, including names and home addresses of respondents, will be made available for public review. Individual respondents may request that their home address be withheld from public disclosure, which will be honored to the extent allowable by law. There may be circumstances in which respondents' identity may also be withheld from public disclosure, as allowable by law. If you wish to have your name and/or address withheld, you must state this prominently at the beginning of your comment. All submissions from organizations, business, and from individuals identifying themselves as representatives or officials of organizations or businesses, will be made available for public disclosure in their entirety.

Dated: June 6, 2005.

Darryl Beckmann,

Deputy Regional Director—UC Region, Bureau of Reclamation.

Dated: June 7, 2005.

Robert W. Johnson,

Regional Director—LC Region, Bureau of Reclamation.

[FR Doc. 05–11776 Filed 6–14–05; 8:45 am]

BILLING CODE 4310–MN–P

DEPARTMENT OF JUSTICE

Office of Community Oriented Policing Services, Agency Information Collection Activities: Proposed Collection; Comments Requested

ACTION: 60-day notice of information collection under review: Annual Report to Congress—Expired COPS Awards Exceeding $5 Million.

The Department of Justice (DOJ) Office of Community Oriented Policing Services (COPS) has submitted the following information collection request to the Office of Management and Budget (OMB) for review and approval in accordance with the Paperwork Reduction Act of 1995. The proposed information collection is published to obtain comments from the public and affected agencies. The purpose of this notice is to allow for 60 days for public comment until August 15, 2005. This process is conducted in accordance with 5 CFR 1320.10.

If you have comments especially on the estimated public burden or associated response time, suggestions, or need a copy of the proposed information collection instrument with instructions or additional information, please contact Rebekah Dorr, Department of Justice Office of Community Oriented Policing Services, 1100 Vermont Avenue, NW., Washington, DC 20530.

Written comments and suggestions from the public and affected agencies concerning the proposed collection of information are encouraged. Your comments should address one or more of the following four points:

—Evaluate whether the proposed collection of information is necessary for the proper performance of the functions of the agency, including whether the information will have practical utility;
—Evaluate the accuracy of the agency's estimate of the burden of the proposed collection of information, including the validity of the methodology and assumptions used;
—Enhance the quality, utility, and clarity of the information to be collected; and
—Minimize the burden of the collection of information on those who are to respond, including through the use of appropriate automated, electronic, mechanical, or other technological collection techniques or other forms of information technology, *e.g.*, permitting electronic submission of responses.

Overview of This Information Collection

(1) *Type of Information Collection:* New Collection.

(2) *Title of the Form/Collection:* Annual Report to Congress—Expired COPS Awards Exceeding $5 Million.

(3) *Agency form number, if any, and the applicable component of the Department sponsoring the collection:* Form Number: None. Office of Community Oriented Policing Services.

(4) *Affected public who will be asked or required to respond, as well as a brief abstract:* Primary: State, Local, or Tribal Government. Law enforcement agencies that are recipients of COPS grants over $5,000,000 that are programmatically and financially closed out or that otherwise ended in the immediately preceding fiscal year.

(5) *An estimate of the total number of respondents and the amount of time estimated for an average respondent to respond/reply:* It is estimated that approximately 10 respondents annually will complete the form within one hour.

(6) *An estimate of the total public burden (in hours) associated with the collection:* There are approximately 10 total annual burden hours associated with this collection.

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or faxed comments should be submitted by October 17, 2005.

John W. Roberts,
Acting Chief, National Register/National Historic Landmarks Program.

ARKANSAS

Faulkner County

Lee, Carl and Esther, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 17493 US 65S, Damascus, 05001170

Tyler—Southerland House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 36 Southerland, Conway, 05001168

Ward, Earl and Mildred, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 1157 Mitchell St., Conway, 05001169

Webb, Joe and Nina, House, (Mixed Masonry Buildings of Silas Owens, Sr. MPS) 2945 Prince, Conway, 05001171

Washington County

Prairie Grove Battlefield (Boundary Increase II), N of US 62, E of Prairie Grove, Prairie Grove, 05001167

COLORADO

Montrose County

North Rim Road, Black Canyon of the Gunnison National Park, Black Canyon of the Gunnison National Park, Crawford, 05001181

GEORGIA

Bartow County

ATCO–Goodyear Mill and Mill Village Historic District, Roughly bounded by Sugar Valley Rd., Cassville rd. and Pettit Creek, Wingfoot Trail and Litchfield St., Cartersville, 05001172

MAINE

Androscoggin County

Keystone Mineral Springs, Keystone Rd., Poland, 05001175

Cumberland County

Battery Steele, Florida Ave., Peaks Island, Portland, 05001176

Lakeside Grange #63, Main St., jct. of Main St. and Lincoln St., Harrison, 05001173

Hancock County

Garland Farm, 1029 ME 3, Bar Harbor, 05001174

MINNESOTA

Cook County

Grand Portage National Monument, Off US 61 within the area of the Grand Portage Indian Reservation, Grand Portage, 05001180

MISSOURI

Madison County

St. Louis, Iron Mountain and Southern Railroad Depot, Allen St., 150 ft. No of Jct. of Allen and Kelly Sts., Fredericktown, 05001178

MONTANA

Park County

Hepburn, John, Place, 626 E. River Rd., Emigrant, 05001177

New Mexico

Santa Fe County

Kelly, Daniel T., House, (Buildings Designed by John Gaw Meem MPS) 531 E. Palace Ave., Santa Fe, 05001182

OREGON

Multnomah County

Harrison Court Apartments, 1834 SW. 5th Ave., Portland, 05001179

[FR Doc. 05–19526 Filed 9–29–05; 8:45 am]

BILLING CODE 4312–51–P

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Colorado River Reservoir Operations: Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead Under Low Reservoir Conditions

AGENCY: Bureau of Reclamation, Interior.

ACTION: Notice of intent to prepare an environmental impact statement (EIS) and notice to solicit comments and hold public scoping meetings on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions.

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA), the Bureau of Reclamation (Reclamation) proposes to conduct public scoping meetings and prepare an EIS for the development of Lower Colorado River Basin Shortage Guidelines and Coordinated Management Strategies for Operation of Lake Powell and Lake Mead Under Low Reservoir Conditions. The Secretary of the Interior (Secretary) has directed Reclamation to develop additional Colorado River management strategies to address operations of Lake Powell and Lake Mead under low reservoir conditions.

The proposed action is to develop these guidelines and strategies. Through the NEPA process initiated by this Federal Register notice, Reclamation is considering development of: (1) Specific guidelines that will identify those circumstances under which the Department of the Interior (Department) would reduce annual water deliveries from Lake Mead to the Lower Basin States below the 7.5 million acre-feet (maf) Lower Basin apportionment and the manner in which those deliveries would be reduced, and (2) coordinated management strategies for the operation of Lake Powell and Lake Mead.

Alternatives to be analyzed in the EIS have not been developed at this time and will be developed through the NEPA process, including through the upcoming EIS scoping meetings.

DATES AND ADDRESSES: Four public meetings will be held to solicit comments on the scope of specific shortage guidelines and other coordinated management strategies and the issues and alternatives that should be analyzed. Oral and written comments will be accepted at the public meetings to be held at the following locations:

- Tuesday, November 1, 2005—6 p.m. to 8 p.m., Hilton Salt Lake City Center, Topaz Room, 255 South West Temple, Salt Lake City, Utah.
- Wednesday, November 2, 2005—6 p.m. to 8 p.m., Adam's Mark Hotel, Tower Court D, 1550 Court Place, Denver, Colorado.
- Thursday, November 3, 2005—6 p.m. to 8 p.m., Arizona Department of Water Resources, Third Floor, Conference Rooms A&B, 500 North Third Street, Phoenix, Arizona.
- Tuesday, November 8, 2005—6 p.m. to 8 p.m., Henderson Convention Center, Grand Ballroom, 200 South Water Street, Henderson, Nevada.

Written comments on the proposed development of these strategies may be sent by close of business on *Wednesday, November 30, 2005*, to: Regional Director, Bureau of Reclamation, Lower Colorado Region, Attention: BCOO–1000, PO Box 61470, Boulder City, Nevada 89006–1470, faxogram at (702) 293–8156, or e-mail at *strategies@lc.usbr.gov*; and/or Regional Director, Bureau of Reclamation, Upper Colorado Region, Attention: UC–402, 125 South State Street, Salt Lake City, Utah 84318–1147, faxogram at (801) 524–3858, or e-mail at *strategies@uc.usbr.gov*.

FOR FURTHER INFORMATION CONTACT: Terrance J. Fulp, PhD., at (702) 293–8500 or e-mail at *strategies@lc.usbr.gov*; and/or Randall Peterson at (801) 524–3633 or e-mail at *strategies@uc.usbr.gov*. If special assistance is required regarding accommodations for attendance at any of the public meetings, please call Nan Yoder at (702) 293–8495, faxogram at (702) 293–8156, or e-mail at *nyoder@lc.usbr.gov* no less than 5 working days prior to the applicable meeting(s).

SUPPLEMENTARY INFORMATION: In recent years the Colorado River Basin experienced the worst five-year drought

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in recorded history. Drought in the Basin has impacted system storage, while demands for Colorado River water supplies have continued to increase. In the future, low reservoir conditions may not be limited to drought periods as additional development of Colorado River water occurs. The Colorado River is of strategic importance in the southwestern United States for water supply, hydropower production, recreation, fish and wildlife habitat, and other benefits. In addition, the Republic of Mexico has an allocation to the waters of the Colorado River pursuant to a 1944 treaty with the United States.

In 2001, the Department adopted Interim Surplus Guidelines (66 FR 7772) that are used by the Secretary in making annual determinations regarding "Normal" and "Surplus" conditions for the operation of Lake Mead. Since adoption, these Guidelines have, among other operational and management benefits, allowed the Department and entities in Arizona, California, and Nevada that rely on the Colorado River greater predictability in identifying when Colorado River water in excess of 7.5 maf will be available for use within these three States. In contrast, at this time the Department does not have detailed guidelines in place for annual determinations of releases from Lake Mead of less than 7.5 maf to water users in the three Lower Division States of Arizona, California, and Nevada (often referred to as a "shortage" condition on the lower Colorado River). Therefore, water users who rely on the Colorado River in these States are not currently able to identify particular reservoir conditions under which the Secretary would release less than 7.5 maf for use on an annual basis. Nor are these water users able to identify the amount of any potential future annual reductions in water deliveries.

Over the past year, the seven Colorado River Basin States have been proactively discussing strategies to address the recent period of system-wide drought in the Colorado River Basin. In addition, Reclamation has conducted detailed briefings for stakeholders in the Colorado River Basin and other interested entities regarding future scenarios for Colorado River operations.

Currently, each year, the Secretary establishes an Annual Operating Plan (AOP) for the Colorado River Reservoirs. The AOP describes how Reclamation will manage the reservoirs over a 12-month period, consistent with the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968 (Long-Range Operating Criteria), the Decree entered by the U.S. Supreme Court in the *Arizona* v. *California* litigation, and other provisions of applicable Federal law. Reclamation consults annually with the Colorado River Basin States, Indian tribes, and other interested parties in the development of the AOP. Further, as part of the AOP process, the Secretary makes annual determinations under the Long-Range Operating Criteria regarding the availability of Colorado River water for deliveries to the Lower Division States. To meet the consultation requirements of Federal law, Reclamation also consults with the Colorado River Basin States, Indian tribes, and other interested parties during the five-year periodic reviews of the Long-Range Operating Criteria.

During the mid-year review of the 2005 AOP conducted this past spring, the Department received conflicting recommendations from the Colorado River Basin States regarding operations of Glen Canyon Dam for the remainder of the 2005 water year. In a May 2, 2005, letter to the Governors of the Colorado River Basin States, issued to complete the 2005 AOP mid-year review, the Secretary directed Reclamation to develop additional strategies to improve coordinated management of the reservoirs in the Colorado River system. Pursuant to that direction, Reclamation conducted a public consultation workshop on May 26, 2005, in Henderson, Nevada; issued a **Federal Register** notice soliciting public comments on June 15, 2005; and conducted public meetings on July 26 and July 28, 2005, in Henderson, Nevada, and Salt Lake City, Utah, respectively. Reclamation received a broad range of public comments and suggestions from these discussions, not all of which can be addressed in this proposed process. In addition, some suggestions may be part of ongoing or future efforts.

In order to assure the continued productive management and use of the Colorado River into the future, Reclamation is now soliciting public comments on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead under low reservoir conditions. Reclamation will utilize a public process pursuant to NEPA. By this notice, Reclamation provides notice of its intent to prepare an EIS on this action, and provides notice of its upcoming EIS scoping meetings. Reclamation invites all interested members of the general public, including the seven Colorado River Basin States, Indian tribes, water and power contractors, environmental organizations, representatives of academic and scientific communities, representatives of the recreation industry, and other organizations and agencies to present oral and written comments concerning the format and scope of specific shortage guidelines and coordinated management strategies, and the issues and alternatives to be considered during the development of these proposed guidelines and strategies. Reclamation anticipates publishing a "scoping report" after completion of the public scoping meetings identified in this **Federal Register** notice.

All comments received will be considered as Reclamation develops formal alternatives under NEPA. Similar to the surplus guidelines referenced above, it is likely that these shortage guidelines will be interim in nature. It is the Department's intent that these guidelines and coordinated management strategies will provide guidance to the Secretary's AOP decisions, and provide more predictability to water users and the public throughout the Colorado River Basin, particularly those in the Lower Division States. The Department does not intend to evaluate the decommissioning of Glen Canyon Dam.

Public Disclosure

Written comments, including names and home addresses of respondents, will be made available for public review. Individual respondents may request that their home address be withheld from public disclosure, which will be honored to the extent allowable by law. There may be circumstances in which respondents' identity may also be withheld from public disclosure, as allowable by law. If you wish to have your name and/or address withheld, you must state this prominently at the beginning of your comment. All submissions from organizations, business, and from individuals identifying themselves as representatives or officials of organizations or businesses, will be made available for public disclosure in their entirety.

Dated: September 22, 2005.

Rick L. Gold,

Regional Director—UC Region, Bureau of Reclamation.

Dated: September 22, 2005.

Jayne Harkins,

Deputy Regional Director—LC Region, Bureau of Reclamation.

[FR Doc. 05–19607 Filed 9–29–05; 8:45 am]

BILLING CODE 4310–MN–P

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respondents will be available for public review at the Ely Field Office during regular business hours 7:30 a.m. to 4:30 p.m., Monday through Friday, except holidays. Individual respondents may request confidentiality. If you wish to withhold your name and address from public review or disclosure under the Freedom of Information Act, you must state this prominently at the beginning of your comments. Such requests will be honored to the extent allowed by law. All submissions from organizations or businesses, and from individuals identifying themselves as representatives or officials of organizations or business, will be made available for public inspection in their entirety.

FOR FURTHER INFORMATION CONTACT: Penny Woods, BLM Nevada State Office, (775) 861–6466. You may also contact Ms Woods to have your name added to the EIS mailing list.

SUPPLEMENTARY INFORMATION: The LCLA Groundwater Development Project is being proposed by the Lincoln County Water District (LCWD) and would be located in southeastern Lincoln County. The proposed project would develop and convey groundwater in the Tule Desert and Clover Valley hydrographic basins to land recently sold by the BLM that is approximately 2 miles north of Mesquite, Nevada. This private land comprises the LCLA development area and consists of approximately 13,000 acres. The volume of water to be transported through the proposed facilities would be approximately 23,824 acre-feet per year. The water would be used to support development in the LCLA development area.

The proposed facilities include approximately 8 groundwater production wells (16 inch diameter) located in the Tule Desert and Clover Valley hydrographic basins, a 23-mile long water transmission pipeline (24 inch diameter), and lateral pipelines (12 inch diameter) to connect the transmission pipeline to the productions wells. The proposed width of the right-of-way for the transmission pipeline would be 30 feet with a temporary width of 60 feet during construction. The proposed width of the right-of-way for the lateral pipelines would be 20 feet with a temporary width of 60 feet during construction. The productions well site rights-of-way would be 100 feet × 100 feet with a temporary construction area of 100 feet × 200 feet. Access roads approximately 12 feet in width would be needed from existing roads in the Tule Desert area to each well site.

The proposed production wells would be located in the well field area authorized for the Toquop Energy Project, which is a 1100 MW gas-fired power plant. The proposed transmission pipeline would follow the same alignment as the approved water pipeline for the power plant. From the power plant, the transmission pipeline would proceed to the LCLA development area.

Electric lines, communication lines, and a natural gas pipeline would be located within the proposed transmission pipeline right-of-way. A pipeline bringing reclaimed water from the LCLA development area to the already authorized Toquop Energy Project site would also be in the proposed right-of-way.

The facilities would be located within and/or across the following public lands north of Mesquite, Nevada:

Mount Diablo Meridian

Tps. 6 to 12 S., Rgs. 69 and 71 E., various sections.

A map of the proposed project is available for viewing at the Bureau of Land Management, Ely Field Office, 702 North Industrial Way, Ely NV 89301.

Dated: March 21, 2006.

Amy Lueders,

Associate State Director, Nevada.

[FR Doc. 06–2932 Filed 3–30–06; 8:45 am]

BILLING CODE 4310–HC–P

DEPARTMENT OF THE INTERIOR

National Park Service

Notice of Proposed National Natural Landmark Designation for the Irvine Ranch Land Reserve, CA

AGENCY: National Park Service, Interior.

ACTION: Notice of proposed National Natural Landmark designation.

SUMMARY: The National Park Service has evaluated and determined that the Irvine Ranch Land Reserve, located forty-five miles south of downtown Los Angeles, in Orange County, California appears to meet the criteria for national significance and proposes to recommend the site for designation as a National Natural Landmark. The public is invited to comment on this recommendation. The proposal will be considered by the National Park System Advisory Board at a meeting to be held on June 8, 2006 at Zion National Park, in the Majestic View Lodge, 2400 Zion Park Blvd., Springdale, Utah.

DATES: Written comments will be accepted until May 30, 2006.

ADDRESSES: Written comments should be sent to Steve Gibbons, National Natural Landmarks Coordinator, North Cascades National Park, 810 State Route 20, Sedro Woolley, Washington 98284, or to his Internet address: *Steve_Gibbons@nps.gov.*

FOR FURTHER INFORMATION CONTACT: Steve Gibbons at 360–856–5700, extension 306.

SUPPLEMENTARY INFORMATION: The Irvine Ranch Land Reserve represents significant biological resources of Mediterranean shrublands, including extensive areas of chaparral and coastal sage scrub associations. These chaparral and coastal sage scrub areas present one of the largest extant areas of this association remaining in the South Pacific Border Province. It is the presence of these large and relative undisturbed ecosystems and their inherent biological diversity that provide the uniqueness of this area. In commensurate with its biological significance the Irvine Ranch Land Reserve geologically represents a remarkably unique, long time-range stratigraphic succession that shows the linkage between tectonic framework, provenances, sedimentology, paleoenvironments, paleontology, paleoclimate, landscape evolution and geologic history. In this regard it is not only outstanding, but represents one of the most critical time intervals and locations in the evolution of the South Pacific Border Province.

Information on the National Natural Landmarks Program can be found in 36 CFR Part 62 or on the Internet at *http://www.nature.nps.gov/nnl.*

Dated: March 28, 2006.

Fran Mainella,

Director, National Park Service.

[FR Doc. 06–3161 Filed 3–30–06; 8:45 am]

BILLING CODE 4312–HJ–P

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Colorado River Reservoir Operations: Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead, Particularly Under Low Reservoir Conditions

AGENCY: Bureau of Reclamation, Interior.

ACTION: Notice of public availability of a Scoping Summary Report on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake

Powell and Lake Mead, particularly under low reservoir conditions.

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, and the Council on Environmental Quality's Regulations for Implementing the Procedural Provisions of NEPA, the Department of the Interior (Department) has issued a Scoping Summary Report on the development of Lower Basin shortage guidelines and coordinated management strategies for the operation of Lake Powell and Lake Mead, particularly under low reservoir conditions. The Scoping Summary Report provides a summary of the issues raised during the scoping process and describes the Department's current assessment of the proposed scope of the environmental analysis to be included in the draft environmental impact statement (EIS). The Department anticipates that the Draft EIS will be published in December 2006. The report also includes a summary of the issues raised and comments received during the scoping process. Among other things, the report identifies how the Department anticipates addressing these issues.

Dates and Addresses: The Department will accept, review, and incorporate, as appropriate, any additional public comments on the information contained in the Scoping Summary Report as part of the development of the Draft EIS, which the Department anticipates will be published in December 2006. The Department would prefer that any such comments be received by May 1, 2006, in order to allow full consideration during the development of the Draft EIS. Send written comments to: Regional Director, Bureau of Reclamation, Lower Colorado Region, Attention: BCOO–1000, P.O. Box 61470, Boulder City, Nevada 89006–1470; faxogram at (702) 293–8156; or e-mail at *strategies@lc.usbr.gov.*

The Scoping Summary Report is available on the Bureau of Reclamation's Web site at *http://www.usbr.gov/lc/region/g4000/strategies/index.html.* If you would like a printed copy of the report, please contact Nan Yoder at telephone (702) 293–8500; facsimile (702) 293–8156; e-mail: *strategies@lc.usbr.gov.*

FOR FURTHER INFORMATION CONTACT: Terrance J. Fulp, Ph.D., at (702) 293–8500 or e-mail at *strategies@lc.usbr.gov;* and/or Randall Peterson at (801) 524–3633 or e-mail at *strategies@lc.usbr.gov.*

SUPPLEMENTARY INFORMATION: The Department is publishing the Scoping Summary Report as a voluntary effort to assist in public understanding of this important process. Based upon information presented in the report and all information submitted to the Department as part of this process, the Department is now undertaking preparation of a Draft EIS.

Proposed Federal Action

The Bureau of Reclamation, acting on behalf of the Secretary of the Interior (Secretary), proposes to take action to adopt specific Colorado River Lower Basin shortage guidelines and coordinated reservoir management strategies to address operations of Lake Powell and Lake Mead, particularly under low reservoir conditions. This action will provide a greater degree of certainty to all water users and managers in the Colorado River Basin by providing more detailed objective guidelines for the operation of Lake Powell and Lake Mead and by allowing water users in the Lower Basin to know when, and by how much, water deliveries will be reduced in drought and other low reservoir conditions. In addition, this action is designed to delay the onset and magnitude of shortages and maximize the protection afforded to water supply, hydropower production, recreation, and environmental benefits by water storage in Lakes Powell and Mead. As a result of analysis of comments and public input received to date, the Department anticipates that the elements of the proposed action will include:

(1) Adoption of guidelines that will identify those circumstances under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead to the Lower Division states (Arizona, California, and Nevada) below 7.5 million acre-feet (maf) (a "Shortage") pursuant to Article II(B)(3) of the Supreme Court Decree in *Arizona* v. *California*; [1]

(2) adoption of guidelines for the coordinated operation of Lake Powell and Lake Mead that are designed to provide improved operation of the two reservoirs, particularly under low reservoir conditions;

(3) adoption of guidelines for the storage and delivery of water in Lake Mead to increase the flexibility to meet water use needs from Lake Mead, particularly under low reservoir conditions. These guidelines are anticipated to address the storage and delivery of non-system water, exchanges, and water conserved by extraordinary measures; and

(4) modification of the substance and term of the existing Interim Surplus Guidelines, published in the **Federal Register** on January 25, 2001 (66 FR 7772–7782), from 2016 to coincide with the proposed new guidelines described above.

The Secretary proposes that these guidelines will be interim in nature and will extend through 2025. Adoption of new guidelines along with modification of existing operational guidelines for a consistent interim period will provide the opportunity to gain valuable experience for operating the reservoirs under the modified operations and should improve the basis for making additional future operational decisions, whether during the interim period or thereafter.

It is the intent of the Department to adopt and implement the above proposed action in a manner that is consistent with applicable Federal law,[2] and further, in a manner that does not require any additional statutory authorization. In this regard, Reclamation proposes to implement the proposed action consistent with the Colorado River Compact of 1922, the Decree entered by the United States Supreme Court in the case of *Arizona* v. *California,* and other provisions of applicable Federal law. It is the intent of the Department that the proposed action will be consistent with and provide implementing guidance that would be used each year by the Department in implementing the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968 (Long-Range Operating Criteria or LROC).

Purpose and Need for the Proposed Federal Action

The purpose of the proposed action is to adopt additional operational strategies to improve the Department's annual management and operation of key Colorado River reservoirs while also providing mainstream users of Colorado River water, particularly those in the Lower Division states of Arizona, California, and Nevada, a greater degree

[1] The Department intends to meet any consultation requirements identified in Article II(B)(3) of the Supreme Court Decree in *Arizona* v. *California* through the ongoing NEPA process initiated by the **Federal Register** Notice of September 30, 2005 (70 FR 57322–57323).

[2] The treaties, compacts, decrees, statutes, regulations, contracts, and other legal documents and agreements applicable to the allocation, appropriation, development, exportation, and management of the waters of the Colorado River Basin are often referred to as the "Law of the River." There is no single, universally-agreed upon definition of the "Law of the River," but it is useful as a shorthand reference to describe this longstanding and complex body of legal agreements governing the Colorado River.

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of predictability with respect to the amount of annual water deliveries in future years, particularly under low reservoir conditions.

The need for the proposed action is based on a number of important considerations including the following reasons:

- The Colorado River flows through the driest portion of the continental United States and is the primary source of water to a region that has experienced continued population growth over recent decades.
- The Colorado River is of strategic importance in the southwestern United States for water supply, hydropower production, flood control, recreation, fish and wildlife habitat, and other benefits. In addition, the United States has a delivery obligation to the Republic of Mexico for certain waters of the Colorado River pursuant to the 1944 U.S.-Mexico Water Treaty.
- The Colorado River Basin experienced the worst five-year drought in recorded history in 2000 through 2004. This drought has impacted system storage, while demands for Colorado River water supplies have continued to increase. During the period from October 1, 1999, to October 1, 2004, storage in Lakes Powell and Mead fell from 47.6 maf (approximately 95% of capacity) to 23.1 maf (approximately 46% of capacity). This drought was also the worst sustained drought experienced in the Colorado River Basin at a time when all major storage facilities were in place, and when use by the Lower Division states met or exceeded the annual ''normal'' apportionment of 7.5 maf pursuant to Article II(B)(1) of the Decree. Moreover, entering the five year drought period with Lake Powell and Lake Mead reservoir storage capacity at 95% fortuitously provided for sufficient water supplies to meet basin demands. This may not be the case in the future. Among other factors, these conditions led the Department to conclude that additional management guidelines are necessary and desirable for the efficient, and coordinated, management of the major mainstem Colorado River reservoirs.
- In the future, low reservoir conditions will likely not be limited to drought periods because of anticipated future demands on Colorado River water supplies. Projected future increases in Colorado River water demands are expected to increase the frequency and magnitude that Colorado River reservoirs are drawn down to low reservoir conditions.
- As a result of actual operating experience and through reviews of the LROC and preparation of Annual Operating Plans, particularly during recent drought years, the Secretary has determined a need for more specific guidelines, consistent with the Decree and other applicable provisions of Federal law, to assist in the Secretary's determination of annual water supply conditions in the Lower Basin. The increased level of predictability is needed by the entities that receive Colorado River water to better plan for and manage available water supplies, and to allow such entities to better integrate the use of Colorado River water with other water supplies that they rely on. To date, storage of water and flows in the Colorado River Basin have been sufficient so that it has not been necessary to reduce Lake Mead annual releases below 7.5 maf; nor has the Department yet identified when water supplies would be reduced, by how much, or who would experience specified reductions.
- After public consultation meetings held in the summer of 2005, the Secretary has also determined the desirability of developing additional operational guidelines that will provide for releases greater than or less than 8.23 maf from Lake Powell.
- To further enhance this coordinated reservoir approach, the Secretary has also determined a need for guidelines that provide water users with the opportunity to conserve, store, and take delivery of water in and from Lake Mead for the purposes of enhancing existing water supplies, particularly under low reservoir conditions.
- Lastly, the Secretary has determined the need to modify and extend the Interim Surplus Guidelines to coincide with the duration of the proposed new guidelines. This will provide an integrated approach for reservoir management and more predictability for future Colorado River Basin water supplies.

Results of Scoping Input

The description of the Proposed Federal Action and the Purpose and Need for the Proposed Federal Action described in this Notice and in the Scoping Summary Report available at Reclamation's Web site noted above, was refined to reflect information and comments received during the scoping meetings and in written and oral scoping comments submitted to the Department.[3] The Proposed Federal Action has been crafted to reflect, among others, three important considerations that were identified by commentors:

(1) *Importance of Encouraging Conservation of Water:* Many comments submitted to the Department focused on the importance of encouraging and utilizing water conservation as an important tool to better manage limited water supplies and therefore minimize the likelihood and severity of potential future shortages. *See e.g.*, comment G–0003, ''Conservation Before Shortage'' proposal submitted to the Department on July 18, 2005, which is available in its entirety in Appendix W of the Scoping Summary Report. Water conservation can occur through a number of approaches that will be identified in the Draft EIS, including: Extraordinary conservation, forbearance, financial incentives to maximize conservation, dry-year options, and associated storage and recovery methodologies and procedures to address conservation actions by particular parties.

(2) *Importance of Consideration of Reservoir Operations at all Operational Levels:* Comments submitted to the Department urged the Department to consider and analyze management and operational guidelines for the full range of operational levels at Lake Powell and Lake Mead. *See e.g.*, comment S–2006, ''Basin States' Preliminary Proposal Regarding Colorado River Interim Operations'' submitted to the Department on February 3, 2006, which is available in its entirety in Appendix Q of the Scoping Summary Report. It was suggested that this approach is integral to the prudent development of new low-reservoir operational guidelines, as the approach and management of these reservoirs at higher elevations has a direct impact on available storage, thereby affecting the likelihood and severity of potential future shortages.

(3) *Term of Operational Guidelines:* Comments submitted to the Department urged the Department to consider interim, rather than permanent, additional operational guidelines. *See e.g.*, comment letters L–2002 through 2006 submitted to the Department by several Arizona municipalities which are available in their entirety in Appendix W of the Scoping Summary Report. In this manner, the Department would have the ability to use actual operating experience for a period of years, thereby facilitating a better understanding of the operational effects of the new guidelines; modifications would then be made, if necessary, during or preferably at the end of the interim period. In particular, the

[3] The Scoping Summary Report also addresses in Section 5.0 those issues raised during scoping that have been determined to be beyond the proposed scope of the EIS.

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Department was also urged to consider adopting additional operational guidelines for both low and higher reservoir elevations for a consistent period of years. At this time, it is important to note, the Department has detailed operational guidelines for declaration of surplus conditions at higher elevations of Lake Mead through 2016, but does not have similar detailed operational guidelines for either Lake Powell or the lower operational levels of Lake Mead.

Public Disclosure

Written comments, including names and home addresses of respondents, will be made available for public review. Individual respondents may request that their home address be withheld from public disclosure, which will be honored to the extent allowable by law. There may be circumstances in which respondents' identity may also be withheld from public disclosure, as allowable by law. If you wish to have your name and/or address withheld, you must state this prominently at the beginning of your comment. All submissions from organizations, business, and from individuals identifying themselves as representatives or officials of organizations or businesses, will be made available for public disclosure in their entirety.

Dated: March 18, 2006.

Robert W. Johnson,

Regional Director, Lower Colorado Region, Bureau of Reclamation.

Dated: March 16, 2006.

Rick L. Gold,

Regional Director, Upper Colorado Region, Bureau of Reclamation.

[FR Doc. E6–4713 Filed 3–30–06; 8:45 am]

BILLING CODE 4310–MN–P

DEPARTMENT OF THE INTERIOR

Office of Surface Mining Reclamation and Enforcement

Notice of Proposed Information Collection for 1029–0025, 1029–0040 and 1029–0104

AGENCY: Office of Surface Mining Reclamation and Enforcement.

ACTION: Notice and request for comments.

SUMMARY: In compliance with the Paperwork Reduction Act of 1995, the Office of Surface Mining Reclamation and Enforcement (OSM) is announcing its intention to request renewed approval for the collections of information for 30 CFR 733, Maintenance of state programs and procedures for substituting federal enforcement of state programs and withdrawing approval of state programs; 785, Requirements for permits for special categories of mining; and 876, Acid mine drainage treatment and abatement program.

DATES: Comments on the proposed information collection activities must be received by May 30, 2006, to be assured of consideration.

ADDRESSES: Comments may be mailed to John A. Trelease, Office of Surface Mining Reclamation and Enforcement, 1951 Constitution Ave., NW., Room 202—SIB, Washington, DC 20240. Comments may also be submitted electronically to *jtreleas@osmre.gov.*

FOR FURTHER INFORMATION CONTACT: To request a copy of the information collection request, explanatory information and related forms, contact John A. Trelease, at (202) 208–2783 or via e-mail at the address listed above.

SUPPLEMENTARY INFORMATION: The Office of Management and Budget (OMB) regulations at 5 CFR 1320, which implement provisions of the Paperwork Reduction Act of 1995 (Pub. L. 104–13), require that interested members of the public and affected agencies have an opportunity to comment on information collection and recordkeeping activities [see 5 CFR 1320.8(d)]. This notice identifies information collections that OSM will be submitting to OMB for approval. These collections are contained in (1) 30 CFR 733, Maintenance of state programs and procedures for substituting federal enforcement of state programs and withdrawing approval of state programs; (2) 30 CFR 785, Requirements for permits for special categories of mining; and (3) 30 CFR 876, Acid mine drainage treatment and abatement program. OSM will request a 3-year term of approval for each information collection activity.

Comments are invited on: (1) The need for the collection of information for the performance of the functions of the agency; (2) the accuracy of the agency's burden estimates; (3) ways to enhance the quality, utility and clarity of the information collection; and (4) ways to minimize the information collection burden on respondents, such as use of automated means of collection of the information. A summary of the public comments will accompany OSM's submission of the information collection request to OMB.

The following information is provided for the information collection: (1) Title of the information collection; (2) OMB control number; (3) summary of the information collection activity; and (4) frequency of collection, description of the respondents, estimated total annual responses, and the total annual reporting and recordkeeping burden for the collection of information.

Title: Maintenance of state programs and procedures for substituting federal enforcement of state programs and withdrawing approval of state programs, 30 CFR 733.

OMB Control Number: 1029–0025.

Summary: This part provides that any interested person may request the Director of OSM to evaluate a State program by setting forth in the request a concise statement of facts that the person believes establishes the need for the evaluation.

Bureau Form Number: None.

Frequency of Collection: Once.

Description of Respondents: Any interested person (individuals, businesses, institutions, organizations).

Total Annual Responses: 1.

Total Annual Burden Hours: 100.

Title: Requirements for permits for special categories of mining, 30 CFR 785.

OMB Control Number: 1029–0040.

Summary: The information is being collected to meet the requirements of section 507, 508, 510, 515, 701 and 711 of Public Law 95–87, which requires applicants for special types of mining activities to provide descriptions, maps, plans and data of the proposed activity. This information will be used by the regulatory authority in determining if the applicant can meet the applicable performance standards for the special type of mining activity.

Bureau Form Number: None.

Frequency of Collection: Once.

Description of Respondents: Applicants for coalmine permits and State Regulatory Authorities.

Total Annual Responses: 228.

Total Annual Burden Hours: 16,146.

Title: Acid mine drainage treatment and abatement program, 30 CFR 876.

OMB Control Number: 1029–0104.

Summary: This part establishes the requirements and procedures allowing states and Indian tribes to establish acid mine drainage abatement and treatment programs under the Abandoned Mine Land fund as directed through Public Law 101–508.

Bureau Form Number: None.

Frequency of Collection: Once.

Description of Respondents: State governments and Indian tribes.

Total Annual Responses: 1.

Total Annual Burden Hours: 350.

Dated: March 27, 2006.

Kathryn S. O'Toole,

Acting Chief, Division of Regulatory Support.

[FR Doc. 06–3130 Filed 3–30–06; 8:45 am]

BILLING CODE 4310–05–M

Appendix M

Modeling Assumptions: Lake Mead Storage and Delivery of Conserved System and Non-system Water

Three of the action alternatives assume some form of a Lake Mead storage and delivery mechanism for conserved system and non-system water (the Basin States, Conservation Before Shortage and Reservoir Storage alternatives). This appendix describes the modeling assumptions used in the CRSS regarding the activities assumed to generate storage credits and the conditions under which the storage credits are assumed to be generated and delivered.

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M.1 Introduction

At this time, it is unknown which entities might participate in a Lake Mead mechanism that allows the storage and delivery of conserved system and non-system water. Furthermore, the timing and magnitude of the storage and delivery of conserved water is unknown. However, modeling assumptions with respect to the entities that might participate and their respective level of participation were needed to enable the evaluation of the mechanism and its potential effects on environmental resources, particularly to reservoir storage and river flows below Lake Mead.

The proposed federal action is for the purpose of adopting additional operational strategies to improve the Department's annual management and operation of key Colorado River reservoirs. However, in order to assess the potential effects of the proposed federal action in this Draft EIS, certain modeling assumptions are used that display projected water deliveries to Mexico. Reclamation's modeling assumptions are not intended to constitute an interpretation or application of the 1944 Treaty or to represent current or future United States policy regarding deliveries to Mexico. The United States will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Treaty with Mexico through the IBWC in consultation with the Department of State. [1]

For two of the action alternatives (the Conservation Before Shortage Alternative and the Reservoir Storage Alternative), it was assumed that storage credits would be generated and used for environmental purposes. These modeling assumptions were utilized in this Draft EIS in order to analyze the potential impacts to environmental resources of the storage and delivery mechanism, particularly with regard to reservoir elevations and river flow impacts. The use of these modeling assumptions does not represent any determination by Reclamation as to whether, or how, these releases could be made under current administration of the river.

M.2 General Modeling Assumptions

Three alternatives assume some form of a Lake Mead storage and delivery mechanism for conserved system and non-system water (the Basin States, Conservation Before Shortage and Reservoir Storage alternatives). This section explains the general modeling assumptions

[1] Notwithstanding the lack of an existing mechanism to implement such modeling assumptions, Reclamation utilized these assumptions for a number of reasons, including the following: (1) a larger volume of potential storage in Lake Mead is identified, (2) the maximum potential impacts on river flows below Hoover Dam are identified, (3) the alternative proponent's recommendations as to participating entities and levels of participation are modeled, (4) the arbitrary assignment of water conservation amounts to entities in the Lower Basin states is avoided, and (5) a program of potential future cooperation between the United States and Mexico is identified.

regarding how storage credits are generated and delivered within the CRSS model. Examples of the accounting of storage credits within the model are also presented below.

M.2.1 Generation of Storage Credits

When storage credits are created, the model assumes either a delivery from Lake Mead is decreased or a new gain to the system is introduced, resulting in an increase to Lake Mead storage. If the reduced delivery is located downstream of Lake Mead, creation of the storage credit results in a reduction in the release from Lake Mead and river flow downstream.

At the beginning of each year, the model assumes that storage credits will be generated based on annual schedules and that the scheduled amount does not change throughout the year. The ability to store conservation credits in Lake Mead is assumed to be in effect from 2008 through 2026 (i.e., conserved water is assumed to not be stored in Lake Mead after 2026).

The activity resulting in the creation of credits is assumed to originate from a point on the river located furthest downstream in order to evaluate the maximum effects of the storage and delivery mechanism on river flows. In general, water conserved for use by a particular state is assumed to be generated by an entity within that state that had an annual depletion schedule sufficiently large enough to accommodate the reductions. In the case of the Conservation Before Shortage and Reservoir Storage alternatives, which assume storage and delivery activities for Mexico and the federal government, these activities were assumed to occur within Mexico because this is the last major user in the lower part of the river and again, this permitted evaluation of the potential effects on river flow reductions.

A one-time system assessment is assumed to be dedicated to the system upon the creation of a storage credit (i.e., when water is placed in storage). The system assessment is assumed to be five percent of the volume of water stored for the Basin States and Conservation Before Shortage alternatives. For the Reservoir Storage Alternative, the system assessment is assumed to be ten percent of the volume of water stored. For example, if an entity wishes to receive credit for 100 kaf, then the credits that must be generated become: 100 kaf / (1 – system assessment).

The model assumes that the accounting of storage credits occurs annually, at the end of the year. Storage credits in Lake Mead are assumed to be subject to the following rules:

- An annual 3 percent deduction for evaporation. The deduction occurs at the end of the year and is based on the available credits at the beginning of the year.
- No evaporation deductions occur during Shortage conditions.
- In the event of a flood control release, all storage credits are eliminated and stored water reverts to the system.
- The total volume of storage credits in Lake Mead at any given time is not included in the determination of a Quantified Surplus using the 70R Strategy.

- The amount of storage credits that may be generated in a single year is constrained by assumed maximum annual and maximum total limits. These assumed limits vary by alternative and are presented in Section M.3.

M.2.2 Delivery of Storage Credits

When storage credits are delivered from Lake Mead, the model assumed that a delivery from Lake Mead was increased for that year, resulting in a decrease in Lake Mead storage. If the increased delivery is located downstream of Lake Mead, delivery of the storage credit results in an increase in the release from Lake Mead and river flow downstream.

At the beginning of each year, the model assumes that storage credits will be delivered based on annual schedules and that the scheduled delivery amount does not change throughout the year. Although the ability to store conservation credits in Lake Mead is assumed to be in effect from 2008 through 2026 (i.e., conserved water may not be stored in Lake Mead after 2026), a 10-year period (from 2027 through 2036) was assumed for entities to take any storage credits remaining after the end of the interim period.

After 2026, some conservation activities assumed to be undertaken by Nevada are assumed to continue through 2060 (tributary conservation, groundwater return flows, and desalinization described further in Section M.3.1). The model assumes delivery of that water to Nevada in the year that the conservation occurs.

M.2.3 Examples of Storage Credit Accounting

Table M-1 provides an example of storage credit accounting in CRSS. A “put” refers to the creation of credits. A “take” is the delivery of credits. Although most calculations in CRSS occur on a monthly basis, the model calculates available storage credits annually, at the end of the year. At the end of year n, the balance of storage credits is determined as,

$$Balance_n = Balance_{n-1} + Put(1 - Assessment\%) - Take - Evap\%(Balance_{n-1})$$

Table M-1
Example of Storage Credit Accounting (af)

Year	Put	Assessment[1]	Put Adjusted for Assessment	Requested Take	Actual Take	Evaporation	Balance
1	0	0	0	0	0	0	0
2	200,000	10,000	190,000	0	0	0	190,000
3	100,000	5,000	95,000	50,000	50,000	5,700	229,300
4	0	0	0	200,000	200,000	6,879	22,421
5	0	0	0	50,000	21,748	673	0

1 Assuming a system assessment of five percent.

Year 1: The storage credit balance is zero and there is no activity for this year.

Year 2: A put of 200 kaf is scheduled for this year. There is a 200 kaf reduction in delivery for this year. Assuming a system assessment of 5 percent, 190 kaf of storage credits are generated for this year and 10 kaf (five percent of 200 kaf) is credited to the system. There are no takes scheduled. Evaporation is counted as 3 percent of the previous year's balance. Because the balance in Year 1 is 0, there is no evaporation loss deducted in Year 2.

Year 3: Applying the scheduled put and take values to the equation above a balance of 229,300 is created.

$$229{,}300 = 190{,}000 + 100{,}000(1 - 0.05) - 50{,}000 - 0.03(190{,}000)$$

Year 4: Applying the scheduled put and take values to the equation above a balance of 22,421 is created.

$$22{,}421 = 229{,}300 + 0(1 - 0.05) - 200{,}000 - 0.03(229{,}300)$$

Year 5: The requested take is higher than the available storage credits. Therefore the actual take is constrained by the available credits to be 21,748 af.

M.3 Modeling Assumptions Specific to Alternatives

Modeling assumptions with respect to the entities that might participate and their respective level of participation were needed to enable the evaluation of the potential effects of the mechanism for each alternative. These assumptions include the maximum amount of storage credits that may be created during any year, the maximum amount of storage credits that may be recovered during any year, and the maximum total amount of storage credits that may be available at any one time. In addition, assumptions with regard to the timing and magnitude of the storage and delivery of conserved water are needed. The assumptions made for each alternative are detailed in the following sections.

M.3.1 Basin States Alternative

As discussed in Section 2.3, the Basin States Alternative assumes the levels of participation as shown in Table M-2.

Table M-2
Basin States Alternative Volume Limitations of Storage and Delivery Mechanism

Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Total	625	2,100	1,000

These volume limitations are recognized in CRSS as are other rules that specify under which water supply conditions conserved system or non-system water may be delivered or stored as summarized in Section M.3.4. The schedules for Arizona, California and Nevada were provided by the Arizona Department of Water Resources (ADWR), the Metropolitan Water District of Southern California (MWD) and the Southern Nevada Water Authority (SNWA), respectively, and are detailed below.

M.3.1.1 Arizona

In order to analyze the maximum effects on river flows, the model assumes that Arizona storage credits are generated through extraordinary conservation by the Yuma County Water Users Association and are delivered to CAP. According to the storage and delivery schedules provided by ADWR, the generation of storage credits begins in 2017, as shown in Table M-3. It was assumed that credits are stored and delivered only during Normal conditions.

M.3.1.2 California

In order to analyze the maximum effects on river flows, the model assumes that California storage credits are generated through extraordinary conservation by the Imperial Irrigation District and are delivered to MWD. Schedules for the generation and delivery of storage credits were provided by MWD. Ninety-nine (99) schedules were provided, corresponding to the 99 hydrologic traces used in the ISM simulations (Section 4.2). As an example, one of these schedules is presented in Table M-3. In 2008 California is assumed to begin with a storage credit balance of 100 kaf due to pilot programs in place in 2006 and 2007. It was assumed that credits are stored and delivered only during Normal conditions.

M.3.1.3 Nevada

As provided by SNWA, four different conservation activities are assumed to be undertaken by Nevada to generate storage credits. Each activity is subject to different assumptions as to when storage credits may be generated and used as described below. The schedules provided by SNWA are shown in Table M-3.

Tributary Conservation. It was assumed that water from extraordinary conservation on the Muddy and Virgin Rivers would generate storage credits. This activity is assumed to be in place during the period from 2009 through 2060. In the CRSS model, a gain to Lake Mead was introduced as the source of these storage credits and it is assumed that delivery is taken by SNWA from Lake Mead. In general, it was assumed that credits may be stored during all water supply conditions (except the Flood Control Surplus condition) and may be delivered during Normal and Shortage conditions. However, it was also assumed that SNWA would take storage credits during a Full Domestic Surplus condition if needed to avoid exceeding the maximum total amount of storage credits. After 2026, it is assumed that the tributary conservation water would continue to be created each year and would be used in the same year. The system assessment is assumed to be in effect through 2060.

Groundwater. SNWA return flows originating from Nevada groundwater development projects are assumed to be available during the period from 2009 through 2060. In the CRSS model, a gain to Lake Mead was introduced as the source of groundwater and it is assumed that delivery is taken by SNWA from Lake Mead. It was assumed that groundwater return flows are stored and delivered only during Normal and Shortage conditions. After 2026, it is assumed that the groundwater return flows would continue to be created each year and would be used in the same year. The system assessment for groundwater is assumed to be in effect through 2060.

Desalinization. SNWA is assumed to receive water generated from desalinization beginning in 2012 through 2060. To account for water created through desalinization, a gain was introduced to the system below Imperial Dam. Desalinization water is assumed to be generated and taken during all water supply conditions except during Flood Control Surplus conditions. After 2026, it is assumed that the desalinization water would continue to be created each year and would be used in the same year. The system assessment for desalinization is assumed to be in effect through 2060.

Drop 2 Reservoir. As discussed in Section 4.2.7, the proposed Drop 2 Reservoir is assumed to be in operation beginning in 2010 and to conserve an average of 69 kafy, reducing the average over-delivery to Mexico from 77 kafy to 8 kafy under all alternatives. Under the three action alternatives that assume a storage and delivery mechanism, SNWA is assumed to use water conserved by the Drop 2 Reservoir beginning in 2013 during Surplus (excluding the Flood Control Surplus condition) and Normal conditions. A system assessment is not applied to Drop 2 Reservoir water. Nevada takes Drop 2 Reservoir water at a maximum rate of 40 kaf each year until a total of 300 kaf has been taken. Thereafter, water conserved by the Drop 2 Reservoir is assumed to be system water.

Table M-3
Assumed Storage and Delivery Schedules for Conservation Activities Under the Basin States Alternative[1]

	Arizona		**California[2]**		**Nevada**					
	Extraordinary Conservation (af)		Extraordinary Conservation (af)		Tributary Conservation (af)		Groundwater (af)		Desalinization (af)	
YEAR	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER
2008	0	0	400,000	0	0	0	0	0	0	0
2009	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0
2010	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0
2011	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0
2012	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0
2013	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0
2014	0	0	100,000	0	30,000	5,000	13,000	13,000	0	0
2015	0	0	0	0	30,000	5,000	13,000	13,000	0	0
2016	0	0	300,000	0	30,000	5,000	13,000	13,000	0	0
2017	100,000	0	400,000	0	30,000	5,000	13,000	13,000	0	0
2018	100,000	0	300,000	0	30,000	5,000	13,000	13,000	0	0
2019	100,000	0	200,000	0	30,000	5,000	13,000	13,000	0	0
2020	0	300,000	0	100,000	30,000	5,000	80,000	80,000	75,000	75,000
2021	100,000	50,000	0	100,000	30,000	5,000	80,000	80,000	75,000	75,000
2022	100,000	0	0	200,000	30,000	5,000	80,000	80,000	75,000	75,000
2023	100,000	0	0	0	30,000	5,000	80,000	80,000	75,000	75,000
2024	50,000	0	100,000	0	30,000	5,000	80,000	80,000	75,000	75,000

Table M-3
Assumed Storage and Delivery Schedules for Conservation Activities Under the Basin States Alternative[1]

	Arizona		California[2]		Nevada					
	Extraordinary Conservation (af)		Extraordinary Conservation (af)		Tributary Conservation (af)		Groundwater (af)		Desalinization (af)	
YEAR	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER
2025	0	50,000	0	100,000	30,000	30,000	80,000	80,000	75,000	75,000
2026	0	50,000	0	400,000	30,000	30,000	80,000	80,000	75,000	75,000
2027	0	50,000	0	300,000	30,000	30,000	80,000	80,000	75,000	75,000
2028	0	50,000	0	200,000	30,000	30,000	80,000	80,000	75,000	75,000
2029	0	50,000	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2030	0	50,000	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2031	0	50,000	0	400,000	30,000	30,000	80,000	80,000	75,000	75,000
2032	0	50,000	0	400,000	30,000	30,000	80,000	80,000	75,000	75,000
2033	0	50,000	0	400,000	30,000	30,000	80,000	80,000	75,000	75,000
2034	0	50,000	0	400,000	30,000	30,000	80,000	80,000	75,000	75,000
2035	0	50,000	0	400,000	30,000	30,000	80,000	80,000	75,000	75,000
2036	0	50,000	0	400,000	30,000	30,000	80,000	80,000	75,000	75,000
2037	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2038	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2039	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2040	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2041	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2042	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2043	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2044	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2045	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2046	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2047	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2048	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2049	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2050	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2051	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2052	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2053	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2054	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2055	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2056	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2057	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2058	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2059	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000
2060	0	0	0	0	30,000	30,000	80,000	80,000	75,000	75,000

1 Actual modeled delivery amounts may be less depending on availability, system assessment and evaporation losses.

2 Reclamation was provided 99 distinct storage and delivery schedules by MWD to be used with the Index Sequential Method. The schedule in this table is an example of one schedule corresponding to one hydrologic sequence.

M.3.2 Conservation Before Shortage

As discussed in Section 2.4, the Conservation Before Shortage Alternative assumes the levels of participation as shown in Table M-4.

Table M-4
Conservation Before Shortage Alternative Volume Limitations of Storage and Delivery Mechanism

Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Unassigned	825	2100	600
Total	1,450	4,200	1,600

These volume limitations are recognized in CRSS as are other rules that specify under which water supply conditions conserved system or non-system water may be delivered or stored as summarized in Section M.3.4. The schedules for the Conservation Before Shortage Alternative for the participation of the Lower Division states were assumed to be identical to those used in the Basin States Alternative (Table M-3). The schedules for the expanded participation by other entities (Unassigned in Table M-4) were provided by the NGOs and are detailed below.

The Conservation Before Shortage proposal includes voluntary, compensated reductions in water use prior to the imposition of involuntary shortages (Section 2.4). To model this proposal, it was assumed that storage credits of 400, 500 and 600 kafy would be created when Lake Mead was at specific elevations within the range of 1,075 feet msl and 1,025 feet msl, as described in Section 2.4.3. For modeling purposes and to maximize river flow effects, these storage credits were assumed to be generated via extraordinary conservation within Mexico. The system assessment is applied when these storage credits are created and it was assumed that these storage credits would remain in Lake Mead and would be counted toward the replacement of the bypass flows to the Cienega de Santa Clara in Mexico.

The model maintains an accounting for the bypass flow replacement. In each year, the model releases 109 kaf (Section 4.2.6) for the bypass flows and deducts that amount from the bypass flow replacement account. Any deficit that accumulates in the account is tracked and offset at a later time when Lake Mead is below elevation 1,075 feet msl and storage credits are created. The maximum positive volume for the account is assumed to be 1.5 maf and any additional water that is conserved above that amount is assumed to convert to system water. Evaporation losses are applied to any positive balance in the account at the end of each year.

The NGOs also postulated that storage credits would be generated by Mexico and be used for the purpose of environmental flows in Mexico. These credits would be subject to the system assessment and evaporation losses and would be stored and delivered during Surplus or Normal conditions, but not during Flood Control Surplus or Shortage conditions. Two sets of environmental flows are assumed to occur. The first are pulse flows to the Colorado River Delta flowing into the Gulf of California, assumed to occur every five years after the last flood control release, with the first flow scheduled for 2012 (referred to as "Delta Pulse Flows" in Table M-5). Each year, storage credits of 50 kaf are assumed to be generated. Delta pulse flows are of magnitude 250 kaf; however, in the fifth year, the storage credit of 50 kaf is assumed to be stored and delivered in the same year and a system assessment is not applied. The model assumes that Delta pulse flows would flow past the NIB and are counted as part of Mexico's delivery. The second set of environmental flows (termed "Other Environmental Flows Below NIB" in Table M-5) is assumed also to occur every five years, with the first scheduled for 2010 at a volume of 80 kaf. Each year 40 kaf of storage credits is scheduled to be created for these flows. After 2010, these flows increase to a volume of 200 kaf and similar to the Delta pulse flows, in the fifth year the 40 kaf is assumed to be stored and delivered in the same year. The model also assumes that this water would flow past the NIB and is counted as part of Mexico's delivery.

The NGOs postulated an additional activity to create 100 kafy of storage credits to be used for environmental uses within the United States (termed "Additional Environmental Uses" in Table M-5). It was assumed that these credits would be created and delivered during Normal and Surplus conditions and would be subject to the system assessment and evaporation losses. For modeling purposes and to maximize river flow effects, this water was also assumed to be generated via extraordinary conservation within Mexico.

The assumed schedules for these activities are presented in Table M-5.

Table M-5
Assumed Storage and Delivery Schedules for
Other Conservation Activities Under the Conservation Before Shortage Alternative[1]

Year	Delta Pulse Flows		Other Environmental Flows Below NIB		Additional Environmental Uses	
	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER
2008	52,632	0	42,105	0	105,263	100,000
2009	52,632	0	42,105	0	105,263	100,000
2010	52,632	0	0	80,000	105,263	100,000
2011	52,632	0	42,105	0	105,263	100,000
2012	50,000	250,000	42,105	0	105,263	100,000
2013	52,632	0	42,105	0	105,263	100,000
2014	52,632	0	42,105	0	105,263	100,000
2015	52,632	0	40,000	200,000	105,263	100,000
2016	52,632	0	42,105	0	105,263	100,000
2017	50,000	250,000	42,105	0	105,263	100,000
2018	52,632	0	42,105	0	105,263	100,000
2019	52,632	0	42,105	0	105,263	100,000
2020	52,632	0	40,000	200,000	105,263	100,000
2021	52,632	0	42,105	0	105,263	100,000
2022	50,000	250,000	42,105	0	105,263	100,000
2023	52,632	0	42,105	0	105,263	100,000
2024	52,632	0	42,105	0	105,263	100,000
2025	52,632	0	40,000	200,000	105,263	100,000
2026	52,632	0	42,105	0	105,263	100,000
2027	50,000	250,000	0	0	0	100,000
2028	0	0	0	0	0	100,000

Table M-5
Assumed Storage and Delivery Schedules for
Other Conservation Activities Under the Conservation Before Shortage Alternative[1]

Year	Delta Pulse Flows		Other Environmental Flows Below NIB		Additional Environmental Uses	
	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER
2029	0	0	0	0	0	100,000
2030	0	0	0	200,000	0	100,000
2031	0	0	0	0	0	100,000
2032	0	250,000	0	0	0	100,000
2033	0	0	0	0	0	100,000
2034	0	0	0	0	0	100,000
2035	0	0	0	200,000	0	100,000
2036	0	0	0	0	0	100,000
2037	0	0	0	0	0	0
2038	0	0	0	0	0	0
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	0	0	0	0	0	0
2044	0	0	0	0	0	0
2045	0	0	0	0	0	0
2046	0	0	0	0	0	0
2047	0	0	0	0	0	0
2048	0	0	0	0	0	0
2049	0	0	0	0	0	0
2050	0	0	0	0	0	0
2051	0	0	0	0	0	0
2052	0	0	0	0	0	0
2053	0	0	0	0	0	0
2054	0	0	0	0	0	0
2055	0	0	0	0	0	0
2056	0	0	0	0	0	0
2057	0	0	0	0	0	0
2058	0	0	0	0	0	0
2059	0	0	0	0	0	0
2060	0	0	0	0	0	0

1 Storage amounts are adjusted for system assessment. Actual modeled delivery amounts may be less depending on availability and evaporation losses.

M.3.3 Reservoir Storage Alternative

As discussed in Section 2.6, the Reservoir Storage Alternative assumes the levels of participation as shown in Table M-6.

Table M-6
Reservoir Storage Alternative Volume Limitations of Storage and Delivery Mechanism

Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Unassigned	475	950	950
Total	1,100	3,050	1,950

These volume limitations are recognized in CRSS as are other rules that specify under which water supply conditions conserved system or non-system water may be delivered or stored as summarized in Section M.3.4. The schedules for the Reservoir Storage Alternative for the participation of the Lower Division states were assumed to be identical to those used in the Basin States Alternative (Table M-3). The schedules for the expanded participation by other entities (Unassigned in Table M-6) are detailed below.

Some of the activities assumed in the Conservation Before Shortage Alternative were also assumed for the Reservoir Storage Alternative. In particular, the schedules for the "Delta Pulse Flows" and "Other Environmental Flows Below NIB" (Table M-5) were assumed to be identical. Other additional activities were assumed for the Reservoir Storage Alternative in order to assess the potential effects of a storage and delivery mechanism with limits different from either the Basin States or the Conservation Before Shortage alternatives.

During all water supply conditions except the Flood Control Surplus condition, storage credits are assumed to be created to replace bypass flows to the Cienega de Santa Clara in Mexico. As noted in Section 4.2.6, the model assumes that 109 kafy is released from Lake Mead for the bypass flows. Because the system assessment for the Reservoir Storage Alternative is assumed to be 10 percent, storage credits of 121 kafy are assumed to be created each year to replace the bypass flows (termed "Bypass Flow Replacement" in Table M-7). For modeling purposes and to maximize river flow effects this water was assumed to be generated via extraordinary conservation within Mexico.

It was also assumed that storage credits of 55 kafy would be created for environmental consumptive uses (in the amount of 50 kafy after the system assessment) in the United States (termed "Environmental Uses" in Table M-7). These credits are assumed to be created and delivered during all conditions (except the Flood Control Surplus condition). For modeling purposes and to maximize river flow effects this water was assumed to be generated via extraordinary conservation within Mexico.

During Normal and Surplus conditions only, an additional 150 kafy is assumed to be created each year with a delivery of 100 kafy (termed “Additional Conservation Activities” in Table M-7). For modeling purposes and to maximize river flow effects, this water was assumed to be generated via extraordinary conservation within Mexico and delivered to SNWA at Lake Mead.

The assumed schedules for these activities are shown in Table M-7.

M.3.4 Summary of Assumed Storage and Delivery Activities

A summary of the activities assumed to occur under the various water supply conditions (Surplus, Normal, and Shortage conditions) for each alternative is presented in Table M-8.

Table M-7
Assumed Storage and Delivery Schedules for Other Conservation Activities Under the Reservoir Storage Alternative[1]

	Environmental Uses		Bypass Flow Replacement		Additional Conservation Activities	
YEAR	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER
2008	55,555	50,000	121,111	109,000	150,000	100,000
2009	55,555	50,000	121,111	109,000	150,000	100,000
2010	55,555	50,000	121,111	109,000	150,000	100,000
2011	55,555	50,000	121,111	109,000	150,000	100,000
2012	55,555	50,000	121,111	109,000	150,000	100,000
2013	55,555	50,000	121,111	109,000	150,000	100,000
2014	55,555	50,000	121,111	109,000	150,000	100,000
2015	55,555	50,000	121,111	109,000	150,000	100,000
2016	55,555	50,000	121,111	109,000	150,000	100,000
2017	55,555	50,000	121,111	109,000	150,000	100,000
2018	55,555	50,000	121,111	109,000	150,000	100,000
2019	55,555	50,000	121,111	109,000	150,000	100,000
2020	55,555	50,000	121,111	109,000	150,000	100,000
2021	55,555	50,000	121,111	109,000	150,000	100,000
2022	55,555	50,000	121,111	109,000	150,000	100,000
2023	55,555	50,000	121,111	109,000	150,000	100,000
2024	55,555	50,000	121,111	109,000	150,000	100,000
2025	55,555	50,000	121,111	109,000	150,000	100,000
2026	55,555	50,000	121,111	109,000	150,000	100,000
2027	0	50,000	0	109,000	0	100,000
2028	0	50,000	0	109,000	0	100,000
2029	0	50,000	0	109,000	0	100,000
2030	0	50,000	0	109,000	0	100,000
2031	0	50,000	0	109,000	0	100,000
2032	0	50,000	0	109,000	0	100,000
2033	0	50,000	0	109,000	0	100,000
2034	0	50,000	0	109,000	0	100,000
2035	0	50,000	0	109,000	0	100,000
2036	0	50,000	0	109,000	0	100,000
2037	0	0	0	0	0	0
2038	0	0	0	0	0	0
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0
2041	0	0	0	0	0	0
2042	0	0	0	0	0	0
2043	0	0	0	0	0	0

Table M-7
Assumed Storage and Delivery Schedules for Other Conservation Activities Under the Reservoir Storage Alternative[1]

YEAR	Environmental Uses STORE	Environmental Uses DELIVER	Bypass Flow Replacement STORE	Bypass Flow Replacement DELIVER	Additional Conservation Activities STORE	Additional Conservation Activities DELIVER
2044	0	0	0	0	0	0
2045	0	0	0	0	0	0
2046	0	0	0	0	0	0
2047	0	0	0	0	0	0
2048	0	0	0	0	0	0
2049	0	0	0	0	0	0
2050	0	0	0	0	0	0
2051	0	0	0	0	0	0
2052	0	0	0	0	0	0
2053	0	0	0	0	0	0
2054	0	0	0	0	0	0
2055	0	0	0	0	0	0
2056	0	0	0	0	0	0
2057	0	0	0	0	0	0
2058	0	0	0	0	0	0
2059	0	0	0	0	0	0
2060	0	0	0	0	0	0

[1] *Storage amounts are adjusted for system assessment. Actual modeled delivery amounts may be less depending on availability and evaporation losses.*

Table M-8
Modeling Assumptions for Storage and Delivery of Conserved System and Non-System Water

Water Supply Condition		BS, CBS & RS [1]						CBS & RS	CBS	RS
		California	Arizona	Nevada				Mexico	Federal	Federal
		Extraordinary Conservation	Extraordinary Conservation	Tributary Conservation	Groundwater	Desalinization	Drop 2 Reservoir [4]	Extraordinary Conservation	Extraordinary Conservation	Extraordinary Conservation
Flood Control Surplus	Store	no	no	no	no	no	no	no	no	no
	Deliver	no	no	no	no	no	no	no	no	no
Quantified (70R) Surplus	Store	no	no	yes	no	yes	yes	yes	yes	yes
	Deliver	no	no	no	no	yes	yes	yes	yes	yes
Full Domestic Surplus	Store	no	no	yes	no	yes	yes	yes	yes	yes
	Deliver	no	no	yes	no	yes	yes	yes	yes	yes
Normal	Store	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Deliver	yes	yes	yes	yes	yes	yes	yes	yes	yes
Shortage (involuntary and voluntary)	Store	no	no	yes	yes	yes	no	no	no [5]	yes
	Deliver	no	no	yes	yes	yes	no	no	no	yes
System Assessment		yes	yes	yes	yes	yes	no	yes	yes	yes
Period of Activity		2006-2026	2017-2026	2009-2060	2009-2060	2020-2060	Temporary	2008-2026	2008-2026	2008-2026

Notes:

1. *BS = Basin States, CBS = Conservation Before Shortage, RS = Reservoir Storage*
2. *yes = Activity assumed to occur*
3. *no = Activity assumed to not occur*
4. *Beginning in 2012, Nevada is assumed to receive 40 kafy of the water conserved by the Drop 2 Reservoir during Normal and Surplus years until a total of 300 kaf has been credited to Nevada. Thereafter, water conserved by the Drop 2 Reservoir is assumed to be system water.*
5. *Under the Conservation Before Shortage Alternative, extraordinary conservation is assumed to be undertaken by the federal government during voluntary shortage conditions but not during involuntary shortage conditions.*

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Appendix N

Analysis of Hydrologic Variability Sensitivity

This appendix contains descriptions of the analyses performed to evaluate the potential effects of using alternate hydrologic inflow scenarios when performing modeling simulations in CRSS. This sensitivity analysis compares three accepted scientific methods for providing hydrologic variability. These alternate hydrologic inflow scenarios use hydrologic inflow data derived from Nonparametric Paleo Hydrologic State information, Parametric Stochastic Natural Flow Records, and Direct Paleo methods. The alternate hydrologic inflow scenarios are compared to the current method used by Reclamation which uses the Index Sequential Method (ISM) for stochastic streamflow reconstruction.

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N.1 Introduction

This appendix was developed to explore the potential effects of using alternate hydrologic inflow scenarios when performing modeling simulations in CRSS. As explained previously in Section 4.2.4 of the Draft EIS hydrologic variability was incorporated in the hydrologic modeling using the Index Sequential Method (ISM) (USBR 1985; Ovarda, et. al. 1997) on the 99-year natural flow record from 1906 to 2004. This sensitivity analysis will compare three other accepted scientific methods for providing hydrologic variability. The three methods used do not incorporate forecasts of future climate variability, but do provide a wider range of hydrologic variability than the application of ISM to the natural flow record, including longer wet and dry periods than seen in the observed record.

N.2 Development of Three Alternate Hydrologic Inflow Scenarios to Compare with the 1906 – 2004 Natural Flow Record using ISM

The CRSS model requires natural flow inputs at 29 sites throughout the Colorado River system. There are 20 sites above and including the Lees Ferry site on the Colorado River. Below the Lees Ferry site are an additional 9 sites. Generation of stochastic natural flows throughout the 29 sites is a critical step towards understanding the impact of natural streamflow variability on model results.

As stated before, Reclamation currently uses the ISM for stochastic streamflow generation. This stochastic method entails a sequential block bootstrap of the observed data, where the block size is determined by the simulation horizon. The ISM cycles through each year in the historic record generating 99 traces, assuming that the record wraps around at the end (i.e., 2004, 1906, 1907, etc.). Each trace will only consist of annual and monthly flow magnitudes and sequences that have occurred in the observed record, with the exception of new sequences being generated as a result of the wrap. This limit ISM’s ability to model a wide range of plausible future streamflows including flow magnitudes and sequences not seen in the observed record. Strengths of this method are it is easy to implement, understandable, and has been widely accepted by stakeholders on the Colorado River.

To address these drawbacks three alternate methods to generate stochastic natural flows were applied and three alternate hydrology scenarios were generated. These methods were chosen to sample a range of techniques available to generate stochastic flows. Each method has strengths and weaknesses that are described below along with the basic concept of the method.

Throughout this appendix the ISM technique as applied to the 1906 to 2004 natural flow record is referred to as Direct Natural Flow Record (DNF).

N.2.1 Nonparametric Paleo Conditioning (NPC)

This technique conditionally resamples historic data based on paleo hydrologic state information (i.e., wet or dry). Hydrologic state sequences are modeled based on the "Lees-B" paleo reconstruction (1490-1997) and flow magnitudes from the observed natural flows (1906-2004) are conditionally resampled generating annual water year flows at Lees Ferry on the Colorado River (Lee, et. al. 2006). Prairie (2006) provides a detailed description of the conditional resampling technique.

The annual flows at Lees Ferry (site 20) are disaggregated, spatially and temporally, throughout the Upper Colorado River Basin using a nonparametric disaggregation method (Prairie, 2006; Prairie et al., 2006). The disaggregation scheme ensures that the flows generated throughout the Upper Colorado River basin are spatially and temporally consistent among the 20 locations that characterize natural flow.

Flows for the 9 gauges below site 20 are resampled from the observed natural flows (1906-2004) based on the analogue year resampled from the observed natural flows when conditionally generating monthly flows. For example, if year 1954 was the analogue year chosen during the disaggregation then the associated monthly flows for each of the 9 lower sites are resampled from 1954 observed monthly natural flows. This method ensures the lower sites are both temporally and spatially correlated with each other and the upper sites. The lower sites 21-29 contribute significantly less flow (eight percent of the total calendar year flow) than the upper sites; therefore, resampling the direct observed natural flows does not adversely affect the ability to model unique and probable flows in the basin as a whole.

For these nonparametric paleo conditioned hydrologies, 125 traces, each 53 years in length, were generated for the 29 sites throughout the Colorado River basin. The traces generated for the upper 20 sites will produce annual calendar year flow sequences that were not seen before. As a result of using the hydrologic state information from the paleo reconstruction data the flow sequences in the generated paleo conditioned hydrologies will reflect sequence properties (i.e., wet or dry) characteristic of the paleo reconstruction. The magnitudes of generated flow on a water year basis match the magnitudes in the observed record (1906-2004). The inability to generate flow magnitude beyond those in the observed record can be a shortcoming of this technique though the increased variety of flow sequences is an advantage of this method when compared to some other stochastic hydrologies.

N.2.2 Parametric Stochastic Natural Flow Record (PS)

This technique uses parametric stochastic methods to fit the observed natural flows (1906-2003) to an appropriate set of stochastic models for streamflow generation and disaggregation. A parameter fitting procedure, hence the name parametric methods, is applied to fit the observed natural flow to the appropriate parametric models. For this project the observed natural flows at two key sites (Lees Ferry and at Imperial Dam on the Colorado River) were fit to a contemporaneous autoregressive order 1 (CAR(1)) model (Salas, 1985). Annual flows at both sites were simultaneously generated producing 100 traces each 53 years in length. The generated flows where then spatially and temporally disaggregated to the 29 sites at a monthly time scale with appropriate parametric disaggregation techniques. Lee et al., 2006 provides a detailed description of the model selection and fitting procedure for the generation and disaggregation of flows. Scheme 2 from Lee et al., (2006) was found to best preserve both the monthly and annual statistical properties of the observed natural flow and was selected for generation of the parametric hydrologies applied in this study.

Note these parametric hydrologies were developed with natural flows only including up to 2003 while the preceding two stochastic methods used observed natural flows though 2004. At the time these parametric hydrologies were developed the 2004 data was not yet available. A Kolmogorov-Smirnov test (KS-test) was performed for each site to determine if the data distribution has significantly changed between these two datasets. This test found no significant differences at any sites at a 95 percent significance level. Therefore, there should be no reason the parametric hydrologies cannot be compared along side the other two alternate hydrologies.

The parametric techniques can generate both flow magnitudes and sequence not seen in the observed record but statistically similar to the observed record A drawback of the parametric methods are they have the ability to generate values must larger or smaller than those in the observed record and can be difficult to justify. They also have difficulty representing non-Gaussian data distribution features.

N.2.3 Direct Paleo (DP)

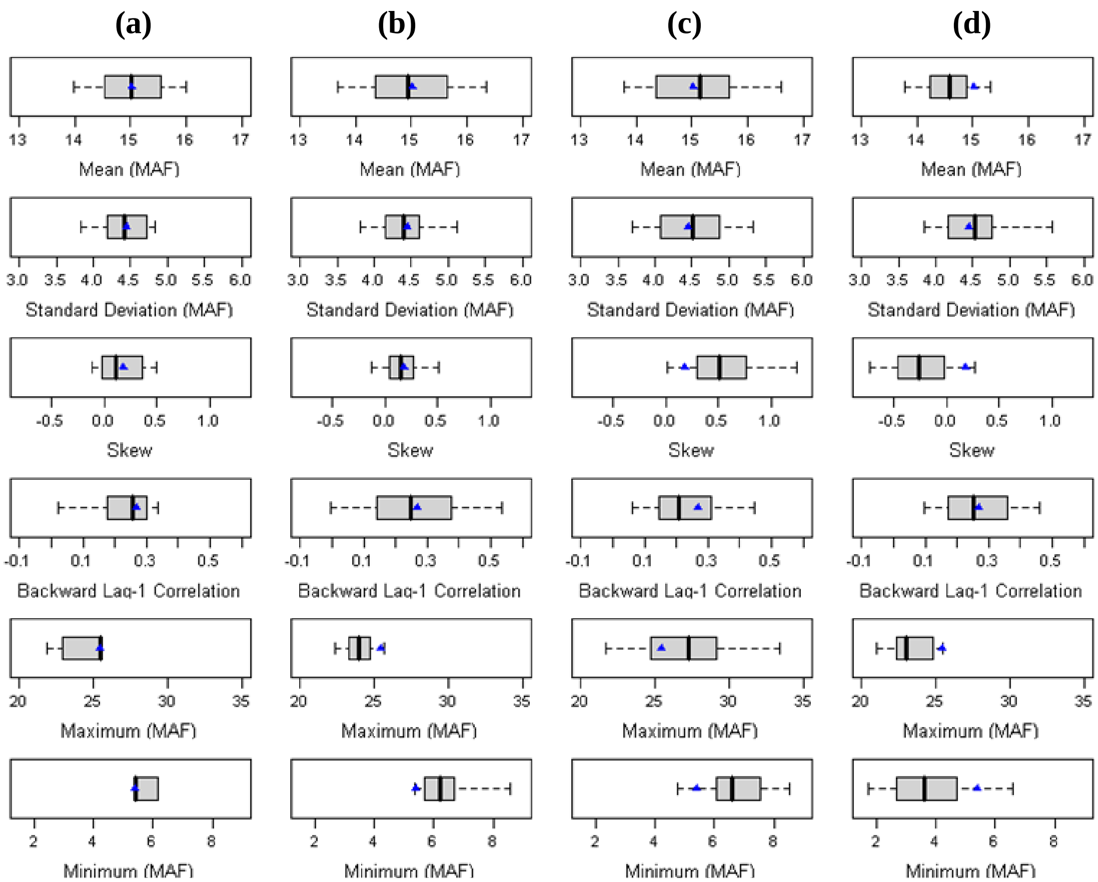
This technique uses the “Lees-B” paleo-reconstruction from Woodhouse et al. (2006). This paleo-reconstruction provides annual water year flows from 1490-1997 on the Colorado River at Lees Ferry. The annual water year flows are disaggregated, spatially and temporally, throughout the Upper Colorado River Basin with the nonparametric disaggregation method (Prairie et al., 2006); the same disaggregation method described in the Section 2.1 Nonparametric Paleo Conditioned. The nine lower sites are resampled as described in Section 2.1.

