Final
Environmental Impact Statement
Volume II — Appendices

Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions

October 2002

U.S. Department of the Interior
Bureau of Reclamation

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APPENDICES

Appendix A

Implementation Agreement

IMPLEMENTATION AGREEMENT

The United States by and through the Secretary of the Interior (Secretary) hereby agrees with the Imperial Irrigation District (IID), the Coachella Valley Water District (CVWD), the Metropolitan Water District of Southern California (MWD), (these three districts are collectively referred to herein as the Districts), and the San Diego County Water Authority (SDCWA) as follows:

A. Predicates to Operative Terms

1. By regulations dated September 28, 1931, the Secretary incorporated the schedule of priorities provided in the Seven Party Agreement dated August 18, 1931, and established priorities One through Seven for use of the waters of the Colorado River within the State of California. The regulations were promulgated pursuant to the Boulder Canyon Project Act (BCPA) and required that contracts be entered into for the delivery of water within those priorities.

2. The Secretary has entered into contracts with, among others, the Palo Verde Irrigation District (PVID), IID, CVWD, and MWD and for the delivery of Colorado River water pursuant to Section 5 of the BCPA (Section 5 Contracts). Under those Section 5 Contracts, PVID, IID, CVWD and MWD have certain rights to the delivery of Colorado River water.

3. IID and MWD have entered into an Agreement for the Implementation of a Water Conservation Program and Use of Conserved Water dated December 22, 1988 (1988 Agreement); IID, MWD, PVID and CVWD have entered into a related Approval Agreement, dated December 19, 1989 (1989 Approval Agreement); and MWD and CVWD have entered into an Agreement to Supplement Approval Agreement, dated December 19, 1989 (1989 Supplemental Agreement).

4. IID and SDCWA have entered into an Agreement for Transfer of Conserved Water, dated April 29, 1998, and a Third Amendment to Agreement For Transfer of Conserved Water dated as of _____________ (as amended, the 1998 IID/SDCWA Transfer Agreement).

5. SDCWA and MWD have entered into an Agreement for the Exchange of Water, dated November 10, 1998 and an Amendment Agreement dated as of _____________, (as amended, the MWD/SDCWA Exchange Agreement).

6. CVWD, IID and MWD have entered into a Quantification Settlement Agreement dated as of ______________ (QSA).

7. IID, CVWD, MWD, PVID, the San Luis Rey Indian Water Rights Settlement Parties and the Secretary have entered into an Agreement pertaining to the water to be conserved from the All American Canal Lining Project and the Coachella Canal Lining Project of even date herewith (Allocation Agreement).

8. CVWD and MWD have entered into a Transfer and Exchange Agreement for 35,000 acre-feet of State Water Project entitlement for Colorado River water of even date herewith (MWD/CVWD Transfer and Exchange Agreement).

9. The 1988 Agreement, the 1989 Approval Agreement, and the 1989 Supplemental Agreement have been modified by Amendatory Agreements of even date herewith to reflect the terms of the QSA (as modified, the Amended 1988 and 1989 Agreements).

10. IID and CVWD have entered into an Agreement for Acquisition of Conserved Water (IID/CVWD Acquisition Agreement).

11. CVWD and MWD have entered into an Agreement for Acquisition of Water (CVWD/MWD Acquisition Agreement).

12. IID and MWD have entered into an Agreement for Acquisition of Conserved Water (IID/MWD Acquisition Agreement).

13. IID, CVWD, MWD and SDCWA desire that, for a temporary period, Priority 3a and 6a Colorado River water be delivered by the Secretary in the manner contemplated by the QSA and the other agreements specifically referenced herein.

14. The Secretary has determined that appropriate environmental review and compliance for this Implementation Agreement (Agreement) have been completed under federal law.

15. The Secretary finds that the water budget components of the QSA and the water budget components of the other agreements specifically referenced herein facilitate and will benefit the Secretary's management of the Colorado River.

16. The Secretary has the authority to enter into this Implementation Agreement on behalf of the United States pursuant to the BCPA, the Decree in Arizona v. California, and other applicable authorities.

B. Operative Terms

1. **Priorities 1, 2, 3b, 6b, and 7 are not affected by this Agreement.**

2. **Water Delivery Contracts**

   a. The Secretary agrees to deliver Colorado River water in the manner set forth in this Agreement during the Quantification Period. The Quantification Period shall commence on the Effective Date of the QSA and shall end on the Termination Date of the QSA. The Secretary shall begin to deliver water in the manner set forth in this Agreement when the Quantification Period begins and shall cease delivering water in the manner provided in this Agreement when the Quantification Period ends; provided, however, that the Secretary's delivery commitment to the San Luis Rey Indian Water Rights Settlement Parties shall not terminate at the end of the Quantification Period but shall instead continue, pursuant to Section 106 of Public Law 100-675, 102 Stat. 4000 et seq., as amended, subject to the terms of the Allocation Agreement.

b. The Districts' respective Section 5 Contracts shall remain in full force and effect throughout the Quantification Period and with this Agreement shall govern the delivery of Colorado River water during the Quantification Period.

c. At the end of the Quantification Period, the Agreement shall terminate; provided, however, that the rights of the Districts under their respective Section 5 Contracts shall be subject to any continuing reparation requirements under any agreements relating to the impacts of delivering surplus; and provided, further, the Secretary shall continue to deliver for the benefit of the San Luis Rey Indian Water Rights Settlement Parties, a maximum of 16,000 AFY of water made available by the lining of portions of the All American Canal and the Coachella Canal in accordance with Section 2.a of this Agreement.

3. Priority 3a - IID's Entitlement

a. Except as otherwise provided in this Section B.3, or as otherwise determined under the Inadvertent Overrun and Payback Program referenced in Section B.8.a hereof, the Secretary shall deliver Colorado River water to IID in an amount up to but not more than IID's QSA Priority 3a consumptive use quantification cap of 3.1 million AFY less the amount of water equal to that conserved by IID for the benefit of others as outlined in paragraphs b, c, d, e and f below. Colorado River water acquired by IID pursuant to a transaction permitted under the QSA or a Related Agreement (as defined in the QSA) and, where necessary, approved by the Secretary after appropriate environmental compliance, shall not count against this cap.

b. The Amended 1988 and 1989 Agreements

i. IID has implemented water conservation measures for the benefit of MWD under the Amended 1988 and 1989 Agreements and has reduced IID's diversion of Colorado River water accordingly by up to 110,000 AFY.

ii. The Secretary shall deliver Priority 3a water for the benefit of MWD in an amount equal to that amount of water conserved by IID for the benefit of MWD in accordance with the terms of the Amended 1988 and 1989 Agreements.

c. **1998 IID/SDCWA Transfer Agreement**

i. IID has agreed to implement water conservation measures for the benefit of SDCWA under the circumstances specified in the 1998 IID/SDCWA Transfer Agreement and to reduce IID's diversions of Colorado River water accordingly by up to 200,000 AFY.

ii. The Secretary shall deliver Priority 3a water for the benefit of SDCWA, in an amount equal to that water conserved by IID for the benefit of SDCWA, in accordance with the terms, including the point of delivery, of the 1998 IID/SDCWA Transfer Agreement. At SDCWA's election, the Secretary shall deliver that water to the intake facilities for the Colorado River Aqueduct and SDCWA may then exchange up to 200,000 AFY of Colorado River water with MWD at Lake Havasu pursuant to, and during the term of, the MWD/SDCWA Exchange Agreement.

iii. The rights and interests of SDCWA under this Agreement are limited to those provided in Section B.3.a., this Section B.3.c., and in Sections B.9, B.10 and B.11 hereof.

d. **Conserved Water for CVWD**

i. IID has agreed to implement water conservation measures for the benefit of CVWD under the circumstances specified in the IID/CVWD Acquisition Agreement in order to reduce IID's diversion of Priority 3a water by amounts up to a total of 100,000 AFY.

ii. The Secretary shall deliver such amount of Priority 3a water to CVWD at Imperial Dam, as and to the extent requested by CVWD in an amount equal to that amount of water conserved by IID for the benefit of CVWD in accordance with the terms of the IID/CVWD Acquisition Agreement. This water shall be in addition to CVWD's entitlement to Priority 3a water under Section B.4. hereof. In the event CVWD declines a portion of this water, and the water is not delivered to others in accordance with Section 5.e. of this Agreement so that CVWD is required to pay IID under the terms of Section 3.6 of the IID/CVWD Acquisition Agreement, the declined water may then be used by CVWD for any lawful purpose anywhere within CVWD's jurisdictional area.

e. **Canal Lining Projects**

i. Pursuant to California Water Code Sections 12560-12565, the State of California has agreed to provide funds to construct a new lined canal parallel to the unlined portion of the All American Canal from Pilot Knob to Drop 3 (the AAC Project), and to line the unlined portion of the Coachella Canal.

ii. The Secretary shall deliver Priority 3a water, available as a result of the AAC Project, to MWD, and/or to IID, and make available Colorado River water for the benefit of the San Luis Rey Indian Water Rights Settlement Parties, in accordance with the terms of the Allocation Agreement and in accordance with Section 106 of Public Law 100-675, 102 Stat. 4000 et seq., as amended.

f. **Miscellaneous and Indian Present Perfected Rights**

i. In any given Year (as Year is defined in the QSA), the Secretary may reduce the amount of water otherwise available for IID's consumptive use by up to 11,500 AFY as a result of the satisfaction within the State of California of the miscellaneous and Indian present perfected rights recognized in the Decree in Arizona v. California, as amended and supplemented.

ii. If the aggregate volume of such miscellaneous and Indian present perfected rights used in any year is less than 14,500 AF, then the maximum amount of reduction will be in accordance with the terms of the IID/CVWD Acquisition Agreement.

iii. Any such reduction shall be charged to IID's rights under Priorities 3a, 6a, or 7 to the extent such rights exist and water is available, as elected by IID for such year.

iv. Nothing herein waives the ability of IID to challenge the exercise of particular miscellaneous or Indian present perfected rights.

4. **Priority 3a - CVWD's Entitlement**

a. Except as otherwise provided in this Section B.4., or as otherwise determined under the Inadvertent Overrun and Payback Program referenced in Section B.8.a. hereof, the Secretary shall deliver Colorado River water to CVWD in an amount up to but not more than CVWD's QSA Priority 3a consumptive use quantification cap of 330,000 AFY less an amount of water equal to that conserved by CVWD for the benefit of others, as outlined in paragraphs c. and d. below. Colorado River water acquired by CVWD pursuant to a transaction permitted under the QSA, or a Related Agreement (as defined in the QSA) and, where necessary, approved by the Secretary after appropriate environmental compliance, shall not count against this cap.

b. CVWD may utilize Colorado River water, in accordance with the provisions of Section 4.5 of the QSA, outside of Improvement District No. 1 for the purpose of maximizing the effectiveness of Improvement District No.1's water use and recharge programs, so long as such utilization occurs within Coachella Valley and is otherwise consistent with the applicable provisions of the QSA.

c. **Canal Lining Projects**

The Secretary shall deliver Priority 3a water, available as a result of the lining of the unlined portion of the Coachella Canal to MWD and/or IID, and make available Colorado River water for the benefit of the San Luis Rey Indian Water Rights Settlement Parties, as and to the extent provided under the Allocation Agreement and in accordance with Section 106 of Public Law 100-675, 102 Stat. 4000 et seq., as amended.

d. **Miscellaneous and Indian Present Perfected Rights**

i. In any given Year (as Year is defined in the QSA), the Secretary may reduce the amount of water otherwise available for CVWD's consumptive use by up to 3,000 AFY as a result of the satisfaction within the State of California of the miscellaneous and Indian present perfected rights recognized in the Decree in Arizona v. California, as amended and supplemented.

ii. If the aggregate volume of such miscellaneous and Indian present perfected rights used in any year is less than 14,500 AF, then the maximum amount of reduction will be in accordance with the terms of the IID/CVWD Acquisition Agreement.

iii. Any such reduction shall be charged to CVWD's rights under Priorities 3a, 6a, or 7 to the extent such rights exist and water is available, as elected by CVWD for such year.

iv. Nothing herein waives the ability of CVWD to challenge the exercise of particular miscellaneous and Indian present perfected rights.

5. **MWD's Entitlement**

a. Except as otherwise provided in this Section B.5., or as otherwise determined under the Inadvertent Overrun and Payback Program referenced in Section B.8.a hereof, the Secretary shall deliver Colorado River water to MWD in an amount up to but not more than 550,000 AFY under Priority 4 and 662,000 AFY under Priority 5; provided, however, if in any given calendar year the use of Colorado River water in accordance with Priorities 1 and 2, together with the use of Colorado River water on PVID Mesa lands in accordance with Priority 3b, exceeds 420,000 AFY, the Secretary will reduce the amount of water available to MWD in Priorities 4, 5 or 6 by the amount that such use exceeds 420,000 AFY. To the extent that the amount of water used in accordance with Priorities 1, 2 and 3b is less than 420,000 AFY, the Secretary shall deliver to MWD the difference.

b. **MWD's Entitlement to be Made Available to CVWD**

   i. The Secretary shall deliver to CVWD at Imperial Dam 20,000 AFY of Priority 3a water made available by MWD under the Amended 1989 Agreement.

   ii. The Secretary shall deliver to CVWD at Imperial Dam up to 50,000 AFY of water made available by MWD in Year 46 (as Year 46 is defined in the QSA) and thereafter under the CVWD/MWD Acquisition Agreement.

   iii. The Secretary shall deliver to CVWD at Imperial Dam up to 35,000 AFY of water under the terms of the MWD/CVWD Transfer and Exchange Agreement.

c. **Miscellaneous and Indian Present Perfected Rights**

   i. In any given Year (as Year is defined in the QSA), the Secretary may reduce the amount of water otherwise available for MWD's consumptive use by the amount necessary to satisfy within the State of California the miscellaneous and Indian present perfected rights, recognized in the Decree in <u>Arizona v. California</u>, as amended and supplemented, to the extent those uses exceed 14,500 AF.

   ii. Any such reduction shall be charged at MWD's election to any Priority pursuant to which MWD has water available.

   iii. Nothing herein waives the ability of MWD to challenge the exercise of particular miscellaneous and Indian present perfected rights.

d. CVWD may decline to take a portion of the water to be conserved by IID pursuant to the IID/CVWD Acquisition Agreement. In this event, the Secretary shall instead deliver such portion of water to IID or MWD, or to other unspecified water users, as and to the extent requested by any of them; provided, however, that any such request must be in accordance with the provisions of the IID/MWD Acquisition Agreement; and <u>provided</u>, <u>further</u>, that any such delivery to an unspecified user is, where necessary, subject to Secretarial approval and must be otherwise lawful and will be subject to any necessary environmental review.

6. **Priority 6a Entitlements**

a. Except as otherwise provided under the Interim Surplus Guidelines, or under the agreements contemplated by those guidelines, the Secretary will deliver Priority 6a water to MWD, IID and CVWD in the following order and volumes: (i) 38,000 AFY to MWD; (ii) 63,000 AFY to IID; and (iii) 119,000 AFY to CVWD.

b. Any water not used by MWD, IID or CVWD as set forth above will be available to satisfy the next listed amount in Section 6.a. Any additional water available for Priority 6.a shall be delivered by the Secretary in accordance with IID and CVWD's entitlements under their respective Section 5 Contracts in effect as of October 15, 1999.

7. Reasonable and Beneficial Use

a. The Secretary has considered the water budget components and transactions contemplated by the QSA. Because of the substantial commitment by IID to implement water conservation measures in accordance with the terms of the QSA and its related agreements, the Secretary has determined no action by the United States Department of the Interior is necessary to consider whether the past use of Colorado River water by IID satisfies applicable requirements for reasonable and beneficial use.

b. The QSA contemplates major conservation activities to be implemented by IID over the course of many years. The Secretary will take IID's conservation measures and the schedule of implementation under the QSA and the related agreements into account in connection with any future assessment of IID's reasonable and beneficial use of water. Subject to IID's implementation of such conservation measures, and absent any material adverse change in IID's irrigation practices or material advances in technology associated with economically feasible irrigation efficiency, and assuming the continuing effectiveness of the QSA, the Secretary, as of the date of the execution of this Agreement, does not anticipate any need to assess IID's reasonable and beneficial use of water prior to Year 20 (as Year 20 is defined in the QSA).

8. Decree Accounting

a. The Secretary acknowledges the ongoing importance to the QSA of the Secretary's recently adopted Inadvertent Overrun and Payback Program, adopted ______, which is consistent in all material respects with that contemplated by the QSA and set forth in Exhibit B thereto. The Secretary also acknowledges that the application of such Program during the Quantification Period has been determined by each of IID, CVWD and MWD to be essential to their willingness to enter into the QSA's related agreements and this Agreement. Accordingly, so long as there is full and timely implementation of the water budget components of the QSA, the Secretary will not materially modify the Inadvertent Overrun and Payback Program for a 30 year period (during which the implementation of the California plan to reduce its use to 4.4 million acre-feet per year is anticipated), absent extraordinary circumstances such as significant Colorado River infrastructure failures, and subject to the provisions of Section 9 of this Agreement. In the event that extraordinary circumstances arise, the Secretary will consult with the Districts and other interested parties before initiating any material change. If at any time implementation of the water budget components falls short of the requirements of the QSA, the Secretary may, after consultation with the Districts and other interested parties, change or alter the Inadvertent Overrun and Payback Program, including but not limited to putting into effect an immediate payback policy for inadvertent overruns.

b. The Secretary also acknowledges the ongoing importance to the QSA, and to the willingness of each of IID, CVWD and MWD to enter into the QSA's related agreements and this Agreement, of the recently adopted Interim Surplus Guidelines and the accompanying Record of Decision.

9. **Shortages**

a. The Secretary's authority under II.B.3 of the Decree in Arizona v. California is not limited in any way by this Agreement, by the QSA, or by the QSA's related agreements which include all agreements specifically referenced herein.

b. If for any reason there is less than 3.85 million AF available under Priorities 1, 2 and 3 during the Quantification Period, any water which is made available by the Secretary to IID shall be delivered to IID, CVWD, MWD and SDCWA in accordance with the shortage sharing provisions in the 1998 IID/SDWCA Transfer Agreement and the Acquisition Agreements.

10. **Amendments**

a. This Agreement may be modified or amended only by written amendment signed by the Secretary, IID, CVWD, and MWD (and, with respect to any modification or amendment of this Section B.3.a., B.3.c., B.10., B.11. or B.12., also by SDCWA).

i. No amendment of the QSA or of any of the QSA's related agreements, including the agreements specifically referenced in this Agreement, shall modify or otherwise affect any right or obligation of the Secretary with respect to the limitations on, or the timing or volume of, any Colorado River water deliveries to be made hereunder without the Secretary's written consent.

11. **Reservation of Legal Positions**

a. IID, CVID, MWD and SDCWA do not agree on the nature or scope of rights to the delivery, use or transfer of Colorado River water within the State of California.

b. IID, CVID, MWD and SDCWA agree not to use this Agreement or any provision hereof, as precedent for purposes of evidence, negotiation or agreement on any issue of California or federal law in any administrative, judicial or legislative proceeding, including without limitation, any attempt by IID and SDCWA to obtain future approval of any water transaction.

c. By executing this Agreement, the Districts and SDCWA are not estopped from asserting in any administrative, judicial or leglislative proceeding, including those involving the United States, that neither this Agreement nor any of its terms was necessary or required in order to effectuate the transactions contemplated herein.

12. Relation to Reclamation Law

a. This Agreement shall not be deemed to be a new or amended contract for the purpose of Section 203(a) of the Reclamation Reform Act of 1982 (Public Law 97-293, 93 Stat. 1263).

UNITED STATES SECRETARY OF THE INTERIOR

____
Gale A. Norton

COACHELLA VALLEY WATER DISTRICT

By______________________________________
Tom Levy
General Manager-Chief Engineer

IMPERIAL IRRIGATION DISTRICT

By______________________________________
Jesse Silva
General Manager

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

By______________________________________
Ronald R. Gastelum
General Manager

SAN DIEGO COUNTY WATER AUTHORITY

By______________________________________
Maureen Stapleton
General Manager

Appendix B

Quantification Settlement Agreement

DRAFT 12-12-00

QUANTIFICATION SETTLEMENT AGREEMENT

THIS AGREEMENT is made and entered into this ___ day of ________________________, 2000, by and among Imperial Irrigation District ("**IID**") a California irrigation district, The Metropolitan Water District of Southern California ("**MWD**"), a California metropolitan water district, and Coachella Valley Water District ("**CVWD**"), a California county water district, each of which is at times referred to individually as "**Party**" and which are at times collectively referred to as "**Parties.**"

RECITALS:

A. IID is an irrigation district organized under the California Irrigation District Law, codified at § 20500 et seq. of the California Water Code, and delivers Colorado River water in Imperial County, California for potable and irrigation purposes.

B. MWD is a metropolitan water district organized under the California Metropolitan Water District Act, codified at § 109-1 of the Appendix to the California Water Code, engaged in developing, storing and distributing water in the counties of Los Angeles, Orange, Riverside, San Bernardino, San Diego and Ventura, California.

C. CVWD is a county water district organized under the California County Water District Law, codified at 30000 et seq. of the California Water Code, and delivers Colorado River water in Riverside County, California, for potable and irrigation purposes.

D. IID, MWD, PVID and CVWD are each contractors with the United States for delivery of Colorado River water as authorized by the Boulder Canyon Project Act (Act of December 21, 1928: 45 Stat. 1057, as amended.)

E. Pursuant to those contracts, PVID, the Yuma Project (Reservation Division), IID and CVWD (collectively "the agricultural agencies") hold California's first three priorities to Colorado River water and are collectively entitled to the beneficial consumptive use as reasonably required of not to exceed 3,850,000 AFY. The fourth and fifth priorities totaling 1,212,000 AFY are held by MWD. The sixth priority of 300,000 AFY is held by IID, CVWD and PVID. The seventh priority of all remaining water available for use within California is reserved for agricultural use in the Colorado River Basin within California, which includes the lands within IID, CVWD and PVID. MWD and CVWD also have surplus water delivery contracts with the Secretary of the Interior.

F. MWD, IID and CVWD recognize that they have differences of opinion over various legal questions including the right to transfer water and the volumes of water to which the various right holders are entitled, but each Party wishes to go forward with this Agreement and associated agreements without regard to certain current or future differences, subject to the provisions of Article 4 hereof.

G. This Agreement and the Related Agreements are intended to consensually settle longstanding disputes regarding the priority, use and transfer of Colorado River water, to establish by agreement the terms for the further distribution of Colorado River water among the Parties for up to seventy-five years based upon the water budgets set forth herein, and to facilitate agreements and actions which will enhance the certainty and reliability of Colorado River water supplies available to the Parties and assist the Parties in meeting their water demands within California's apportionment of Colorado River water by identifying the terms, conditions and incentives for the conservation and distribution of Colorado River water within California.

H. IID seeks to settle disputes with CVWD and MWD and to use proceeds from the acquisition of Conserved Water by those Parties from IID to improve the reliability, efficiency and management of its Colorado River supply.

I. CVWD seeks to settle disputes with IID and MWD and to acquire Conserved Water for agricultural uses to accommodate anticipated reductions in groundwater extraction.

J. MWD seeks to settle disputes with IID and CVWD and to ensure the reliability of its Colorado River supplies.

K. The Parties intend that the Effective Date (defined below) of this Agreement will be contingent upon the completion of review and adequate provision for any required mitigation under and in compliance with the California Environmental Quality Act, California Public Resources Code § 2100 et seq. ("**CEQA**").

ARTICLE 1
DEFINITIONS

1.1 **Definitions.** As used in this Agreement, the following terms have the following meanings:

(1) **Approval Agreement.** The agreement between IID, MWD, CVWD and PVID dated December 19, 1989, and entitled Approval Agreement.

(2) **1998 IID/SDCWA Transfer Agreement.** The Agreement for Transfer of Conserved Water by and between IID and the San Diego County Water Authority dated April 29, 1998 as amended by Conditional Amendment Agreement dated __, 2000, with such changes thereto as IID and SDCWA may from time to time agree subject to the provisions of Section 4.9 hereof.

(3) **Acquisition Agreements.** Collectively, the 1998 IID/SDCWA Transfer Agreement, the IID/SDCWA Early Transfer Agreement, the CVWD/MWD Acquisition Agreement, the IID/MWD Acquisition Agreement, the IID/CVWD Acquisition Agreement, and the MWD/CVWD Transfer and Exchange Agreement.

(4) **AF.** Acre-foot, a measure of volume.

(5) AFY. Acre-feet per Calendar Year.

(6) All-American Canal. The canal and appurtenant works from Imperial Dam to the Imperial and Coachella Valleys authorized in Section 1 of the Boulder Canyon Project Act.

(7) Allocation Agreement. The Agreement dated as of the Closing Date among the Parties, SDCWA, PVID, City of Escondido, Vista Irrigation District, San Luis Rey River Indian Water Authority, the La Jolla, Pala, Pauma, Rincon and San Pasqual Bands of Mission Indians and the Secretary concerning the allocation of Conserved Water created by the lining of the All-American Canal and the Coachella Canal.

(8) Assignment (or Assign). Any sale, gift, pledge, hypothecation, encumbrance, or other transfer of all or any portion of the rights in or arising from this Agreement to any person or entity (excluding such a transfer by operation of law), regardless of the legal form of the transaction in which the attempted transfer occurs.

(9) BOR. The United States Bureau of Reclamation.

(10) Business Day. A day that is not a Saturday, Sunday, or federal or California state legal holiday.

(11) Calendar Year. The 12-month period running from January 1 through December 31.

(12) CEQA. As defined in Recital K.

(13) Closing Date. The date established by the Parties as soon as practicable after each Party determines that the respective conditions set forth in Section 6.2 applicable to all Parties and in Sections 7.1, 8.1 and 9.1 applicable to IID, CVWD and MWD, respectively, have been satisfied or waived, which date shall be no later than December 31, 2002.

(14) Coachella Canal. The Coachella branch of the All American Canal leading from the All American Canal to the CVWD service area authorized in Section 1 of the Boulder Canyon Project Act.

(15) Colorado River Aqueduct. The aqueduct system owned and operated by MWD and extending from Lake Havasu to Lake Mathews in Riverside County.

(16) Conserved Water. Water made available for acquisition under this Agreement and the Related Agreements attributable to: (a) Temporary Land Fallowing or crop rotation, if an allowed use is for irrigation, or (b) projects or programs that enable the use of less water to accomplish the same purpose or purposes of allowed use; provided, however, that such term does not include water attributable to:

(i) the activities described in (a) or (b) above not voluntarily undertaken; or

(ii) to the activities described in (a) above voluntarily undertaken in exchange for money payment or other valuable consideration received from a governmental source; and

(iii) the resulting volume of reduced water used from (i) or (ii) above cannot be used anywhere within the IID service area, as described in IID's Section 5 Contract as in effect on October 15, 1999.

(17) Consumptive Use. The diversion of water from the main stream of the Colorado River, including water drawn from the main stream by underground pumping, net of measured and unmeasured return flows.

(18) Conveyance Loss. The actual loss of water to evaporation, seepage, or other similar cause resulting from any transportation of Conserved Water from Imperial Dam to the CVWD service area or to the MWD service area, as the case may be.

(19) CVWD. As defined in Recital C.

(20) CVWD/MWD Acquisition Agreement. The agreement between CVWD and MWD date as of the Closing Date regarding the acquisition of Conserved Water in the form attached hereto as Exhibit ___, with such changes thereto as CVWD and MWD may from time to time agree subject to the provisions of Section 4.9 hereof.

(21) CVWD/MWD Supplemental Agreement. The agreement between CVWD and MWD dated December 19, 1989 and entitled Agreement to Supplement Approval Agreement.

(22) Date of Non-consensual Termination of the 1998 IID/SDCWA Transfer Agreement. The date on which the Non-consensual Termination of the 1998 IID/SDCWA Transfer Agreement becomes effective.

(23) Delegation (or Delegate). Any sale, gift, pledge, hypothecation, encumbrance, or other transfer of all or any portion of the obligations or liabilities in or arising from this Agreement to any person or entity (excluding such a transfer by operation of law), regardless of the legal form of the transaction in which the attempted transfer occurs.

(24) Decree Accounting Program. The BOR Program described in and contemplated under Section 9.1 (1) hereof.

(25) Effective Date. The "initial transfer date" as such term is defined in and determined under the 1998 IID/SDCWA Transfer Agreement.

(26) Environmental Cost Sharing Agreement. The Agreement among IID, CVWD, SDCWA and MWD dated as of ____, 2000, concerning the sharing and payment of certain environmental review and mitigation costs pertaining to this Agreement and the Related Agreements.

(27) **Environmental Cost Condition Precedent Test Date**. The ninetieth day after the first date on which all environmental review and assessment contemplated under Section 6.2(2) (a) hereof are completed and all resource approvals contemplated under Section 6.2 (2) (b) hereof have been obtained. In the event that any action is filed challenging any such review, assessment or approval and is not finally resolved before such ninetieth day, the "Second Environmental Cost Condition Precedent Test Date" shall be the ninetieth day after the first date on which all such actions are finally resolved.

(28) **Environmental Mitigation Insurance**. One or more insurance policies which may be obtained and maintained by and with the consent of each of the Parties and SDCWA insuring IID and SDCWA (and CVWD and MWD to the extent their interests may appear) by indemnity or other means, at coverage levels and upon other terms acceptable to them, in their discretion, against the risk of unanticipated environmental consequences that may result in mitigation costs with respect to the transactions contemplated by the 1998 IID/SDCWA Transfer Agreement in excess of the IID Environmental Cost Ceiling and the Authority Environmental Cost Ceiling, as such terms are defined in the 1998 IID/SDCWA Transfer Agreement.