These disaggregated flows (508 years of monthly flows at 29 sites) are resampled with the ISM generating 508 traces each 53 years in length. As ISM sequentially block bootstraps the disaggregated streamflow data, the generated traces will consist of annual flow magnitudes and sequences that are present in the paleo reconstructed streamflows, with the exception of the sequences created as a result of the wrap.

N.2.4 Comparison of Three Alternate Inflow Scenarios

Basic statistics from the Direct Natural Flow Record inflow and the three alternate inflow scenarios are shown in Figure N-1. The statistics are computed from total calendar year flow at Lees Ferry on the Colorado River. These statistics include the mean, standard deviation, skew, lag-1 autocorrelation, maximum and minimum. The observed statistic (1906-2004) is shown as a blue triangle. While the statistics based on the inflow scenario are shown as boxplots. The boxplots display the interquartile range (IQR), where 25 percent to 75 percent of the values lie, with the median represented as a vertical line within the IQR. The whiskers extend to the five percent to 95 percent range of the values. Performance is generally judged as appropriate when the observed statistics is captured within the IQR

Figure N-1
Boxplots of Basic Statistics for
(a) Direct Natural Flow Record, (b) Nonparametric Paleo Conditioned,
(c) Parametric Stochastic Natural Flow Record, and (d) Direct Paleo



The each inflow scenario is presented in a column and the five statistics are presented in each row. The observed mean is reproduced well by the first three scenarios (Direct Natural Flow Record, Nonparametric Paleo Conditioned, and Parametric Stochastic Natural Flow Record) as expected. The Direct Paleo scenario underestimates the observed mean, as expected, because this paleo reconstruction has a lower mean (14.6 million acre-feet [maf]) than the observed period (15.0 maf). The standard deviation is well reproduce by all scenarios. The skew is over estimated by the Parametric Stochastic Natural Flow Record, a difficult statistics for parametric techniques to capture, while the Direct Paleo underestimates the skew. The lag-1 autocorrelation is captured by all inflow scenarios. The observed maximum is not exceeded by the Direct Natural Flow Record or Direct Paleo scenarios and only slightly exceeded by the Nonparametric Paleo Conditioned but the Parametric Stochastic scenario is able to reproduce much higher flows than observed, approximately 8.0 maf higher five percent of the time. The observed minimum flow is not exceeded by the ISM or Nonparametric Paleo Conditioned, while the Parametric Stochastic Natural Flow Record generates a few lower values. The Direct Paleo is able to generate much lower flows that observed, approximately 3.7 maf lower five percent of the time. It was expected the Direct Paleo would generate lower flows than observed as these are characteristic of Lees Ferry streamflow reconstructions.

N.3 Results

This section is separated into two parts. Section 3.1 examines the effects of the alternate hydrologic inflow scenarios by holding constant the alternative and varying the hydrologic inflow sequences. Section 3.2 examines the performance of each alternative under the alternate hydrologic inflow scenarios by holding constant the inflow scenario while varying the alternative

N.3.1 Effects of Alternate Hydrology on No Action Alternative

This section describes the sensitivity of the No Action Alternative to the hydrologic variability provided by the three alternate hydrologic inflow scenarios described in the previous sections. This will be done through comparing the No Action Alternative, simulated using ISM and the 99-year natural flow record, Direct Natural Flow Record (DNF), to the No Action Alternative simulated with three alternate hydrologic inflow scenarios.

N.3.1.1 Percentile Elevations

Figure N-2 presents a comparison of the 90th, 50th, and 10th percentile lines of Lake Powell elevations obtained for DNF and the three alternate hydrologic inflow scenarios, operated under the No Action Alternative.

The 90th percentile range of the four hydrologic methods shows smaller variation between the scenarios, largely because Lake Powell is at or near its maximum reservoir capacity.

At the 50th percentile range the DP hydrologic inflow scenario consistently produces the lowest elevations, while the NPC and the PS hydrologic inflow scenarios generally produce higher median elevations than DNF.

Variation between the various hydrologic inflow methods is highest at the 10th percentile range. The higher variability from year to year at the 10th percentile level for the NPC and the PS hydrologic inflow scenarios is a result of sample size. The DNF and DP hydrologic inflow scenarios are resampled with the ISM, which guarantees year to year hydrologic inflow scenario statistics that are identical. The year to year variation seen in these scenarios only results from reservoir operations. The NPC and PS hydrologic inflow scenarios are generated with stochastic methods that do not generate identical hydrologic inflow scenario statistics on a year to year basis; although with increased sample size, these scenarios will produce an average year to year statistic which is similar but not identical. This property is present in most stochastic techniques other than ISM.

Figure N-2
Lake Powell End-of-July Elevations
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
90th, 50th and 10th Percentile Values

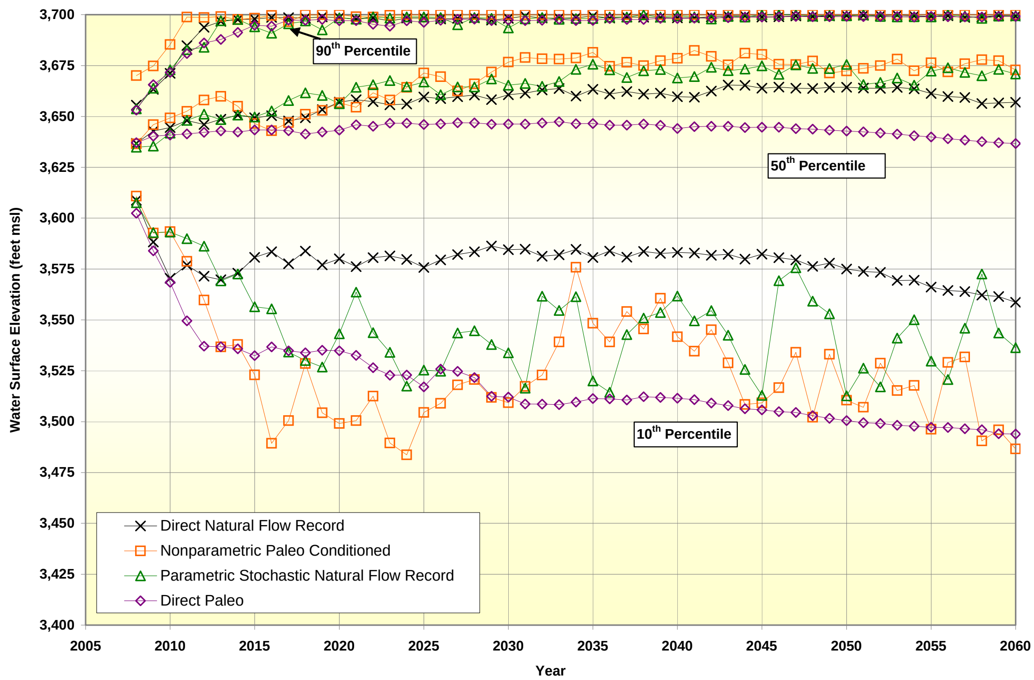
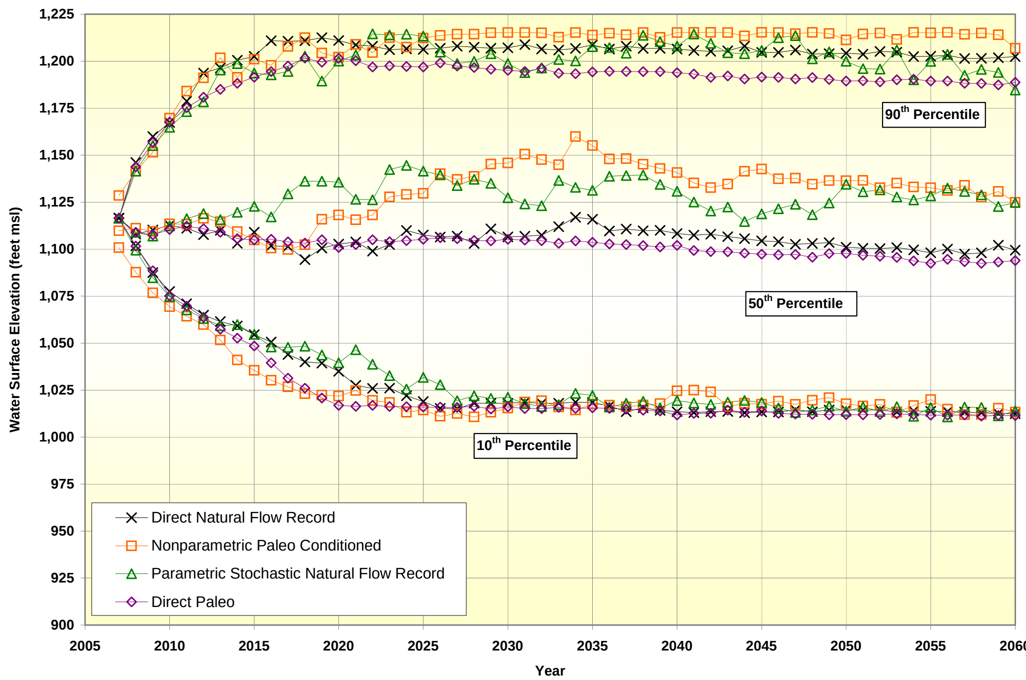


Figure N-3 presents a comparison of the 90th, 50th, and 10th percentile lines of Lake Mead elevations obtained for DNF and the three alternate hydrologic inflow scenarios, operated under the No Action Alternative. At each percentile, DP is consistently lower than DNF even though both utilized the same sampling technique because the DP hydrology set has a higher magnitude and droughts of longer duration. At the 90th and 50th percentile, NPC and PC are generally higher than DNF due to higher magnitude and longer duration wet cycles in the two data sets.

Figure N-3
Lake Mead End-of-December Elevations
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
90th, 50th and 10th Percentile Values



N.3.1.2 Probability of Being Below Key Elevations

Figure N-4 presents a comparison of the likelihood of Lake Powell end-of-July elevations being at or below the minimum power pool for DNF and for the three alternate hydrologic inflow scenarios. DNF shows nearly no chance of Lake Powell elevations falling below minimum power pool. NPC indicates the highest likelihood of occurrence at 14 percent, followed by the DP (nine percent), PS (nine percent), and DNF (one percent).

Figure N-4
Lake Powell End-of-July Elevations
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
Percent of Values Less Than or Equal to 3,490 feet msl

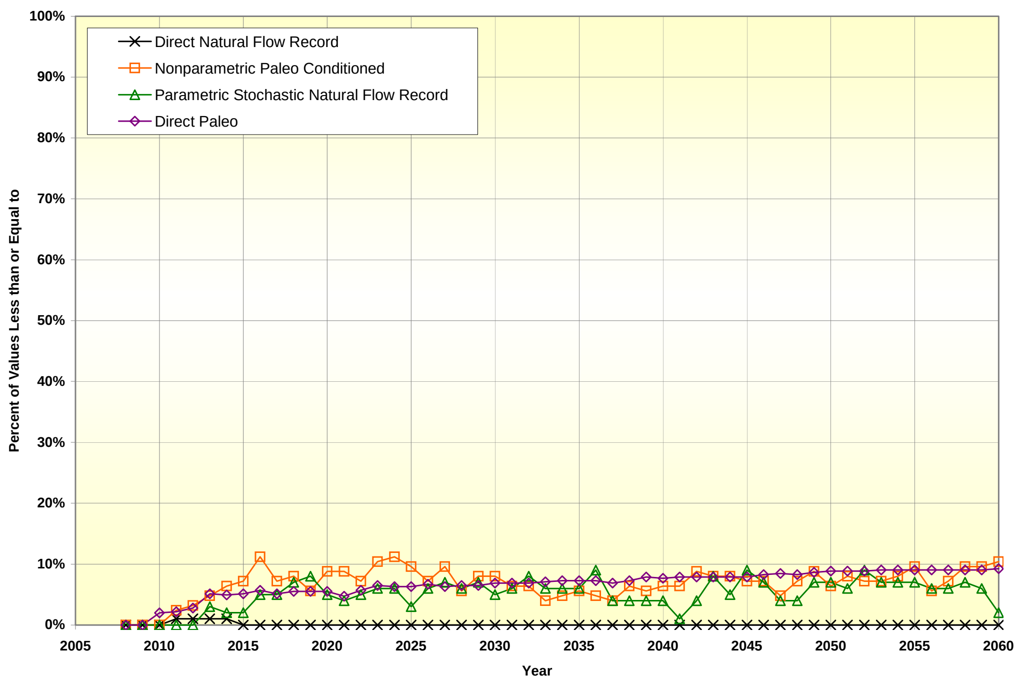


Figure N-5 presents a comparison of the likelihood of Lake Mead end-of-December elevations being at or below the minimum power pool for DNF and for the three alternate hydrologic inflow scenarios. PS shows the lowest chance for all years of Lake Mead elevations falling below minimum power pool. DP and DNF indicate the highest likelihood for most years.

Figure N-5
Lake Mead End-of-December Elevations
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
Percent of Values Less Than or Equal to 1,050 feet msl

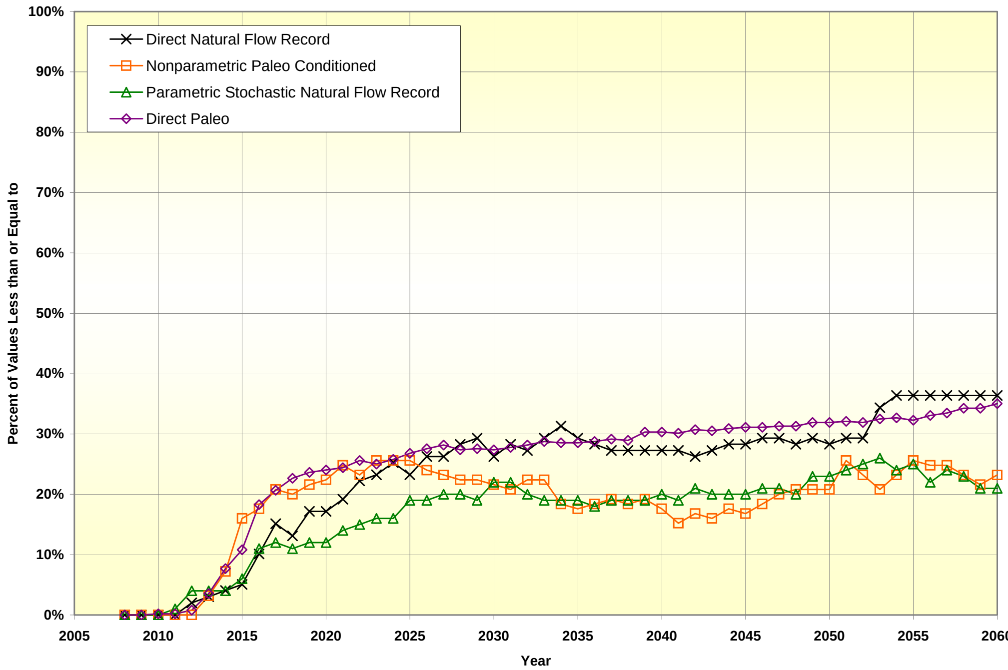
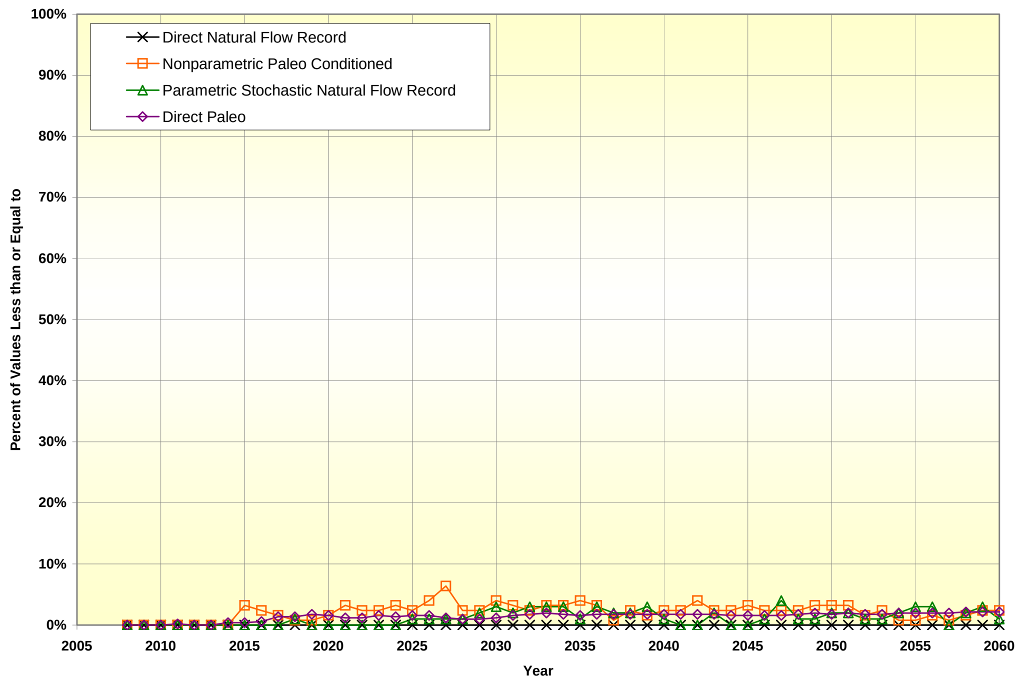


Figure N-6 presents a comparison of the likelihood of Lake Mead end-of-December elevations being at or below 1,000 feet msl for DNF and for the three alternate hydrologic inflow scenarios. DNF shows no chance of Lake Mead elevations falling below 1,000 feet msl. NPC indicates the highest likelihood of occurrence at six percent in 2022, followed by the PS (four percent), and DP (one percent).

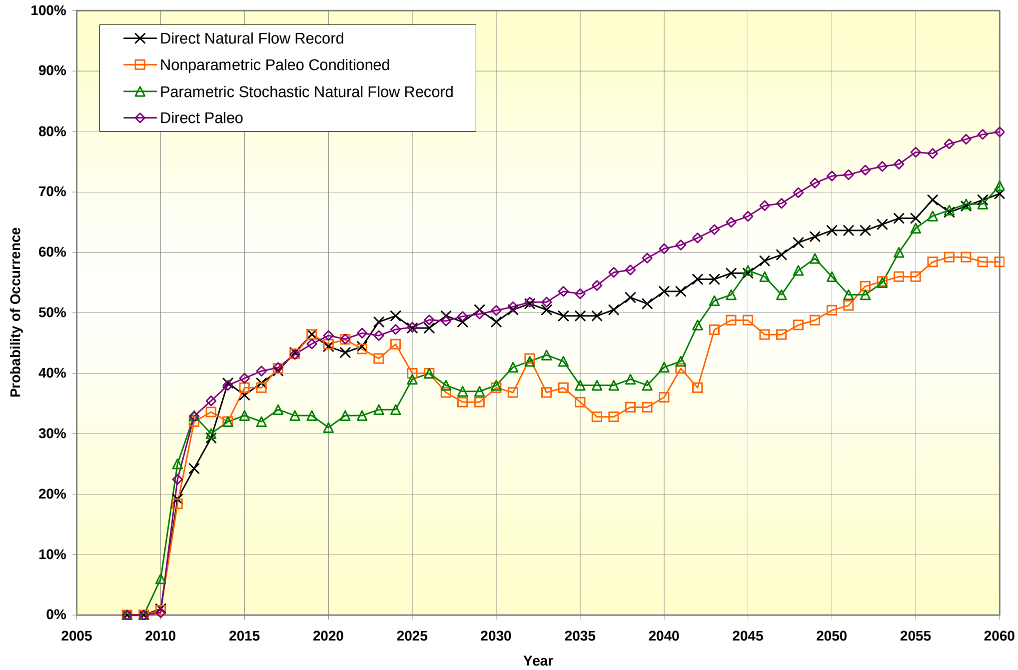
Figure N-6
Lake Mead End-of-December Elevations
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
Percent of Values Less Than or Equal to 1,000 feet msl



N.3.1.3 Lower Basin Shortage

Figure N-7 shows the probability of shortage to the Lower Basin and Mexico under the No Action Alternative obtained for DNF and the three alternate hydrologic inflow scenarios. The higher variability observed with the NPC and PS methods are a function of sample size, as described under Section 3.1.1. NPC and PS have a lower probability of shortage than DNF for most of the period of analysis due to the extended wet periods in both data sets. Before 2015, NPC has a higher shortage probability than DNF because of NPC's initial dry conditioning. The highest probability of shortage for each alternative occurs after 2055 with the following approximate values: DNF, 69 percent; DP, 80 percent; NPC, 62 percent; and PS, 71 percent.

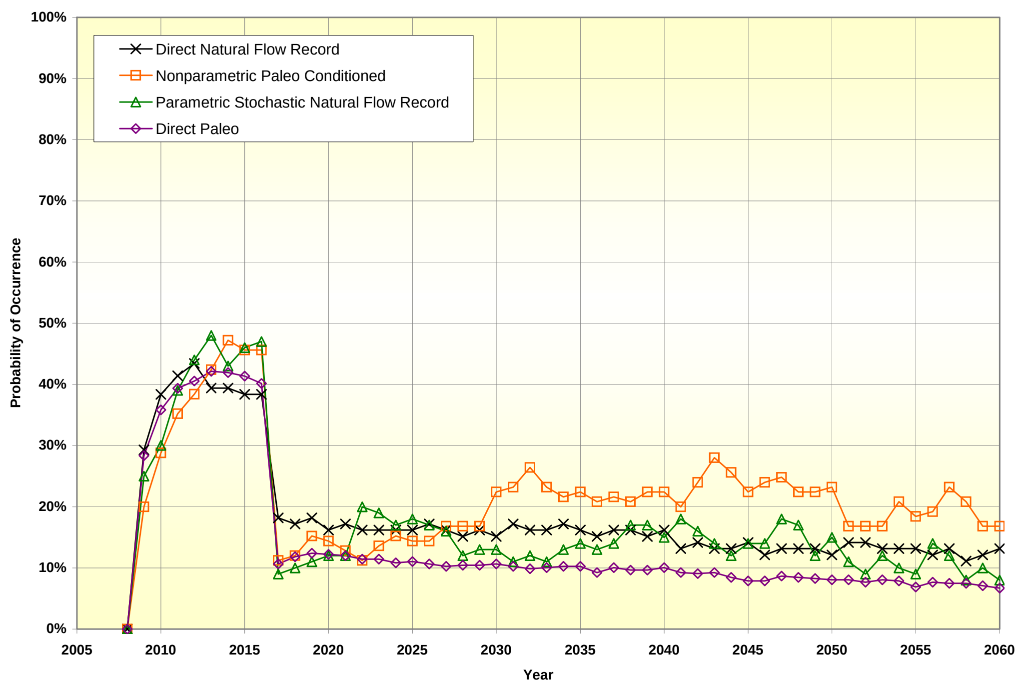
Figure N-7
Lower Basin and Mexico Shortage
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
Probability of Occurrence



N.3.1.4 Lower Basin Surplus

Figure N-8 shows the probability of any surplus to the Lower Division states under the No Action Alternative obtained for DNF and the three alternate hydrologic inflow scenarios. Note: this plot includes the probability of Flood Control surplus where Mexico would also receive a surplus. The higher variability observed with the NPC and PS methods are a function of sample size. NPC and PS have a higher probability of surplus than DNF for most of the period of analysis due to the extended wet periods in both data sets. Before 2015, NPC has a lower surplus probability than DNF because of NPC's initial dry conditioning. The highest probability of surplus for each alternative occurs before 2017 with the following approximate values: DNF, 44 percent; DP, 42 percent; NPC, 44 percent; and PS, 48 percent. Beginning in 2017, under the No Action Alternative, only 70R and Flood Control surpluses occur, which reduces the probability of shortage to below 25 percent.

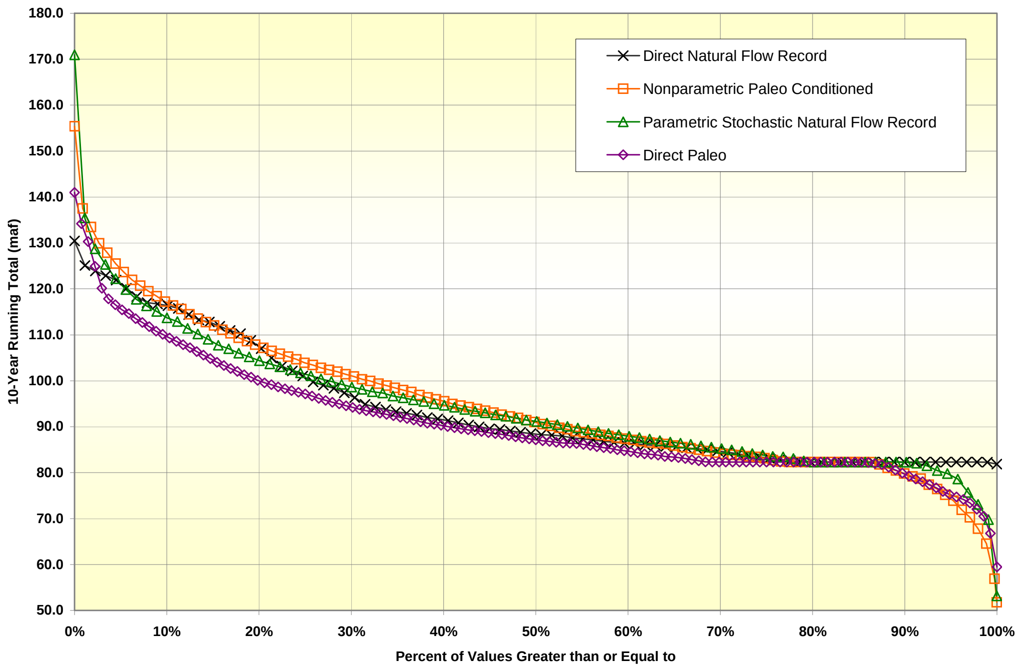
Figure N-8
Lower Basin Surplus
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
Probability of Occurrence



N.3.1.5 Releases from Glen Canyon Dam

Figure N-9 presents a comparison of 10-year release volumes from Glen Canyon Dam for DNF and the three alternate hydrologic scenarios. The largest differences in the frequency of flow volumes are observed at the highest and lowest volumes, where the NPC hydrologic sequence shows the lowest low extreme values and DNF shows the lowest high extreme values. The PS hydrologic sequence “fills the gaps” in the data resulting in the smoothest curve and the highest extreme value.

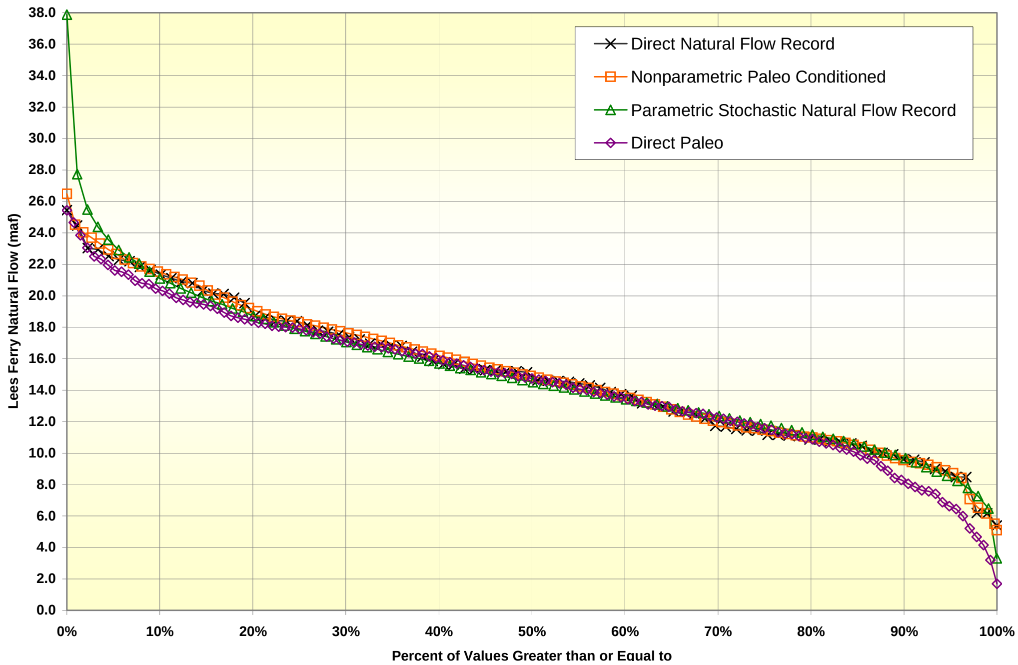
Figure N-9
Glen Canyon Dam 10-Year Release Volume
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
Percent of Values Greater than or Equal to (Years 2008 to 2060)



N.3.1.6 Flow at Lees Ferry

Figure N-10 presents a comparison of annual flow volumes past Lees Ferry for DNF and the three alternate hydrologic scenarios. The largest differences in the frequency of flow volumes are observed at the highest and lowest volumes, where the DP hydrologic sequence shows the lowest extreme values. The PS hydrologic sequence “fills the gaps” in the data resulting in the smoothest curve and the highest extreme value. The maximum flows produced under the PS scenario are much higher than the maximum flows by any other method in this analysis.

Figure N-10
Annual Flow at Lees Ferry
Comparison of Direct Natural Flow Record to Three Alternate Hydrologic Sequences
No Action Alternative
Percent of Values Greater than or Equal to for Years 2008-2060



N.3.2 Effects of Alternate Hydrology on Action Alternatives

This section describes the sensitivity of the No Action and action alternatives to the hydrologic variability provided by the three alternate hydrologic inflow scenarios described in Section N.2. Below are the reservoir percentile figures and tables under DNF for reference and comparison (Figures N-11 through N-12 and Tables N-1 through N-2).

Figure N-11
Lake Powell End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Direct Natural Flow Record Inflow Hydrology
90th, 50th and 10th Percentile Values

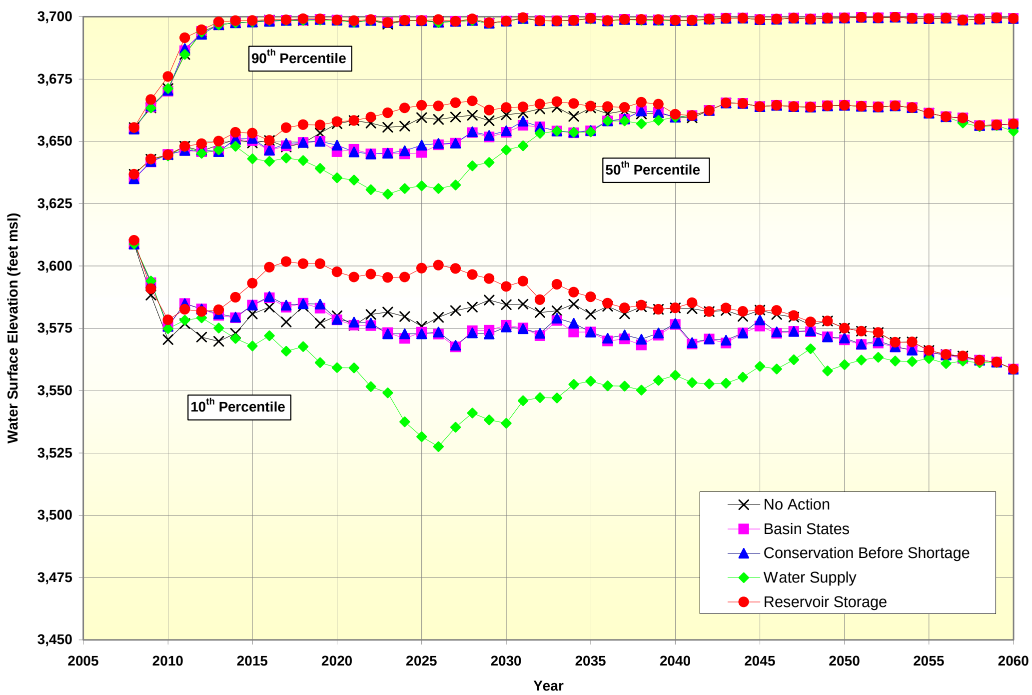


Table N-1
Lake Powell End-of-July Elevations (feet, msl)
Comparison of Action Alternatives to No Action Alternative
Direct Natural Flow Record
90th, 50th and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	3,697.90	3,658.75	3,579.43	3,699.27	3,656.99	3,558.63
Basin States	3,697.71	3,648.61	3,572.63	3,699.27	3,656.99	3,558.63
Conservation Before Shortage	3,697.74	3,649.20	3,573.50	3,699.27	3,656.99	3,558.63
Water Supply	3,697.64	3,631.02	3,527.55	3,699.27	3,654.00	3,558.63
Reservoir Storage	3,698.85	3,664.17	3,600.29	3,699.27	3,656.99	3,558.63

Figure N-12
Lake Mead End-of-December Elevations
Comparison of Action Alternatives to No Action Alternative
Direct Natural Flow Record Inflow Hydrology
90th, 50th and 10th Percentile Values

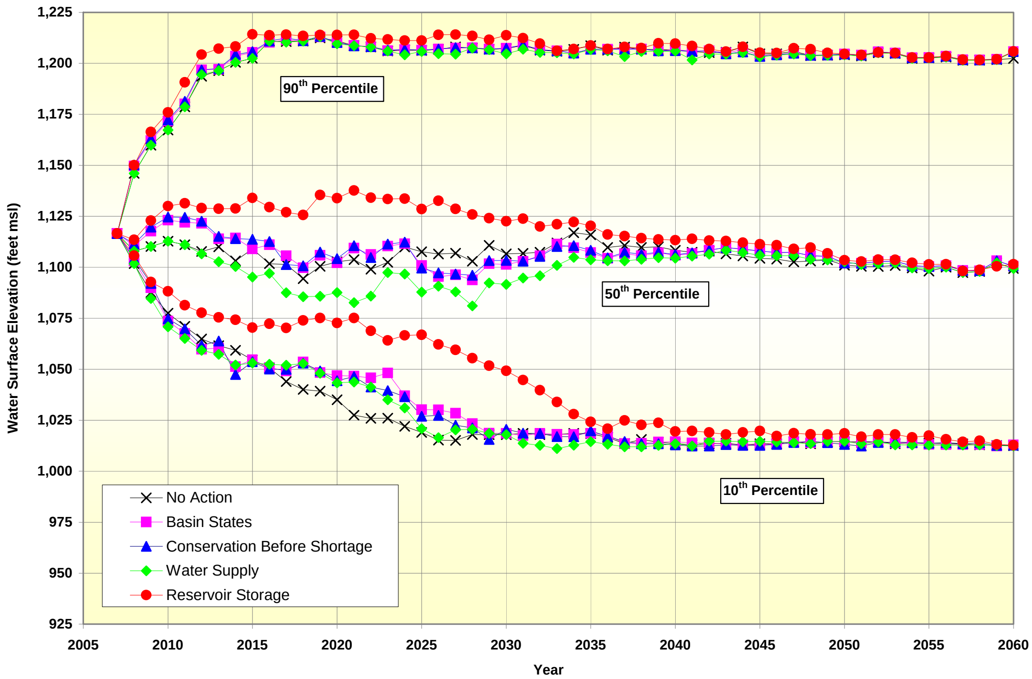


Table N-2
Lake Mead End-of-December Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
Direct Natural Flow Record
90th, 50th and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	1,206.87	1,106.50	1,015.31	1,202.39	1,099.41	1,012.44
Basin States	1,207.05	1,095.39	1,030.07	1,205.79	1,100.55	1,012.95
Conservation Before Shortage	1,207.05	1,097.22	1,027.39	1,205.79	1,100.55	1,012.70
Water Supply	1,204.72	1,090.78	1,016.47	1,205.59	1,099.41	1,012.42
Reservoir Storage	1,214.05	1,132.64	1,062.16	1,205.80	1,101.47	1,012.75

N.3.2.1 Nonparametric Paleo Conditioned – Reservoir Levels

Figure N-13 and Table N-3 presents a comparison of the 90th, 50th, and 10th percentile lines obtained for the No Action and action alternatives under the NPC hydrologic inflow scenario. The NPC inflow hydrology method is explained in detail in Section 2.1.

Median Lake Powell elevations as depicted on the 50th percentile lines are consistently lower under the Water Supply Alternative than the No Action Alternative until year 2038, with a maximum difference of 32 feet in year 2026.

In the 10th percentile category, elevations under the Water Supply Alternative drop below elevations under the No Action Alternative in year 2016, reaching a maximum difference of 39 feet below the No Action Alternative in year 2020. Elevations in the 10th percentile from the Basin States, Conservation Before Shortage and Reservoir Storage action alternatives remain above No Action Alternative elevations for most years before year 2033, and thereafter the differences are minimal.

Figure N-13
Lake Powell End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Nonparametric Paleo Conditioned Inflow Hydrology
90th, 50th and 10th Percentile Values

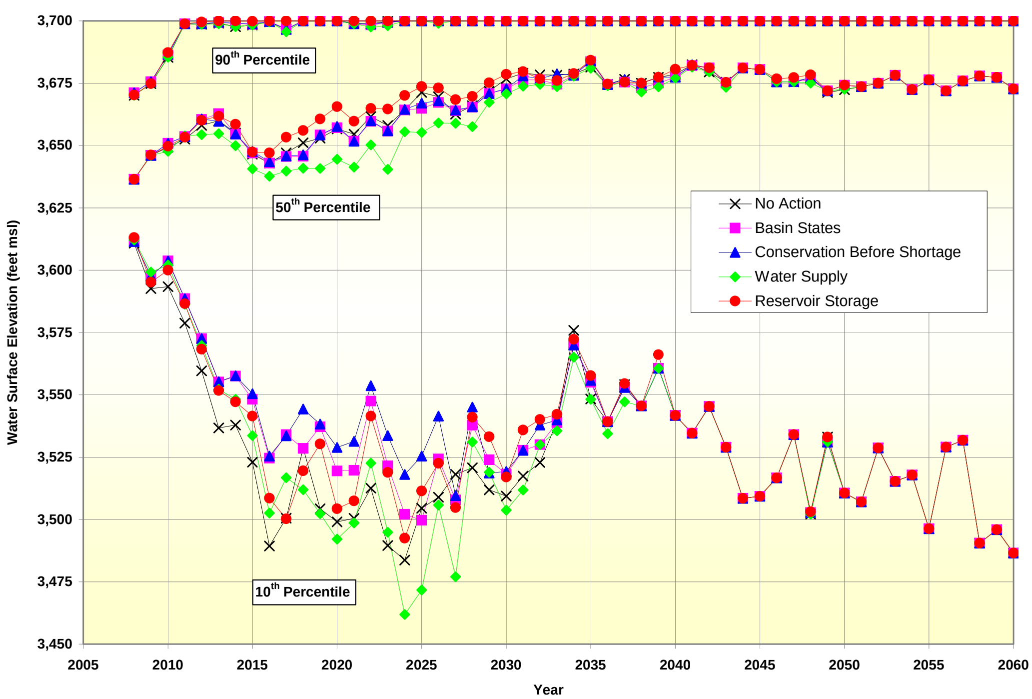


Table N-3
Lake Powell End-of-July Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
Nonparametric Paleo Conditioned
90th, 50th and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	3,700.00	3,669.57	3,508.94	3,700.00	3,672.76	3,486.56
Basin States	3,700.00	3,667.27	3,524.31	3,700.00	3,672.76	3,486.56
Conservation Before Shortage	3,700.00	3,668.01	3,541.49	3,700.00	3,672.76	3,486.56
Water Supply	3,699.06	3,659.05	3,505.77	3,700.00	3,672.76	3,486.56
Reservoir Storage	3,700.00	3,673.14	3,522.48	3,700.00	3,672.76	3,486.56

Figure N-14 and Table N-4 presents a comparison of the 90th, 50th, and 10th percentile elevations at Lake Mead. The relationship between alternatives is maintained under NPC hydrologic sequences at Lake Mead 50th and 90th percentiles as both percentiles lie in the same elevation range as under DNF. Because the 10th percentile is lower in the reservoir (ranging from 25 to 100 feet through 2026), whether or not an alternative includes the absolute protection of 1,000 feet msl is important. For example, the Conservation Before Shortage and Basin States Alternatives are very similar at the 10th percentile under DNF. The absolute protection of 1,000 feet msl as part of the CONSERVATION BEFORE SHORTAGE Alternative and not the Basin States results in keeping Lake Mead higher at the 10th percentile. The Water Supply, Basin States and Conservation Before Shortage Alternatives are lower than No Action Alternative at the 10th percentile due to reduced releases from Lake Powell. The Water Supply Alternative has the lower 10th percentile than all other alternate inflow scenarios.

Figure N-14
Lake Mead End-of-December Elevations
Comparison of Action Alternatives to No Action Alternative
Nonparametric Paleo Conditioned Inflow Hydrology
90th, 50th and 10th Percentile Values

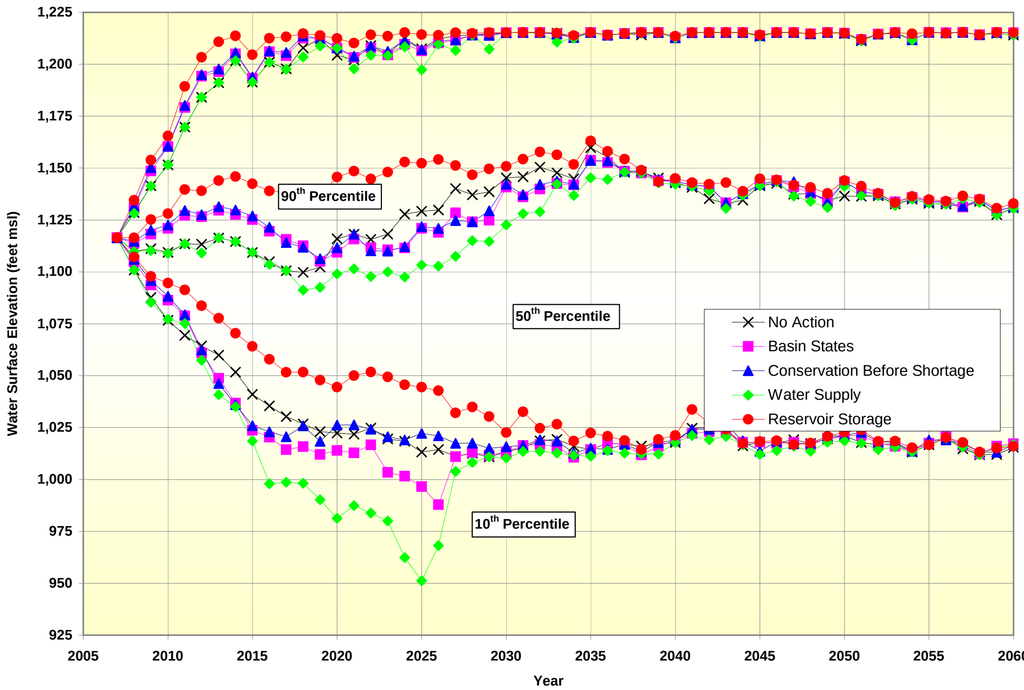


Table N-4
Lake Mead End-of-December Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
Nonparametric Paleo Conditioned
90th, 50th and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	1,212.28	1,129.74	1,014.41	1,214.02	1,130.74	1,015.44
Basin States	1,210.33	1,118.96	987.85	1,215.22	1,131.33	1,017.20
Conservation Before Shortage	1,211.10	1,120.93	1,021.01	1,215.02	1,131.33	1,016.76
Water Supply	1,209.71	1,102.77	968.18	1,214.02	1,130.50	1,016.86
Reservoir Storage	1,213.95	1,154.10	1,042.77	1,215.22	1,132.93	1,015.93

N.3.2.2 Parametric Stochastic – Reservoir Levels

Figure N-15 and Table N-5 presents a comparison of the 90th, 50th, and 10th percentile lines obtained for the No Action and the action alternatives under the PS hydrologic inflow scenario. The PS inflow hydrology method is explained in detail in Section 2.2.

Median Lake Powell elevations as depicted on the 50th percentile lines are consistently lower under the Water Supply Alternative than the No Action Alternative until year 2036, with a maximum difference of eight feet in year 2029.

In the 10th percentile category, elevations under the Water Supply Alternative drop below elevations under No Action Alternative in year 2011, reaching a maximum difference of 46 feet below No Action Alternative in year 2028. Following year 2035, these differences are minimal. Elevations in the 10th percentile under the Basin States, Conservation Before Shortage and Reservoir Storage Alternatives remain above the No Action Alternative elevation until year 2030.

Figure N-15
Lake Powell End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Parametric Stochastic Natural Flow Record Inflow Hydrology
90th, 50th and 10th Percentile Values

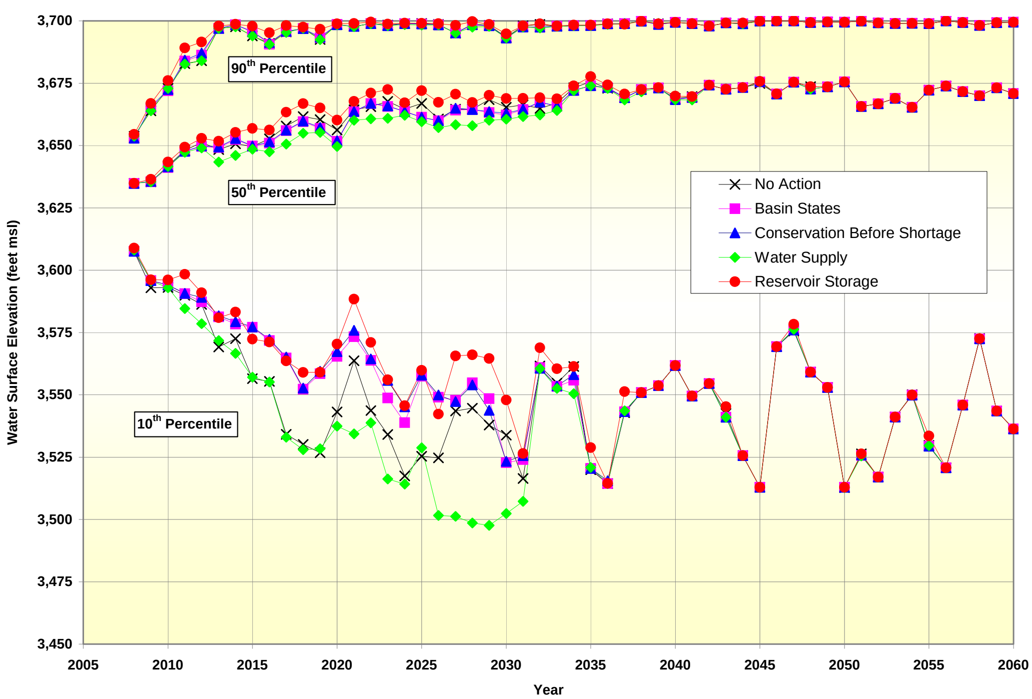


Table N-5
Lake Powell End-of-July Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
Parametric Stochastic Natural Flow Record
90th, 50th and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	3,698.61	3,660.60	3,524.76	3,699.46	3,670.91	3,536.35
Basin States	3,698.34	3,659.99	3,549.06	3,699.46	3,670.91	3,536.35
Conservation Before Shortage	3,698.36	3,659.99	3,549.93	3,699.46	3,670.91	3,536.35
Water Supply	3,698.36	3,657.22	3,501.62	3,699.46	3,670.91	3,536.35
Reservoir Storage	3,698.90	3,667.34	3,542.31	3,699.46	3,670.91	3,536.35

Figure N-16 and Table N-6 presents a comparison of the 90th, 50th, and 10th percentile elevations at Lake Mead. As with the NPC hydrologic sequences, the relationship between alternatives is maintained at Lake Mead 50th and 90th percentiles. The 50th percentile is about 25 feet higher in the reservoir compared to DNF. The 10th percentile is lower in the reservoir (about 15 feet) than with DNF but not as low as with NPC. Whether or not an alternative include the absolute protection of 1,000 feet msl is not as dominate here as with NPC as seen as the smaller difference between the Conservation Before Shortage and Basin States Alternatives. The Water Supply Alternative drops lower than under DNF, due to the possible more extreme droughts resulting in lower Lake Powell inflow. The position of the Reservoir Storage Alternative remains almost unchanged compared to DNF at the 10th percentile.

Figure N-16
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Parametric Stochastic Natural Flow Record Inflow Hydrology
90th, 50th and 10th Percentile Values

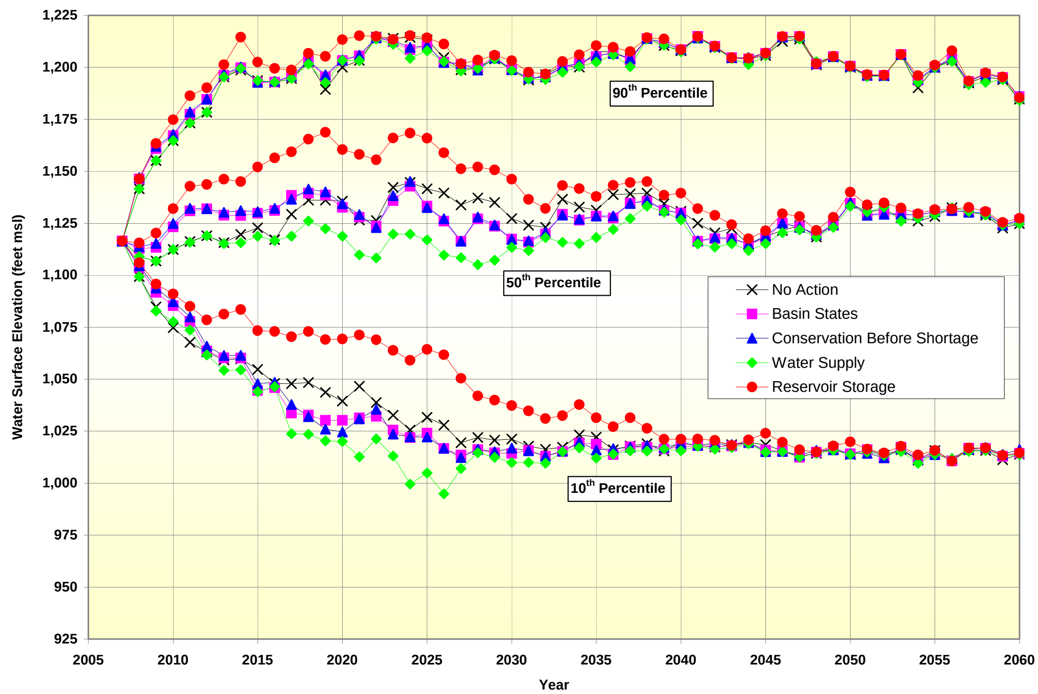


Table N-6
Lake Mead End-of-December Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
Parametric Stochastic Natural Flow Record
90th, 50th and 10th Percentile Values

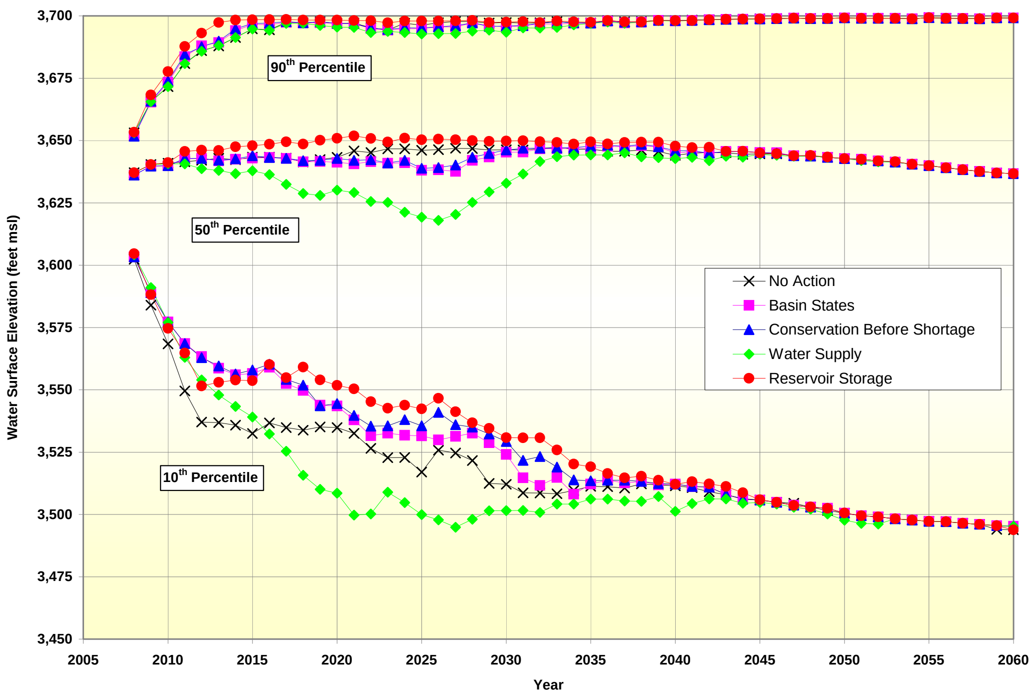
Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	1,204.76	1,139.61	1,027.90	1,184.74	1,124.79	1,013.93
Basin States	1,202.49	1,126.05	1,016.66	1,185.98	1,126.46	1,014.31
Conservation Before Shortage	1,202.39	1,127.21	1,016.83	1,186.02	1,126.46	1,016.18
Water Supply	1,202.79	1,109.70	994.88	1,184.05	1,124.78	1,013.58
Reservoir Storage	1,211.22	1,158.98	1,061.76	1,185.53	1,127.35	1,014.59

N.3.2.3 Direct Paleo – Reservoir Levels

Figure N-17 and Table N-7 presents a comparison of the 90th, 50th, and 10th percentile lines obtained for the No Action and action alternatives under the DP hydrologic inflow scenario. The DP inflow hydrology method is explained in detail in Section 2.3.

The median Lake Powell elevation for all five scenarios generally declines over the period of analysis, due to increasing Upper Basin depletions. Figure N-17 also illustrates that median Lake Powell elevations as depicted on the 50th percentile lines are consistently lower under the Water Supply Alternative until year 2047, with a maximum difference of 33 feet in year 2026. These differences are insignificant by year 2047.

Figure N-17
Lake Powell End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
Direct Paleo Inflow Hydrology
90th, 50th and 10th Percentile Values



In the 10th percentile category, elevations under the Water Supply Alternative drop below those of the No Action Alternative in year 2016, reaching a maximum difference of 33 feet below No Action Alternative in year 2021. Elevations in the 10th percentile from the Basin States, Conservation Before Shortage and Reservoir Storage action alternatives remain above No Action Alternative elevations until 2038.

Table N-7
Lake Powell End-of-July Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
Direct Paleo
90th, 50th and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	3,697.24	3,646.33	3,525.79	3,699.17	3,636.71	3,493.86
Basin States	3,695.52	3,638.28	3,529.95	3,699.17	3,636.71	3,495.25
Conservation Before Shortage	3,695.62	3,639.13	3,540.96	3,699.17	3,636.71	3,495.25
Water Supply	3,692.83	3,617.99	3,497.83	3,699.17	3,636.71	3,495.25
Reservoir Storage	3,697.89	3,650.61	3,546.57	3,699.17	3,636.71	3,493.86

Figure N-18 and Table N-8 presents a comparison of the 90th, 50th, and 10th percentile elevations at Lake Mead. The position of these percentiles is most similar to DNF with DP. All relationships are preserved with the exception of the Water Supply Alternative and No Action Alternative at the 10th percentile. The Basin States and Conservation Before Shortage Alternatives remain below No Action Alternative from 2012 to 2019 as Lake Powell make reduced releases. The same is true for the Water Supply Alternative. This alternative drops almost 40 feet lower in 2026 at the 10th percentile compared to DNF. Lake Powell is unable to provide balancing releases that benefit Lake Mead due to lower inflow sequences.

Figure N-18
Lake Mead End-of-December Elevations
Comparison of Action Alternatives to No Action Alternative
Direct Paleo Inflow Hydrology
90th, 50th and 10th Percentile Values

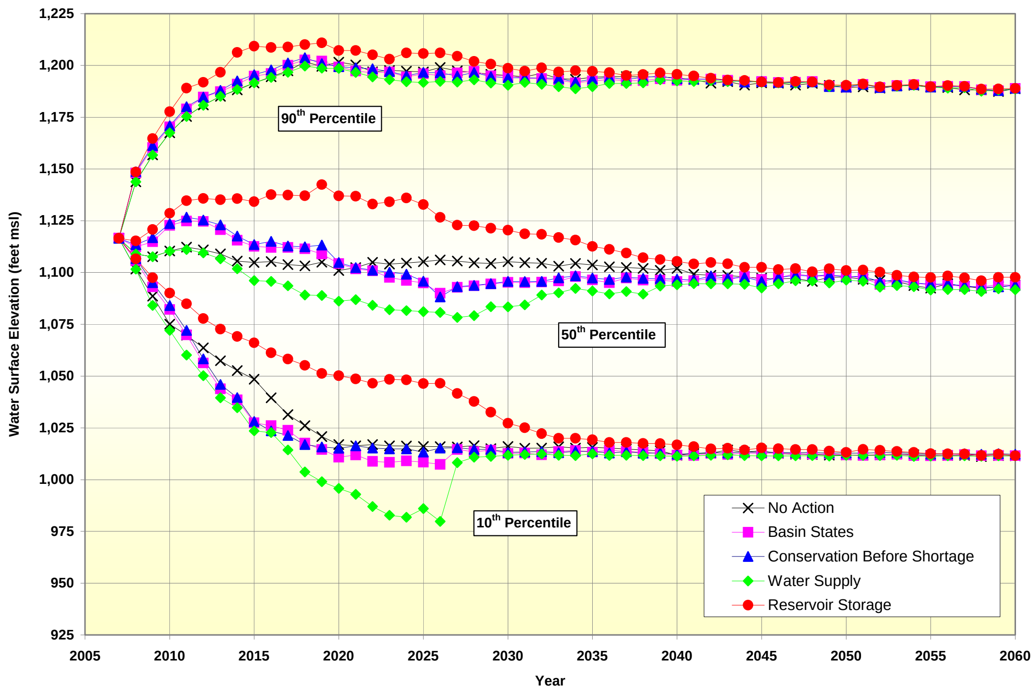


Table N-8
Lake Mead End-of-December Elevations (feet msl)
Comparison of Action Alternatives to No Action Alternative
Direct Paleo
90th, 50th and 10th Percentile Values

Alternative	Year 2026			Year 2060		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
No Action	1,199.04	1,106.10	1,015.94	1,188.70	1,093.89	1,011.47
Basin States	1,195.10	1,090.03	1,007.41	1,188.89	1,093.63	1,011.59
Conservation Before Shortage	1,196.39	1,088.23	1,015.23	1,188.89	1,093.88	1,012.23
Water Supply	1,192.33	1,080.72	979.86	1,188.52	1,091.73	1,011.54
Reservoir Storage	1,206.10	1,126.68	1,046.47	1,188.91	1,097.71	1,011.61

N.3.2.4 All Inflow Scenarios – Shortage Magnitude and Frequency

Table N-9 and N-10 compares the probabilities of shortages occurring between 0 and 500 kaf, 500 and 750 kaf, 750 and 1.0 maf, 1.0 and 1.5 maf, 1.5 and 2.0 maf, 2.0 and 2.5 maf and above 2.5 maf for the years 2010, 2017, 2026 and 2060. The upper range of the shortage increment is inclusive. These years and shortage ranges are compared for all alternatives and inflow scenarios.

2010. The earliest occurrence of shortage, for all alternative and inflow scenarios, is 2010. Most of these occurrences are under the Reservoir Storage Alternative due to the highest trigger elevation of the alternatives at 1,100 feet msl. The probability of these occurrences are within 4 percent except for DNF which is the highest.

2017. In 2017, about halfway through the interim period, the majority of the shortages are less than 1.0 maf. Deeper shortages occur with NPC under all alternatives. With NPC there is a 5 percent occurrence of a 1.2 maf shortage under the Reservoir Storage Alternative which never occurs under DNF. The 15 percent chance of a shortage under the Water Supply Alternative with NPC indicates that Lake Mead is lowest under this hydrology as there is no reduction in demand unless Lake Mead is below 1,000 feet msl.

2026. In 2026, the last year of the interim period, the majority of the shortages still fall below 1.0 maf. However, with all inflow scenarios, a larger portion of the shortages are distributed at deeper levels. Under DP and NPC there are more shortages above 750 kaf than below in the Reservoir Storage Alternative.

2060. In 2060 the majority of the shortages are 500 kaf or below. All alternatives have reverted to No Action Alternative and are all under the same shortage strategy. The distribution of shortage above 500 kaf is similar across all alternatives and inflow scenarios. This indicates that by 2060 the effects of the alternatives have washed out. Lake Mead is receiving a steady release from Lake Powell and therefore does not fluctuate as much as during the interim period.

Table N-9
Distribution and Probability of Lower Basin and Mexico Shortage (percent)
Comparison of Action Alternatives to No Action Alternative for All Alternate Hydrologic Sequences

Shortage (kaf)	Sequence	NA	BS	CBS	WS	RS	NA	BS	CBS	WS	RS
		2010					2017				
0 to 500	ISM	0	2	0	0	0	39	25	0	0	0
	NPC	0	0	0	0	0	30	20	2	15	0
	PS	0	0	0	0	0	25	15	0	7	0
	DP	0	1	0	0	0	34	22	3	9	0
500 to 750	ISM	1	0	0	0	24	0	2	0	0	22
	NPC	1	0	0	0	10	0	5	0	0	15
	PS	6	0	0	0	18	3	3	1	0	14
	DP	0	0	0	0	14	2	5	1	0	14
750 to 1,000	ISM	0	0	0	0	0	1	0	1	0	11
	NPC	0	0	0	0	0	1	7	1	0	14
	PS	0	0	0	0	0	1	3	1	0	11
	DP	0	0	0	0	0	0	5	1	0	19
1,000 to 1,500	ISM	0	0	0	0	0	0	0	0	0	0
	NPC	0	0	0	0	0	6	0	2	0	5
	PS	0	0	0	0	0	2	0	0	0	0
	DP	0	0	0	0	0	2	0	0	0	2
1,500 to 2,000	ISM	0	0	0	0	0	0	0	0	0	0
	NPC	0	0	0	0	0	2	0	2	0	0
	PS	0	0	0	0	0	3	0	0	0	0
	DP	0	0	0	0	0	2	0	1	0	0
2,000 to 2,500	ISM	0	0	0	0	0	0	0	0	0	0
	NPC	0	0	0	0	0	0	0	2	0	0
	PS	0	0	0	0	0	0	0	2	0	0
	DP	0	0	0	0	0	0	0	1	0	0
2,500 +	ISM	0	0	0	0	0	0	0	0	0	0
	NPC	0	0	0	0	0	2	0	3	0	0
	PS	0	0	0	0	0	0	0	0	0	0
	DP	0	0	0	0	0	1	0	1	0	0

Table N-10
Distribution and Probability of Lower Basin and Mexico Shortage (percent)
Comparison of Action Alternatives to No Action Alternative for All Alternate Hydrologic Sequences

Shortage (kaf)	Sequence	NA	BS	CBS	WS	RS	NA	BS	CBS	WS	RS
		2026					2060				
0 to 500	ISM	39	28	2	9	0	55	53	49	53	54
	NPC	24	19	1	22	0	40	41	40	41	40
	PS	33	22	2	12	0	55	56	55	55	56
	DP	36	22	4	17	0	60	60	59	59	60
500 to 750	ISM	2	7	2	0	19	5	5	8	5	5
	NPC	6	4	2	0	8	3	3	3	3	3
	PS	2	7	0	0	16	3	2	2	3	3
	DP	3	8	2	0	13	4	4	5	4	5

Table N-10
Distribution and Probability of Lower Basin and Mexico Shortage (percent)
Comparison of Action Alternatives to No Action Alternative for All Alternate Hydrologic Sequences

Shortage (kaf)	Sequence	NA	BS	CBS	WS	RS	NA	BS	CBS	WS	RS
		2026					2060				
750 to 1,000	ISM	4	0	3	0	18	3	2	2	3	1
	NPC	2	11	0	0	16	4	2	3	3	3
	PS	1	4	5	0	11	2	3	4	2	1
	DP	2	9	2	0	20	3	3	3	3	2
1,000 to 1,500	ISM	0	0	0	0	0	3	3	4	3	4
	NPC	2	0	1	0	6	3	3	4	3	3
	PS	2	0	1	0	3	5	3	3	4	3
	DP	2	0	0	0	3	4	4	5	4	5
1,500 to 2,000	ISM	2	0	1	0	0	4	4	3	4	3
	NPC	1	0	1	0	0	4	5	4	4	4
	PS	1	0	1	0	0	3	3	3	3	4
	DP	3	0	2	0	0	4	5	5	5	4
2,000 to 2,500	ISM	0	0	0	0	0	0	0	0	0	0
	NPC	0	0	4	0	0	1	1	1	1	2
	PS	0	0	0	0	0	2	2	2	1	1
	DP	1	0	3	0	0	2	1	1	1	1
2,500 +	ISM	0	0	0	0	0	0	0	0	0	0
	NPC	6	0	2	0	0	3	3	3	3	3
	PS	1	0	1	0	0	1	1	1	2	1
	DP	2	0	1	0	0	3	3	3	3	3

N.4 References

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Appendix O

Analysis of Power and Energy Impacts to Glen Canyon Dam, Shortage Criteria EIS

This appendix includes the methodology and analysis conducted by the Western regarding energy resources at Glen Canyon Dam Powerplant. The analysis in Section 4.11 uses Western's analysis of generation capacity and its associated economic value.

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O.1 Methodology Overview

The methodology used by the Western Area Power Administration (Western) to estimate the economics of Shortage Criteria Environmental Impact Statement (EIS) alternatives is a multi-step procedure of data processing and computer simulations. A flow diagram depicting the major components of this procedure and component interactions is displayed in Figure O-1. The procedure uses monthly results produced by the Colorado River Simulation System (CRSS) for each of the five EIS alternatives. This includes monthly values of turbine-water releases, power conversion factors, and the physical production capability of the Glen Canyon Dam (GCD) hydropower plant. The CRSS model also simulates operations for other Colorado River System Project (CRSP) reservoirs. However, EIS alternatives only impact the Glen Canyon Dam and are therefore the focus of this analysis.

CRSS results along with operating constraints mandated by the Glen Canyon Dam EIS Record of Decision (ROD) are input into an Excel spreadsheet that prepares input data for a customized variation of the Generation and Transmission Maximization (GTMax) model. To distinguish this customized version from the original model, it is referred to as GTMax-Lite in this document. The Data Processor spreadsheet uses power conversion factors to translate CRSS releases and ROD constraints from water units into a power equivalent. For example, monthly turbine water releases specified in terms of acre-feet (af) in CRSS output tables are converted into an equivalent electricity production in units of Mega-Watt-hours (MWh). The spreadsheet also selects a subset of CRSS results and calculates statistics that are analyzed in more detail by other processes.

Physical monthly operating limits for capacity and energy along with ROD operational constraints are used by the GTMax-Lite model to simulate hourly Glen Canyon Dam power plant generation levels. The model determines the hourly operation schedule over a one-week period (i.e., 168 hours) that maximizes the economic value of the hydropower resource. The operation schedule produced by the model is within the physical limitations of the power plant and it complies with all environmental and institutional regulations.

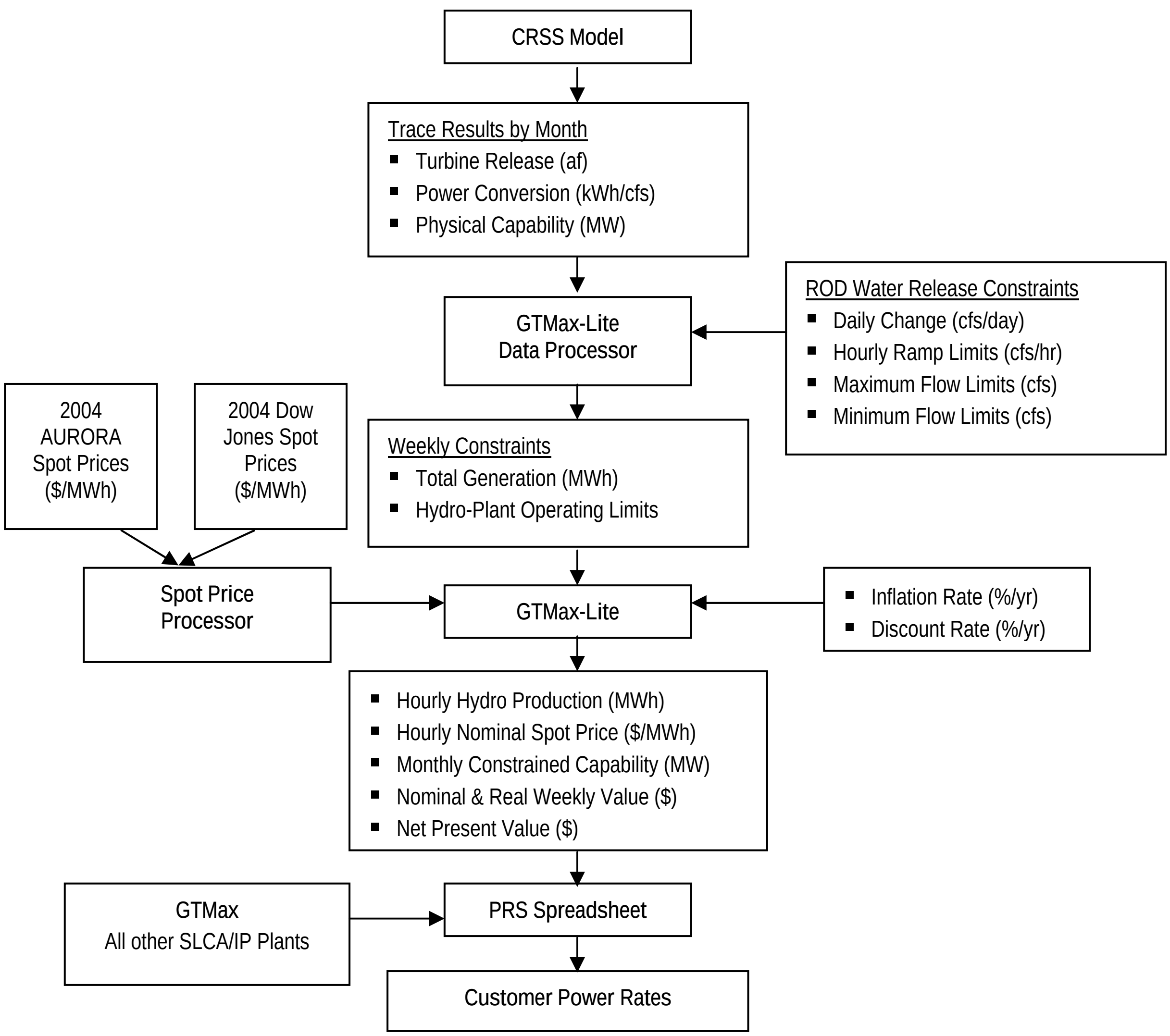
The GTMax-Lite model uses a projection of market prices as a measure of the future economic value of hydropower generation. These prices heavily influence the generation schedule produced by the model when it optimizes the hydropower plant resource. Future hourly price signals are estimated over the study period by a second Excel spreadsheet referred to as the Spot Price Processor. It uses 2004 hourly spot market price patterns produced by the AURORA model (Electric Power Information Solutions, Inc. 2005), an estimate of historical 2004 market prices for the Palo-Verde market hub as reported in the Dow-Jones index, and a nominal inflation rate.

GTMax results include an estimate of the economic value of Glen Canyon power plant capacity and energy production over the simulation period. It also includes an estimate of the hydropower plant maximum production capability taking into account ROD operational constraints. This measure of capacity is mostly, but not always, substantially less than the physical capability of the plant based only on hydrological head; that is, the physical capability estimated by CRSS.

Western customer power rates are calculated using a power repayment study (PRS) spreadsheet-based computer program that contains both general and specific repayment rules associated with a particular hydropower project. This spreadsheet uses GTMax-Lite results for Glen Canyon and from the full-scale GTMax model for all other Salt Lake City Area Integrated Project (SLCA/IP) plants.

A more detailed explanation of the methodology used for the Shortage Criteria EIS is provided in the following sections. This includes both data processing algorithms and the GTMax-Lite simulation model. Detailed explanations of other models, such as CRSS that feed into the process, but are not run by Western, are provided elsewhere.

Figure O-1
Diagram Depicting Major Modeling Components and Processes



O.1.1 CRSS Model

The CRSS model mimics operational decisions that are made for CRSP reservoirs. Since EIS alternatives have unique criteria, each simulation contains alternative-specific operating rules that affect monthly and annual water releases. Monthly release patterns affect the economic value of the hydropower resource since the value of power is highly sensitive to seasonal and hourly variations in market prices. Typically market prices are the highest in the summer and winter seasons. Therefore, from a myopic power viewpoint, water releases would ideally be concentrated during these two seasons. However, from a broader perspective power benefits must be weighted against other operational objectives such as flood control, irrigation, municipal and industrial water supplies, recreation, and the environment.

Shortage Criteria alternatives also affect reservoir forebay elevations and the amount of water that bypass turbines. The forebay elevation determines the hydraulic head and is the primary factor that influences the amount of power that is produced per volume of water released through the turbines. High forebay elevations typically translate into more power production per af of turbine water releases as compared to lower forebay elevations. However, maintaining full or nearly full reservoirs increases the risk of releasing water through bypass tubes and spillways. Sudden unexpected inflows under a full reservoir condition may require reservoir releases that exceed maximum turbine flow rates. Maintaining lower reservoir levels on the other hand will reduce the risk of non-turbine water releases during flood conditions, but it will also increase the risk of lowering the forebay elevation below turbine inlet tubes during droughts. When this occurs, both power production and the plant capacity is zero. Operating rules must therefore balance the risks associated with either having too much or not enough water stored in Lake Powell.