(29) **Execution Date**. The date on which the Parties have signed this Agreement; provided, however, that, if the Parties sign on different dates, the Execution Date is the date on which the later-to-sign Party has signed this Agreement.

(30) **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 U. S. Army Corps of Engineers and the BOR, and the U. S. Army Corps of Engineers regulations contained in Volume 33 of the Code of Federal Regulations, Part 208.11.

(31) **Force Majeure**. An event, not within the control of the Parties, which materially and adversely affects the performance of their respective obligations and duties to properly construct, operate establish, implement or maintain the means of creating or receiving deliveries of Conserved Water.

(32) **IID**. As defined in Recital A.

(33) **IID/CVWD Acquisition Agreement**. The agreement between the IID and CVWD, dated as of the Closing Date, regarding the acquisition of Conserved Water, in the form attached hereto as Exhibit ___, with such changes thereto as the IID and CVWD may from time to time agree subject to the provisions of Section 4.9 hereof.

(34) **IID/MWD 1988 Agreement**. The agreement between IID and MWD dated December 22, 1988, and entitled Agreement for the Implementation of a Water Conservation Program and Use of Conserved Water.

(35) **IID/MWD Acquisition Agreement**. The agreement between the IID and MWD dated as of the Closing Date regarding the acquisition of Conserved Water in the form attached hereto as Exhibit ___, with such changes thereto as the IID and MWD may from time to time agree subject to the provisions of Section 4.9 hereof.

(36) Inadvertent Overrun Program. The BOR program described in and contemplated under Section 6.2(4) hereof.

(37) Implementation Agreement. The agreement among the Parties, SDCWA, and the Secretary, dated as of the Closing Date, containing the terms of agreement with the Secretary to honor the terms of this Agreement and the Related Agreements in taking actions concerning the Colorado River, in the form attached hereto as Exhibit ___, with such changes thereto as the Parties and the Secretary may from time to time approve.

(38) Interim Surplus Guidelines. The federal guidelines described in and contemplated under Section 6.2(5) hereof.

(39) MWD. As defined in Recital B.

(40) Improvement District No. 1. That area of land described in Exhibit "B" of the Contract for Construction of Capacity in Diversion Dam, Main Canal and Appurtenant Structures and for delivery of Water between the United States and Coachella Valley County Water District dated October 15, 1934, as heretofore or hereafter modified under Section 15 of the Agreement of Compromise between Imperial Irrigation District and Coachella Valley County Water District dated February 14, 1934; provided, however, that any modification that requires IID's consent shall also require MWD's consent for purposes of this definition.

(41) Inflation Index. For the period starting January 1, 1999, the arithmetic average of the Producer Price Index for the Materials and Components for Construction (ID# WPU2200) published monthly by the United States ______; and the Gross Domestic Product Implicit Price Deflator (ID#____________) published monthly by the United States __________. If the publication of the Producers Price Index for the Materials and Components for Construction (ID# WPU2200) or the Gross Domestic Product Implicit Price Deflator (ID#________) is discontinued, or if the Producers Price Index for the Materials and Components for Construction (ID# WPU2200) or the Gross Domestic Product Implicit Price Deflator (ID#_________) is altered in some material manner, including changing the name of the index, the geographic area covered, or the base year, the Parties must use their reasonable best efforts to agree on a substitute index or procedure that reasonably reflects and monitors inflation impacts on prices.

(42) MWD/CVWD Transfer and Exchange Agreement. The agreement between MWD and CVWD dated as of the Closing Date regarding the transfer by MWD to CVWD of thirty-five thousand AFY of MWD's State Water Project entitlement and the exchange of such water for Colorado River water, with such changes thereto as MWD and CVWD may from time to time agree subject to the provisions of Section 4.9 hereof.

(43) "N" Dollars. That nominal dollar amount which, when adjusted based on the Inflation Index, is equivalent to the specified dollar amount in the Agreement measured as of January 1, Year "N." The adjustment is calculated according to the following formula:

$$\text{Nominal-Dollar Amount} = \$\text{nnn(Year N)} \times \frac{\text{Inflation Index}_n}{\text{Inflation Index}_e}$$

Where:

Inflation Index$_e$ is the most currently available monthly published Inflation Index before January 1, Year N, and

Inflation Index$_n$ is the most currently available monthly published Inflation Index before the applicable adjustment date, and

$nnn (Year N) is the amount stated in the Agreement.

Suppose, for example, that the applicable provision requires payment of one hundred dollars ($100.00) in 1999 Dollars and the payment date is July 1, 2010. Assume further that the Inflation Index$_e$ is 161.5, and that the Inflation Index$_n$ is 172 because (i) the arithmetic average of the Producer Price Index for the Materials and Components for Construction and the Gross Domestic Product Implicit Price Deflator for the most current month published before January 1, 1999 equals 161.5, and (ii) the arithmetic average of the Producer Price Index for the Materials and Components for Construction and the Gross Domestic Product Implicit Price Deflator for the most current month published before July 1, 2010 equals 172.0. The actual amount that must be paid is:

$$\$106.50 = \$100.00\ (1999)\ \text{x}\ \frac{172.0}{161.5}$$

(44) Neutral County. Any county other than Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego or Ventura.

(45) Non-consensual Termination of the 1988 IID/SDCWA Transfer Agreement. The termination of the 1998 IID/SDCWA Transfer Agreement after the Effective Date,

(i) other than by the mutual voluntary agreement or consent of IID and SDCWA;

(ii) by reason of the environmental condition subsequent contained in Sections 7.1 (b) (iii) and 8.1 (b) (iii) of the 1998 IID/SDCWA Transfer Agreement, but only after the later of December 31, 2016 or December 31 of the fifteenth (15th) year after the initial implementation of the Interim Surplus Guidelines, and after taking into account any proceeds of, or the value of other benefits provided by, any Environmental Mitigation Insurance, and without IID or SDCWA exercising rights under Sections 7.3 or 8.3 of the 1998 IID/SDCWA Transfer Agreement; or

(iii) by reason of the expiration of the Initial Term without the commencement of a Renewal Term in Year 46, as defined in the 1998 IID/SDCWA Transfer Agreement, as it existed on April 29, 1998, or as the Initial and Renewal Term may be modified to change Year 46 to Year 31.

(46) Priority "Z". The contractual priority level of the right to Colorado River water by the California agencies with Section 5 Contracts, with "Z" varying between Priority 1 and Priority 7, as set forth in the provisions of Article I, Sections 1-7 of the Seven-Party Agreement of 1931, which provisions are included in each Section 5 Contract.

(47) **PVID.** The Palo Verde Irrigation District, an irrigation district organized under the California Irrigation District Law, codified at § 20500 et seq. of the California Water Code.

(48) **Related Agreements.** The Acquisition Agreements, the Allocation Agreement, the Implementation Agreement, the IID/MWD 1988 Agreement, the 1989 Approval Agreement, the CVWD/MWD Supplemental Agreement, and any other agreements, amendments and waivers entered into or adopted by or with the written consent of all Parties in connection with this Agreement or made pursuant to Section 4.9 hereof.

(49) **SDCWA.** The San Diego County Water Authority, a California county water authority incorporated under the California County Water Authority Act, Stats. 1943, c. 545 as amended.

(50) **Secretary.** The Secretary of the United States Department of the Interior, and duly appointed successors, representatives and others with properly delegated authority.

(51) **Section 5 Contract.** A contract between the Secretary and a California agency for permanent service for the delivery of Colorado River water, established pursuant to Section 5 of the Boulder Canyon Project Act, 43 U.S.C. § 617d.

(52) **SWRCB.** The California State Water Resources Control Board.

(53) **Temporary Land Fallowing.** The creation of Conserved Water from the retirement of land from crop production activities for a period starting no earlier than the Effective Date and ending on or prior to the Termination Date.

(54) **Termination Date.** If the Closing Date has not occurred by December 31, 2002, the Termination date is December 31, 2002; if the Closing Date has by then occurred, the Termination Date is the earlier of (i) the Date of Non-consensual Termination of the 1998 IID/SDCWA Transfer Agreement, or (ii) December 31 of Year 75.

(55) **"Year ____ " (e.g., Year 25.)** One in the series of Calendar Years occurring after the Effective Date with Year 1 being the first full Calendar Year after the Effective Date; provided, however, that, if the Effective Date occurs on or before June 30th of any Calendar Year, Year 1 shall commence on the Effective Date and end on December 31st of that Calendar Year.

1.2 **Rules of Construction and Word Usage.** Unless the context clearly requires otherwise:

(1) The Recitals to this Agreement are a part of this Agreement to the same extent as the Articles;

(2) The Exhibits attached to this Agreement are incorporated by reference and are to be considered part of the terms of this Agreement;

(3) The plural and singular numbers include the other;

(4) The masculine, feminine, and neuter genders include the others;

(5) "Shall," "will," "must," and "agrees" are each mandatory;

(6) "May" is permissive;

(7) "May not" is prohibitory;

(8) "Or" is not exclusive;

(9) "Includes" and "including" are not limiting;

(10) "Between" includes the ends of the identified range;

(11) "Person" includes any natural person or legal entity; and

(12) "Transfer," when used herein or in the Related Agreeements in relation to a transaction involving Conserved Water, does not mean or imply that the Parties agree as to whether any such transaction is properly characterized as a transfer under California law or whether such transaction is subject to SWRCB jurisdiction.

ARTICLE 2
WATER BUDGETS

2.1 IID Water Budget.

(1) **Priority 3a Cap.** IID's Consumptive Use entitlement under its share of Priority 3a is capped by this Agreement at three million one hundred thousand (3,100,000) AFY at Imperial Dam, less (i) the Conserved Water made available by IID for use by others hereunder, and (ii) the water made available under Paragraph (2) of this Section 2.1 to the extent charged to Priority 3a. This cap shall be subject to adjustment in any Year to the extent permitted under or required by the Inadvertent Overrun Program. Any Colorado River water permitted to be acquired under Section 4.3 hereof shall be in addition to this cap.

(2) **Miscellaneous and Indian PPR's.** IID shall forbear Consumptive Use when necessary, in conjunction with the Inadvertent Overrun Program, to permit the Secretary to make available for Consumptive Use by holders of miscellaneous and Indian present perfected Colorado River water rights the aggregate amount necessary to satisfy individually their respective present perfected rights to Colorado River water, up to a maximum of eleven thousand five hundred (11,500) AFY. IID's obligation to forbear use of water for this purpose may be charged, at IID's option, to its rights under Priorities 6a, 7 or 3a as available. In the event it is not necessary in any Year for IID and CVWD to collectively forbear a total of fourteen thousand five hundred (14,500) AF for this purpose, then a credit equal to the difference between 14,500

AF and the amount of actual necessary forbearance responsibility shall be shared seventy-five percent (75%) to IID and twenty-five percent (25%) to CVWD.

(3) **IID Priority 6a Forbearance and Priority 7 Use.** IID agrees to forbear Consumptive Use under Priority 6a sufficient to enable IID, CVWD and MWD to Consumptively Use Priority 6a water as it may be available in accordance with the following order of use, except as may otherwise be required under the Interim Surplus Guidelines: first, thirty-eight thousand (38,000) AFY to MWD; second, sixty-three thousand (63,000) AFY to IID; third, one hundred nineteen thousand (119,000) AFY to CVWD; fourth, any balance of Priority 6a and 7 water available in accordance with the priorities identified in IID, CVWD and MWD Section 5 Contracts, as in effect on October 15, 1999. Should IID, CVWD or MWD not Consumptively Use all or any of the Priority 6a or 7 water available to it as provided above, any unused volume shall be available in the above order to meet the next lower order Consumptive Use needs.

(4) **Acquisition Mechanism and Location.** IID performs its obligations to make Conserved Water available for CVWD and MWD acquisition as contemplated by this Agreement by reducing its Consumptive Use at Imperial Dam by an amount equal to the Conserved Water to be acquired. When IID acts in that manner, IID has satisfied its obligation to make Conserved Water available for acquisition. CVWD and MWD each accept responsibility for any arrangements and facilities necessary to divert the Conserved Water made available to either of them and for any Conveyance Loss. CVWD and MWD have no duty to divert any or all of the Conserved Water. The payments by CVWD and MWD to IID under their respective Acquisition Agreements are for the conservation and acquisition of the Conserved Water, whether or not CVWD or MWD actually diverts that Conserved Water.

(5) **Conserved Water for CVWD.** IID shall make Conserved Water available to CVWD under and subject to the terms and conditions of the IID/CVWD Acquisition Agreement.

(6) **Conserved Water for SDCWA.** The terms and conditions applicable to IID's conservation and transfer of Conserved Water to SDCWA contemplated by this Agreement shall be as set forth in the 1998 IID/SDCWA Transfer Agreement and the IID/SDCWA Early Transfer Agreement.

(7) **Conserved Water for MWD.** IID shall make Conserved Water available to MWD under and subject to the terms and conditions of the IID/MWD Acquisition Agreement.

(8) **Conserved Water from Canal Lining Projects.** Conserved water resulting from the lining of the All American Canal and the Coachella Canal shall be made available to MWD under and subject to the terms and conditions of the Allocation Agreement.

2.2 CVWD Water Budget.

(1) **Priority 3a Cap.** CVWD's Consumptive Use entitlement under its share of Priority 3a is capped by this Agreement at three hundred thirty thousand (330,000) AFY at Imperial Dam, less (i) Conserved Water made available from the lining of the Coachella Canal,

as provided under Section ____ of the CVWD/MWD Acquisition Agreement, and (ii) the water made available under Paragraph (2) of this Section 2.2 to the extent charged to Priority 3a. This cap shall be subject to adjustment in any Year to the extent permitted under or required by the Inadvertent Overrun Program and Decree Accounting Program. Any Colorado River water acquired from any Party pursuant to a transaction contemplated by this Agreement or permitted to be acquired under Section 4.3 hereof shall be in addition to this cap.

(2) Miscellaneous and Indian PPR's. CVWD shall forbear Consumptive Use when necessary, in conjunction with the Inadvertent Overrun Program, to permit the Secretary to make available for Consumptive Use by holders of miscellaneous and Indian present perfected Colorado River water rights the aggregate amount necessary to satisfy individually their respective present perfected rights to Colorado River water, up to a maximum of three thousand (3,000) AFY. CVWD's obligation to forbear use of water for this purpose may be charged, at CVWD's option to its rights under Priorities 6, 7 or 3 as available. In the event that it is not necessary in any Year for IID and CVWD to collectively forbear a total of fourteen thousand five hundred (14,500) AF for this purpose, then a credit equal to the difference between 14,500 AF for this purpose and the amount of actual necessary forbearance responsibility shall be shared seventy-five percent (75%) to IID and twenty-five percent (25%) to CVWD.

(3) CVWD Priority 6a Forbearance and Priority 7 Use. CVWD agrees to forbear Consumptive Use under Priority 6a sufficient to enable IID, CVWD and MWD to Consumptively Use Priority 6a water as it may be available in accordance with the following order of use, except as may otherwise be provided under the Interim Surplus Guidelines: first, thirty-eight thousand (38,000) AFY to MWD; second, sixty-three thousand (63,000) AFY to IID; third, one hundred nineteen thousand (119,000) AFY to CVWD; fourth, any balance of Priority 6a and 7 water available in accordance with the priorities identified in the IID, CVWD and MWD Section 5 Contracts, as in effect on October 15, 1999. Should IID, CVWD or MWD not consumptively use all or any of the Priority 6a or 7 water available to it as provided above, any unused volume shall be available in the above order to meet the next lower order Consumptive Use needs.

(4) Acquisition From IID. The terms and conditions applicable the acquisition of Conserved Water by CVWD from IID, as contemplated by this Agreement, shall be as set forth in the IID/CVWD Acquisition Agreement.

(5) Acquisition From MWD. The terms and conditions of the acquisition of water and entitlement to water by CVWD from MWD, as contemplated by this Agreement, shall be as set forth in the CVWD/MWD Acquisition Agreement, the MWD/CVWD Transfer and Exchange Agreement.

2.3 MWD Water Budget.

(1) MWD Priority 4 and 5 Cap. MWD's Consumptive Use entitlements under Priorities 4 and 5 are capped by this Agreement at five hundred fifty thousand (550,000) AFY, and six hundred sixty-two thousand (662,000) AF, respectively, at Lake Havasu, less the water made available under paragraph (2) of this Section 2.3 to the extent charged to Priority 4 or 5. This cap shall be subject to adjustment in any Year to the extent permitted under or required by the Inadvertent Overrun Program. Water made available by MWD to CVWD in any Year pursuant to this Agreement shall be charged at MWD's option to any water available to MWD in that Year. Any Colorado River water acquired from any Party pursuant to a transaction contemplated by this Agreement or permitted to be acquired under Section 4.3 hereof shall be in addition to this cap.

(2) Miscellaneous and Indian PPR's. MWD shall forbear Consumptive Use when necessary, in conjunction with the Inadvertent Overrun Program, to permit the Secretary to make available for Consumptive Use by holders of miscellaneous and Indian present perfected Colorado River water rights the aggregate amount necessary to satisfy individually their respective present perfected rights to Colorado River water in excess of fourteen thousand five hundred (14,500) AFY. MWD's obligation to forbear Consumptive Use for this purpose shall be charged at MWD's option to any Priority pursuant to which MWD has water available.

(3) Priorities 1 & 2 Consumptive Use Over and Under 420,000 AF. MWD shall be responsible when necessary, in conjunction with the Inadvertent Overrun Program and the Decree Accounting Program, for repayment of any overrun as a result of aggregate use by Priorities 1, 2 and 3b in excess of four hundred twenty thousand (420,000) AFY; and to the extent that Priorities 1, 2 and 3b use is less than 420,000 AFY, MWD shall have the exclusive right to Consumptively Use such unused water.

(4) Acquisitions From IID. The terms and conditions applicable to the acquisition of Conserved Water by MWD from IID, as contemplated by this Agreement, shall be as set forth in the IID/MWD Acquisition Agreement and the Implementation Agreement.

(5) Acquisition From CVWD. The terms and conditions of the acquisition of water by MWD from CVWD, as contemplated by this Agreement, shall be as set forth in the CVWD/MWD Acquisition Agreement.

(6) Acquisition by CVWD. The terms and conditions of the acquisition of water and entitlement to water by CVWD from MWD, as contemplated by this Agreement, shall be as set forth in the CVWD/MWD Acquisition Agreement, the MWD/CVWD Transfer and Exchange Agreement.

ARTICLE 3
TERM/CLOSING/EFFECTIVE DATE

3.1 Term. This Agreement shall commence on the Execution Date and shall terminate on the Termination Date.

3.2 Closing Date. As of the Closing Date, provided that the parties shall each have completed any necessary public or other review process and shall each have received a final determination of approval from its governing board concerning the obligations contemplated by this Agreement, each Party shall execute and deliver the Acquisition Agreements and the

Implementation Agreement to which it is a signatory and shall use its reasonable efforts to obtain the execution and delivery of the Implementation Agreement by the Secretary.

3.3 **Effective Date.** Notwithstanding any other provision of this Agreement, the obligations of the Parties under Articles 2 and 4, and under the related provisions of the Acquisition Agreements and the Implementation Agreement contemplated by this Agreement, shall be contingent upon the occurrence of, and shall not become effective until, the Effective Date.

3.4 **Early Termination.** In the event of Non-consensual Termination of the 1998 IID/SDCWA Transfer Agreement:

(1) **Advance Notice.** IID shall to the extent reasonably possible, give the other Parties, SWRCB, BOR and the Secretary at least 12 months advance written notice of such event together with a written explanation of the underlying factors and calculations;

(2) **Relief or Contribution.** Any termination pursuant to Section 1.1 (44) (ii) shall not be effective and shall be of no further force or effect, if, prior to the Date of Non-consensual Termination of the 1998 IID/SDCWA Transfer Agreement, SDCWA or IID, as applicable, shall have exercised its rights under Sections 7.3 or 8.3 of the 1998 IID/SDCWA Transfer Agreement, or funding for or other relief from the environmental excess costs, as reasonably determined pursuant to the 1998 IID/SDCWA Transfer Agreement, shall have been covered by Environmental Mitigation Insurance or authorized by enactment of California or federal legislation, or by final California or federal administrative action, or one or both of the other Parties shall have agreed to fund the excess cost amount; and

(3) **Base Obligation.** In the event that relief or contribution is timely provided or agreed to in accordance with the foregoing, IID shall undertake the additional measures and pay for the excess environmental costs, subject to its entitlement to such relief or contribution.

3.5 **Effect of Termination.** As of the Termination Date, neither the terms of this Agreement nor the conduct of the Parties in performance of this Agreement shall be construed to enhance or diminish the rights of any of the Parties as such rights existed at the Execution Date, including any enhancement or diminishment by reason of an alleged application of common law principles of reliance, estoppel, intervening public use, domestic or municipal priority, shortage or emergency, or equitable apportionment. Notwithstanding any provision to the contrary in this Agreement, in the Acquisition Agreements, or in the Implementation Agreement, all water budget components contemplated under Article 2 of this Agreement and all state and federal approvals, permits and water contract amendments issued or adopted in connection therewith, other than environmental related permits with continuing mitigation obligations, shall thereupon terminate by consent of each of the Parties, which consents are hereby given, and which consents shall be reaffirmed in writing at the request of any Party, and the rights of the Parties shall revert to the status quo as though the Parties had never entered into, or intended to enter into, this Agreement, the Acquisition Agreements, or the Implementation Agreement.

ARTICLE 4
ADDITIONAL SETTLEMENT PROVISIONS

4.1 **General Settlement Provisions; No Admission of Settlement Terms; Reservation of Rights and Claims.** The Parties do not agree on the nature or scope of their relative rights to the delivery, use or transfer of Colorado River water. This Agreement is a consensual, comprehensive settlement arrangement acceptable to all Parties. It does not reflect any Party's rights or claims singularly or collectively, nor does it reflect the anticipated, predicted or possible outcome to any of the many disputes between the Parties if they were to be resolved without consensus. The Parties acknowledge that this Agreement is, in fact, a settlement and thus may not be used for any purpose in any judicial, legislative or administrative proceeding, and may not be used in any future attempt to reallocate water or water rights or to reorder the priorities of the Parties upon the termination of this Agreement. Subject to the provisions of this Agreement which compromise such matters, the legal rights, duties, obligations, powers and claims of each Party are preserved and may be acted upon by any Party during the term of this Agreement.

4.2 **All American Canal and Coachella Canal Lining Projects Conserved Water.**

(1) The Parties agree that sixty seven thousand seven hundred (67,700) AFY and twenty six thousand (26,000) AFY are to be the amounts of Conserved Water from the completed All American Canal Lining Project and the Coachella Canal Lining Project, respectively.

(2) After the Effective Date, subject to the terms and conditions of the Allocation Agreement, up to sixteen thousand (16,000) AFY of Conserved Water attributable to the lining of the All American and Coachella Canals will be made available to be utilized by the Secretary to facilitate implementation of the San Luis Rey Indian Water Rights Settlement Act. The volume of Conserved Water from each canal lining project made available for this purpose shall be in proportion to its percentage of the total water conserved, eleven thousand five hundred (11,500) AFY from the All American Canal and four thousand five hundred (4,500) AFY from the Coachella Canal. The remaining amount of Conserved Water from such canal lining projects shall be made available to MWD, except under the circumstances specified in the Allocation Agreement.

(3) For decree accounting purposes, Consumptive Use of the Conserved Water utilized by the Secretary to facilitate implementation of the San Luis Rey Indian Water Rights Settlement Agreement will be assigned and will not be charged to IID or CVWD, but will be deducted from IID's Consumptive Use cap under Section 2.1(1) and CVWD's Consumptive Use cap under Section 2.2(1) in proportion to the Conserved Water from the All American Canal and Coachella Canal, respectively. For decree accounting purposes, Consumptive Use of the Conserved Water utilized by MWD will be deducted from IID's Consumptive Use cap under Section 2.1 (1) and CVWD's Consumptive Use cap under Section 2.2 (1) in proportion to the Conserved Water from the All American Canal and Coachella Canal, respectively.

(4) As the Conserved Water to be made available by the lining of the All American and Coachella Canals is produced, it will be made available 83 percent to MWD and

17 percent to the Secretary for the benefit of the San Luis Rey Settlement Parties, except under the circumstances specified in the Allocation Agreement.

(5) The specific terms and conditions governing the distribution of Conserved Water as contemplated by this Section 4.2 shall be as set forth in the Allocation Agreement.

4.3 **Other Acquisitions of Colorado River Water.** During the period from the Effective Date to the Termination Date, the Parties may acquire Colorado River water from any person, without objection by any of the Parties, so long as any such acquisition is not inconsistent with any other term of this Agreement for the Related Agreements and does not materially reduce the water available to the Parties.

4.4 **Salinity Control Act Interim Period.** IID, CVWD and MWD will submit annual estimates of water diversions to the BOR with the modifier "to the extent Colorado River water is available to this requesting agency under its entitlements, the Quantification Settlement Agreement and otherwise."

4.5 CVWD Utilization of Water.

(1) Other than as provided in Section 3.6 of the IID/CVWD Acquisition Agreement, CVWD shall not utilize its water budget to facilitate any water use outside of Improvement District No. 1 other than for direct and in lieu recharge, and shall use its best efforts to utilize its water budget to address the groundwater overdraft problem in Improvement District No. 1 and to implement a program that is designed to achieve a safe yield within Improvement District No. 1 by the end of CVWD's water budget ramp-up in approximately Year 30.

(2) IID and MWD shall not object to the utilization of Colorado River water in the Coachella Valley, but outside Improvement District No. 1 in order to maximize the effectiveness of Improvement District No. 1's water use and recharge programs.

(3) CVWD shall make no claim as a matter of right to any additional Colorado River water in Priorities 3 or 6.

(4) This Agreement does not affect CVWD's rights under its surplus contract with the Secretary dated [__________], including its right to use water delivered under that contract anywhere within its boundaries.

4.6 **CVWD Groundwater Storage of IID Water.** Subject to the physical availability of storage in the Coachella Valley after accounting for the storage to be utilized by CVWD for the MWD/CVWD conjunctive use program, if implemented, CVWD will provide groundwater storage for IID's use in accordance with the IID/CVWD Acquisition Agreement.

4.7 **Public Awareness Program.** The Parties will each implement and maintain a water conservation public awareness program.

4.8 **Shortage and Sharing of Reduced Water Availability.** If for any reason there is less than 3.85 million (3,850,000) AF available to Priorities 1, 2 and 3 in any Year, there will be no termination of this Agreement. Shortages will be shared pursuant to the particular provisions of the Acquisition Agreements and the Allocation Agreement.

4.9 Amendments to Acquisition Agreements. The Parties to each Acquisition Agreement shall have the right to amend that Agreement from time to time without the consent of any other Party hereto (a "non-signatory Party"); provided, however, that prompt notice and a copy of any such amendment is provided to each non-signatory Party, the Secretary, BOR and, with respect to the transfers to SDCWA contemplated under the 1998 IID/SDCWA Transfer Agreement and acquisitions from IID by CVWD under the IID/CVWD Acquisition Agreement, SWRCB; and provided, further, that no such amendment shall be given any force or effect, or be binding on any Party, if:

(1) such amendment would affect in any respect the rights of any non-signatory Party to Colorado River water; or

(2) such amendment could reasonably have a significant adverse effect on the interests of a non-signatory Party; unless or until

(3) in the circumstances of either (1) or (2), the written consent to such amendment shall have been obtained from each non-signatory Party, which consent shall not be unreasonably withheld and, if determined to have been unreasonably withheld, shall be effective retroactively to the date originally requested.

4.10 MWD Mitigation of Certain Effects of Interim Surplus Guidelines. In the event that Priority 3a Consumptive Use by IID and CVWD, consistent with and as adjusted by this Agreement, are reduced as a direct result of the application and operation of Interim Surplus Guidelines, referenced in Section 6.2 (5) hereof, MWD will assume any such resulting water use overruns by IID and CVWD as MWD overruns up to the amount of surplus water Consumptively Used by MWD under the Full Domestic Surplus and/or Partial Domestic Surplus conditions specified in the Interim Surplus Guidelines.

4.11 SWRCB Proceeding. The terms and conditions applicable to the Parties in connection with the matters referenced in Section 6.2 (11) hereof shall be as set forth in the Protest Dismissal Agreement attached hereto as Exhibit [ ].

ARTICLE 5
REPRESENTATIONS AND WARRANTIES

5.1 IID's Representations and Warranties.

(1) Subject only to the determinations and approvals contemplated by Section 6.2(2) of this Agreement and compliance with environmental laws as contemplated by Section 6.2(2) of this Agreement: (i) IID has all legal power and authority to enter into this Agreement and to perform its obligations hereunder on the terms set forth in this Agreement and (ii) the execution and delivery hereof by IID and the performance by IID of its obligations hereunder will not violate or constitute an event of default under the terms or provisions of any agreement, document or instrument to which IID is a party or by which IID is bound.

(2) **Signatories.** The persons executing this Agreement on behalf of IID have the full power and authority to bind IID to the terms of this Agreement. In addition, the persons signing this Agreement on IID's behalf personally warrant and represent that they have such power and authority. Furthermore, the persons signing this Agreement on the IID's behalf personally warrant and represent that they have reviewed this Agreement, understand its terms and conditions, and have been advised by counsel regarding the same.

(3) **Enforceability.** Subject only to the determinations and approvals contemplated by Section 6.2(2) of this Agreement, compliance with environmental laws as contemplated by Section 6.2(2) of this Agreement, and satisfaction or waiver of the conditions set forth in Sections 6.2 and 7.1 of this Agreement, this Agreement constitutes a valid and binding agreement of IID, enforceable against IID in accordance with its terms.

(4) **No Pending or Threatened Disputes.** Except as disclosed in Appendix 5.1, attached to this Agreement, there are no actions, suits, legal or administrative proceedings, or governmental investigations pending or, to IID's knowledge, threatened against or affecting the IID relating to the performance contemplated by this Agreement.

(5) **Notice of Developments.** IID agrees to give prompt notice to the parties if the IID discovers that any of its own representations and warranties were untrue when made or determines that any of its own representations and warranties will be untrue as of the Closing Date.

5.2 CVWD's Representations and Warranties.

(1) Subject only to the determinations and approvals as contemplated by Section 6.2(2) of this Agreement and compliance with environmental laws as contemplated by Section 6.2(2) of this Agreement: (i) CVWD has all legal power and authority to enter into this Agreement and to perform its obligations hereunder on the terms set forth in this Agreement and (ii) the execution and delivery hereof by CVWD and the performance by CVWD of its obligations hereunder will not violate or constitute an event of default under the terms or provisions of any agreement, document or instrument to which CVWD is a party or by which CVWD is bound.

(2) **Signatories.** The persons executing this Agreement on behalf of CVWD have the full power and authority to bind CVWD to the terms of this Agreement. In addition, the persons signing this Agreement on CVWD's behalf personally warrant and represent that they have such power and authority. Furthermore, the persons signing this Agreement on CVWD's behalf personally warrant and represent that they have reviewed this Agreement, understand its terms and conditions, and have been advised by counsel regarding the same

(3) **Enforceability.** Subject only to the determinations and approvals contemplated by Section 6.2(2) of this Agreement, compliance with environmental laws as contemplated Section 6.2(2) of this Agreement, and satisfaction or waiver of the conditions set forth in Sections 6.2 and 8.1 of this Agreement, this Agreement constitutes a valid and binding agreement of CVWD, enforceable against CVWD in accordance with its terms.

(4) **No Pending or Threatened Disputes.** Except as disclosed in Appendix 5.2, attached to this Agreement, there are no actions, suits, legal or administrative proceedings, or governmental investigations pending or, to CVWD's knowledge, threatened against or affecting CVWD relating to the performance contemplated by this Agreement.

(5) **Notice of Developments.** CVWD agrees to give prompt notice to the parties if CVWD discovers that any of its own representations and warranties were untrue when made or determines that any of its own representations and warranties will be untrue as of the Closing Date.

5.3 MWD's Representations and Warranties.

(1) Subject only to the determinations and approvals contemplated by Section 6.2(2) of this Agreement and compliance with environmental laws as contemplated by Section 6.2(2) of this Agreement: (i) MWD has all legal power and authority to enter into this Agreement and to perform its obligations hereunder on the terms set forth in this Agreement and (ii) the execution and delivery hereof by MWD and the performance by MWD of its obligations hereunder will not violate or constitute an event of default under the terms or provisions of any agreement, document or instrument to which MWD is a party or by which MWD is bound.

(2) **Signatories.** The persons executing this Agreement on behalf of MWD have the full power and authority to bind MWD to the terms of this Agreement. In addition, the persons signing this Agreement on MWD's behalf personally warrant and represent that they have such power and authority. Furthermore, the persons signing this Agreement on MWD's behalf personally warrant and represent that they have reviewed this Agreement, understand its terms and conditions, and have been advised by counsel regarding the same.

(3) **Enforceability.** Subject only to the determinations and approvals contemplated by Section 6.2(2) of this Agreement, compliance with environmental laws as contemplated by Section 6.2(2) of this Agreement, and satisfaction or waiver of the conditions set forth in Sections 6.2 and 9.1 of this Agreement, this Agreement constitutes a valid and binding agreement of MWD, enforceable against MWD in accordance with its terms.

(4) **No Pending or Threatened Disputes.** Except as disclosed in Appendix 5.3, attached to this Agreement, there are no actions, suits, legal or administrative proceedings, or governmental investigations pending or, to MWD's knowledge, threatened against or affecting MWD relating to the performance contemplated by this Agreement.

(5) **Notice of Developments.** MWD agrees to give prompt notice to the parties if MWD discovers that any of its own representations and warranties were untrue when made or determines that any of its own representations and warranties will be untrue as of the Closing Date.

ARTICLE 6
GENERAL CONDITIONS TO IID, MWD AND CVWD OBLIGATIONS

6.1 Performance by IID, CVWD and MWD. IID's, MWD's and CVWD's obligations under Articles 2 and 4 of this Agreement are subject to the satisfaction or waiver of the general conditions set forth in Section 6.2 and the particular conditions set forth in Articles 7, 8 and 9, in each case on or before December 31, 2002. IID, MWD and CVWD shall each proceed in good faith with reasonable diligence and use reasonable efforts to satisfy the conditions for which it has responsibility, including the conditions set forth in the Related Agreements and in the Implementation Agreement.

6.2 Satisfaction of General Conditions to IID's, MWD's and CVWD's Obligations.

(1) Representations and Warranties. The representations and warranties of each of the Parties shall be true as of the date each such Party signs this Agreement, and as of the Closing Date.

(2) Environmental Obligations.

(a) Environmental Review. All environmental review and assessment required under CEQA, NEPA and applicable federal, state and agency regulations implementing the same have been completed, to the extent required to authorize implementation of the activities contemplated by this Agreement. An environmental review process will be deemed "completed" only when all required Notices of Determination pursuant to CEQA have been duly filed; all required Records of Decision pursuant to NEPA have been duly issued; all administrative appeal periods have expired; all statutes of limitation for filing an action challenging any environmental process pursuant to CEQA have expired; as of the deadline for satisfying these conditions, no action challenging any environmental process has been filed, or, if filed, has been resolved by a final judgment which upholds or sustains the environmental review process and allows implementation of the covered activities and all judicial appeal periods have expired. The environmental review processes described above shall include, but are not limited to:

(1) The federal programmatic Environmental Assessment (or EIS if BOR determines that an EIS is required) in connection with this Agreement, to be prepared by BOR as the lead agency;

(2) The EIS relating to the Interim Surplus Guidelines, to be prepared by BOR as the lead agency;

(3) Any federal assessment required to implement the Inadvertent Overrun Program and the Decree Accounting Program, to be prepared by BOR as the lead agency;

(4) The program EIR relating to this Agreement, to be prepared by IID, MWD, CVWD and SDCWA as co-lead agencies;

(5) The joint EIR/EIS relating to the conservation and transfer by IID of up to three hundred thousand (300,000) AFY and IID's Priority 3 cap, to be prepared by IID as the lead agency under CEQA and BOR as the lead agency under NEPA;

(6) Final approval by all necessary federal and state agencies of a mitigation plan, a cultural resources plan and any other documents required to allow implementation of the All American Canal Lining project pursuant to the certified EIR/EIS for that project;

(7) Final approval by all necessary federal and state agencies of a mitigation plan, a cultural resource plan and any other documents required to allow implementation of the Coachella Canal Lining project pursuant to the certified EIR/EIS for that project; and

(8) The program EIR for the CVWD Groundwater Recharge project, to be prepared by CVWD as the lead agency.

(b) **Resource Approvals.** All permits, approvals, authorizations, opinions, assessments and agreements pursuant to the federal Endangered Species Act ("ESA"), the California Endangered Species Act ("CESA") and any other federal or state environmental resource protection laws, and applicable federal or state regulations implementing the same (collectively "Resource Approvals"), have been finalized, to the extent required by such statutes or regulations or deemed necessary or appropriate by the U.S. Fish and Wildlife Service ("USFWS"), the California Department of Fish and Game ("CDFG"), BOR or IID to document compliance therewith and to authorize implementation of the 1998 IID/SDCWA Transfer Agreement, the conservation by IID of up to three hundred thousand (300,000) AFY and IID's Priority 3a cap. A Resource Approval shall be deemed "final" only when all required environmental review has been completed as described in Section 6.2(2)(a) above; final action has been taken and all required documents have been approved and executed by the resource agencies and the applicant; all required biological assessments and biological opinions have been issued; all administrative appeal periods have expired; as of the deadline for satisfying these conditions, no action challenging any Resource Approval has been filed, or, if filed, has been resolved by a final judgment which upholds or sustains the Resource Approval in a manner acceptable to the resource agencies and the applicant and all judicial appeal periods have expired. The Resource Approvals described above shall include, but are not limited to, all required approvals by federal and state agencies of:

(1) The change in the point of diversion on the Colorado River and transfer of up to three hundred thousand (300,000) AFY of water to be conserved by IID;

(2) Incidental take authorization pursuant to ESA and CESA, to the extent required to implement the change in the point of diversion on the Colorado River, the water transfer described above, the Interim Surplus Criteria, the Inadvertent Overrun Program and the Decree Accounting Program, the All American Canal Lining project, and the Coachella Canal Lining project; and

(3) A habitat conservation plan and an incidental take permit and execution of an implementation agreement by and among USFWS, CDFG and IID, permitting implementation of conservation and water use activities within the IID service area consistent with this Agreement, including impacts on the Salton Sea and areas outside of IID's service area, and including "No Surprises" assurances pursuant to ESA Section 10(a), all of the foregoing acceptable in form, substance, scope and coverage to IID.

(c) **Party Approvals of Environmental Requirements.** Each Party, by action of its governing board, has approved and accepted the terms, conditions and mitigation measures of the environmental review processes described in Section 6.2(2)(a) above and the Resource Approvals described in Section 6.2(2)(b) above (collectively, "Environmental Requirements"), to the extent such Party is responsible, in whole or in part, for compliance, performance or payment of the costs of such Environmental Requirements.

(d) **Assurances.** "No Surprises" assurances pursuant to ESA Section 10 (a) shall have been obtained by IID and CVWD for 50 years for the first fifty thousand (50,000) AFY acquisition by CVWD and through Year 50 or, if appropriate, Year 45 for the second fifty thousand (50,000) AFY acquisition by CVWD, as contemplated under Sections 2.1(5) and 2.2(4) hereof and the IID/CVWD Acquisition Agreement.

(3) **Yuma Island.** The Secretary shall have appointed an independent panel to conduct a public review and, based thereon, to provide recommendations to the Secretary regarding the determination of the amount of Consumptive Use of water on the Yuma Island and whether such use is charged to Priority 2.

(4) **Inadvertent Overrun Program.** The BOR shall have adopted on or before the Closing Date standards and procedures for an Inadvertent Overrun Program to be implemented over a period commencing on or before the Effective Date and ending on or after the Termination Date that is in all material respects in conformity with the proposal set forth in Exhibit [ ] hereto, or is otherwise acceptable to IID, MWD and CVWD.

(5) **Interim Surplus Guidelines.** The BOR shall have adopted on or before the Closing Date interim surplus guidelines, to be implemented over a period commencing on or before the Effective Date and ending on or after Year 15, which guidelines are in all material respects in conformity with the proposal set forth in Exhibit __ hereto, or are otherwise acceptable to MWD.

(6) **PVID Waiver.** PVID shall have agreed for the period commencing on or before the Effective Date and ending on the Termination Date: (a) to waive any call rights on Conserved Water from the lining of the All American Canal and the Coachella Canal, as contemplated by this Agreement, (b) to limit use on the PVID Mesa, (c) to forego any rights to Priority 6b water, and (d) to the amendment to the 1989 Approval Agreement contemplated under the CVWD/MWD Acquisition Agreement.

(7) **The IID/CVWD Acquisition Agreement** shall have been executed by the Parties signatory thereto for delivery as of the Closing Date.

(8) **The IID/MWD Acquisition Agreement** shall have been executed by the Parties signatory thereto for delivery as of the Closing Date.

(9) **The CVWD/MWD Acquisition Agreement and the MWD/CVWD Transfer and Exchange Agreement** shall have been executed by the Parties signatory thereto for delivery as of the Closing Date.

(10) **The Implementation Agreement** shall have been executed by the Parties, SDCWA, and the Secretary for delivery as of the Closing Date.

(11) **SWRCB Approval.** The SWRCB shall have entered a final order of approval of the Petition for Change relating to the 1998 IID/SDCWA Transfer Agreement and the IID/CVWD Acquisition Agreement in conformity with the Protest Dismissal Agreement attached hereto as Exhibit __, which order in effect establishes that:

(a) IID has presented substantial evidence to support the transfers to SDCWA and the acquisitions by CVWD contemplated hereunder;

(b) As of the effective date of such final order, such substantial evidence, which includes the provisions of the Petition Process Agreement, satisfies any existing SWRCB concerns with respect to IID reasonable and beneficial use and with respect to injury to junior right holders;

(c) Pursuant to the request of IID, CVWD, MWD and SDCWA, such final order shall have no binding precedential effect on the applicability of California or any other law to any other water transfer transaction;

(d) In light of the substantial evidence, and based upon the continuing effectiveness of this Agreement and the continuing fulfillment of IID's contractual commitments to undertake major conservation activities, the SWRCB does not anticipate a need to reassess the reasonable and beneficial use of water by IID until the end of the Year 20, absent any substantial material adverse change in IID's irrigation practices or advances in economically feasible technology associated with irrigation efficiency.

(e) The order by its terms shall lapse and be of no force or effect if this Agreement terminates.

(12) **Effectiveness of 1998 IID/SDCWA Transfer Agreement.** IID's obligations to undertake "water conservation" efforts and to transfer "conserved water," as defined in and determined under the 1998 IID/SDCWA Transfer Agreement, shall have become effective as of the Closing Date, subject only to the execution and delivery of the other Acquisition Agreements and the Implementation Agreement contemplated by Section 3.2 hereof.

(13) **Environmental Cost Sharing Agreement.** The Environmental Cost Sharing Agreement shall be in full force and effect, and each party thereto shall be in full compliance with the provisions thereof applicable to it.

6.3 **<u>Contribution to Satisfaction of Environmental Obligations Condition</u>.** With respect to any required environmental mitigation, contemplated under Section 6.2(2), and except as otherwise expressly provided under an Acquisition Agreement, a Party may, but shall not be in any way compelled to, contribute the additional cost, in excess of a specified cap, such that the net economic effect to the responsible Party is the same as if the condition had been satisfied directly. In that event, the condition shall be deemed satisfied with respect to that Party, and such Party may not terminate this Agreement on the basis that the condition has not been satisfied.

6.4 **<u>Written Waiver of Conditions</u>.** The Parties agree that a Party may waive in writing any one or more of the conditions to its obligations under Articles 2 and 4, <u>provided, however</u>, that no Party shall waive compliance with CEQA, NEPA or other requirements under applicable laws. A written waiver of a condition must be delivered in accordance with the notice provisions of Section 11.1 hereof. As to any condition to the obligations of all Parties, a waiver of that condition will be effective only if made by all Parties.

6.5 **<u>Determination of Environmental Cost Conditions</u>.** The Parties shall cooperate in their determinations of costs applicable to their respective environmental cost ceilings for purposes of Articles 7, 8 and 9 hereof. Each Party shall use reasonable assumptions and methods in making such determinations, and, at the request of any other Party, shall promptly provide a written explanation of such assumptions and methods. In the event of any disagreement between or among Parties as to the reasonableness of any such method or assumption, the Parties shall in good faith try to resolve such disagreement through negotiation.

ARTICLE 7
PARTICULAR CONDITIONS TO IID'S OBLIGATIONS

7.1 <u>Conditions to IID's Obligations</u>.

(1) **<u>IID Environmental Costs</u>.** IID shall have determined that the environmental process and mitigation costs for which it is responsible under the terms and conditions of the Environmental Cost Sharing Agreement will not exceed in total present value as of the Environmental Cost Condition Precedent Test Date (and, if applicable, the Second Environmental Cost Condition Precedent Test Date) $15,000,000 (in 1998 Dollars) after taking into account any contribution to such costs by any other person.

ARTICLE 8
PARTICULAR CONDITIONS TO CVWD'S OBLIGATIONS

8.1 <u>Conditions to CVWD's Obligations</u>.

(1) **<u>Salinity Control Act.</u>** The Amendment to Amendatory Contract between the United States of America and Coachella Valley Water District for Replacing a Portion of the Coachella Canal in the form attached as Exhibit __ shall have been executed by the United States.

(2) CVWD Environmental Costs. CVWD shall have determined that the environmental process and mitigation costs for which it is responsible under the terms and conditions of the Environmental Cost Sharing Agreement will not exceed in total present value as of the Environmental Cost Condition Precedent Test Date (and, if applicable, the Second Environmental Cost Condition Precedent Test Date) $2,100,000 (in 2001 Dollars) after taking into account any contribution to such costs by any other person.

ARTICLE 9
PARTICULAR CONDITIONS TO MWD'S OBLIGATIONS

9.1 Conditions to MWD's Obligations.

(1) Decree Accounting.

(a) BOR shall have adopted and implemented standards and procedures for decree accounting for annual Consumptive Use by Priorities 1, 2 and 3b which utilize a 25-year running average, that is in all material respects in conformity with the proposal set forth in Exhibit __ hereto.

(b) BOR shall have agreed with the Parties to develop a process for establishing a statistically significant trend test for increases in use by Priorities 1, 2 and 3b.

(2) Waiver. SDCWA shall have waived any and all rights under the 1998 IID/SDCWA Transfer Agreement with respect to Conserved Water that may be acquired by MWD pursuant to the IID/MWD Acquisition Agreement, in conjunction with MWD's agreement that, should IID transfer less than the full two hundred thousand (200,000)AFY to SDCWA as part of the stabilized primary quantity under the 1998 IID/SDCWA Transfer Agreement, but later make available additional Conserved Water for transfer to SDCWA, MWD will exchange such additional amounts up to a total of two hundred thousand (200,000) AFY under the terms of the 1998 Agreement between MWD and SDCWA for the Exchange of Water.

(3) MWD Environmental Costs. MWD shall have determined that the environmental process and mitigation costs for which it is responsible under the terms and conditions of the Environmental Cost Sharing Agreement will not exceed in total present value as of the Environmental Cost Condition Precedent Test Date (and, if applicable, the Second Environmental Cost Condition Precedent Test Date) $5,000,000 (in 2001 Dollars) after taking into account any contribution to such costs by any other person.

ARTICLE 10
REMEDIES

10.1 Specific Performance. Each Party recognizes that the rights and obligations of the Parties under this Agreement are unique and of such a nature as to be inherently difficult or impossible to value monetarily. If one Party does not perform in accordance with this Agreement, the other Parties will likely suffer harm curable only by the imposition of an injunction requiring specific performance. Thus, each of the Parties agrees that any breach of this Agreement by any Party shall entitle the non-breaching Parties, or any one of them, to injunctive relief, including but not limited to a decree of specific performance, in addition to any other remedies at law or in equity that may be available in the circumstances.

10.2 Cumulative Rights and Remedies. The Parties do not intend that any right or remedy given to a Party on the breach of any provision under this Agreement be exclusive; each such right or remedy is cumulative and in addition to any other remedy provided in this Agreement or otherwise available at law or in equity. If the non-breaching Party fails to exercise or delays in exercising any such right or remedy, the non-breaching Party does not thereby waive that right or remedy. In addition, no single or partial exercise of any right, power or privilege precludes any other or further exercise of a right, power or privilege granted by this Agreement or otherwise.

10.3 Action or Proceeding between the Parties. Each Party acknowledges that it is a "local agency" within the meaning of § 394(c) of the California Code of Civil Procedure (CCP). Each Party further acknowledges that any action or proceeding commenced by one Party against the other would, under § 394(a) of the CCP, as a matter of law be subject to:

(1) being transferred to a "Neutral County," or instead

(2) having a disinterested judge from a Neutral County assigned by the Chairman of the Judicial Council to hear the action or proceeding.

(3) A "Neutral County" is any county other than Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego or Ventura. In the event an action is filed by either Party against the other to enforce this Agreement and to obtain damages for its alleged breach, each Party hereby:

(i) Stipulates to the action or proceeding being transferred to a Neutral County or to having a disinterested judge from a Neutral County assigned to hear the action;

(ii) Waives the usual notice required under the law-and-motion provisions of Rule 317 of the California Rules of Court;

(iii) Consents to having any motion under § 394(c) heard with notice as an ex parte matter under Rule 379 of the California Rules of Court; and

(iv) Acknowledges that this Agreement, and in particular this Paragraph 8.3, may be submitted to the court as part of the moving papers.

(4) Nothing in this Section, however, shall impair or limit the ability of a Party to contest the suitability of any particular county to serve as a Neutral County, or shall operate to waive any other rights.

ARTICLE 11
GENERAL PROVISIONS

11.1 **Notices.** All notices, requests, demands, or other communications under this Agreement must be in writing, and sent to the addresses of each Party set forth below. Notice will be sufficiently given for all purposes as follows:

Personal Delivery. When personally delivered to the recipient. Notice is effective on delivery.

Certified Mail. When mailed certified mail, return receipt requested. Notice is effective on receipt, if a return receipt confirms delivery.

Overnight Delivery. When delivered by an overnight delivery service such as Federal Express, charges prepaid or charged to the sender's account. Notice is effective on delivery, if delivery is confirmed by the delivery service.

Facsimile Transmission. Notice is effective on receipt, provided that the facsimile machine provides the sender a notice that indicates the transmission was successful, and that a copy is mailed by first-class mail on the facsimile transmission date.

Addresses for purpose of giving notice are as follows:

To IID:
Imperial Irrigation District
Attn.: General Manager

Address for U.S. Mail
P.O. Box 937
Imperial, California 92251

Address for Personal or Overnight Delivery:
333 E. Barioni Boulevard
Imperial, California 92251

Telephone: 760-398-9477
Facsimile: 760-398-5893

With a copy delivered by the same means to:

Horton, Knox, Carter & Foote
895 Broadway
El Centro, CA 92243

Attention: John P. Carter, Esq.

Telephone: 760-352-2821
Facsimile: 760-352-8540

To MWD:

The Metropolitan Water District of
Southern California
Attn.: General Manager

Address for U.S. Mail

P.O. Box 54153
Los Angeles, California 90054

Address for Personal or Overnight Delivery:

700 North Alameda Street
Los Angeles, California 90012-2944

Telephone: 213-217-6000
Facsimile: 213-217-6950

With a copy delivered by the same means and at the same address to:

The Metropolitan Water District of
Southern California
Attn: General Counsel

To CVWD:

Coachella Valley Water District
Attn.: General Manager-Chief Engineer

Address for U.S. Mail

P.O. Box 1058
Coachella, California 92236

Address for Personal or Overnight Delivery:

Highway 111 and Avenue 52
Coachella, California 92236

Telephone: 760-398-2651
Facsimile: 760-398-3711

With a copy delivered by the same means and at the same address to:

Redwine & Sherrill
1950 Market Street
Riverside, CA 92501

Telephone: 909-684-2520
Facsimile: 909-684-9583

(1) A correctly addressed notice that is refused, unclaimed, or undeliverable because of an act or omission by the Party to be notified will be deemed effective as of the first date that notice was refused, unclaimed, or deemed undeliverable by the postal authorities, messenger, or overnight delivery service.

(2) A Party may change its address by giving the other Parties notice of the change in any manner permitted by this Agreement.

11.2 Waiver. No waiver of a breach, failure of condition, or any right or remedy contained in or granted by the provisions of this Agreement is effective unless it is in writing and signed by the Party waiving the breach, failure, right or remedy. No waiver of a breach, failure of condition or right or remedy is or may be deemed a waiver of any other breach, failure, right or remedy, whether similar or not. In addition, no waiver will constitute a continuing waiver unless the writing so specifies.

11.3 Post-Closing Notices. Each Party will give the other Parties prompt notice from time to time after the Closing Date and prior to the Termination Date of any actions, suits, legal or administrative proceedings, or governmental investigations pending or, to such Party's knowledge, threatened against or affecting any Party relating to the performance contemplated by this Agreement and the Related Agreements.

11.4 Counterparts. This Agreement may be executed in three or more counterparts, each of which, when executed and delivered, shall be an original and all of which together shall constitute one instrument, with the same force and effect as though all signatures appeared on a single document.

11.5 No Third-Party Rights. This Agreement is made solely for the benefit of the Parties and their respective permitted successors and assigns (if any). Except for such a permitted successor or assign, no other person or entity may have or acquire any right by virtue of this Agreement.

11.6 Ambiguities. Each Party and its counsel have participated fully in the drafting, review and revision of this Agreement. A rule of construction to the effect that ambiguities are to be resolved against the drafting Party will not apply in interpreting this Agreement, including any amendments or modifications.

11.8 Governing Law. This Agreement shall be governed by and construed in accordance with the laws of the State of California, without giving effect to conflict of law provisions; provided, however, that federal law shall be applied as appropriate to the extent it bears on the resolution of any claim or issue relating to the permissibility of the acquisitions of Colorado River water contemplated herein.

11.9 Binding Effect and No Assignment. This Agreement is and will be binding upon and will inure to the benefit of the Parties and, upon dissolution, the legal successors and assigns of their assets and liabilities. No Party may assign any of its rights or Delegate any of its duties under this Agreement or the Related Agreements, and any such Assignment or Delegation made in violation of this Section 11.8 shall be void and of no force or effect.

11.10 Joint Defense. The Parties agree to cooperate, to proceed with reasonable diligence, and to use reasonable best efforts to defend any lawsuit or administrative proceeding challenging the legality, validity or enforceability of any term of this Agreement, or any Party's right to act in accordance with any of the terms of this Agreement. Except as otherwise provided in the Environmental Cost Sharing Agreement, each Party shall bear its own costs of participation and representation in any such defense.

11.11 **Entire Agreement.** This Agreement (including the exhibits and other agreements attached to and referenced in this agreement) constitutes the final, complete, and exclusive statement of the terms of the Agreement among the Parties pertaining to its subject matter and supersedes all prior and contemporaneous understandings or agreements of the Parties. No Party has been induced to enter into this Agreement by, nor is any Party relying on, any representation or warranty outside those expressly set forth in this Agreement.

11.12 **Modification.** This Agreement may be supplemented, amended, or modified only by the written agreement of the Parties. No supplement, amendment, or modification will be binding unless it is in writing and signed by all Parties.

IMPERIAL IRRIGATION DISTRICT

Dated
By:________________________
JESSE SILVA
GENERAL MANAGER

COACHELLA VALLEY WATER DISTRICT

Dated
By:________________________
TOM LEVY
GENERAL MANAGER-CHIEF
ENGINEER

THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

Dated
By:________________________
RONALD R. GASTELUM
GENERAL MANAGER

Appendix C

Technical Memorandum No. 2
Evaluation of Hydrologic Effects of Proposed Draft Inadvertent Overrun and Payback Policy

TECHNICAL MEMORANDUM NO. 2

EVALUATION OF HYDROLOGIC EFFECTS OF THE PROPOSED DRAFT INADVERTENT OVERRUN AND PAYBACK POLICY

Prepared as Part of the

ENVIRONMENTAL IMPACT STATEMENT FOR THE IMPLEMENTATION AGREEMENT, INADVERTENT OVERRUN AND PAYBACK POLICY, AND RELATED FEDERAL ACTIONS

October 18, 2002

TABLES

FIGURES

FIGURES

FIGURES

TECHNICAL MEMORANDUM NO. 2
EVALUATION OF POTENTIAL HYDROLOGIC EFFECTS OF THE PROPOSED DRAFT INADVERTENT OVERRUN POLICY

The Bureau of Reclamation (Reclamation) proposes a policy that will identify inadvertent overruns, establish procedures that account for inadvertent overruns, and define subsequent payback requirements to the Colorado River mainstream. This Inadvertent Overrun and Payback Policy (IOP) is a condition precedent of the Quantification Settlement Agreement (QSA) between three California water agencies. The implementation of an IOP is a federal action. As such, the National Environmental Policy Act (NEPA) requires the evaluation of potential environmental impacts resulting from this proposed federal action.

This technical memorandum describes the methodology employed to evaluate the potential hydrologic effects resulting from the proposed implementation of the IOP. Also included in this technical memorandum is a summary of the evaluation results, findings and conclusions.

BACKGROUND

In its June 3, 1963 opinion in the case of *Arizona v. California* (373 U.S. 546), the Supreme Court of the United States held that the Congress has directed the Secretary of the Interior (Secretary) to administer a network of useful projects constructed by the Federal Government on the lower Colorado River, and it has entrusted the Secretary with sufficient power to direct, manage, and coordinate their operation. The Court held that this power must be construed to permit the Secretary to allocate and distribute the waters of the mainstream of the Colorado River within the boundaries set down by the Boulder Canyon Project Act (45 Stat. 1057, 43 U.S.C. 617) (BCPA). The Secretary has entered into contracts for the delivery of Colorado River water with entities in Arizona, California, and Nevada in accordance with section 5 of the BCPA.

The Secretary has the responsibility of operating Federal facilities on the Colorado River and delivering mainstream Colorado River water to users in Arizona, California, and Nevada that hold entitlements, including present perfected rights, to such water.

Article V of the Decree of the Supreme Court of the United States in *Arizona v. California* dated March 9, 1964 (376 U.S. 340) requires the Secretary to compile and maintain records of diversions of water from the mainstream, of return flow of such water to the mainstream as is available for consumptive use in the United States or in satisfaction of the Mexican Treaty obligation, and of consumptive use of such water. Reclamation reports this data each year in the Decree Accounting Record.

Pursuant to the Criteria for Coordinated Long-Range Operation of Colorado River reservoirs developed as a result of the Colorado River Basin Project Act of September 30, 1968, the Secretary annually consults with representatives of the governors of the Colorado River Basin States, general public and others and issues an Annual Operating Plan (AOP) for the coordinated operation of the Colorado River reservoirs. Reclamation also requires the major Colorado River water users in the Lower Basin to schedule water deliveries in advance for the following calendar year (calendar year is the annual basis for

Decree Accounting of consumptive use in the lower Colorado basin). Reclamation requires each water user to later report its actual water diversions and returns to the mainstream.