Balancing risks in a basin with large variations of water inflows, such as CRSP, require a full-spectrum examination of hydrological conditions. Therefore, the CRSS model produces numerous simulation results for each month. These results represent a range of plausible futures from which probability distributions of future hydropower conditions are constructed. Distributions are influenced by initial reservoir conditions such that distributions are relatively narrow for near-term projections. This represents a relatively low level of uncertainty about the future. However, as the projection period extends further into the future, the distribution widens as uncertainty grows.

CRSS results include scenario-specific estimates of monthly energy production and physical capability for 99 possible futures throughout the analysis period which extends from the beginning of January 2008 through the end of December 2060. For the Shortage Criteria EIS, forecasts are made by simulating reservoir operations with 99 different sequences of inflows. Each sequence is based on a chronological inflow pattern that has occurred in the past, and is referred to as a trace. Refer to Appendix A for a detailed explanation of CRSS reservoir operating rules and traces.

O.1.2 Hydrological Conditions Studied

Ideally detailed simulations of hourly operations at the Glen Canyon Dam hydropower plant would be performed for each of the 99 traces over the 53 year analysis period. However, it is computationally impractical. Therefore, a simplified approach was used to measure differences among alternatives. This involves analyzing only selected points from the monthly distributions produced by CRSS. The Data Processor spreadsheet computes statistics and extracts pertinent information from the CRSS output.

Western chose four hydrological conditions to study to ensure a representative look at the differences between the alternatives. The four conditions are: Mean, Median, 90% Exceedence, and Trace 94, and are explained below.

Mean: An average value of the 99 CRSS traces was computed for each month of the study period, for each alternative.

Median: The 50th percentile value of the 99 CRSS traces was computed for each month of the study period, for each alternative.

90% Exceedence: The 10th percentile value of the 99 CRSS traces was computed for each month of the study period. 90% exceedence is often referred to as 10th percentile in Western and Reclamation hydrological studies; the two terms are synonymous.

Trace 94: Individual traces of the CRSS output were examined. Trace 94 was selected by Western as representing especially poor conditions for generation at GCD, with periods of no generation due to low Lake Powell reservoir elevations (below 3490'). Trace 94 was selected to examine the difference in performance of the five alternatives under conditions of complete loss of GCD generation for an extended period of time. Trace 94 also allows for examination of a time-connected series of potential GCD operations, showing drops and recoveries of Lake Powell elevation over time. The other three hydrological conditions studied are not time-connected in the same manner that a single trace is.

Mean, median and 90% exceedance values for capability and energy are computed separately. Furthermore, capability statistics are based only on hydrologic head as computed by CRSS. However, under current operating constraints imposed on Glen Canyon, sustainable capability is a function of both the physical powerplant capability and the monthly water release volume (refer to the next section for more details). Although it may be more accurate to compute capacity statistics using both the hydrologic head and monthly water releases, this process would have been very computationally intensive with only a marginal increase in precision. As a simplification, statistical values for <u>physical</u> capability and energy are first calculated and then sustainable capacity is estimated by the GTMax-Lite model using these statistical values.

O.1.3 Glen Canyon Dam Record of Decision

The economics of Shortage Criteria Alternatives is not only a function of monthly water release volumes, but also of physical and institutional limitations on daily and hourly operations. Of particular importance is the Glen Canyon Dam Record of Decision (ROD) that affirmed the selection of the Modified Low Fluctuating Flow Alternative as the preferred operating alternative. The Bureau of Reclamation (Reclamation) issued the operating criteria for Glen Canyon Dam early in 1997. The ROD criteria expanded on the operational rules contained in the Glen Canyon Dam Operation EIS and ROD. It also provided Western and Reclamation staff with guidance on the operation of the dam and the Salt Lake City Area Integrated Projects (SLCA/IP) power system.

The ROD imposed a limit on the maximum allowable release from Glen Canyon Dam to 25,000 cubic feet of water per second (cfs) and included exceptions to the maximum release for Beach/Habitat Building Flows and Habitat Maintenance Flows such as occurred in March 1996. Exceptions were also made to avoid spills or flood flow releases during high runoff years. During high hydropower conditions when the total monthly water release volume is greater than a constant 25,000 cfs release rate throughout the month, the maximum release rate is relaxed. However, releases are restricted to a flat-flow operating regime.

Releases must also be at least 8,000 cfs between the daytime hours of 7:00 a.m. to 7:00 p.m., and 5,000 cfs or more at night. The ROD also set limits on the allowable release fluctuations in any continuous 24-hour period. The amounts vary depending on the volume of water scheduled to be released in a given month. For example, the allowable daily change is 5,000 cfs/24 hours for months in which scheduled water releases through the dam are less than 600 thousand acre feet (kaf). Fluctuations will be held at 6,000 cfs/24 hours for months of scheduled releases between 600 and 800 kaf, and at 8,000 cfs/24 hours for months of scheduled releases greater than 800 kaf/month. Finally, the limits the rate at which the generators may ramp up or down during a one-hour time period. The maximum power plant ramp rates are set at 4,000 cfs per hour increasing and 1,500 cfs per hour decreasing.

O.1.4 GTMax-Lite Data Processor

The Data Processor spreadsheet prepares input data for the GTMax-Lite model by translating CRSS and ROD information from water units into equivalent power and energy units. Equations that are used by the spreadsheet are summarized in Table O-1. For example, the processor multiplies a power conversion factor by the ROD allowable maximum flow rate to compute the maximum power plant output. Power factors are approximated by CRSS for each trace in all study months. The maximum output level computed by the data processor is not always achieved since the maximum daily change restriction and hourly up and down ramp rate limits further constrain operations.

It should be noted that the monthly water releases in table are scaled to represent the amount of water that is released in a typical week. GTMax-Lite model is executed for only one week per study period month. Total generation during this “typical” week is based on CRSS monthly water release volumes times a scaling factor. This factor is equal to the number of days in the week (i.e., 7) divided by the number of days in a simulated month. For example, the scaling factor for January equals 7 divided by 31. The inverse of this factor is used to obtain monthly values by scaling-up weekly results.

Table O-1
Equations for Converting ROD Operating Criteria and CRSS Output

CRSS/ROD Criteria	Power Equivalent for GTMax-Lite Input
Monthly Water Release	$E_w^{pow} = \frac{TR_m^{wat} \times CF_m^{w-p}}{1000} \times \frac{7}{ND_m} \ \forall \ m \mid m = 1, \ldots, NM$
Maximum Release	$C_w^{pow} = \mathrm{Max}\left(C_m^{CRSS}, \frac{MR_m^{wat} \times CF_m^{w-p}}{1000} \times 0.082644 \right) \ \forall \ m \mid m = 1, \ldots, NM$
Maximum Daily Change	$DC_w^{pow} = \frac{DC_m^{wat} \times CF_m^{w-p}}{1000} \times 0.082644 \ \forall \ m \mid m = 1, \ldots, NM$
Hourly Up-Ramp Rate Limit	$HU_w^{pow} = \frac{HU_m^{wat} \times CF_m^{w-p}}{1000} \times 0.082644 \ \forall \ m \mid m = 1, \ldots, NM$
Hourly Down-Ramp Rate Limit	$HD_w^{pow} = \frac{HD_m^{wat} \times CF_m^{w-p}}{1000} \times 0.082644 \ \forall \ m \mid m = 1, \ldots, NM$
Minimum Daytime Release	$DM_w^{pow} = \frac{DM_m^{wat} \times CF_m^{w-p}}{1000} \times 0.082644 \ \forall \ m \mid m = 1, \ldots, NM$
Minimum Nighttime Release	$MN_w^{pow} = \frac{MN_m^{wat} \times CF_m^{w-p}}{1000} \times 0.082644 \ \forall \ m \mid m = 1, \ldots, NM$

where,

m = Simulation month index

w = Simulation week index with one representative week per month

ND_m = Number of simulation days in month m

NM = Number of simulation months; $636 = 12 \times 53$

E_w^{pow} = Weekly generation (MWh) during week w

TR_m^{wat} = Total water volume (AF) released during month m

C_w^{pow} = Weekly capability (MW) during week w

C_m^{CRSS} = CRSS physical capability (MW) during month m

MR_m^{wat} = Maximum release rate (cfs) during month m; dependent on TR_w^{wat}

DC_w^{pow} = Maximum daily change (MW/day) during week w

DC_m^{wat} = Maximum daily change (cfs/day) during month m; dependent on TR_w^{wat}

HU_w^{pow} = Maximum hourly power increase (MW/h) during week w

HU_m^{wat} = Maximum hourly up-ramp rate (cfs/hr) during month m

HD_w^{pow} = Maximum hourly power decrease (MW/h) during week w

HD_m^{wat} = Maximum hourly down-ramp rate (cfs/hr) during month m

MD_w^{pow} = Minimum daytime hourly generation (MWh) during week w

MD_m^{wat} = Minimum daytime release rate (cfs) during month m

MN_w^{pow} = Minimum nighttime hourly generation (MWh) during week w

MN_m^{wat} = Minimum nighttime release rate (cfs) during month m

O.1.5 Market Prices

Representative energy and capacity prices are essential for an economic evaluation of Shortage Criteria Alternatives. Pricing assumptions tend to be controversial because there are many sources of information, and because the price assumed can make a large difference in the resulting valuation of energy and capacity. Some analysts prefer using historical energy and capacity prices because they can be tied to a specific set of purchase transactions. Others prefer to use estimates of future costs under the assumption that historical costs do not necessarily predict future prices. Prices for historical or future energy can be obtained fairly easily from a variety of sources. However, prices for capacity are more difficult to obtain since they are more closely identified to a particular utility or power generation facility and usually are considered proprietary information by the facility owner.

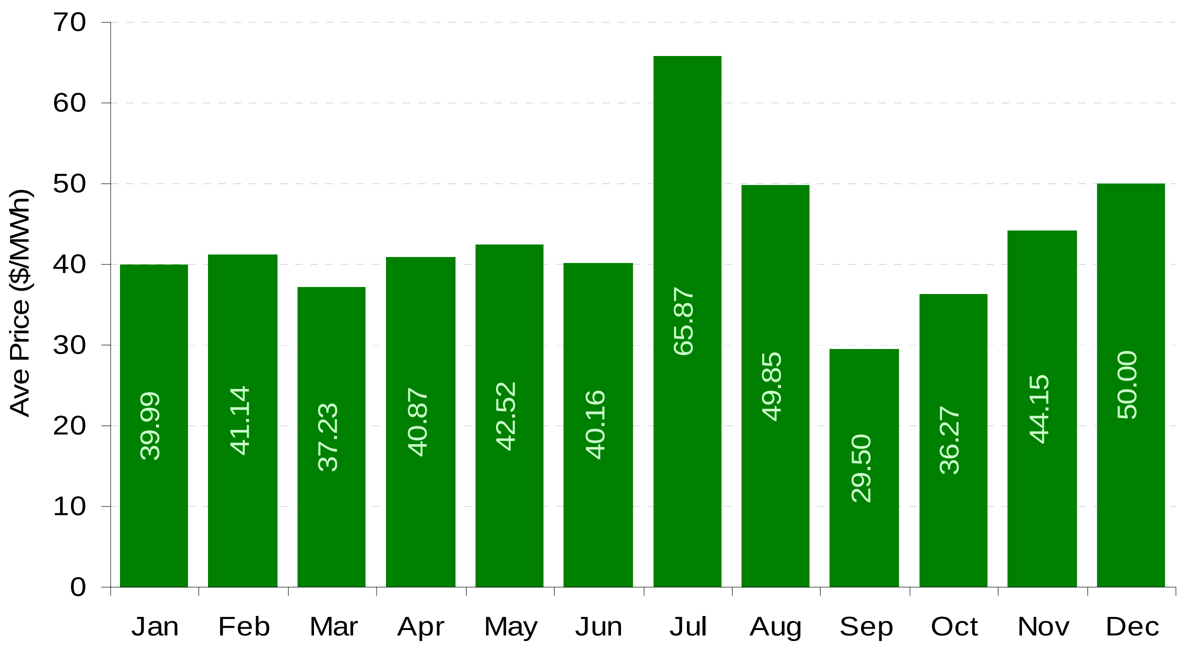
Western coordinated energy prices with Reclamation to ensure that both agencies were using the same data. The two agencies agree upon a method that combined two types of energy prices. These data include a historical price index for the Palo-Verde market hub contained in a Dow Jones, Inc. database and hourly market price patterns produced by the AURORA model. Both the historical and modeled data are for the year 2004. Prices for 2005 were rejected from consideration due to the anomalies caused by fuel supply disruptions resulting from hurricane damage that occurred in the summer and autumn.

A review of hourly 2004 Dow Jones price data identified numerous anomalies such as atypically high prices on several Sundays over the course of the year. There were also long and frequent periods of missing data. Although the Dow Jones month average prices, shown in Figure O-2, are representative and would suffice for Reclamation's monthly energy modeling, the quality of the hourly price data was inadequate for Western's hourly modeling. To eliminate the hourly energy price problems, Reclamation provided Western with AURORA model simulated market prices for 2004. The Aurora model results had hourly and weekly prices that represented typical weekly price profiles, but average price levels were significantly less than historical levels. To match the Dow Jones index prices, the AURORA hourly model output was scaled such that the average monthly values matched the Dow Jones monthly average values. A more detailed description of the scaling process is provided in the next section.

Some of the anomalies associated the Dow Jones, Inc. price index may be a reflection of the energy market that is currently functioning in the WECC and small number of reported transactions that is used to calculate the index. For any given hour the Dow index is the weighted average price for all reported bilateral exchanges. A bilateral exchange is a private transaction between two parties at a negotiated price. It should also be noted that only a small percentage of bilateral contracts are reported to the Dow Jones. Although monthly average prices follow a typical pattern, the extent to which the Dow Jones prices reflect the broader WECC electricity market is not known. This method of price discovery differs from a market price that is determined through a central clearinghouse whereby individual buyers and sellers do not directly communicate with each other. Instead a price is determined by the intersection of supply and demand bid curves.

AURORA model simulations used in this analysis were developed for and used in the Northwest Power and Conservation Council's *Fifth Northwest Electric Power and Conservation Plan* (NWPCC 2005). The Northwest Power and Conservation Council is primarily interested in Northwestern electricity markets. Relatively less attention is devoted to characterizing market conditions in other parts of the WECC region. Consequently, the Palo Verde forecast described in this analysis primarily reflects the default data supplied with the AURORA model.

Figure O-2
Average Market Prices for 2004 Based on the Dow Jones Index



O.1.6 Market Price Processor

The GTMax-Lite model uses a projection of market prices as a measure of the future economic value of hydropower generation. This assumption implies that market prices reflect the marginal economic cost of serving the last megawatts-hour (MWh) of load in the system (i.e., system lambda). Furthermore, Glen Canyon power injections into the grid are minuscule relative to the entire power system in which it operates. Therefore, its operations do not influence the marginal value of energy. Given the size and complexity of the Western Electricity Coordinating Council (WECC) power grid and the markets that it functions in, these assumptions are reasonable. It should also be noted that the relative economic differences among alternatives are of importance, rather than the absolute economic value of a specific alternative.

The Spot Price Processor prepares typical energy price profiles for GTMax based on the AURORA model results. Instead of using each hourly price, typical spot price patterns were computed for three different day types in each month. These include Sunday, weekday, and Saturday. A daily price pattern is obtained by computing an average hourly price for each similar hour. For example, the weekday price at 1:00 AM is the average of AURORA prices at 1:00 AM for all days in a month that are between Monday and Friday, inclusive. Each day of the month is then assigned hourly prices depending on the month and type of day. For example, every weekday in January is assigned the average price pattern for January weekdays.

The final step of the process scales monthly prices to match the simple (i.e., unweighted) mean of hourly Palo-Verde prices contained in the Dow Jones database. These monthly average prices follow a typical seasonal pattern for the Southwestern United States. Prices are the highest during the summer months reflecting an elevated demand for air conditioning. On the other hand, prices during the spring and autumn seasons are relatively low. Winter prices are somewhat higher than these shoulder seasons as loads are elevated by more lighting and heating demands. Prices are inflated to approximate hourly prices for future years. For this analysis, the annual inflation rate is assumed to be 2.2 percent.

The use of typical (i.e., average) hourly price profiles to estimate Glen Canyon power plant generation patterns is more realistic than estimating generation patterns based on individual hourly prices. This is in part due to the recognition that power marketers have excellent foresight regarding overall daily price patterns over the upcoming week, but the magnitude and individual hourly variations from the typical pattern cannot be accurately predicted. In contrast, the GTMax model has perfect foresight and if provided with the detailed price profile it will react to each individual “perfectly predicted” price. When GTMax is provided with the typical or average pattern, it produces a generation pattern that more closely emulates actual energy scheduling practices.

Market prices have a profound influence on generation schedules prepared by power marketers as well as those produced by optimization models. Figures O-3 and O-4 show hourly used by GTMax for a winter month, December, and for a summer month, July. The hourly price pattern for weekdays in December follows a typical winter profile with two separate daily peaks. The first peak occurs in the morning followed by a midday price slump. Prices rise again in the evening reaching a high between 6 PM to 8 PM. The lowest prices hours are in the middle of the night, bottoming out at 2 AM to 4 AM. Prices are somewhat lower during the weekends, especially on Sunday. Also weekend hourly price patterns deviate somewhat from weekday price profiles.

While winter prices exhibit a two-hump price pattern, prices during the summer months peak only once during the day – typically in the late afternoon between 4 PM to 6 PM during the hottest part of the day. Similar to the wintertime, prices are at a minimum in the middle of the night.

Figure O-3
December AURORA Prices Scaled to the Dow Jones Monthly Average

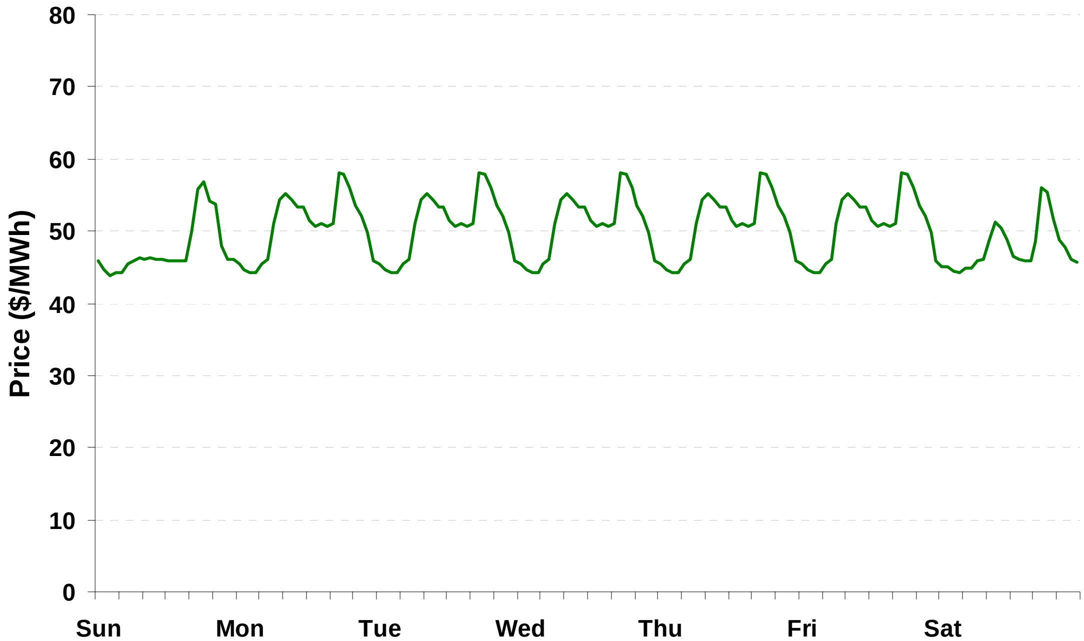
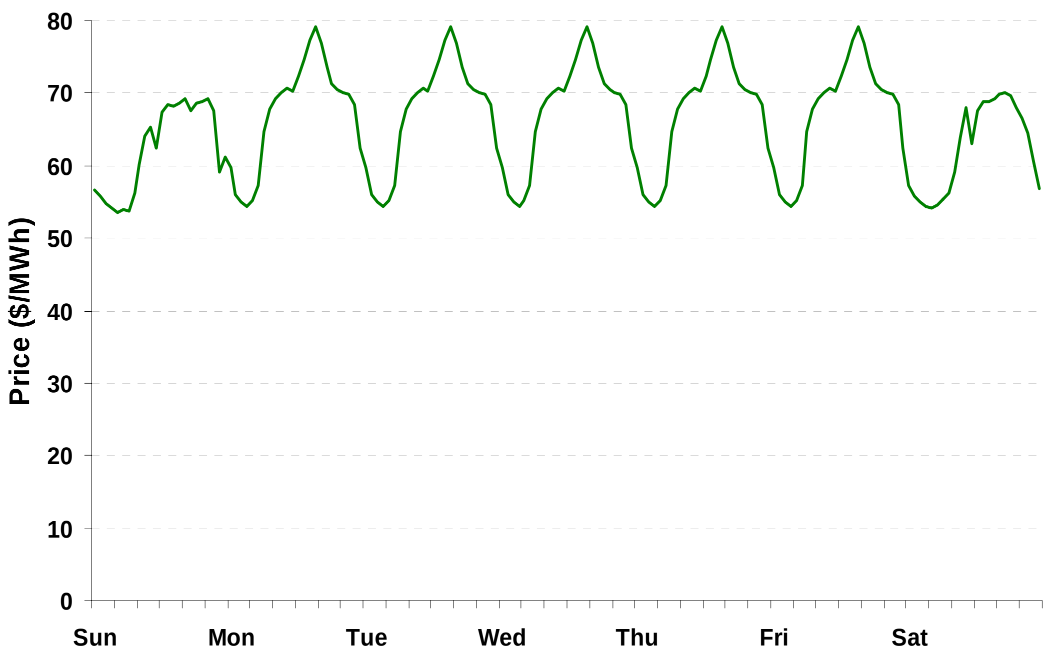


Figure O-4
July AURORA Prices Scaled to the Dow Jones Monthly Average



O.1.7 GTMax-Lite Model

Western and Argonne National Laboratory simulated Glen Canyon hydropower plant operations on an hourly time step the with the GTMax-Lite modeling software. GTMax-Lite is similar to the full version of the GTMax model except it only contains those features that are required to perform an economic evaluation of Shortage Criteria Alternatives. Model run time and data transfers are significantly shorter, while a level of simulation accuracy equivalent to the full version is retained.

The GTMax-Lite objective function is to produce an hourly generation schedule over a one-week time period that maximizes the economic value of the hydropower resource. Market prices input into the model convey the economic value of hydropower generation. These prices heavily influence the generation schedule produced by the model when optimizing the hydropower plant resource. To the extent possible the GTMax-Lite model uses its limited energy resource to first generate electricity during on-peak hours when it has the highest economic value. Any remaining energy is scheduled during lower-priced hours.

Glen Canyon power plant operations are subject to a set of constraints. These include a physical operating capability and a limit on the total weekly electricity production. As described in previous sections, these constraints are consistent with CRSS model results. In addition to physical operating constraints, the GTMax-Lite model also complies with the ROD Criteria. Table O-2 contains the GTMax-Lite mathematical formulations consisting of an objections function and a set of operating constraints.

In practice, hydropower plant operations do not always strictly follow an economic optimization regime as suggested by mathematical models. This occurs because models are a simplification of reality and typically only include those elements that can be described in the form of in mathematical equations. In GTMax-Lite, equations are used to model the power plant based on an economic maximization function subject to physical and legal operating limits. However, marketers must often include other important factors which result in operations that often deviate from the simplified mathematical optimal. Some of these factors include individual risk tolerance levels and intricacies associated with bilateral contracts, block spot purchase patterns, grid limitations, and power exchanges and interchanges. Other factors not included in GTMax-Lite are general agreements that have been made with affected parties, but that are not contained in a legally binding decree.

Despite its limitations, the GTMax-Lite model usually simulates daily and hourly generation patterns that are similar to actual operations. However, compared typical operations, the GTMax-Lite model will at times schedule less power during the weekend when market prices are low, shifting more power to higher-priced weekdays. Although operations comply with ROD constraints, the GTMax-Lite schedule may have some detrimental implications for the environment. Therefore, additional constraints that specify a minimum allocation of daily generation among the days of the weeks are incorporated into the GTMax-Lite mathematical formulation.

Daily minimums are specified as the ratio of daily generation during a weekend day relative to the average daily generation during a weekday. For example, a value of 0.9 assigned to Saturday requires that the total generation during that day must be at least 90 percent of a weekday's generation. Values assigned to the daily generation restrictions are based on historical operations and vary by month as shown in Table O-3. Minimum daily generation levels are often not binding in the model and water releases scheduled by GTMax-Lite on Saturday and Sunday frequently are more than the minimum.

Glen Canyon power plant operations simulated by GTMax-Lite under median hydrological conditions for a typical week in the wintertime, 2^{nd} week in December, 2010, are depicted in Figure O-5. To maximize the economic value of the hydropower resource, the model generates as much power as possible during hours when market prices are the highest. Generation tends to drop as the spot price decreases; for example, during the midday price valley. Generation during on-peak hours are constrained by the ROD daily change, reaching a peak of about 610 megawatts (MW). That is substantially less than (approximately half) the median capability of 1,205 megawatts (MW) estimated by CRSS based on the Powell Reservoir forebay elevation.

Simulated operations during the summertime also tend to follow prices. As shown in Figure O-6, Glen Canyon generation exhibits a one-hump pattern that has a shape similar to the market price profile. Simulated operations are for July 2010 under median conditions. Comparable to the wintertime, peak generation levels are constrained to slightly more than 600 megawatts (MW) despite a hydrological head that is capable of supporting generation levels of approximately 1,232 MW.

Under dry hydrological conditions, maximum generation levels simulated by GTMax-Lite drop even further. Figure O-7 shows that on-peak production levels are less than 475 MW. Under the driest conditions, forebay elevations dip below turbine water inlet tubes resulting in zero monthly electricity generation and zero power plant capacity.

Table O-2
GTMax-Lite Equations

Description	GTMax-Lite Equation
Objective Function	$Maximize: \quad SP_h \times Gen_h \quad \forall\ h \mid h = 1,\ldots,168$
Maximum Hourly Generation	$Gen_h \le C_w^{pow} \quad \forall\ h \mid h = 1,\ldots 168$
Weekly Generation	$WGen_w = \sum_{h=1}^{168} Gen_h$
Maximum Daily Change	$DC_w^{pow} \ge Gen_{j+k-wrap} - Gen_j \quad \forall\ j \mid j = 1,\ldots,168$ and for each $j,\ k = 1,\ldots,23$ $when\ j + k > 168,\ wrap = j + k - 168\ else\ wrap = 0$
Hourly Up-Ramp Rate Limit	$HU_w^{pow} \ge Gen_h - Gen_{h-1+Wrap} \quad \forall\ h \mid h = 1,\ldots 168$ when $h > 1$ $wrap = 0$ else $wrap = 168$
Hourly Down-Ramp Rate Limit	$HD_w^{pow} \ge Gen_{h-1+wrap} - Gen_h \quad \forall\ h \mid h = 1,\ldots 168$ when $h > 1$ $wrap = 0$ else $wrap = 168$
Minimum Daytime Release	$MD_w^{pow} \le Gen_h \quad \forall\ h \mid h = 1,\ldots,7,20,\ldots,31,44,\ldots,55,68,\ldots,79,92,\ldots,103,$ $116,\ldots,127,140,\ldots,151,164,\ldots 168$
Minimum Nighttime Release	$MN_w^{pow} \le Gen_h \quad \forall\ h \mid h = 8,\ldots,19,32,\ldots,43,56,\ldots,67,80,\ldots,91,104,\ldots,115,$ $128,\ldots,139,152,\ldots,163$
Daily Generation	$DGen_d = \sum_{i=1}^{24} Gen_{(d-1)\times 24+i} \quad \forall d \mid d = 1,\ldots,7$
Minimum Daily Generation for Weekend Days	$DGen_d \ge DGen_2 \times DMin_d \quad \forall d \mid d = 1,7$
Identical Weekday Total Generation Levels	$DGen_2 = DGen_d \quad \forall d \mid d = 3,4,5$

where,

$h =$ Simulation hour index

$d =$ Simulation day index where 1=Sun, 2= Mon, etc.

$wrap =$ index parameter to address temporal boundary conditions

$Gen_h =$ Average generation level (MWh) during hour h

$SP_h =$ Spot market price index ($/MWh) for hour h

$WGen_w =$ Total generation (MWh) during week w

$DGen_d =$ Total generation (MWh) during day d

$DMin_d =$ Minimum daily generation fraction for day d (see Table X)

Table O-3
Daily Generation Fractions for Weekend Days

Month	Sunday	Saturday
January	0.86349	0.88511
February	0.86861	0.94269
March	0.90666	0.94367
April	0.91358	0.98481
May	0.93182	0.95657
June	0.86247	0.89126
July	0.94368	0.96479
August	0.92117	0.94085
September	0.95205	0.96890
October	0.97621	0.97621
November	0.94810	0.98237
December	0.90623	0.96419

Figure O-5
Glen Canyon Powerplant Operations under Median Winter Conditions

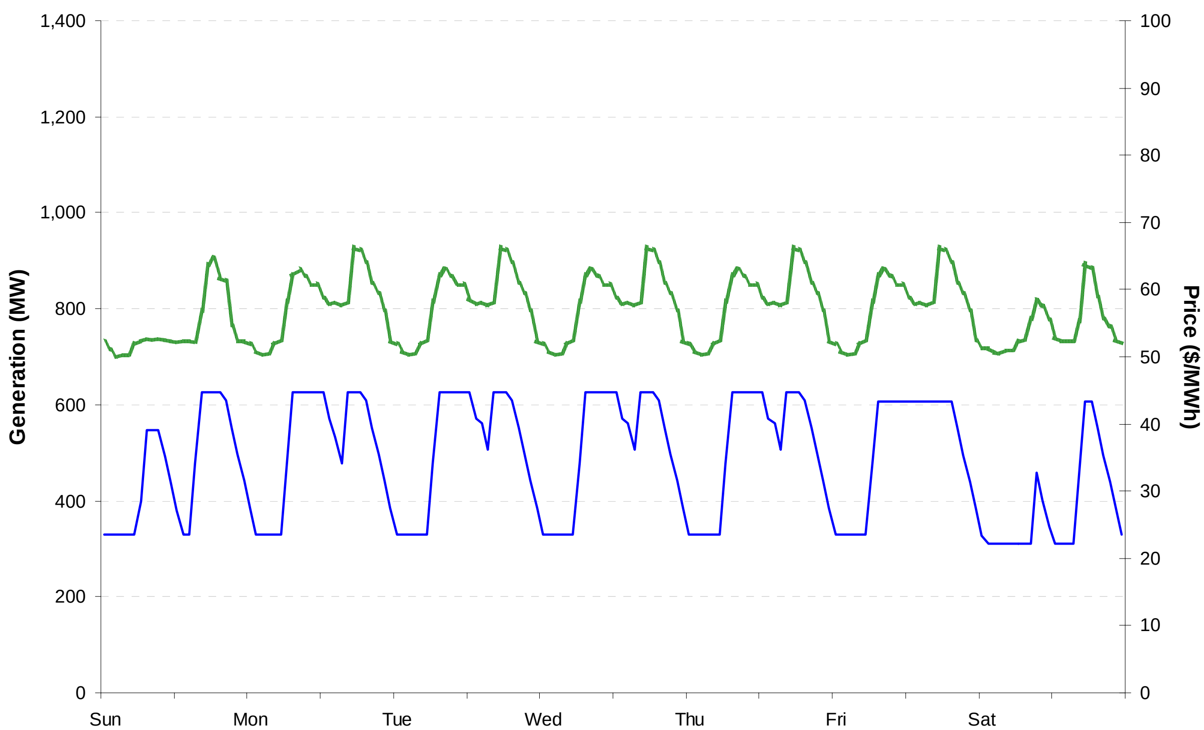


Figure O-6
Glen Canyon Powerplant Operations under Median Summer Conditions

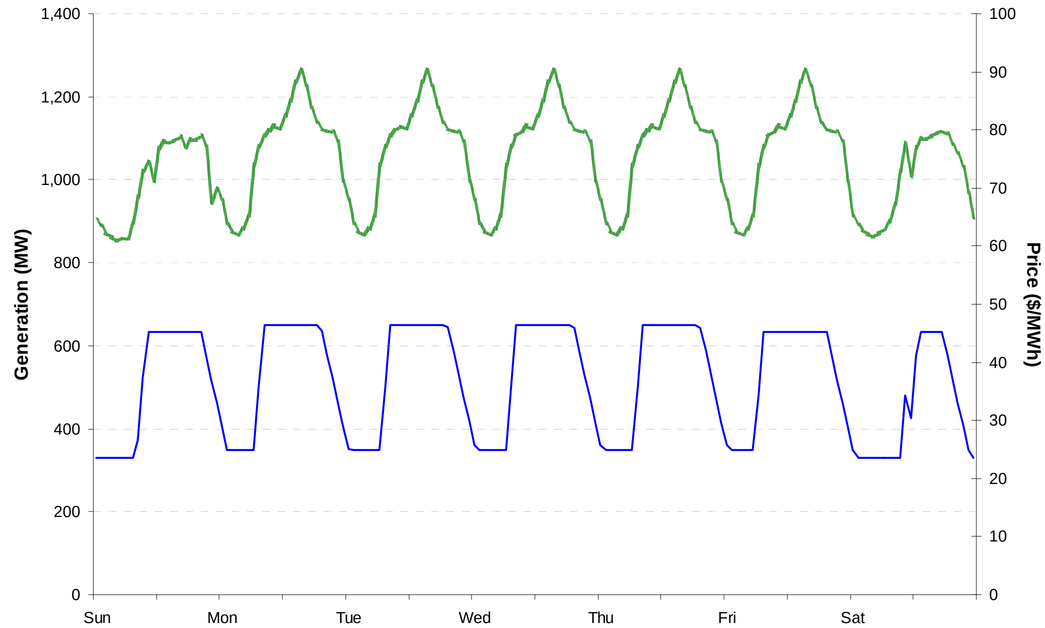
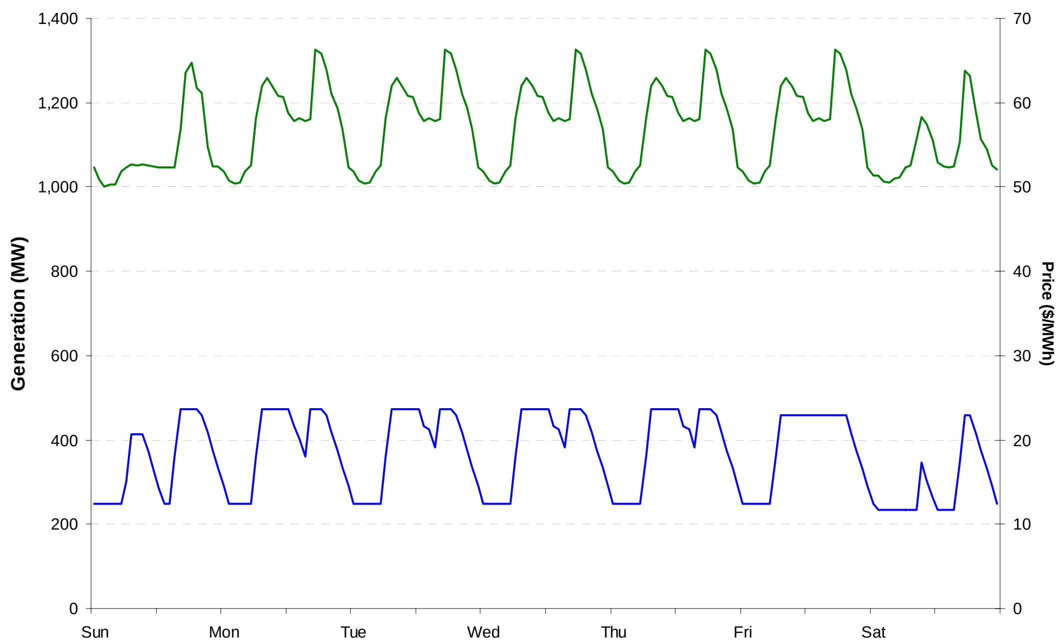


Figure O-7
Glen Canyon Powerplant Operations under Dry Winter Conditions



O.1.8 Economic Calculations

The economic value of the Glen Canyon Dam energy is computed by multiplying power plant generation estimated by GTMax-Lite by the market price. Since the model only simulates operations for one representative week in each month, economic values are scaled. This scaling factor equals the number of days in a projection month divided by 7. A net present value (NPV) of the monthly economic values over the study period was calculated by discounting monthly values at an annual rate of 4.875%. When discounting, it was assumed that the stream of hourly economic benefits in a month occurred mid-month as a single lump-sum value.

Differences in annual energy and capacity generation were calculated between the No Action Alternative and each Action Alternative. The annual capacity difference in terms of megawatts was assigned a value using a capacity price of $6.32/kilowatt-month. That price represents the market value of generation in 2007 dollars. For valuing capacity, Western obtained a cost of constructing a new combined cycle natural gas power plant. Capacity was valued at the replacement cost identified by some SLCA/IP customer utilities who have recently constructed facilities which provide load following capacity. These customer data were collected in order to get information regarding the construction cost per megawatt of a recently built facility that provides electrical services similar to the GCD power plant.

This value is higher than the average cost of capacity from existing facilities on the system, but was selected for two reasons. 1) Over the 53 year study period, available capacity from existing sources will not be adequate to serve growing loads. New capacity will have to be built. 2) Renewable resource requirements in states such as California could cause new capacity costs to escalate at a rate faster than the 2.2% assumed in this analysis.

The two Western offices performing analyses coordinated capacity values, so the same capacity values were used for GCD and for the Lower Basin power plants.

Capacity values were converted to a present value using the same method as for energy, and were then added to the energy present value to obtain a total value of the difference in generation between the No Action alternative and each Action alternative. Reclamation did not value capacity differences in their analysis.

O.2 Results of Western's Analysis

Western Area Power Administration's financial analysis of the alternatives concentrated on the effect each alternative has on energy generation and capacity generation at Glen Canyon Dam (GCD). The effects are measured by the difference in generation in gigawatthours (GWh) of energy and megawatts (MW) of capacity between the No Action alternative and each of the Action alternatives, for the four representative hydrological conditions outlined above. The analysis includes the economic effect of changes to capacity and energy calculated by applying energy and capacity costs to the changes in generation. Finally, a NPV calculation was performed to develop a single value to compare each Action alternative to No Action. The sections below break down the results of the analysis into each of the aspects studied.

O.2.1 Glen Canyon Dam Energy Generation

The energy generation at GCD for each alternative was summed over the 53-year study (2008-2060) period and is displayed in Table O-4 below in GWh. (One GWh is equal to 1 million kilowatt hours.) The difference in generation of the Action alternatives as compared to No Action is shown in Table O-5. Table O-6 has those same differences as percentages.

Table O-4
Energy Generation

Alternatives	Generation Mean GWh	Generation Median GWh	Generation 90% Exceed GWh	Generation Trace 94 GWh
No Action	4,261.89	3,747.44	3,159.31	4,319.24
Basin States	4,249.67	3,799.02	3,081.67	4,623.61
Conservation Before Shortage	4,251.35	3,799.67	3,089.61	4,423.55
Water Supply	4,149.86	3,784.11	2,956.92	4,391.75
Reservoir Storage	4,291.84	3,768.42	3,160.89	4,389.03

Table O-5
Change in Energy Generation

Alternatives	Change in Generation Mean GWh	Change in Generation Median GWh	Change in Generation 90% Exceed GWh	Change in Generation Trace 94 GWh
No Action	0.00	0.00	0.00	0.00
Basin States	(12.21)	51.57	(77.64)	304.37
Conservation Before Shortage	(10.54)	52.23	(69.70)	104.31
Water Supply	(112.03)	36.67	(202.39)	72.51
Reservoir Storage	29.96	20.98	1.57	69.79

Table O-6
Percent Change in Energy

Alternatives	Change in Generation Mean Percent	Change in Generation Median Percent	Change in Generation 90% Exceed Percent	Change in Generation Trace 94 Percent
No Action	0.00%	0.00%	0.00%	0.00%
Basin States	(0.21%)	0.98%	(1.74%)	5.17%
Conservation Before Shortage	(0.18%)	0.99%	(1.56%)	1.77%
Water Supply	(1.89%)	0.70%	(4.54%)	1.23%
Reservoir Storage	0.51%	0.40%	0.04%	1.19%

O.2.2 Glen Canyon Dam Capacity Generation

Generation of capacity at GCD was calculated and averaged over the same study period as shown in Table O-7. The numbers in the table represent the average peak capacity output of GCD in megawatts, and is much lower than the power plant capability based on lake elevation. Table O-8 displays the difference between each alternative and the No Action alternative. Table O-9 has those same differences as percentages.

Table O-7
Capacity Generation

Alternatives	Average Capacity Mean Megawatts	Average Capacity Median Megawatts	Average Capacity 90% Exceed Megawatts	Average Capacity Trace 94 Megawatts
No Action	602.98	546.23	455.22	605.14
Basin States	606.42	552.41	442.55	647.20
Conservation Before Shortage	606.61	552.42	443.77	620.07
Water Supply	591.77	550.31	425.11	615.60
Reservoir Storage	612.57	549.08	452.74	614.20

Table O-8
Change in Capacity Generation

Alternatives	Change in Capacity Mean Megawatts	Change in Capacity Median Megawatts	Change in Capacity 90% Exceed Megawatts	Change in Capacity Trace 94 Megawatts
No Action	0.00	0.00	0.00	0.00
Basin States	3.44	6.18	(12.67)	42.06
Conservation Before Shortage	3.63	6.20	(11.45)	14.93
Water Supply	(11.21)	4.08	(30.11)	10.47
Reservoir Storage	9.59	2.85	(2.48)	9.06

Table O-9
Percent Change in Capacity

Alternatives	Change in Capacity Mean Percent	Change in Capacity Median Percent	Change in Capacity 90% Exceed Percent	Change in Capacity Trace 94 Percent
No Action	0.00%	0.00%	0.00%	0.00%
Basin States	0.06%	0.12%	(0.28%)	0.71%
Conservation Before Shortage	0.06%	0.12%	(0.26%)	0.25%
Water Supply	(0.19%)	0.08%	(0.68%)	0.18%
Reservoir Storage	0.16%	0.05%	(0.06%)	0.15%

O.2.3 Present Value of Energy

The NPV of energy generation at GCD was calculated for each Alternative at each hydrological condition. Each of the Action alternatives was compared to the No Action alternative to determine the difference in NPV of energy generation in GWh over the study period. Table O-10 shows the NPV of each alternative studied. Table O-11 displays the difference between each of the Action alternatives and the No Action alternative. Table O-12 has those same differences as percentages.

Table O-10
PV of Energy

Alternatives	NPV Mean $ Million	NPV Median $ Million	NPV 90% Exceed $ Million	NPV Trace 94 $ Million
No Action	$5,913.18	$5,263.89	$4,458.09	$5,887.55
Basin States	$5,979.28	$5,368.44	$4,309.47	$6,647.15
Conservation Before Shortage	$5,981.13	$5,369.32	$4,323.33	$6,107.39
Water Supply	$5,855.53	$5,352.21	$4,154.08	$6,062.79
Reservoir Storage	$6,039.16	$5,298.89	$4,428.16	$6,032.95

Table O-11
Dollar Change in PV of Energy

Alternatives	Change in NPV Mean $ Million	Change in NPV Median $ Million	Change in NPV 90% Exceed $ Million	Change in NPV Trace 94 $ Million
No Action	$0.00	$0.00	$0.00	$0.00
Basin States	$66.10	$104.55	($148.62)	$759.60
Conservation Before Shortage	$67.95	$105.43	($134.75)	$219.84
Water Supply	($57.65)	$88.32	($304.01)	$175.23
Reservoir Storage	$125.98	$35.00	($29.93)	$145.39

Table O-12.
Percent Change in PV of Energy

Alternatives	Change in NPV Mean Percent	Change in NPV Median Percent	Change in NPV 90% Exceed Percent	Change in NPV Trace 94 Percent
No Action	0.00%	0.00%	0.00%	0.00%
Basin States	1.12%	1.99%	(3.33%)	12.90%
Conservation Before Shortage	1.15%	2.00%	(3.02%)	3.73%
Water Supply	(0.97%)	1.68%	(6.82%)	2.98%
Reservoir Storage	2.13%	0.66%	(0.67%)	2.47%

O.2.4 Present Value of Capacity and Energy and Capacity Combined

Table O-13 displays the combined change in NPV of energy in Table O-11 above and capacity in Table O-15 below. The difference values shown in Tables O-11, O-13, and O-15 all refer back to the No Action values shown in Table O-10. Tables O-14 and O-16 are the differences in Table O-13 and O-15 shown as percentages.

Table O-13
Change in PV, Energy & Capacity

Alternatives	Change in NPV Mean $ Million	Change in NPV Median $ Million	Change in NPV 90% Exceed $ Million	Change in NPV Trace 94 $ Million
No Action	$0.00	$0.00	$0.00	$0.00
Basin States	$75.96	$125.59	($183.66)	$927.22
Conservation Before Shortage	$78.11	$126.43	($166.36)	$272.03
Water Supply	($78.86)	$105.23	($374.12)	$213.56
Reservoir Storage	$148.67	$42.48	($41.53)	$176.72

Table O-14
Percent Change in PV of Capacity

Alternatives	Change in NPV Mean Percent	Change in NPV Median Percent	Change in NPV 90% Exceed Percent	Change in NPV Trace 94 Percent
No Action	0.00%	0.00%	0.00%	0.00%
Basin States	1.28%	2.39%	(4.12%)	15.75%
Conservation Before Shortage	1.32%	2.40%	(3.73%)	4.62%
Water Supply	(1.33%)	2.00%	(8.39%)	3.63%
Reservoir Storage	2.51%	0.81%	(0.93)	3.00%

Table O-15
Dollar Change in PV of Capacity

Alternatives	Change in NPV Mean $ Million	Change in NPV Median $ Million	Change in NPV 90% Exceed $ Million	Change in NPV Trace 94 $ Million
No Action	$0.00	$0.00	$0.00	$0.00
Basin States	$9.87	$21.04	($35.04)	$167.62
Conservation Before Shortage	$10.15	$21.00	($31.61)	$52.19
Water Supply	($21.22)	$16.91	($70.11)	$38.32
Reservoir Storage	$22.68	$7.48	($11.61)	$31.33

Table O-16
Percent Change in PV of Capacity

Alternatives	Change in NPV Mean Percent	Change in NPV Median Percent	Change in NPV 90% Exceed Percent	Change in NPV Trace 94 Percent
No Action	0.00%	0.00%	0.00%	0.00%
Basin States	0.17%	0.40%	(0.79%)	2.85%
Conservation Before Shortage	0.17%	0.40%	(0.71%)	0.89%
Water Supply	(0.36%)	0.32%	(1.57%)	0.65%
Reservoir Storage	0.38%	0.14%	(0.26%)	0.53%

O.2.5 Impact to Western Area Power Administration's SLCA/IP Firm Power Rate

Western performed a rate analysis of the present value results summarized in Table O-13 above. Table O-17 shows the results of the analysis on the SLCA/IP firm power rate, while Table O-18 shows the difference of each alternative as compared to the No Action alternative, both in mills/kWh and in percent change. Because of time constraints, the rate analysis was confined to the Median and 90% exceedence hydrological conditions (The 90% exceedence No Action SLCA/IP rate is a cursory study meant to illustrate the higher rate at low hydrologic levels. It shouldn't be interpreted as the result of a thorough rate PRS.) An explanation of the methodology Western used to perform the rate analysis is presented below Tables O-17 and O-18.

Table O-17
SLIP Firm Power Rate

Alternatives	Mill/kWh SLIP Rate Median	Mill/kWh SLIP Rate 90% Exceed
No Action	25.28	27.34
Basin States	23.43	29.15
Conservation Before Shortage	23.43	29.13
Water Supply	23.36	28.86
Reservoir Storage	24.89	29.64

Table O-18
Change in SLIP Firm Power Rate

Alternatives	Mill/kWh Change in SLIP Rate Median	Percent Change in SLIP Rate Median	Mill/kWh Change in SLIP Rate 90% Exceed	Percent Change in SLIP Rate 90% Exceed
No Action	0.00	0.00%	0.00	0.00%
Basin States	(1.85)	(7.32%)	1.81	6.62%
Conservation Before Shortage	(1.85)	(7.32%)	1.79	6.55%
Water Supply	(1.92)	(7.59%)	1.52	5.56%
Reservoir Storage	(0.39)	(1.54%)	2.30	8.41%

O.3 Customer Rates

Western sets rates for firm electric service from Federal hydropower projects in its marketing territory based on Department of Energy regulations and applicable Federal statutes. Power rates are calculated using what is referred to as a power repayment study. The PRS is a special spreadsheet-based computer program that contains the general and any specific repayment rules associated with a particular hydro project such as the SLCA/IP. [The SLCA/IP comprises the Colorado River Storage Project (CRSP), Rio Grande, Collbran, Dolores, and Seedskadee Projects, consolidated for marketing and ratemaking purposes.] When coupled with pertinent project historical data and future projections, the PRS calculates the power rate that is charged to customers who receive SLCA/IP power. The PRS ensures that all identified project costs are repaid within the time frames established by law and regulation.

For the rate analysis work done for this report, two base case PRS's were developed. There two base cases correspond to the power rates for the No Action alternatives at Median and 90% Exceedence hydrological conditions. The first is basically the same as the PRS Western used for its current firm power rate. This case is based on Median hydrological conditions, meaning that it includes firming purchase cost estimates for future years based on Median generation estimates. The second base case is the same as the first, except that future firming purchase estimates are based on 90% exceedence (10^{th} percentile) estimates of future generation, and firming purchases.

These two base case PRS's produce a rate of 25.28 mills per KWh (Median) and 27.34 mills per KWh (90% Exceedence). Once the base case PRS's are done, the difference in NPV dollars of each Action alternative as compared to the No Action alternative is inserted into the PRS's and a change in the power rate is computed. These PRS results are what are displayed in Tables 5 and 5a above.

O.4 Discussion of Results

Overall, at all hydrological conditions, the Reservoir Storage alternative provides the most favorable conditions for power at GCD, while the Water Supply alternative provides the worst results for power generation, based on the above financial analysis. The Basin States and Conservation Before Shortage alternatives show similar results and are ranked between the Reservoir Storage alternative and the Water Supply alternative in their effect on power resources at GCD.

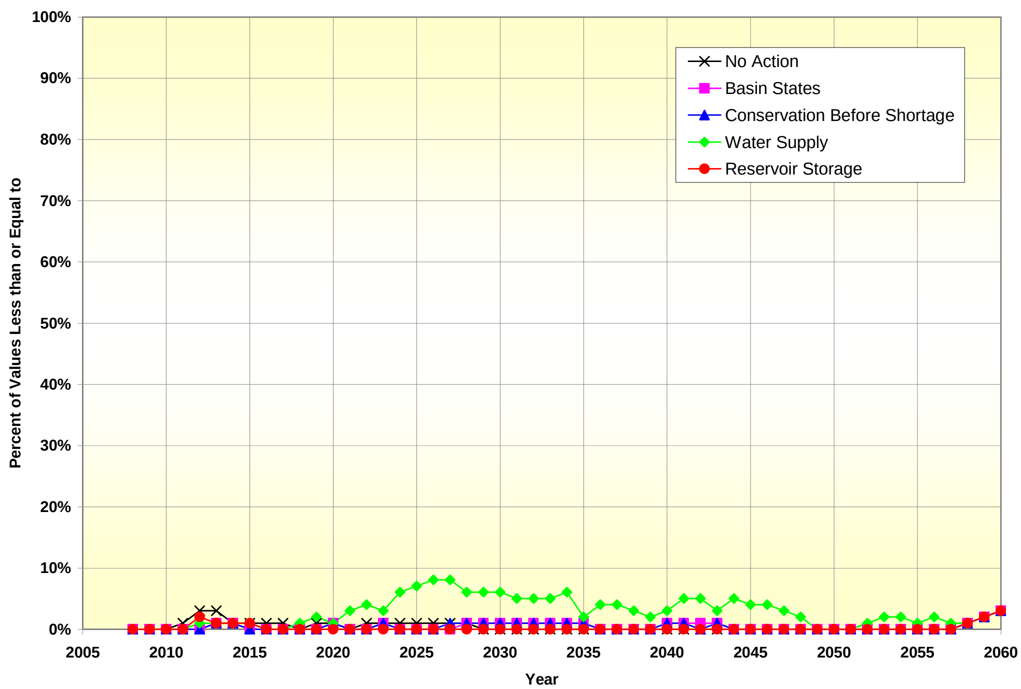
One result is common to Table 5a as well in the preceding tables. At 90% exeedence level, the Action alternatives show consistently worse results (lower energy and capacity generation, lower NPV, higher SLCA/IP rate) than the No Action alternative. Likewise, at Median conditions, the Action alternatives show better results than the No Action alternative. Results at the Mean conditions are more mixed, with some results being better under No Action, and others at one or more of Action alternatives. Trace 94 shows consistent improvement in results of the Action alternatives as compared to No Action.

The practical effect of Action alternatives is to produce a widening effect on power generation, revenues, and rates as hydrological conditions range from wet to dry and back to wet. As conditions get drier, generation drops more under the Action alternatives as compared to No Action. Conversely, as conditions go from drier to wetter, generation improves more under the Action alternatives as compared to No Action. This could result in more variation in the CRSP Basin Fund cash reserves, and could lead to additional actions, such as power rate adjustments, rate surcharges, or reductions to customer allocations to respond to shortfalls in revenue under dry conditions. Under the Action alternatives, Western and its power customers would need to quickly respond to changing hydrological conditions to forestall financial problems.

Notwithstanding the financial analysis discussed above, the most important aspect of any of the Action alternatives to Western and the firm power customers is whether and how much the alternative reduces the probability of a total loss of generation from GCD. Loss of GCD generation would result in a huge loss of revenue to Western, Reclamation and various environmental programs in the Upper Basin; loss of generation and replacement costs for power customers; and degradation to power system reliability.

Figure O-8 below is a graph showing the percentage of trace monthly elevations from Reclamation's CRSS modeling output that are less than or equal to elevation 3490'. This graph is an indicator of how well each alternative is able to forestall a shutdown of GCD generation as compared to the No Action alternative.

Figure O-8
Lake Powell End-of-March Elevations
Comparison of Action Alternatives to No Action Alternative
Percent of Values Less Than or Equal to Elevation 3490 feet msl



Using this measure, the Water Supply alternative is much worse than the No Action alternative, while the Reservoir Storage, Basin States, and Conservation before Shortage alternatives are equal to or slightly better than No Action.

O.5 References Cited

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Ouarda, Taha B.M.J. John W. Labadie and Darrell G. Fontane. “Indexed Sequential Hydrologic Modeling for Hydropower Capacity Estimation.” *Journal of the American Water Resources Association*. 33 No. 6 (December 1997):1337-1349.

Appendix P

Additional CRSS Modeling Output

This Appendix contains additional supporting CRSS modeling output. Figures in this appendix consists of hydrologic information that is referenced in the Water Quality, Air Quality, Biological Resources, Cultural Resources, Electrical Power Resources, and Water Delivery Sections.

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Table of Contents

Water Quality

Air Quality

Biological and Cultural Resources

Electrical Power Resources

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Water Quality

This section contains additional CRSS modeling output referenced in the Water Quality Section.

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Figure P-1
Colorado River Salinity Below Hoover Dam
Comparison of Action Alternatives to No Action Alternative
Flow-weighted Annual Average Salinity Concentrations

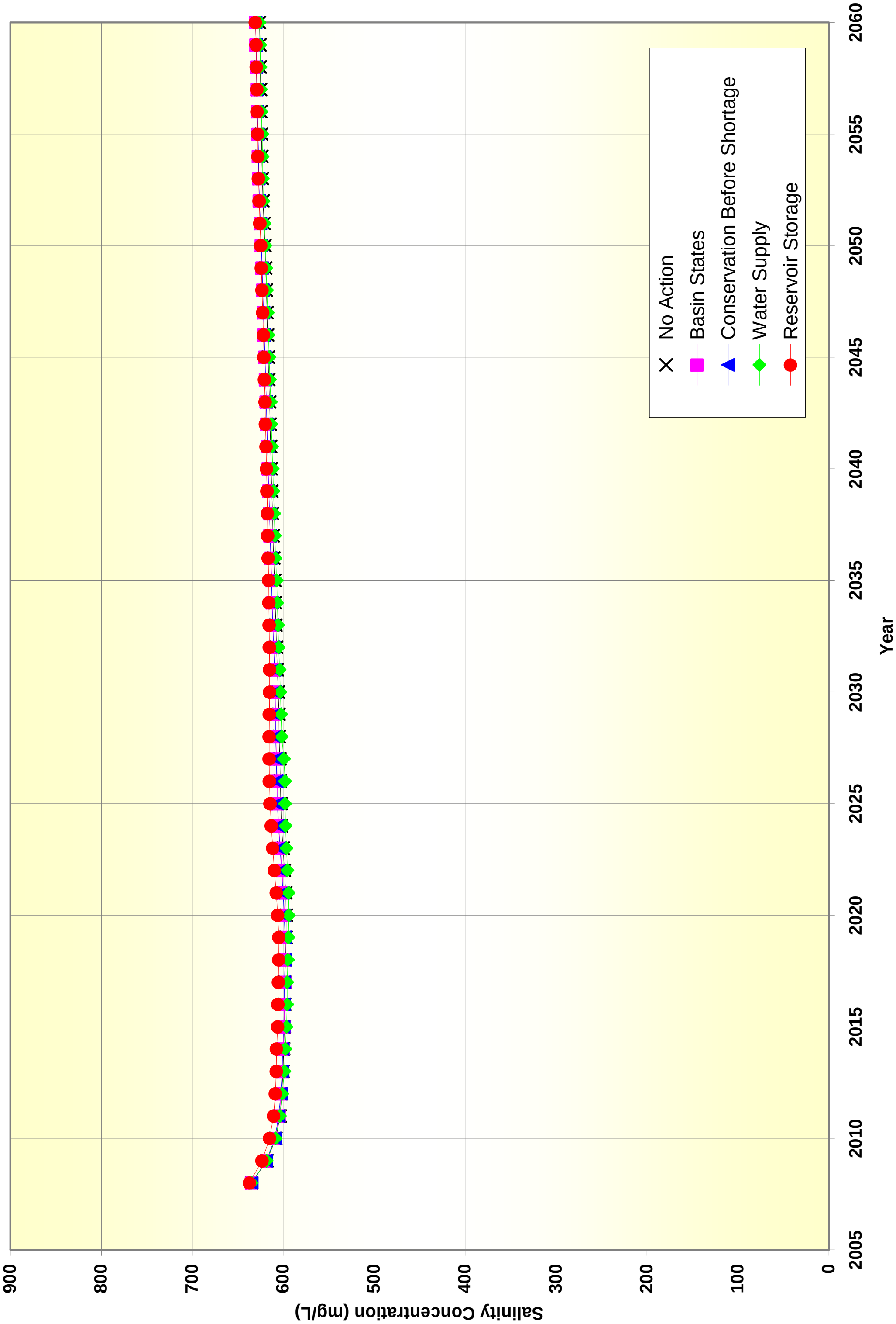

Figure P-2
Colorado River Salinity Below Parker Dam
Comparison of Action Alternatives to No Action Alternative
Flow-weighted Annual Average Salinity Concentrations

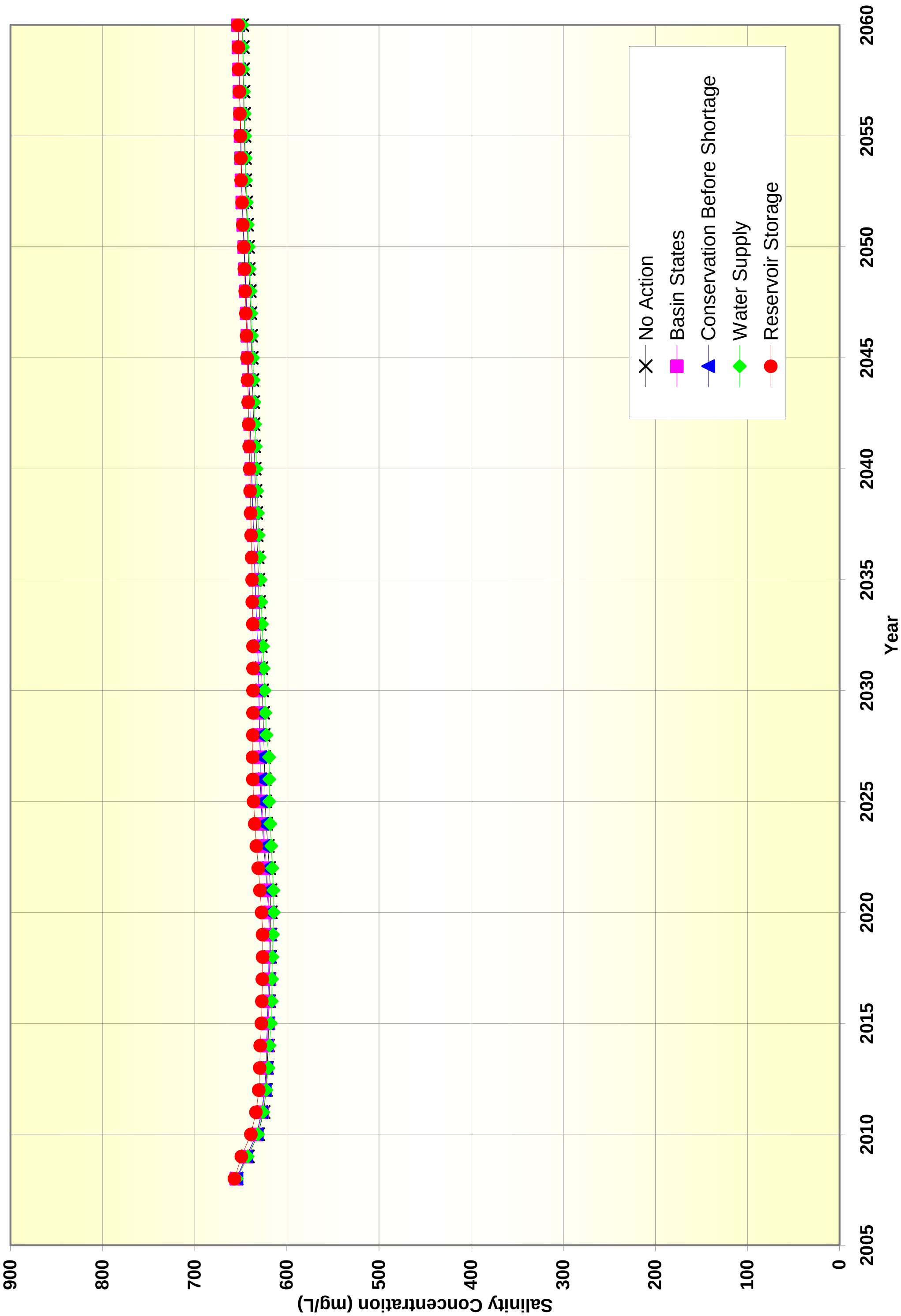

Figure P-3
Colorado River Salinity Above Imperial Dam
Comparison of Action Alternatives to No Action Alternative
Flow-weighted Annual Average Salinity Concentrations

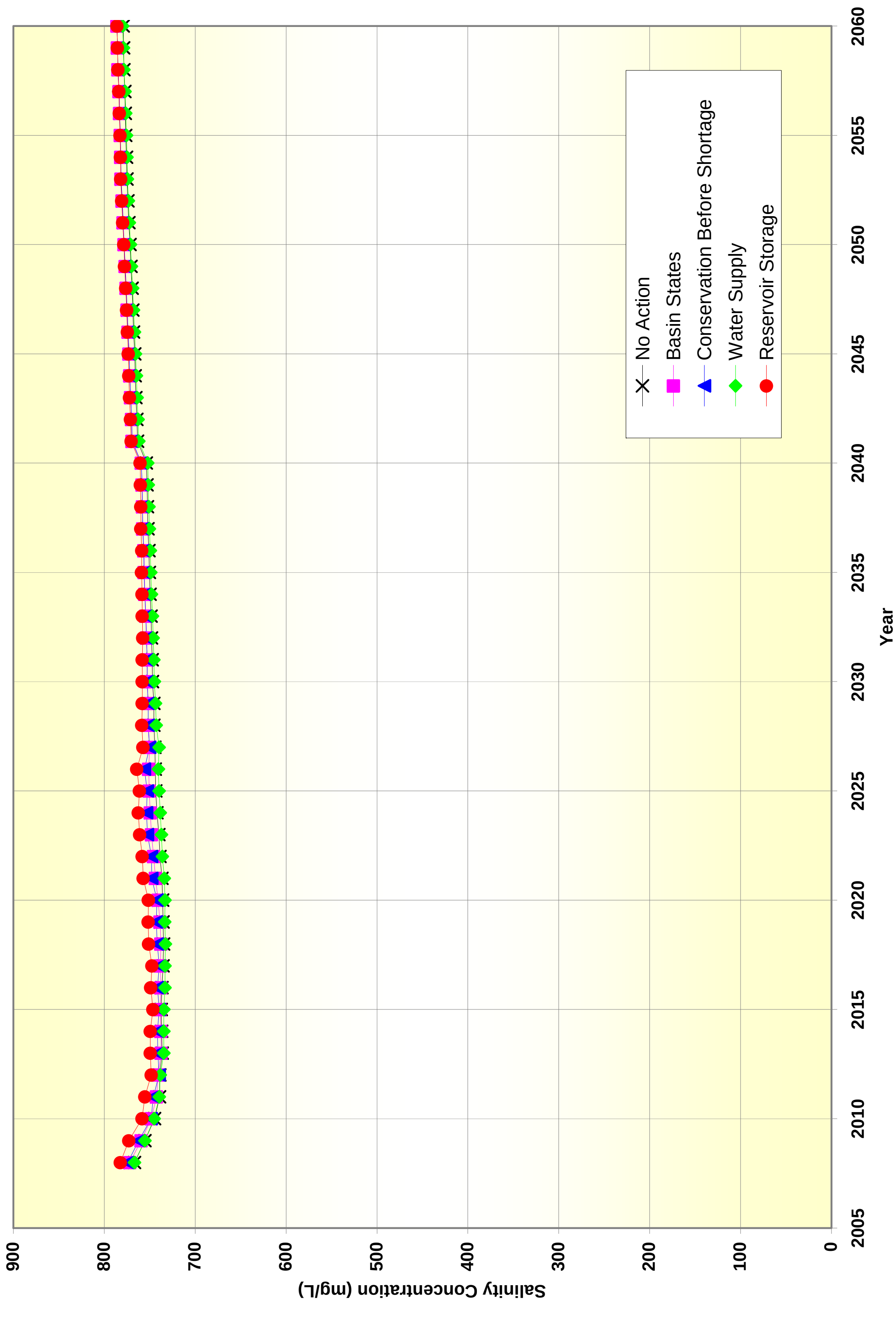

Figure P-4
Lake Powell End-of-October Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

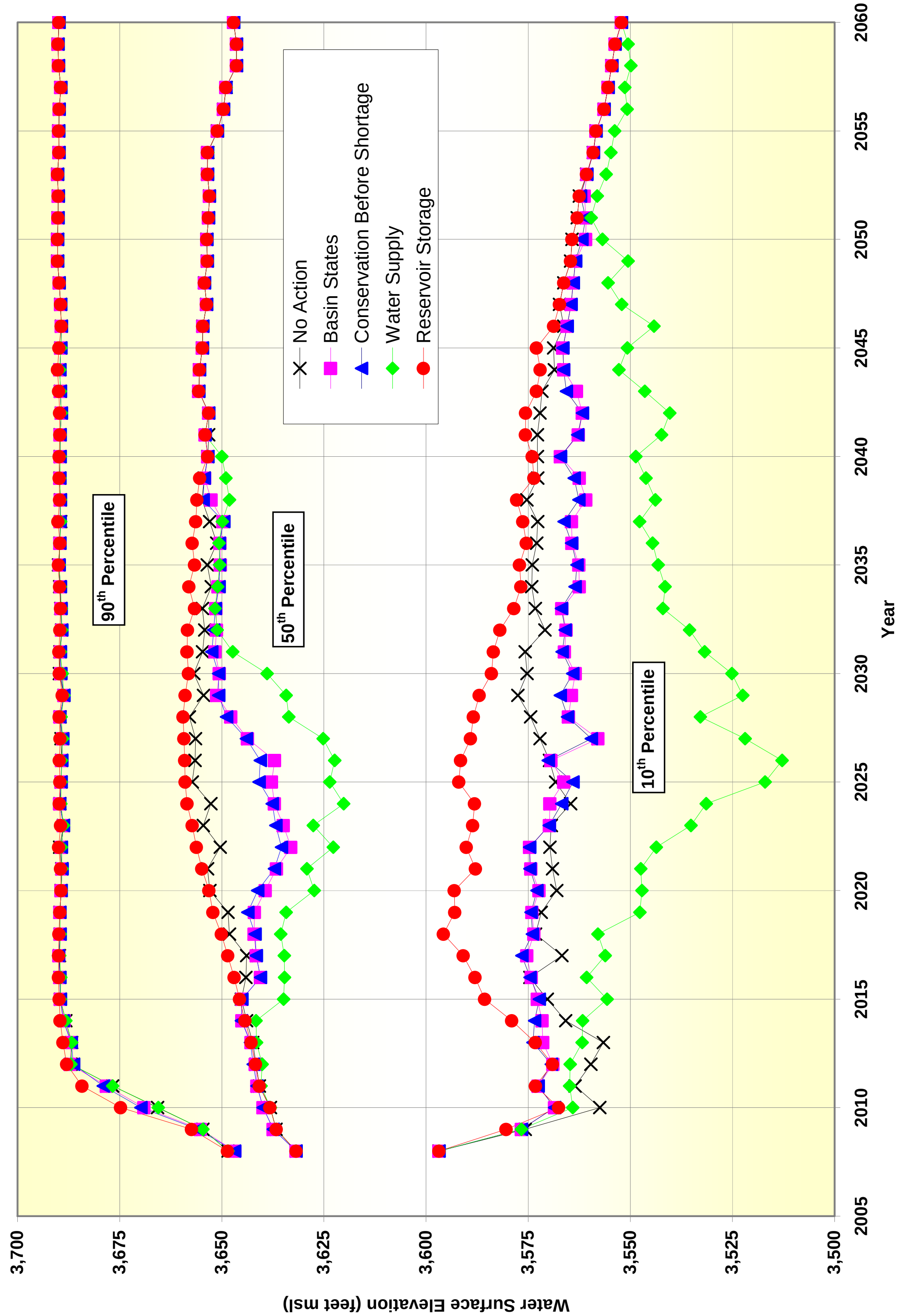

Figure P-5
Lake Mead End-of-October Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

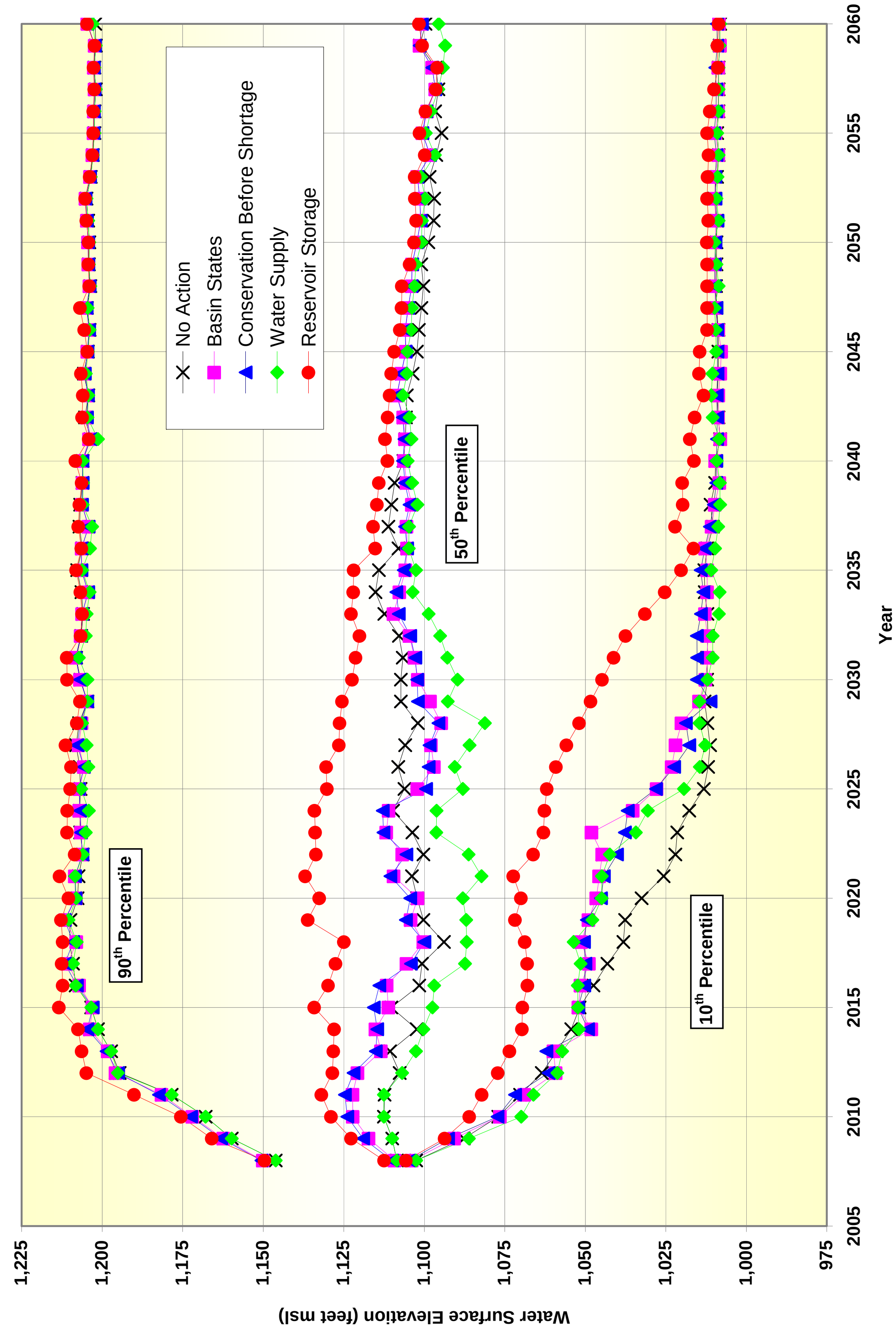

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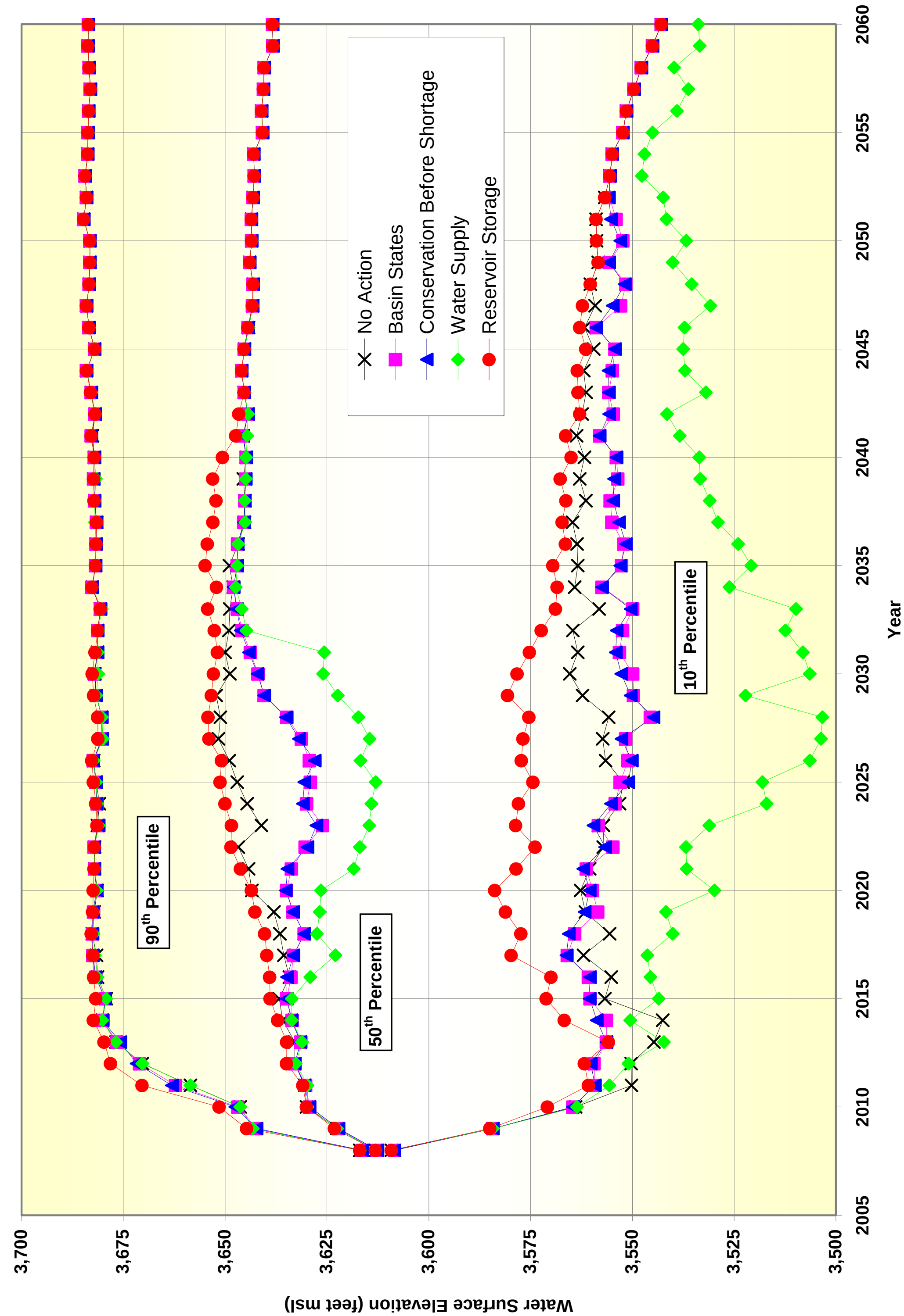
Figure P-6
Lake Powell End-of-March Elevations
Comparison of Action Alternatives to No Action Alternative
90^{th}, 50^{th} and 10^{th} Percentile Values



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Air Quality

This section contains additional CRSS modeling output referenced in the Air Quality Section.

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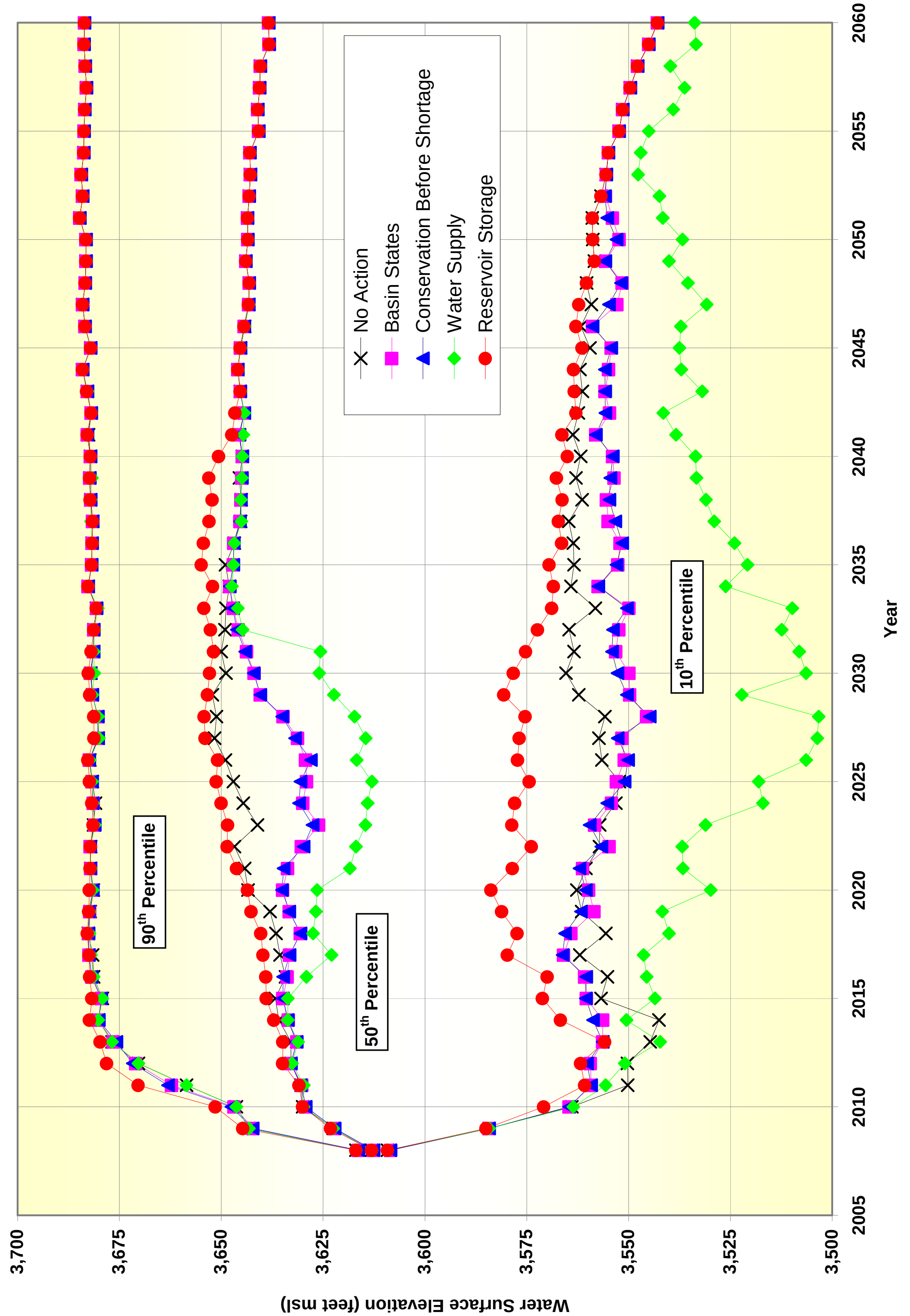
Figure P-7
Lake Powell End-of-March Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values



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Biological and Cultural Resources

This section contains additional CRSS modeling output referenced in the Biological and Cultural Resources Section.

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Figure P-8
Lake Powell End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

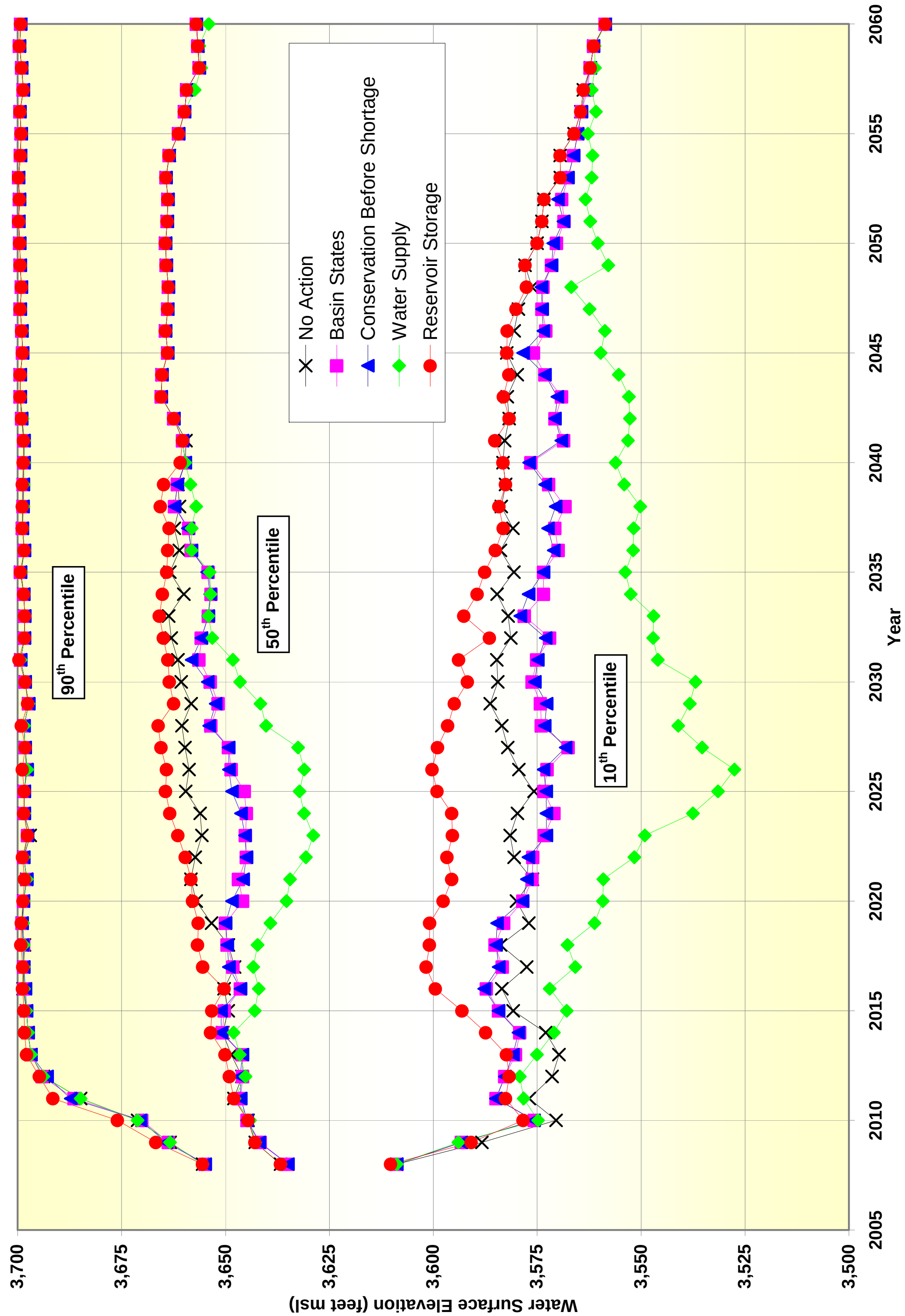

Figure P-9
Lake Powell End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

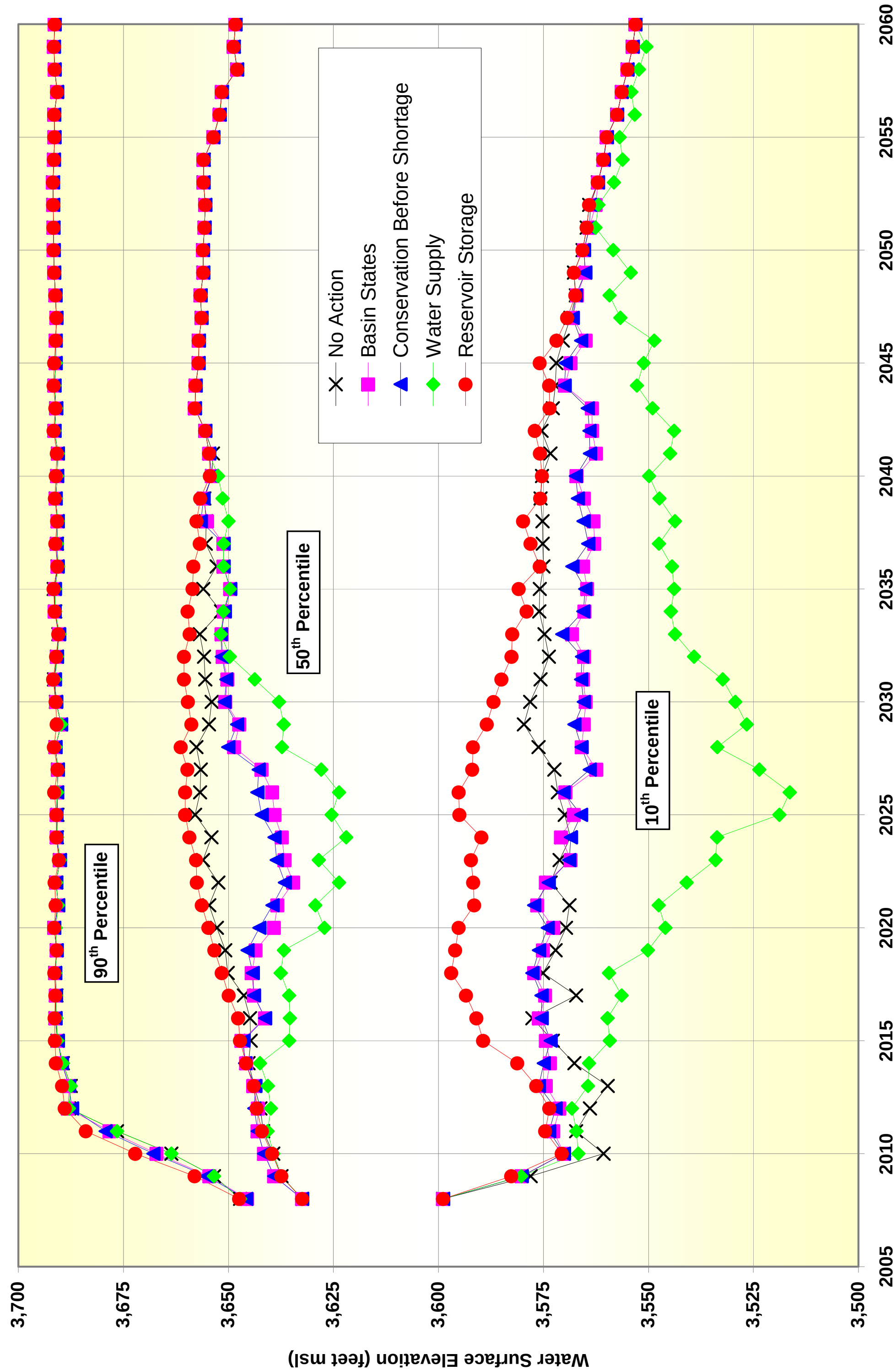

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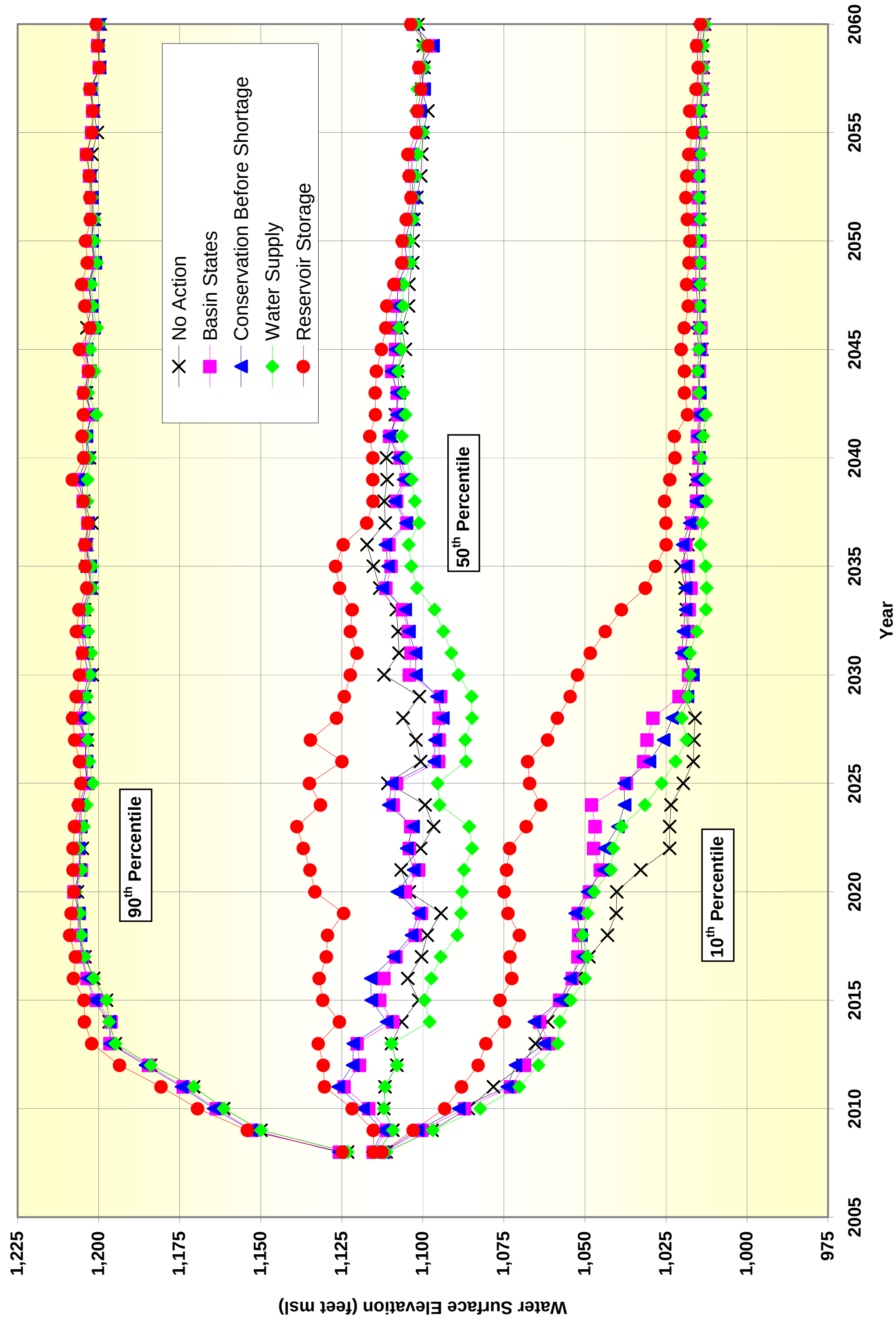
Figure P-10
Lake Mead End-of-March Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values



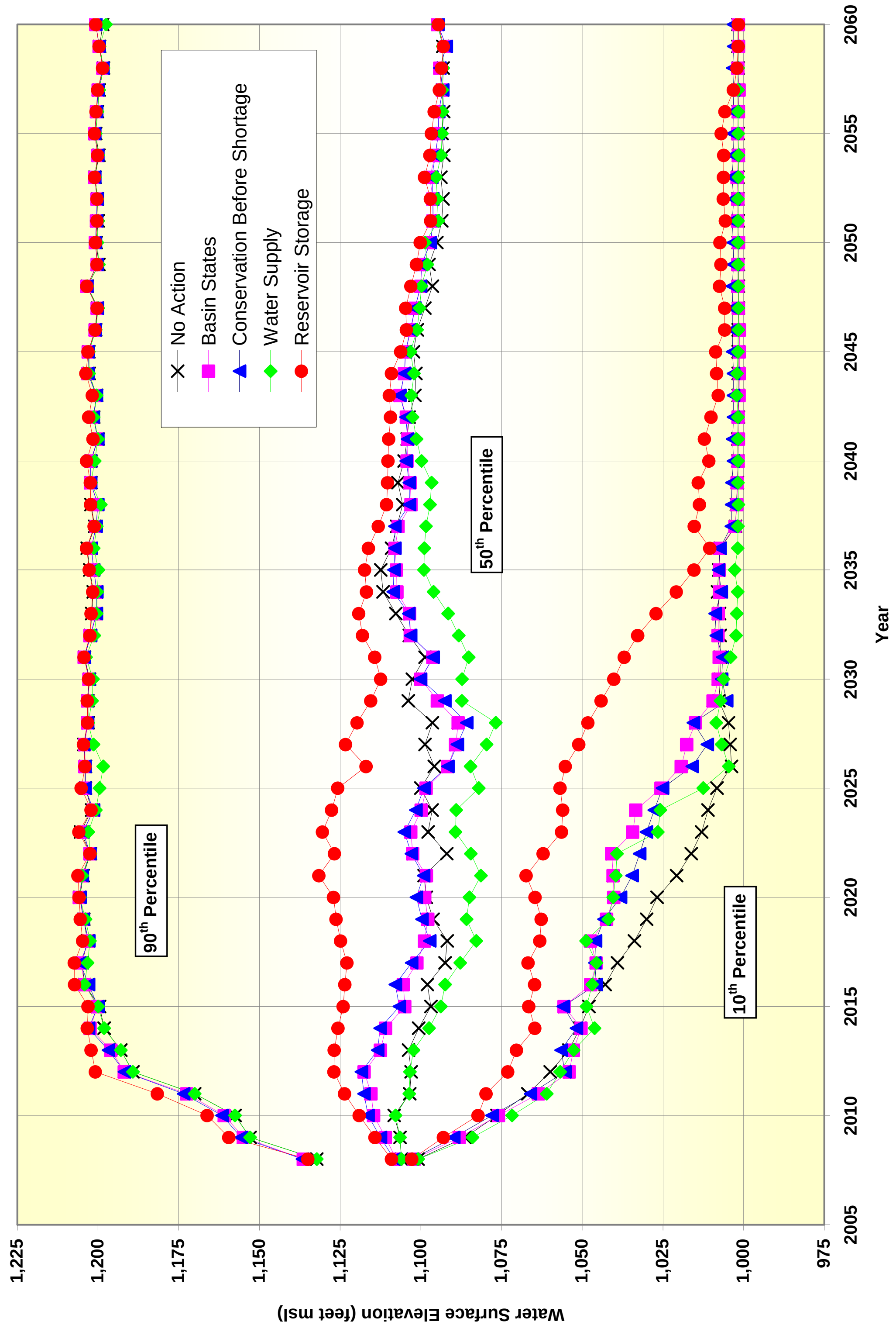


Figure P-11
Lake Mead End-of-July Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

Figure P-12
Lake Mead End-of-September Elevations
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

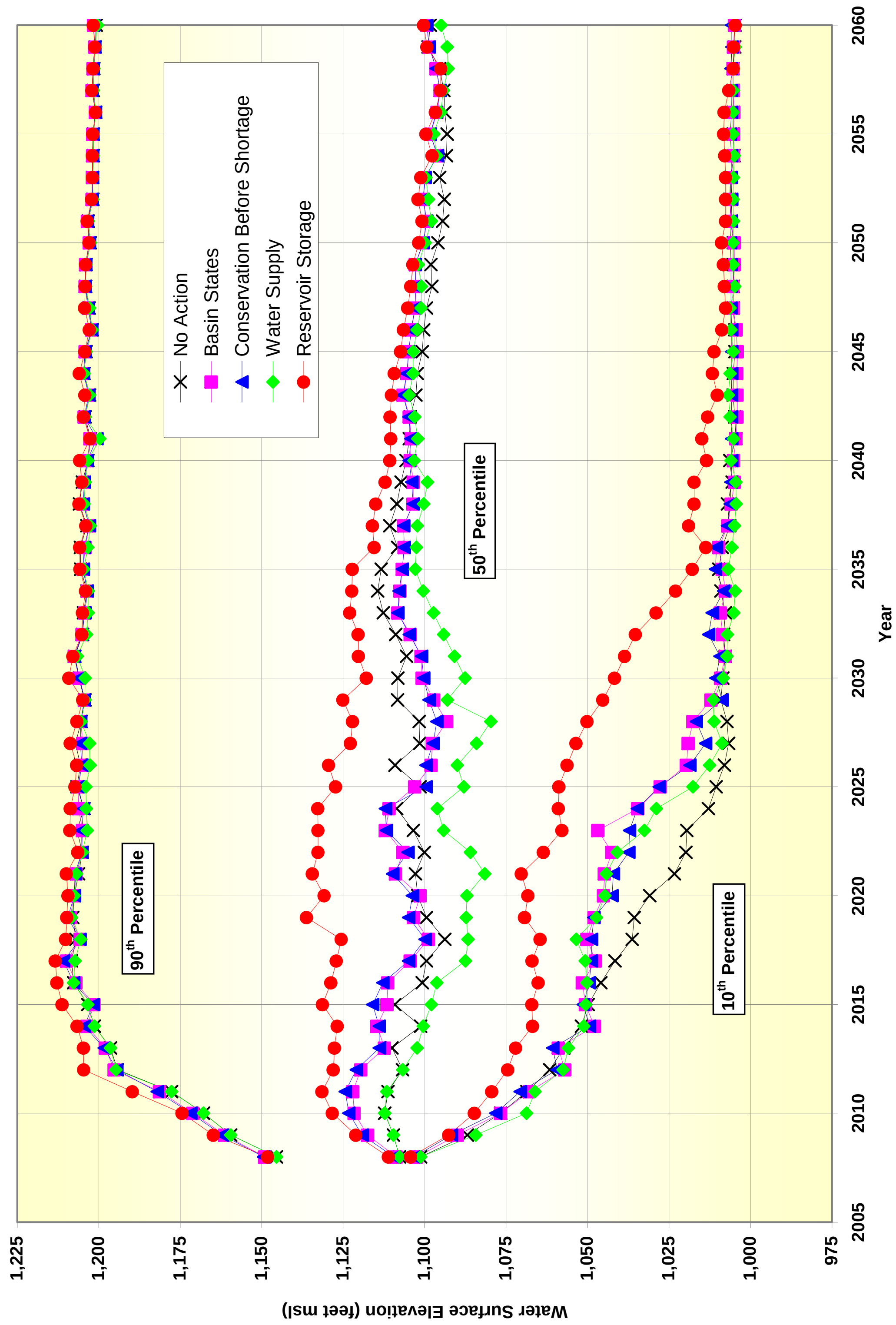


Figure P-13
Glen Canyon Dam January Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

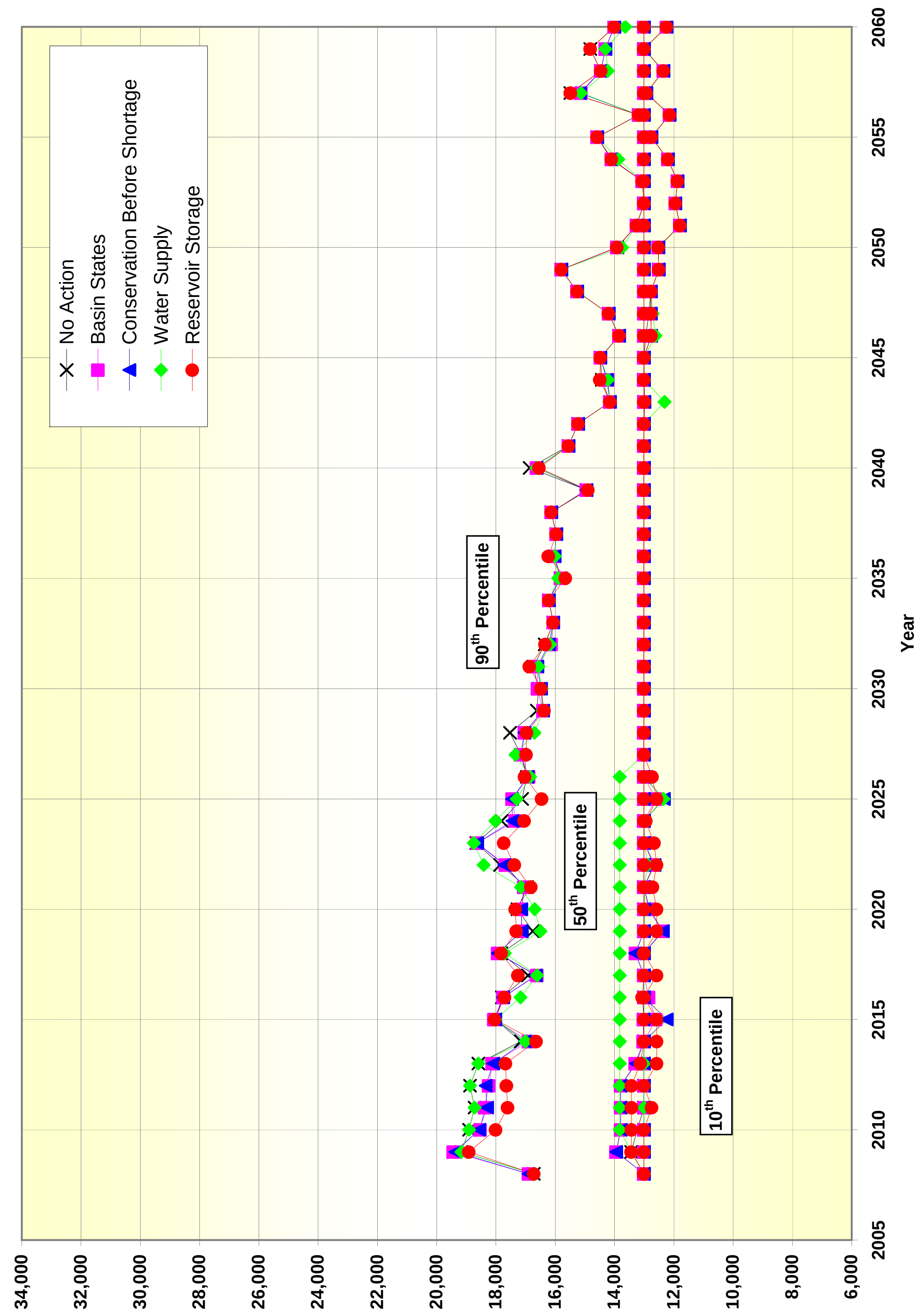


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Figure P-14
Glen Canyon Dam February Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

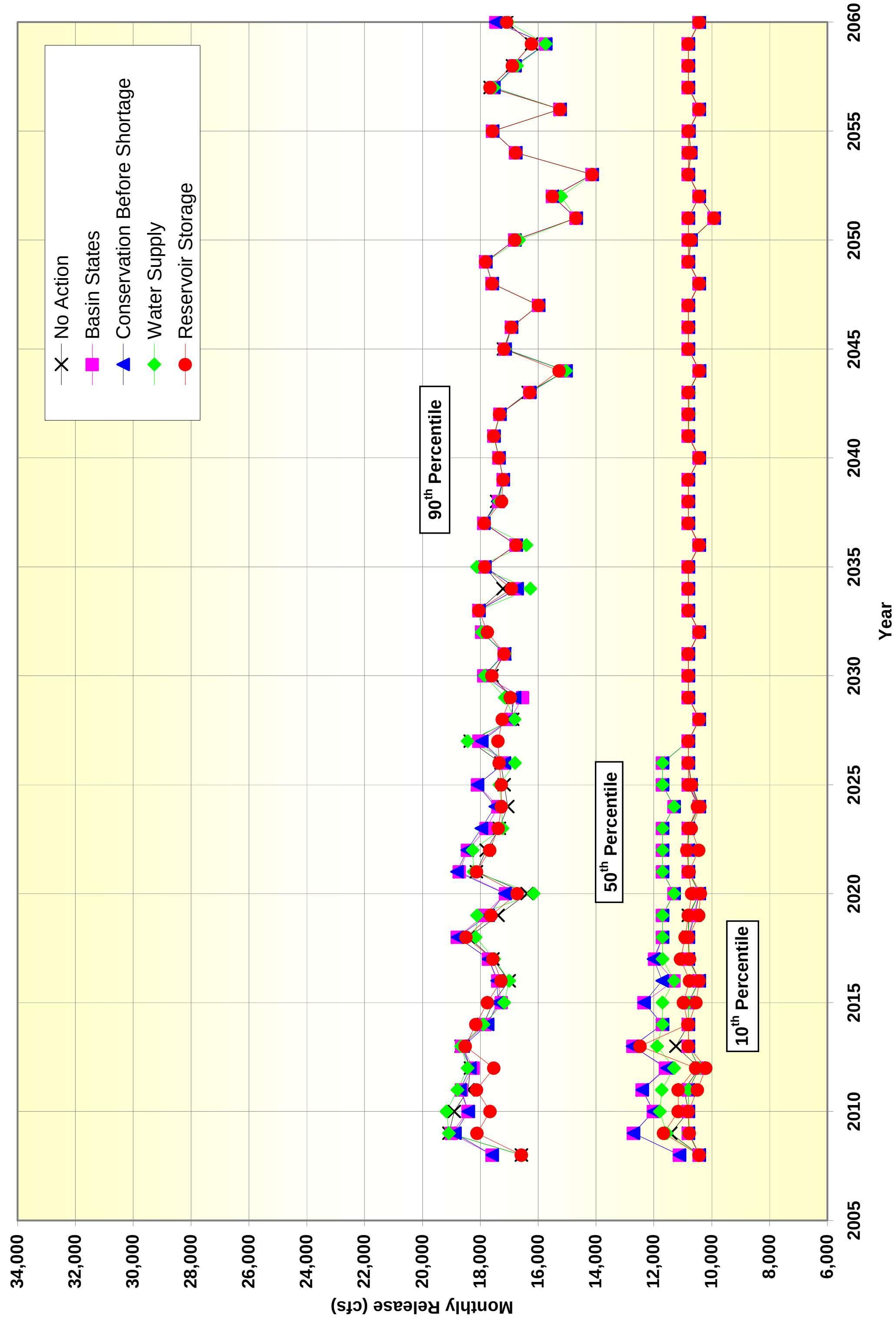

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Figure P-15
Glen Canyon Dam March Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

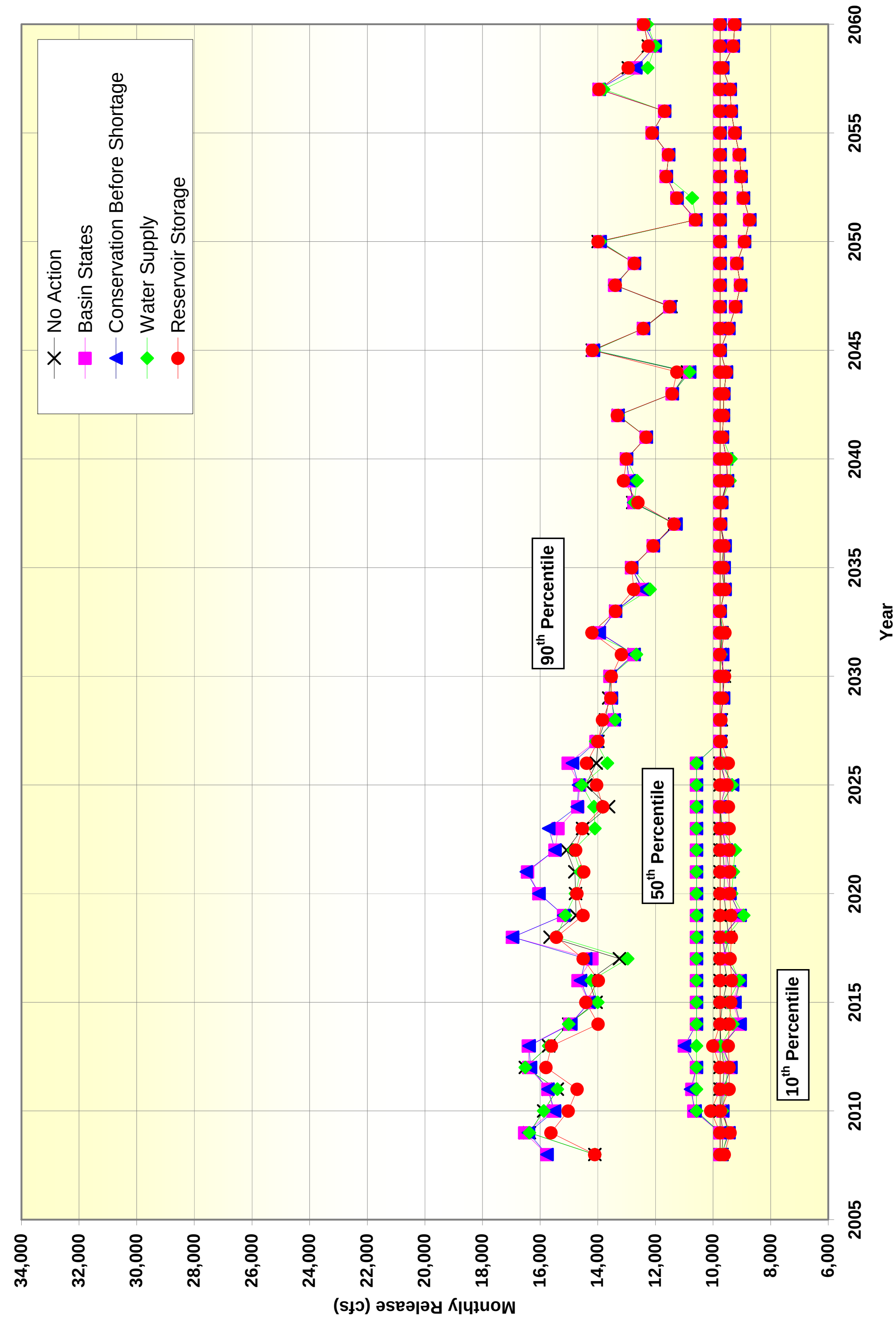

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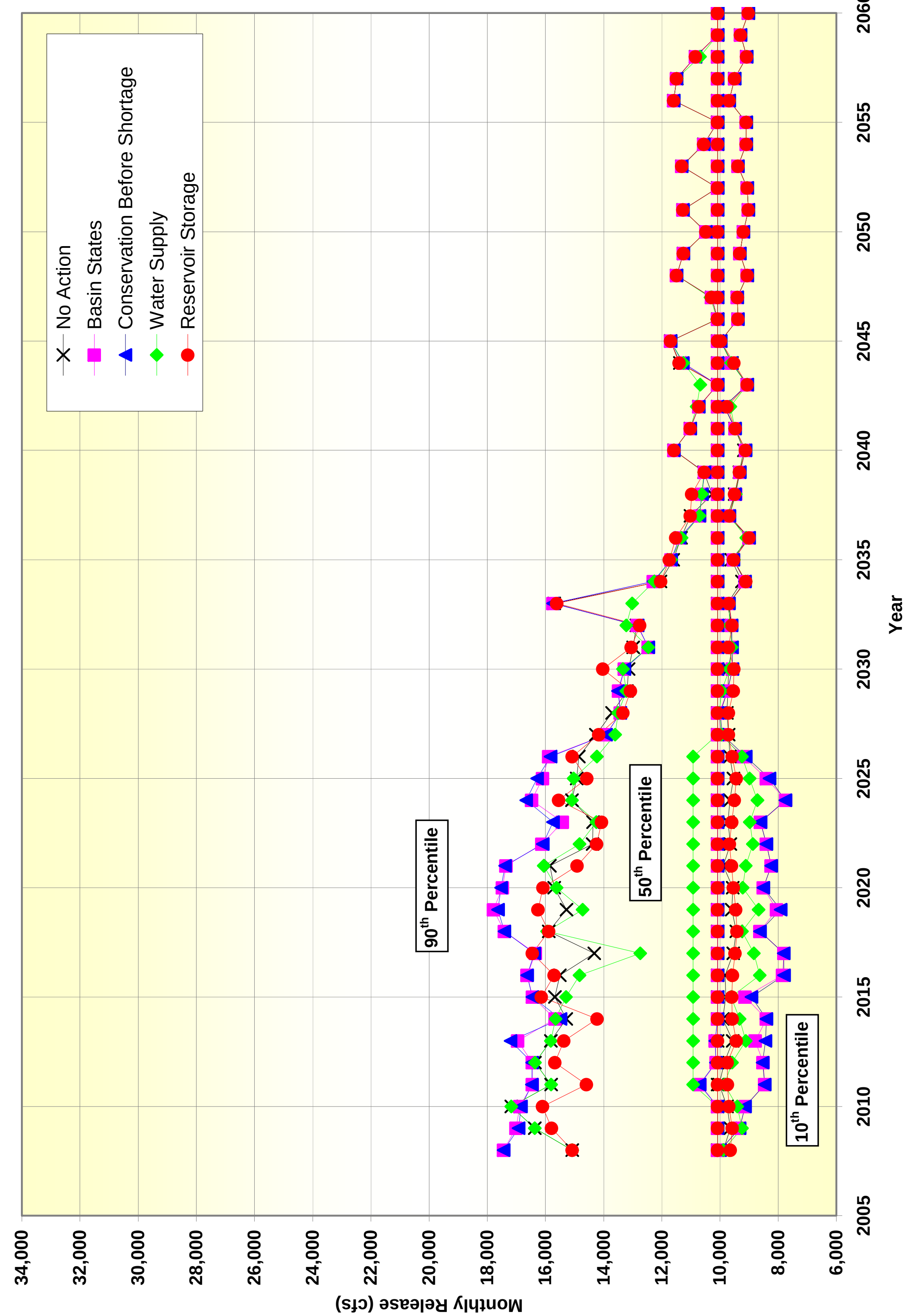
Figure P-16
Glen Canyon Dam April Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values



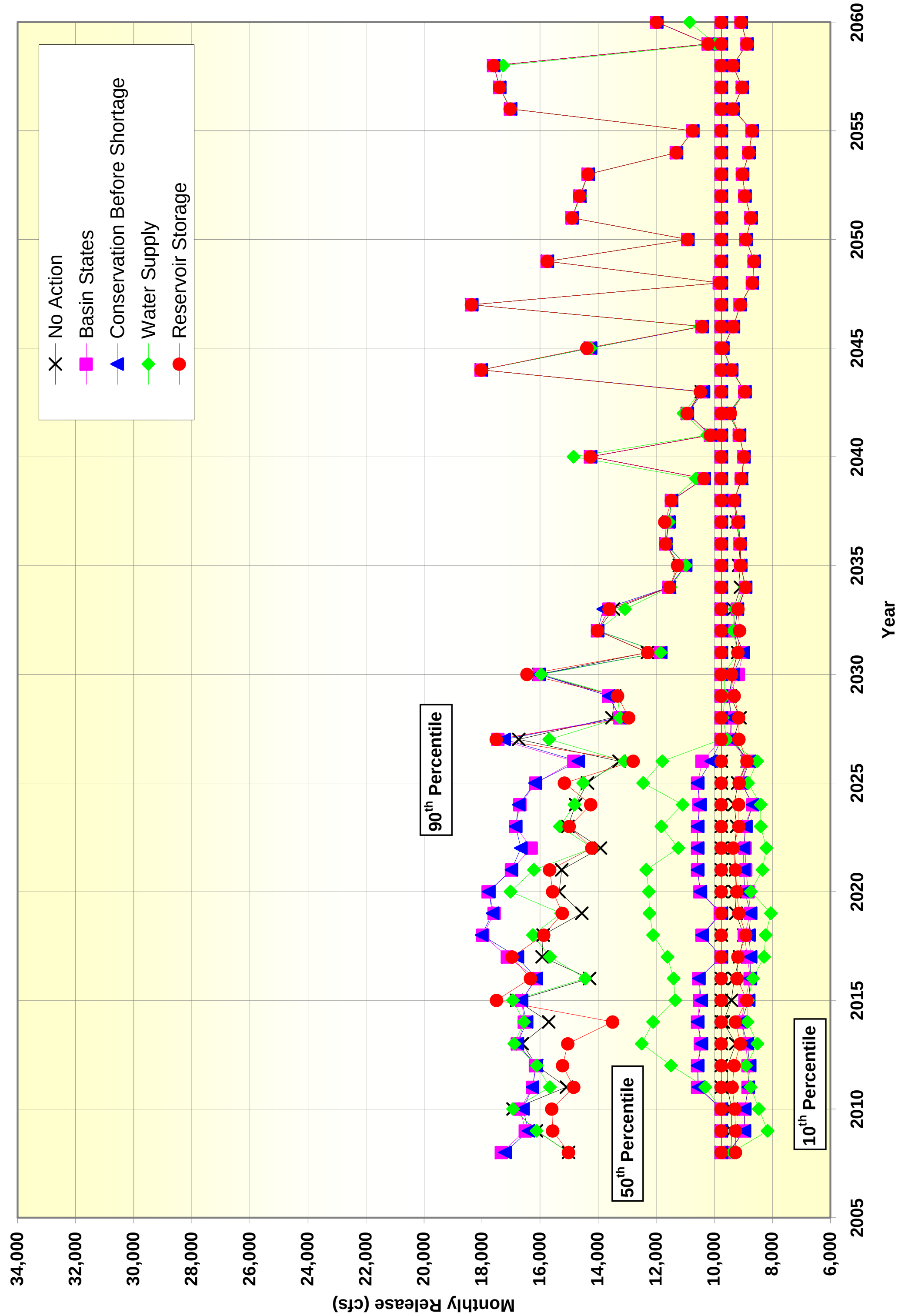


Figure P-17
Glen Canyon Dam May Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

Figure P-18
Glen Canyon Dam June Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

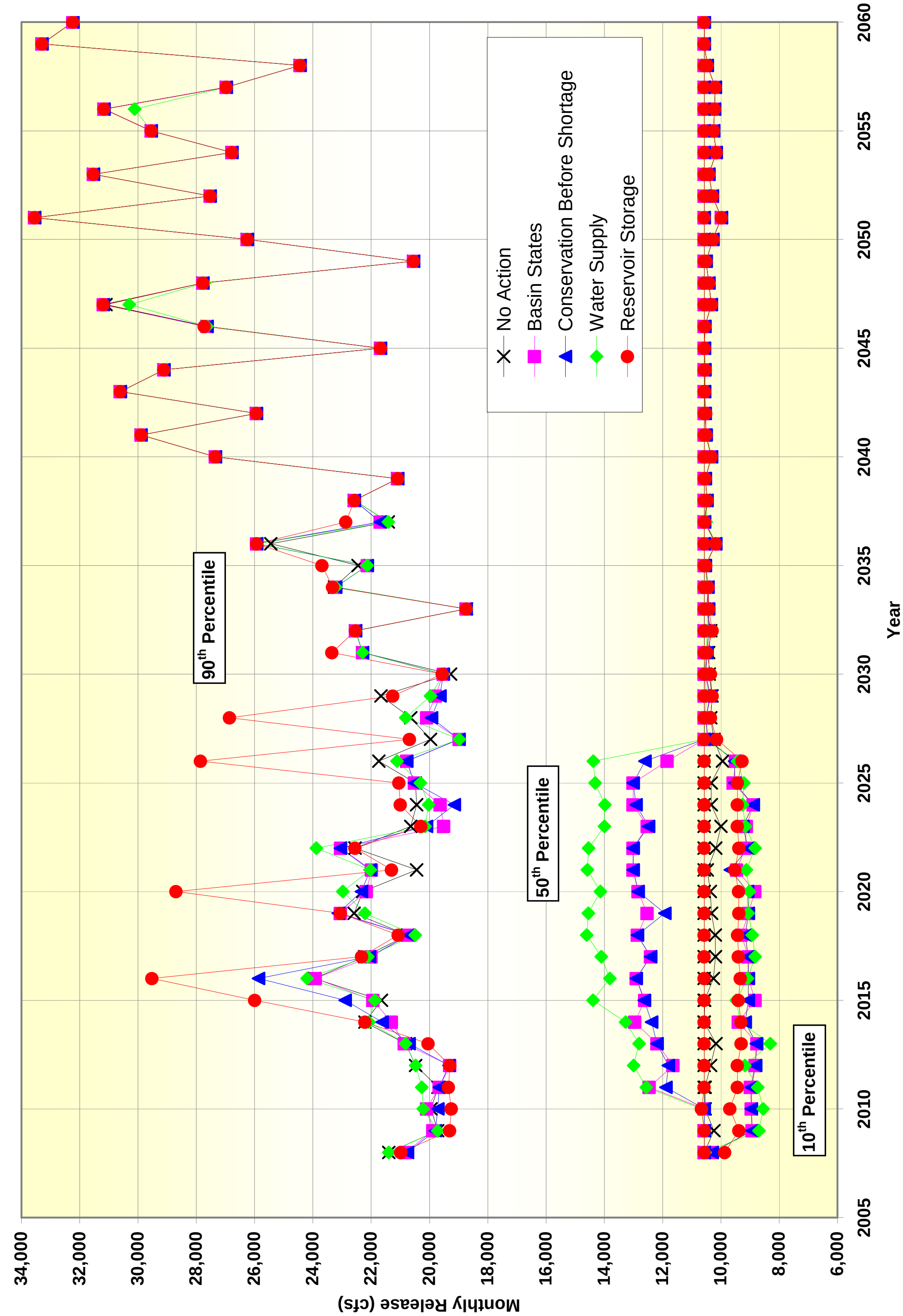


Figure P-19
Glen Canyon Dam July Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

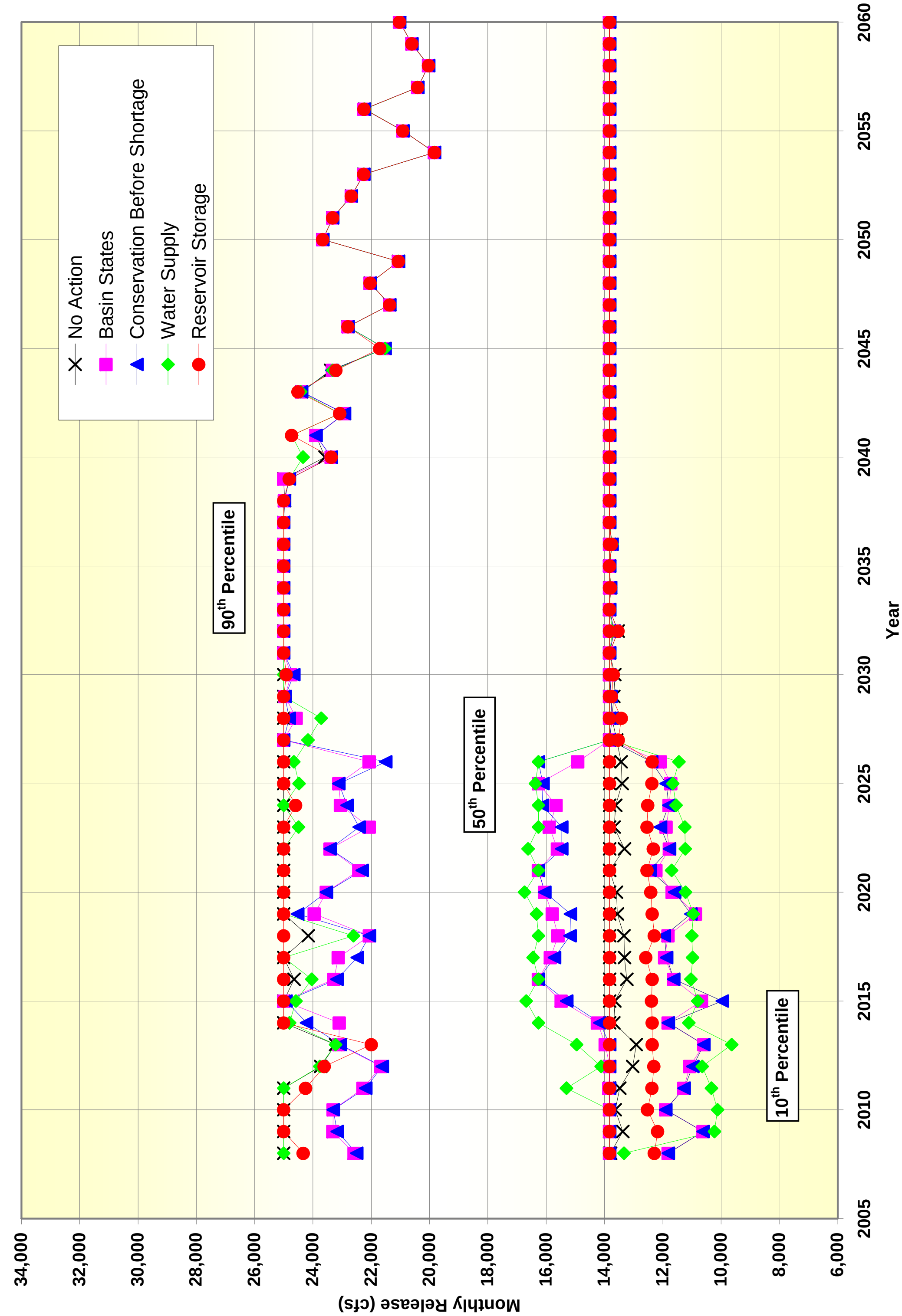


Figure P-20
Glen Canyon Dam August Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

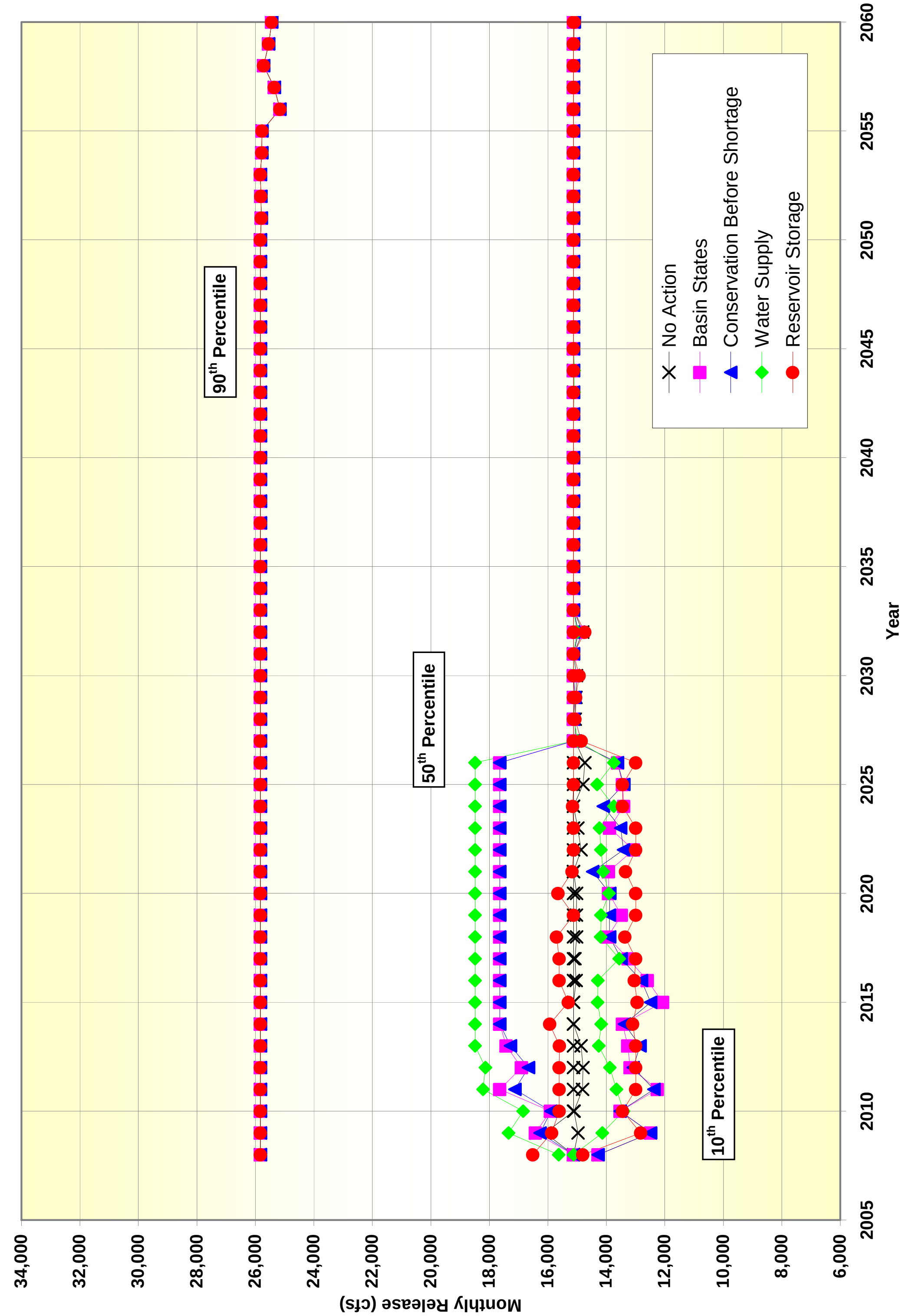


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Figure P-21
Glen Canyon Dam September Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

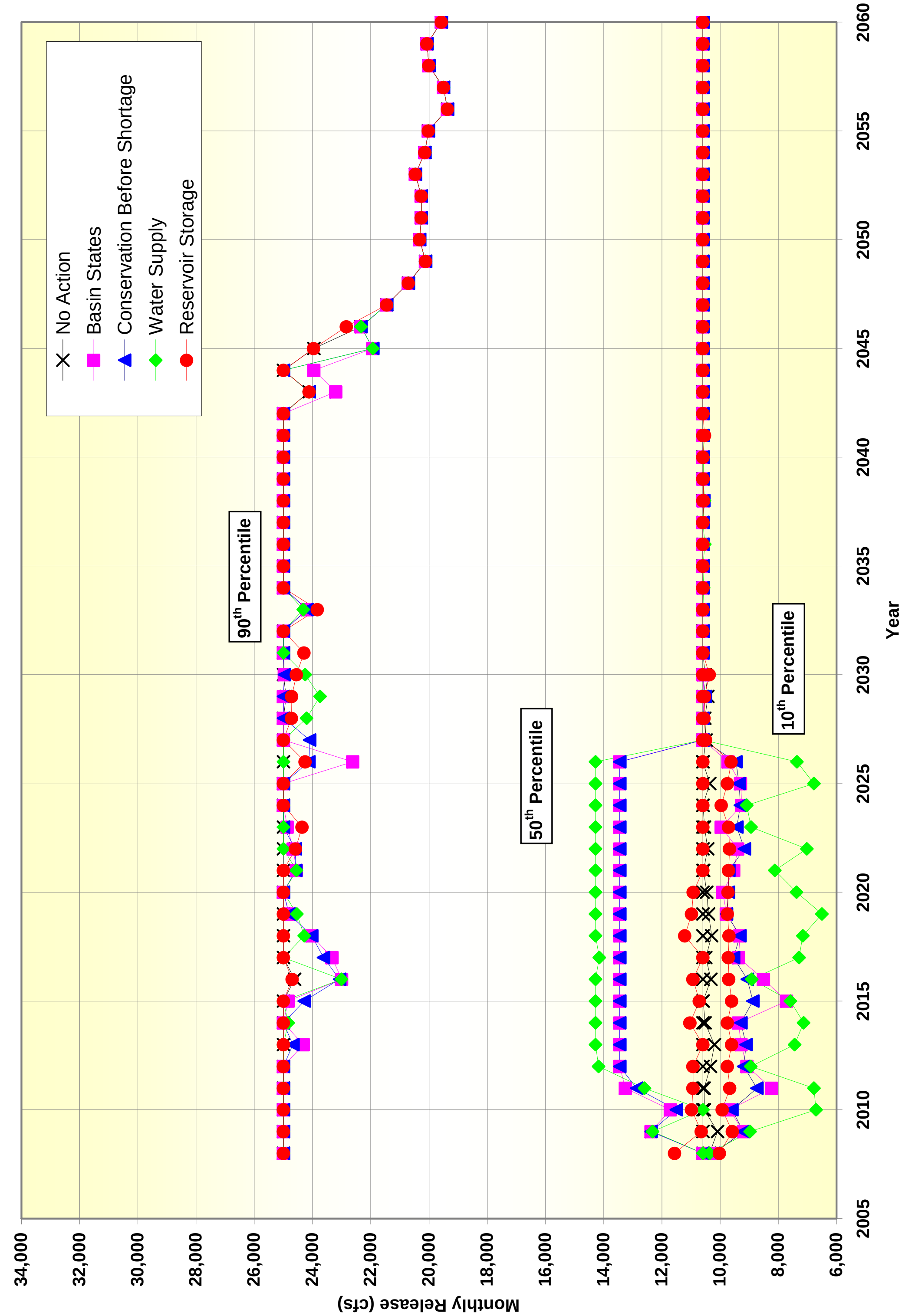

Figure P-22
Glen Canyon Dam October Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

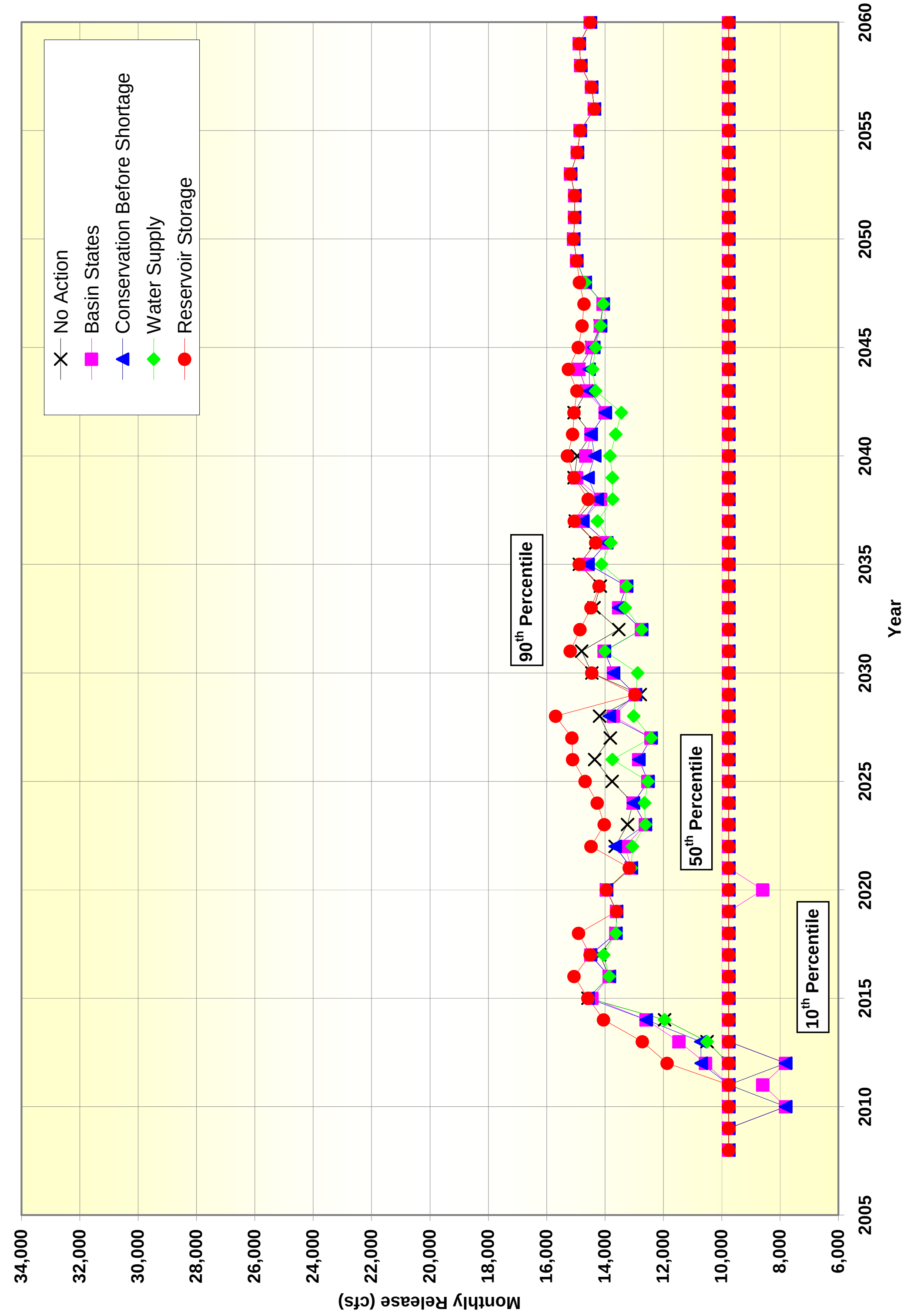

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Figure P-23
Glen Canyon Dam November Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

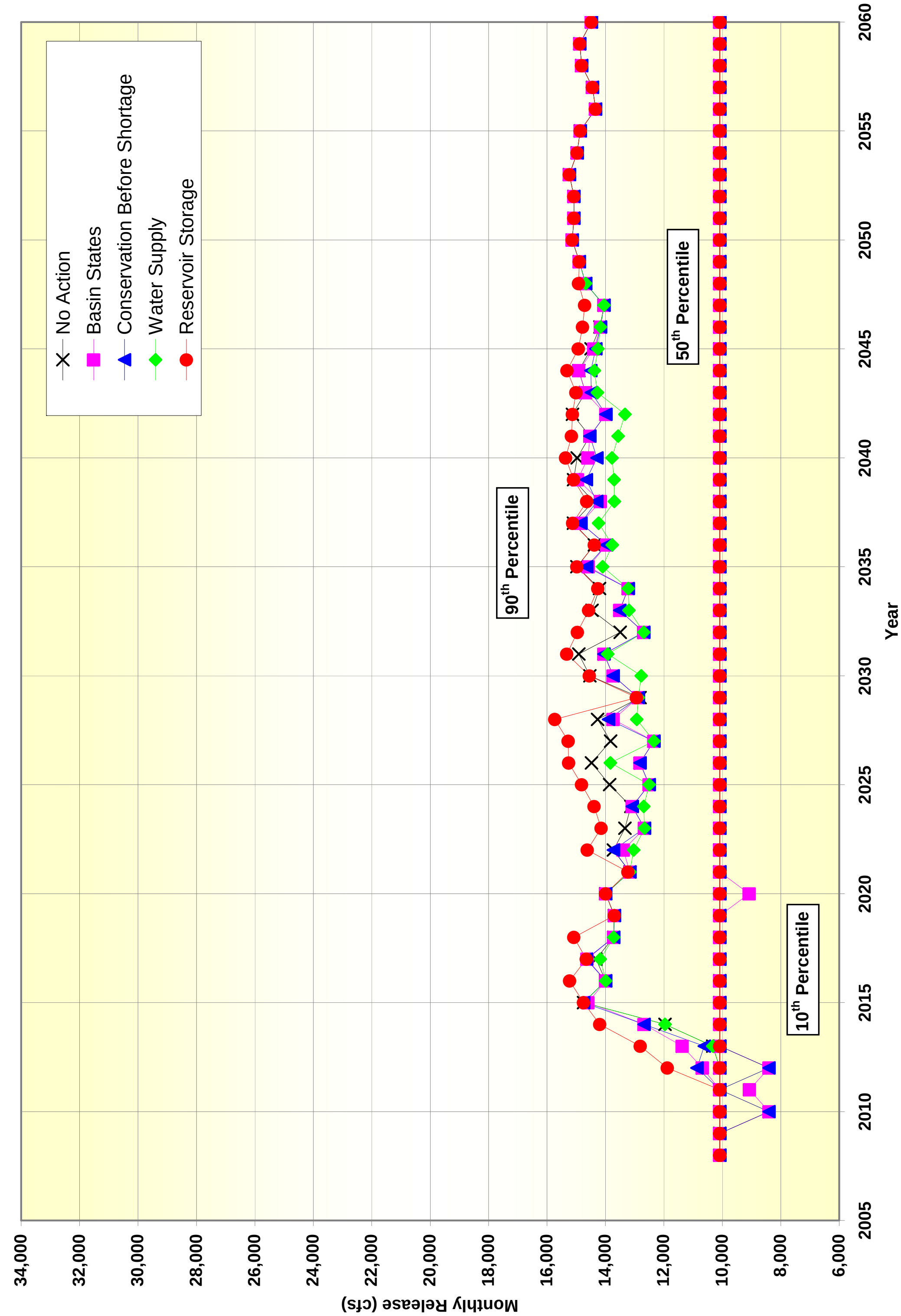

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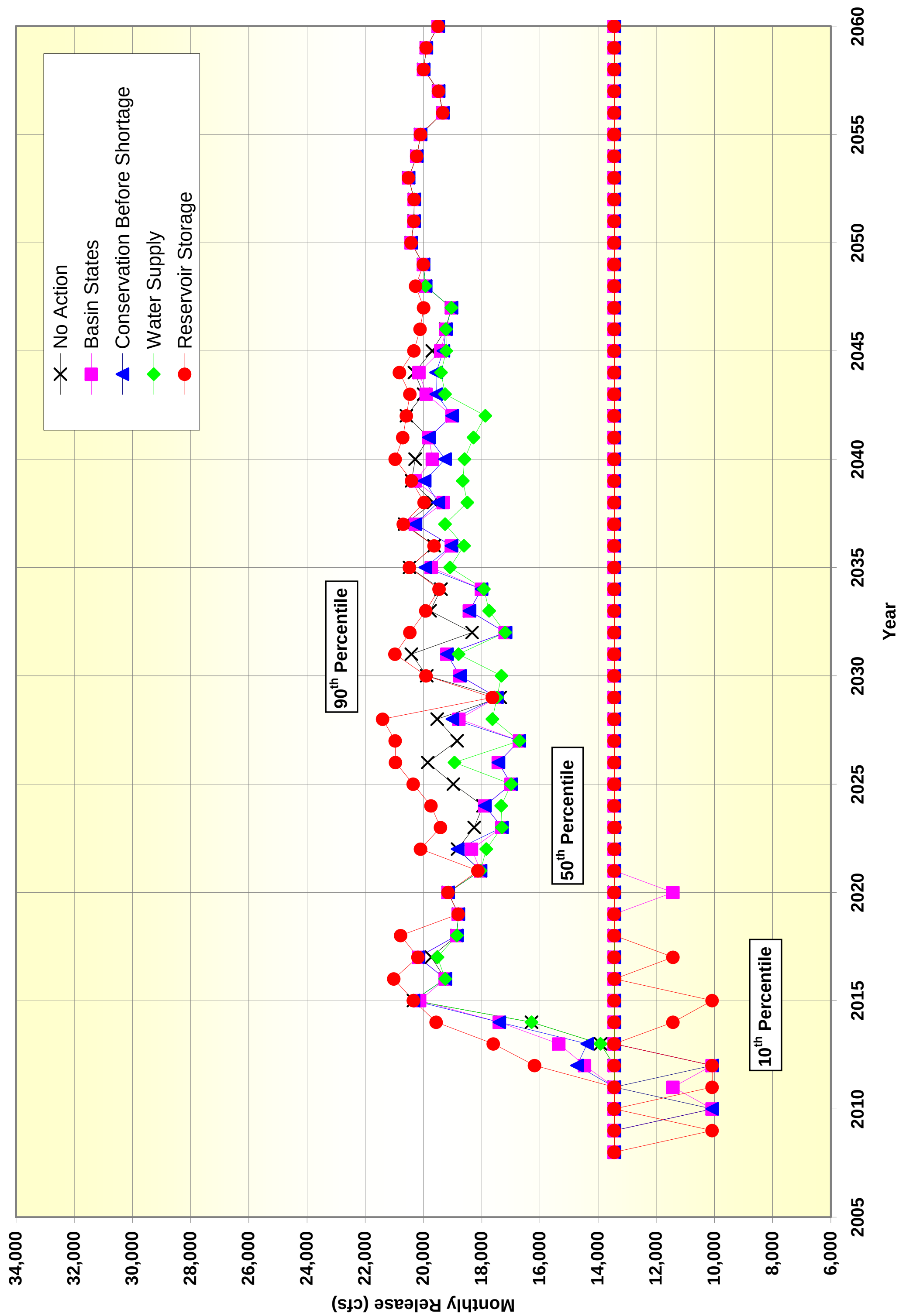
Figure P-24
Glen Canyon Dam December Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values



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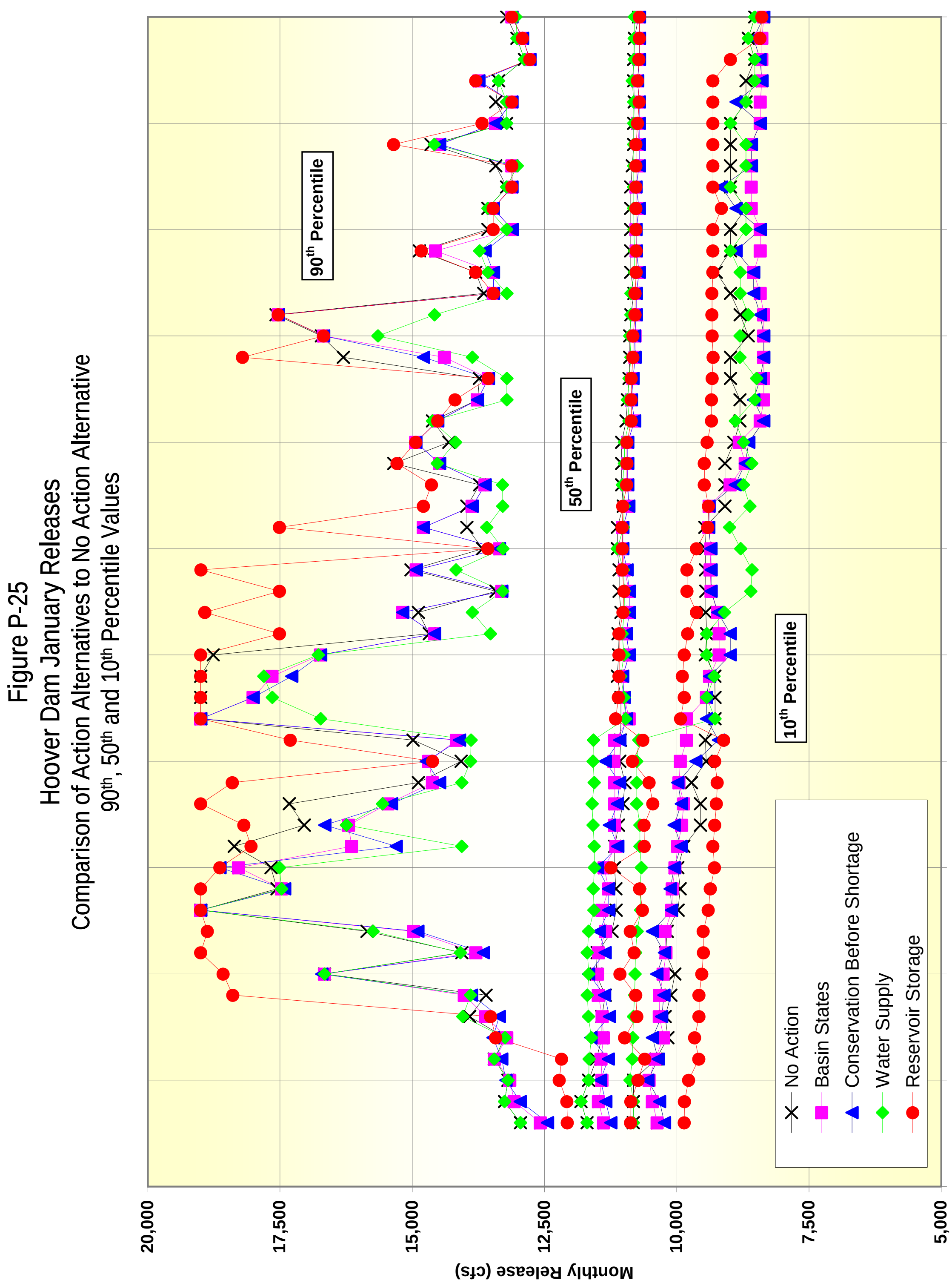