Pursuant to 43 CFR part 417, prior to the beginning of each calendar year, Reclamation consults with entities holding BCPA section 5 contracts (Contractor) for the delivery of water. Under these consultations, Reclamation makes recommendations relating to water conservation measures and operating practices in the diversion, delivery, distribution, and use of Colorado River water. Reclamation also makes a determination of the Contractor's estimated water requirements for the ensuing calendar year to the end that deliveries of Colorado River water to each Contractor will not exceed those reasonably required for beneficial use under the respective BCPA contract or other authorization for use of Colorado River water. Reclamation then monitors the actual water orders, receives reports of measured diversions and return flows from major contractors and federal establishments, estimates unmeasured diversions and return flows, calculates consumptive use from preliminary diversions and measured and unmeasured return flows, and reports these records on an individual and aggregate monthly basis. Later, when final records are available, Reclamation prepares and publishes the final Decree Accounting Record on a calendar year basis.

For various reasons, a user may inadvertently consumptively use Colorado River water in an amount that exceeds the amount available under its entitlement (inadvertent overrun). Further, the final Decree Accounting Record may show that an entitlement holder inadvertently diverted water in excess of the quantity of the entitlement that may not have been evident from the preliminary records. Reclamation is therefore considering an administrative policy to define inadvertent overruns, establish procedures that account for the inadvertent overruns and define the subsequent requirements for payback to the Colorado River mainstream.

IOP FEATURES CONSIDERED

The following features of Reclamation's proposed Lower Colorado River Basin IOP were considered in this evaluation:

a. Inadvertent overruns are those that the Secretary deems to be beyond the control of the water user. Examples of inadvertent overruns include; overruns resulting from discrepancies between preliminary and final stream flow and diversion records and overruns resulting from an unanticipated but lawful use by a higher-priority water user.

b. An inadvertent overrun is Colorado River water diverted, pumped or received by an entitlement holder of the Lower Division States that is in excess of the water user's entitlement for that year. The inadvertent overrun policy provides a structure to pay back the amount of water diverted, pumped or received in excess of entitlement. The inadvertent overrun policy does not create any right or entitlement to this water, nor does it expand the underlying entitlement in any way. An entitlement holder has no right to order, divert, pump or receive an inadvertent overrun. If, however, water is diverted, pumped or received inadvertently in excess of entitlement, and the Contractor's State's apportionment of Colorado River water for that year is exceeded, the inadvertent overrun policy will govern the payback. The IOP cannot be applied to diversion or acreage based entitlements without appropriate methodology, nor does this policy apply in any manner to the deliveries made under the United States Mexico Water Treaty of 1944.

c. Payback will be required to commence in the calendar year that immediately follows the release date of a Decree Accounting Record that reports uses that are in excess of an individual's entitlement.

d. Payback must be made only from measures that are above and beyond the normal consumptive use of water (extraordinary conservation measures). Extraordinary conservation measures mean actions taken to conserve water that otherwise would not return to the mainstream of the Colorado River and be available for beneficial consumptive use in the United States or to satisfy the Mexican treaty obligation. Any entitlement holder with a payback obligation must submit to Reclamation, along with its water order, a plan that will show how it will intentionally forbear use of Colorado River water by extraordinary conservation and/or fallowing measures sufficient to meet its payback obligation and that demonstrates that the measures being proposed are in addition to those being implemented to meet an existing transfer or conservation agreement, and that are in addition to the measures found in its Reclamation approved conservation plan. Plans for payback could also include supplementing Colorado River system water supplies with non-system water supplies through exchange or forbearance or other accepTable arrangements, provided that non-system water is not physically introduced into the system. Water banked off-stream or groundwater from areas not hydrologically connected to the Colorado River or its tributaries are examples of such supplemental supplies. Water ordered but subsequently not diverted is not included in this policy in any manner. If such water is not charged against a user's entitlement, it will not be counted in any other manner with respect to decree accounting.

e. Maximum cumulative inadvertent overrun accounts will be specified for individual entitlement holders as ten percent of an entitlement holder's normal year consumptive use entitlement. With regard to a conservation transfer, the specific terms of the transfer would address whether or not the proportionate overrun account is also transferred. (Normal year means a year for which the Secretary has determined that sufficient mainstream Colorado River water is available for release to satisfy 7.5 maf of annual consumptive use in the States of California, Arizona and Nevada.)

f. The number of years within which an overrun (calculated from consumptive uses reported in final Decree Accounting Records) must be paid back and the minimum payback required for each year shall be as follows:

    1. In a year in which the Secretary makes a flood control release or a space building release, any accumulated amount in the overrun account will be forgiven.
    2. If the Secretary has declared a 70R surplus in the AOP, any payback obligation will be deferred at the entitlement holder's option.
    3. In a year when the Lake Mead water surface elevation is between the elevation for a 70R surplus declaration and elevation 1,125 feet above mean sea level on January 1, the payback obligation incurred in that year must be paid back in full within 3 years of the reporting of the obligation, with a minimum payback each year being the greater of 20 percent of the individual entitlement holder's maximum allowable cumulative overrun account amount or 33.3 percent of the total account balance.

4. In a year when the Lake Mead water surface elevation is at or below elevation 1,125 feet above mean sea level on January 1, the total account balance will be paid back in full in that calendar year.
5. For any year in which the Secretary declares a shortage under the Decree, the total account will be paid back in full that calendar year, and further accumulation of inadvertent overruns will be suspended as long as shortage conditions prevail.

g. A separate inadvertent overrun account may be established in those limited cases in which a lower priority user is, or has agreed to be, responsible for consumptive uses by one or more un-quantified senior water entitlement or right holders having finite service area acreage. The separate inadvertent overrun account will be limited to a maximum cumulative amount of 10 percent of the senior right holders average consumptive use. Such inadvertent overrun accounts will be the assigned responsibility of the lower priority user in addition to their own entitlement based inadvertent overrun account. If, however, such senior entitlement or right holders' approved aggregate calendar year water orders are in excess of the specified amount above which the lower priority user will be responsible, such excess will not be deemed inadvertent and the lower priority user's water order for that year will be reduced accordingly by Reclamation.

h. Each month, Reclamation will monitor the actual water orders, receive reports of measured diversions and return flows from Contractors and federal establishments, estimate unmeasured diversions and return flows, and project individual and aggregate consumptive uses for the year. Should preliminary determinations indicate that monthly consumptive uses by individual users, or aggregate uses, when added to the approved schedule of uses for the remainder of that year, exceed contract entitlements but are not exceeding the maximum inadvertent overrun account amount, Reclamation will notify in writing the appropriate entities that the preliminary determinations are forecasting annual uses in excess of their entitlements.

i. During years in which an entitlement holder is forbearing use to meet its payback obligation, Reclamation would monitor the implementation of the extra-ordinary conservation measures and require that the district's consumptive use be at or below their adjusted entitlement. Should the district's actual monthly deliveries for about the first five months of the year exceed their forecasted orders, and projections indicate the district's end-of-year use is likely to be five percent above their adjusted entitlement, Reclamation will notify the district in writing. At the end of about seven months, if it continues to appear that the district is likely to be above their adjusted entitlement, Reclamation will notify the district that they are at risk of exceeding their adjusted entitlement and having their next years orders placed under enforcement proceedings.

j. Under enforcement proceedings, during the year, Reclamation would again monitor the implementation of the extra-ordinary conservation measures and require that the districts consumptive use be at or below their re-adjusted entitlement. Should the district's actual monthly deliveries for about the first five months exceed their forecasted orders and projections indicate the district's end-of-year use is likely to be five percent above their re-adjusted entitlement, Reclamation will notify the district in writing that they are at risk of being subjected to enforcement proceedings. Should the district's actual monthly deliveries for the first seven months exceed their forecasted orders, and projections indicate the district's end-of-year use is likely to be above their adjusted entitlement Reclamation would advise the entitlement holder in writing by

July 31, consult with the entitlement holder on a modified diversion schedule and then limit diversions to the entitlement holder for the remainder of the year such that by the end of the year, the individual entitlement holder has met their payback obligation.

k. Procedures will be established for accounting for inadvertent overruns on an annual basis and for supplementing the final Decree Accounting Record. The procedures and measures for administering the IOP will be reviewed every five years under the Long Range Operating Procedures review.

MODELING APPROACH

A numeric model was used to analyze the potential hydrological effects associated with the proposed implementation of the IOP. The model was used to provide projections of potential future Colorado River system conditions (i.e., reservoir releases, reservoir surface elevations, diversions and depletions, and river flows) under the various operational scenarios being considered under the IOP. The modeling results were then used to compare the potential future conditions under the action and no action alternatives. Specifically, the analyses presented herein are based on potential effects of changed river flows and water levels within the Colorado River and mainstream reservoirs. The analysis was limited to the portion of the river and facilities that extend from Lake Mead to the Northerly International Boundary upstream of Morelos Dam.

Certain assumptions were developed and used to model the potential users that could potentially incur inadvertent overruns in the future, the quantities of overruns and the payback requirements. The assumed annual overrun and payback amounts were converted to annual flow volumes that were then reflected as increases or decreases to river flows and reservoir releases.

A general overview of the steps taken to model the potential effects that could result from the implementation of the proposed IOP follows:

1. Developed assumptions with respect to which Colorado River water users potentially would incur overruns and therefore be subject to the IOP payback requirements. This was achieved through a combination of the following activities:
    a. Identification of agencies with quantified water entitlements,
    b. An evaluation of historical delivery requests and actual depletion records to identify agencies with a history of incurred overruns, and
    c. An evaluation of current agency water management practices to determine if sufficient scheduling, measurement and reporting practices are in place to enable the agency to minimize, control, or eliminate future overruns.
2. A reasonable estimate of future overrun account balances was then developed for those agencies identified as having the potential to incur future overruns and that are subject to IOP payback requirements. This was achieved through the following steps:
    a. The historic depletions of each affected agency were quantified, verified and evaluated to ascertain the historic and more recent water use trends. In several instances, the analysis of the agency historic demands were focused on only the most recent 12 years of depletion data since

it became apparent that these values most accurately represent the current demand trends of these agencies and are reflective of current water management practices, service area water demands and cropping patterns, where applicable.

b. The historical demand data for each agency were used to project the future demand conditions. Where appropriate, the projected demands were adjusted to reflect the projected increases in demand provided by the individual agencies. The historical pattern of fluctuating annual demands was then replicated over the projected demands in order to achieve a more reasonable estimate of future depletion conditions for the 75-year study period. The integrity of this process was maintained by making sure that the average of the fluctuating demands was equal to the average of the projected normalized demands. In some instances, such as in the case of the Imperial Irrigation District, projected demands developed by them and used for similar studies were made available for use in this study.

c. Using the projected future depletion conditions discussed above, an estimate of future depletion conditions without the IOP (no overruns allowed) was then developed and used in the modeling of the No Action alternative. To reflect the "no overrun conditions", the depletions for each agency (or group of agencies) were limited by the provisions of their existing contracts.

d. The numeric model was then used to simulate the future depletion conditions with the IOP and future depletion conditions without the IOP (No Action alternative). A total of six different scenarios were run for each agency or combination of agencies (see Table 1). Each run considered a different combination of maximum allowed overrun account balance and payback period. The maximum allowed overrun account balance was based on a percentage of the agency entitlement. Two percentages were considered, ten percent and five percent. Also, three payback periods were considered – three years, one year and zero years. The zero year payback schedule represents the shortage water supply conditions. Under these conditions, there would be no overruns allowed and previously existing balances would need to be paid back in full in the current existing calendar year. The following Table provides a summary of the different simulated IOP scenarios.

Table 1
Modeled Scenarios

Scenario No.	Maximum Allowed Overrun Account Balance	Payback Period (years)
1	10%	3
2	10%	1
3	10%	0
4	5%	3
5	5%	1
6	5%	0

Scenario accounting was then performed to determine how each combination of maximum allowed overrun account balance and payback period conditions compared to the modeled No Action conditions (future conditions without the IOP). The differences are believed to represent a reasonable estimate of future overrun account balances under each of the respective modeled IOP scenarios.

3. For each modeled scenario, the range of estimated future overrun account balances over the 75-year period that was analyzed was then ranked and analyzed statistically. Key statistics identified for each modeled scenario included the mean and maximum values and cumulative distribution.

4. The mean and maximum values were then used to analyze the potential effects to Colorado River flow below Hoover Dam and effects on storage and releases from storage at lakes Mead, Mohave and Havasu resulting from each modeled IOP scenario. The hydrological effects identified in this technical memorandum were then used to further analyze potential effects on other resources. The analysis of these other resources was a separate analysis by others and the results of said analyses are addressed in the Draft EIS. The hydrological effects were generally determined as follows:

    a. **Evaluation of River Flow Impacts** – The proposed implementation of the IOP could affect Colorado River flows in two ways. First, when an overrun is incurred, the flows in the river are increased by an amount equivalent to the amount of inadvertent overrun incurred in that specific year. For analysis purposes, the average value of the range of estimated future overrun amounts under each modeled IOP scenario was assumed to represent the most likely scenario and the maximum value was assumed to represent the potential maximum effect on river flows under the first condition – river flow increase due to incurred overrun.

       Secondly, in a payback period, the flows in the river are decreased by an amount equivalent to the amount of payback required in each year of the payback period. The potential river flow reductions under this condition are greatly affected by the length of the payback period. For example, the potential river flow reduction resulting from a one-year payback period requirement could potentially be three times that which would be incurred under a three-year payback period. However, it was assumed that in any given year under IOP, some of the IOP participating agencies would be incurring overruns while others would be in a payback cycle. Based on this most likely scenario, the mean value of the range of estimated future overrun account balances under each modeled IOP scenario was assumed to represent the potential maximum effect on river flows under this condition – river flow reductions due to required IOP payback.

    b. **Evaluation of Lake Level Imp**acts – The proposed implementation of the IOP could affect Colorado River mainstream reservoirs by reducing the amount of water in storage. Again, this analysis was limited to the portion of the river and facilities that extend from Lake Powell to the Northerly International Boundary upstream of Morelos Dam. Therefore, only those mainstream reservoirs located within that portion of the river system were evaluated. This included lakes Powell, Mead, Mohave and Havasu. A reduction in the amount of water in storage and water levels in Lake Mead (and Lake Powell due to equalization) could potentially occur when an inadvertent overrun is incurred. The amount of reduction in these two reservoirs would be equivalent to the amount of inadvertent overrun incurred in that specific year. However, this is believed to be a temporary condition since the depletion resulting from the inadvertent overrun would be restored though the payback system or with flood waters. At the end of the payback period, the depletion resulting from the inadvertent overrun is assumed to be offset and therefore, the long-term effect is considered to be negligible. For analysis purposes, the maximum value of the range of estimated future overrun account balances under each modeled IOP scenario was assumed to represent the potential maximum effect on reservoir storage content, albeit a temporary effect.

c. **Evaluation of Flood Control Releases and Excess Flows to Mexico Impacts** - The proposed implementation of the IOP could affect Lake Mead flood control releases and excess flows by reducing the amount of water in storage at Lake Mead. For the purposes of this analysis, excess flows to Mexico are assumed to occur entirely due to flood control releases originating at Hoover Dam. A reduction in the amount of water in storage would effectively increase the ability of Lake Mead to capture more water and thereby reduce flood releases. The reduction in the amount of water in storage would be equivalent to the amount of inadvertent overrun incurred in that specific year in addition to any unpaid account balances. Again, this is believed to be a temporary condition since depletion resulting from the inadvertent overrun would be restored through the payback system. For analysis purposes, the mean and maximum values of the range of estimated future overrun account balances under each modeled IOP scenario were used to evaluate the potential effect on Lake Mead flood control releases and excess flows to Mexico.

To accomplish this evaluation, it was necessary to integrate the results from the previously described numeric model with the RiverWare model. The mean and maximum values of the range of estimated future overrun account balances under each modeled IOP scenario were used as Lake Mead depletions in the Implementation Agreement and Cumulative Analysis modeled conditions. A detailed explanation of these and other operation scenarios considered and evaluated as part of the overall environmental impact study can be found in Technical Memorandum No. 1 - Analysis of River Operations And Water Supply (Appendix G of EIS). The overrun account balance was simulated by holding the respective overrun account balance as a depletion from Lake Mead. To ensure that the affect of an overrun account balance was reflected in every flood control year, an overrun account balance was assumed to exist in year one. Thereafter, the same amount was removed from the Lake Mead content every time there was a flood release from Lake Mead. This approach generally held the depleted content amount constant throughout the 75-year period of analysis. In actuality, this would not be the case because overrun account balances will vary from year to year and may not exist in some years. Nevertheless, this approach provided a means of identifying the worst-case potential impact that could occur in any given year under each of the modeled IOP scenarios. However, it should be noted that the probability that such an effect would occur is uncertain, although believed to be low, due to the low likelihood that flood release event will coincide with a period when all entities have maximum overrun account balances.

POTENTIAL INADVERTENT OVERRUN USERS

A discussion of which Lower Basin States and agencies were assumed would incur inadvertent overruns in the future follows. The assumed amounts of inadvertent overruns that could be incurred by each state and agency are also discussed below.

POTENTIAL ARIZONA INADVERTENT OVERRUN CONDITIONS

Arizona Colorado River water users were segregated into two groups to facilitate evaluation of historical and future Arizona water depletions. The two groups were - Central Arizona Project (CAP) users, and other Arizona users. An assessment of the likelihood that each one of these groups could incur future inadvertent overruns was then made.

An evaluation of historical depletion records identified few instances where the depletions of Arizona agricultural users located below Parker Dam approached their respective entitlements. The likelihood that these users would incur future inadvertent overruns was thus considered to be very low. Therefore, for modeling purposes, the assumption was made that this group of Arizona users would not incur future inadvertent overruns.

The agricultural users located along the river have a higher priority than the CAP users. As such, the beneficial use requirements for the agricultural users would, in most instances, be fully satisfied. The CAP users would then be entitled to use the remaining water supplies that are within Arizona's 2.8 maf normal year Colorado River water apportionment. The CAP has several water management programs that can be used to minimize or eliminate Arizona's inadvertent overruns. First, the CAP intends to use Lake Pleasant and various central Arizona groundwater storage programs to manage future available Colorado River water supplies. CAP will use water supplies stored in these facilities to minimize or offset any inadvertent overruns that may be incurred by the higher priority Arizona agricultural users. Further, CAP has the ability to adjust its diversions on a near daily basis. Given these water management systems, it is highly probable that Arizona will be able to adhere to its depletion schedules and stay within its apportioned amounts.

The recorded Arizona depletions for the most recent 12 years were used to represent the current demand trends. This period was used because the depletions are probably most indicative of current water management practices, service area water demands and cropping patterns, where applicable. Table 2 presents the historical depletions of the Arizona Other Users for the most recent twelve years.

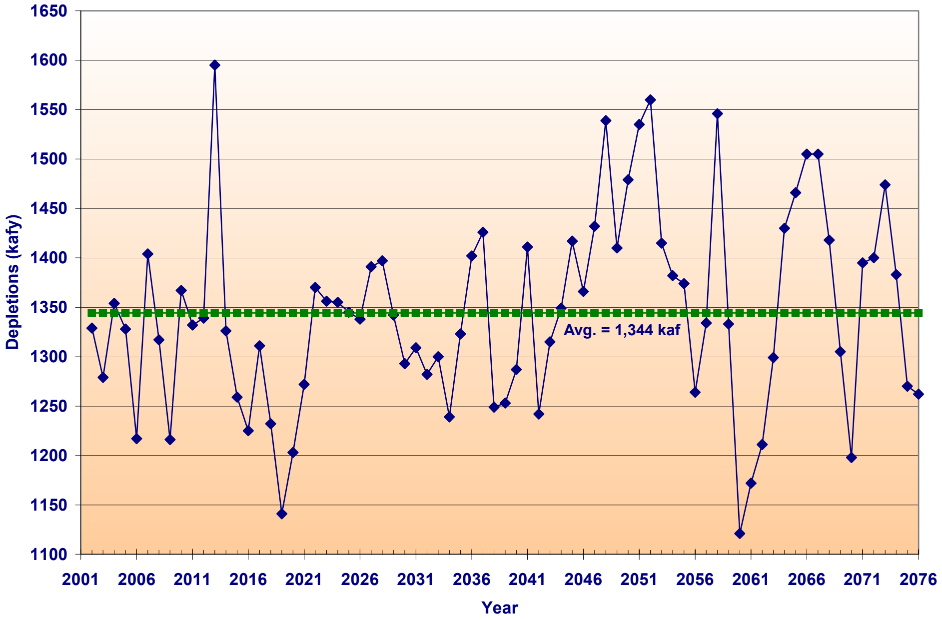
Table 2
Historical Depletions of Arizona Other Users

Year	Depletion (kaf)
1988	1,423
1989	1,471
1990	1,481
1991	1,411
1992	1,314
1993	1,222
1994	1,421
1995	1,436
1996	1,519
1997	1,440
1998	1,338
1999	1,340

The historic demand data was normalized and then extrapolated to provide a basis for future demand conditions. Recognizing that the historic demand data does not reflect recent water management practices, the historic demand data was normalized to remove any increasing or decreasing trend and it was also adjusted in a manner that the average of the historic demand data was made equal to the average of the demand data for the most recent 12-years. The focus of the analysis being on the fluctuation or departure from the average demand data. The projected future demands were also adjusted to reflect ADWR's projected 70 kaf per year water demand increase, as published in Appendix H of Reclamations 2001 Surplus EIS. The historical pattern of fluctuating annual demands was then replicated over the projected demands in order to achieve a more reasonable estimate of future depletion conditions. The integrity of this process was maintained by making sure that the average of the fluctuating demands was equal to the average of the projected normalized demands. Figure 1 presents the projected future Arizona Other demands that were used to assess the likelihood and magnitude of future potential Arizona inadvertent overruns.

Figure 1 shows total projected demands for Arizona Others (AZOTH) average approximately 1.34 mafy and fluctuate an average of approximately 50 kaf from year to year, with the maximum annual fluctuation being approximately 260 kaf in year 2013. Since CAP has the capacity to divert up to 180 kaf per month, it is reasonable to assume that CAP will be able to monitor Arizona's total scheduled deliveries and monthly diversions, and make the necessary adjustments to remain essentially even, offsetting any inadvertent overruns that might be incurred by the Arizona Others users. These adjustments could occur in the later lower water use months, i.e., November and December. With this approach, CAP could potentially keep overruns to less than 5 kafy.

Figure 1
Projected Future Depletions for Arizona Others



However, there could still be instances of additional inadvertent overruns by the Arizona groundwater pumpers. These depletions are typically not totaled until the final Decree Accounting is completed. This accounting does not occur until after the close of the accounting year, usually March or April of the following year. However, an evaluation of recent historical Arizona groundwater pumpers' depletions suggests that inadvertent overruns incurred by these users are usually less than 5 kaf, with a maximum of 15 kaf.

Recognizing that the CAP can make day-to-day adjustments to their December diversions to match the remaining amounts available, the total future inadvertent overruns for Arizona are not expected to be significant. Because of the complexity involved in modeling such a small amount of potential inadvertent overrun, and recognizing that the real time operation would be refined with experience the decision was made to not include this amount in the analysis. However, it should be noted that this does not mean that these inadvertent overruns would not be subject to the requirements of the IOP, if and when such a policy is implemented.

POTENTIAL NEVADA INADVERTENT OVERRUN CONDITIONS

The portion of Nevada that depends on Colorado River water is limited to southern Nevada, primarily the Las Vegas Valley and the Laughlin area further south. The Colorado River Commission and the Southern Nevada Water Agency (SNWA) manage Nevada's Colorado River water supply. The SNWA coordinates the distribution and use of the water by its member agencies whose systems provide retail distribution. Nevada has five principal points of diversion for Colorado River water. The largest occurs in the Las Vegas Valley that pumps water from Lake Mead at Saddle Island (on the west shore of the lake's Boulder Basin) through facilities of SNWA. The water is pumped at two adjacent pumping plants. Three other diversion points are downstream of Davis Dam. They serve the community of Laughlin, Southern California Edison's coal fired Mohave Generating Station and uses on that portion of the Fort Mojave Indian Reservation lying in Nevada. The fifth diversion consists of water used by federal agencies in Nevada, primarily the National Park Service and its concessionaires at various points on lakes Mead and Mohave. Nevada’s current Colorado River water demand now exceeds its Colorado River normal water apportionment of 300 kafy. SNWA depletions represent approximately 90 percent of this amount.

Nevada has no history of incurring inadvertent overruns. Further, since SNWA manages Nevada's Colorado River water supply and its own depletions account for over 90 percent of Nevada’s total depletions, the responsibility of managing and controlling future inadvertent overruns will fall on SNWA. SNWA intends to use its groundwater supplies within the Las Vegas Valley to manage future available Colorado River water supplies. It was assumed that SNWA’s ability to adjust its diversions on a near daily basis and its use of groundwater supplies would be effective in minimizing and offsetting any inadvertent overruns that may be incurred by other Nevada users. As such, it is highly probable that Nevada will be able to adhere to its future depletion schedules and stay within its apportioned amounts. Therefore, for modeling purposes, the inadvertent overruns that may be incurred by Nevada users other than SNWA are believed to be minimal and therefore were not modeled or analyzed.

POTENTIAL CALIFORNIA INADVERTENT OVERRUN CONDITIONS

California does not have a history of exceeding their entitlement. This is due to the fact that Article II(B)6 of the Decree allows some agencies to utilize unused Lower Basin apportionment and also Colorado River water contracts allow some agencies to receive surplus water supplies that are made available coincident with Lake Mead flood release conditions. The Seven Party Agreement provides up to 3.85 mafy to California water users, in three priorities during a normal year. The Palo Verde Irrigation District (PVID) and the Yuma Project Reservation Division (YPRD) hold the first two priorities. Within this priority, PVID’s water use is restricted to 104,500 acres of valley land. Imperial Irrigation District (IID), Coachella Valley Water District (CVWD) and 16,000 acres of PVID Mesa lands hold third priority.

Within this priority are PVID's mesa lands. In addition, the 1934 Agreement of Compromise gave IID a higher priority, within this third priority, than CVWD. Metropolitan Water District of Southern California (MWD) holds fourth priority.

PVID and YPRD do not have quantified water rights. Their Colorado River water depletions are restricted by the number of acres that they are allowed to irrigate with Colorado River water. PVID's entitlement is tied to their right to irrigate 104,500 acres with Priority 1 water in the valley and an additional 16,000 acres associated with Priority 3B. YPRD's entitlement is tied to their right to irrigate 25,000 acres within the Project boundary.

Currently there is no specific quantification of the rights of each of the above named irrigation districts. In any given year, the depletions by each of these agencies will vary, with the only restriction being that the total use by the four districts cannot exceed the 3.85 mafy cap in a normal year. An exception to this occurs under surplus determinations by the Secretary. Also, 1989 Approval Agreement among IID, CVWD, PVID, and MWD amended the 3.85 maf cap by allowing MWD to access up to 110 kaf of water conserved under the 1988 MWD/IID agreement, provided that under certain specified conditions, CVWD would be given the right to use the first 50 kaf. As such, the current cap for the four districts (PVID, YPRD, IID and CVWD) is from 3.74 to 3.80 maf, during a normal year depending upon certain specified conditions. Consistent with utilizing an assumed 3.80 maf cap for modeling purposes, the IID projected depletions also assumed that the IID/MWD conservation agreement is also in place. In addition, the CVWD demands were assumed to be the demands that CVWD would seek to maintain consistent with their current entitlement.

Because of the similar water rights of PVID and YPRD, the historic and future depletions of these two agencies were analyzed together. For similar reasons, the historic and future depletions of CVWD and IID were also analyzed together. PVID/YPRD historic depletions were normalized and extrapolated to develop projected Colorado River water depletions for these agencies. The historic PVID data was first normalized which removed any increasing or decreasing trend in the historic demands data. (In the earlier years, PVID use was increasing as the amounts of land under irrigation was increasing). Normalizing the data allowed the analysis to focus on the potential for overruns assuming more recent farming and water management practices. However, since the historic depletions for YPRD include a significantly higher percentage of estimated unmeasured returns and is less accurate, the normalized data for PVID was increased such that the projected average depletions and the average depletions over the last 12 years for both districts combined equaled 420 kaf. The 420 kaf average is consistent with Decree Accounting records.

The inadvertent overrun analysis focuses on the potential for MWD overruns as they relate to PVID fluctuations. In the analysis, the maximum overrun that can occur due to a PVID fluctuation in use is calculated by adding 10% of the estimated 420 kaf that MWD is responsible for and 10% of MWD base entitlement of 550 kaf. It needs to be noted that prior to determining the amount of overage MWD is responsible for as it relates to uses of the first two priorities, the IID and Coachella incurred depletions are first considered. If any unused entitlement is available to MWD from IID/CVWD, that unused supply was assumed to be applied that year against any uses above the 420 kaf related to PVID/YPRD.

For the purpose of this analysis, it was also assumed that MWD would not exceed its annual entitlement amount and therefore would not incur any direct overruns. The bases for this modeling assumption include the knowledge that MWD has access to other supplies and that it has the ability to accurately monitor and measure their diversions. Further, because of its responsibility to payback overruns incurred by PVID, it was assumed that MWD would attempt to minimize additional overruns beyond those that are assigned to MWD by way of PVID fluctuations. As such, no direct MWD overruns were modeled as part of this analysis. Figure 2 presents the projected future PVID depletions.

Figure 2
Projected Future Depletions for PVID

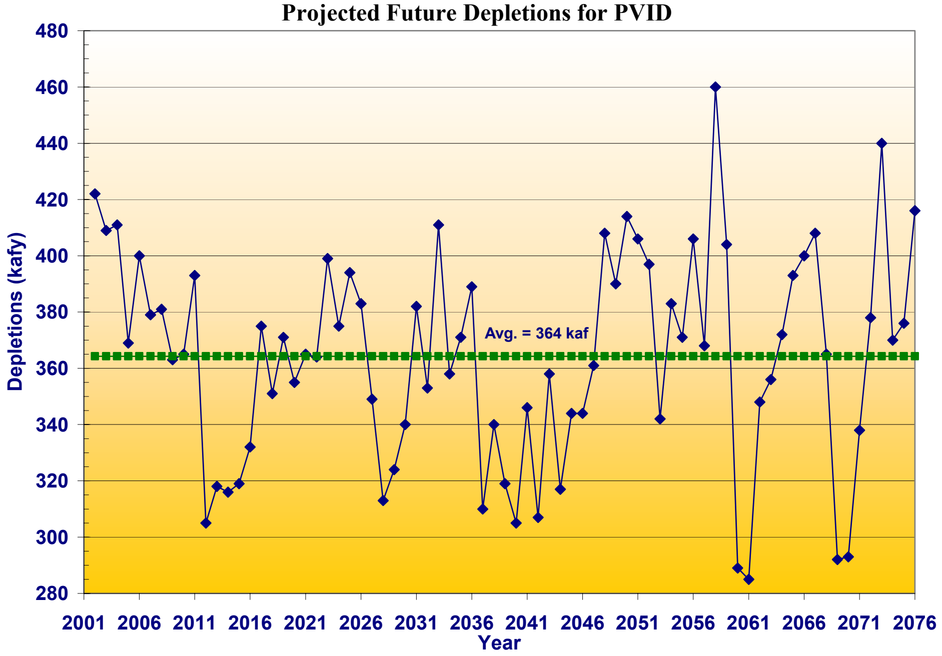
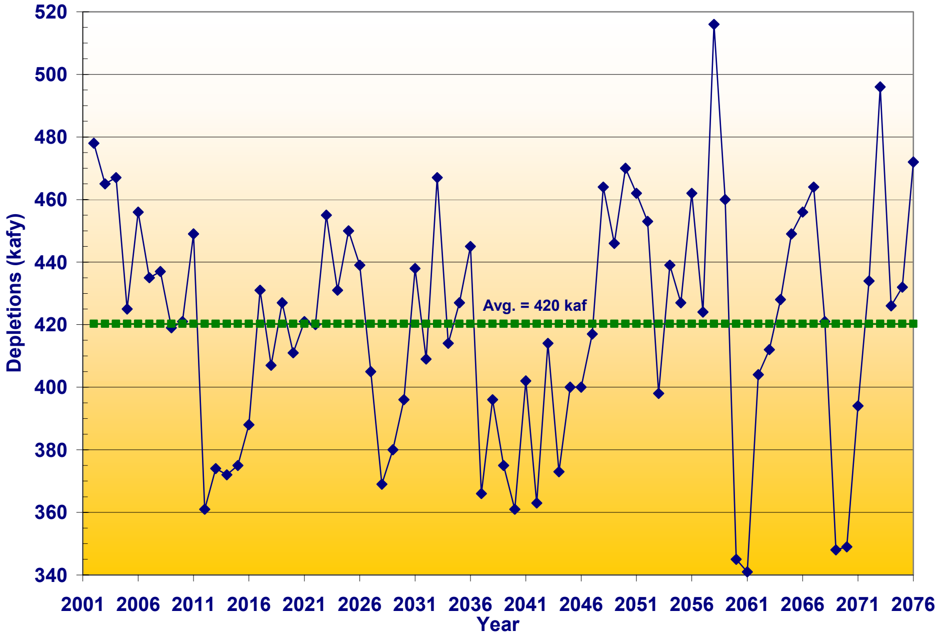


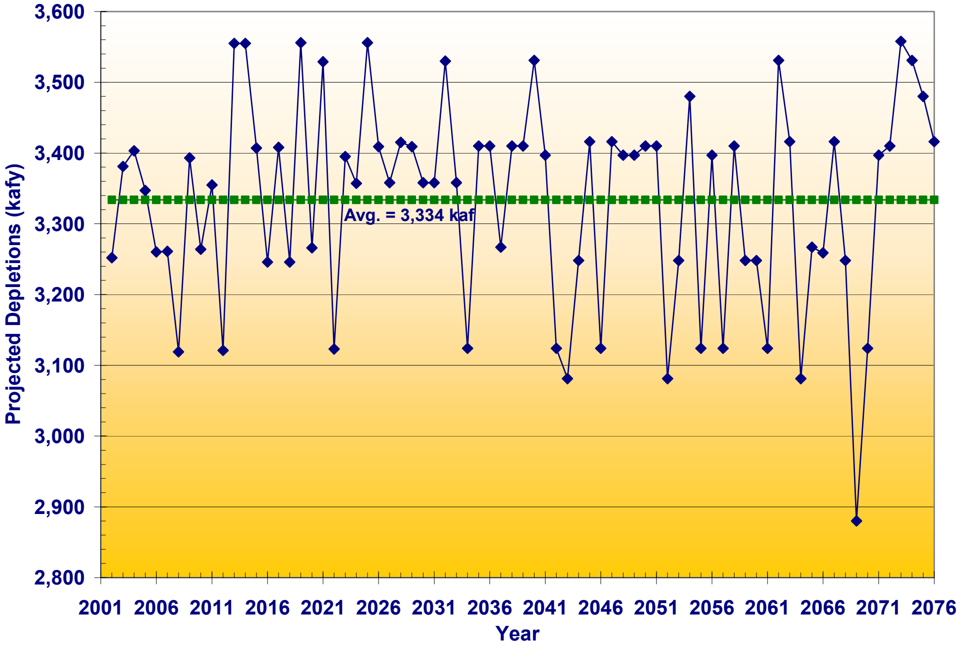
Figure 3
Projected Future Depletions for PVID/YPRD



The projected future YPRD depletions were then added to the projected future PVID depletions to represent the combined PVID/YPRD future depletions (California Priorities 1 and 2 demands). Figure 3 presents the projected future PVID/YPRD depletions.

The projected future IID/CVWD depletion schedule was developed similar to that developed for PVID but with some differences. While the historic data was normalized based on the 12-year depletion record, the normalization method applied to the projected depletions differed. IID previously developed an elaborate model based on the 12-year gate delivery records for the period between 1987 to 1998. IID used this model to evaluate the potential effects of the conservation transfers currently being considered. The model allows alternate conservation methods to be considered by different farming operations and yields change in drainflow, drainflow quality, and change in gate delivery data for each different modeled scenario. In order to extend the 12-year base historic data to 75 years, the historic fluctuations were mapped using net Eto. Further details on how this mapping occurred is explained in the IID/SDWA EIR/EIS. The projected future CVWD depletions were added to the projected future IID depletion schedule. Figure 4 presents the projected IID/CVWD depletions. It should be noted that the any differences between the projected future depletions for IID/CVWD used in this study and those being used by IID in their own studies related to assumptions with respect to the transfer programs that are considered to be put in place at different points in the future. Any minor differences are expected to be reconciled prior to the preparation of the Final EIS for this study.

Figure 4
Projected Future Depletions for IID/CVWD



Development of Projected California Depletion Schedules for the No Action Alternative

The Seven Party Agreement provides up to 3.85 mafy to California water users holding priorities one to three, during a normal year. However, because of existing water conservation agreements between the

California agricultural agencies and MWD , the total entitlement under priorities one thru three were modeled as being limited to 3.80 maf (explanation of assumed 3.8 maf cap previously provided in section entitled – "Potential Future California Inadvertent Overrun Conditions", page 12). PVID/YPRD holds the first two priorities. IID/CVWD/PVID hold third priority and MWD holds the fourth priority. PVID/YPRD do not have quantified water rights. PVID/YPRD depletions are restricted by the number of acres that they are allowed to irrigate with Colorado River water and their district/project boundaries.

Under nearly all water supply conditions, the water demands of the two highest priorities (PVID/YPRD) must be fully satisfied. This condition was maintained in the development of the No Action modeled condition. As such, the IID/CVWD No Action condition depletion schedule was calculated by subtracting the PVID/YPRD annual depletions from 3.80 maf. The depletion schedules provided by IID/CVWD were compared to the IID/CVWD No Action condition depletion schedule. In years where the IID/CVWD No Action condition depletion was greater than the amount shown on the depletion schedules provided by IID/CVWD, the difference was said to be water that could be made available for use by MWD (unused Priority 1, 2 & 3 supply) in accordance with the provisions of the Seven Party Agreement. As such, the MWD No Action condition depletion schedule (the amount remaining of the 4.4 maf) was calculated by subtracting from 4.4 maf the lesser of either the depletion schedules provided by IID/CVWD or IID/CVWD No Action condition depletion schedule, the PVID/YPRD annual depletion schedule, and the Present Perfected Rights (50 kaf). Tables A2, A3 and A4 in Appendix A provide the detailed calculations for each modeled year.

Accounting Effects of Quantification Settlement Agreement:

During the negotiations for the Quantification Settlement Agreement (QSA) it was recognized that constantly fluctuating uses by PVID/YPRD would make it very difficult for IID to plan for and assure a specific quantity of urban transfer. To accommodate this issue, MWD agreed to assume responsibility for any uses by PVID/YPRD that exceed their long-term annual average depletion of 420 kaf provided that other provisions of the key terms of the QSA that benefited MWD were realized. For the purposes of modeling the IOP, PVID/YPRD's use in excess of 420 kafy is treated as an inadvertent overrun. However, the obligation for payback of this overrun is assumed by MWD. Under this same agreement, MWD receives the right to use any unused portion of the 420 kafy PVID/YPRD target supply without claims by IID or CVWD to use of this water.

This provision of the QSA provides a slight modification to the manner that water is allocated under the Seven-Party Agreement. It will have a tendency to stabilize the widely fluctuating depletions of the first three priorities as well as the Priority 4 supply (MWD). This provision of the QSA was modeled by holding IID/CVWD's annual depletion to 3.38 maf. The depletion schedules provided by IID/CVWD were compared to this capped depletion schedule. In years when the depletion was less than the amount shown on the capped depletion schedule, the difference was assumed to be water available for use by MWD (unused Priority 1, 2 & 3 supply). In years where PVID/YPRD's use was over the target of 420 kaf, the average was assumed to be MWD's payback obligation. In years where the IID/CVWD's use was less than 3.38 maf, MWD's payback obligation was reduced by the difference between the observed IID/CVWD use and the 3.38 maf The results of these calculations are shown in Table A-4 in Appendix A. The depletion schedule that was calculated and used to model MWD's annual depletions is also shown on Table A-4, in Appendix A.

For modeling purposes, it was assumed that the 420 kaf target depletion for PVID/YPRD was a fixed cap obligation for MWD. The responsibility for paying back the amount over the 420 kaf target depletion is assumed by MWD. Thus any amount of use over the 420 kaf would need to be paid back. Normal reduced PVID/YPRD uses the following year would not be considered a payback. To further facilitate the modeling process, the assumption was made that MWD's minimum annual depletion was 550 kaf per year.

The analysis assumed that MWD would utilize any unused portion of the 3.38 mafy to reduce or avoid an overrun incurred by PVID/YPRD. To account for the unused IID/CVWD entitlement that is made available to MWD, the IID/CVWD-provided depletion schedules were first capped at 3.38 maf. Any unused portion of the 3.38 maf - Capped Projected Use is assumed to equal the amount of water under IID/CVWD's entitlement that would be available to MWD to offset any uses by PVID/YPRD above 420 kaf. The amount available was then subtracted from the projected PVID/YPRD use to calculate MWD's obligation account. In years when MWD's obligation account exceeded 420 kaf, the overage was added to MWD's payback schedule. This schedule represents the assumed debt that is assumed for PVID/YPRD overages beyond the target 420 kafy.

Under the No Action modeled conditions, there may be future circumstances where IID/CVWD's annual depletions total less than 3.38 maf. Under such conditions, MWD would be able to use the unused remaining entitlement to avoid an overrun, or reduce its need for surplus Colorado River water.

OTHER MODELING AND DECREE ACCOUNTING CONSIDERATIONS

The following additional assumptions were used in the modeling of the operational scenarios being considered.

DECREE ACCOUNTING METHOD

A factor which may affect the ability for CAP and other low priority users to accurately utilize the amount of state apportionment remaining, is the methodology used in determining use. This analysis assumes current Decree Accounting which emphasizes measured diversions and measured return flow data, and estimates the unmeasured return flow values as a factor times the diversion. While there may be methods to make the current method of estimating use more accurate, the current method does provide immediate depletion information which results in a lag in Reclamation's recordation and accounting system. In order to improve the accuracy of the existing system, Reclamation is considering using an evapotranspiration method that would enable it to develop more accurate estimates that could be then used to forecast total end-of-year use. An evapotranspiration approach could include the use of multiple variables and thereby potentially yield more accurate estimates. However the timeliness of such an approach could be affected by the need to collect a large amount of data. At this time, the decision to pursue this type of approach has not been made, as such, this analysis does not evaluate the potential impacts to the current Decree Accounting or to the proposed inadvertent overruns and paybacks that could result from the use of a different methodology.

A comparison of consumptive use values produced by the current Decree Accounting methodology and a future methodology utilizing an evapotranspiration approach is available in the Reclamation report entitled, "Lower Colorado River Accounting System Demonstration of Technology Calendar Year 2000" available from Reclamation's Boulder Canyon Operations Office in Boulder City.

MODELING OVERRUN VS. MODELING OF TRANSFERS

Overruns can be a characteristic of unforcasted year-to-year changes in agricultural use. In the lower Colorado River corridor there is a significant relationship between lack of rainfall and agricultural demand in the Lower Colorado River corridor. This can be demonstrated by comparing the measured inflows minus measured outflows per acre of PVID to local rainfall. As PVID cannot predict next year's rainfall, there is reasonable certainty that the order developed in August of the previous year will not be the actual amount diverted. Similarly the other agricultural irrigation districts that depend upon the leftover amounts know that the amounts predicted to be available would likely not prove out. Thus, the potential for unexpected overruns is ever present yet cannot be accurately predicted.

Transfers, however, are not related to year-to-year variations in rainfall or to agricultural irrigation needs. Transfer water conserved from a quantified baseline, due to canal lining, conservation of tailwater, or system improvements, are reductions in use that would consistently reduce the consumptive use below what it would have been, regardless of the variability in year to year uses. Modeling of the effects due to the water transfers generally assumed baselines where IID was fully utilizing their entitlement. The water conservation and transfer programs modeled further considered the reductions in use from a quantified baseline. Therefore, a gradual reduction in use that is associated with the planned development and implementation of conservation programs was utilized in the modeling of the Implementation Agreement to evaluate river impacts associated with the water transfers.

Another assumption with respect to the overruns and water transfers is that the magnitude of inadvertent overruns would remain constant over the period of analysis. Although, the use of Colorado River water for agricultural irrigation use is expected to fluctuate above and below a declining average as the water conservation and transfer programs are implemented, the level of the modeled inadvertent overruns is assumed to remain unchanged. This assumption reflects the probability that the final IOP or the water transfer agreements will include provisions for an agency to retain or transfer the overrun right associated with the transferred water.

QUANTIFIED OR CAP SYSTEMS

Under the Quantification Agreement, IID and CVWD would be accepting a quantified entitlement "subject to the provisions of the IOP" policy, and MWD would be assuming responsibility for the uses of the first two priorities when they exceed 420 kaf, but would receive the benefits when uses are less than 420 kaf. This analysis assumes the QSA sets the upper limit rights for IID and CVWD. As an upper limit right, (and not a right to an average use), exceeding the right cannot be paid back by a simple under-use the following year. Some form of extraordinary conservation such as fallowing, or importing water from another source such as recovering stored groundwater would need to be implemented to "payback" the over-use.

VERIFICATION OF PAYBACK

This analysis assumes that the verification of extraordinary conservation prescribed in the draft IOP will include verification that the payback reduces the consumptive use from the Colorado River system. Extraordinary conservation, such as land fallowing, recovery of off-stream stored Colorado River water or importing water from another source, must reduce the use from what it could have been at the specific location, and the reduction in use or increase in supply can be verified. However, whether the extraordinary measure actually results in a reduced diversion or consumptive use from the Colorado River is dependent upon all the other uses within a district. Changes in cropping patterns, leaching, tailwater practices, weather conditions, recharge operations, reductions in other importations, as well as changes in district system operations, and on-farm conservation practices may consume the "saved or recovered water". This analysis assumes that; 1) the consumptive use from the river will be the final measure of payback, 2) that in a payback year a district must do extraordinary conservation, and 3) that the measured depletion must show a reduction in river consumptive use equal to or greater than their base entitlement minus the payback amount. In a payback year, an entity in a payback cycle has an "entitlement target." The entitlement target is assumed to consist of:

[Base Entitlement] +/- [Conservation Transfers] – [Extraordinary Conservation]

Note: The conservation transfers is added for entities receiving water and subtracted for entities transferring water.

When intent to payback has been confirmed through verification of extraordinary conservation measures, Reclamation will not undertake a strict enforcement process. Rather, Reclamation will compare the final diversion records to the entitlement target. More detail is provided in the section entitled "IOP Features Considered," bullets g thru j.

FORGIVENESS VS. NO FORGIVENESS

Two of the top priorities established for the operation of Hoover Dam and Lake Mead are flood control and the maximization of water supplies. Today, developments along the river have restricted the flood plain downstream of Hoover Dam such that releases greater than 45,000 cfs can cause extensive property damage to homes and property located within the flood plain. In the past, flood control releases on the Colorado River have typically occurred in clusters. An example of this is the flood control releases that occurred in 1998, 1999, and 2000. This series of flood release events showed that once the Colorado River system storage fills, it does not require a very high runoff the following year to cause the system to spill again.

Insisting on payback following a flood control event would increase the likelihood of a flood control spill and would also increase the risk of flood damaging flows. Further, the spilling of water diminishes the water supply that can be made available for consumptive use by Colorado River water users. As such, Reclamation believes that overrun accounts balances should be forgiven upon a flood release or space building release. Reclamation further believes that the principal of "forgiveness" is consistent with the previously stated priorities in the operation of Hoover Dam and Lake Mead.

The opportunities for flood control forgiveness are not expected to occur all that frequently. Again, the only instances where forgiveness would occur is in the event of a flood control release or space building release. Probability studies conducted by Reclamation indicate that, in the future, the Colorado River system may be operated under flood control conditions about 20 percent of the time. Given this level of probability and the fact that the flood release events occur in clusters, the actual probability of forgiveness is uncertain but believed to be very low. Further, preliminary modeling of the "No Forgiveness" alternative showed that paybacks after a flood control event would not significantly impact long-term reservoir storage or the magnitude of excess flows to Mexico. This is because most of the payback required after a flood event would most likely be released as surplus water in the years that follow, rather than staying in the reservoir and augmenting a later flood flow. Because this preliminary modeling showed that the "No Forgiveness" alternative varied so little from the "Forgiveness" alternative, it was determined that additional detailed modeling of the "No Forgiveness" alternative was not needed.

MODELING RESULTS

GENERAL MODELING RESULTS AND ANALYSES

To evaluate the potential impacts that the proposed implementation of the IOP could have on river flows, storage, and excess flows to Mexico, the following additional assumptions were made:

- The payback period was held constant for each model run. Three different payback periods were considered (3-year, 1-year and 0-year). Some model runs assumed that the Lower Basin was in a 3-year payback condition all the time (Lake Mead always stayed above elevation 1125 feet). Although this represents an unrealistic condition, it facilitated and simplified the analysis. The model was also run with the assumption that the Lower Basin was always in 1-year payback conditions (Lake Mead always stayed below elevation 1125 feet).
- The sum of the mean and the sum of the maximum observed IID/CVWD and PVID/YPRD overrun amounts were used as the basis for evaluating the most likely and maximum possible increase in river flows for the reach of the Colorado River located between Parker Dam and Imperial Dam, respectively.
- The mean and maximum observed IID/CVWD payback amounts were used as the basis for evaluating the most likely and maximum possible reduction in river flows for the reach of the Colorado River located between Parker Dam and Imperial Dam, respectively.
- The sum of the mean and the sum of the maximum observed IID/CVWD and PVID/YPRD overrun amounts were used as the basis for evaluating the most likely and the maximum possible increase in river flows for the reach of the Colorado River located between Hoover Dam and Parker Dam, respectively.
- The sum of the mean and sum of the maximum observed IID/CVWD and MWD (as incurred by PVID/YPRD) payback amounts were used as the basis for evaluating the most likely and the maximum possible reduction in river flows for the reach of the Colorado River located between Hoover Dam and Parker Dam, respectively.
- The sum of the mean and the sum of the maximum observed IID/CVWD and PVID/YPRD overrun account balances were used as the basis for evaluating the most likely and the maximum possible effect on storage and excess flows to Mexico, respectively.

A summary of the values used in each respective analysis, the respective modeled conditions and the source of the data is presented in Table 3.

Table 3
Summary of Data Used in the Analysis

Analysis Application	Modeled Value (kaf)	Value Source Reference	Modeled Conditions
Effect on River Flows - Between Hoover Dam and Parker Dam			
Maximum Overrun	313	Column 7, Table A-9	IID/CVWD + MWD - 10% Overrun with 1-Year Payback
Average Overrun	90	Column 7, Table A-9	IID/CVWD + MWD - 10% Overrun with 1-Year Payback
Maximum Payback	206	Column 7, Table A-9	IID/CVWD + MWD - 10% Overrun with 1-Year Payback
Average Payback	72	Column 7, Table A-9	IID/CVWD + MWD - 10% Overrun with 1-Year Payback
Effect on River Flows - Between Parker Dam and Imperial Dam			
Maximum Overrun	313	Column 7, Table A-9	IID/CVWD + MWD - 10% Overrun with 1-Year Payback
Average Overrun	90	Column 7, Table A-9	IID/CVWD + MWD - 10% Overrun with 1-Year Payback
Maximum Payback	176	Coumn 8, Table A-6	IID/CVWD - 10% Overrun with 1-Year Payback
Average Payback	63	Coumn 8, Table A-6	IID/CVWD - 10% Overrun with 1-Year Payback
Effect on Storage			
Maximum Overrun Account Balance	331	Column 7, Table A-11	IID/CVWD + MWD - 10% Overrun with 3-Year Payback
Average Overrun Account Balance	66	Column 7, Table A-11	IID/CVWD + MWD - 10% Overrun with 3-Year Payback
Effect on Excess Flows to Mexico			
Maximum Overrun Account Balance	331	Column 7, Table A-11	IID/CVWD + MWD - 10% Overrun with 3-Year Payback
Average Overrun Account Balance	66	Column 7, Table A-11	IID/CVWD + MWD - 10% Overrun with 3-Year Payback

EVALUATION OF POTENTIAL RIVER FLOW IMPACTS

A modeling assumption made with respect to IOP effects on river flows is that the proposed Quantification Settlement Agreement and IOP will not affect future Colorado River water deliveries to PVID and YPRD. PVID's and YPRD's Priority 1 and 2 water rights are preserved. This means that these two agencies are not directly subject to the entitlement quantification requirements under the QSA and to the payback requirements of the IOP. However, it should be noted that delivery of Colorado River water to these agencies will affect the remaining water supplies that are available to the other California Colorado River water users. As such, the delivery of Colorado River water to PVID and YPRD may have an indirect effect on river flows.

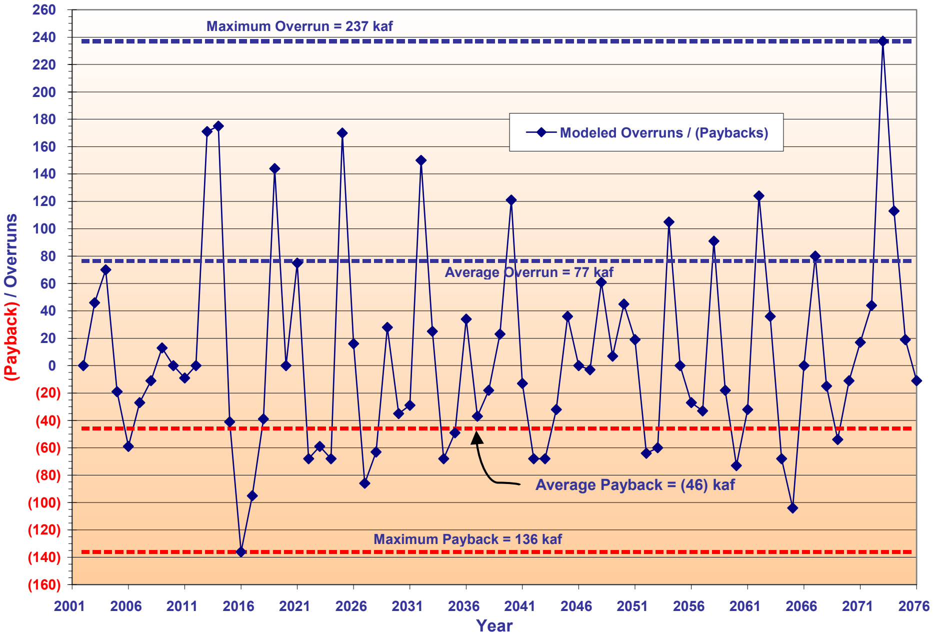
As noted above, under existing contracts, water deliveries to PVID/YPRD directly affect the amount of water that is available for use by IID/CVWD. Additionally, the total amount of water that is used by PVID, YPRD, IID and CVWD directly affects the amount of water that is available for use by MWD. The amount of water delivered to each of these agencies also has a direct effect on the water available in the Colorado River as does the amount of water delivered to the other basin states and to Mexico. As the delivery of water to each agency increases or decreases, so does the flow in the reach of the river that serves the respective agency(s). The exception to this is the overruns and payback requirements that are incurred by PVID/YPRD. Any amount of water that is used by PVID/YPRD over 420 kafy is treated as an incurred overrun that MWD is obligated to payback. When MWD is required to pay back a

PVID/YPRD incurred overrun, only that part of the river that is located between Hoover Dam and Parker Dam is affected. However, a PVID/YPRD incurred overrun is considered to affect both reaches of the river, Parker Dam to Imperial Dam and Hoover Dam to Parker Dam. A description of the hydrological effects observed in each of the two above noted river reaches follows:

River Flow Between Hoover Dam And Parker Dam

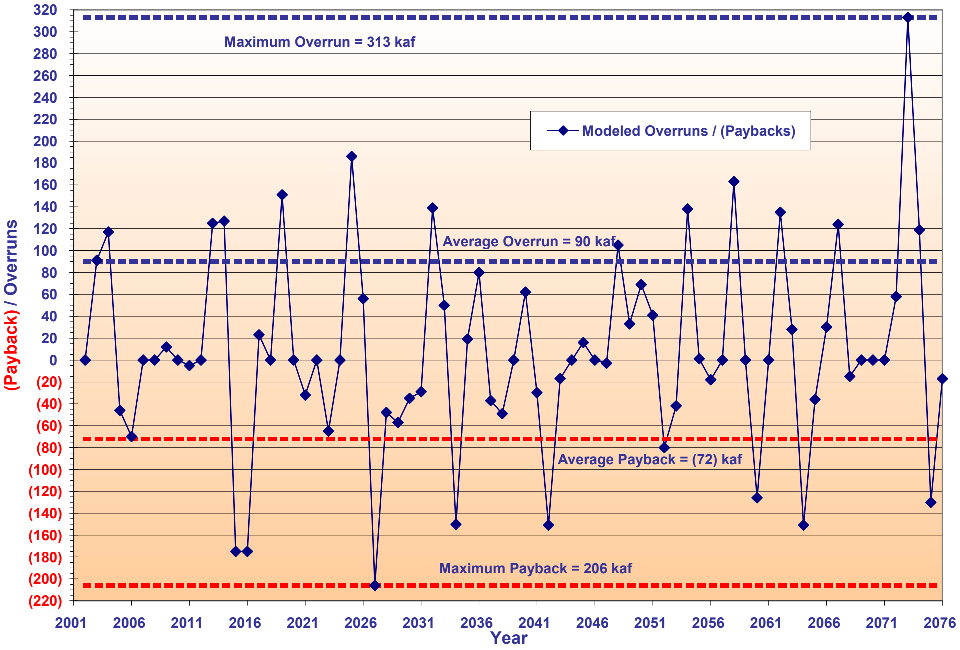
Figures 5 and 6 present the modeling results for the 3-year and 1-year overrun and payback conditions and their effect on the river reach between Hoover Dam and Parker Dam. The data used to produce these figures was generated using the numeric model (simulation accounting) and can be found in Table A-9 in Appendix A. The two modeled conditions show the modeled overruns and paybacks values relating to MWD (for overruns incurred by PVID/YPRD) and IID/CVWD. That is - the payback amounts for these modeled conditions consist of the sum of the paybacks required by MWD (for overruns incurred by PVID/YPRD) and IID/CVWD. The overrun amounts consist of the sum of the overrun incurred by MWD (for overruns incurred by PVID/YPRD) and IID/CVWD. Both conditions assume that the maximum allowed overrun is equal to 10 percent of the Colorado River water entitlement of each respective agency. In the case of MWD, the payback requirements reflect the amount of water that PVID/YPRD used beyond 420 kafy. The detailed Tables that present the accounting results for the various modeled conditions are presented in Appendix B. Additional modeled conditions that considered a lower maximum allowed overrun amount (5 percent) are also included in Appendix B. However, only the condition that considers a maximum allowed overrun equal to 10 percent of entitlement is shown here since these conditions reflect the worst-case scenario.