Figure P-25
Hoover Dam January Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

Figure P-26
Hoover Dam February Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

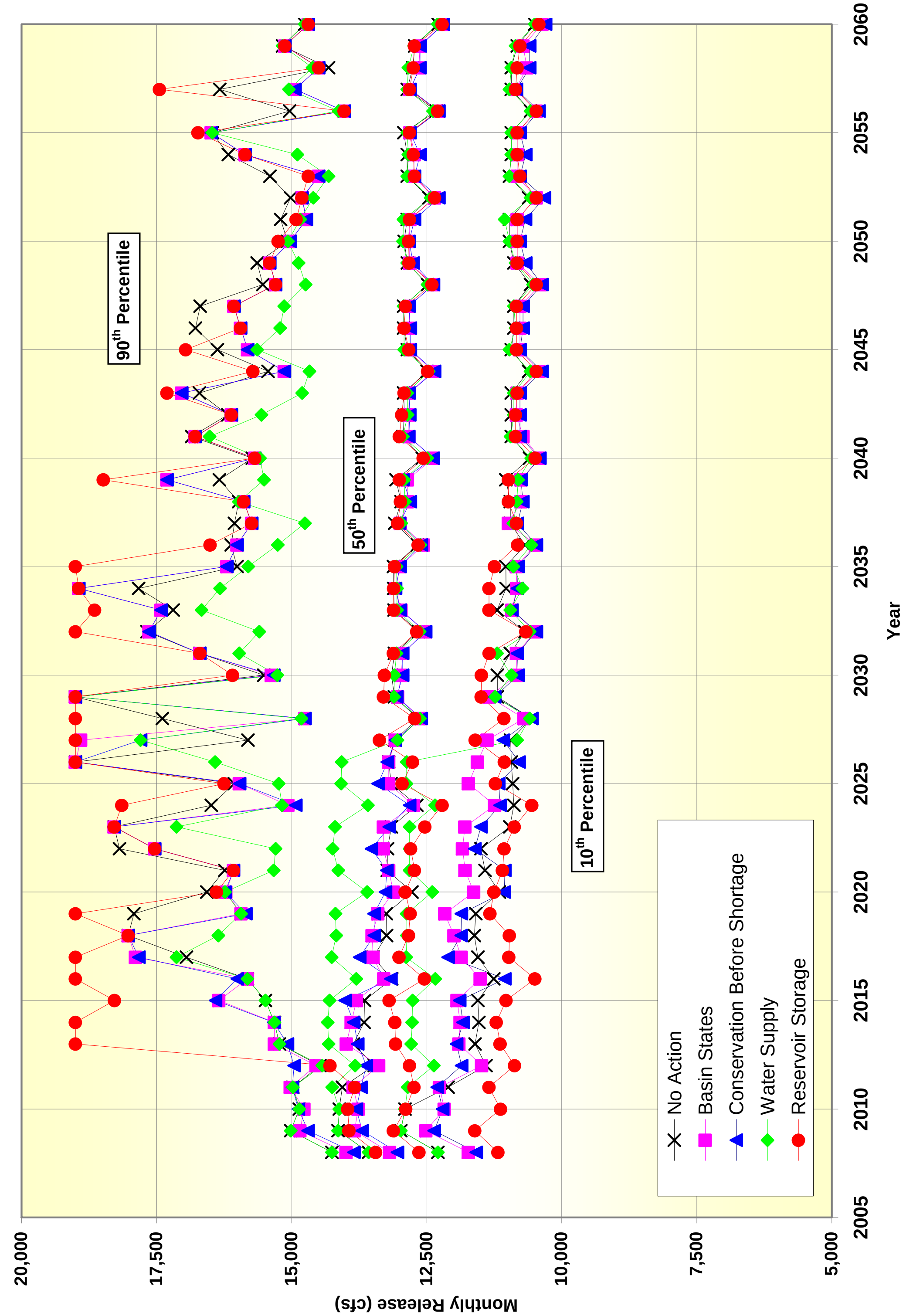

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Figure P-27
Hoover Dam March Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

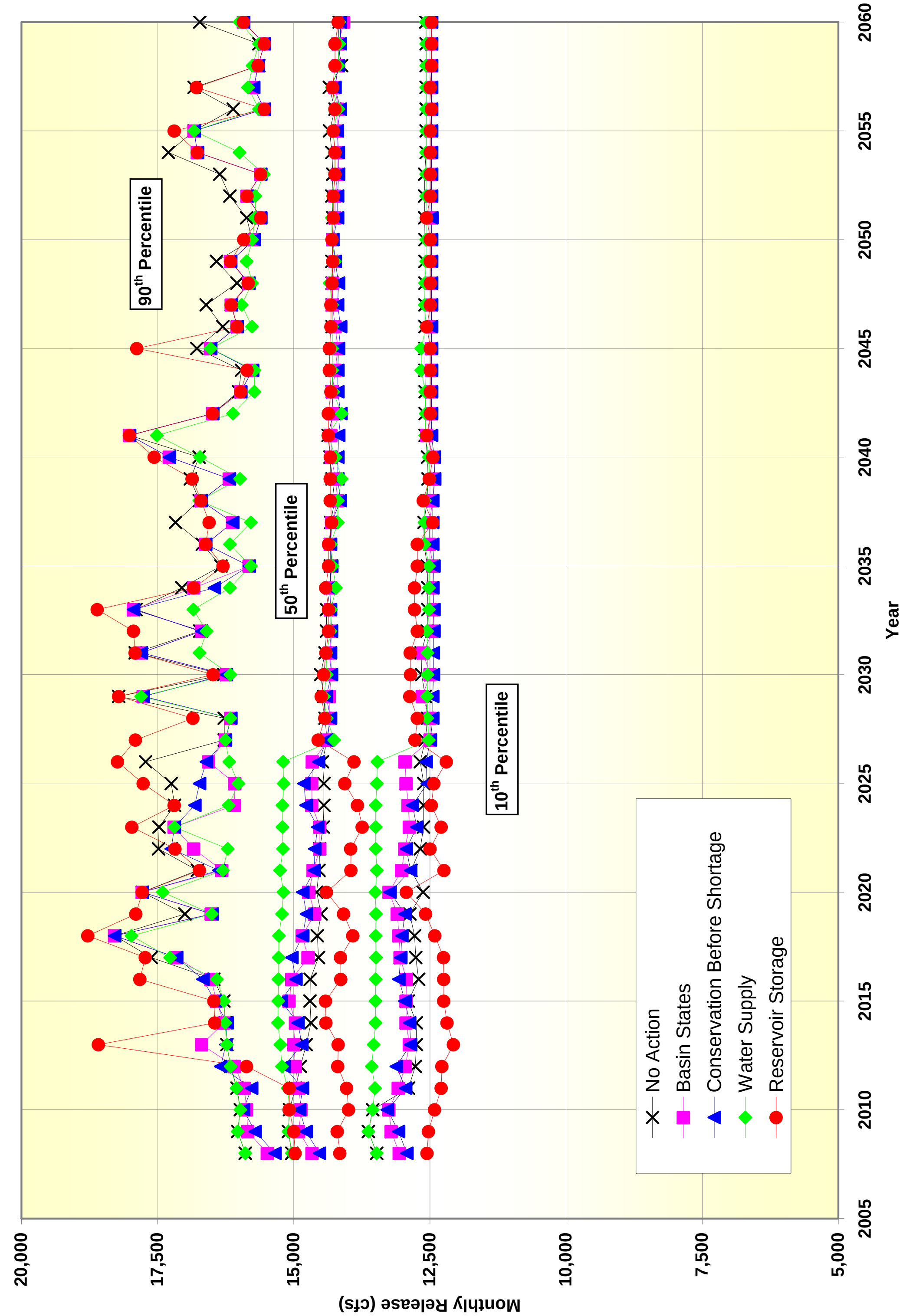

Figure P-28
Hoover Dam April Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

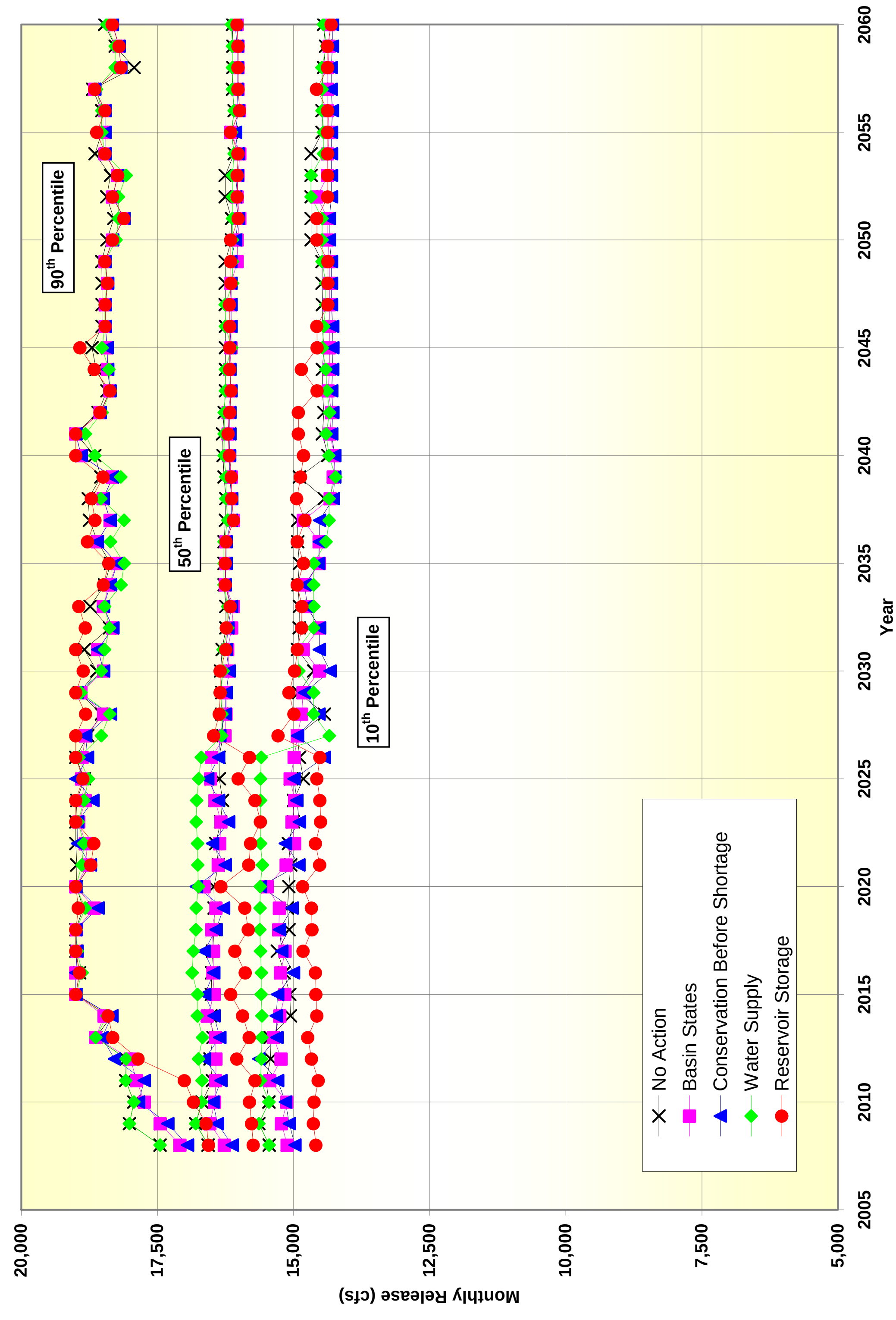

Figure P-29
Hoover Dam May Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

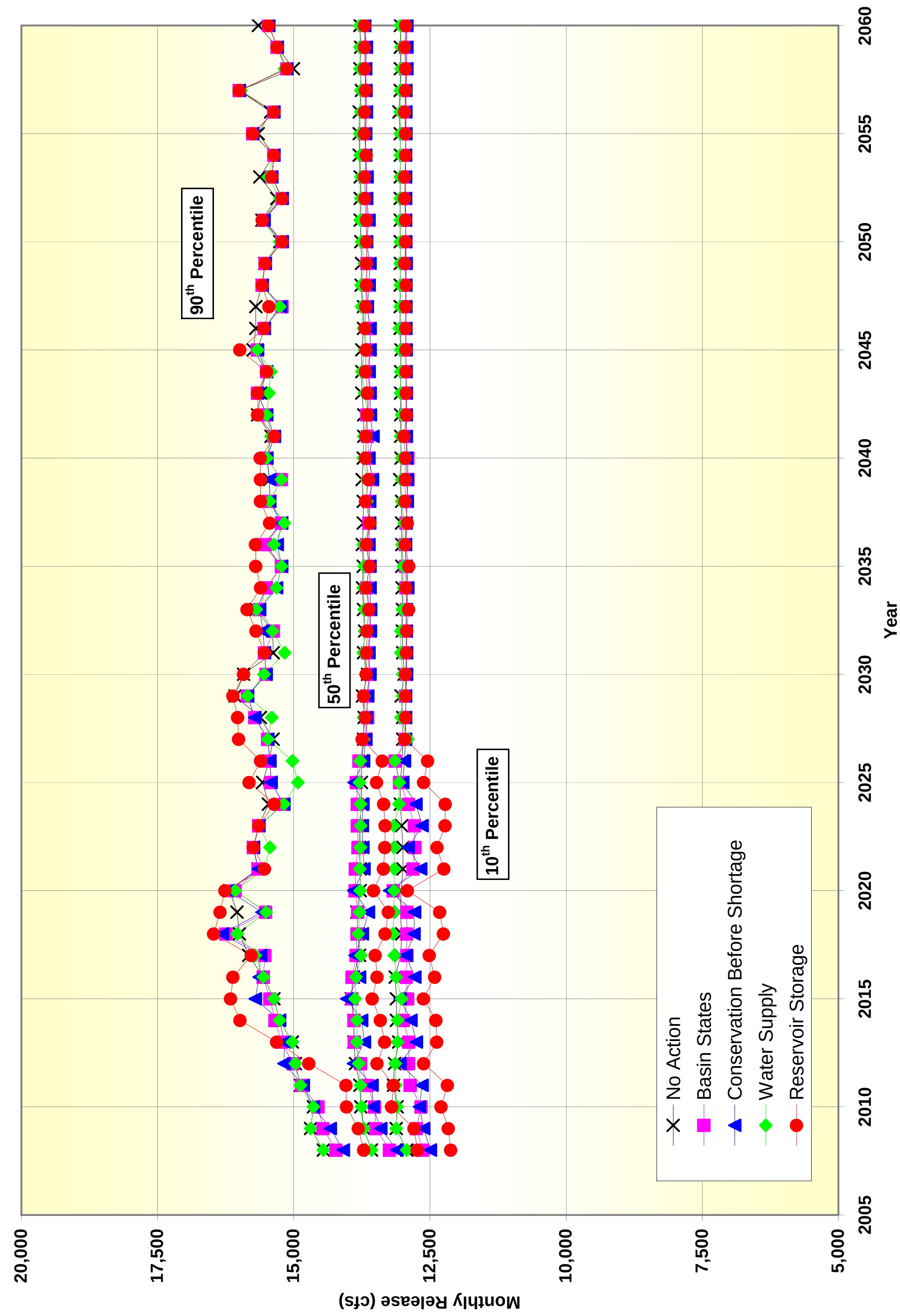

Figure P-30
Hoover Dam June Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

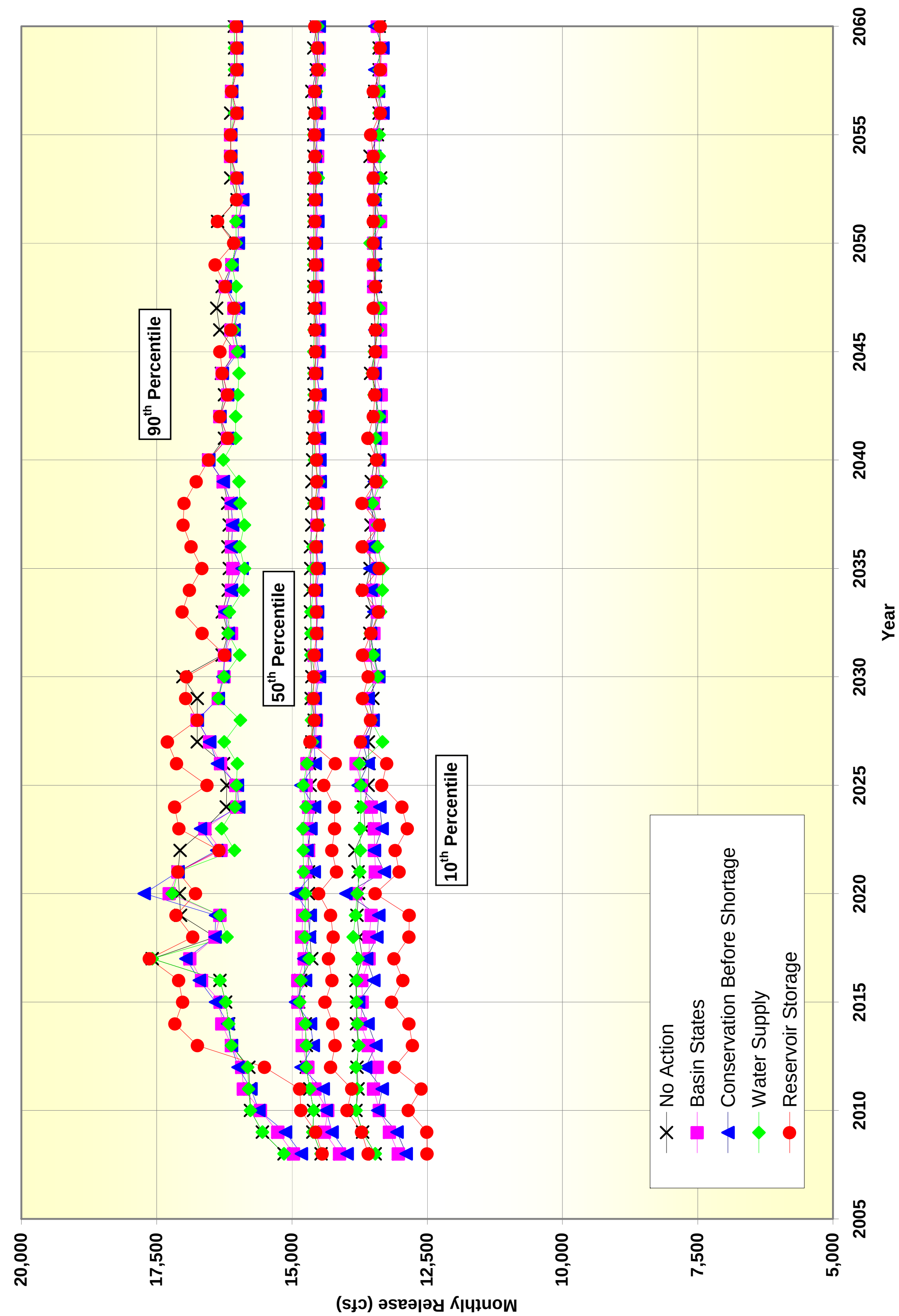

Figure P-31
Hoover Dam July Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

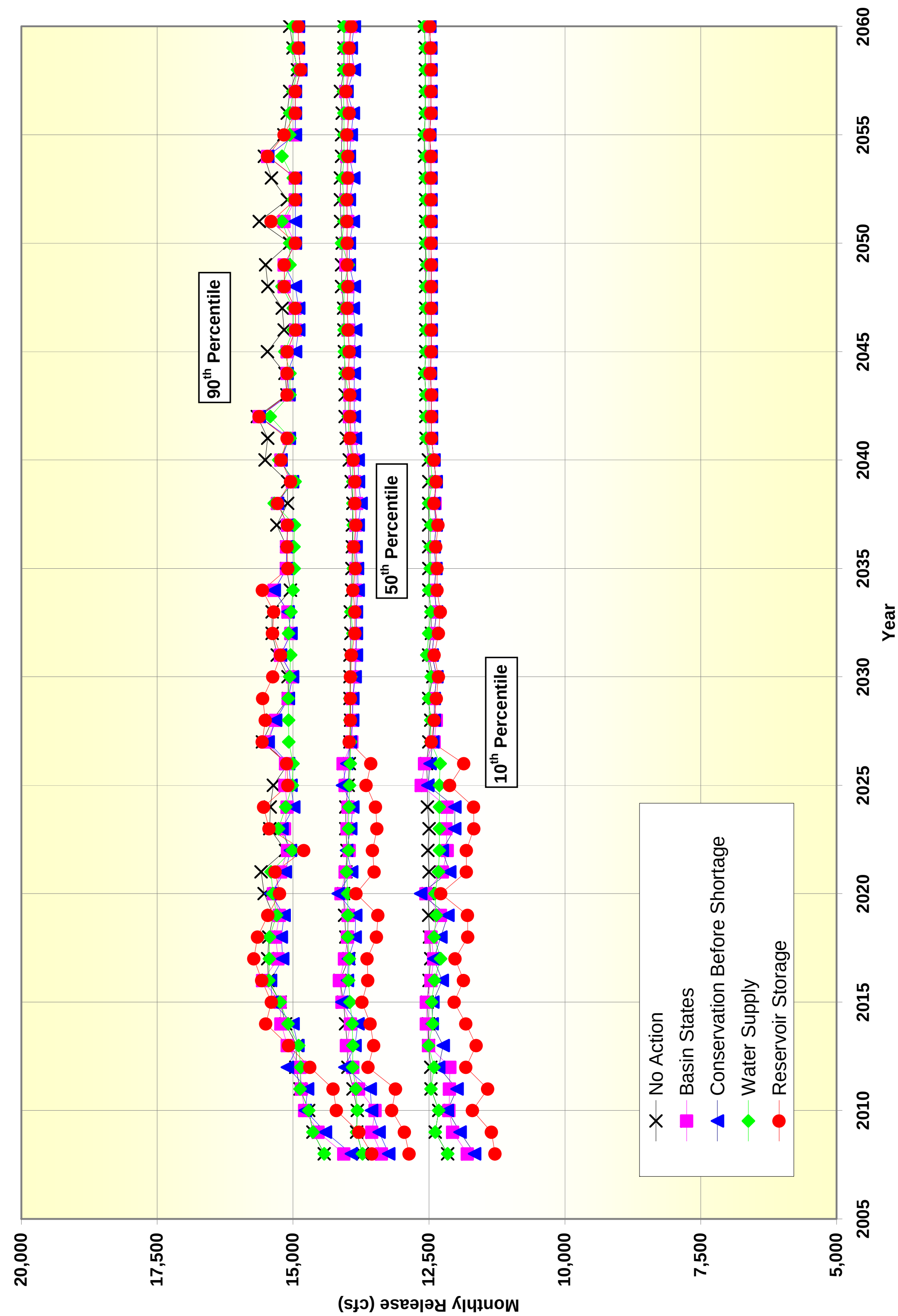

Figure P-32
Hoover Dam August Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

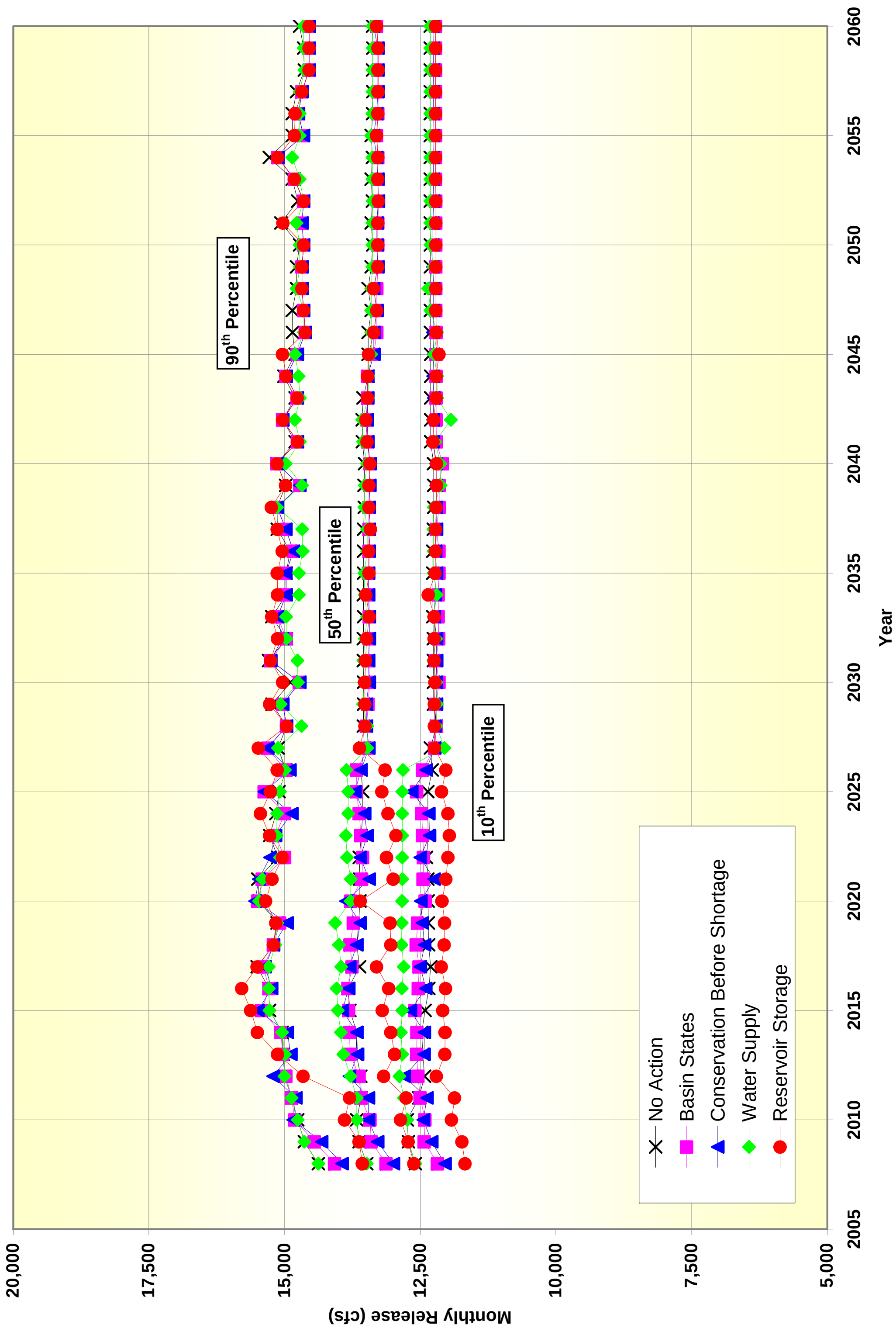

Figure P-33
Hoover Dam September Releases
Comparison of Action Alternatives to No Action Alternative
90^{th}, 50^{th} and 10^{th} Percentile Values

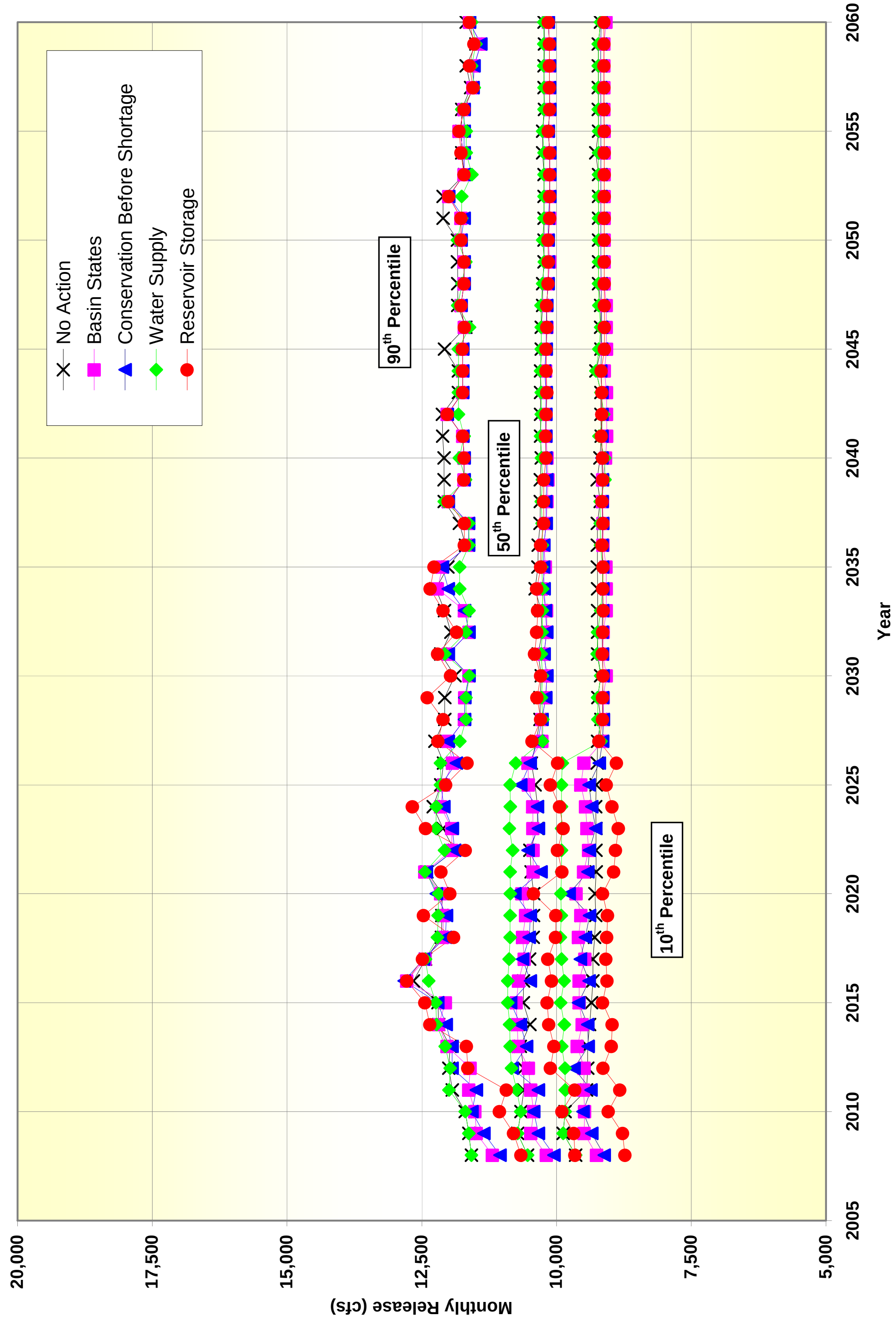

Figure P-34
Hoover Dam October Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

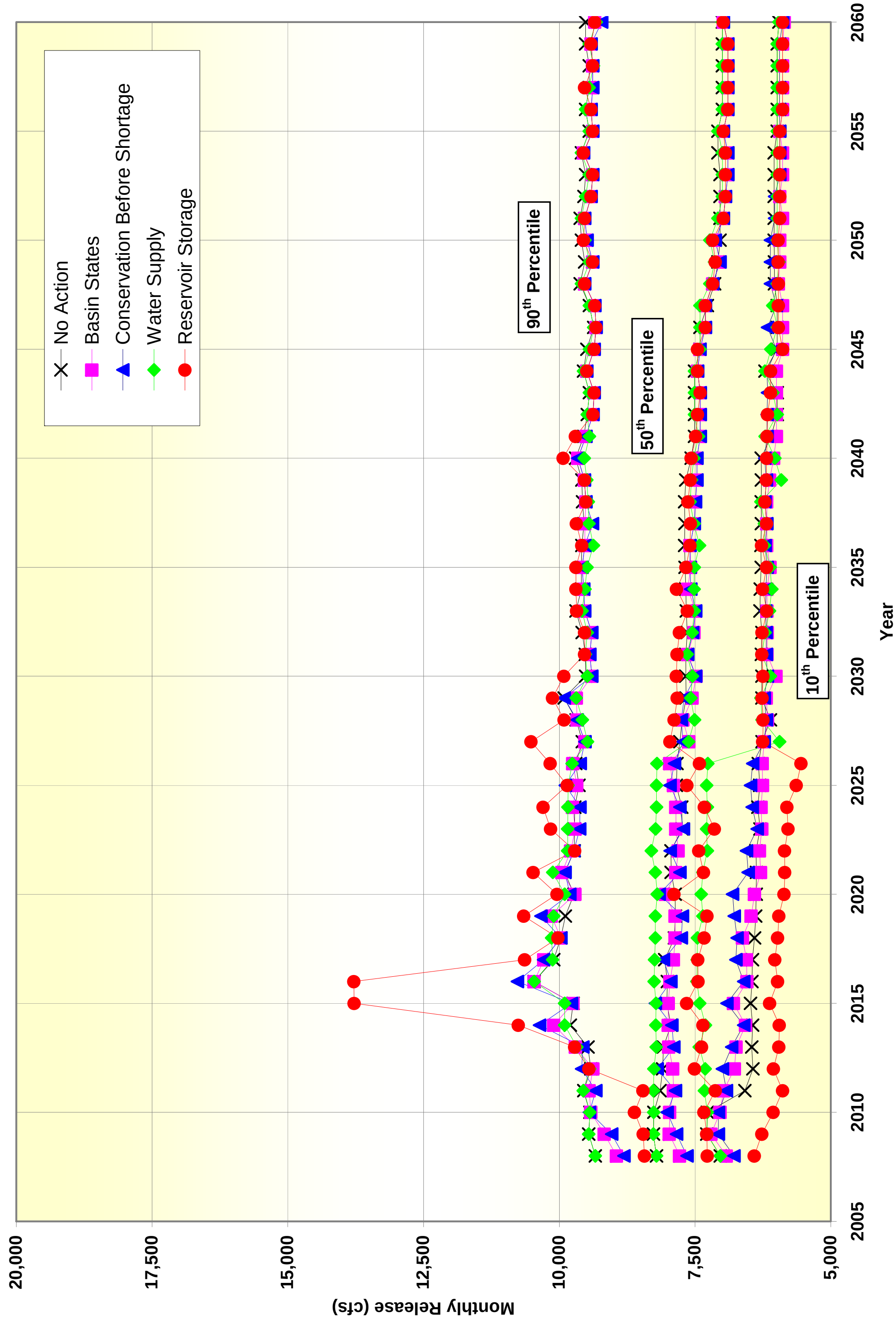

Figure P-35
Hoover Dam November Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

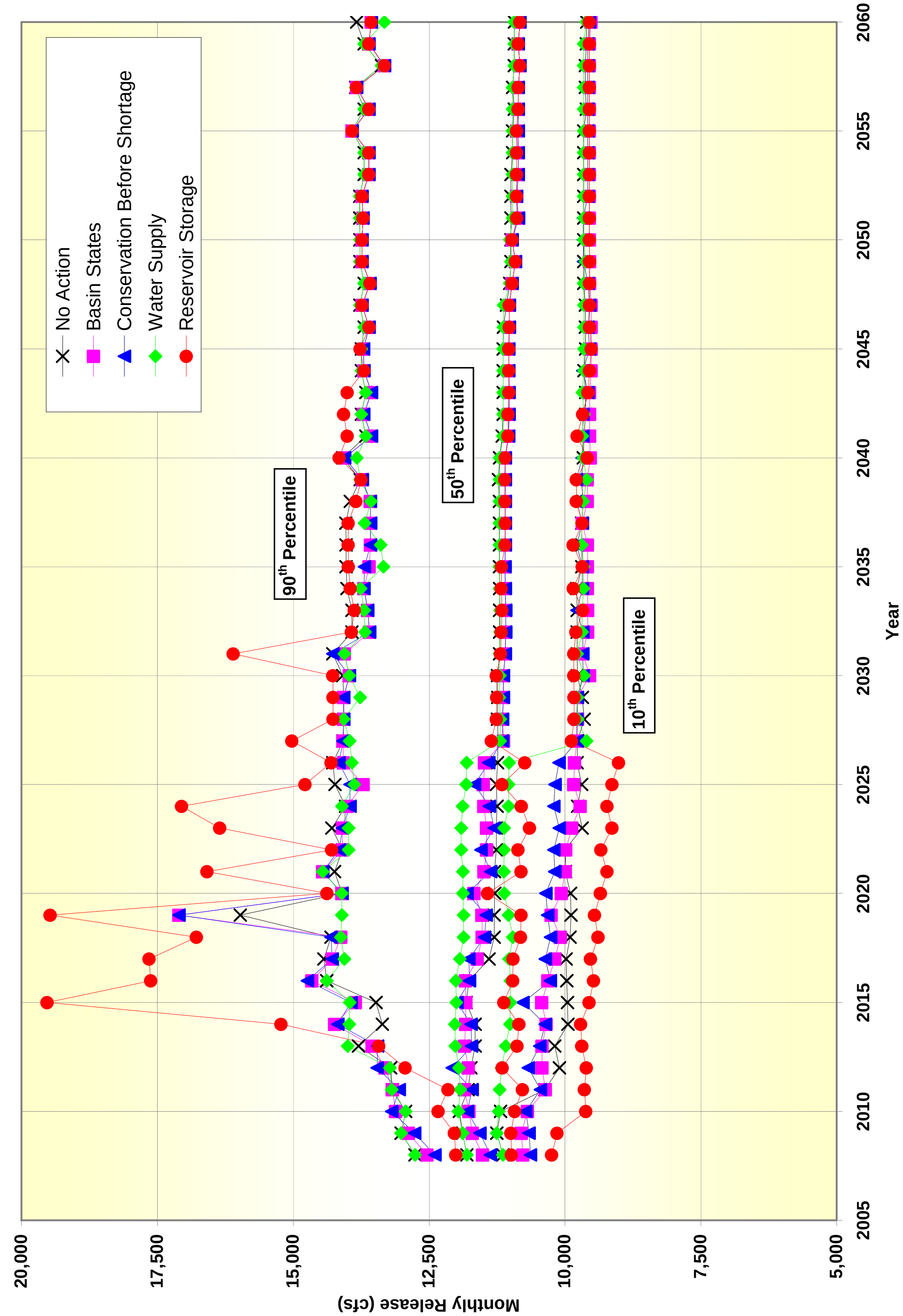

Figure P-36
Hoover Dam December Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

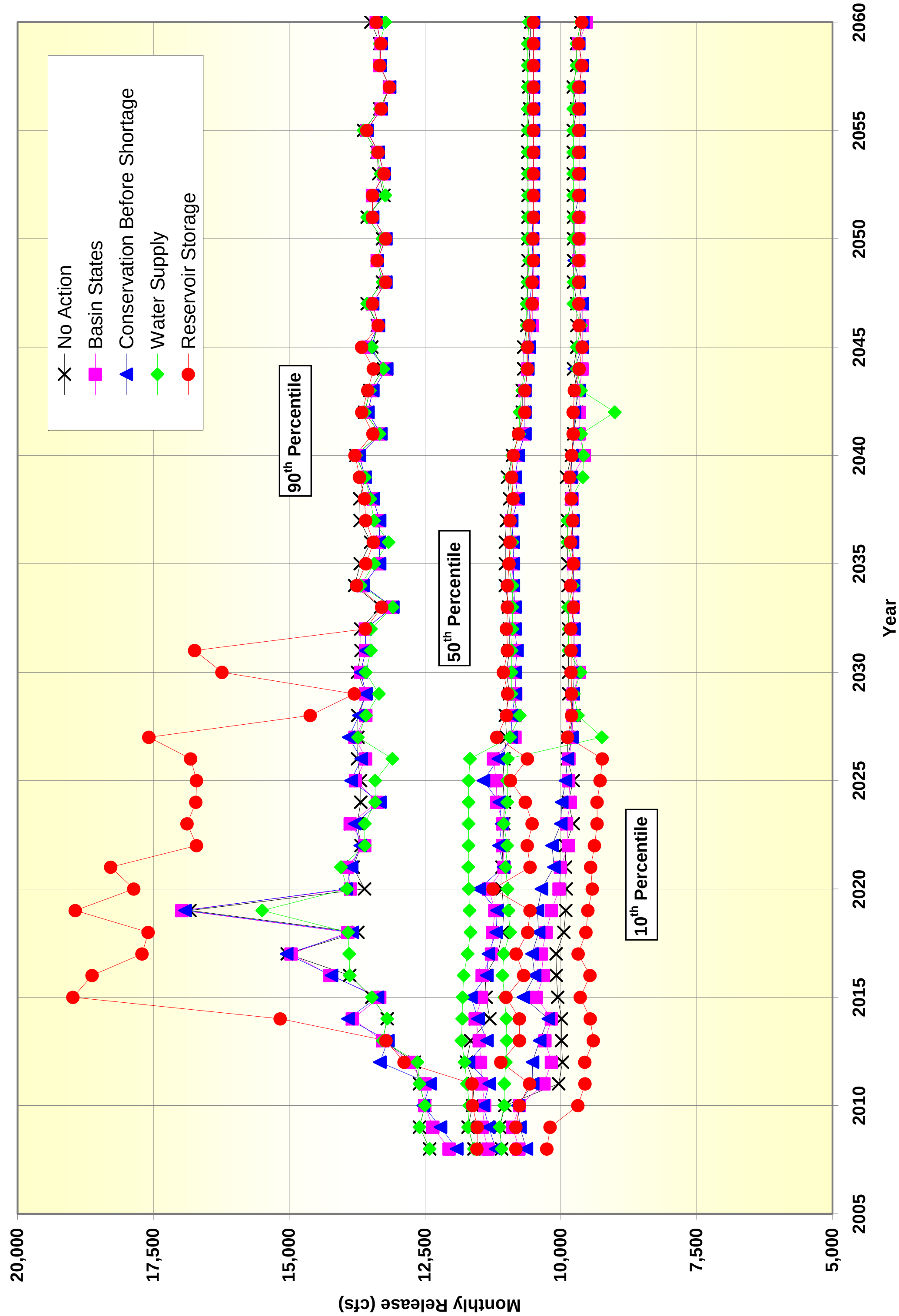

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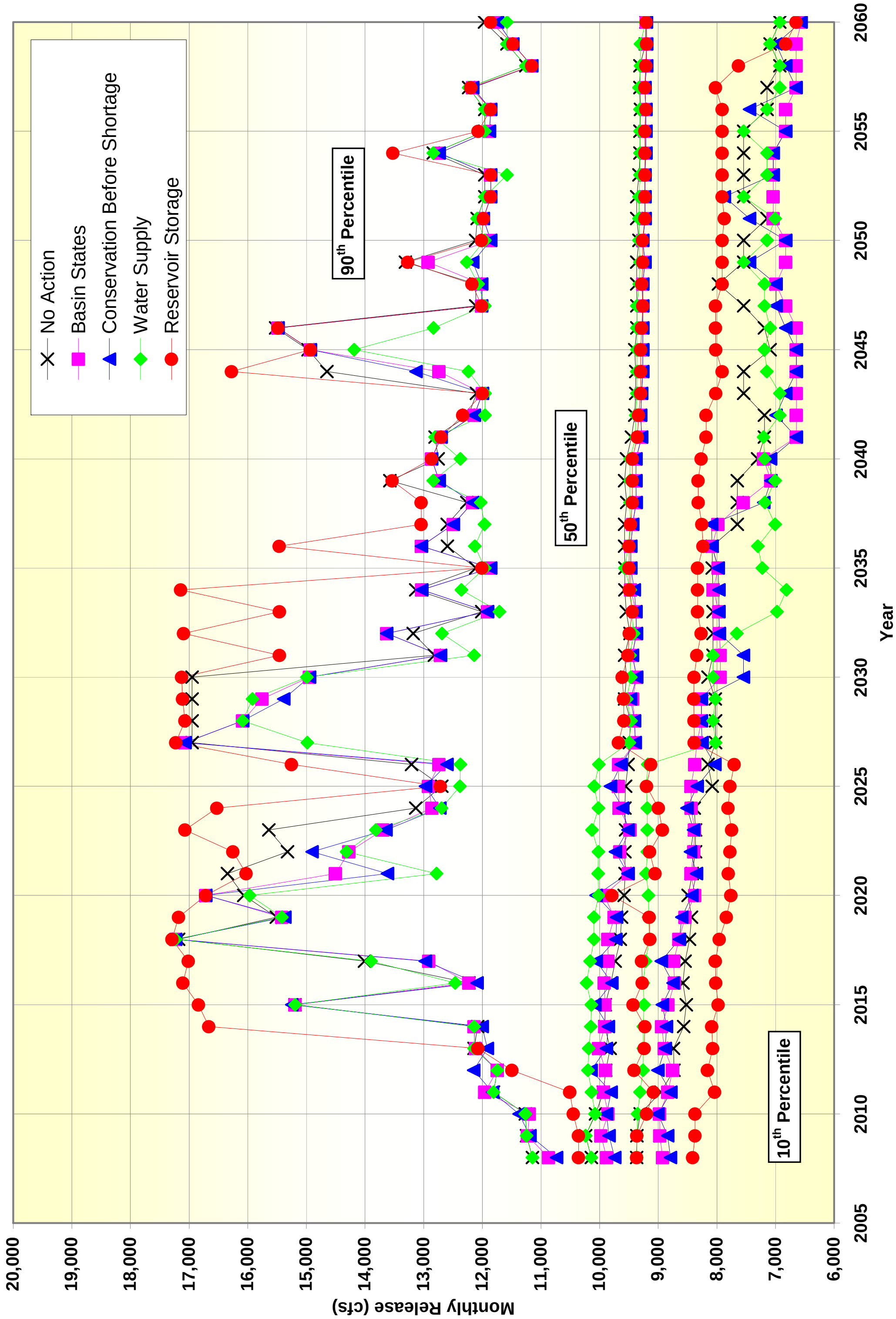
Figure P-37
Davis Dam January Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values



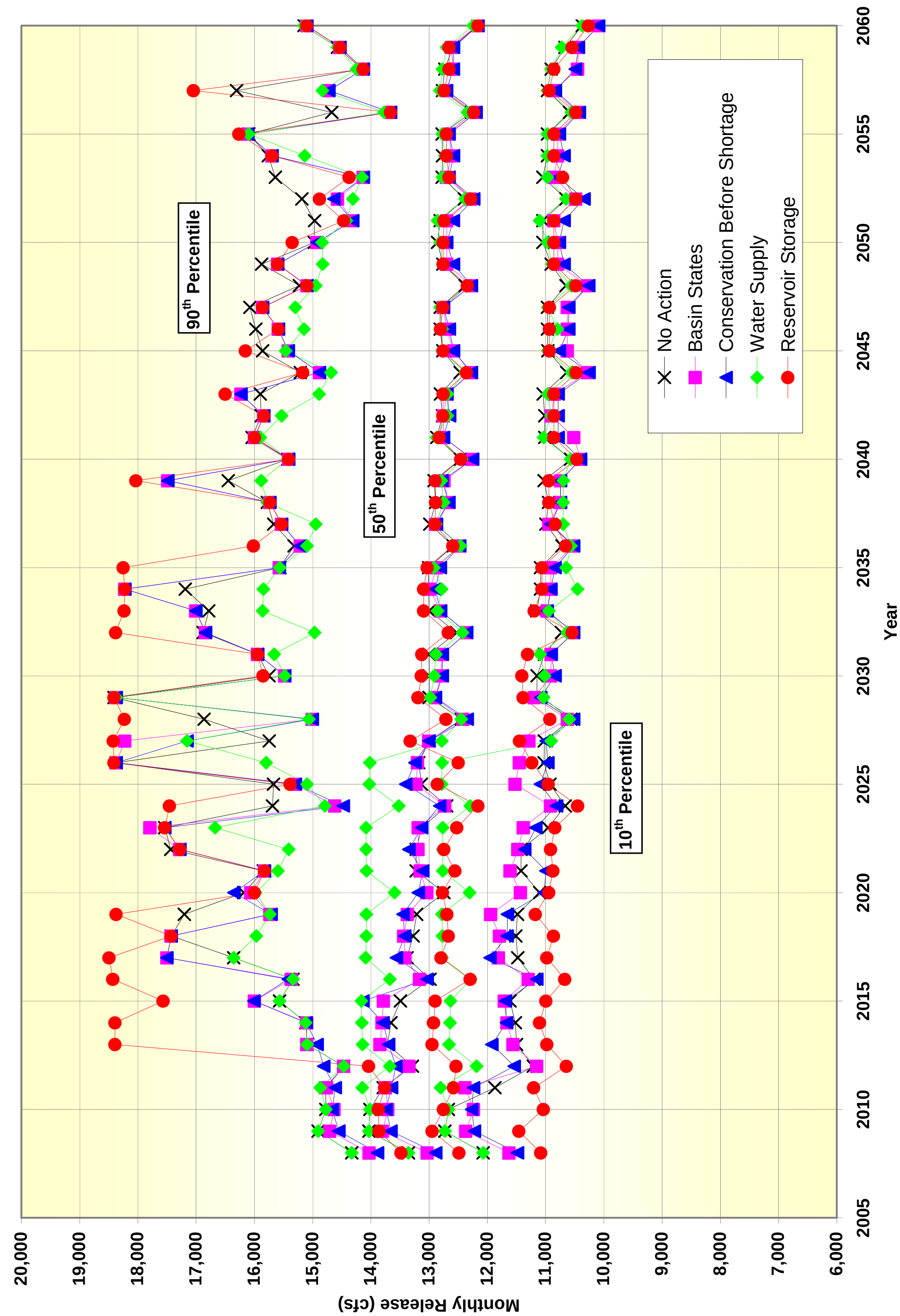


Figure P-38
Davis Dam February Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

Figure P-39
Davis Dam March Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

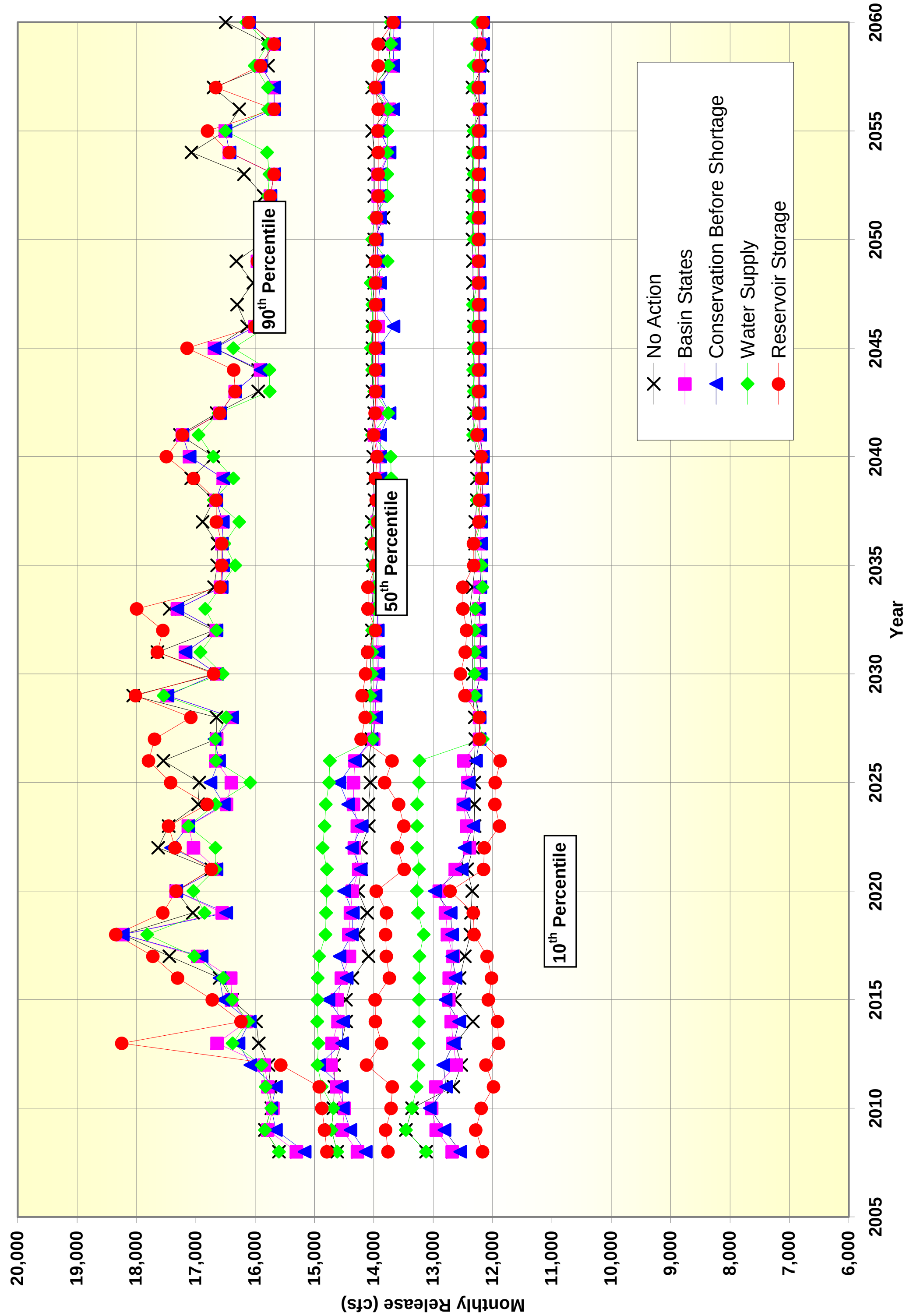


Figure P-40
Davis Dam April Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

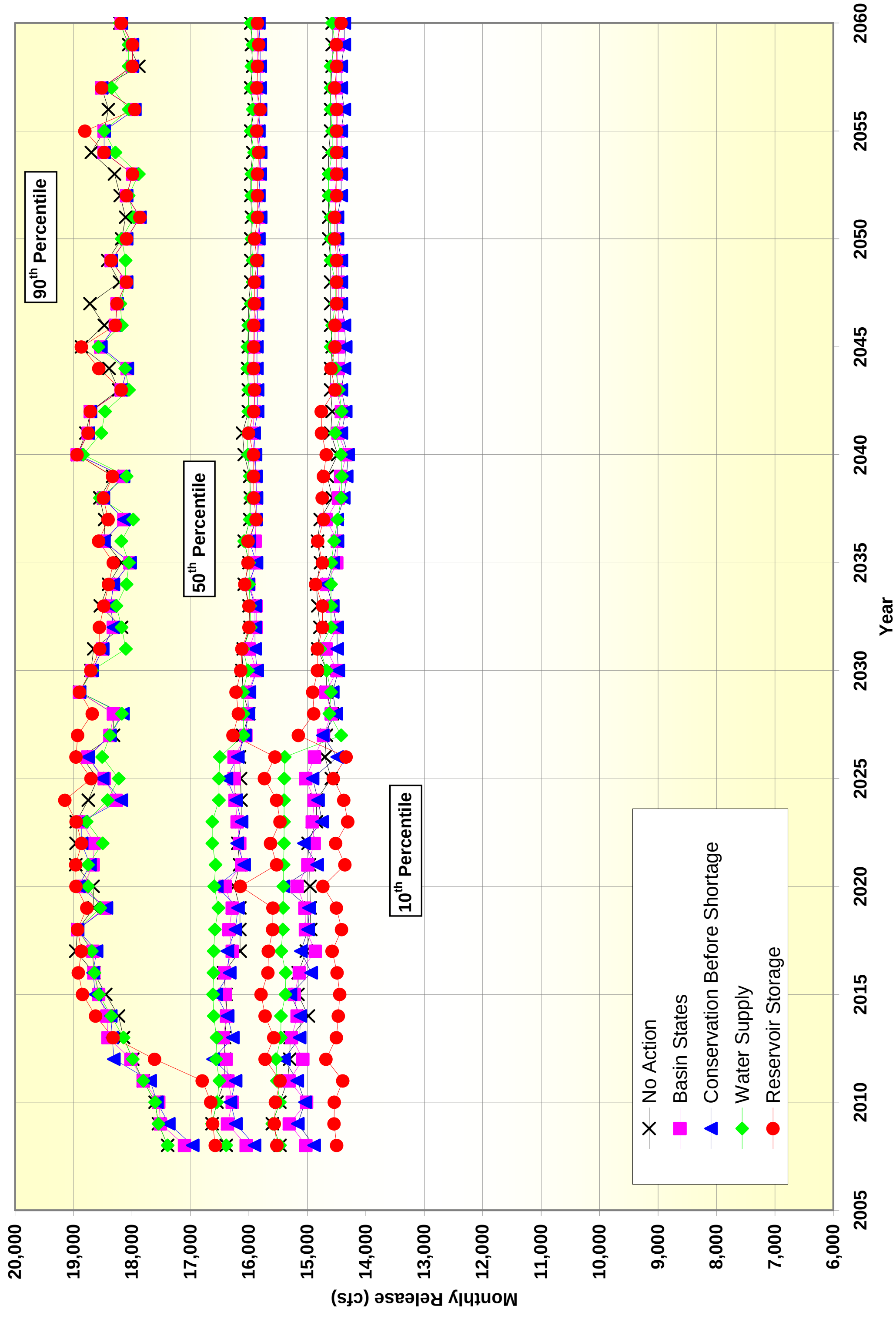


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Figure P-41
Davis Dam May Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

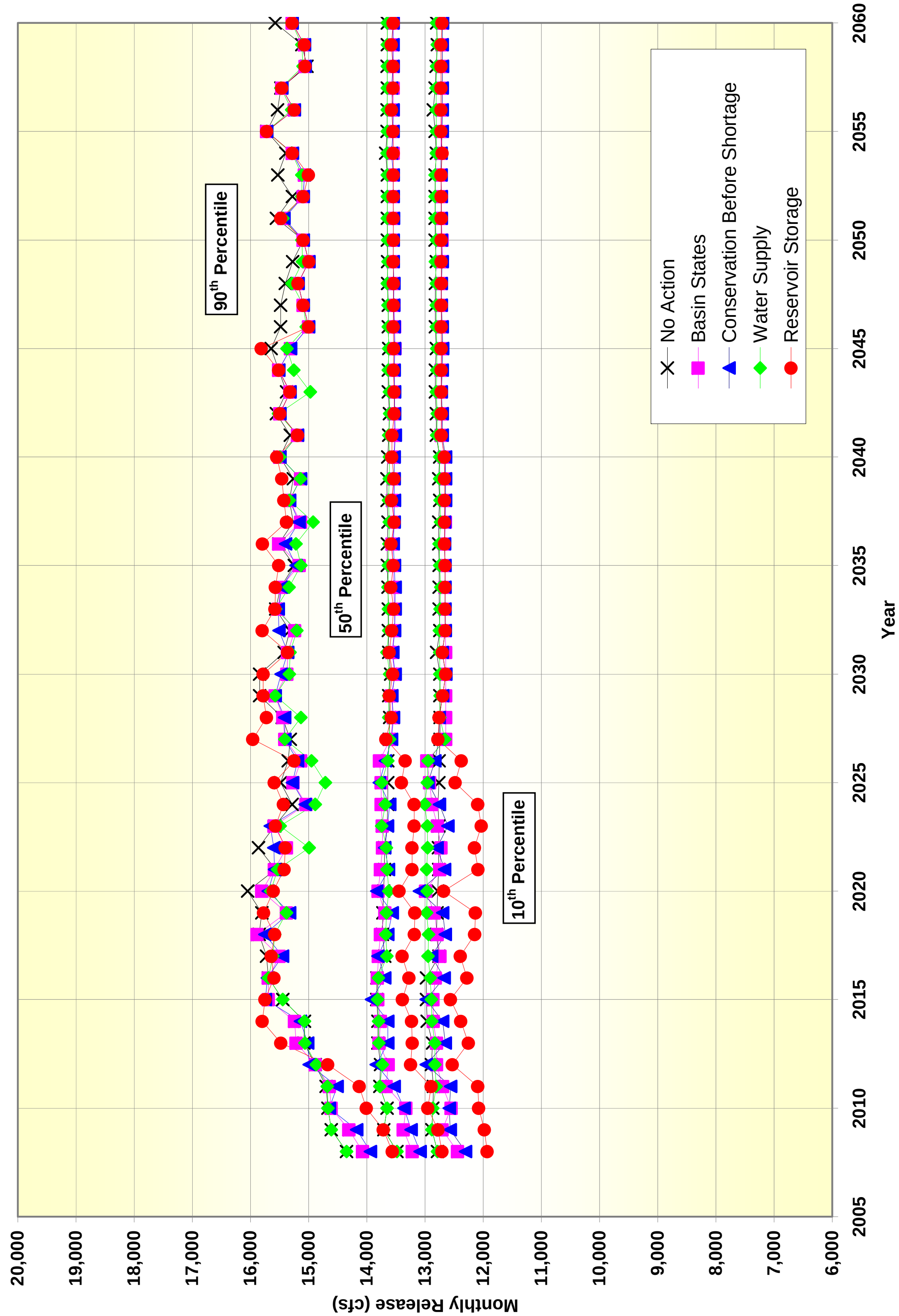

Figure P-42
Davis Dam June Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

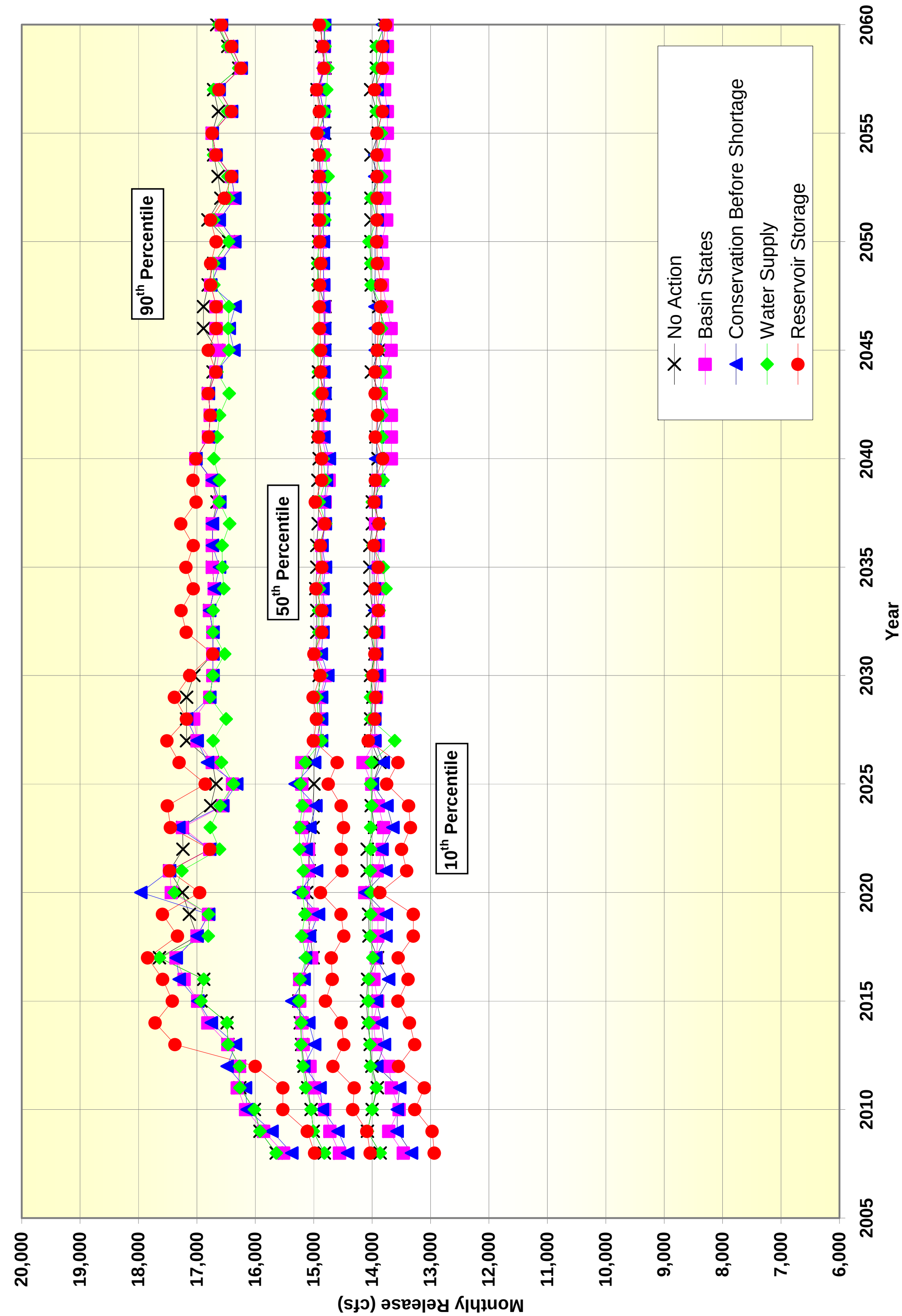

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Figure P-43
Davis Dam July Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

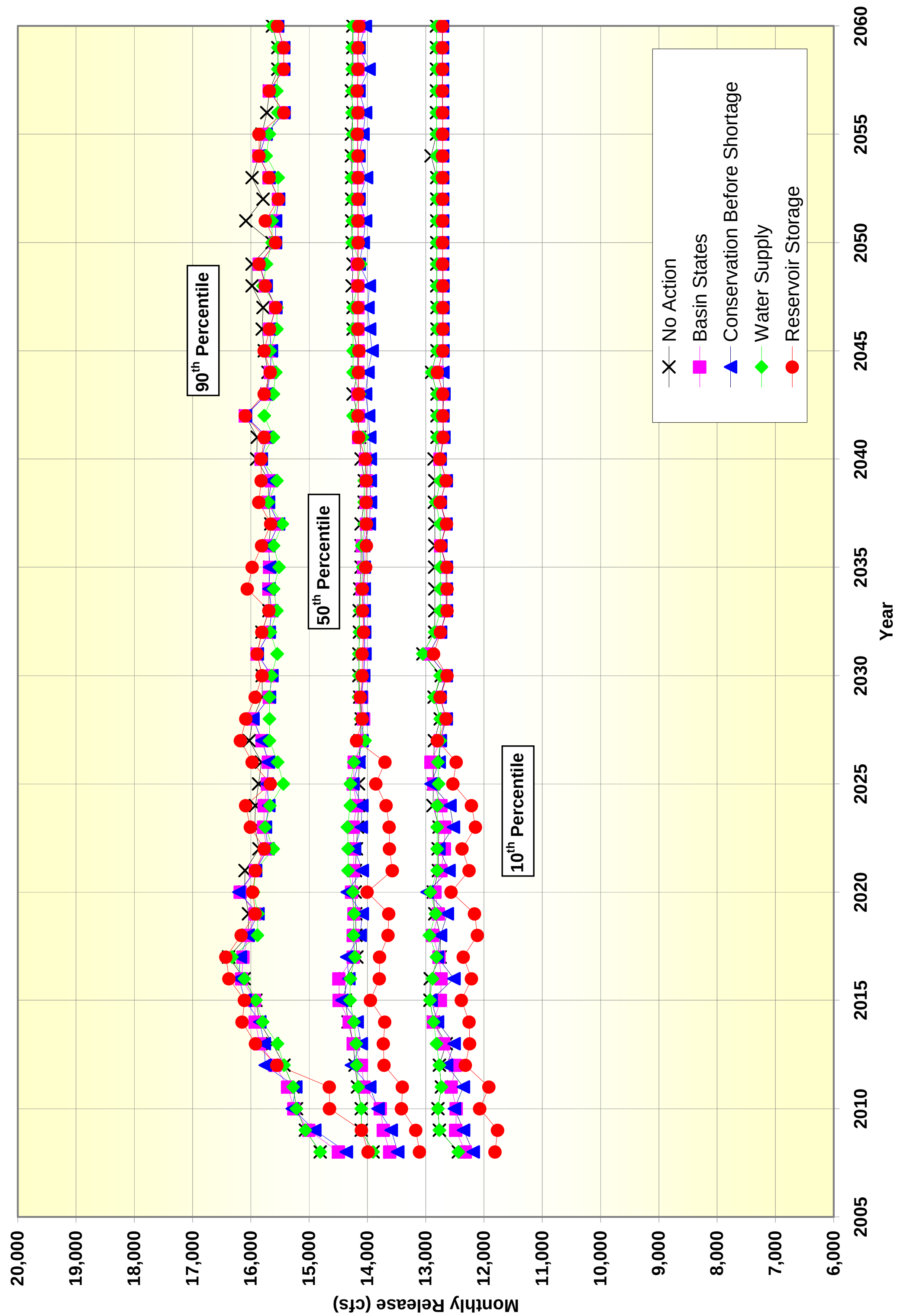

Figure P-44
Davis Dam August Releases
Comparison of Action Alternatives to No Action Alternative
90^{th}, 50^{th} and 10^{th} Percentile Values

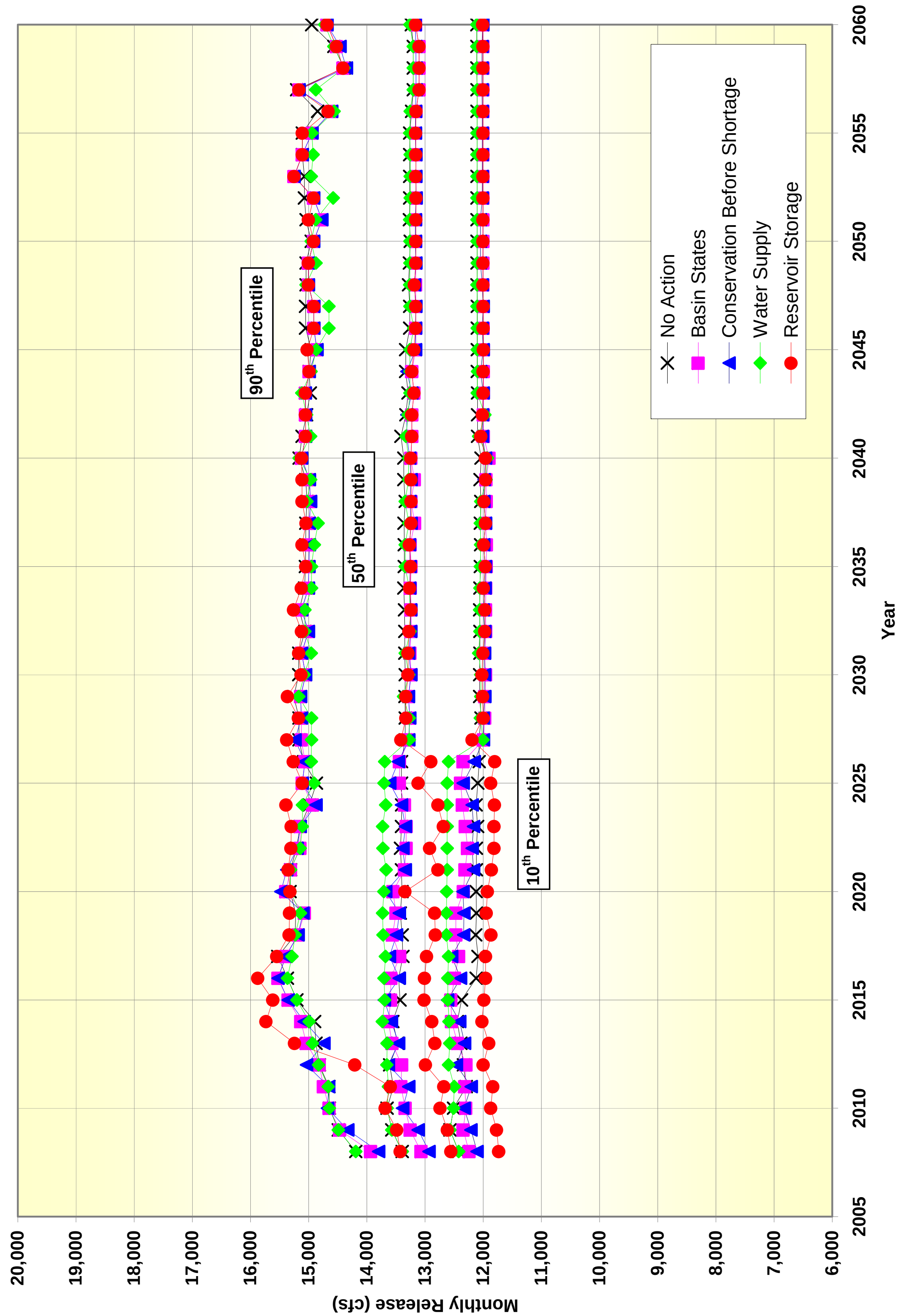

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Figure P-45
Davis Dam September Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

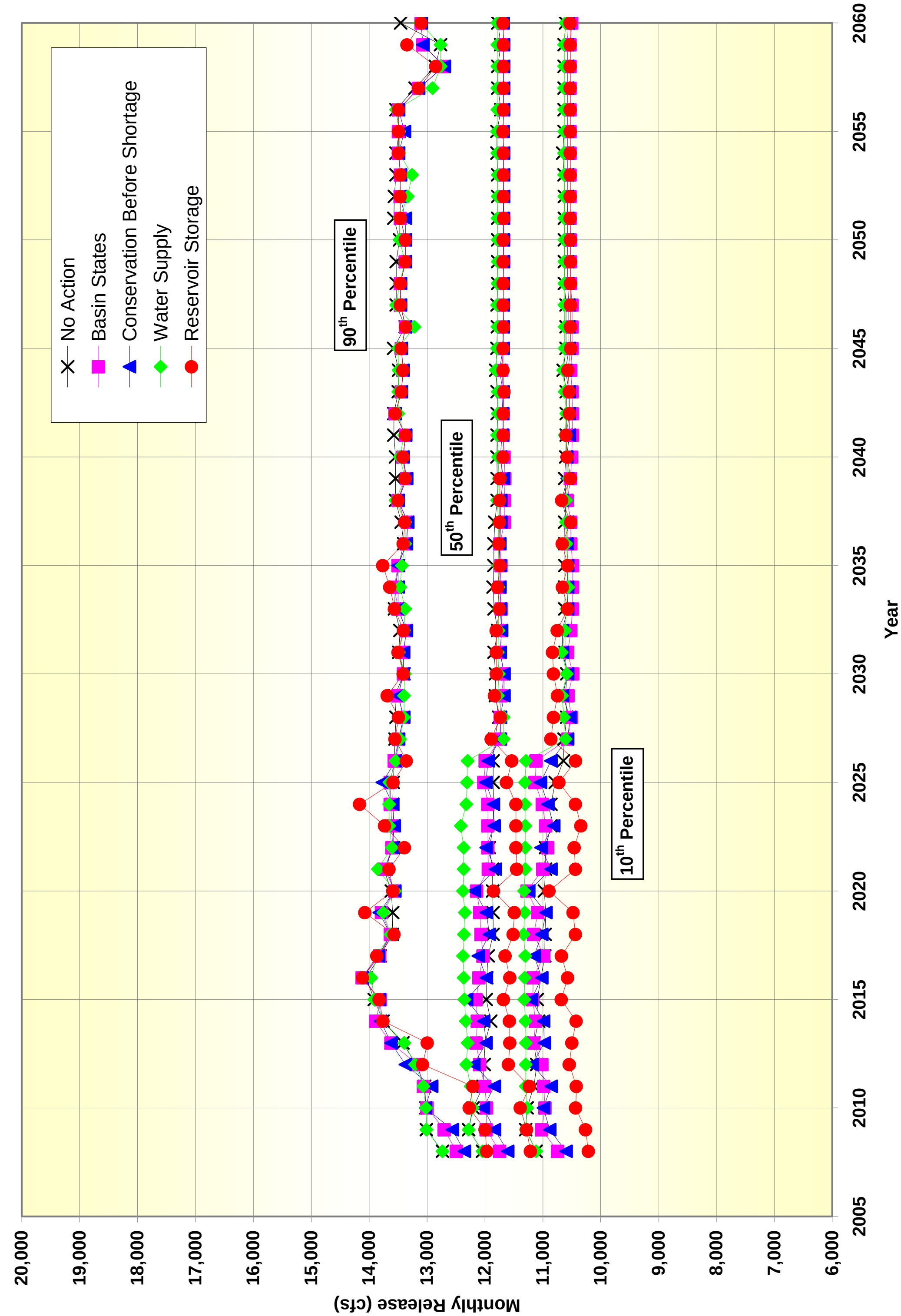

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Figure P-46
Davis Dam October Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