Figure 5
MWD + IID/CVWD Modeled Overruns and Paybacks and
Resulting River Flow Effects Between Hoover Dam and Parker Dam
Based on 3-Year Payback Schedule w/ Maximum Overrun Equal to 10% of Entitlement



As shown in Figure 5, the average and maximum reduction in river flow resulting from the 3-year payback modeled scenario is 46 and 136 kafy, respectively. The average and maximum increase in river flow resulting from the PVID/YPRD and IID/CVWD incurred overruns under these conditions are 77 and 237 kafy, respectively. Figure 6 shows that the average and maximum reduction in river flow resulting from the 1-year payback modeled conditions is 72 and 206 kafy, respectively. The average and maximum increase in river flow resulting from the PVID/YPRD and IID/CVWD incurred overruns under these conditions are 90 and 313 kafy, respectively.

Figure 6
MWD + IID/CVWD Modeled Overruns and Paybacks and
Resulting River Flow Effects Between Hoover Dam and Parker Dam
Based on 1-Year Payback Schedule w/ Maximum Overrun Equal to 10% of Entitlement



River Flow Between Parker Dam and Imperial Dam

Figures 7 and 8 present the modeling results for the 3-year and 1-year payback conditions and their effect on the river reach between Parker Dam and Imperial Dam. The data used to produce these figures was also generated using the numeric model (simulation accounting). The results of this simulation can be found in Table A-6 in Appendix A. Figures 7 and 8 show only the payback requirement relating to IID/CVWD. The overruns and their effect on this reach of the river are assumed to be equal to those presented above for the portion of the river between Hoover Dam and Parker Dam and were therefore not shown in these figures. The payback amounts for these modeled conditions consist of the paybacks required by IID/CVWD only since the obligation for payback of the PVID/YPRD is assumed by MWD. Paybacks made by MWD for PVID/YPRD incurred overruns affect only that reach of the river between Hoover Dam and Parker Dam. The effect of an MWD payback is a reduction in flow equal to the amount of payback.

The modeled conditions described herein assume that the maximum allowed overrun is equal to 10 percent of the Colorado River water entitlement of each respective agency. The detailed Tables that present the accounting results for these modeled conditions are presented in Appendix B. Additional modeled conditions that considered a lower maximum allowed overrun amount (5 percent) are also included in Appendix B. However, only the condition that considers a maximum allowed overrun equal to 10 percent of entitlement is shown here since these conditions reflect the worst-case scenario.

As shown in Figure 7, the average and maximum reduction in river flow resulting from the 3-year payback modeled conditions is 47 and 136 kafy, respectively. Figure 8 shows that the average and maximum reduction in river flow resulting from the 1-year payback modeled conditions is 63 and 176 kafy, respectively. Again, the overrun results and their resulting potential increase in river flows for this portion of the river are assumed to be similar to those previously described for the portion of the river extending from Hoover Dam to Parker Dam.

Figure 7
IID/CVWD Modeled Paybacks and
Resulting River Flow Effects Between Parker Dam and Imperial Dam
Based on 3-Year Payback Schedule w/ Maximum Overrun Equal to 10% of Entitlement

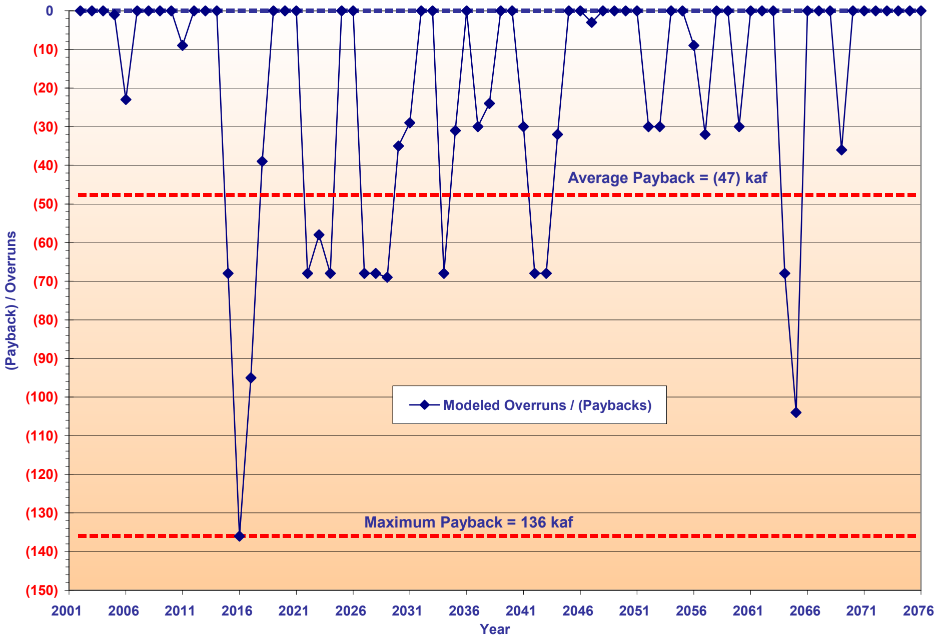
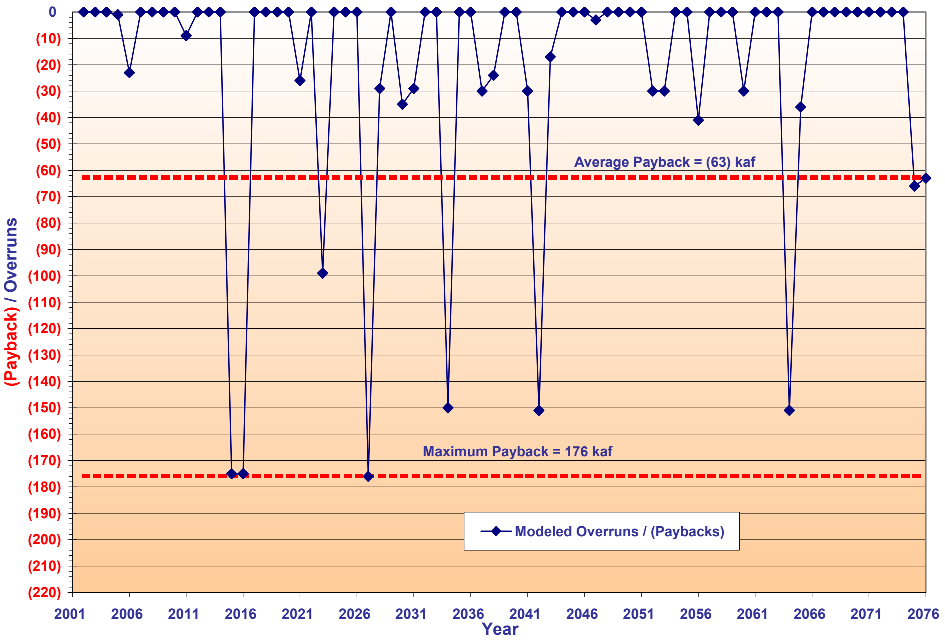


Figure 8
IID/CVWD Modeled Paybacks and
Resulting River Flow Effects Between Parker Dam and Imperial Dam
Based on 1-Year Payback Schedule w/ Maximum Overrun Equal to 10% of Entitlement



EVALUATION OF POTENTIAL STORAGE IMPACTS

Implementation of the IOP could affect Colorado River mainstream reservoirs by reducing the amount of water in storage. Every time that an overrun occurs, the amount of water in storage is reduced. The facilities that could be directly impacted include lakes Mead, Mohave and Havasu. Lake Powell could also be impacted, although indirectly. The indirect effect could be due to the equalization requirements between lakes Powell and Mead. Lakes Mohave and Havasu are regulating reservoirs and are operated under rule curves. Therefore, there would be no affect on the water levels and water in storage.

The facility that could potentially be impacted the most is Lake Mead. A reduction in the amount of water in storage and water levels in this reservoir could potentially occur when an inadvertent overrun is incurred. The amount of reduction would be equivalent to the amount of inadvertent overrun incurred in that specific year. However, this is believed to be a temporary condition since the depletion resulting from the inadvertent overrun would be restored through the payback system, flood waters or a combination of both. At the end of the payback period, the depletion resulting from the inadvertent overrun is assumed to be offset and therefore, the long-term effect is considered to be negligible.

For analysis purposes, the average value of the range of estimated future overrun account balances under each modeled IOP scenario was assumed to represent the most likely scenario and representative of the most likely impacts that could be anticipated. Similarly, the maximum value of the range of estimated future overrun account balances under each modeled IOP scenario was assumed to represent the potential maximum effect on reservoir storage content. However, this is considered to be a condition that has an extremely low probability of occurrence. The likelihood that all agencies would incur an overrun equivalent to the maximum analyzed overrun amount at the same time is an unlikely scenario. Because of the accounting and overrun restrictions, it is most likely that the agencies that will participate in the program will be in different stages of the overrun/payback cycle in any given year. This means that in any given year, some agencies will be incurring an overrun, others will be paying back the overrun they incurred in a previous year, and still others will have a zero balance on their overrun account. The net effect of this is a balancing or stabilization of the overruns and paybacks and their effect on water in storage and lake levels.

To evaluate the potential impacts that the proposed implementation of the IOP could have on storage and lake levels, the following additional assumptions were made:

- Storage impacts were evaluated under IOP conditions that allow a maximum overrun equal to 10 percent of entitlement and 5 percent of entitlement. Each of these conditions was also evaluated under two different payback schedules, 3-year and 1-year payback. The average overrun balance account under each of these modeled conditions was used to evaluate the resulting reduction in storage.
- The payback period was held constant for each model run. Two different payback periods were considered (3-year and 1-year). This means that some model runs assumed that the Lower Basin was in a 3-year payback condition all the time (Lake Mead always stayed above elevation 1125 feet). Although this represents an unrealistic condition, it facilitated and simplified the analysis. The model was also run with the assumption that the Lower Basin was always in 1-year payback conditions (Lake Mead always stayed below elevation 1125 feet).
- The sum of the maximum observed IID/CVWD and PVID/YPRD end-of-year overrun account balances were used as the basis for evaluating the maximum possible reductions in Lake Mead water surface levels, albeit a temporary and highly infrequent condition.
- The sum of the average of the IID/CVWD and PVID/YPRD end-of-year overrun account balances were used as the basis for evaluating the most likely scenario with respect to possible reductions in Lake Mead water surface levels.

Figures 9 and 10 present the modeling results for the 3-year payback modeled scenario and assuming that the maximum allowed overrun is equal to 10 percent of the Colorado River water entitlement of each agency. Both conditions reflect the end-of-year overrun account balances and the potential volume of reduced Lake Mead storage under the respective modeled conditions. The end-of-year overrun account balances for these modeled conditions consist of the sum of the end-of-year overrun account balances for PVID/YPRD and IID/CVWD. However, as noted before, PVID/YPRD modeled overruns are treated differently than those incurred by IID/CVWD and MWD is responsible for the payback of PVID/YPRD overruns. The detailed Tables that present the accounting results for these modeled conditions are presented in Appendix B. Additional modeled conditions that considered a lower maximum allowed overrun amount (5 percent) are also included in Appendix B.

As shown in Figure 9, the average and maximum reduction in Lake Mead storage resulting from the 3-year payback modeled conditions is 66 and 331 kafy, respectively. Figure 10 shows that the average and maximum reduction in Lake Mead storage resulting from the 1-year payback modeled conditions is 42 and 254 kafy, respectively.

Figure 9
End-of-Year Overrun Account Balances and Resulting Reductions in Lake Mead Storage
(PVID/YPRD/IID/CVWD End-of-Year Overrun Account Balances – Based on 10% O.R. & 3-Year Payback Schedule)

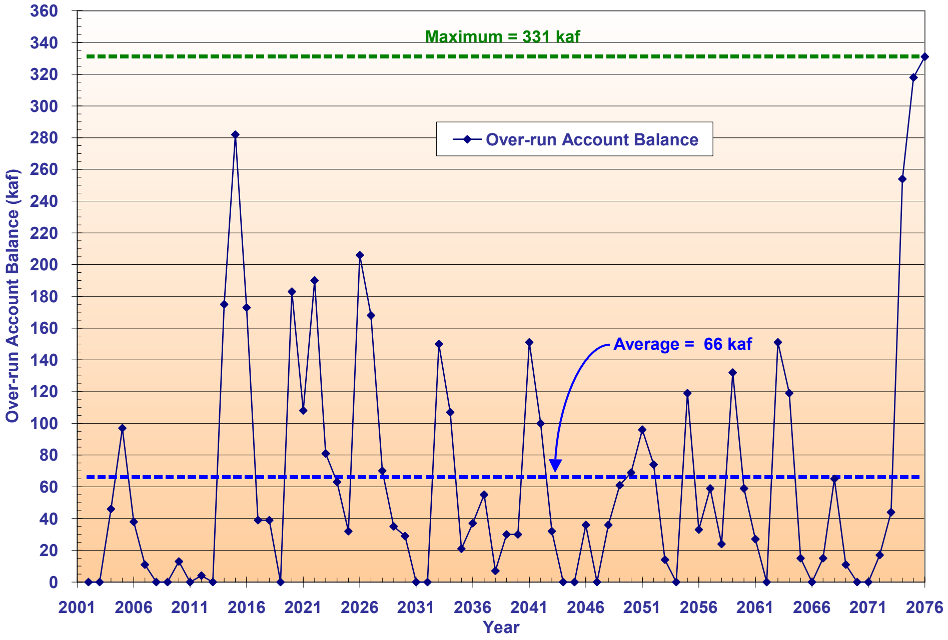
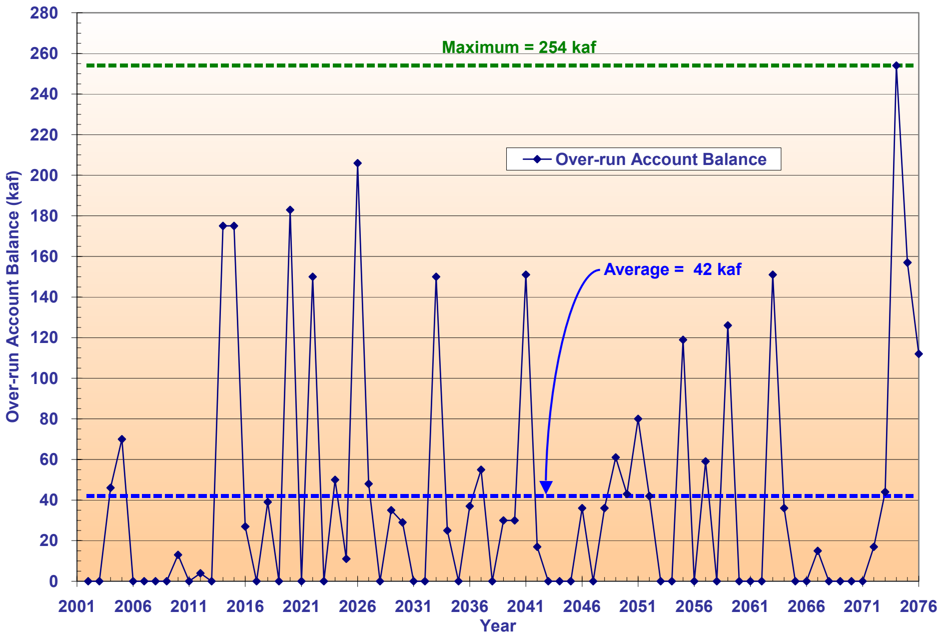


Figure 10
End-of-Year Overrun Account Balances and Resulting Reductions in Lake Mead Storage
(PVID/YPRD/IID/CVWD End-of-Year Overrun Account Balances – Based on 10% O.R. & 1-Year Payback Schedule



EVALUATION OF POTENTIAL IMPACTS TO FLOOD RELEASES AND EXCESS FLOWS TO MEXICO

The proposed implementation of the IOP could impact Lake Mead flood control releases and excess flows by reducing the amount of water in storage at Lake Mead. For the purposes of this analysis, excess flows consist of any water in excess of 1.7 maf that is delivered to Mexico at the Northerly International Boundary (NIB) located upstream of Morelos Dam. These excess flows are assumed to occur entirely due to flood control releases originating at Hoover Dam. A reduction in the amount of water in storage would effectively increase the ability of Lake Mead to capture more water and thereby reduce the frequency of flood releases. The annual reduction in the amount of water in storage would be equivalent to the amount of inadvertent overrun incurred in that specific year. Again, this is believed to be a temporary condition since any depletion resulting from the inadvertent overrun would be restored through the payback system. For analysis purposes, the mean and maximum values of the range of estimated future overrun account balances under each modeled IOP scenario were used to evaluate the potential effect on Lake Mead flood control releases and excess flows to Mexico.

Analysis of Water Transfers and IOP

This section compares the results of the evaluation of the effect of the IOP on the frequency of flood control releases from Hoover Dam and impacts to the delivery of excess flows to Mexico under the Implementation Agreement modeled conditions to the No Action modeled conditions. More properly, this analysis evaluates the effect of the combined water transfers and IOP. The results of a separate analysis that compares the observed flood control frequencies and impacts to the delivery of excess flows to Mexico under the Cumulative Analysis modeled conditions to the Baseline for Cumulative Analysis modeled conditions is provided in the subsequent section.

Figures 11 and 12 show the effect of the IOP on the frequency of flood control releases from Hoover Dam. Both of the figures compare the observed flood control frequencies under the No Action modeled conditions to the modeled Implementation Agreement modeled conditions that included the IOP criteria. For this analysis, the IOP criteria was added to the RiverWare model run that was used to model the Implementation Agreement conditions and only considered the overrun account balances that were calculated using the maximum allowed 10 percent overrun criteria with a 3-year payback schedule. The flood flow frequency for each year was calculated by counting the number of traces that showed flood flows and dividing that number by 85, the number of total traces simulated in the model (RiverWare).

Figure 11 compares the differences in flood release frequencies when the average observed overrun account balance of 66 kaf was used to model the depleted storage on Lake Mead. As shown in this figure, the frequency differed in only 15 of the 75 years modeled. In approximately one-third of these years the modeled IOP criteria actually yielded a slightly higher frequency of flood release than those observed under the No Action conditions, albeit a maximum of 1.2 percent better. In 10 of the 75 years modeled, the modeled IOP criteria resulted in a reduced frequency of flood releases. The maximum observed reduction in flood control frequency was 1.2 percent.

Figure 12 compares the differences in flood release frequencies when the maximum overrun account balance of 331 kaf was used to model the depleted storage in Lake Mead. The frequency differed with the modeled IOP criteria yielding a generally slightly lower frequency of flood release than those observed under the No Action conditions. A decrease in frequency occurred in approximately 40 of the 75 years modeled and the decreases generally ranged between 1 percent to a maximum of 3.5 percent. The average decrease in frequency was approximately 1.8 percent. However, an increase in frequency did occur in five of the 75 years modeled. The average frequency increase in these years was approximately 1.18 percent.

Figure 11
Comparison of Lake Mead Flood Release Frequency
No Action to IA-IOP w/ Average Lower Basin Overrun Account Balance of 66 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

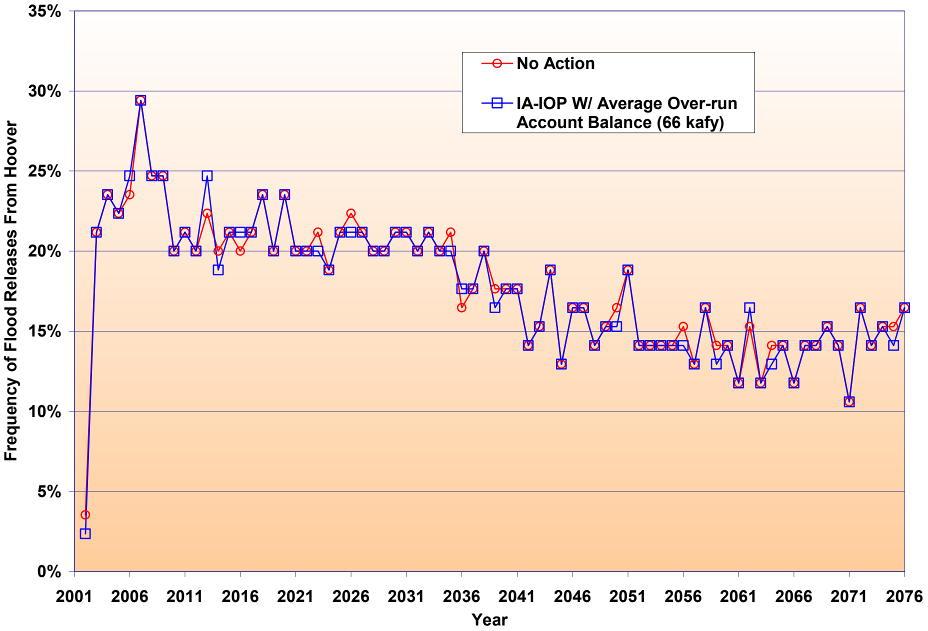
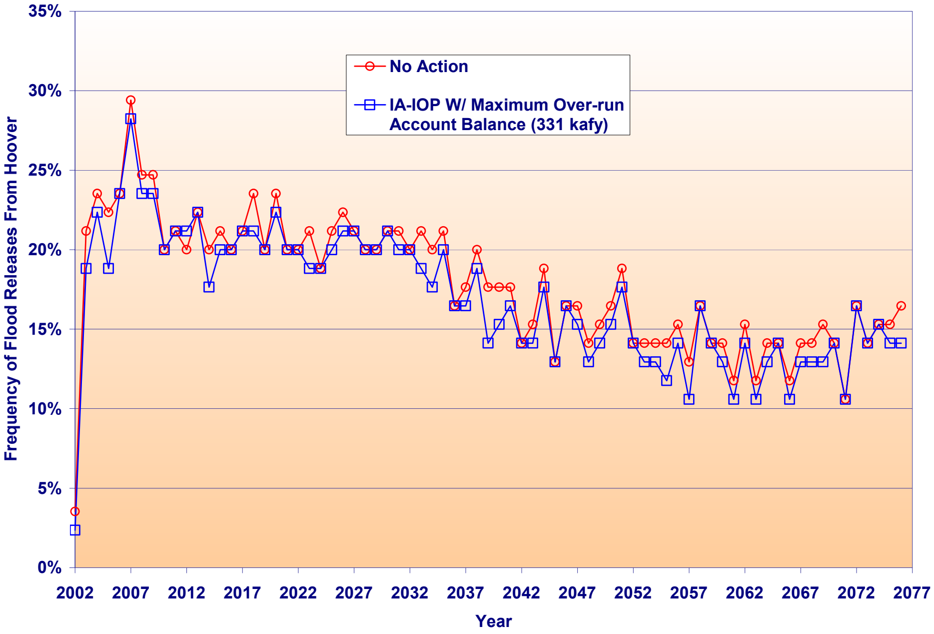


Figure 12
Comparison of Lake Mead Flood Release Frequency
No Action to IA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule



dditional analyses were performed to evaluate the potential impacts that the IOP combined with the Implementation Agreement modeled conditions would have on excess flows that occur below the Mexico diversion at Morelos Dam. Specifically, these additional analyses compared the probability of occurrence of excess flows greater than 250 kaf and 1.0 maf below the Mexico diversion at Morelos Dam between the different modeled conditions. The results of these analyses are provided in Attachment C to this technical memorandum. A summary of the results is presented in Table 4.

Table 4
Probability Of Occurrence Of Excess Flows Greater Than 250 Kaf And 1.0 Maf
Below The Mexico Diversion At Morelos Dam
Comparison Between No Action and Combined Implementation Agreement and IOP Modeled Conditions

	Differences in Probability of Excess Flows Greater than 250 kaf		**Differences in Probability of Excess Flows Greater than 1.0 maf**	
Differences in Probability	**NA to IA-IOP w/ Overrun Account Balance of 66 kaf**	**NA to IA-IOP w/ Account Balance of 331 kaf**	**NA to IA-IOP w/ Overrun Account Balance of 66 kaf**	**NA to IA-IOP w/ Overrun Account Balance of 331 kaf**
No. of Years w/ Observed Differences	10	45	22	33
No. of Years w/ Observed Increases	5	8	4	4
No. of Years w/ Observed Decreases	5	37	18	29
Average Difference	0.0%	-0.7%	-0.2%	-0.5%
Maximum Increase	1.2%	2.4%	1.2%	1.2%
Maximum Decrease	-1.2%	-3.5%	-2.4%	-3.5%

Figures 11 and 12 provided an assessment of the effect of the combined Implementation Agreement and IOP modeled criteria on the frequency of flood releases. The figures that follow (Figures 13 through 20) provide an assessment on the potential impact to the magnitude of excess flows below Morelos Dam. Again, these excess flows represent the volume over the 1.7 mafy entitlement that is delivered to Mexico under the Treaty.

Figures 13 through 16 compare the magnitude of excess flows under the No Action to the combined Implementation Agreement and IOP criteria. The IOP criteria used in these model runs considers the average Lower Division states' overrun account balance of 66 kafy, a 10 percent maximum allowed overrun and a 3-year payback schedule. Figure 13 shows the range of observed magnitudes of excess flows for year 2006, Figure 14 shows the range of observed magnitudes of excess flows for year 2016, Figure 15 shows the range of observed magnitudes of excess flows for year 2026, and Figure 16 shows the range of observed magnitudes of excess flows for year 2050. In all these years, the results of the analysis indicate that the magnitude of observed excess flows is essentially the same under the two model conditions.

Figure 13
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2006
No Action to IA-IOP w/ Average Lower Basin Over-run Account Balance of 66 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

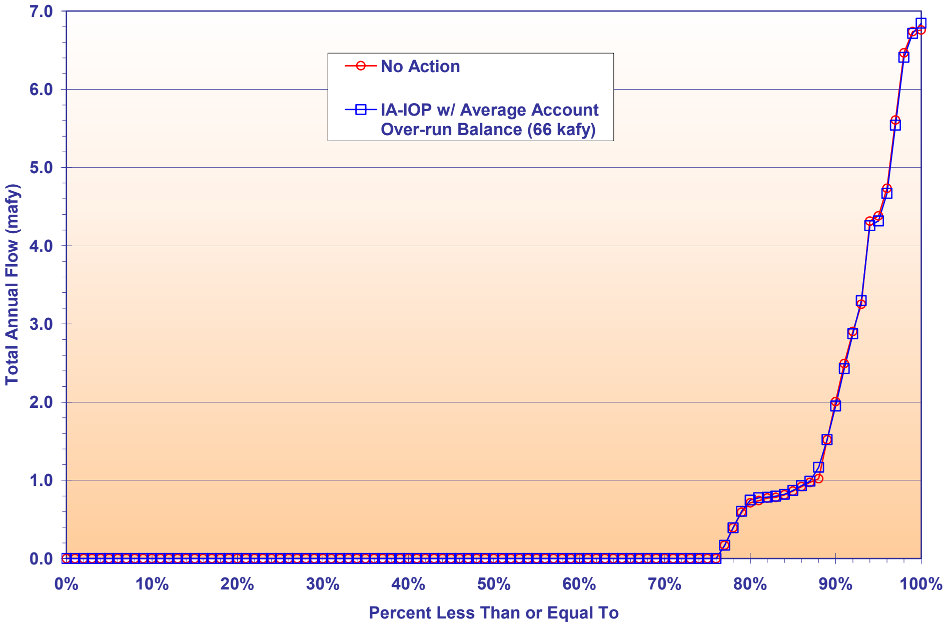


Figure 14
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2016
No Action to IA-IOP w/ Average Lower Basin Overrun Account Balance of 66 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

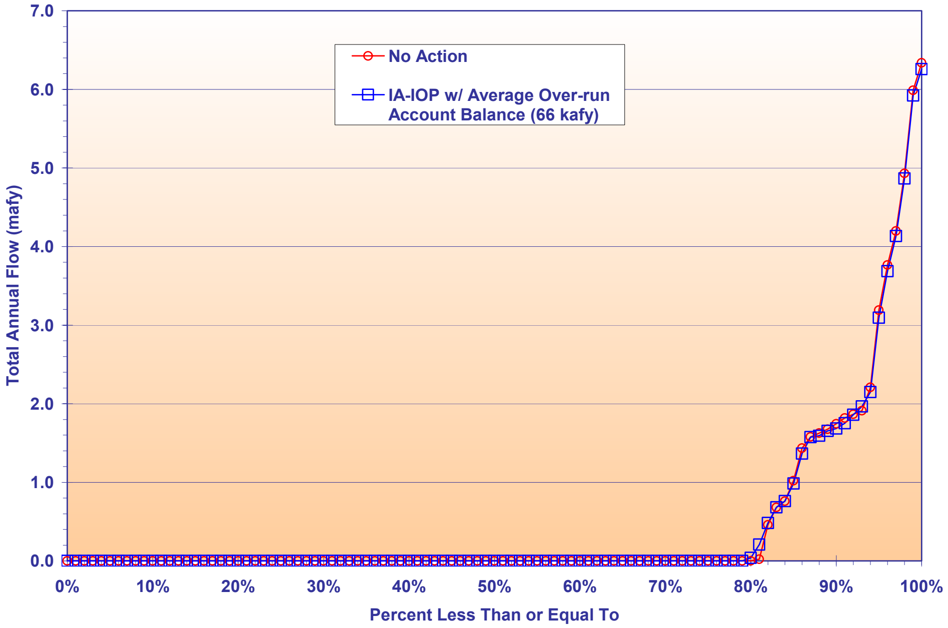


Figure 15
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2026
No Action to IA-IOP w/ Average Lower Basin Overrun Account Balance of 66 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

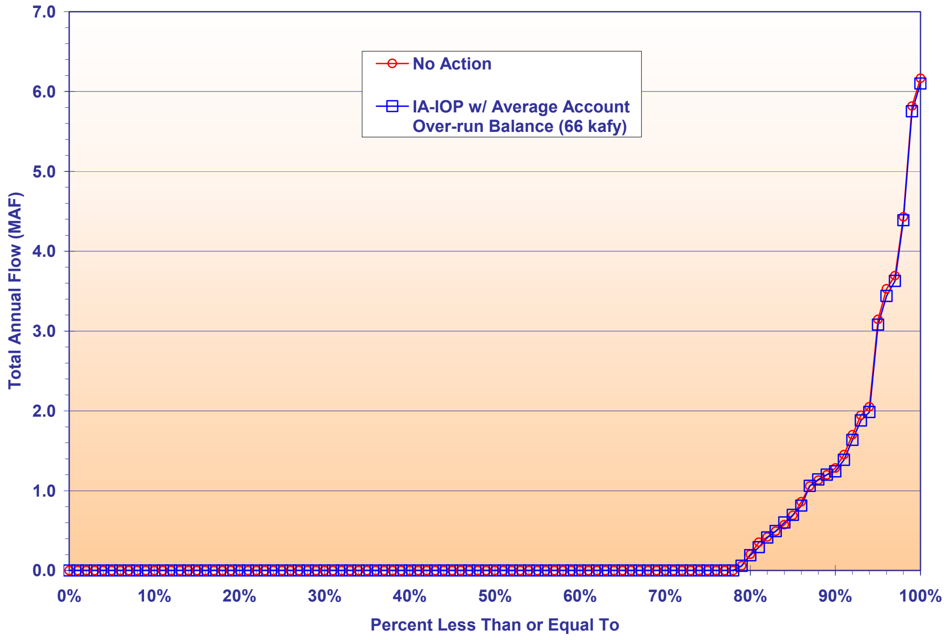
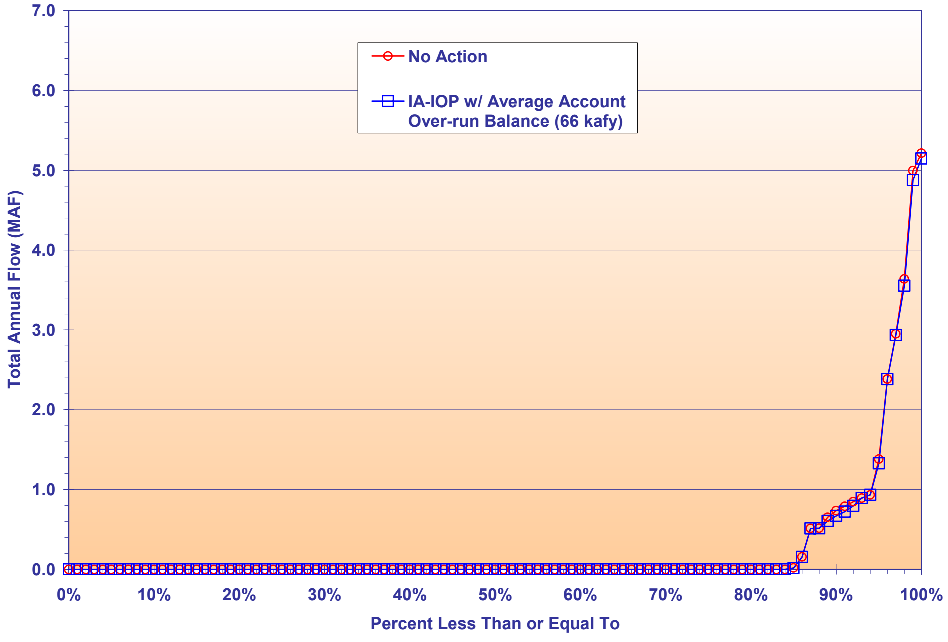


Figure 16
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2050
No Action to IA-IOP w/ Average Lower Basin Overrun Account Balance of 66 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule



Figures 17 through 20 present a similar comparison of the magnitude of excess flows under the No Action to the combined Implementation Agreement and IOP criteria. However, under these modeled conditions, the IOP criteria used in this model run considered the maximum observed Lower Basin overrun account balance of 331 kafy. The maximum allowed overrun and payback schedule remained the same (maximum 10 percent overrun allowed with 3-year payback).

Figure 17 shows the range of observed magnitudes of excess flows for year 2006, Figure 18 shows the range of observed magnitudes of excess flows for year 2016, Figure 19 shows the range of observed magnitudes of excess flows for year 2026, and Figure 20 shows the range of observed magnitudes of excess flows for year 2050. In year 2006, the magnitude of the observed excess flows are essentially the same, albeit with a slight change in the frequency. The positive effect seen in the lower excess flow range (excess flows less than 1.0 mafy) is perhaps more related to the effect of the water transfers modeled as part of the Implementation Agreement conditions. The negative effect seen on the higher range of the excess flows (excess flows greater than 1.0 mafy) can be mostly attributed to the IOP modeled criteria. The same generally applies to years 2016, 2026 and 2050. The observed increases in magnitude ranged from approximately 2,000 af to approximately 148,000 af with the average being around 88,000 af. The observed decreases in magnitude ranged from approximately 1,300 af to approximately 742,000 af with the average being around 230,000 af.

Figure 17
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2006
No Action to IA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

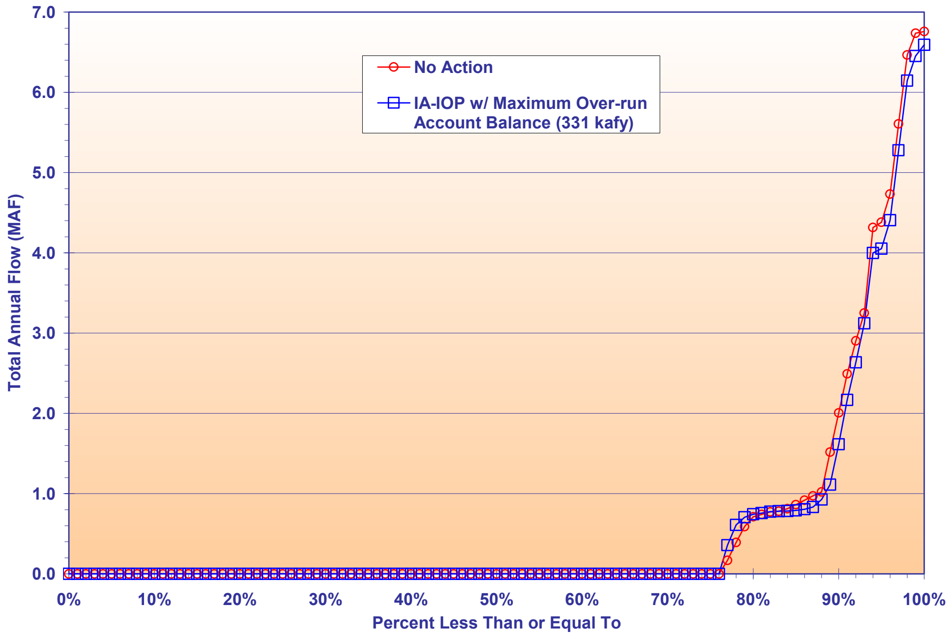


Figure 18
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2016
No Action to IA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

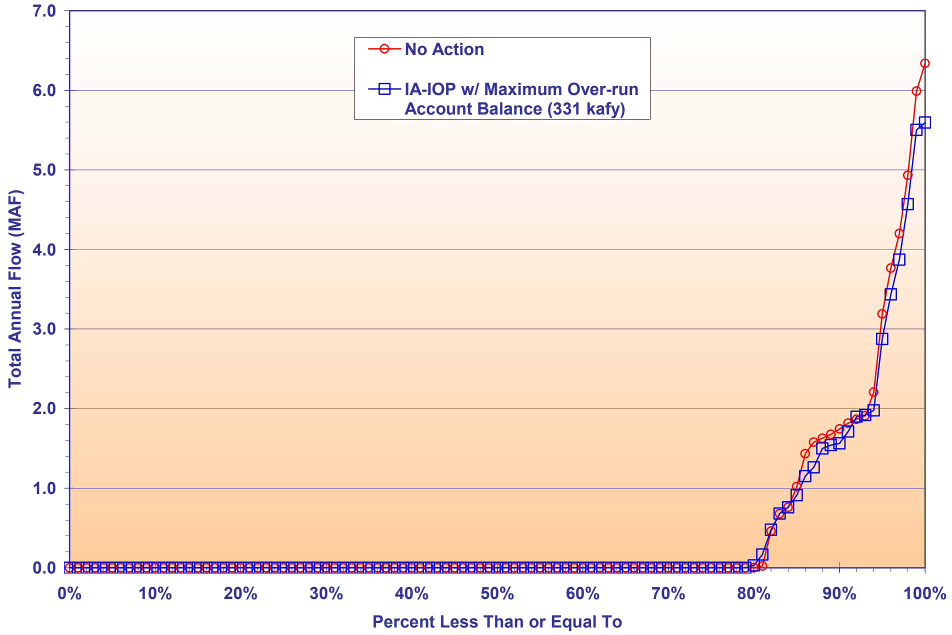


Figure 19
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2026
No Action to IA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

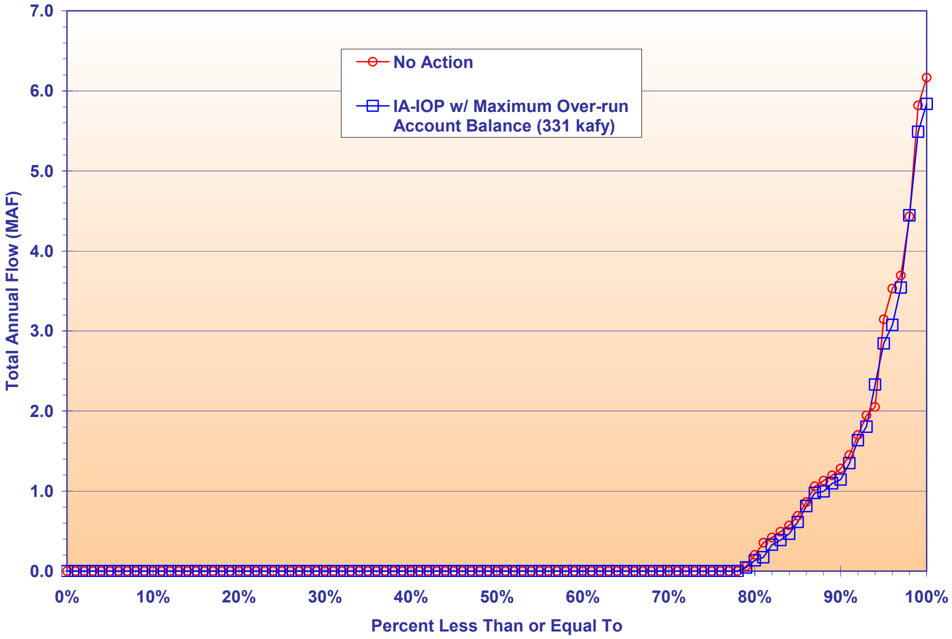
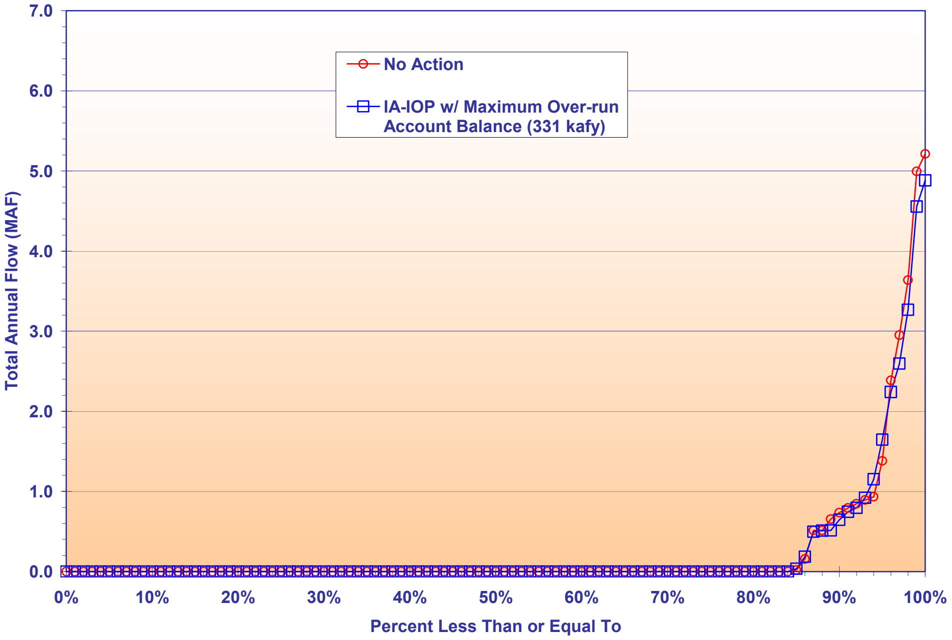


Figure 20
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2050
No Action to IA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule



Tables 5 through 8 present a tabular summary of the data depicted in Figures 13 through 20. These Tables compare and provide a summary of the differences between the No Action and the Implementation Agreement that considered an average Lower Basin Overrun Account Balance of 66 kafy and the differences between the No Action and the Implementation Agreement that considered a Lower Basin Overrun Account Balance of 331 kafy. Table 5 provides the comparison of the modeled results for year 2006, and Tables 6, 7 and 8 provide the comparisons of years 2016, 2026 and 2050, respectively. Again, all of these modeled conditions further considered a 10 Percent Maximum Allowed Overrun and a 3-Year Payback Schedule.

Table 5A
Comparison of Observed Excess Flows Below Morelos Dam for Year 2006
Under No Action, IA-IOP 66 kafy, and IA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	No Action	IA-IOP 66 kafy	IA-IOP 331 kafy
Number of Traces	85	85	85
Number of Occurrences of Observed Excess Flows	20	20	20
Range of Observed Excess Flows (afy)	247,434 to 6,757,064	247,434 to 6,843,182	525,724 to 6,590,573
Mean of Observed Excess Flows (afy)	2,542,361	2,539,481	2,395,568

Table 5B Differences in Observed Excess Flows Below Morelos Dam for Year 2006 Comparison of the No Action to IA-IOP 66 kafy and No Action to IA-IOP 331 kafy Modeled Conditions 10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule		
Comparison Factor	**Differences Between No Action and IA-IOP 66 kafy**	**Differences Between No Action to IA-IOP 331 kafy**
Number of Occurrences of No Difference in Excess Flows	5	4
Number of Occurrences of Observed Decreased Flows	10	15
Range of Differences in Decreased Flows (af)	35,841 to 67,267	17,429 to 505,924
Average of Differences in Decreased Flows (af)	60,783	231,370
Number of Occurrences of Observed Increased Flows	5	1
Range of Differences in Increased Flows (af)	4,357 to 214,934	534,704 to 534,704
Average of Differences in Increased Flows (af)	110,049	534,704
Average Difference of Observed Excess Flows (af)	-2,879	-146,792

As noted in Table 5, for year 2006, the average of the differences in observed excess flows below Morelos Dam between the No Action and the Implementation Agreement that considered an average Lower Basin Overrun Account Balance of 66 kafy modeled conditions, is a decrease of 2,879 af. This volume represents an approximately 0.11 percent reduction from the average excess flow (2,542,361 af) observed under the No Action modeled conditions. The average of the differences in observed excess flows between the No Action and the Implementation Agreement that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, is a decrease of 146,792 af, which represents an approximately 5.8 percent reduction from the average excess flow (2,542,361 af) observed under the No Action modeled conditions, for year 2006.

Table 6A Comparison of Observed Excess Flows Below Morelos Dam for Year 2016 Under No Action, IA-IOP 66 kafy, and IA-IOP 331 kafy Modeled Conditions 10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule			
Comparison Factor	**No Action**	**IA-IOP 66 kafy**	**IA-IOP 331 kafy**
Number of Traces	85	85	85
Number of Occurrences of Observed Excess Flows	16	17	17
Range of Observed Excess Flows (afy)	522,340 to 6,337,995	194,557 to 6,259,313	150,599 to 5,595,282
Mean of Observed Excess Flows (afy)	2,510,881	2,336,563	2,172,049

Table 6B Differences in Observed Excess Flows Below Morelos Dam for Year 2016 Comparison of the No Action to IA-IOP 66 kafy and No Action to IA-IOP 331 kafy Modeled Conditions 10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule		
Comparison Factor	**Differences Between No Action and IA-IOP 66 kafy**	**Differences Between No Action to IA-IOP 331 kafy**
Number of Occurrences of No Difference in Excess Flows	5	4
Number of Occurrences of Observed Decreased Flows	10	10
Range of Differences in Decreased Flows (af)	35,728 to 194,398	142,270 to 852,726
Average of Differences in Decreased Flows (af)	80,399	387,853
Number of Occurrences of Observed Increased Flows	2	3
Range of Differences in Increased Flows (af)	156,919 to 194,437	150,479 to 280,119
Average of Differences in Increased Flows (af)	175,678	209,714
Average Difference of Observed Excess Flows (af)	-26,626	-191,140

Table 6 presented a summary and compared the observed excess flows for the modeled year 2016. For this modeled year, the average of the differences in observed excess flows below Morelos Dam between the No Action and the Implementation Agreement that considered an average Lower Basin Overrun

Account Balance of 66 kafy modeled conditions, is a decrease of 26,626 af, which represents an approximately 1.1 percent reduction from the average observed excess flow (2,510,881 af) observed under the No Action modeled conditions. The average of the differences in observed excess flows below Morelos Dan between the No Action and the Implementation Agreement that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, is a decrease of 191,140 af, which represents an approximately 7.6 percent reduction from the average excess flow (2,510,881 af) observed under the No Action modeled conditions, for year 2016.

Table 7A
Comparison of Observed Excess Flows Below Morelos Dam for Year 2026
Under No Action, IA-IOP 66 kafy, and IA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	No Action	IA-IOP 66 kafy	IA-IOP 331 kafy
Number of Traces	85	85	85
Number of Occurrences of Observed Excess Flows	18	18	18
Range of Observed Excess Flows (afy)	166,276 to 6,166,892	166,275 to 6,101,057	125,648 to 5,836,797
Mean of Observed Excess Flows (afy)	1,997,028	1,960,524	1,867,481

Table 7B
Differences in Observed Excess Flows Below Morelos Dam for Year 2026
Comparison of the No Action to IA-IOP 66 kafy and No Action to IA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Differences Between No Action and IA-IOP 66 kafy	Differences Between No Action to IA-IOP 331 kafy
Number of Occurrences of No Difference in Excess Flows	4	1
Number of Occurrences of Observed Decreased Flows	12	14
Range of Differences in Decreased Flows (af)	1 to 102,811	1 to 455,996
Average of Differences in Decreased Flows (af)	60,048	271,088
Number of Occurrences of Observed Increased Flows	2	3
Range of Differences in Increased Flows (af)	10,924 to 52,575	178,103 to 747,608
Average of Differences in Increased Flows (af)	31,750	487,793
Average Difference of Observed Excess Flows (af)	-36,504	-129,547

Table 7 presented a summary and compared the observed excess flows for the modeled year 2026. For this modeled year, the average of the differences in observed excess flows below Morelos Dam between the No Action and the Implementation Agreement that considered an average Lower Basin Overrun Account Balance of 66 kafy modeled conditions, is a decrease of 36,504 af, which represents an approximately 1.8 percent reduction from the average observed excess flow (1,997,028 af) observed under the No Action modeled conditions. The average of the differences in observed excess flows below Morelos Dan between the No Action and the Implementation Agreement that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, is a decrease of 129,547 af, which represents an approximately 6.5 percent reduction from the average excess flow (1,997,028 af) observed under the No Action modeled conditions, for year 2026.

Table 8A
Comparison of Observed Excess Flows Below Morelos Dam for Year 2050
Under No Action, IA-IOP 66 kafy, and IA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	No Action	IA-IOP 66 kafy	IA-IOP 331 kafy
Number of Traces	85	85	85
Number of Occurrences of Observed Excess Flows	13	13	13
Range of Observed Excess Flows (afy)	45,156 to 5,212,767	44,859 to 5,147,031	88,274 to 4,883,090
Mean of Observed Excess Flows (afy)	1,750,421	1,712,683	1,654,026

Table 8B
Differences in Observed Excess Flows Below Morelos Dam for Year 2050
Comparison of the No Action to IA-IOP 66 kafy and No Action to IA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Differences Between No Action and IA-IOP 66 kafy	Differences Between No Action to IA-IOP 331 kafy
Number of Occurrences of No Difference in Excess Flows	5	4
Number of Occurrences of Observed Decreased Flows	7	7
Range of Differences in Decreased Flows (af)	297 to 137,449	201,193 to 460,039
Average of Differences in Decreased Flows (af)	74,758	337,922
Number of Occurrences of Observed Increased Flows	1	2
Range of Differences in Increased Flows (af)	32,715 to 32,715	43,118 to 1,069,202
Average of Differences in Increased Flows (af)	32,715	556,160
Average Difference of Observed Excess Flows (af)	-37,738	-96,395

Table 8 presented a summary and compared the observed excess flows for the modeled year 2050. For this modeled year, the average of the differences in observed excess flows below Morelos Dam between the No Action and the Implementation Agreement that considered an average Lower Basin Overrun Account Balance of 66 kafy modeled conditions, is a decrease of 37,738 af, which represents an approximately 2.2 percent reduction from the average observed excess flow (1,750,421 af) observed under the No Action modeled conditions. The average of the differences in observed excess flows below Morelos Dan between the No Action and the Implementation Agreement that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, is a decrease of 96,395 af, which represents an approximately 5.5 percent reduction from the average excess flow (1,750,421 af) observed under the No Action modeled conditions, for year 2050.

It should be emphasized that not all of the differences in observed excess flows were negative (reductions). In both comparisons, there were modeled years where the differences were positive, which represented increases in the magnitude of observed excess flows. For example, in the evaluation of the comparison of the differences in the observed excess flows below Morelos Dam between the No Action and the Implementation Agreement that considered an average Lower Basin Overrun Account Balance of 66 kafy modeled conditions, approximately 16.3 percent of instances where differences were observed, the differences were positive which represented increase in the magnitude of excess flows. However, for the 75-year period of analysis, the average of the differences was a reduction of 35,811 af.

In the evaluation of the comparison of the differences in the observed excess flows below Morelos Dam between the No Action and the Implementation Agreement that considered a Lower Basin Overrun Account Balance of 331kafy modeled conditions, approximately 11.7 percent of instances where differences were observed, the differences were positive which represented increase in the magnitude of excess flows. However, for the 75-year period of analysis, the average of the differences was a reduction of 219,539 af.

Analysis of Cumulative Impact

The previous section provided a comparison of the results of the evaluation of the effect of the IOP on the frequency of flood control releases from Hoover Dam and impacts to the delivery of excess flows to Mexico under the Implementation Agreement modeled conditions to the No Action modeled conditions. This section compares the results of the evaluation of the effect of the IOP on the frequency of flood control releases from Hoover Dam and impacts to the delivery of excess flows to Mexico under the Cumulative Analysis modeled conditions to the Baseline for Cumulative Analysis (Baseline) modeled conditions.

Figures 21 and 22 show the effect of the IOP on the frequency of flood control releases from Hoover Dam. Both of the figures compare the observed flood control frequencies under the Baseline for Cumulative Analysis modeled conditions to the modeled conditions that included the IOP criteria. For this analysis, the IOP criteria was added to the RiverWare model run that was used to model the Cumulative Analysis conditions and only considered the overrun account balances that were calculated using the maximum allowed 10 percent overrun criteria with a 3-year payback schedule. The flood flow frequency for each year was calculated by counting the number of traces that showed flood flows and dividing that number by 85, the number of total traces simulated in the model (RiverWare).

Figure 21 compares the differences in flood release frequencies when the average observed overrun account balance of 66 kaf was used to model the depleted storage on Lake Mead. As shown in this figure, the frequency differed in 32 of the 75 years modeled. A decrease in frequency occurred in approximately 31 of the 75 years modeled and the decreases generally ranged between 1 percent to a maximum of 3.5 percent. The average decrease in frequency was approximately 1.9 percent. However, an increase in frequency did occur in one of the 75 years modeled. The frequency increase in this year was approximately 1.18 percent.

Figure 22 compares the differences in flood release frequencies when the maximum overrun account balance of 331 kaf was used to model the depleted storage in Lake Mead. The frequency differed with the modeled IOP criteria yielding a generally slightly lower frequency of flood release than those observed under the Baseline for Cumulative Analysis conditions. A decrease in frequency occurred in approximately 54 of the 75 years modeled and the decreases generally ranged between 1 percent to a maximum of 4.7 percent. The average decrease in frequency was approximately 2.1 percent. An increase in frequency did not occur in any of the 75 years modeled.

Additional analyses were performed to evaluate the potential impacts that the IOP combined with the Cumulative Analysis modeled conditions would have on excess flows that occur below the Mexico diversion at Morelos Dam. Specifically, these additional analyses compared the probability of occurrence of excess flows greater than 250 kaf and 1.0 maf below the Mexico diversion at Morelos Dam between the different modeled conditions. The results of these analyses are provided in Attachment C to this technical memorandum. A summary of the results is presented in Table 9.

Table 9
Probability Of Occurrence Of Excess Flows Greater Than 250 Kaf And 1.0 Maf Below The Mexico Diversion At Morelos Dam
Comparison Between Baseline and Combined Cumulative Analysis and IOP Modeled Conditions

	Probability of Excess Flows Greater than 250 kaf		Probability of Excess Flows Greater than 1.0 maf	
Differences in Probability	Baseline to CA-IOP w/ Overrun Account Balance of 66 kaf	Baseline to CA-IOP w/ Overrun Account Balance of 331 kaf	Baseline to CA--IOP w/ Overrun Account Balance of 66 kaf	Baseline to CA--IOP w/ Overrun Account Balance of 331 kaf
No. of Years w/ Observed Differences	34	48	37	43
No. of Years w/ Observed Increases	4	3	7	2
No. of Years w/ Observed Decreases	30	45	30	41
Average Difference	-0.8%	-1.4%	-0.6%	-1.1%
Maximum Increase	1.2%	1.2%	2.4%	1.2%
Maximum Decrease	-4.7%	-5.9%	-3.5%	-3.5%

Figures 21 and 22 provide an assessment of the effect of the combined Cumulative Analysis and IOP modeled criteria on the frequency of flood releases. The figures that follow (Figures 23 through 30) provide an assessment on the potential impact to the magnitude of excess flows below Morelos Dam. Again, these excess flows represent the volume over the 1.7 mafy entitlement that is delivered to Mexico under the Treaty.

Figure 21
Comparison of Lake Mead Flood Release Frequency
Baseline to CA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

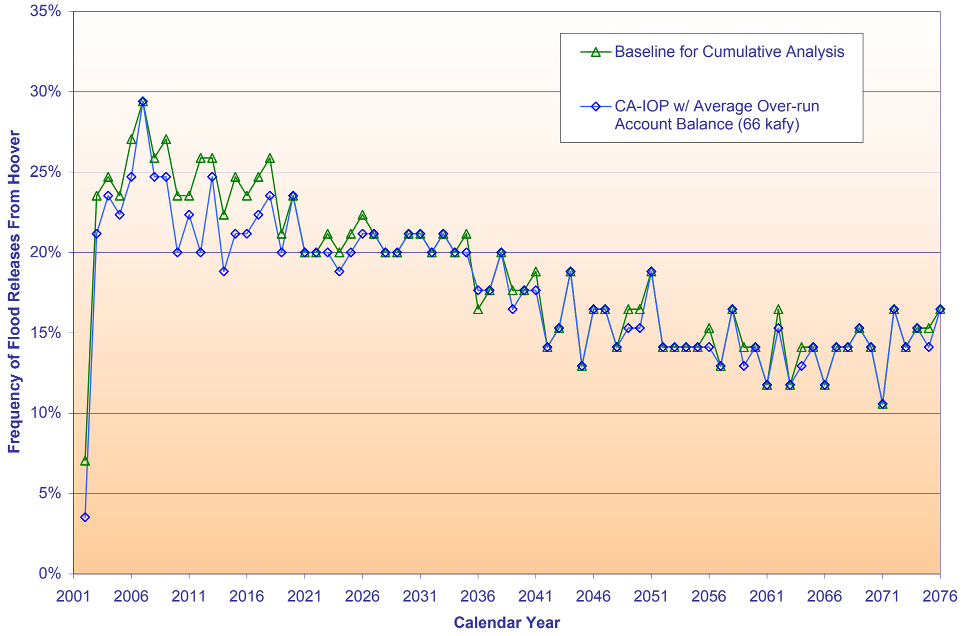
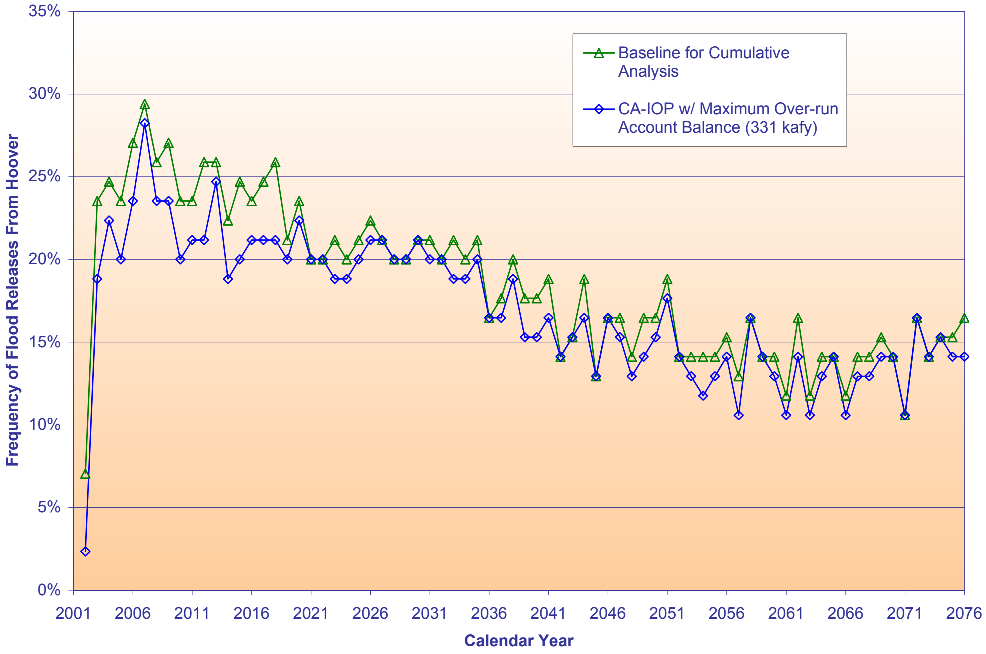


Figure 22
Comparison of Lake Mead Flood Release Frequency
Baseline to CA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule



Figures 23 through 26 compare the magnitude of excess flows under the Baseline for Cumulative Analysis to the combined Cumulative Analysis and IOP criteria. The IOP criteria used in these model runs considers the average Lower Division states' overrun account balance of 66 kafy, a 10 percent maximum allowed overrun and a 3-year payback schedule. Figure 23 shows the range of observed magnitudes of excess flows for year 2006, Figure 24 shows the range of observed magnitudes of excess flows for year 2016, Figure 25 shows the range of observed magnitudes of excess flows for year 2026, and Figure 26 shows the range of observed magnitudes of excess flows for year 2050. In all these years, the results of the analysis indicate that the magnitude of observed excess flows is essentially the same under the two model conditions.