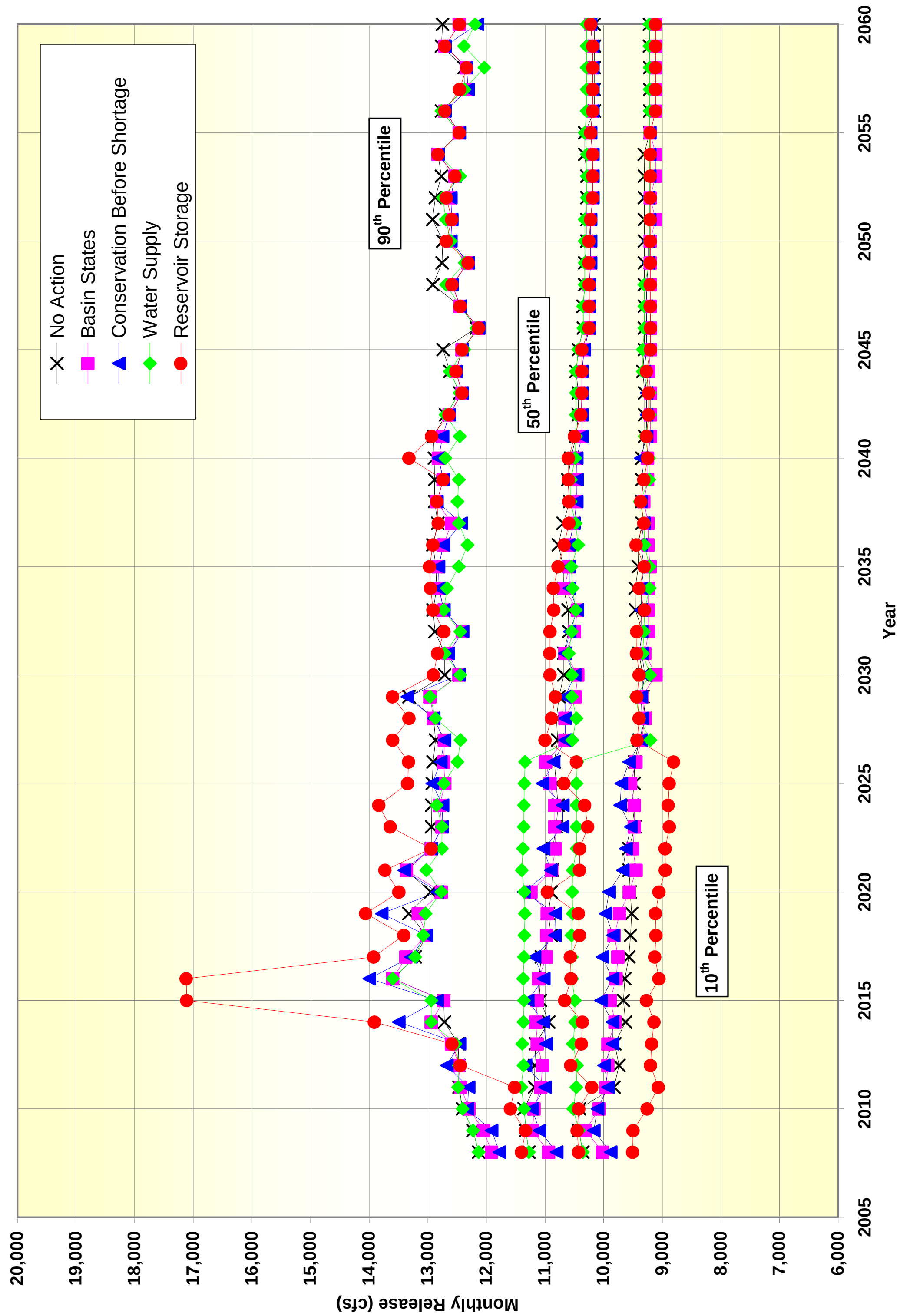

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Figure P-47
Davis Dam November Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

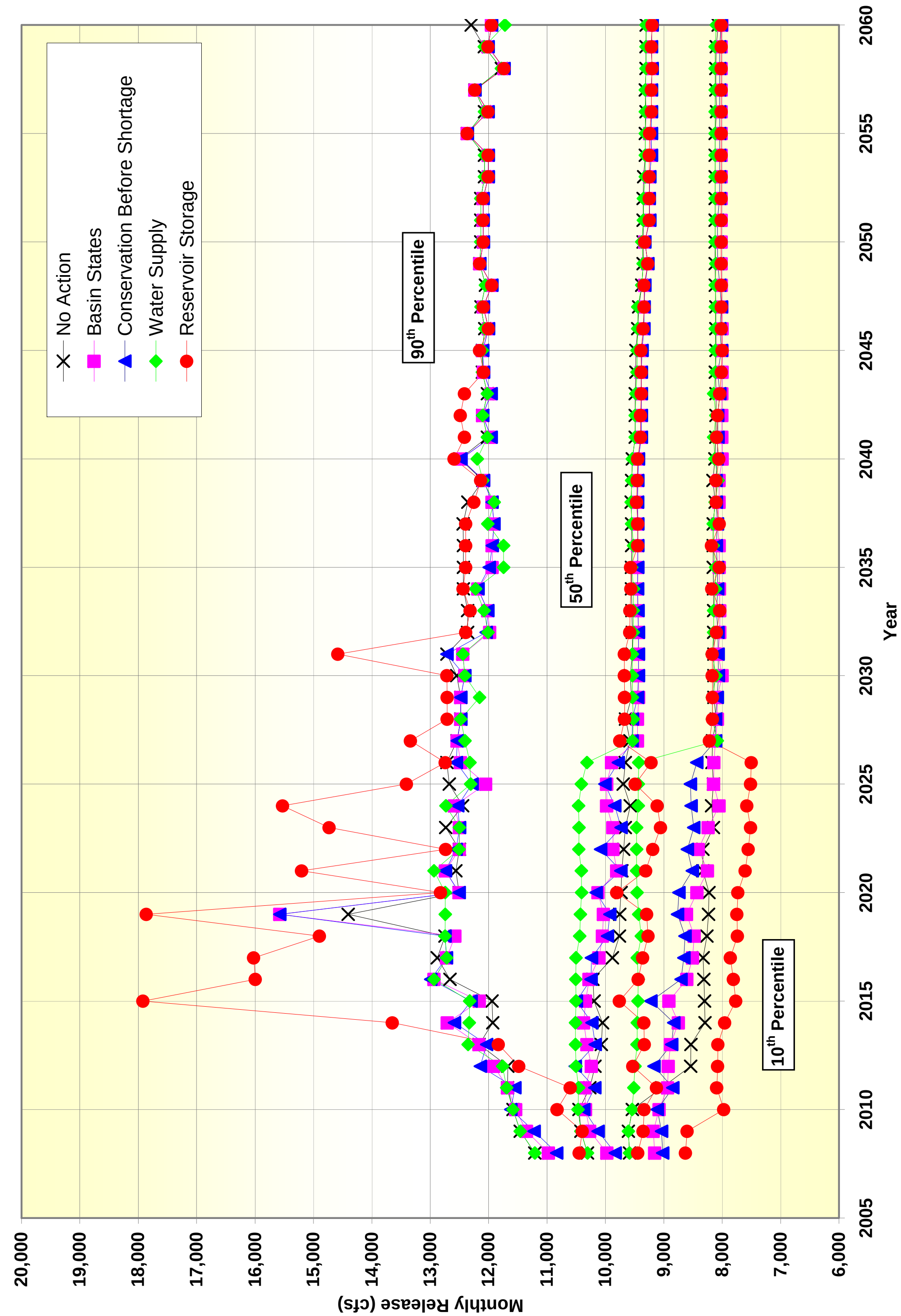

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Figure P-48
Davis Dam December Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

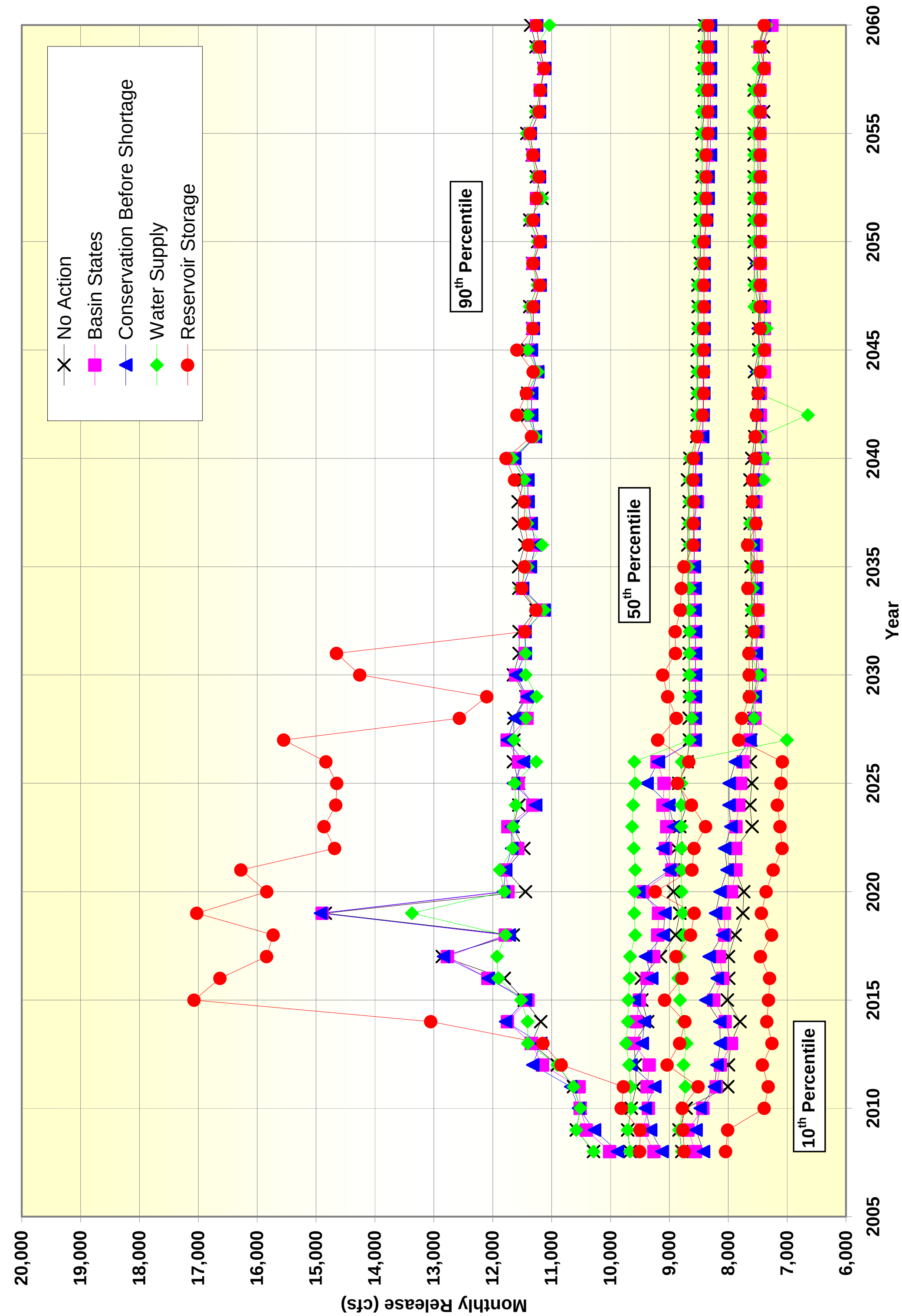

Figure P-49
Parker Dam January Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

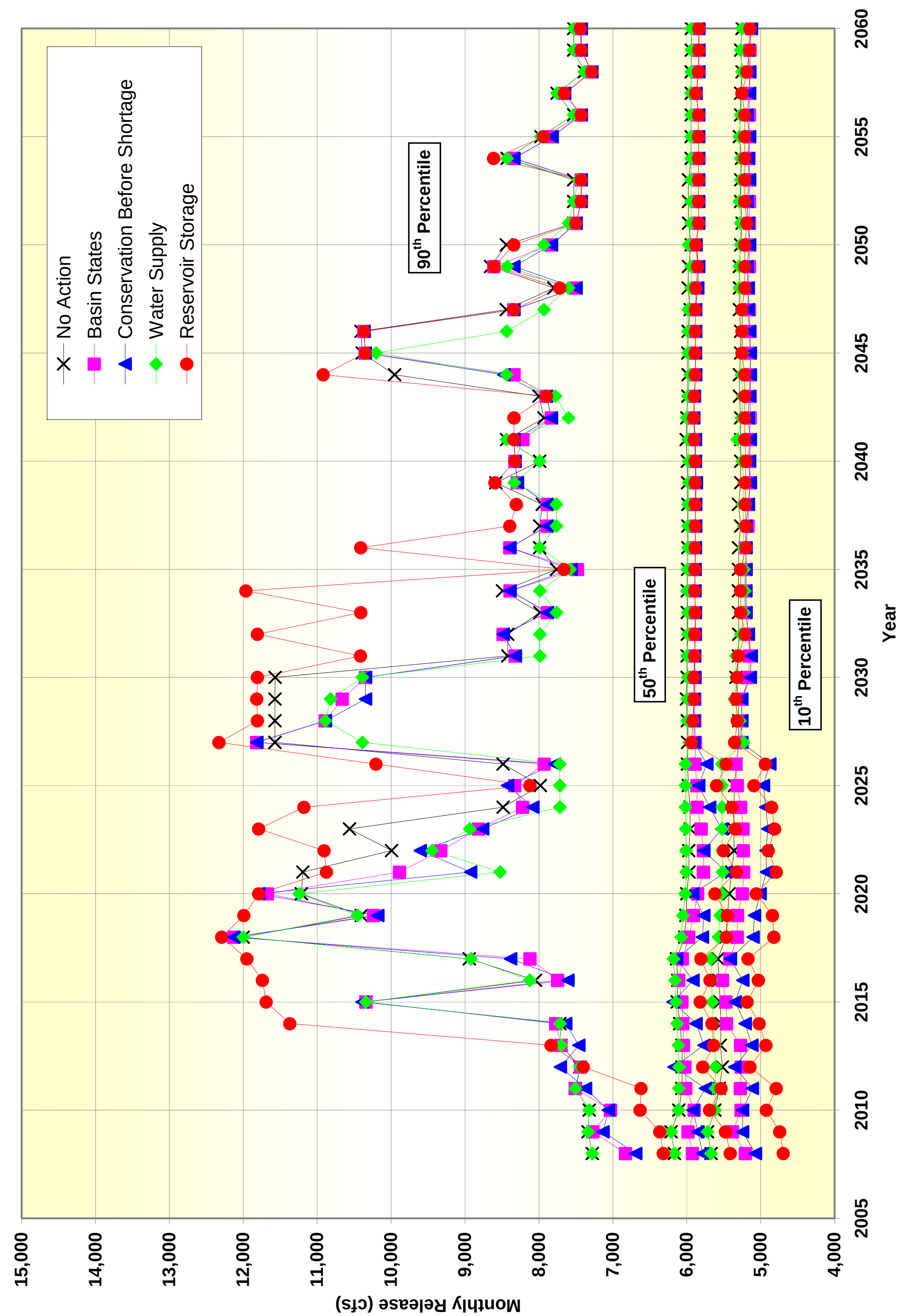

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Figure P-50
Parker Dam February Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

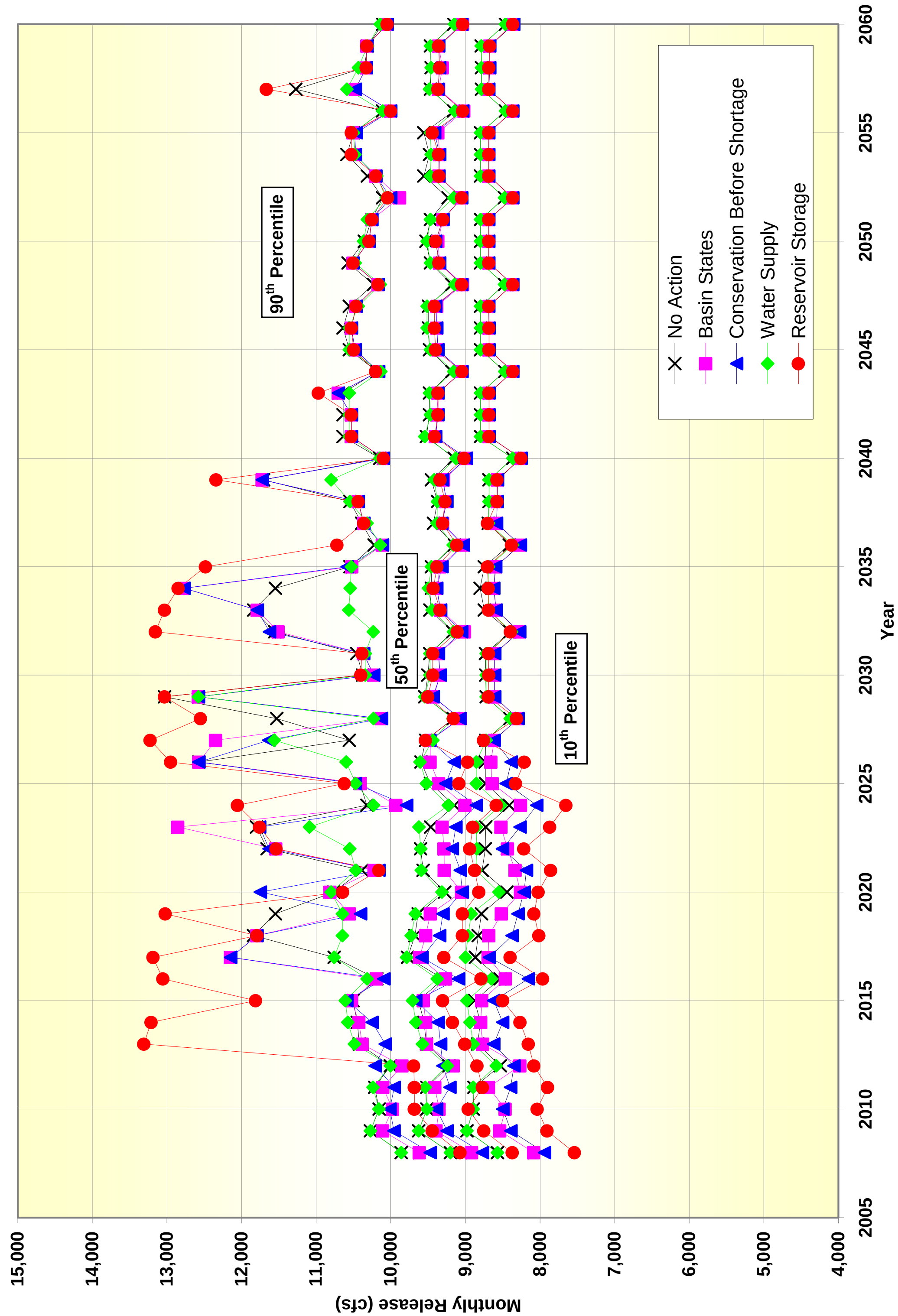

Figure P-51
Parker Dam March Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

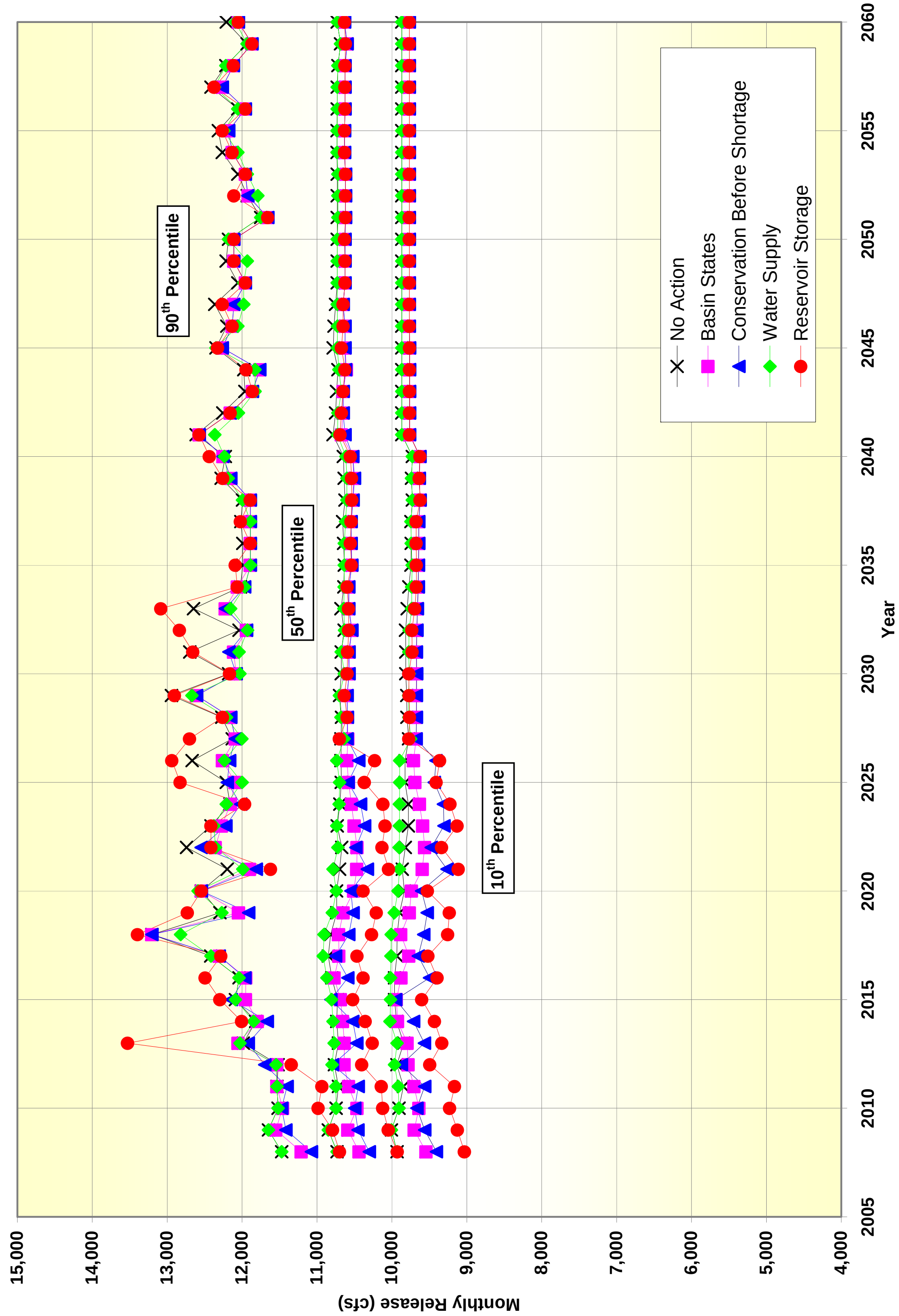

Figure P-52
Parker Dam April Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

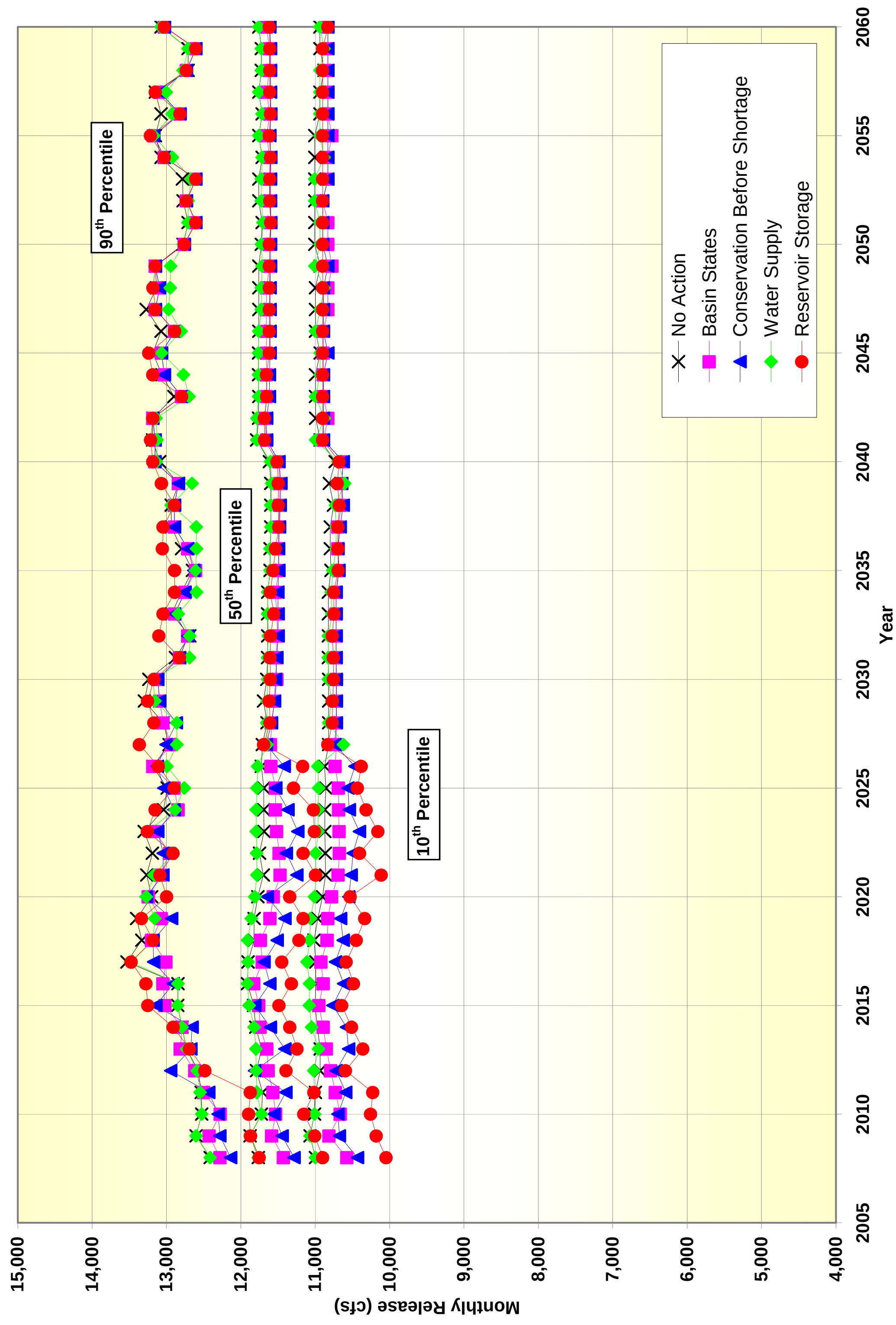

Figure P-53
Parker Dam May Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

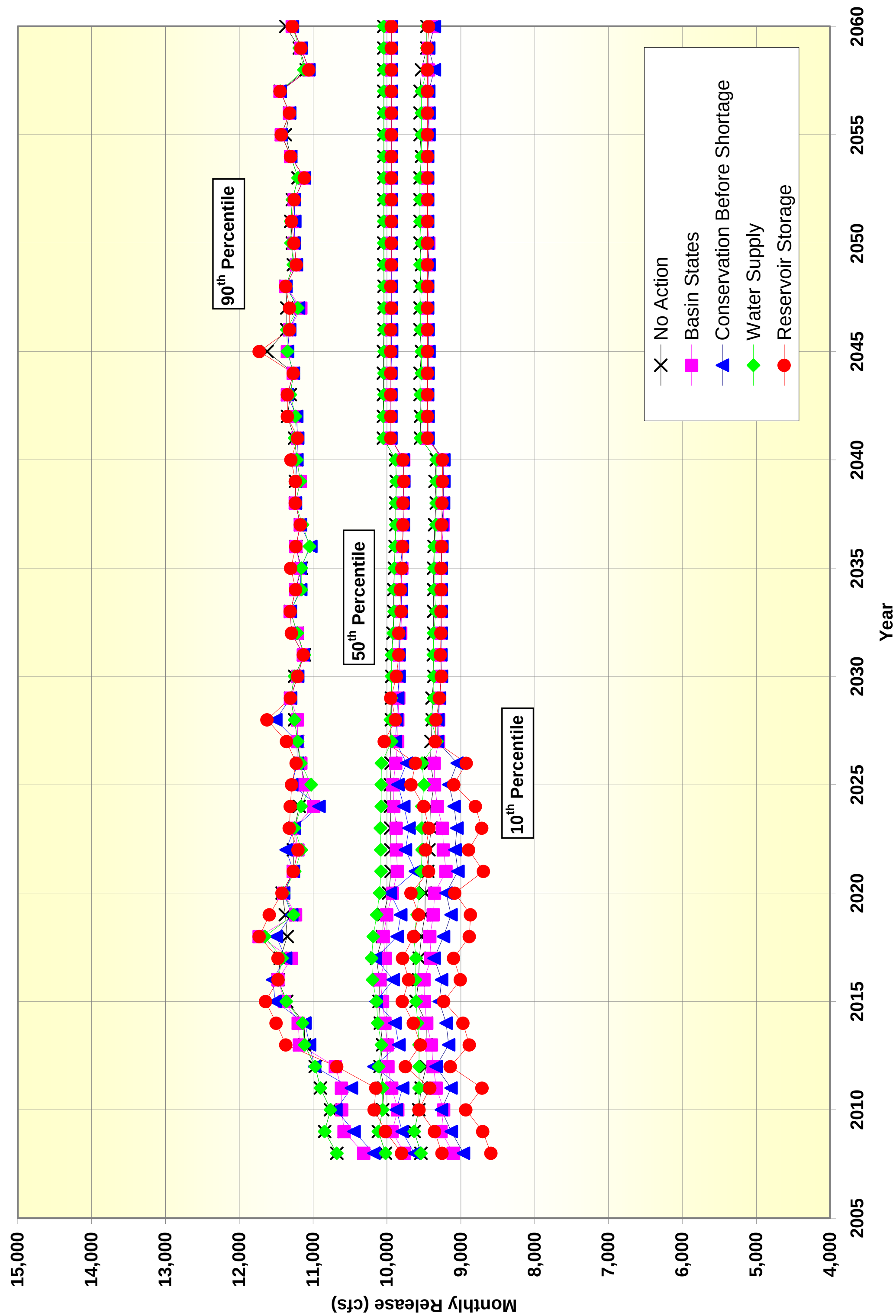

Figure P-54
Parker Dam June Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

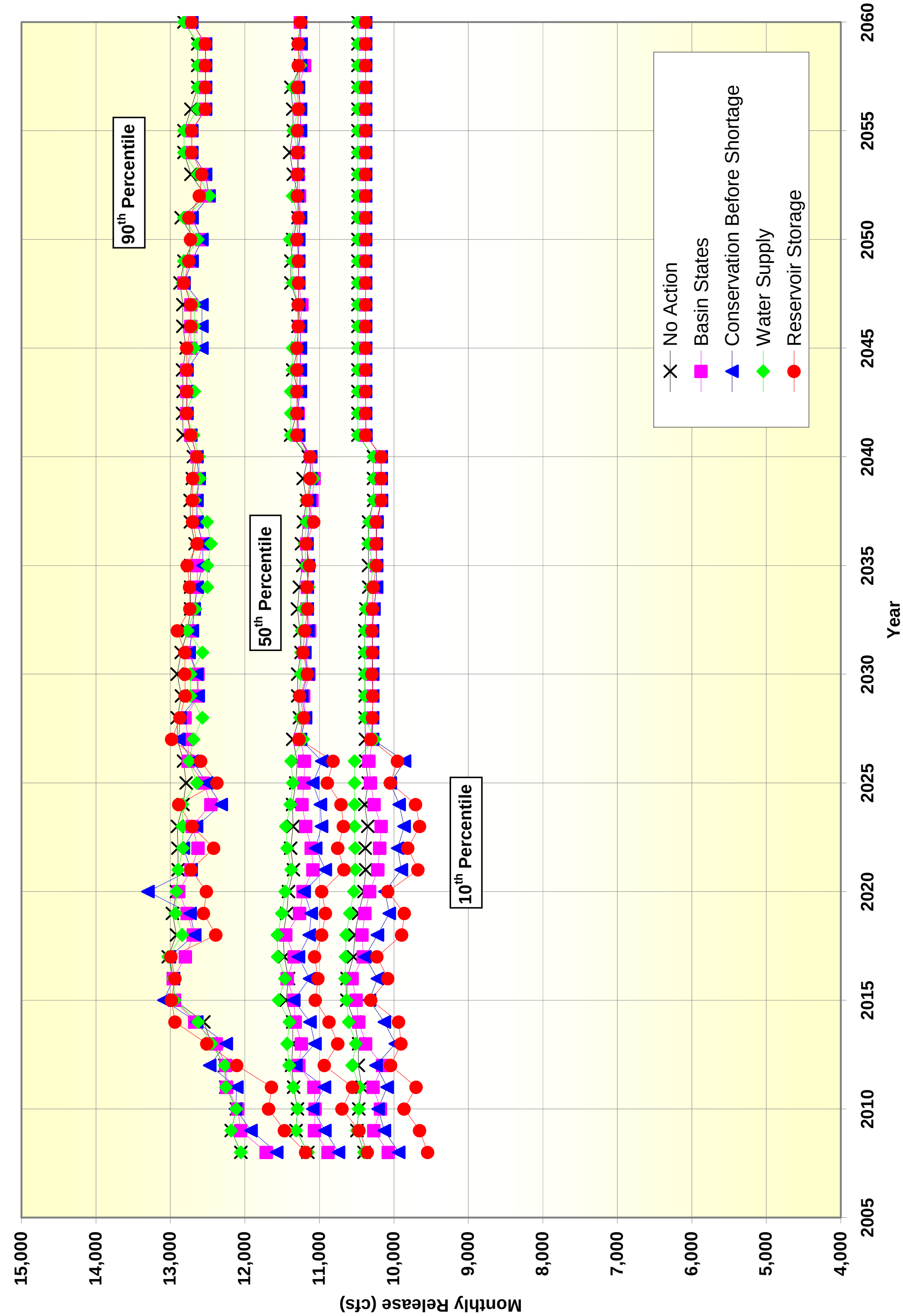

Figure P-55
Parker Dam July Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

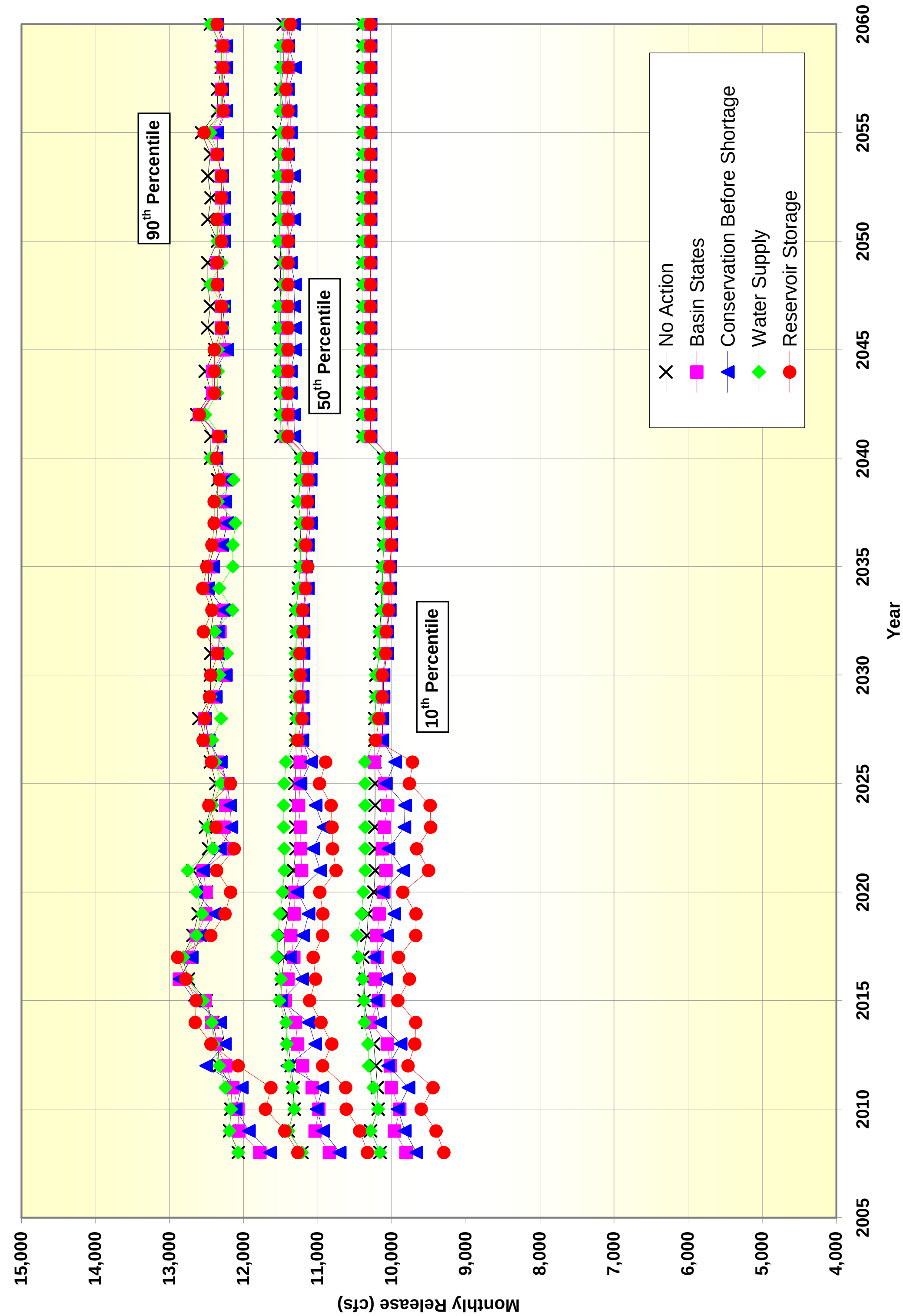

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Figure P-56
Parker Dam August Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

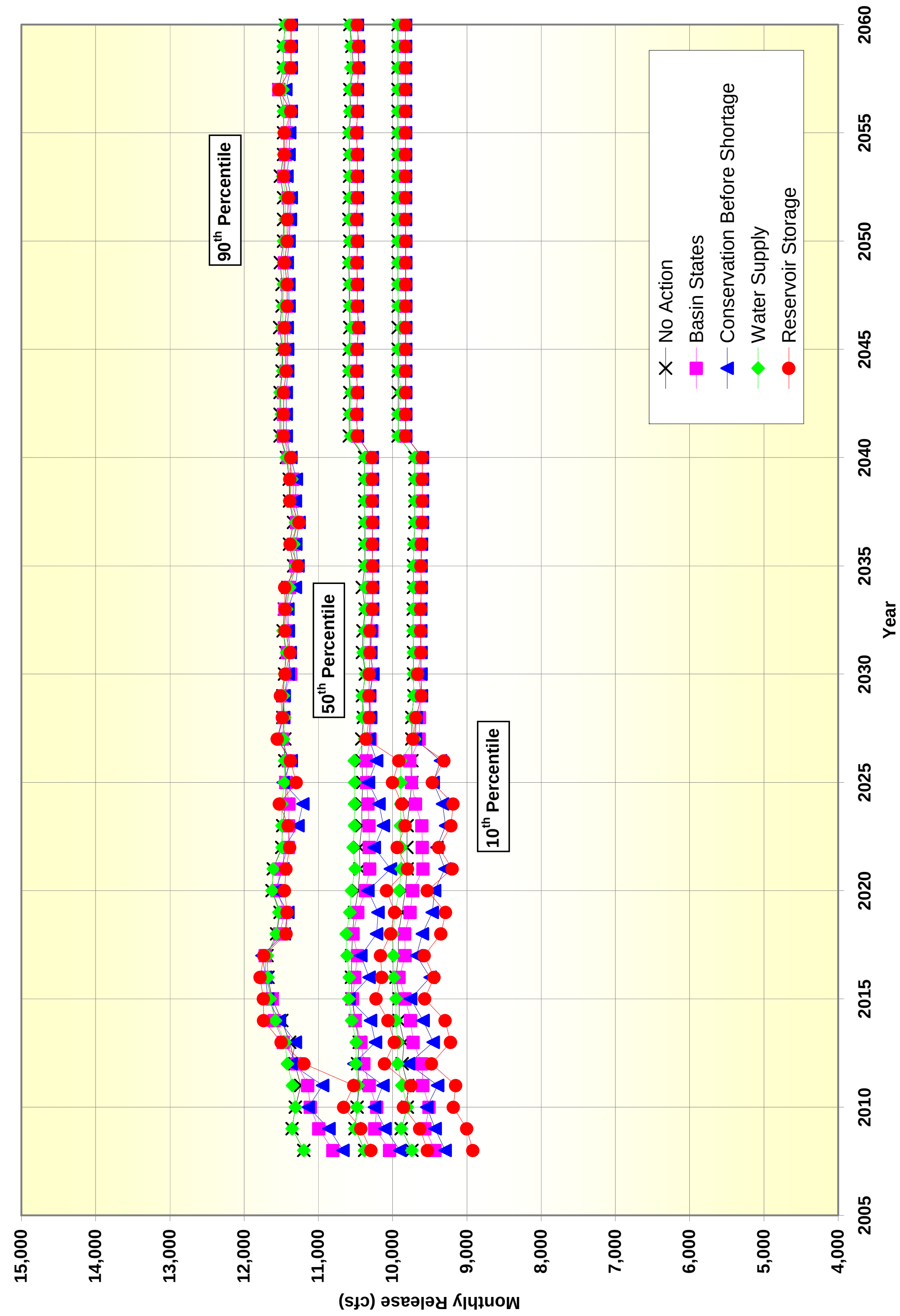

Figure P-57
Parker Dam September Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

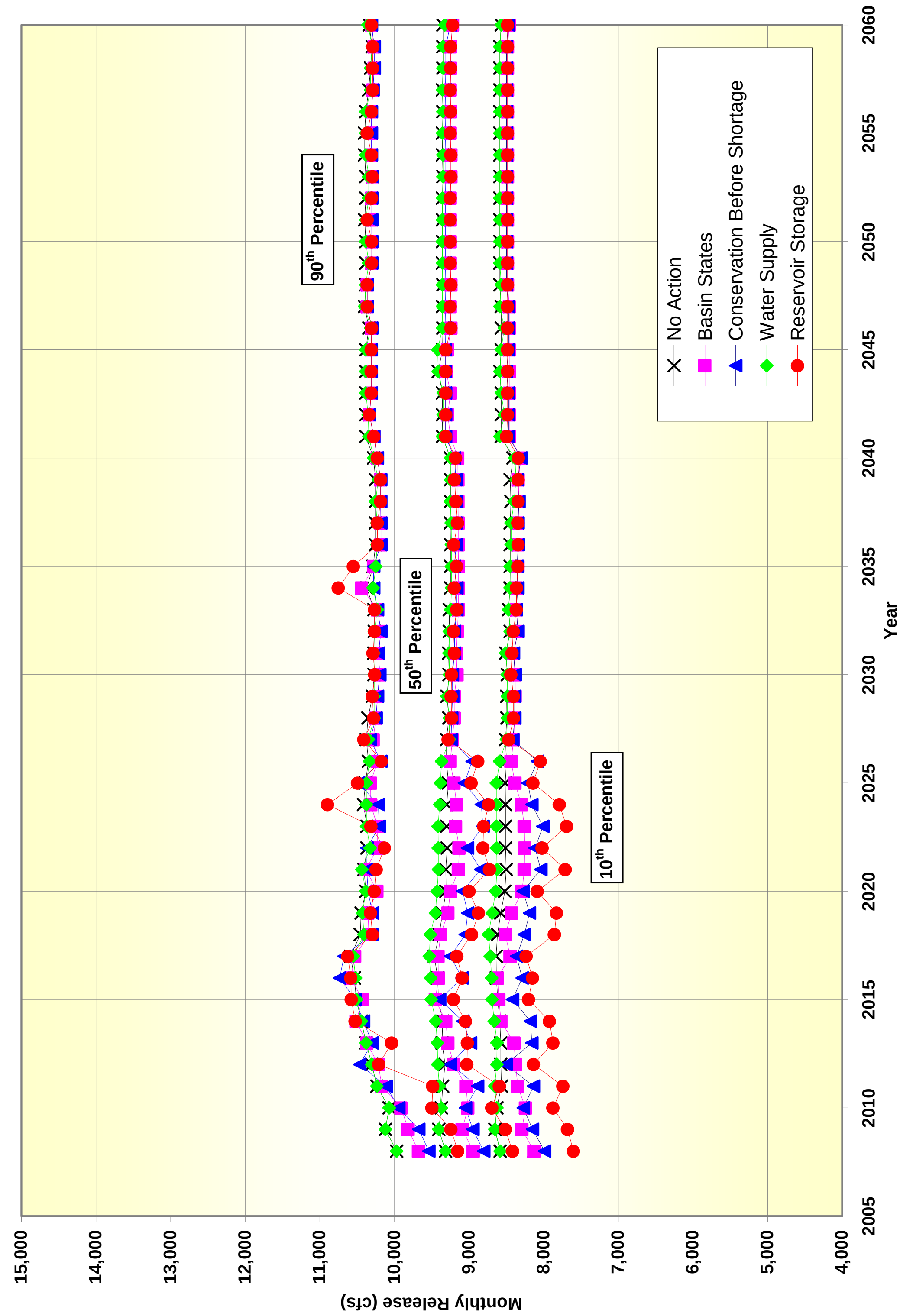

Figure P-58
Parker Dam October Releases
Comparison of Action Alternatives to No Action Alternative
90^{th}, 50^{th} and 10^{th} Percentile Values

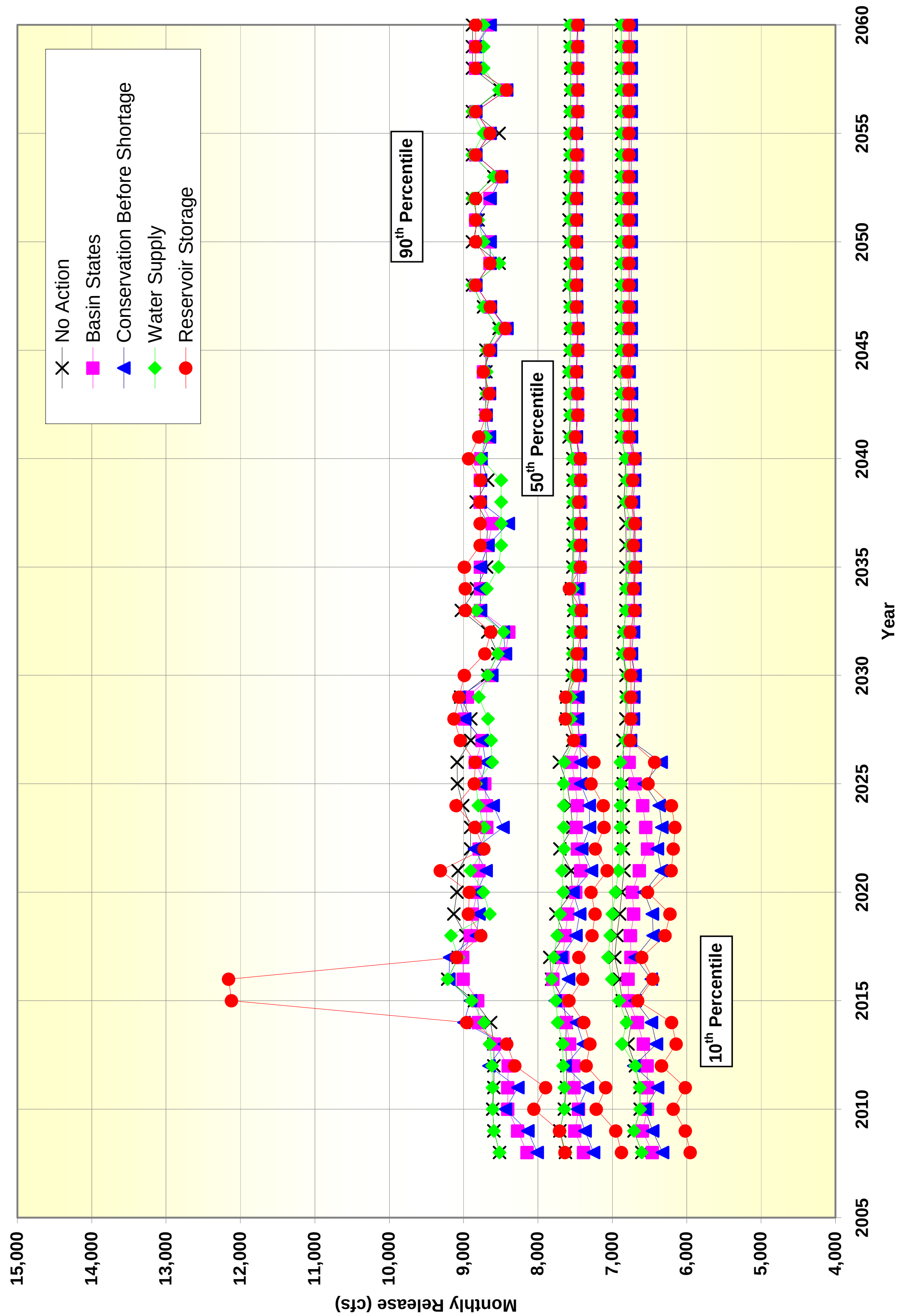

Figure P-59
Parker Dam November Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

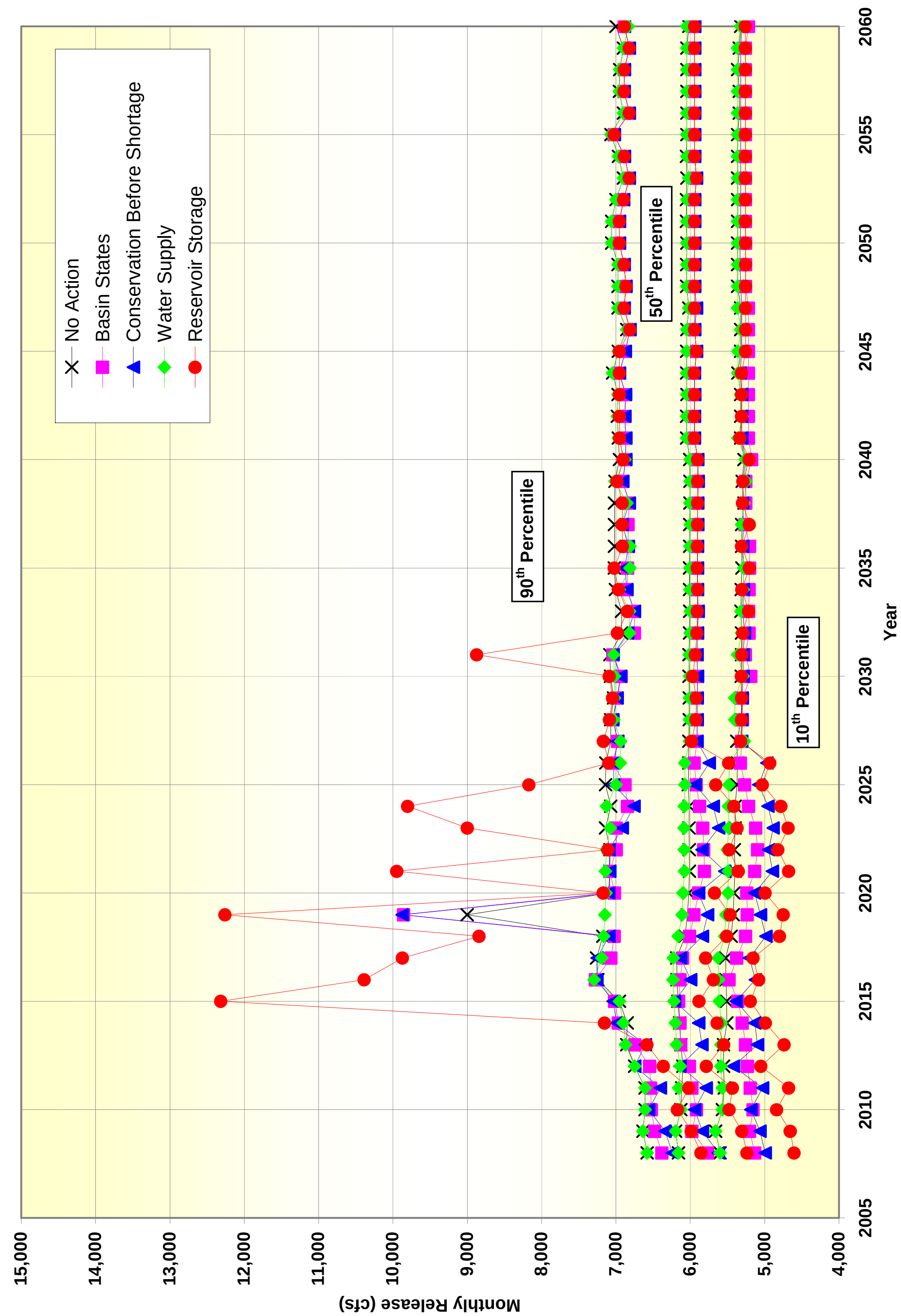

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Figure P-60
Parker Dam December Releases
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

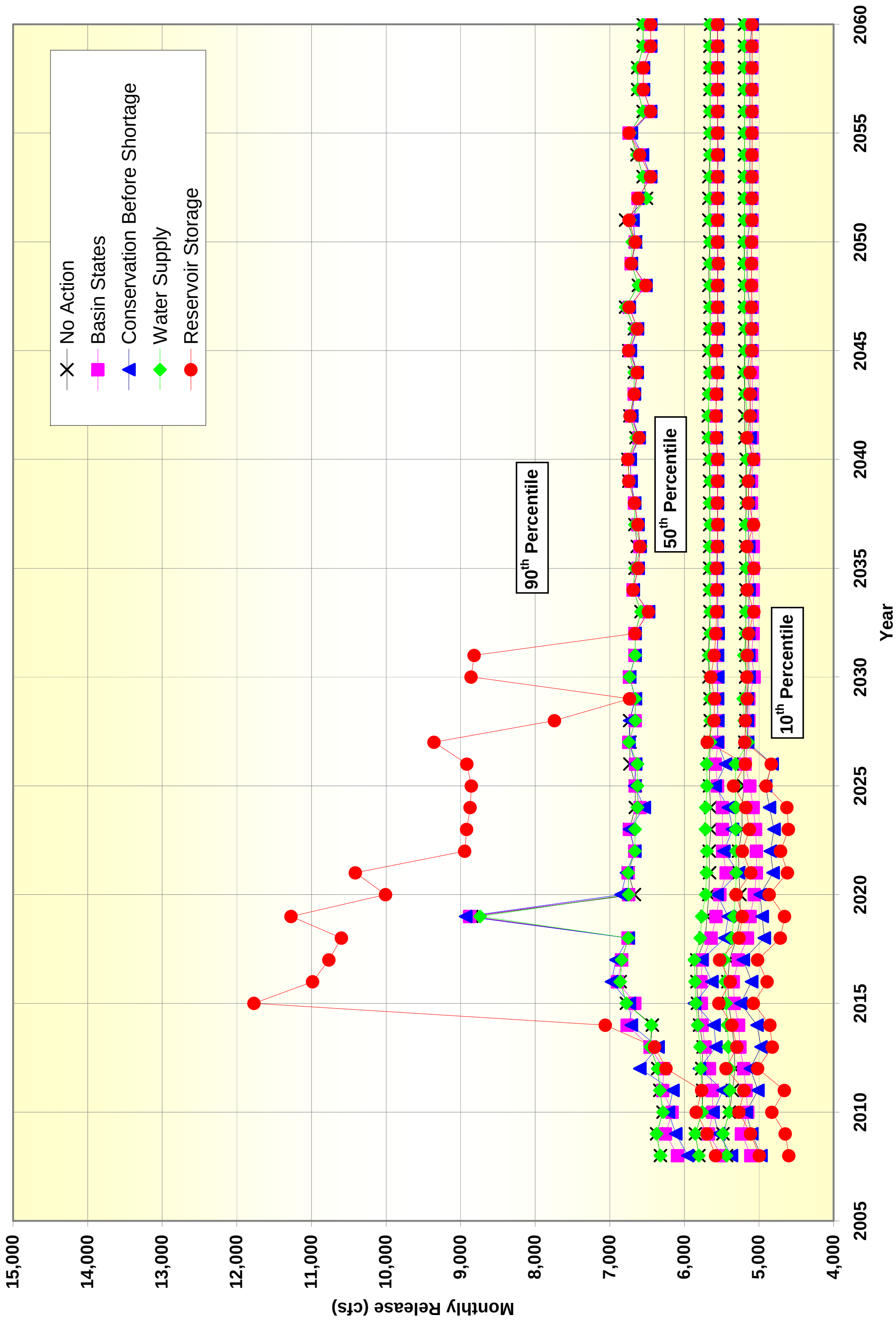

Figure P-61
Excess Flows Below Morelos Diversion Dam
Comparison of Action Alternatives to No Action Alternative
Probability of Occurence

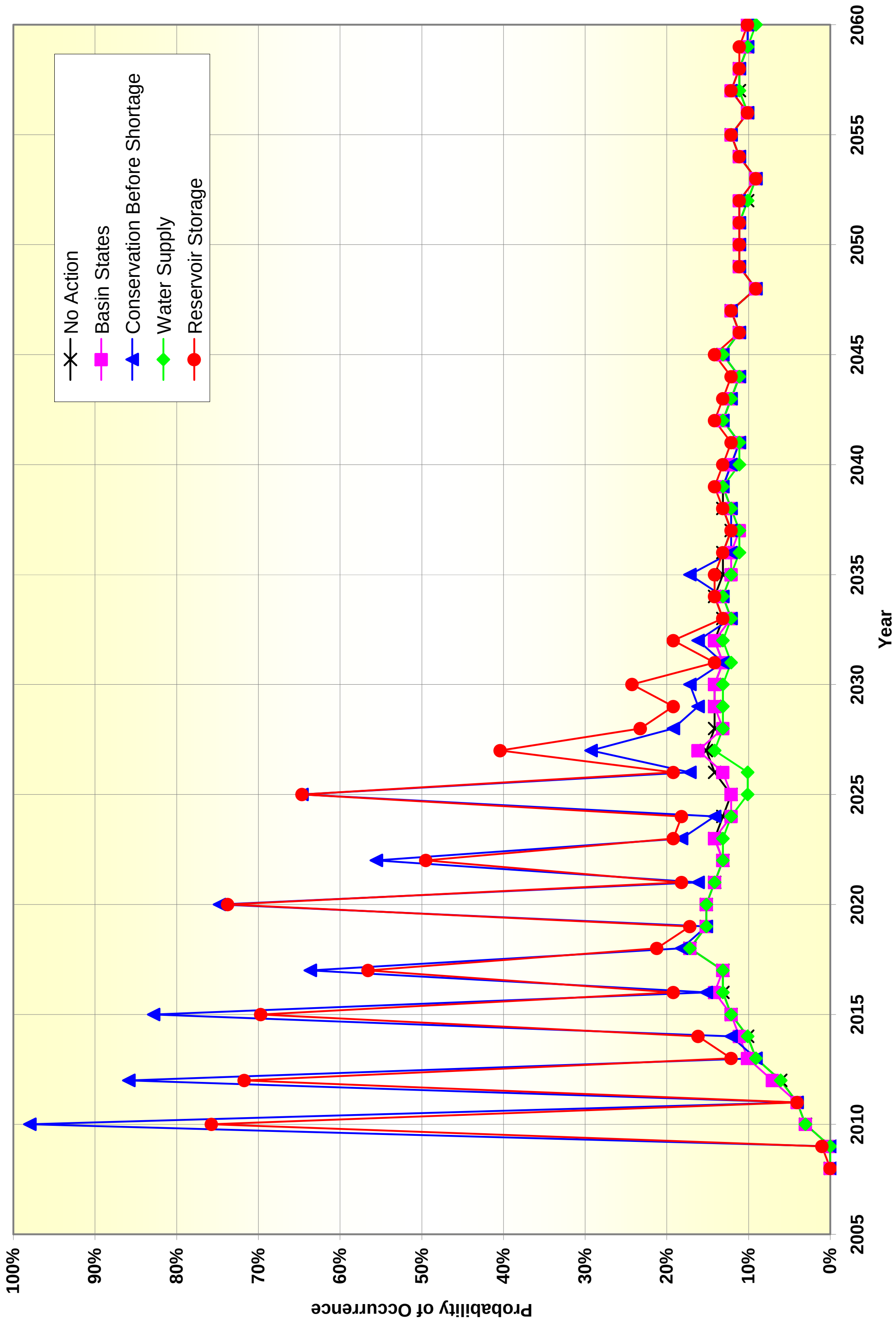

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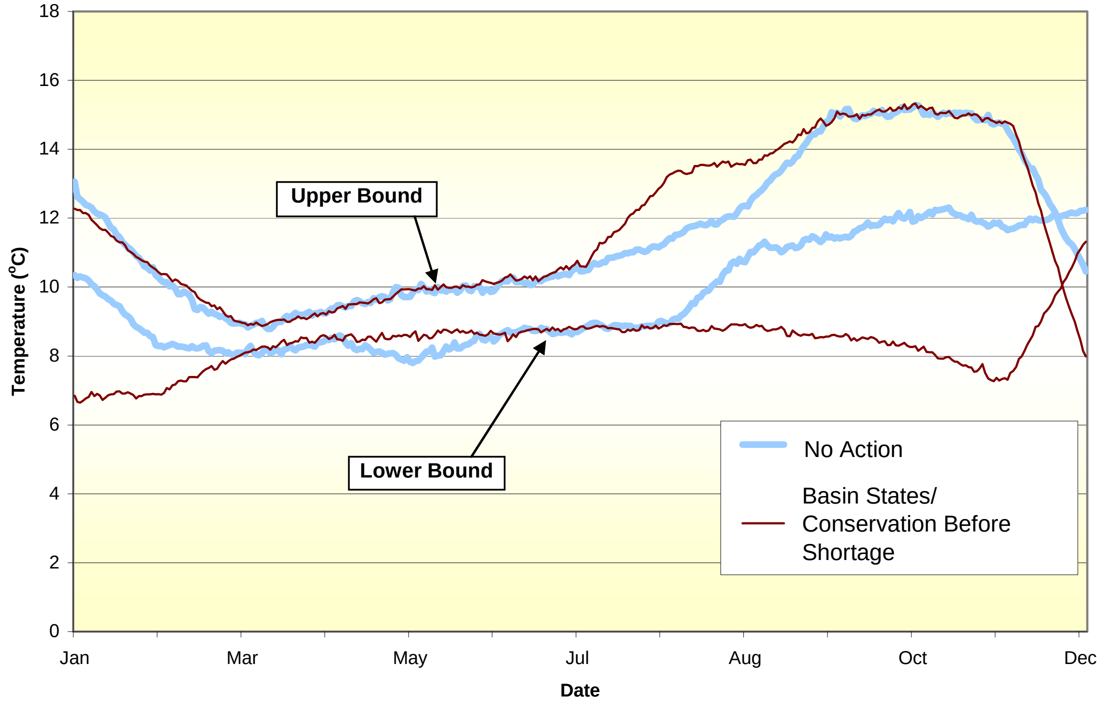
Figure P-62
Colorado River at Lees Ferry
50th Percentile Temperatures
Upper and Lower Bound



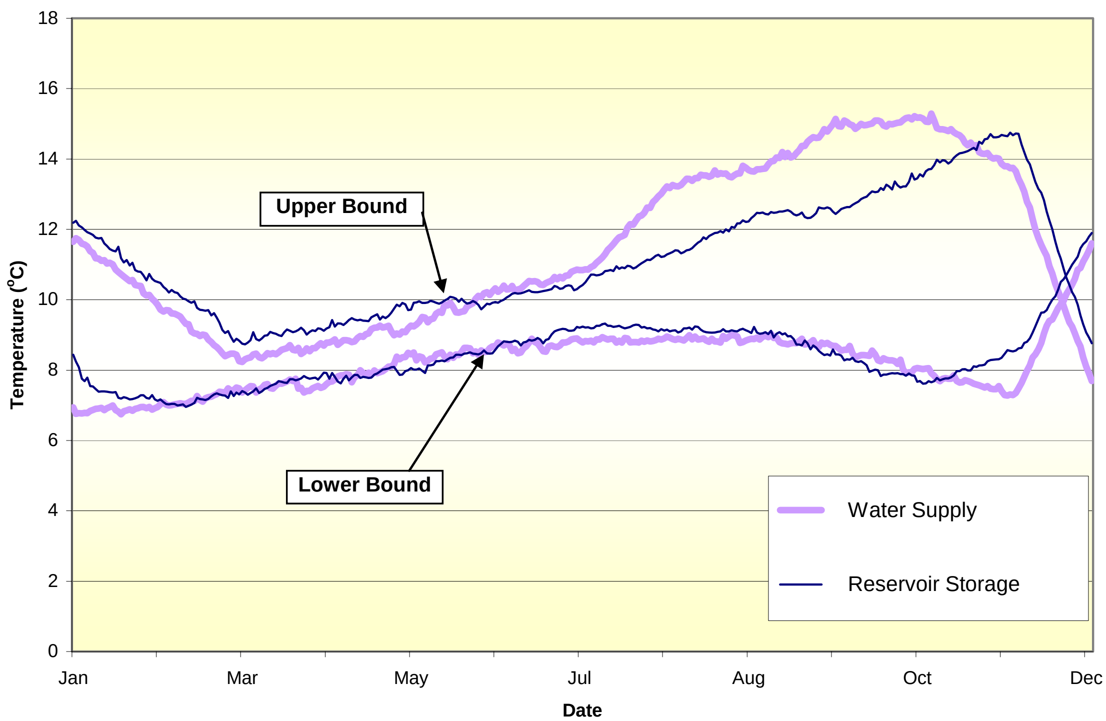
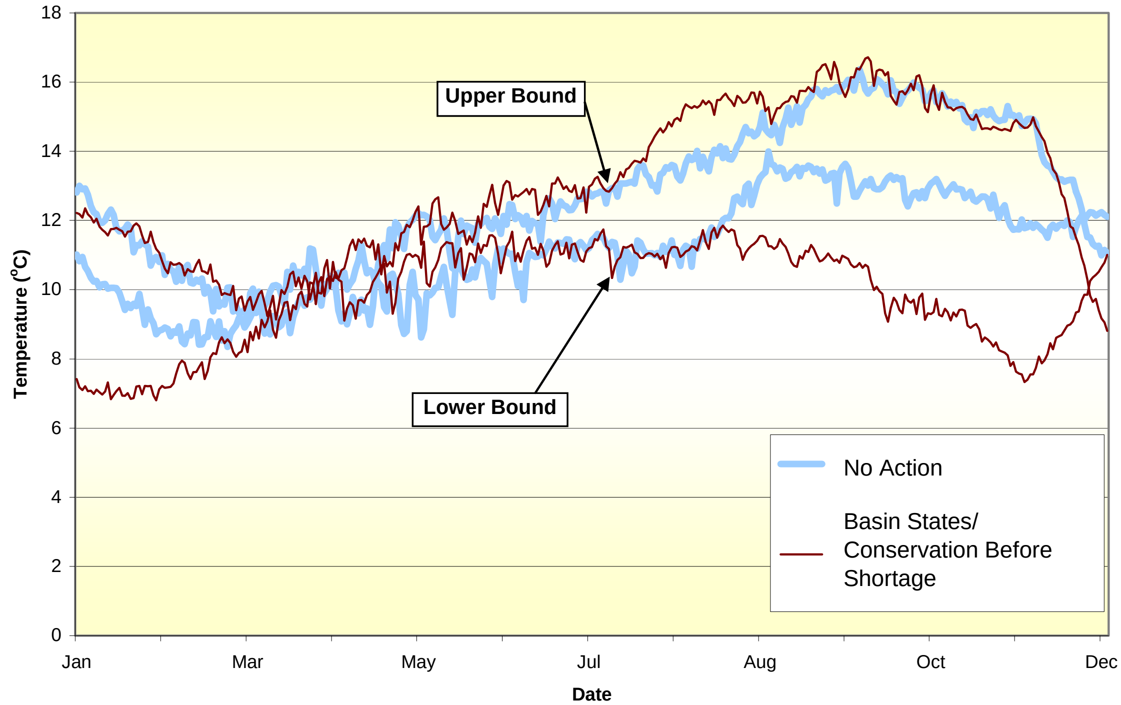


Figure P-63
Colorado River Below Little Colorado River Confluence
50th Percentile Temperatures
Upper and Lower Bound



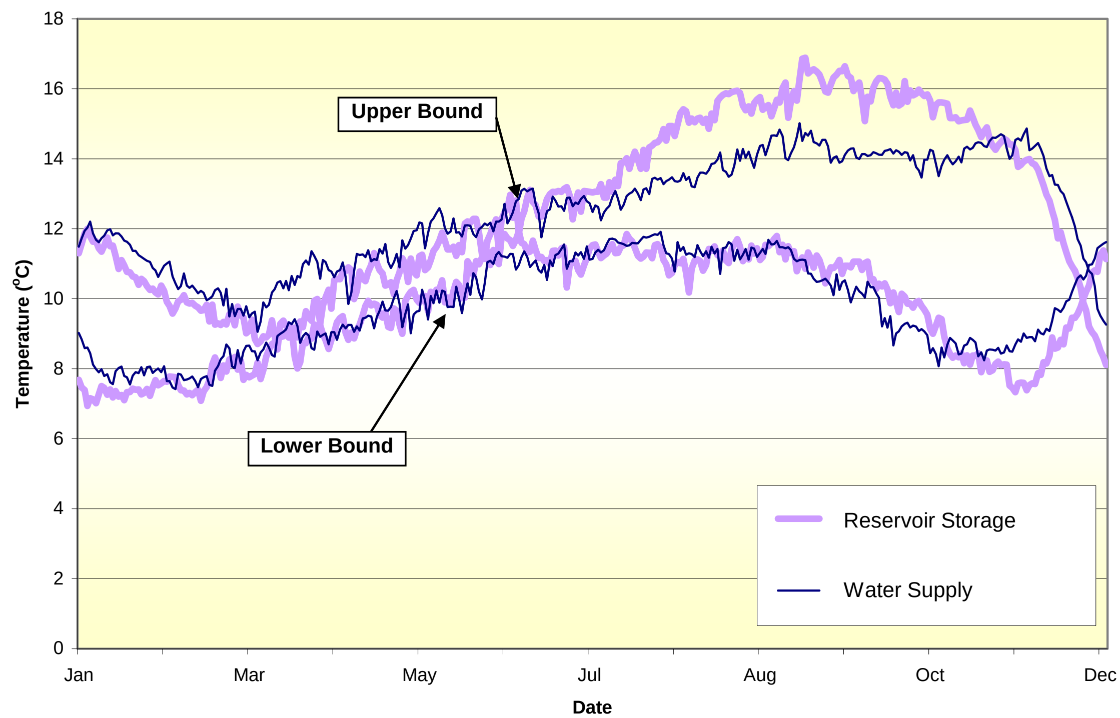


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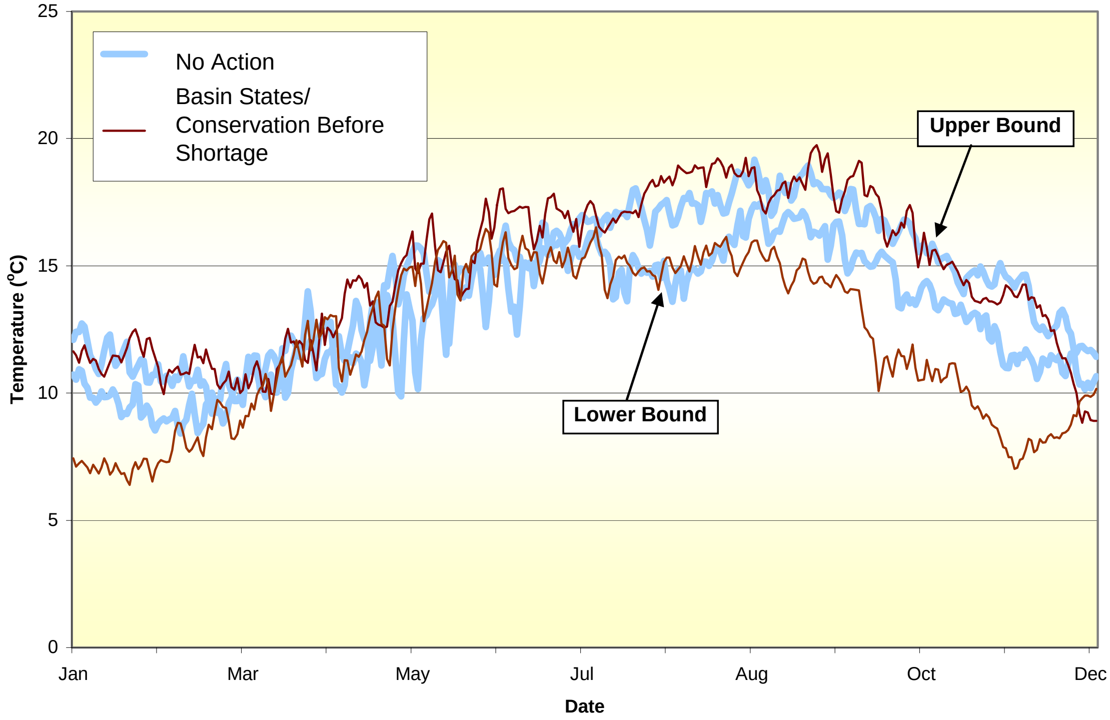
Figure P-64
Colorado River Near Diamond Creek
50th Percentile Temperatures
Upper and Lower Bound



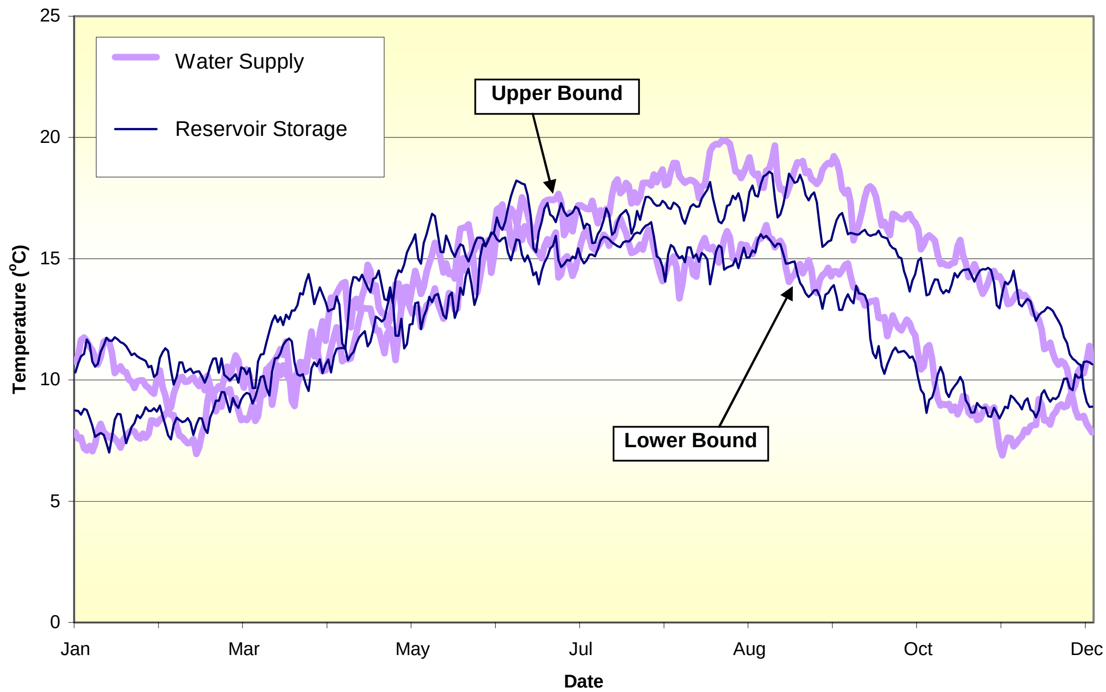


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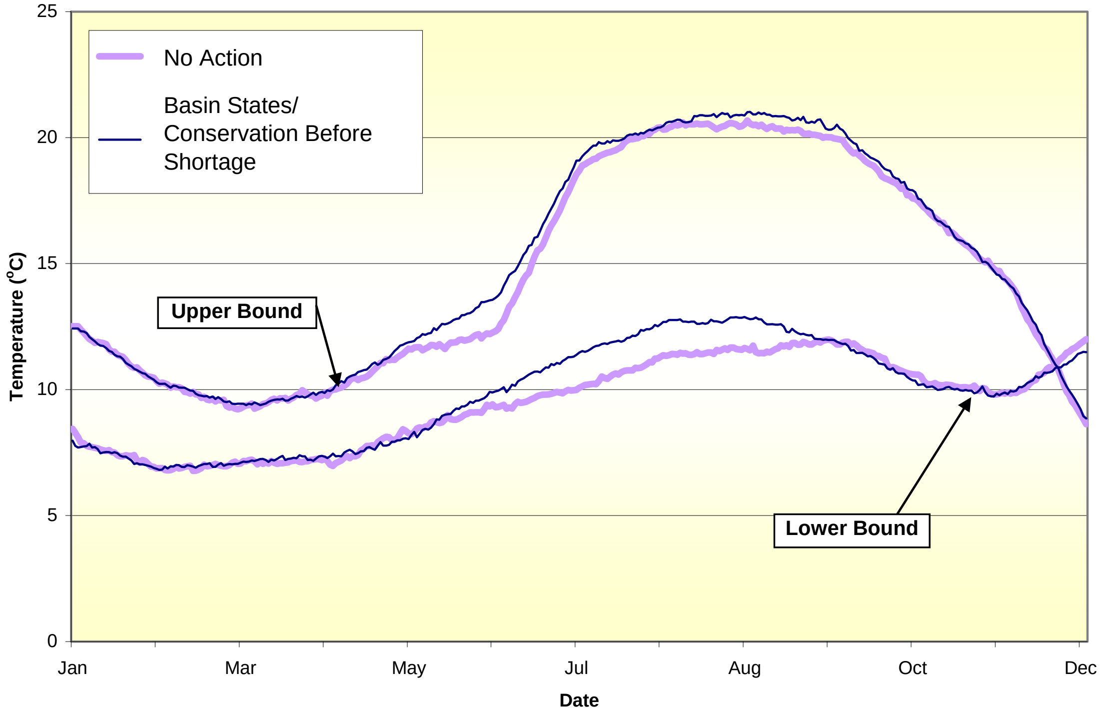
Figure P-65
Colorado River at Lees Ferry
10th Percentile Temperatures
Upper and Lower Bound



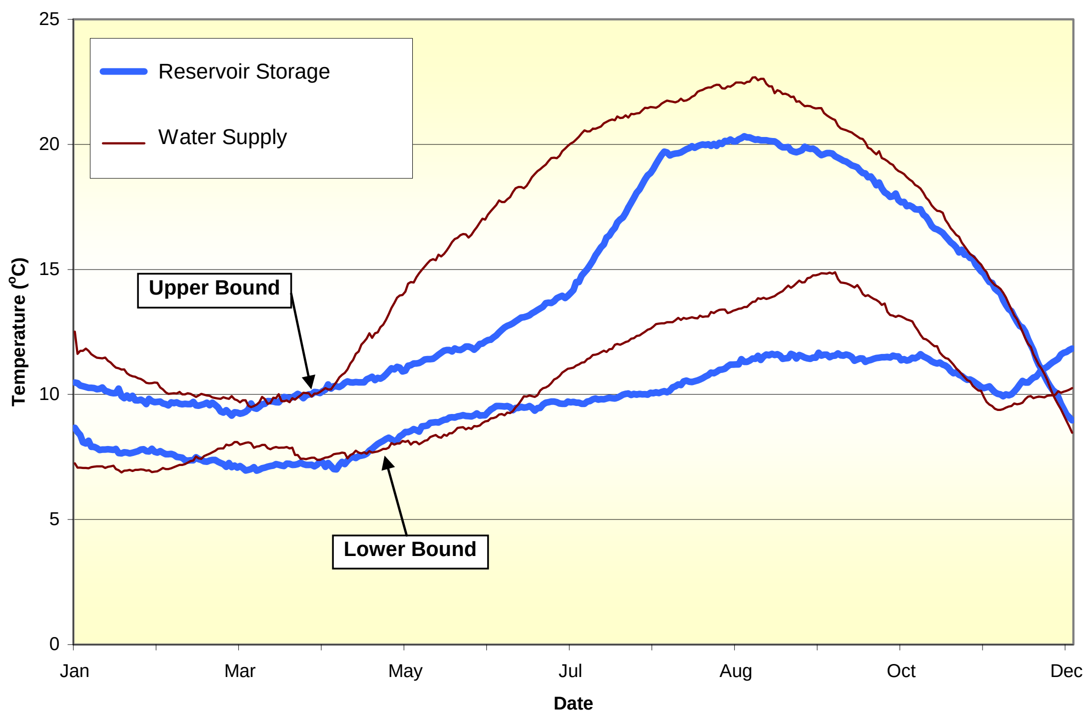
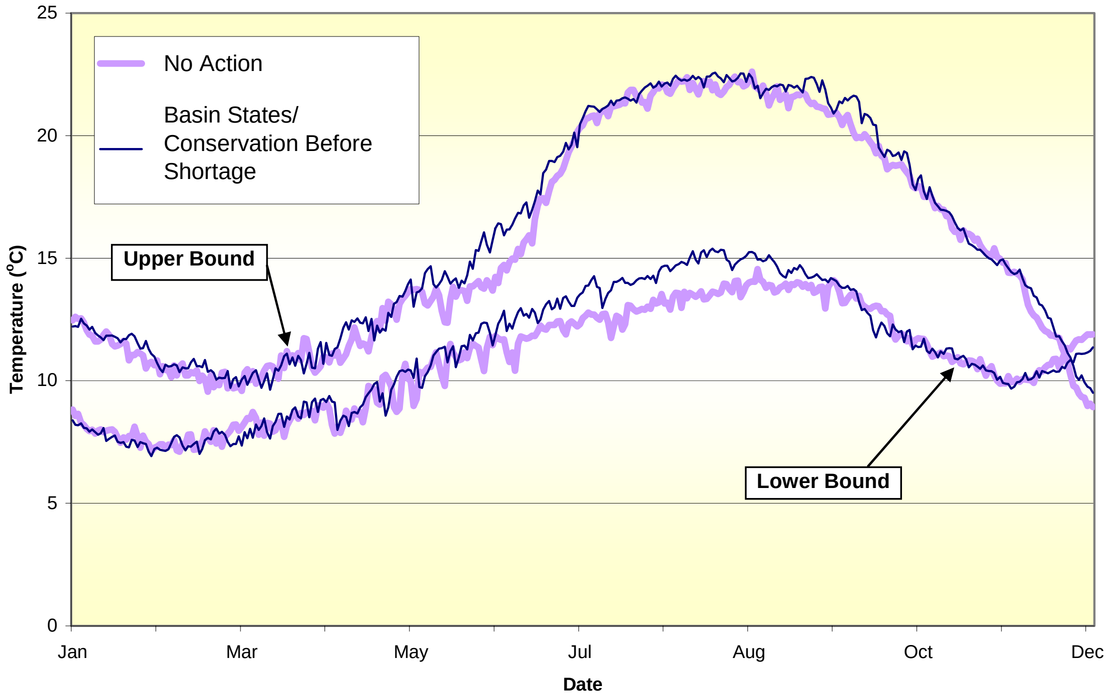


Figure P-66
Colorado River Below Little Colorado River Confluence
10th Percentile Temperatures
Upper and Lower Bound



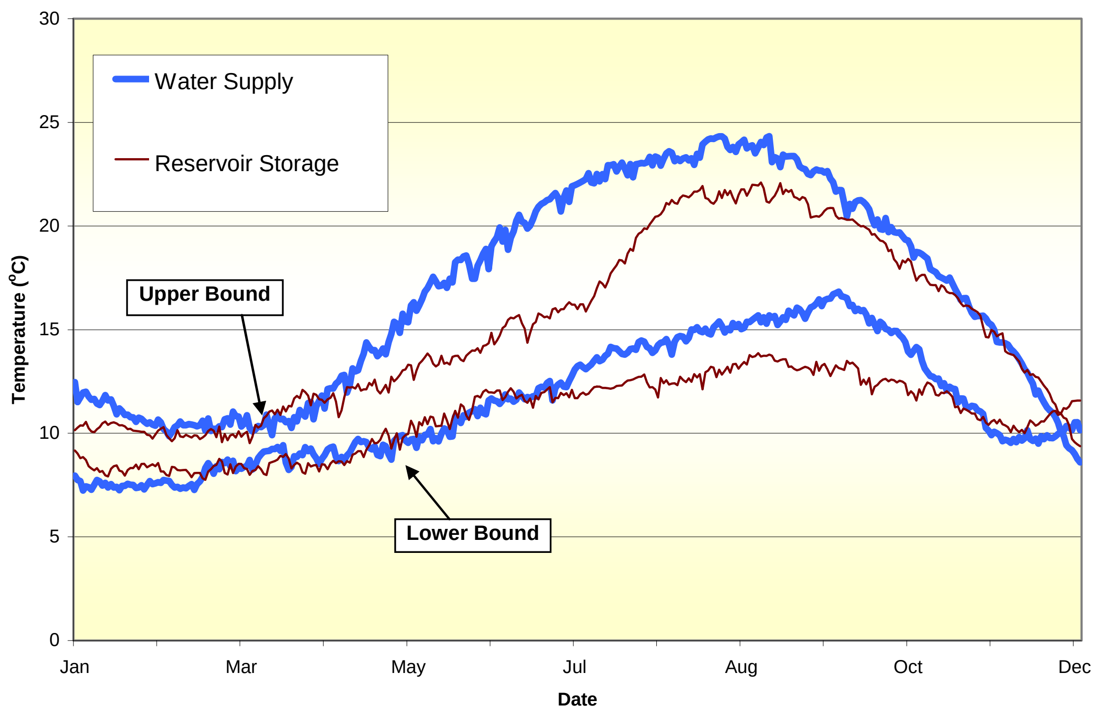


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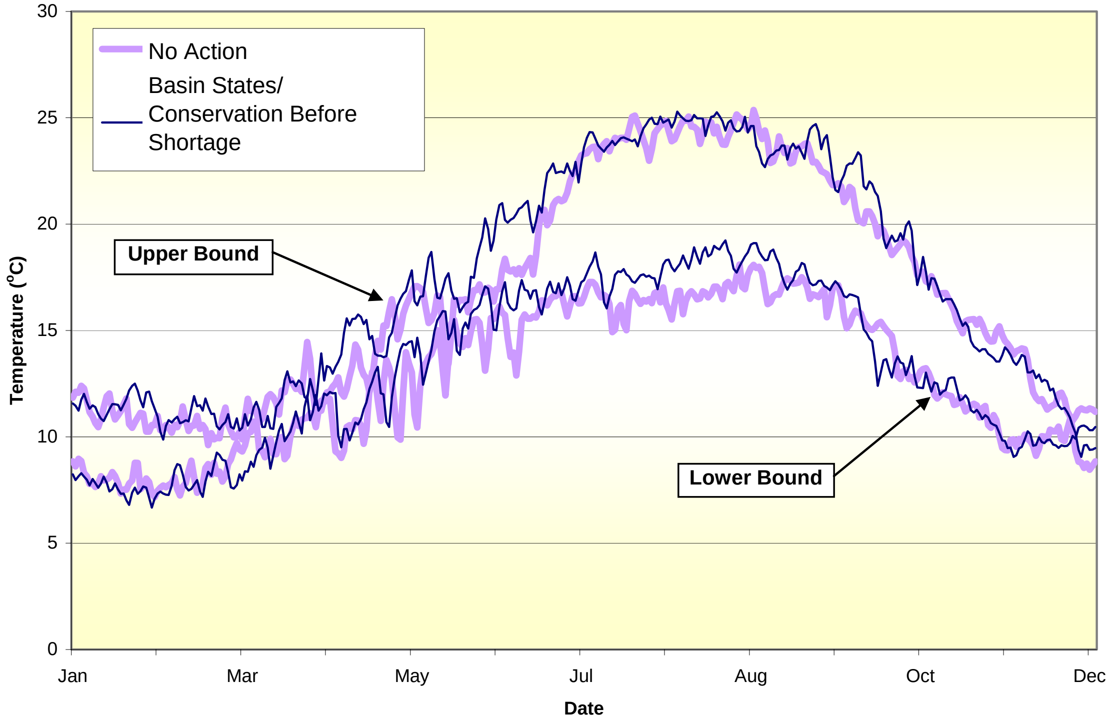
Figure P-67
Colorado River Near Diamond Creek
10th Percentile Temperatures
Upper and Lower Bound



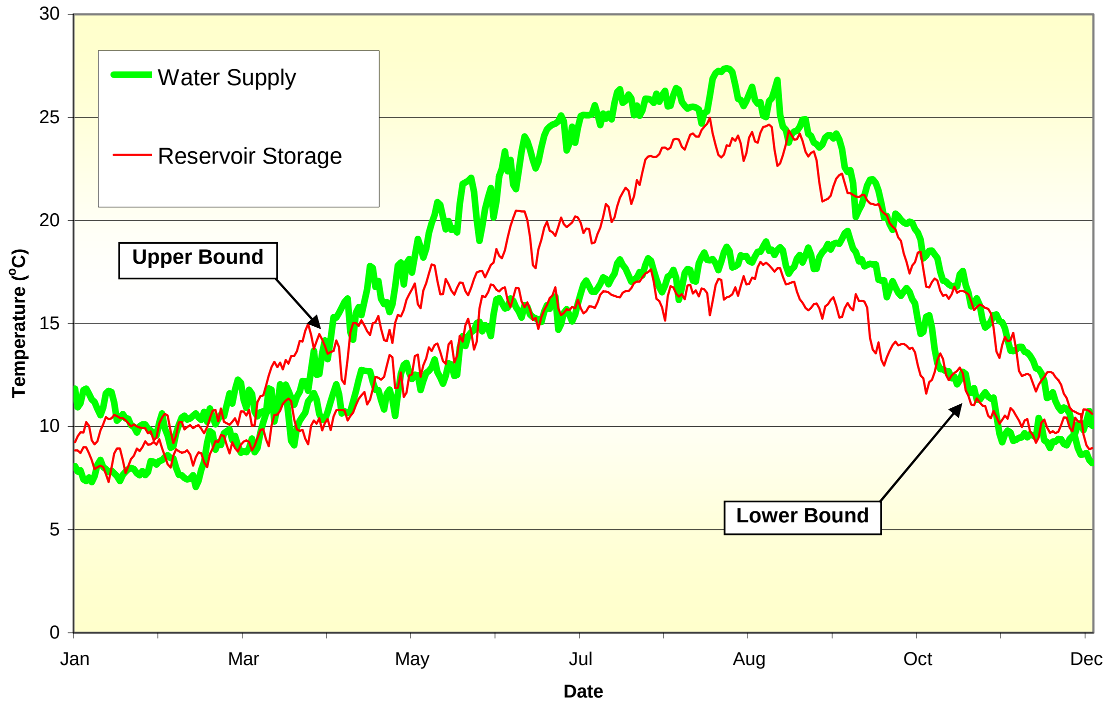


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Figure P-68
Colorado River at Lees Ferry
Under No Action Alternative
Min and Max Temperature Bounds

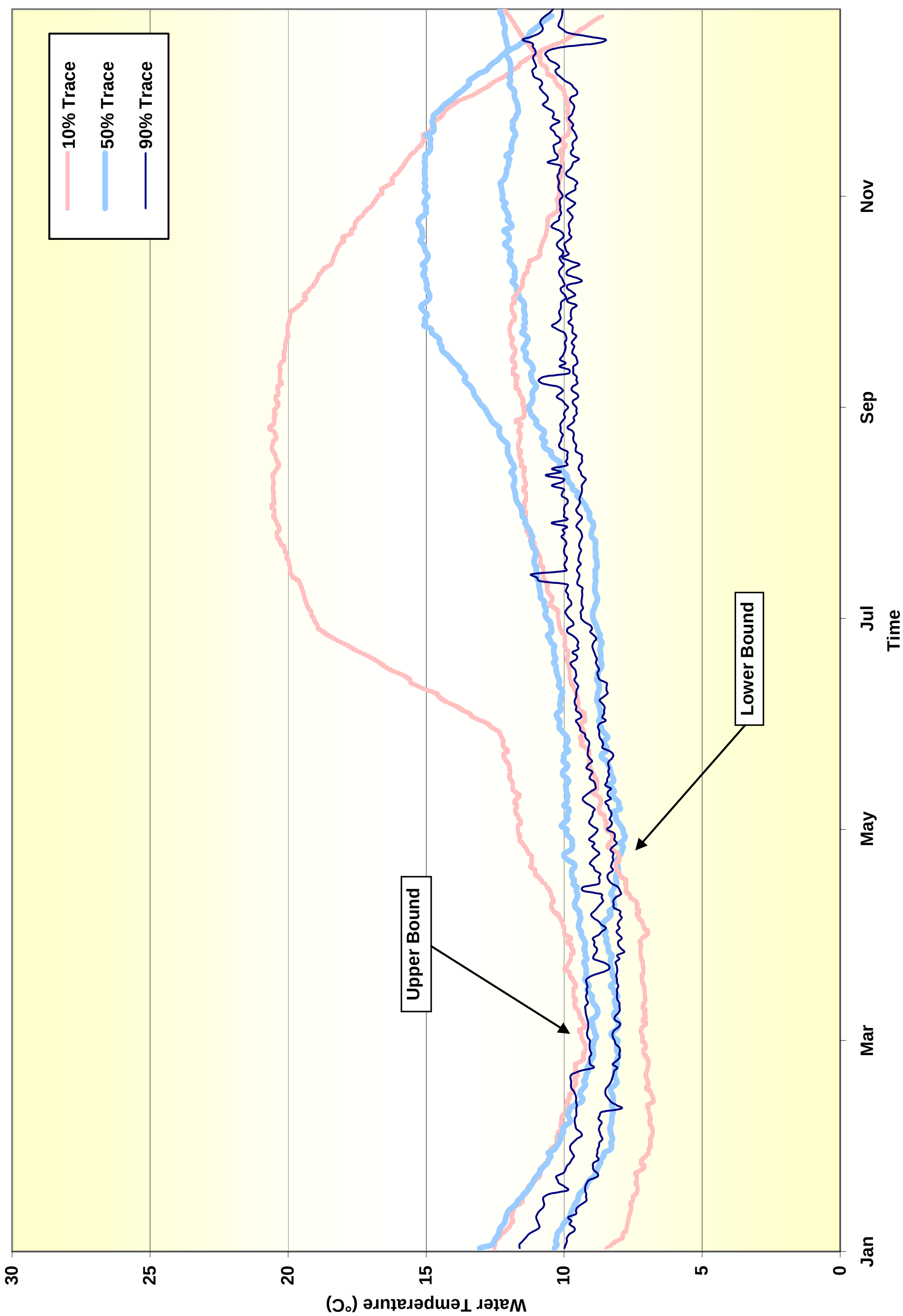

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Figure P-69
Colorado River Below Little Colorado River Confluence
Under No Action Alternative
Min and Max Temperature Bounds

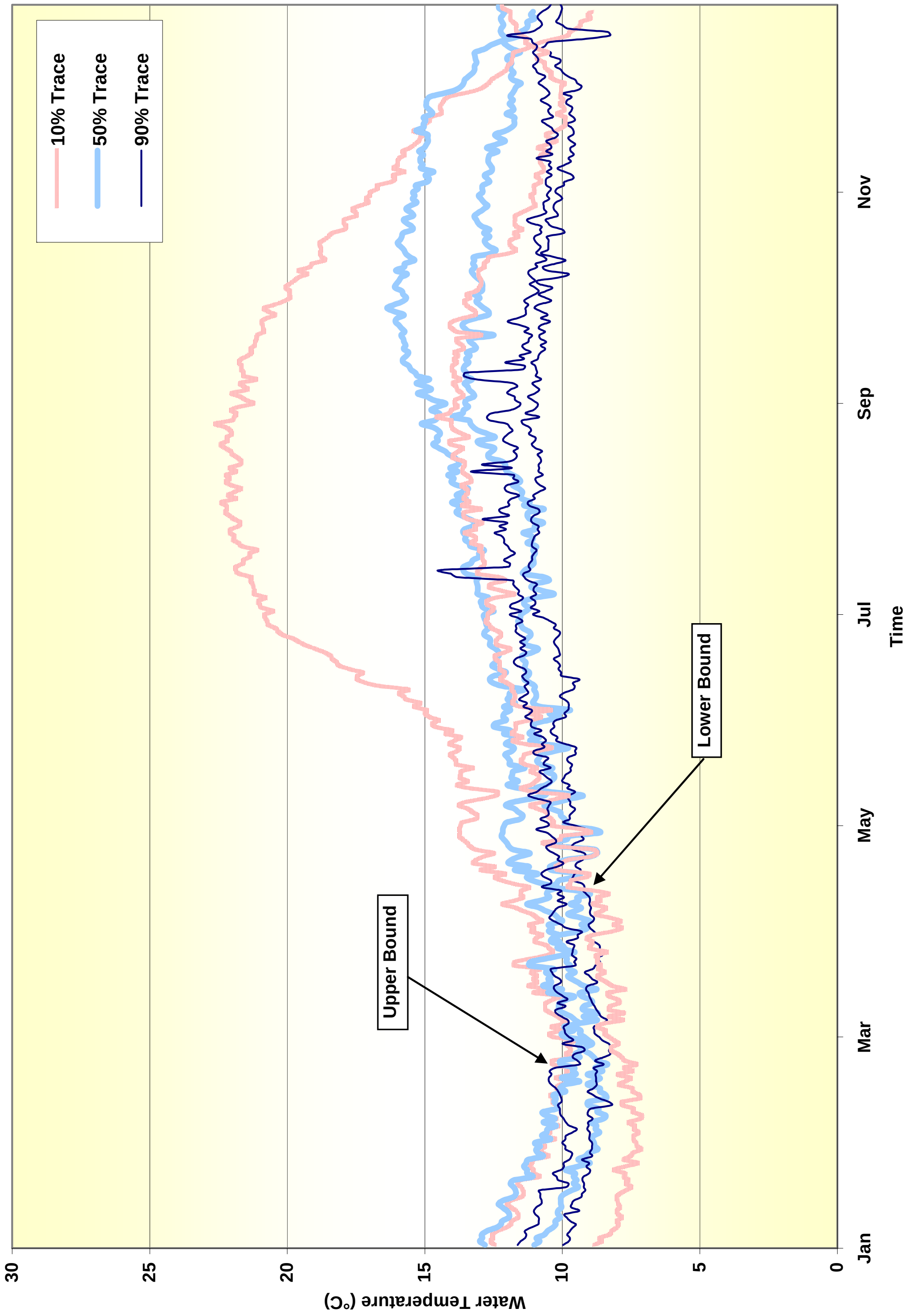

Figure P-70
Colorado River Near Diamond Creek
Under No Action Alternative
Min and Max Temperature Bounds

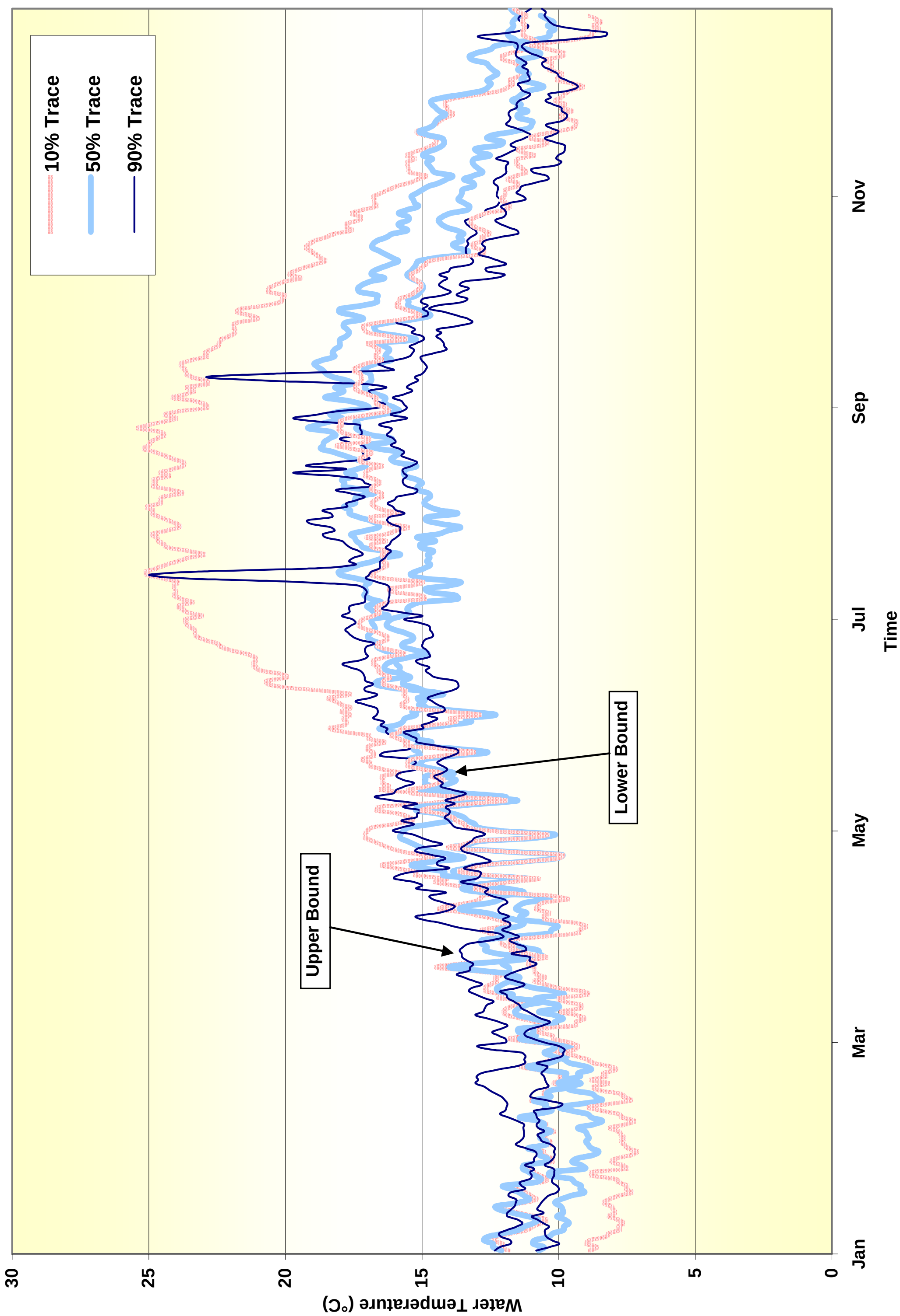

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Figure P-71
Colorado River at Lees Ferry
Under Basin States and Conservation Before Shortage Alternative
Min and Max Temperature Bounds

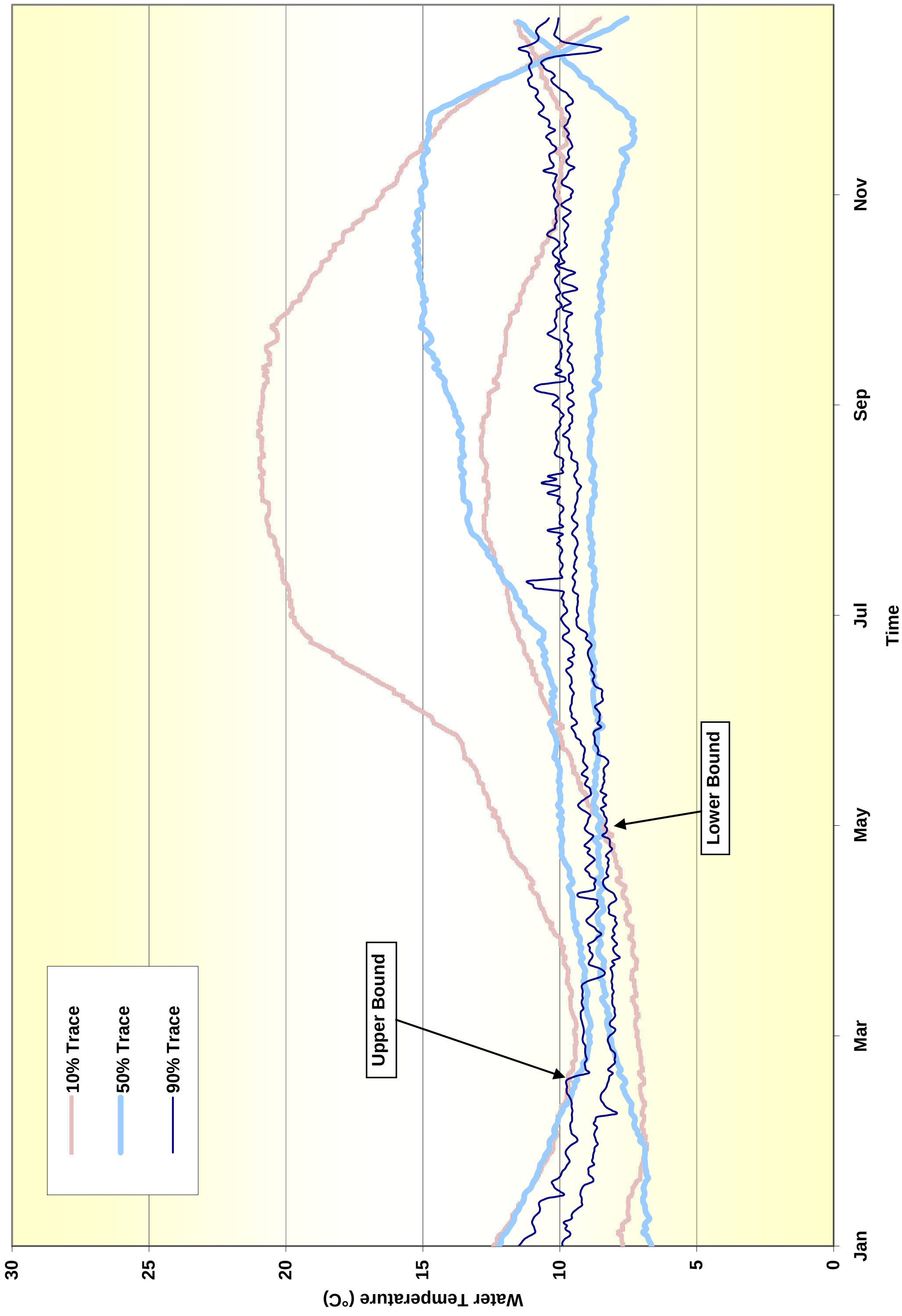

Figure P-72
Colorado River Below Little Colorado River Confluence
Under Basin States and Conservation Before Shortage Alternative
Min and Max Temperature Bounds

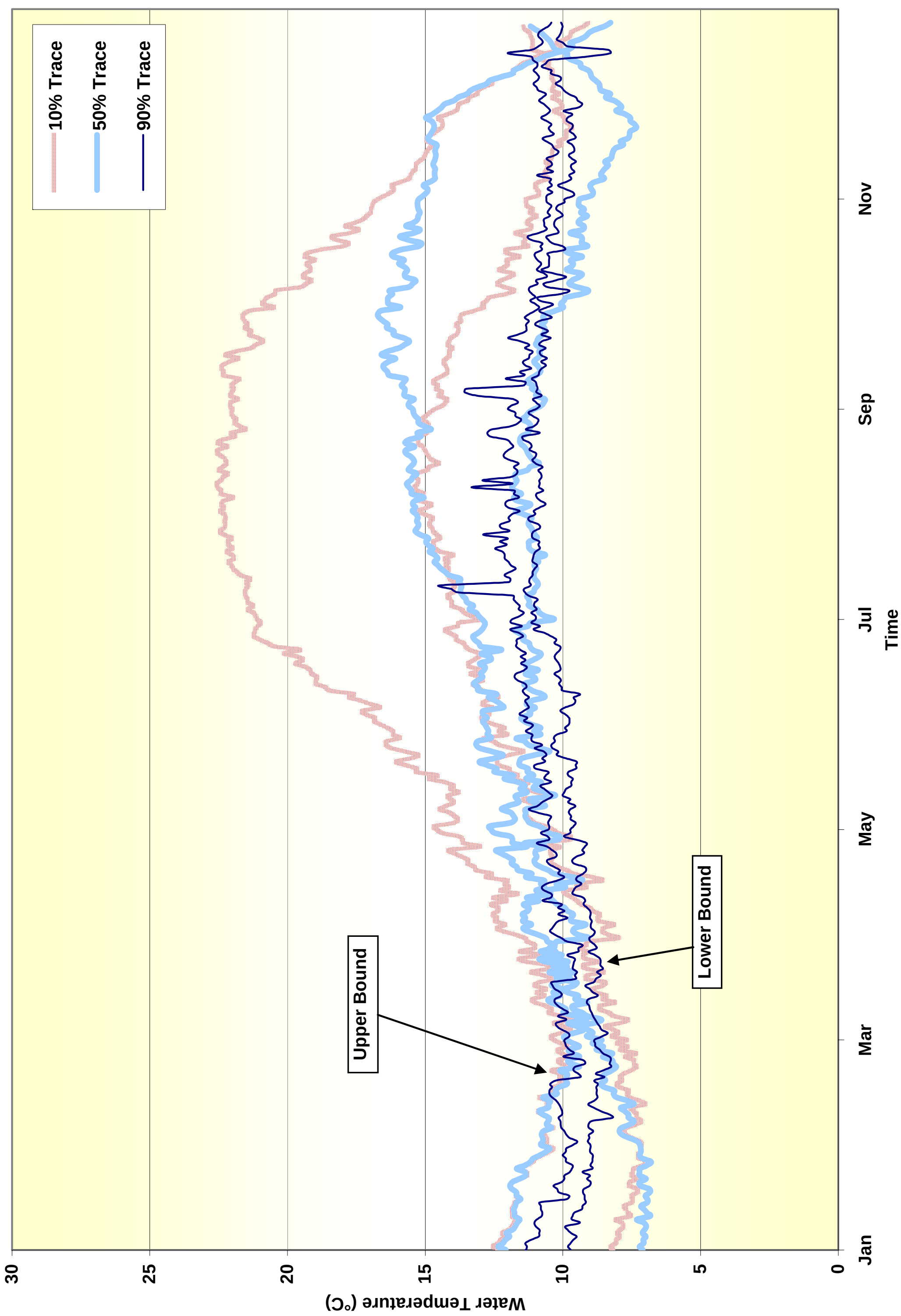

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Figure P-73
Colorado River Near Diamond Creek
Under Basin States and Conservation Before Shortage Alternative
Min and Max Temperature Bounds

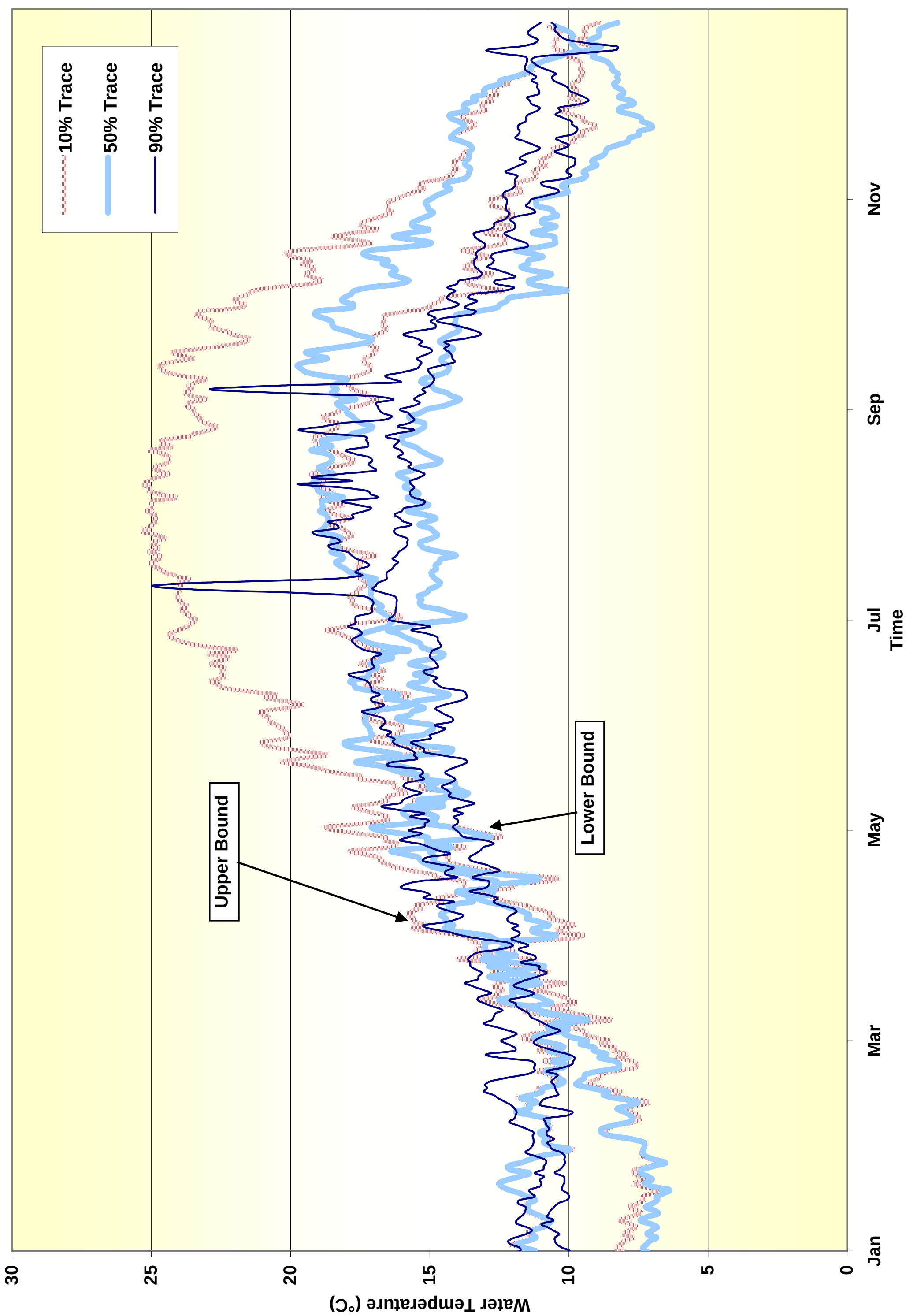

Figure P-74
Colorado River at Lees Ferry
Under Water Supply Alternative
Min and Max Temperature Bounds

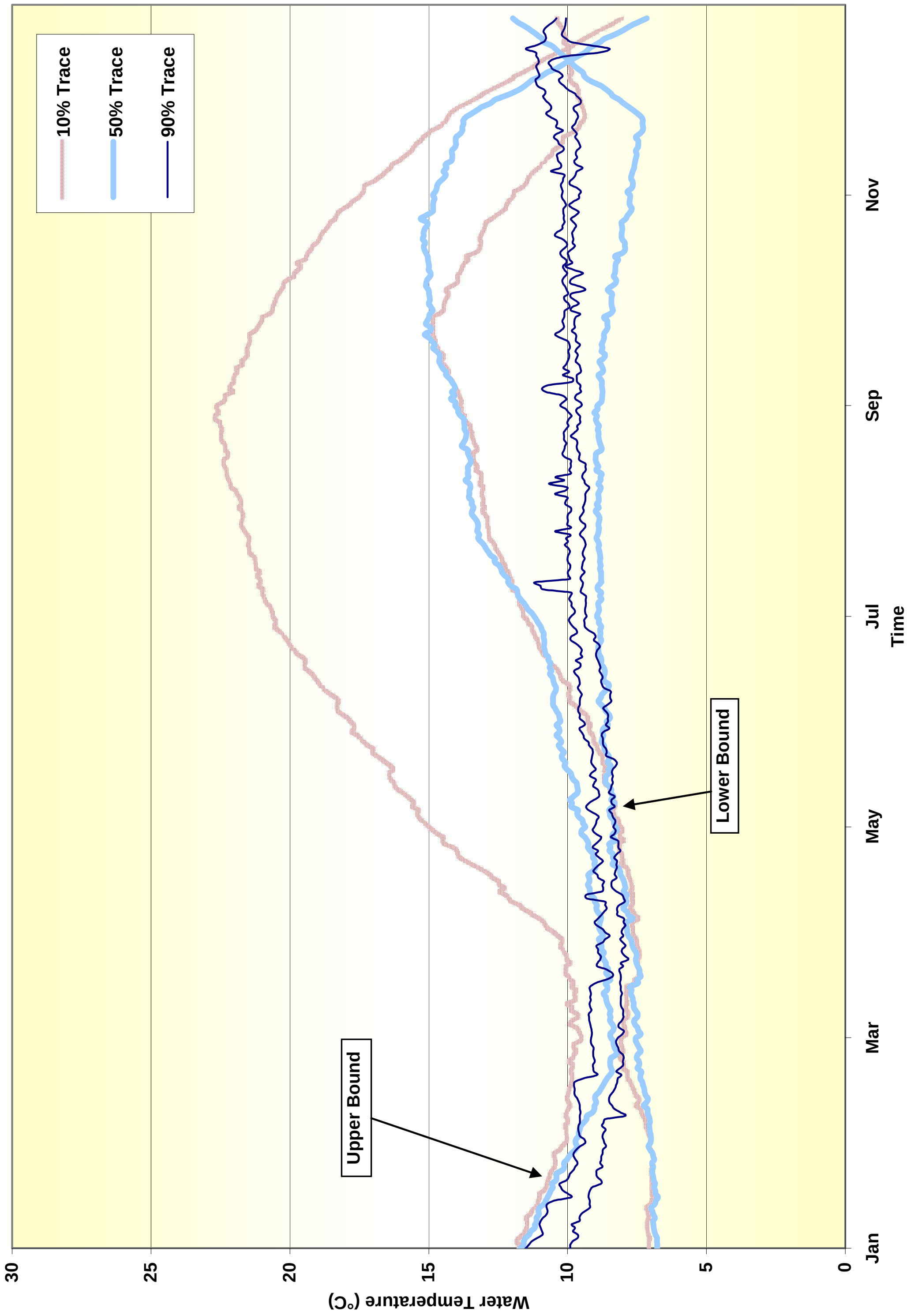

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Figure P-75
Colorado River Below Little Colorado River Confluence
Under Water Supply Alternative
Min and Max Temperature Bounds

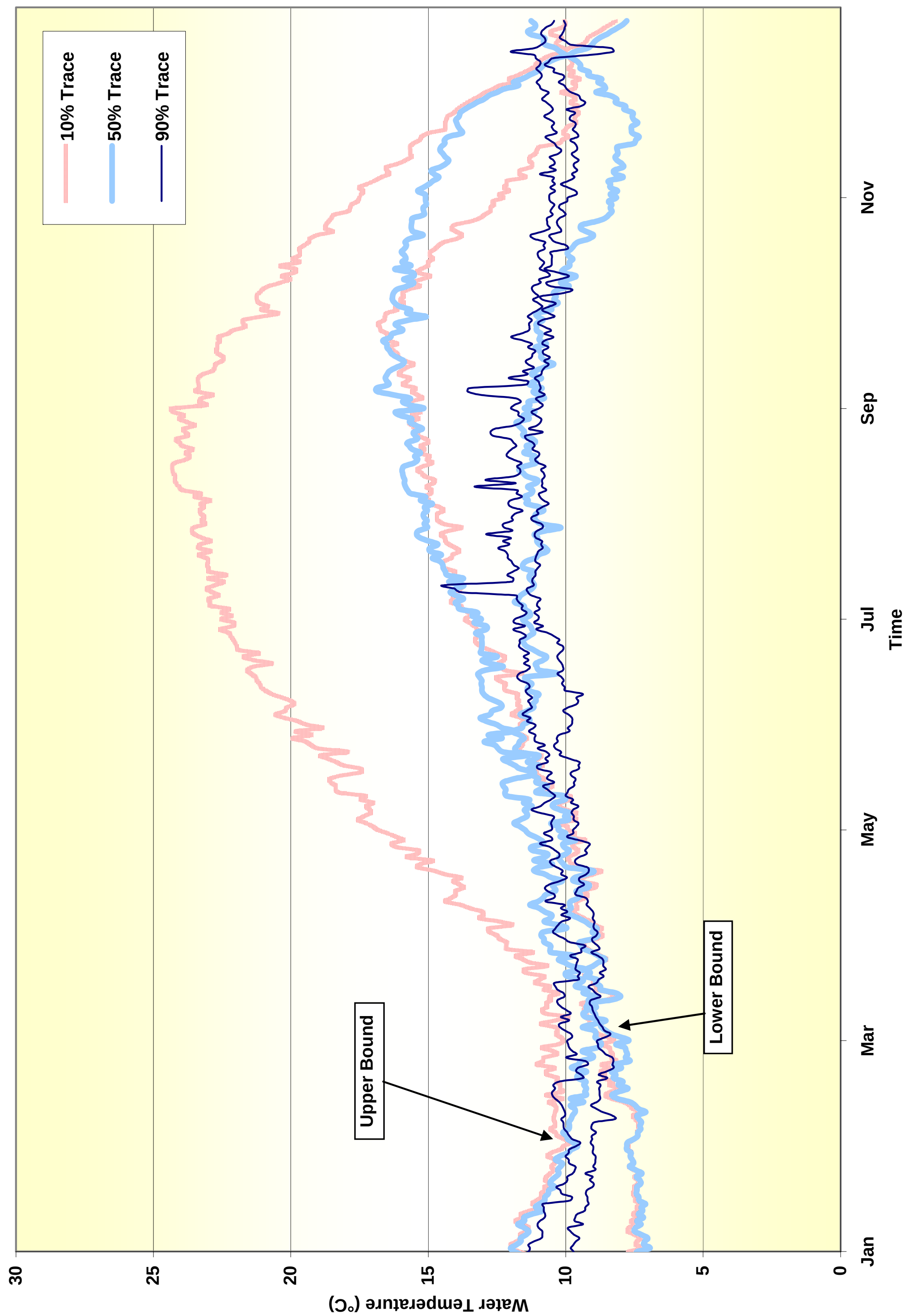

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Figure P-76
Colorado River Near Diamond Creek
Under Water Supply Alternative
Min and Max Temperature Bounds

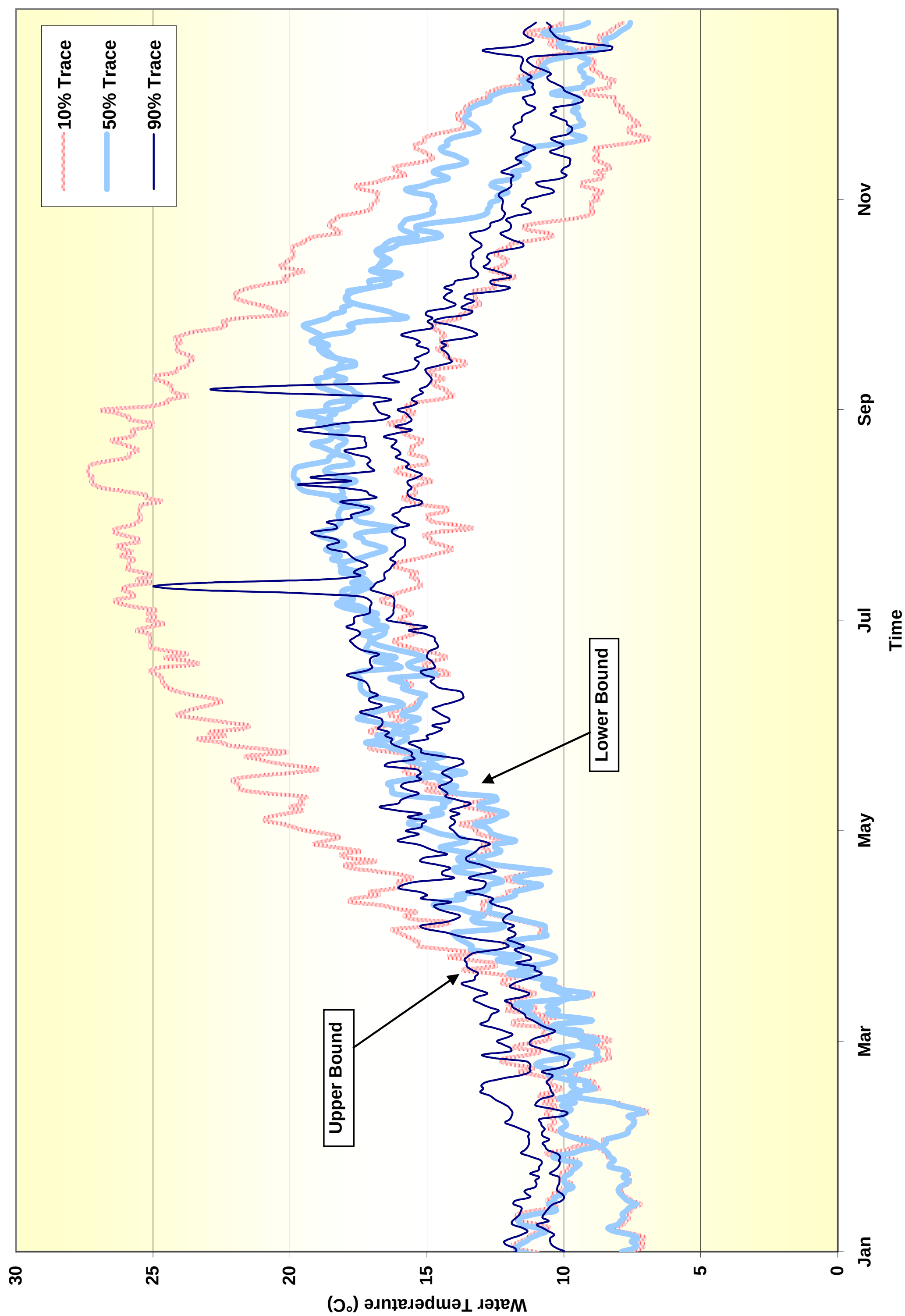

Figure P-77
Colorado River at Lees Ferry
Under Reservoir Storage Alternative
Min and Max Temperature Bounds

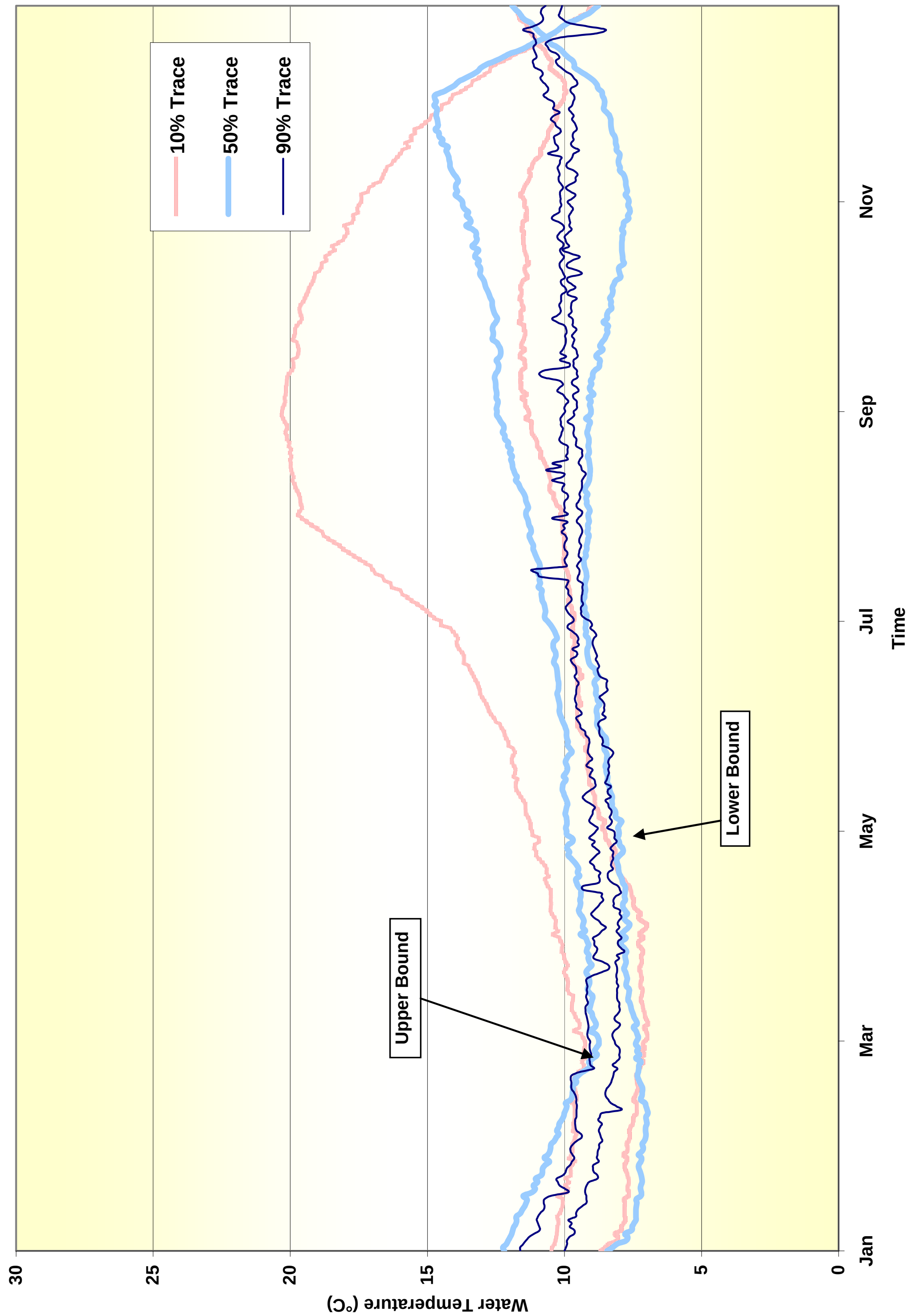

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Figure P-78
Colorado River Below Little Colorado River Confluence
Under Reservoir Storage Alternative
Min and Max Temperature Bounds

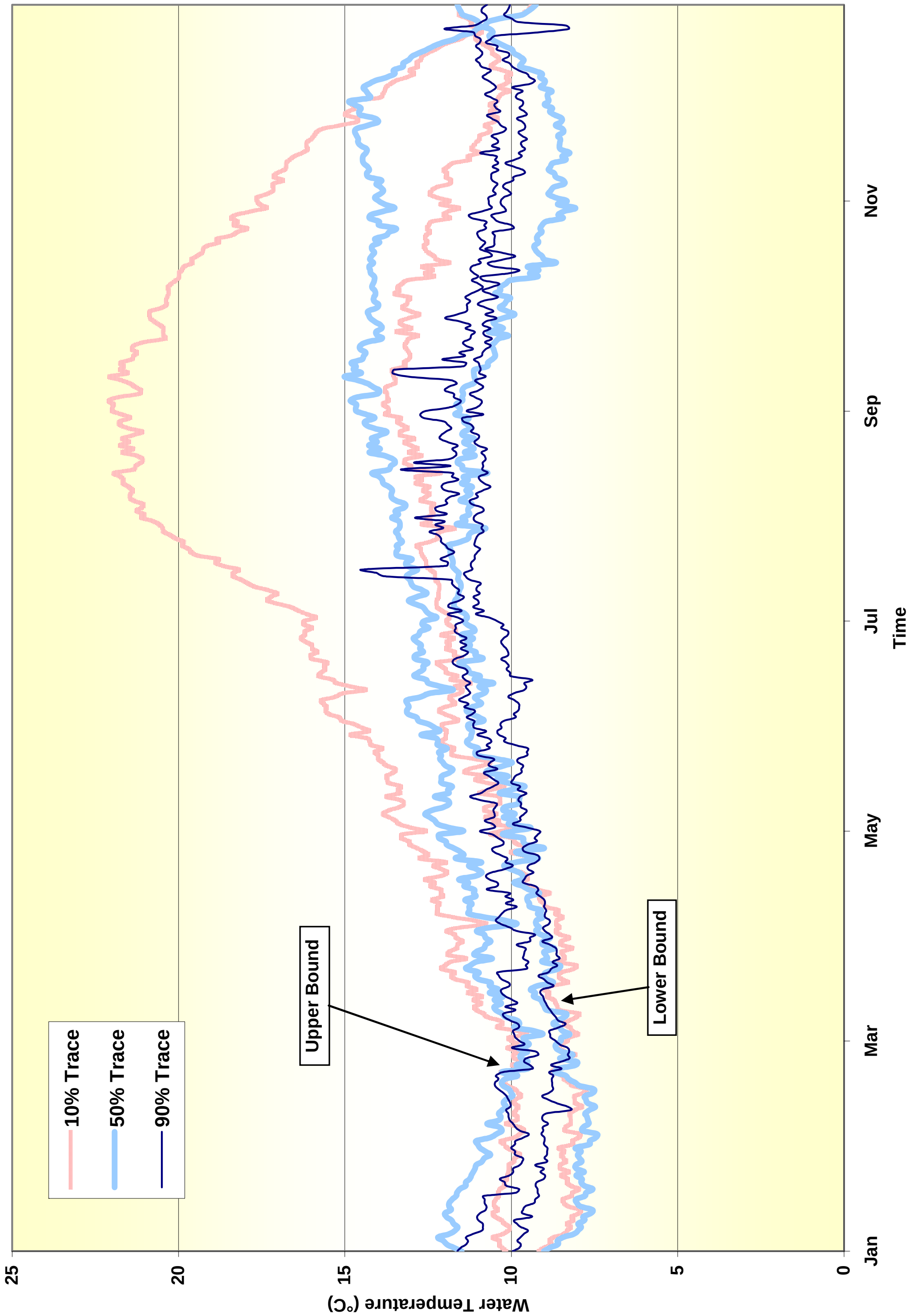

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Figure P-79
Colorado River Near Diamond Creek
Under Reservoir Storage Alternative
Min and Max Temperature Bounds

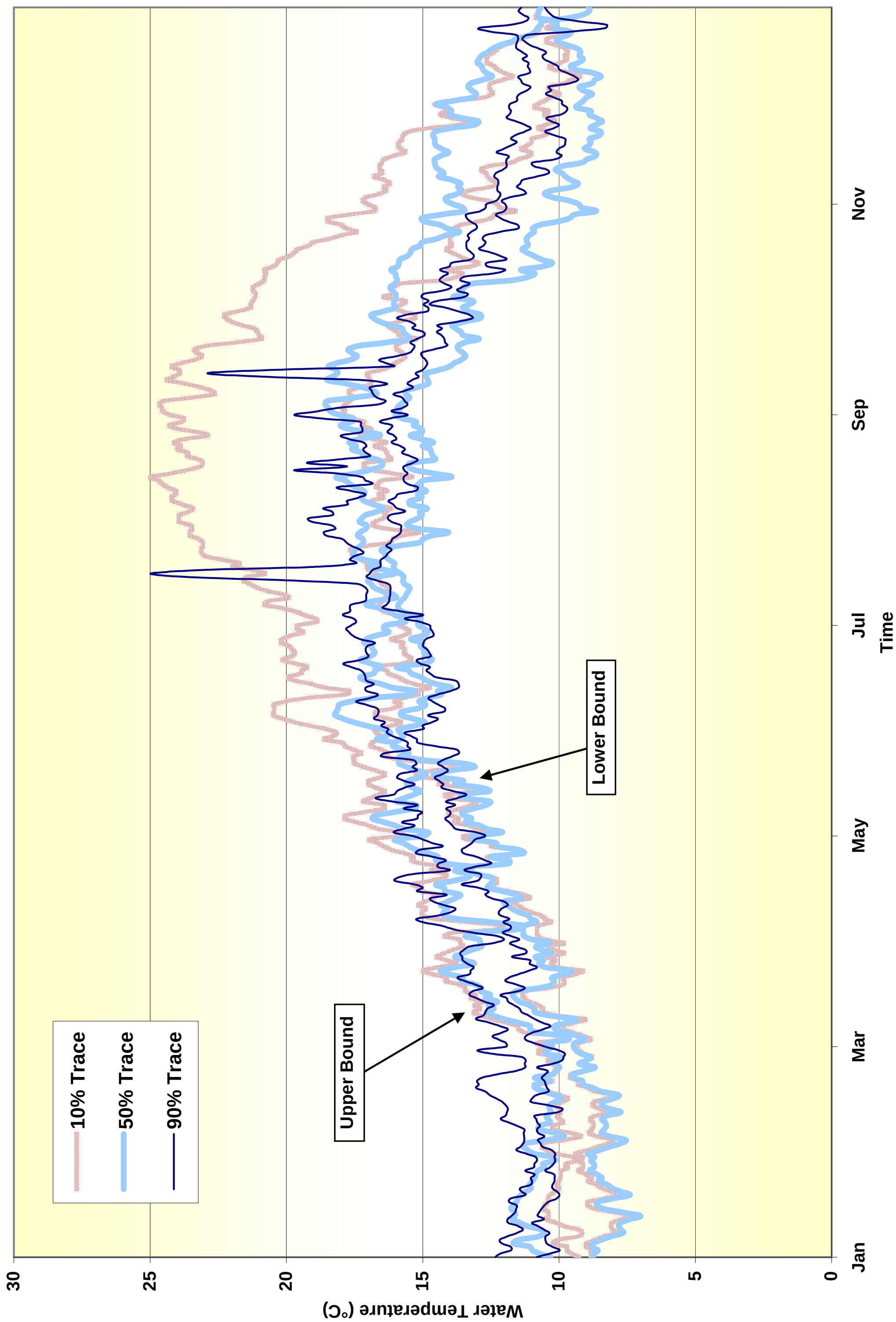

Figure P-80
Glen Canyon Dam Release Temperatures
Comparison of Action Alternatives to No Action Alternative
90th Percentile Upper and Lower Bounds for Release Temperatures

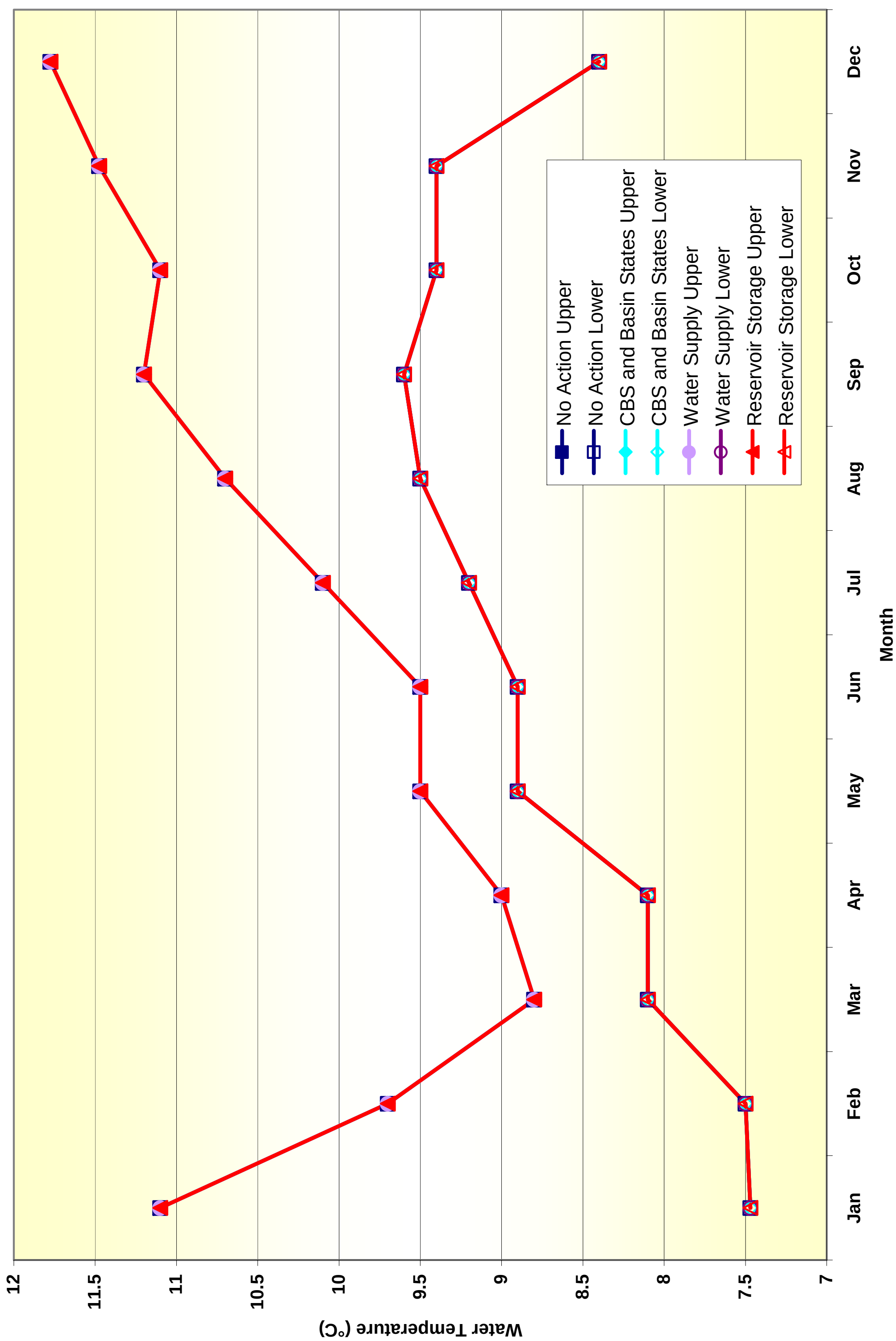

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Figure P-81
Glen Canyon Dam Release Temperatures
Comparison of Action Alternatives to No Action Alternative
50th Percentile Upper and Lower Bounds for Release Temperatures

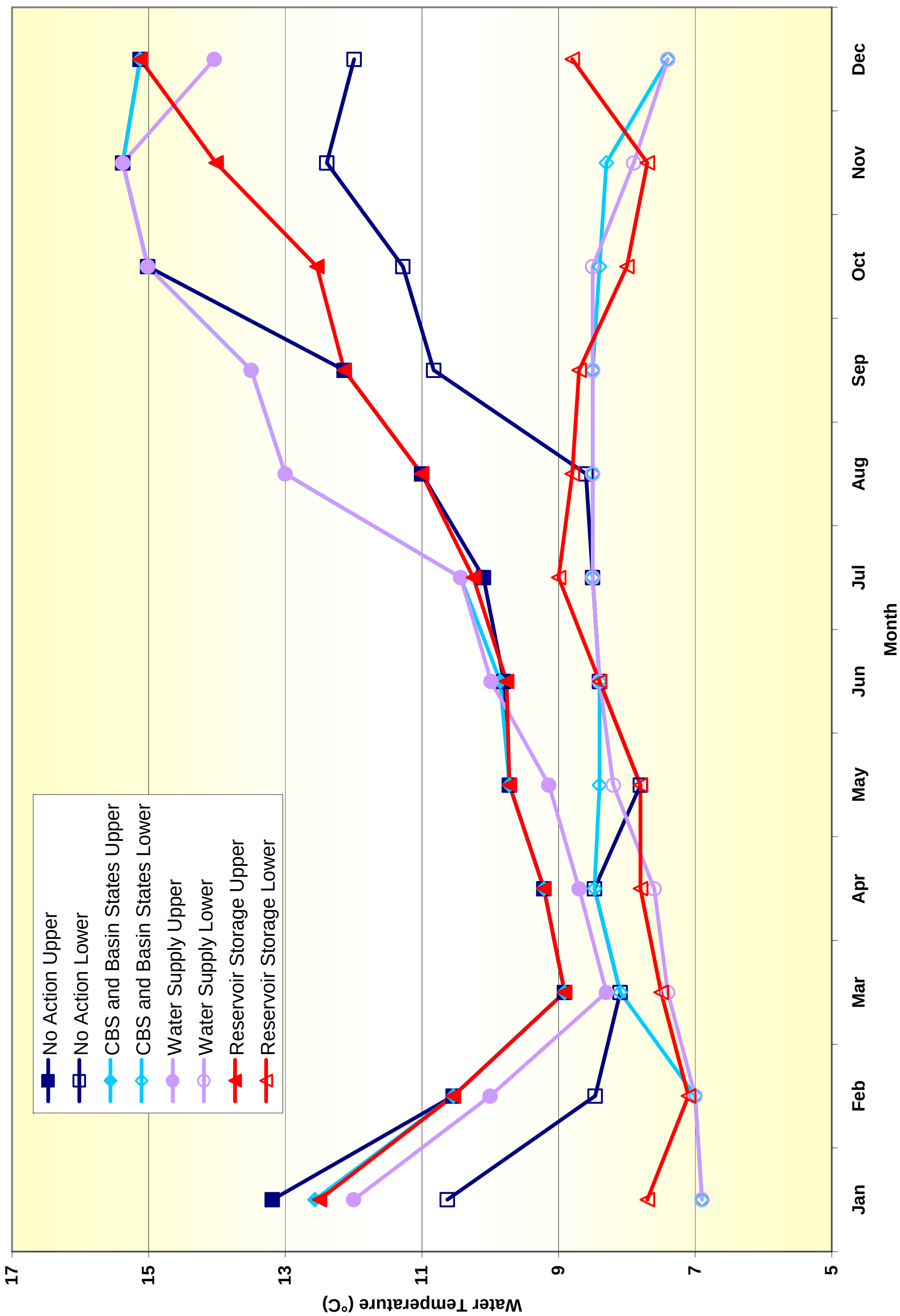

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Figure P-82
Glen Canyon Dam Release Temperatures
Comparison of Action Alternatives to No Action Alternative
10th Percentile Upper and Lower Bounds for Release Temperatures

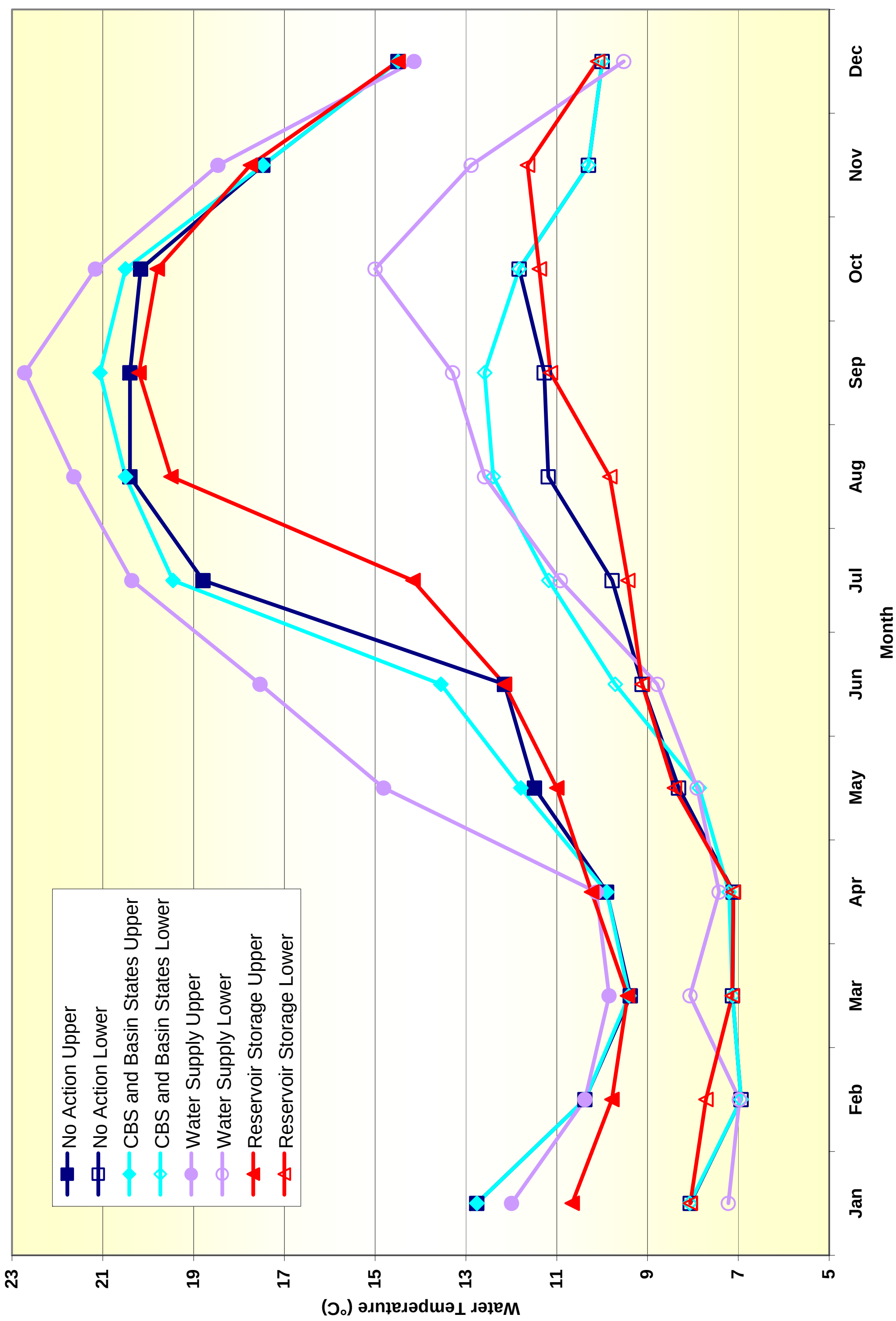

Figure P-83
Glen Canyon Dam Release Temperatures
No Action Alternative
Upper and Lower Bounds for Release Temperatures

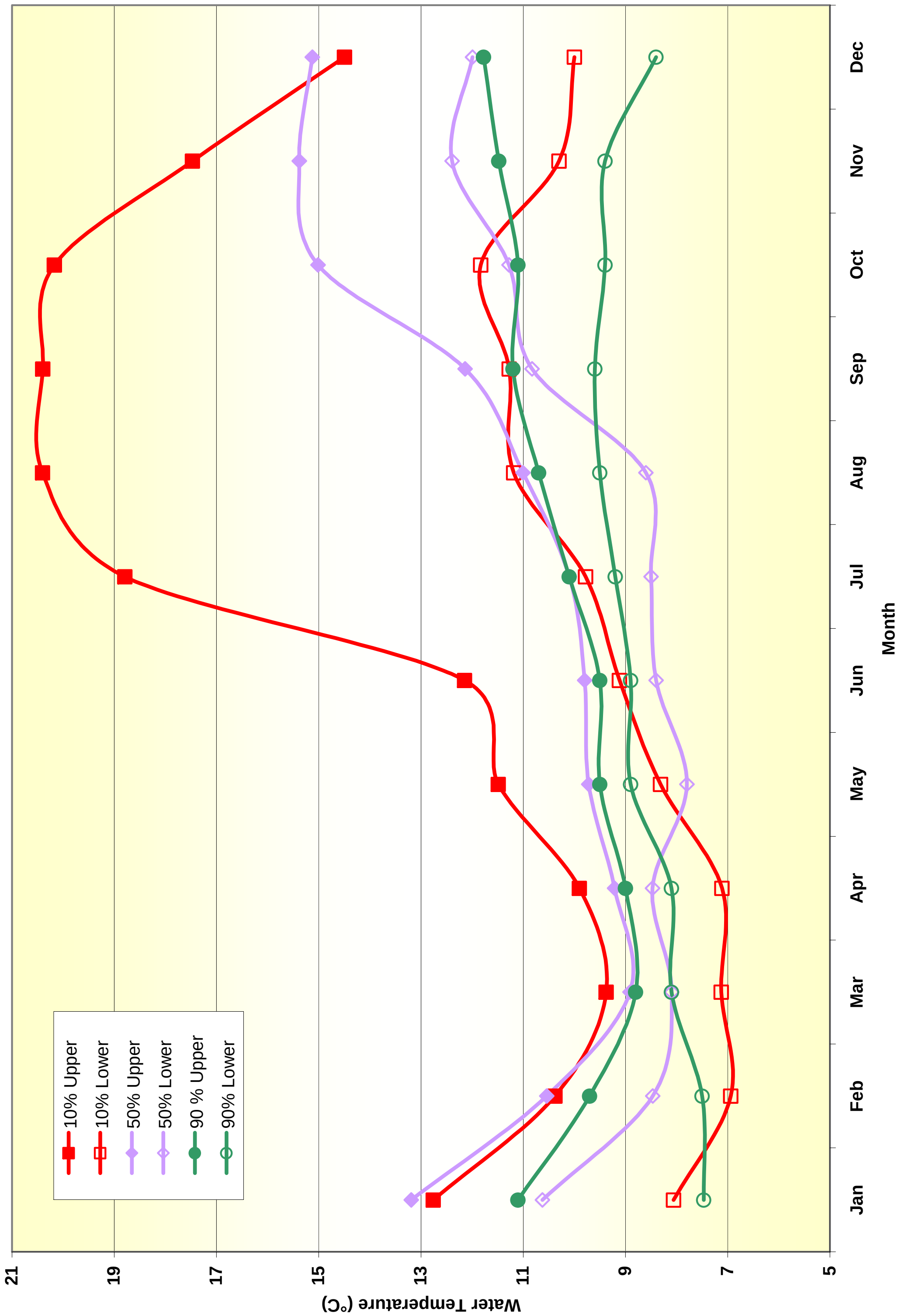

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Figure P-84
Glen Canyon Dam Release Temperatures
Conservation Before Shortage and Basin States Alternative
Upper and Lower Bounds for Release Temperatures

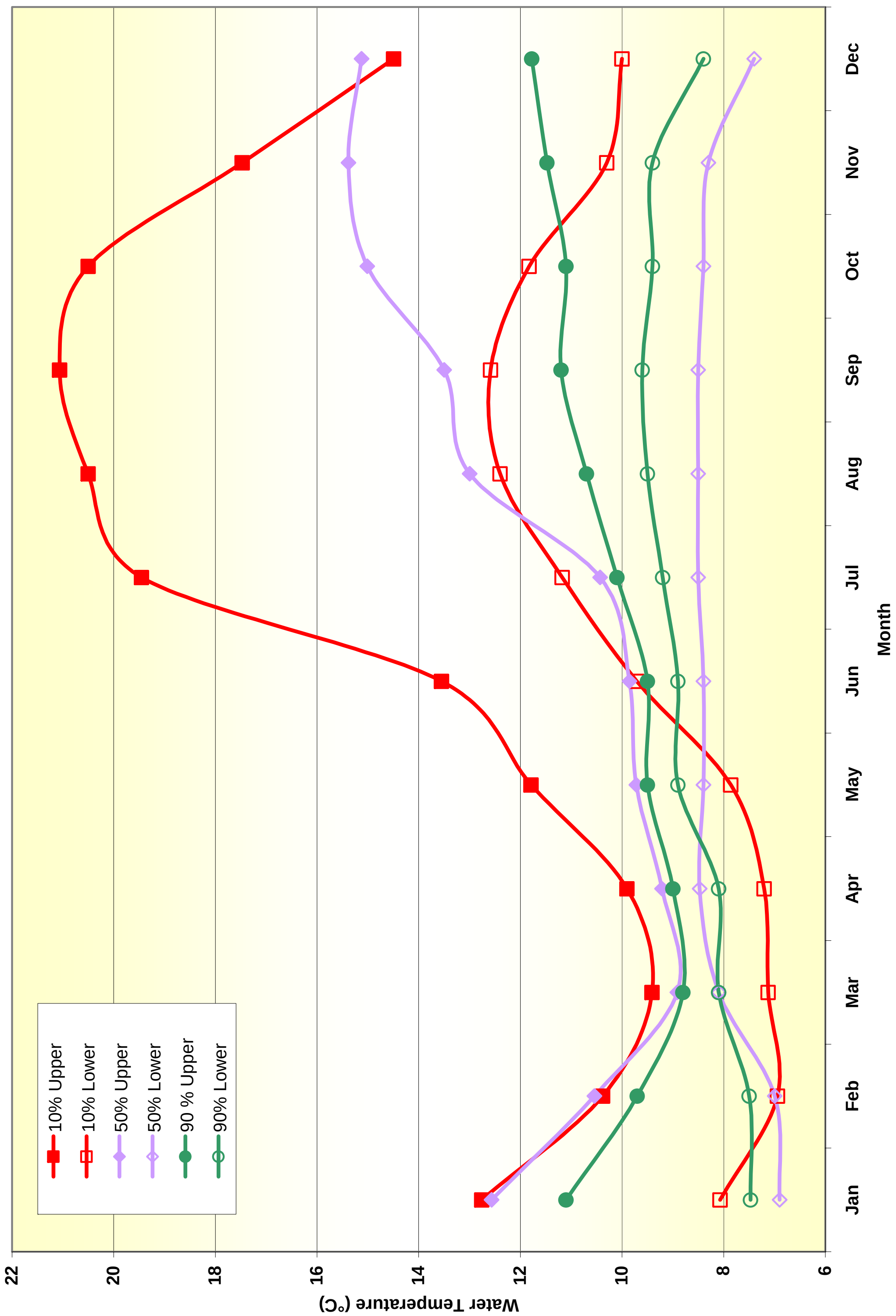

Figure P-85
Glen Canyon Dam Release Temperatures
Water Supply Alternative
Upper and Lower Bounds for Release Temperatures

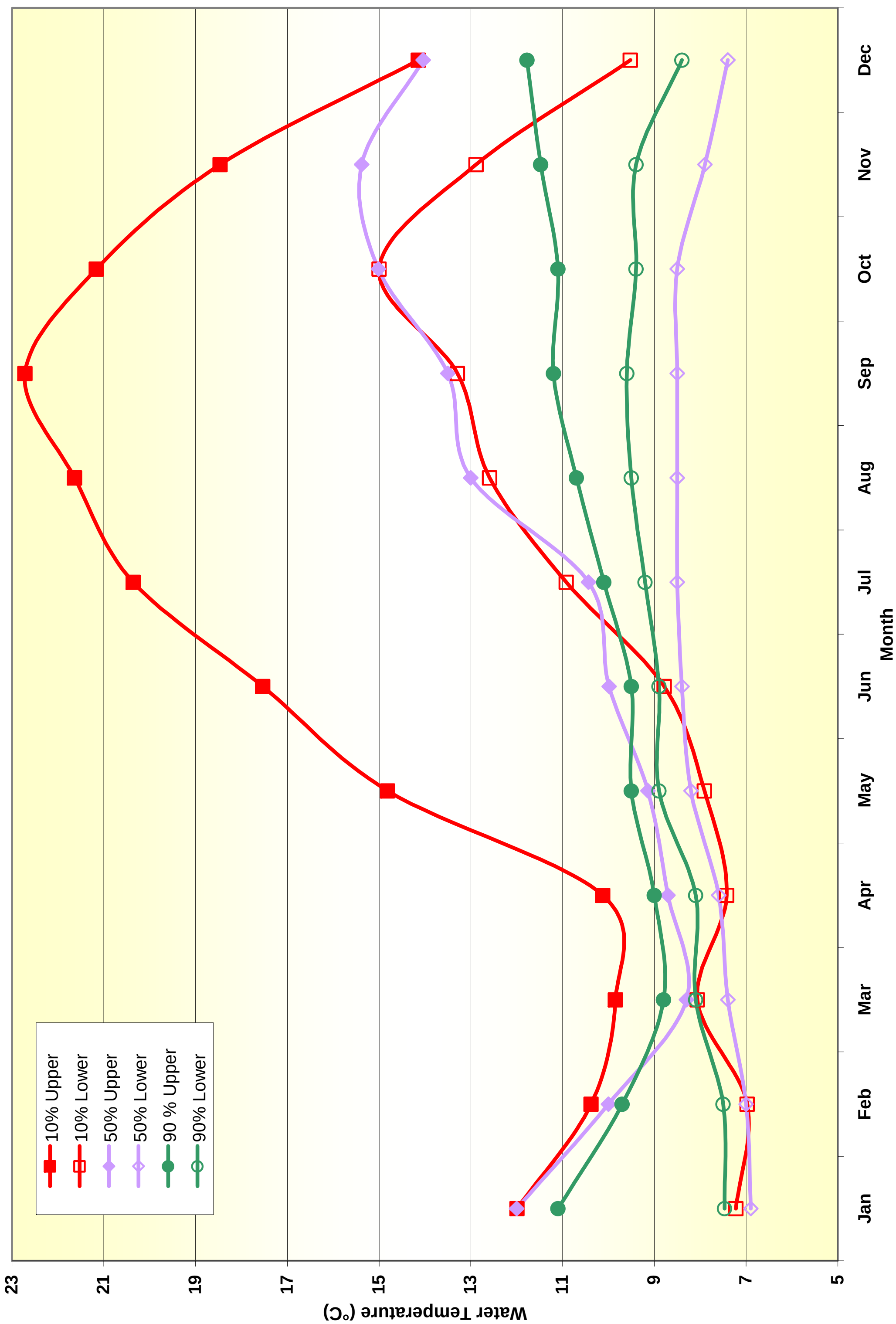

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Figure P-86
Glen Canyon Dam Release Temperatures
Reservoir Storage Alternative
Upper and Lower Bounds for Release Temperatures

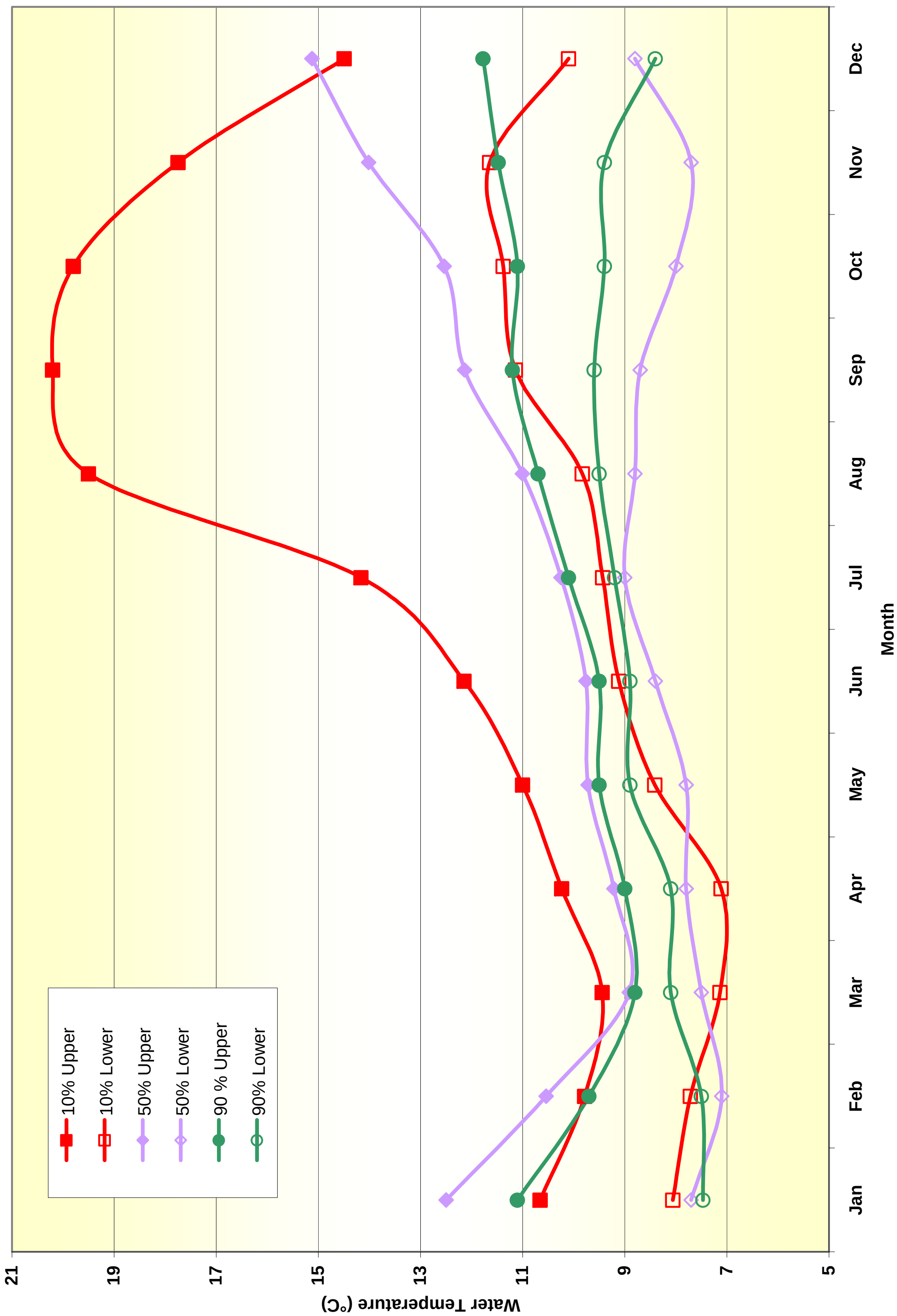

Figure P-87
Hoover Dam Release Temperatures
Comparison of Action Alternatives to No Action Alternative
90th Percentile Upper and Lower Bounds for Release Temperatures

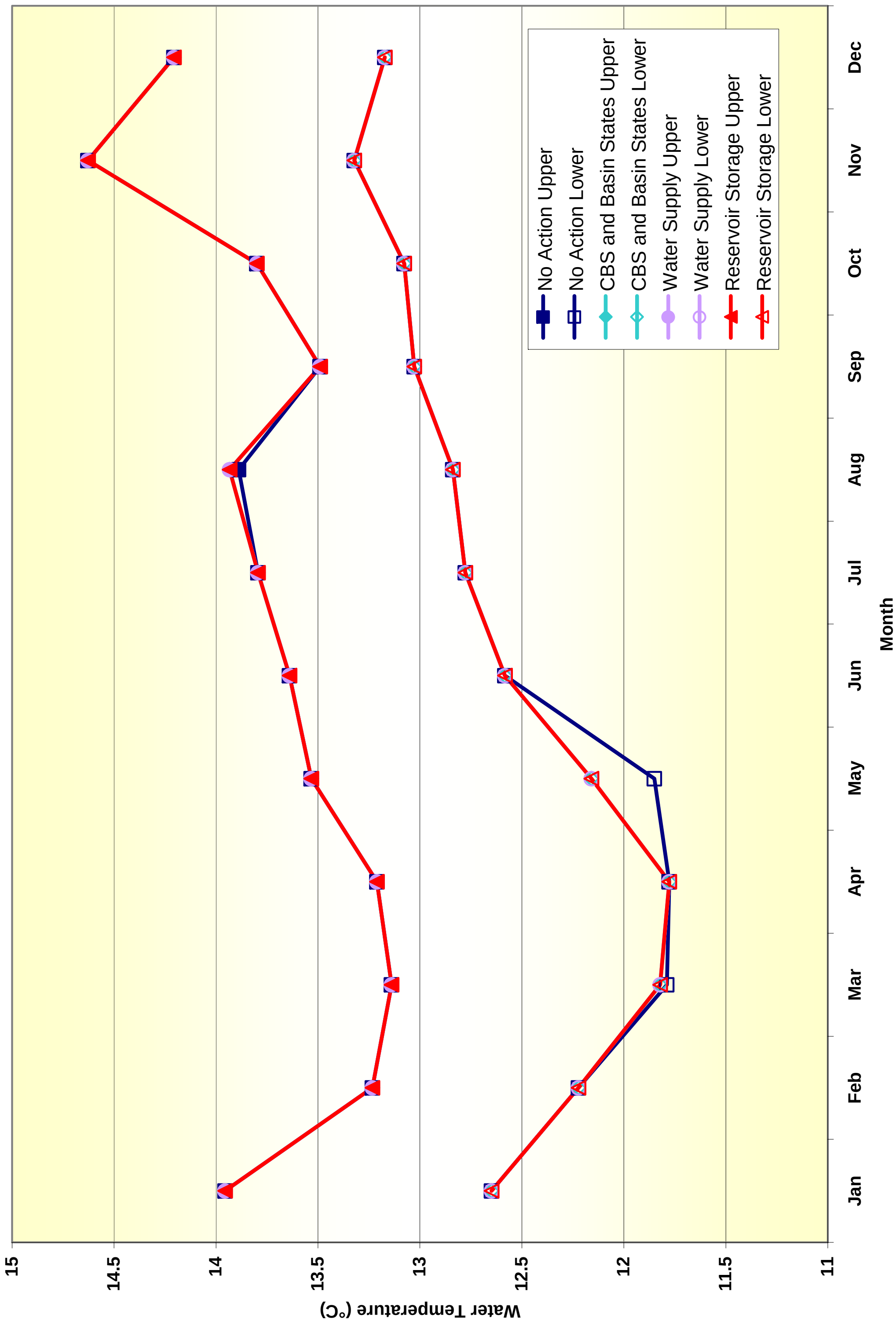

Figure P-88
Hoover Dam Release Temperatures
Comparison of Action Alternatives to No Action Alternative
50th Percentile Upper and Lower Bounds for Release Temperatures

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Figure P-89
Hoover Dam Release Temperatures
Comparison of Action Alternatives to No Action Alternative
10th Percentile Upper and Lower Bounds for Release Temperatures

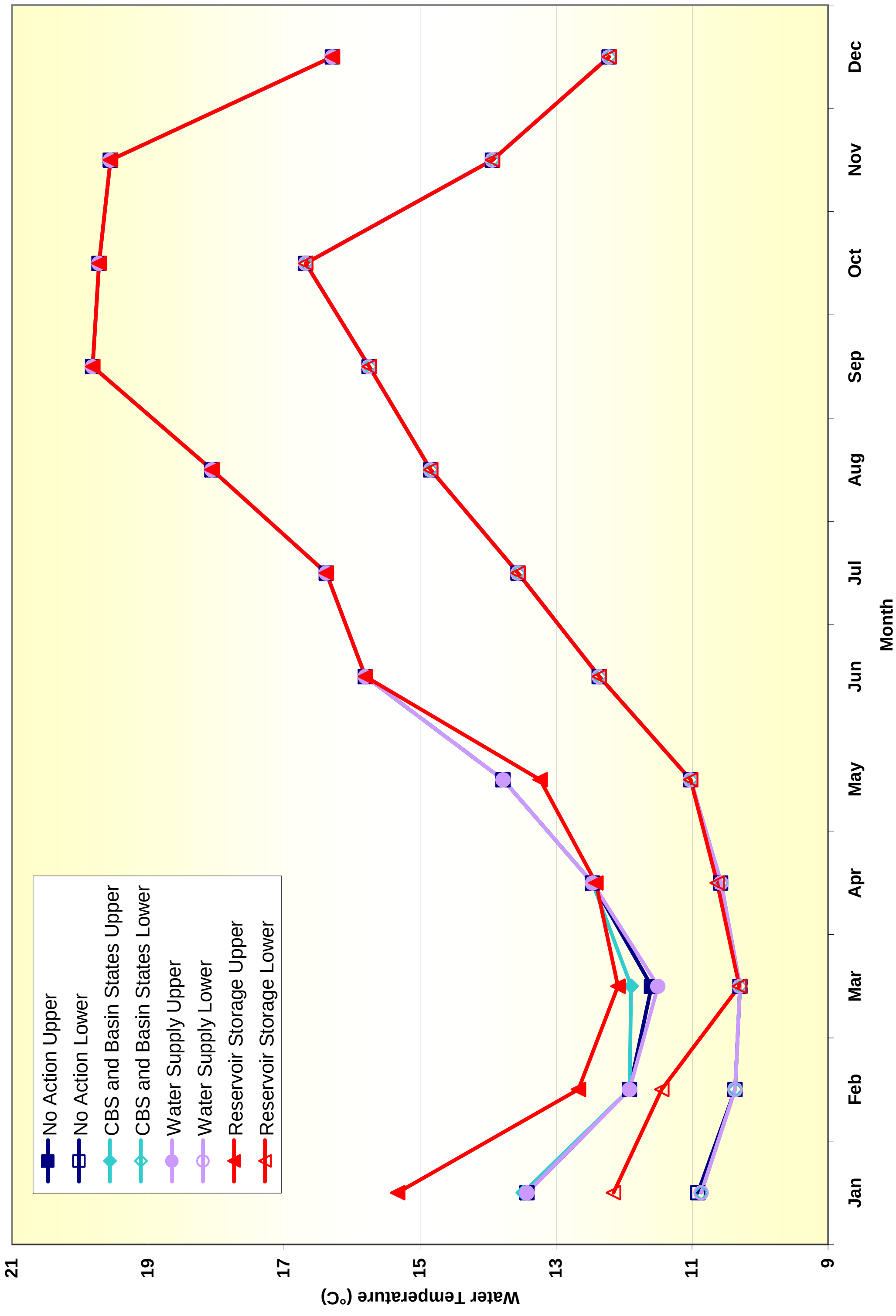

Figure P-90
Hoover Dam Release Temperatures
No Action Alternative
Upper and Lower Bounds for Release Temperatures

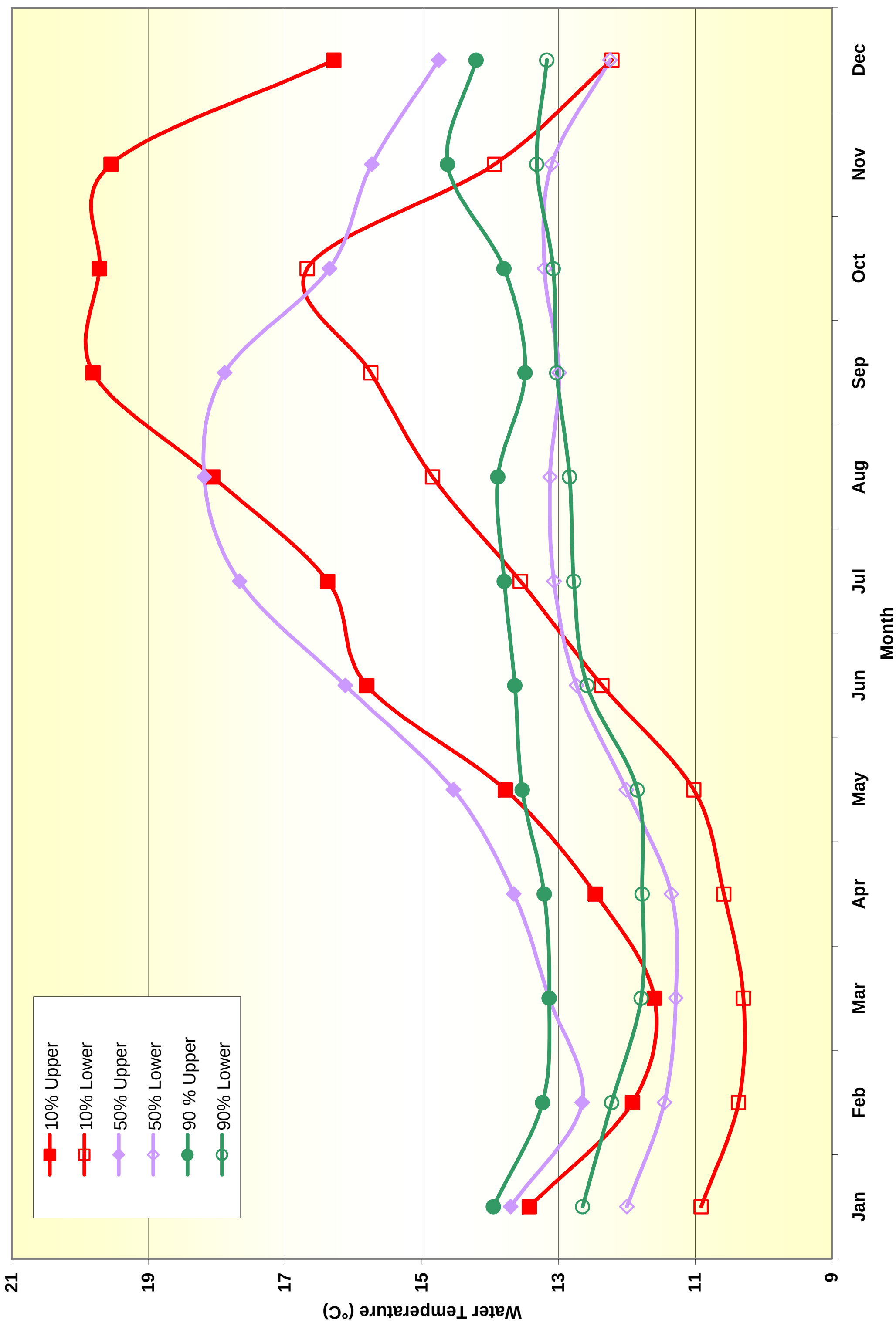

Figure P-91
Hoover Dam Release Temperatures
Conservation Before Shortage and Basin States Alternative
Upper and Lower Bounds for Release Temperatures

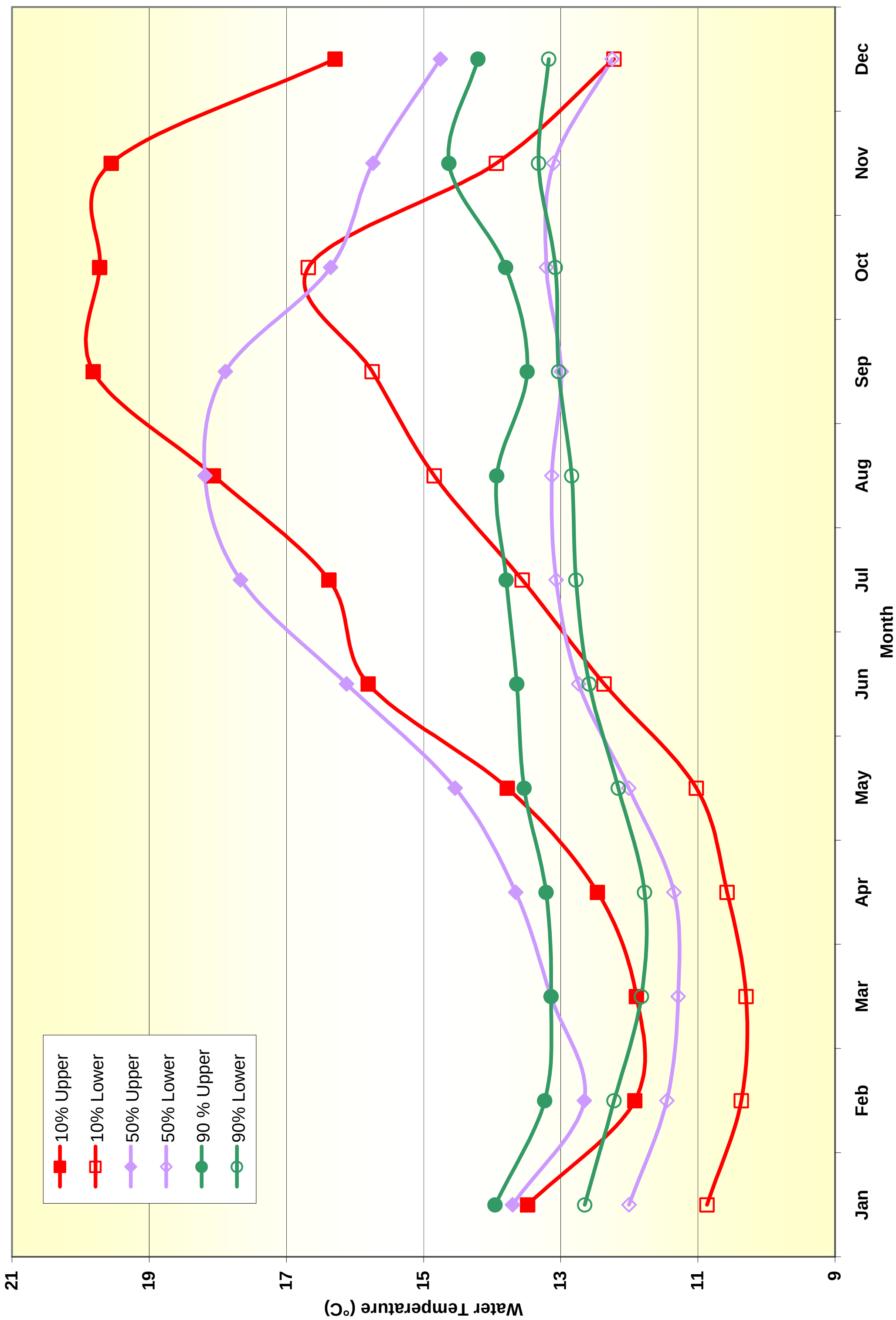

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Figure P-92
Hoover Dam Release Temperatures
Water Supply Alternative
Upper and Lower Bounds for Release Temperatures

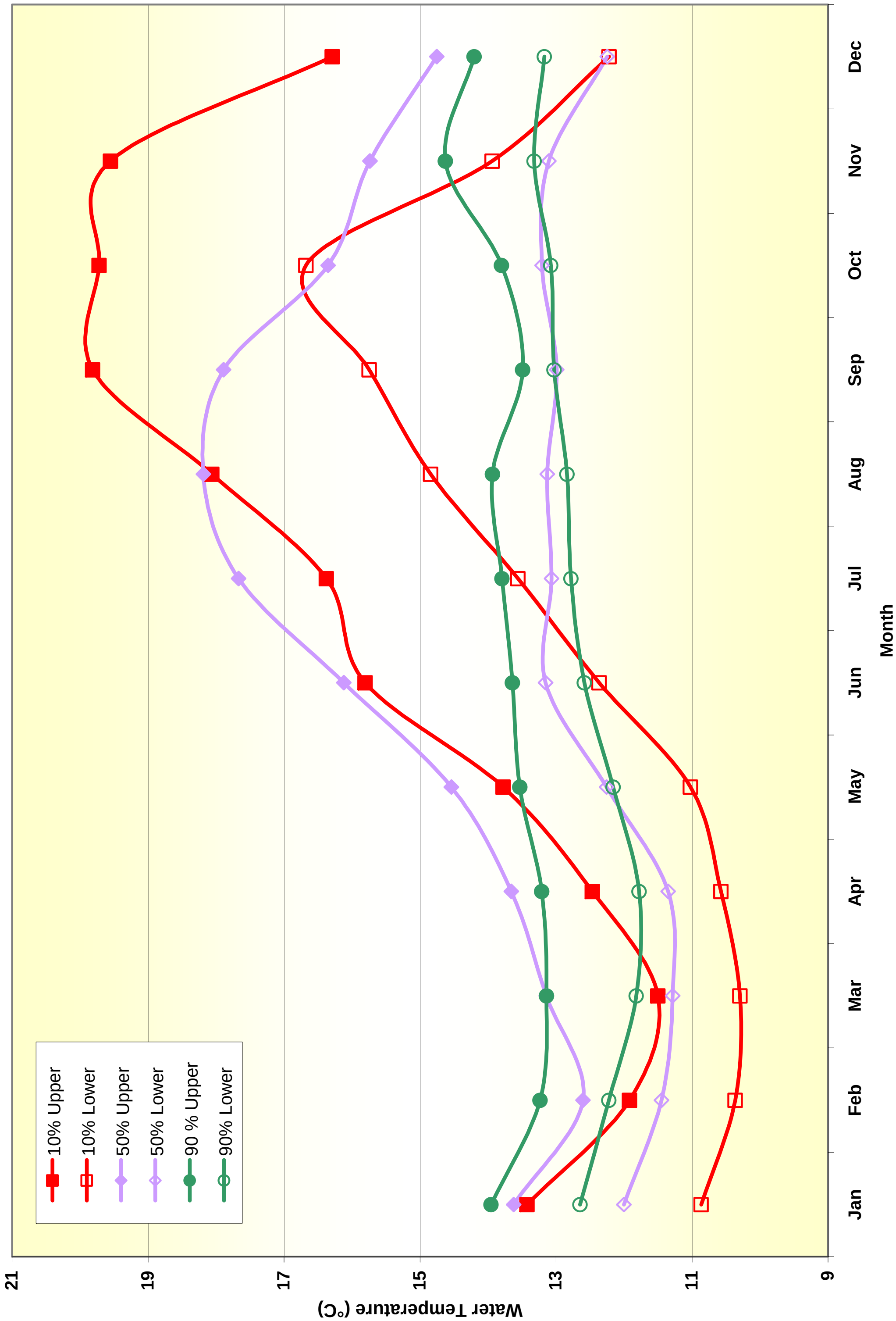
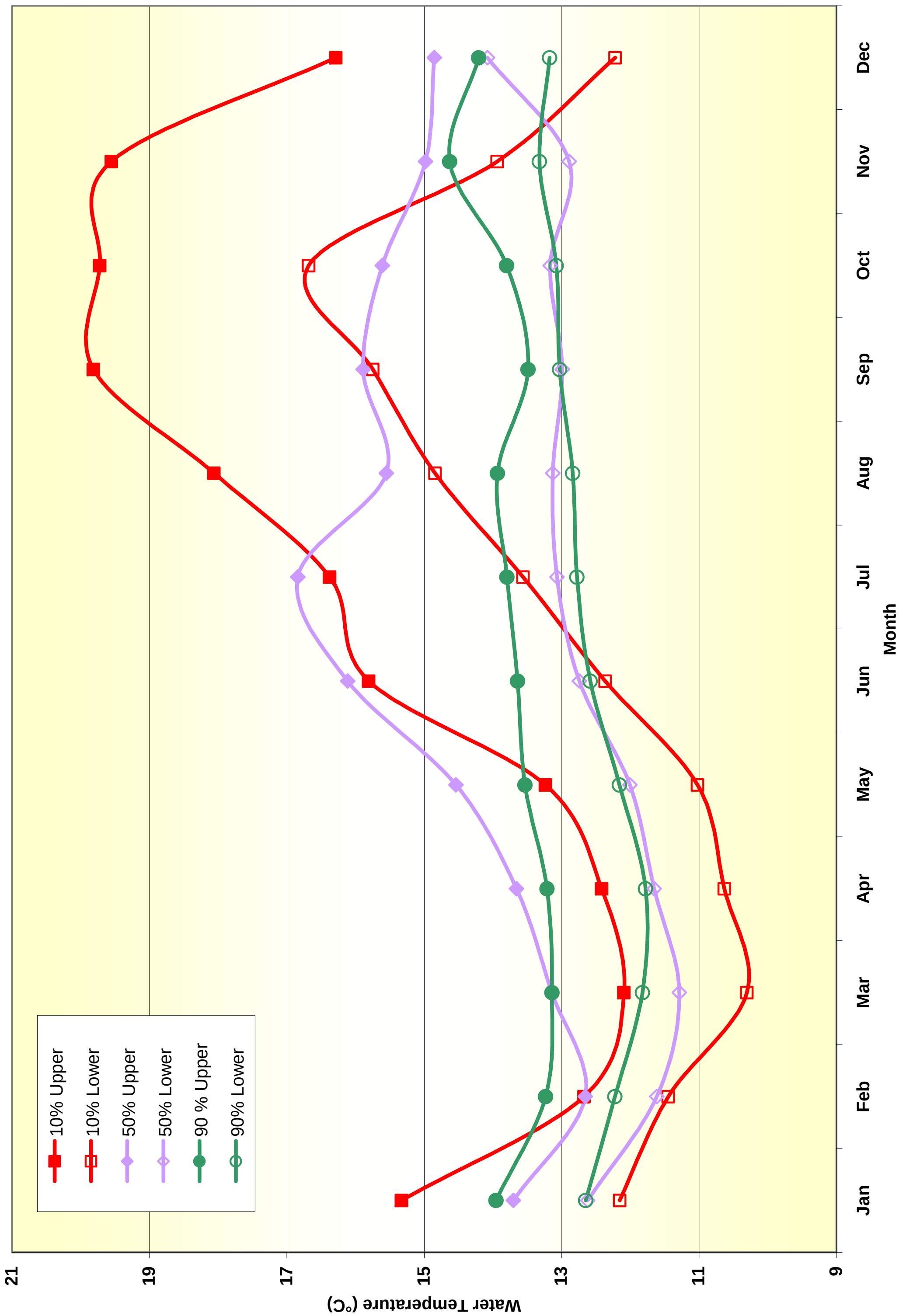


Figure P-93
Hoover Dam Release Temperatures
Reservoir Storage Alternative
Upper and Lower Bounds for Release Temperatures



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Electrical Power Resources

This section contains additional CRSS modeling output referenced in the Electrical Power Resources Section.

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Figure P-94
Glen Canyon Powerplant Annual Energy Production
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

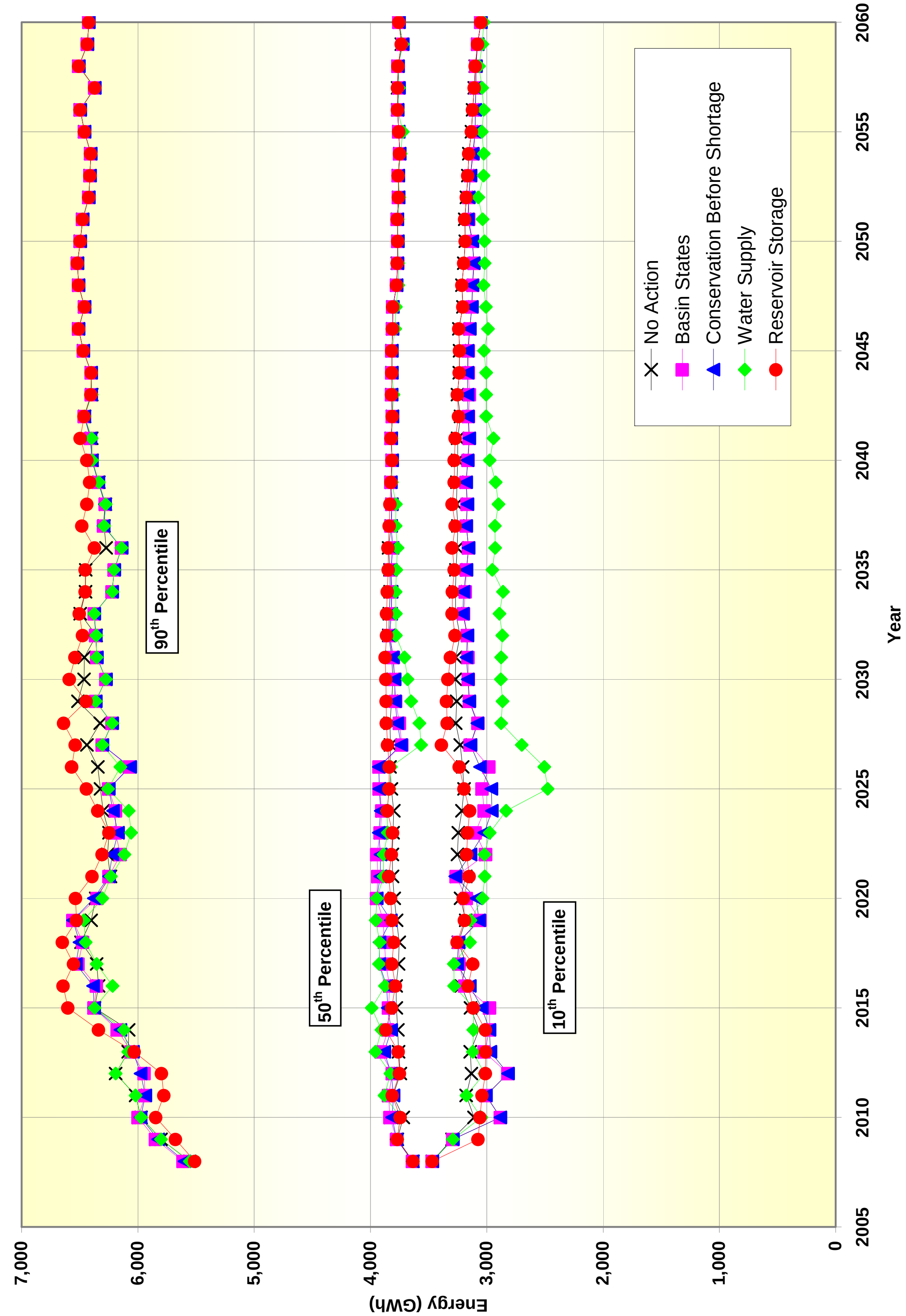

Figure P-95
Hoover Powerplant Annual Energy Production
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

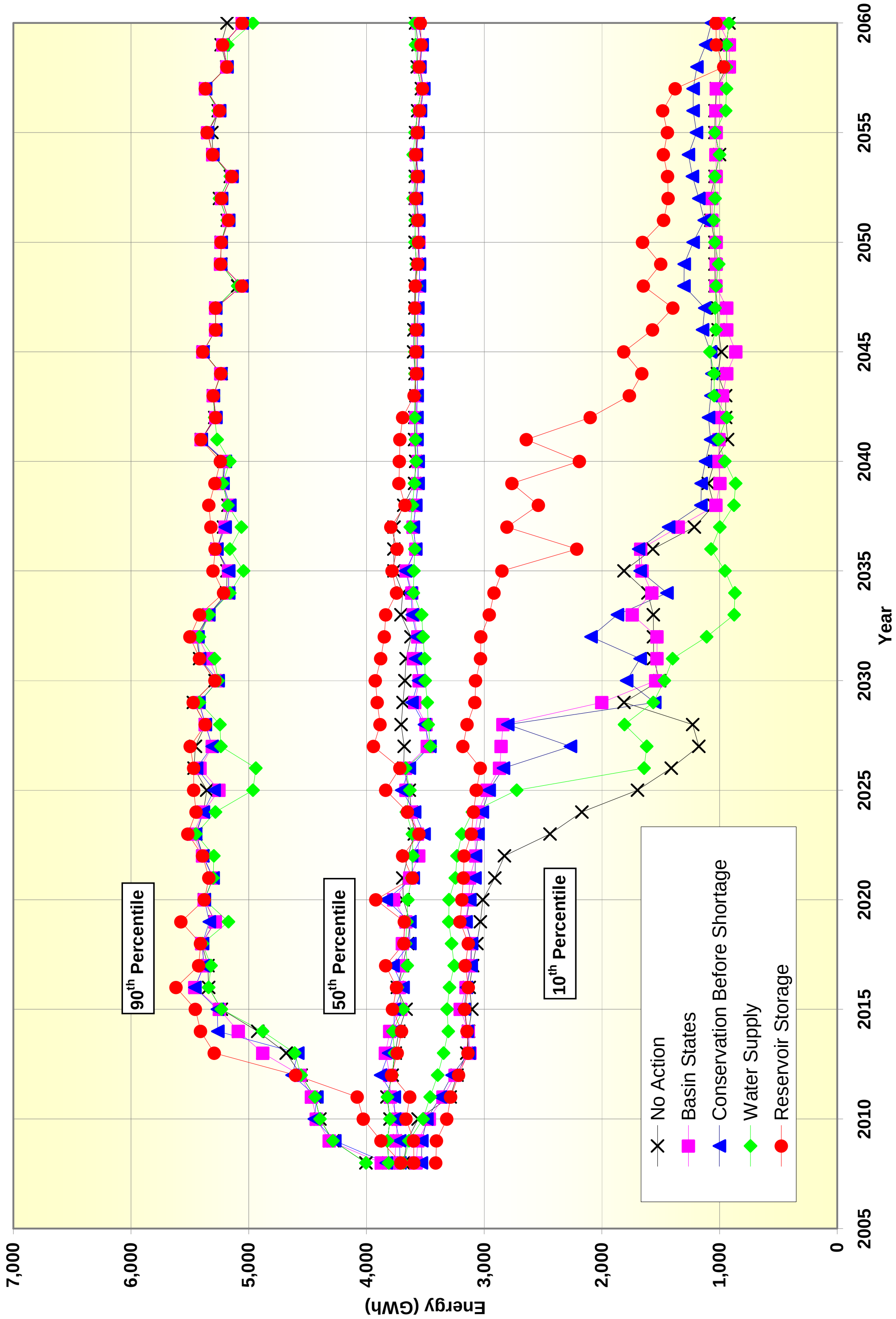

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Figure P-96
Davis Powerplant Annual Energy Production
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

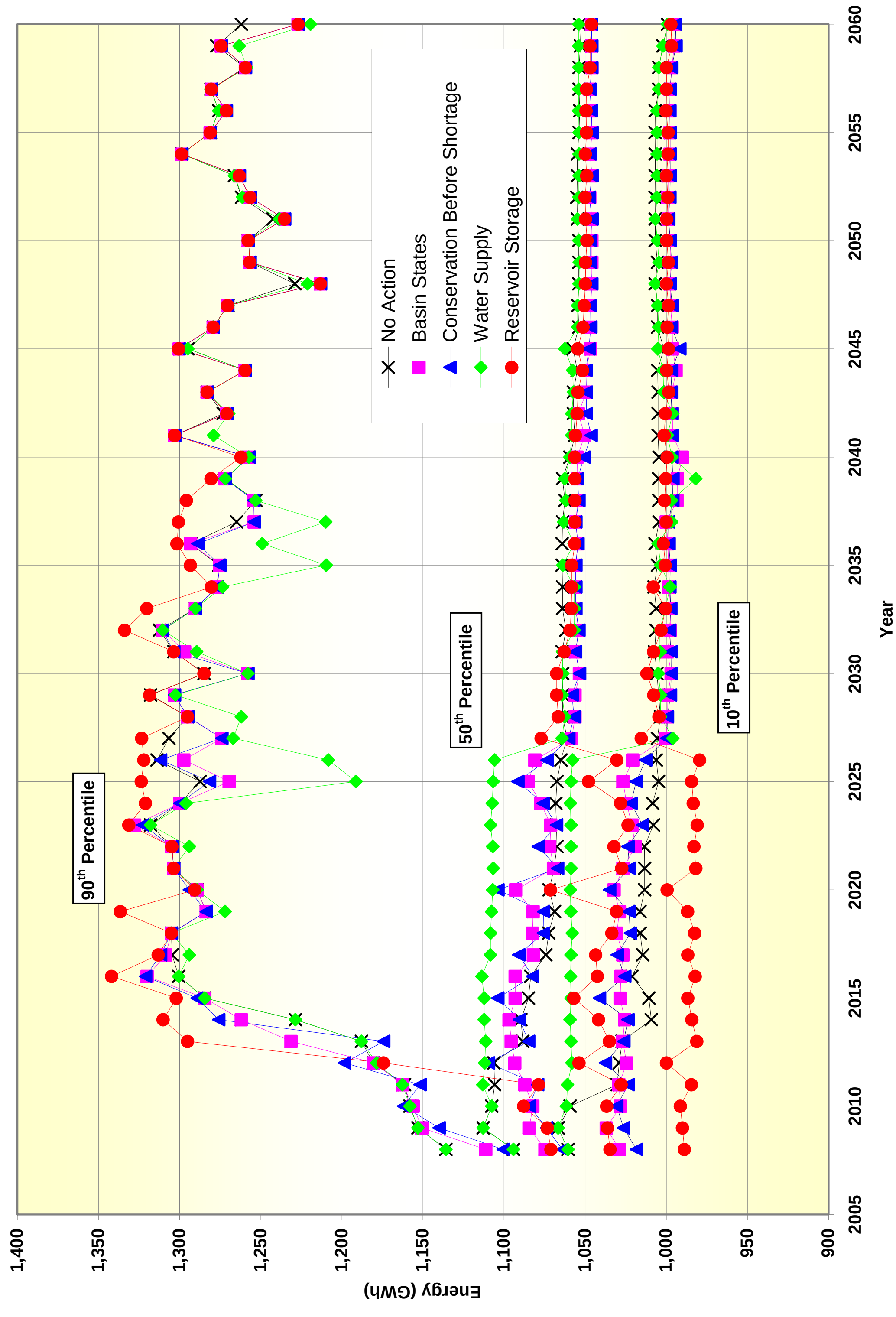

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Figure P-97
Parker Powerplant Annual Energy Production
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

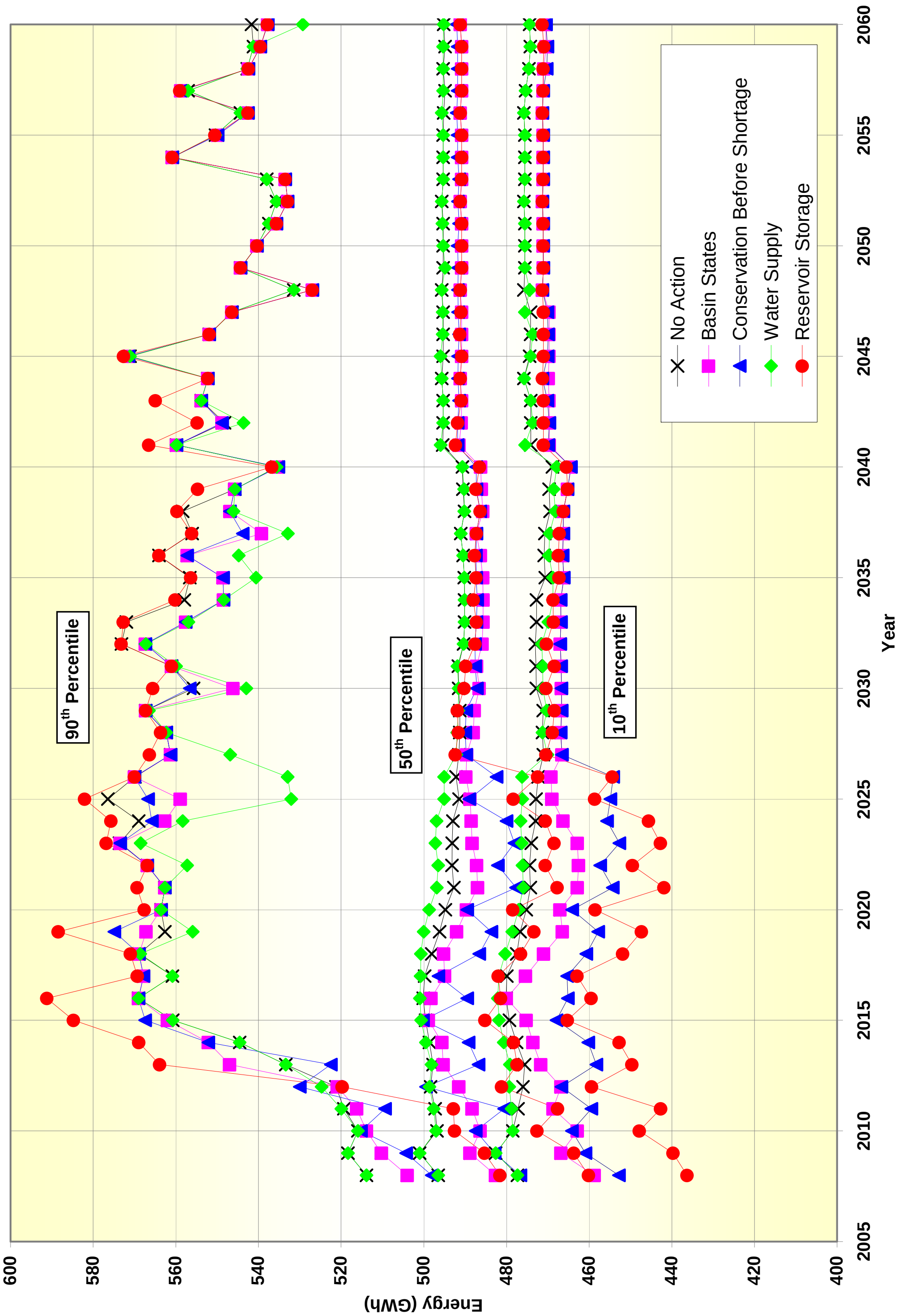

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Figure P-98
Lake Powell End-of-July Water Elevtions
Comparison of Action Alternatives to No Action Alternative
50th and 10th Percentile Values

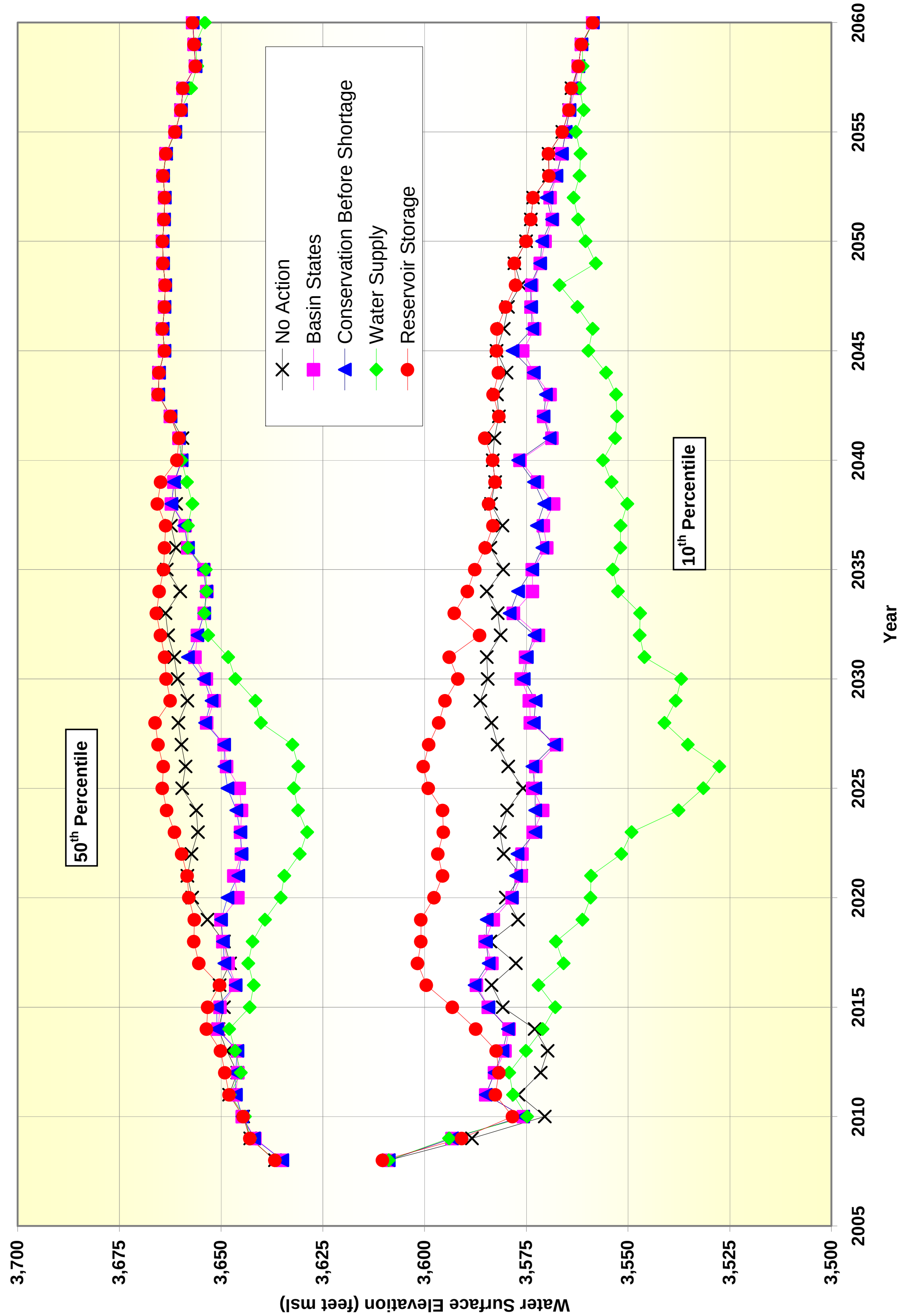

Figure P-99
Lake Mead End-of-December Water Elevtions
Comparison of Action Alternatives to No Action Alternative
50th and 10th Percentile Values

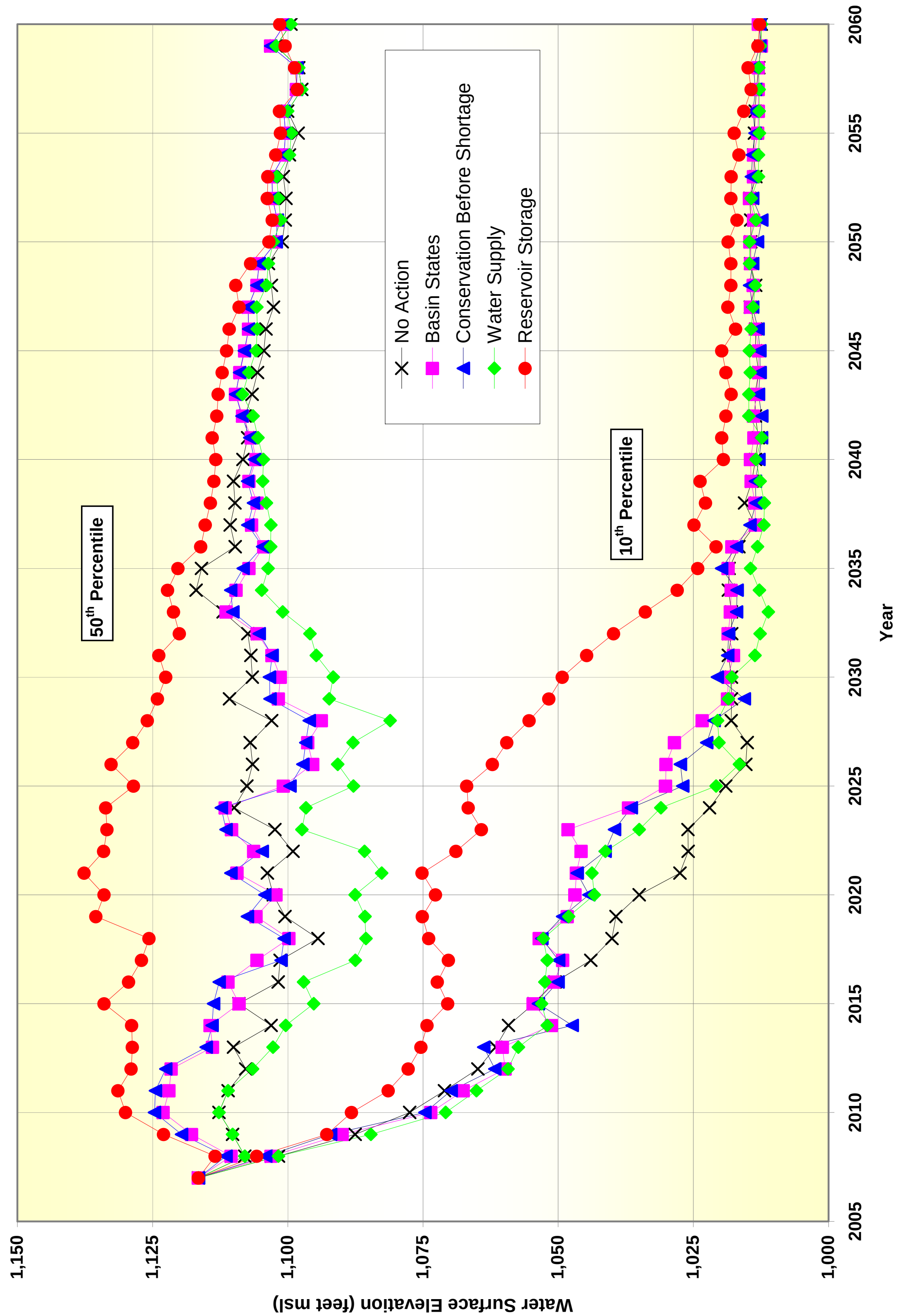

Figure P-100
Headgate Rock Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
90^{th}, 50^{th} and 10^{th} Percentile Values

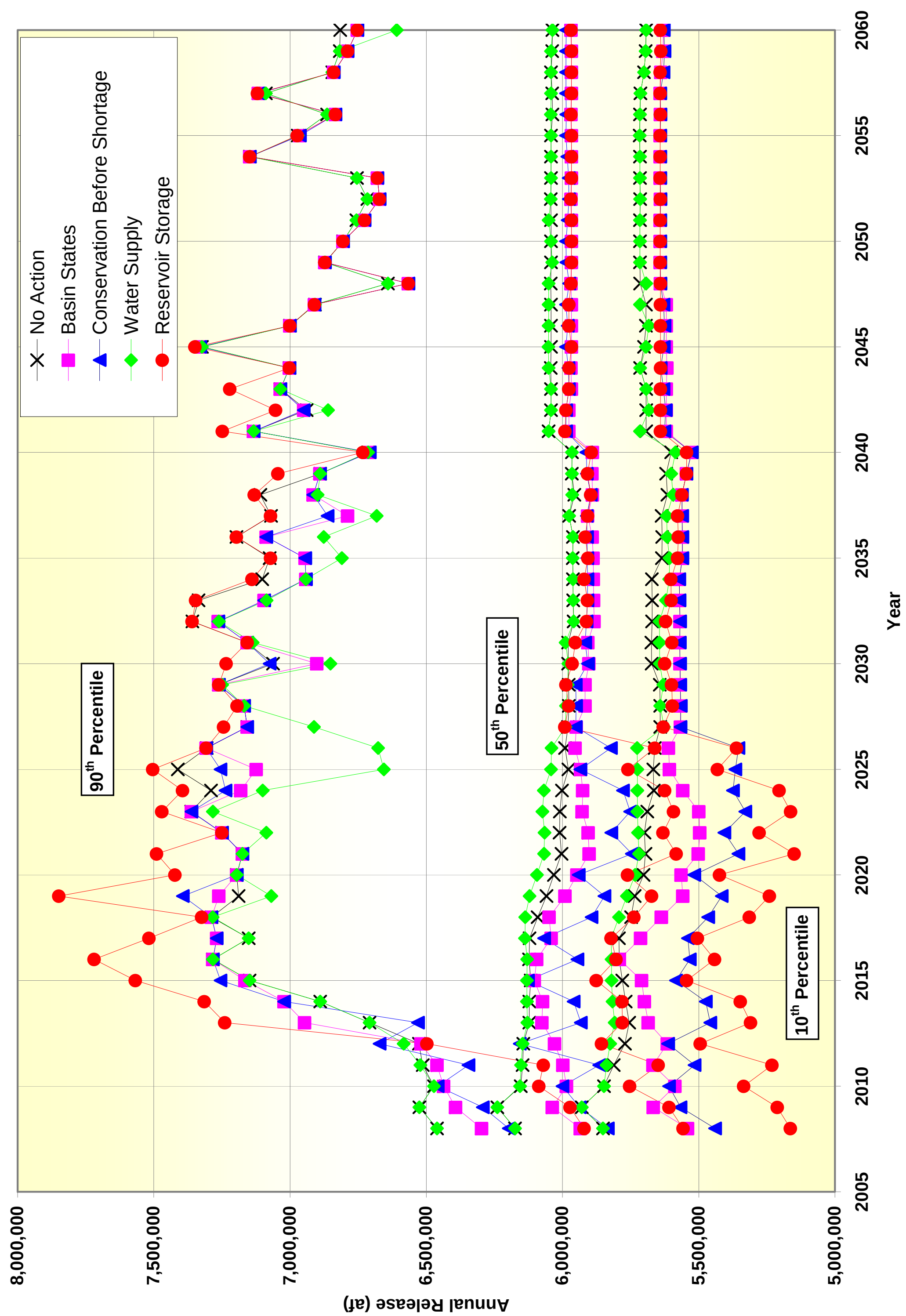

Figure P-101
Headgate Rock Dam Annual Releases
Comparison of Action Alternatives to No Action Alternative
9verage Values

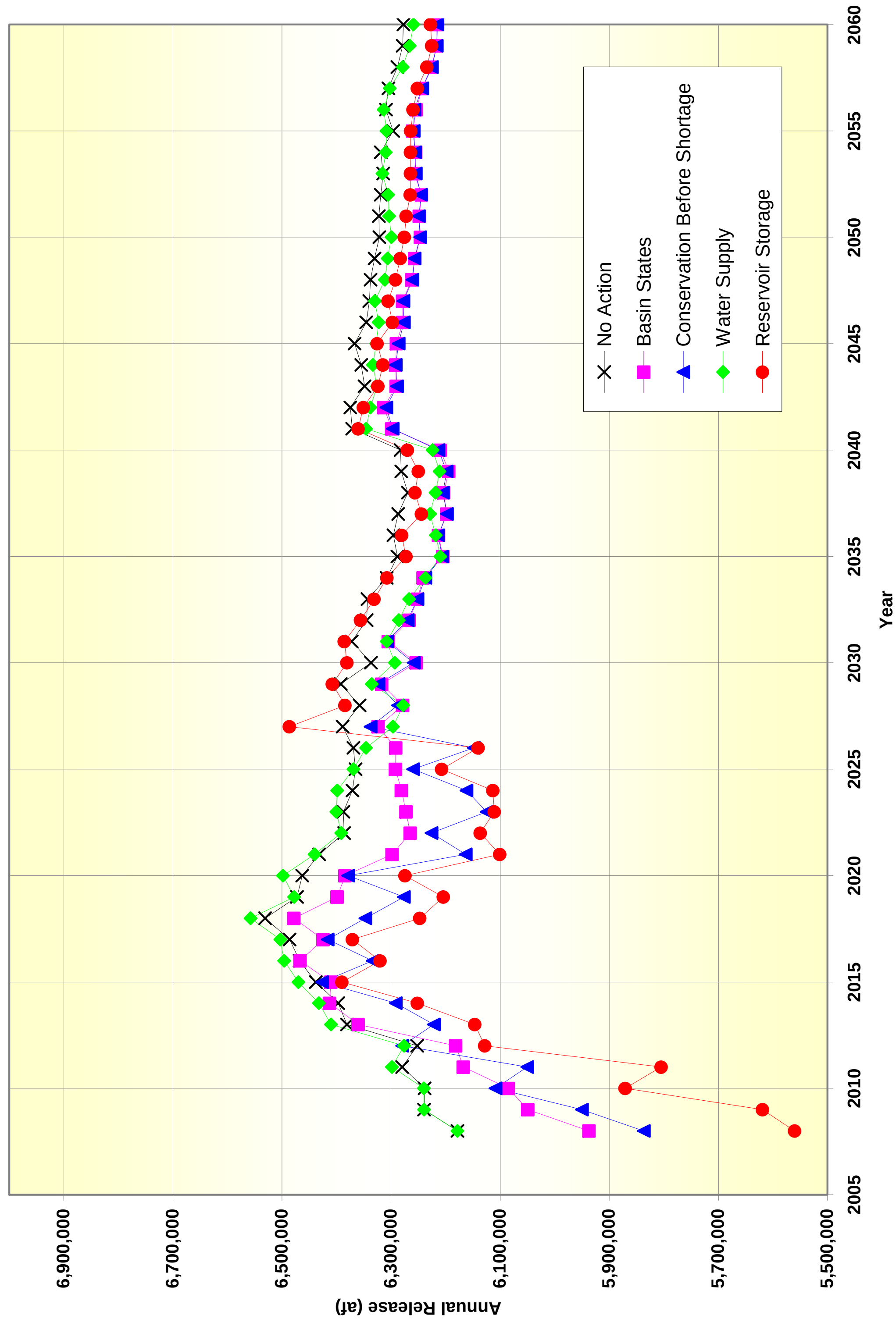

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Figure P-102
Headgate Rock Powerplant Annual Energy Production
Comparison of Action Alternatives to No Action Alternative
90th, 50th and 10th Percentile Values

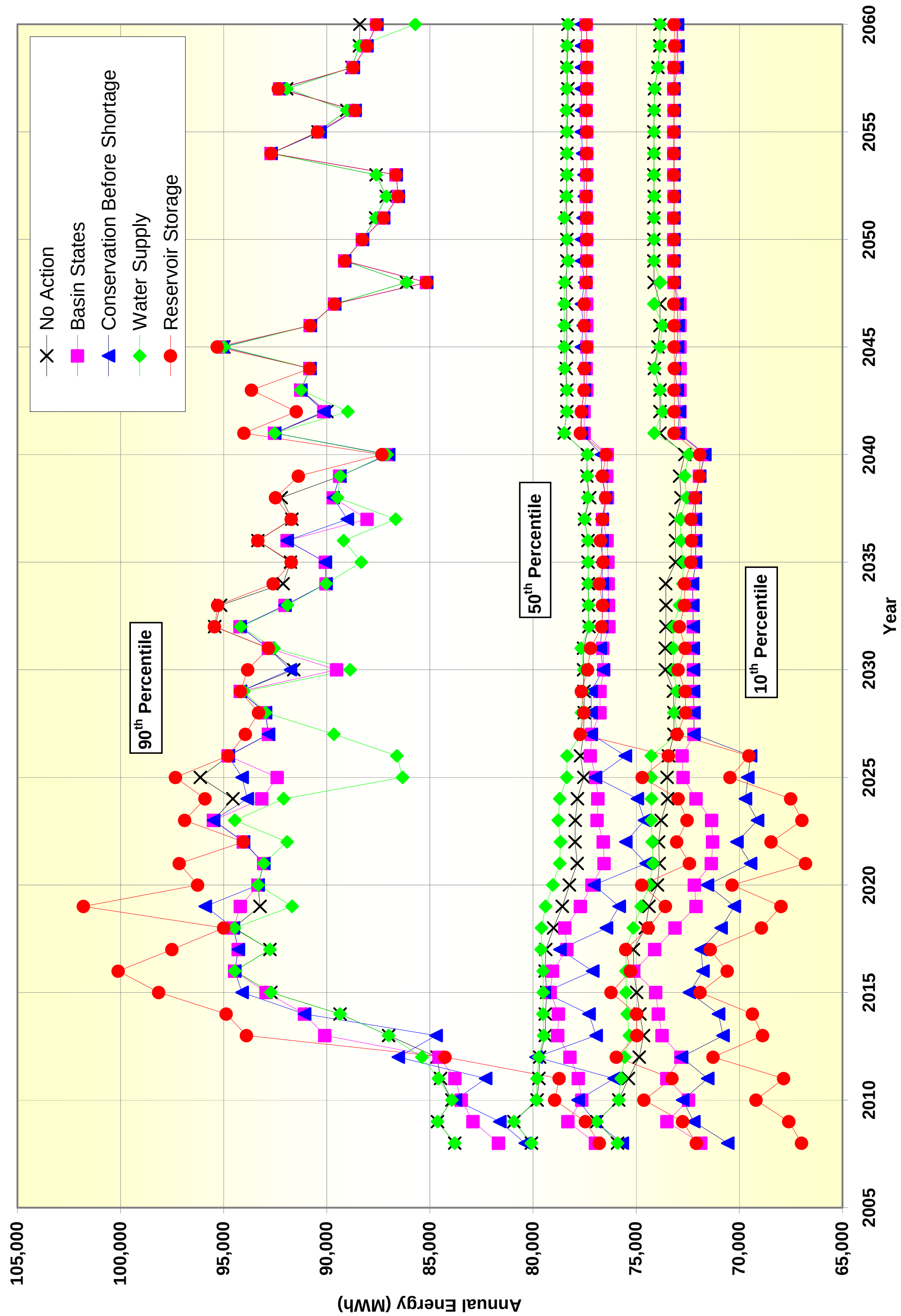

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Figure P-103
Headgate Rock Powerplant Annual Energy Production
Comparison of Action Alternatives to No Action Alternative
Average Values