Figure 23
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2026
Baseline to CA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

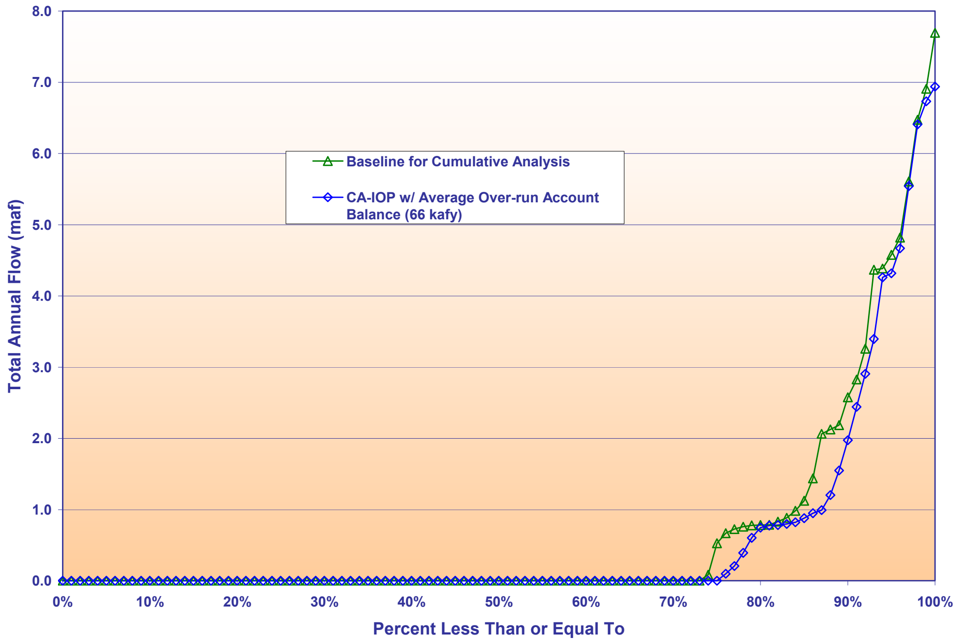


Figure 24
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2016
Baseline to CA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

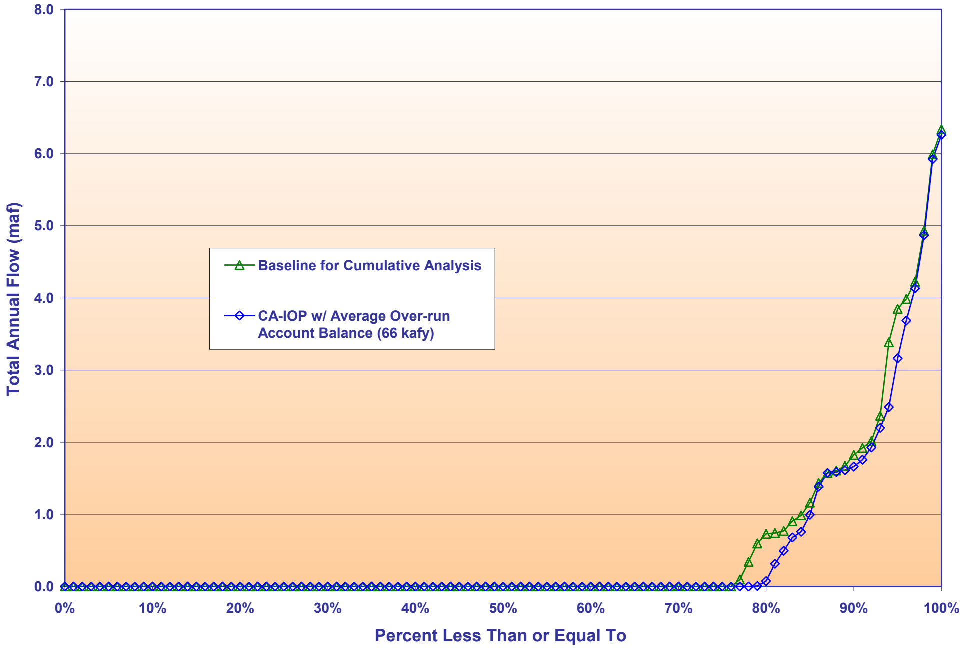


Figure 25
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2026
Baseline to CA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

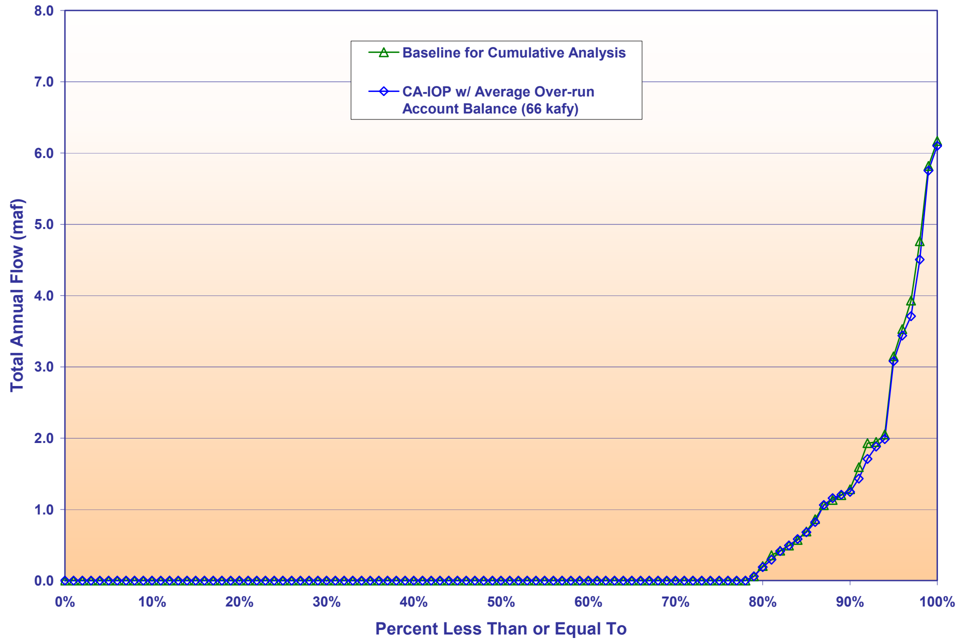
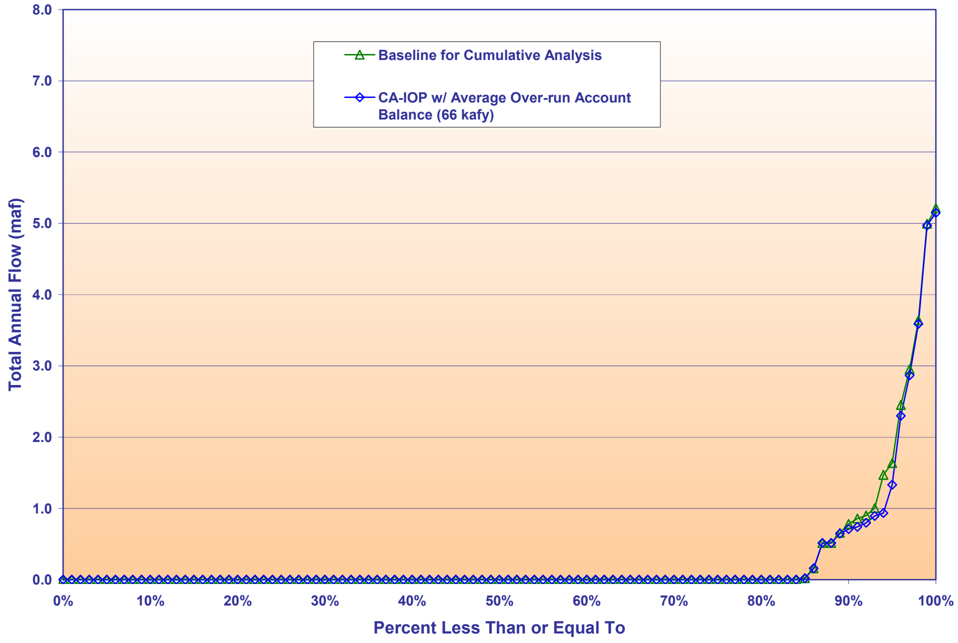


Figure 26
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2050
Baseline to CA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule



Figures 27 through 30 present a similar comparison of the magnitude of excess flows under the Baseline for Cumulative Analysis to the combined Cumulative Analysis and IOP criteria. However, under these modeled conditions, the IOP criteria used in this model run considered the maximum observed Lower Basin overrun account balance of 331 kafy. The maximum allowed overrun and payback schedule remained the same (maximum 10 percent overrun allowed with 3-year payback).

Figure 27 shows the range of observed magnitudes of excess flows for year 2006, Figure 28 shows the range of observed magnitudes of excess flows for year 2016, Figure 29 shows the range of observed magnitudes of excess flows for year 2026, and Figure 30 shows the range of observed magnitudes of excess flows for year 2050. In year 2006, the magnitude of the observed excess flows are essentially the same, albeit with a slight change in the frequency. The positive effect seen in the lower excess flow range (excess flows less than 1.0 mafy) is perhaps more related to the effect of the water transfers modeled as part of the Cumulative Analysis conditions. The negative effect seen on the higher range of the excess flows (excess flows greater than 1.0 mafy) can be mostly attributed to the IOP modeled criteria. The same generally applies to years 2016, 2026 and 2050. The observed increases in magnitude ranged from approximately 2,000 af to approximately 148,000 af with the average being around 88,000 af. The observed decreases in magnitude ranged from approximately 1,300 af to approximately 742,000 af with the average being around 230,000 af.

Figure 27
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2006
Baseline to CA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

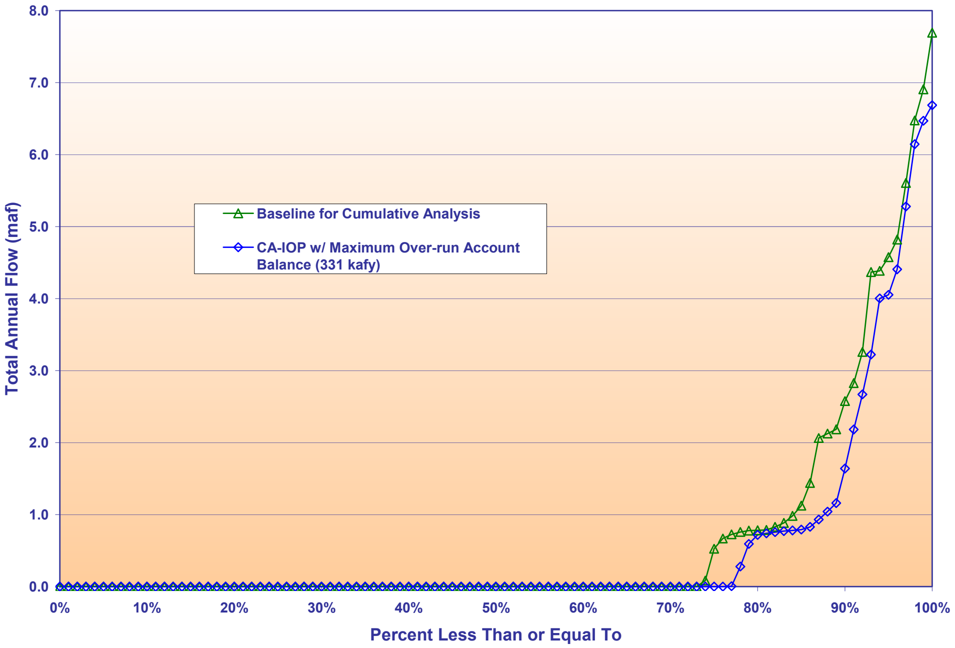


Figure 28
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2016
Baseline to CA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

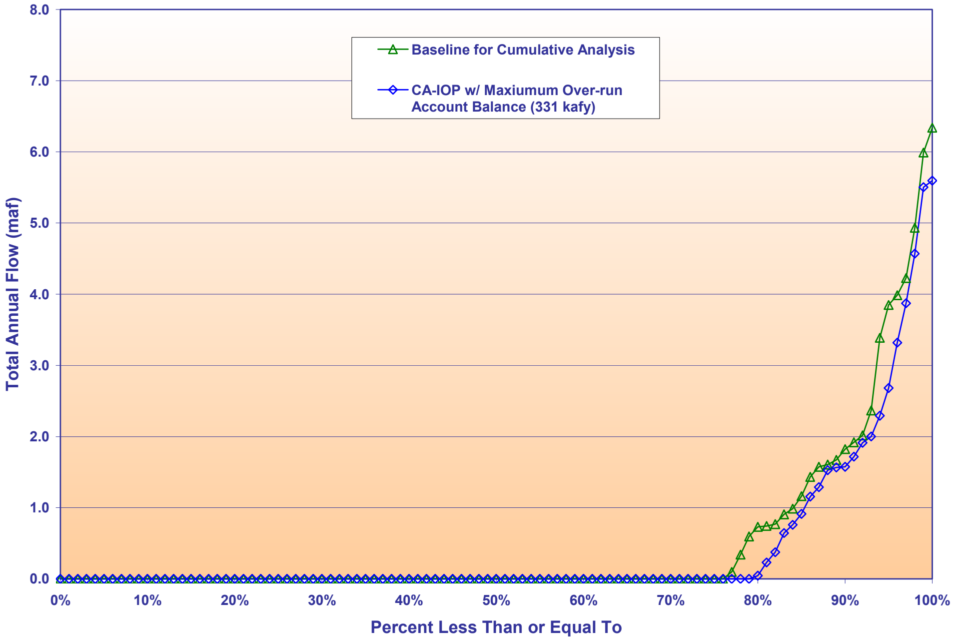


Figure 29
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2026
Baseline to CA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

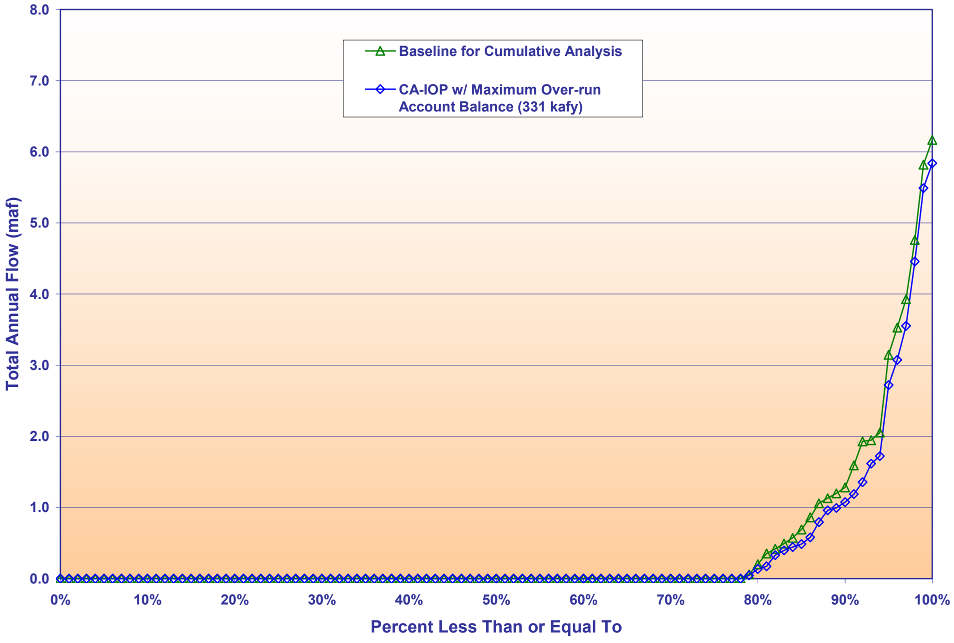
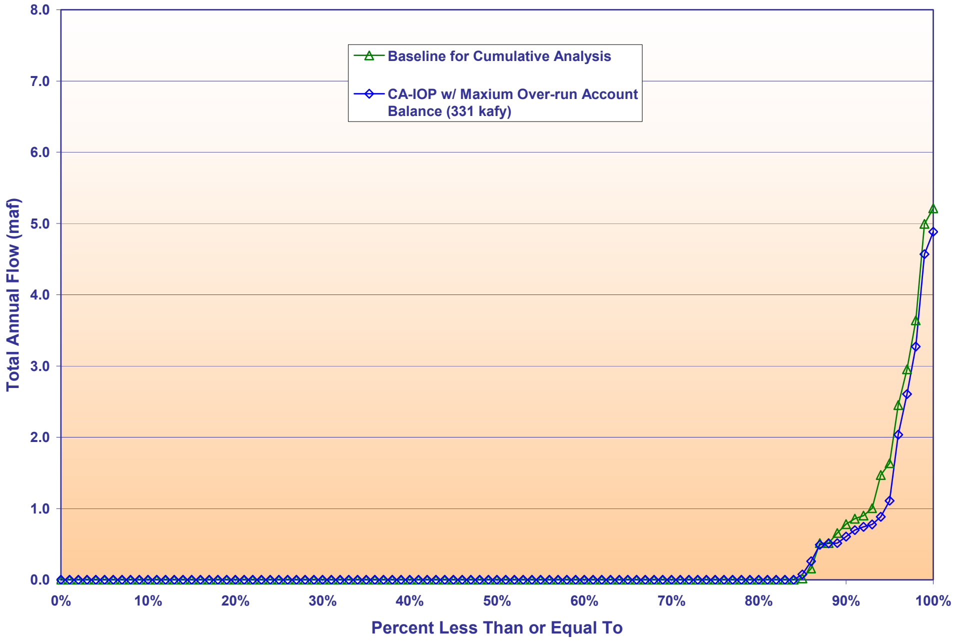


Figure 30
Comparison of Magnitude of Excess Flows Below Morelos Dam in Year 2050
Baseline to CA-IOP w/ Maximum Observed Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule



Tables 10 through 13 present a tabular summary of the data depicted in Figures 23 through 30. These Tables compare and provide a summary of the differences between the Baseline and the Cumulative Analysis that considered an average Lower Basin Overrun Account Balance of 66 kafy and the differences between the Baseline and the Cumulative Analysis that considered a Lower Basin Overrun Account Balance of 331 kafy. Table 10 provides the comparison of the modeled results for year 2006, and Table 11, 12 and 13 provide the comparison of the results of years 2016, 2026 and 2050, respectively. Again, all of these modeled conditions further considered a 10 Percent Maximum Allowed Overrun and a 3-Year Payback Schedule.

Table 10A
Comparison of Observed Excess Flows Below Morelos Dam for Year 2006
Under Baseline, CA-IOP 66 kafy, and CA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Baseline	CA-IOP 66 kafy	CA-IOP 331 kafy
Number of Traces	85	85	85
Number of Occurrences of Observed Excess Flows	22	21	20
Range of Observed Excess Flows (afy)	525,724 to 7,692,917	118,574 to 6,938,588	8,313 to 6,686,053
Mean of Observed Excess Flows (afy)	2,702,982	2,439,502	2,381,791

Table 10B
Differences in Observed Excess Flows Below Morelos Dam for Year 2006
Comparison of the Baseline to CA-IOP 66 kafy and Baseline to CA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Differences Between Baseline and CA-IOP 66 kafy	Differences Between Baseline to CA-IOP 331 kafy
Number of Occurrences of No Difference in Excess Flows	3	2
Number of Occurrences of Observed Decreased Flows	16	17
Range of Differences in Decreased Flows (af)	35,841 to 1,854,919	35,841 to 1,905,349
Average of Differences in Decreased Flows (af)	538,527	696,749
Number of Occurrences of Observed Increased Flows	2	1
Range of Differences in Increased Flows (af)	133,650 to 246,861	15,203 to 15,203
Average of Differences in Increased Flows (af)	190,256	15,203
Average Difference of Observed Excess Flows (af)	-374,360	-537,706

As noted in Table 10, for year 2006, the average of the differences in observed excess flows below Morelos Dam between the Baseline and the Cumulative Analysis that considered an average Lower Basin Overrun Account Balance of 66 kafy modeled conditions, is a decrease of 374,360 af. This volume represents an approximately 13.8 percent reduction from the average excess flow (2,702,982 af) observed under the Baseline modeled conditions. The average of the differences in observed excess flows between the Baseline and the Cumulative Analysis that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, is a decrease of 537,706 af, which represents an approximately 19.9 percent reduction from the average excess flow (2,702,982 af) observed under the Baseline modeled conditions, for year 2006.

Table 11A
Comparison of Observed Excess Flows Below Morelos Dam for Year 2016
Under Baseline, CA-IOP 66 kafy, and CA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Baseline	CA-IOP 66 kafy	CA-IOP 331 kafy
Number of Traces	85	85	85
Number of Occurrences of Observed Excess Flows	20	18	17
Range of Observed Excess Flows (afy)	143,242 to 6,337,995	18,952 to 6,259,752	223,667 to 5,595,282
Mean of Observed Excess Flows (afy)	2,266,241	2,243,940	2,176,529

Table 11B
Differences in Observed Excess Flows Below Morelos Dam for Year 2016
Comparison of the Baseline to CA-IOP 66 kafy and Baseline to CA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Differences Between Baseline and CA-IOP 66 kafy	Differences Between Baseline to CA-IOP 331 kafy
Number of Occurrences of No Difference in Excess Flows	3	0
Number of Occurrences of Observed Decreased Flows	14	14
Range of Differences in Decreased Flows (af)	65,055 to 1,610,062	127,193 to 1,699,417
Average of Differences in Decreased Flows (af)	397,320	624,037
Number of Occurrences of Observed Increased Flows	1	3
Range of Differences in Increased Flows (af)	628,825 to 628,825	24,642 to 307,996
Average of Differences in Increased Flows (af)	628,825	137,688
Average Difference of Observed Excess Flows (af)	-246,683	-416,173

Table 11 presented a summary and compared the observed excess flows for the modeled year 2016. For this modeled year, the average of the differences in observed excess flows below Morelos Dam between the Baseline and the Cumulative Analysis that considered an average Lower Basin Overrun Account

Balance of 66 kafy modeled conditions, is a decrease of 246,683 af, which represents an approximately 10.9 percent reduction from the average observed excess flow (2,266,241 af) observed under the Baseline modeled conditions. The average of the differences in observed excess flows below Morelos Dan between the Baseline and the Cumulative Analysis that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, is a decrease of 416,173 af, which represents an approximately 18.4 percent reduction from the average excess flow (2,266,241 af) observed under the Baseline modeled conditions, for year 2016.

Table 12A
Comparison of Observed Excess Flows Below Morelos Dam for Year 2026
Under Baseline, CA-IOP 66 kafy, and CA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Baseline	CA-IOP 66 kafy	CA-IOP 331 kafy
Number of Traces	85	85	85
Number of Occurrences of Observed Excess Flows	18	18	18
Range of Observed Excess Flows (afy)	166,276 to 6,166,892	166,275 to 6,101,057	125,648 to 5,836,797
Mean of Observed Excess Flows (afy)	2,041,729	1,975,135	1,770,989

Table 12B
Differences in Observed Excess Flows Below Morelos Dam for Year 2026
Comparison of the Baseline to CA-IOP 66 kafy and Baseline to CA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Differences Between Baseline and CA-IOP 66 kafy	Differences Between Baseline to CA-IOP 331 kafy
Number of Occurrences of No Difference in Excess Flows	4	1
Number of Occurrences of Observed Decreased Flows	12	17
Range of Differences in Decreased Flows (af)	1 to 346,386	1 to 665,675
Average of Differences in Decreased Flows (af)	103,637	286,666
Number of Occurrences of Observed Increased Flows	2	0
Range of Differences in Increased Flows (af)	17,452 to 27,492	NA
Average of Differences in Increased Flows (af)	22,472	NA
Average Difference of Observed Excess Flows (af)	-66,594	-270,740

Table 12 presented a summary and compared the observed excess flows for the modeled year 2026. For this modeled year, the average of the differences in observed excess flows below Morelos Dam between the Baseline and the Cumulative Analysis that considered an average Lower Basin Overrun Account Balance of 66 kafy modeled conditions, is a decrease of 66,594 af, which represents an approximately 3.3 percent reduction from the average observed excess flow (2,041,729 af) observed under the Baseline modeled conditions. The average of the differences in observed excess flows below Morelos Dan between the Baseline and the Cumulative Analysis that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, is a decrease of 270,740 af, which represents an approximately 13.3 percent reduction from the average excess flow (2,041,729 af) observed under the Baseline modeled conditions, for year 2026.

Table 13A
Comparison of Observed Excess Flows Below Morelos Dam for Year 2050
Under Baseline, CA-IOP 66 kafy, and CA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Baseline	CA-IOP 66 kafy	CA-IOP 331 kafy
Number of Traces	85	85	85
Number of Occurrences of Observed Excess Flows	13	13	13
Range of Observed Excess Flows (afy)	45,156 to 5,212,767	44,864 to 5,147,031	186,149 to 4,883,090
Mean of Observed Excess Flows (afy)	1,820,599	1,716,903	1,578,693

Table 13B
Differences in Observed Excess Flows Below Morelos Dam for Year 2050
Comparison of the Baseline to CA-IOP 66 kafy and Baseline to CA-IOP 331 kafy Modeled Conditions
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

Comparison Factor	Differences Between Baseline and CA-IOP 66 kafy	Differences Between Baseline to CA-IOP 331 kafy
Number of Occurrences of No Difference in Excess Flows	4	3
Number of Occurrences of Observed Decreased Flows	8	8
Range of Differences in Decreased Flows (af)	292 to 949,205	201,193 to 1,007,188
Average of Differences in Decreased Flows (af)	176,210	418,425
Number of Occurrences of Observed Increased Flows	1	2
Range of Differences in Increased Flows (af)	61,630 to 61,630	61,630 to 140,993
Average of Differences in Increased Flows (af)	61,630	101,312
Average Difference of Observed Excess Flows (af)	-103,696	-241,906

Table 13 presented a summary and compared the observed excess flows for the modeled year 2050. For this modeled year, the average of the differences in observed excess flows below Morelos Dam between the Baseline and the Cumulative Analysis that considered an average Lower Basin Overrun Account Balance of 66 kafy modeled conditions, is a decrease of 103,696 af, which represents an approximately 5.7 percent reduction from the average observed excess flow (1,820,599 af) observed under the Baseline modeled conditions. The average of the differences in observed excess flows below Morelos Dan between the Baseline and the Cumulative Analysis that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, is a decrease of 241,906 af, which represents an approximately 13.3 percent reduction from the average excess flow (1,820,599 af) observed under the Baseline modeled conditions, for year 2050.

It should be emphasized that not all of the differences in observed excess flows were negative (reductions). In both comparisons, there were modeled years where the differences were positive, which represented increases in the magnitude of observed excess flows. For example, in the evaluation of the comparison of the differences in the observed excess flows below Morelos Dam between the Baseline and the Cumulative Analysis that considered an average Lower Basin Overrun Account Balance of 66 kafy modeled conditions, approximately 12.1 percent of instances where differences were observed, the differences were positive which represented increase in the magnitude of excess flows. However, for the 75-year period of analysis, the average of the differences was a reduction of 153,090 af.

In the evaluation of the comparison of the differences in the observed excess flows below Morelos Dam between the Baseline and the Cumulative Analysis that considered a Lower Basin Overrun Account Balance of 331 kafy modeled conditions, approximately 8.0 percent of instances where differences were observed, the differences were positive which represented increase in the magnitude of excess flows. However, for the 75-year period of analysis, the average of the differences was a reduction of 323,112 af.

ATTACHMENT A

INADVERTENT OVERRUN ACCOUNTING

Table A-1
Comparison of Historical Arizona Projected and Actual Depletions

Column 1	**2**	**3**	**4**	**5**	**6**	**7**
CY	AZPUMP FORCAST	AZPUMP ACTUAL	AZPUMP DIFF	AZOTH FORCAST	AZOTH ACTUAL	AZOTH DIFF
1990	71,000	36,360	34,640	1,465,000	1,481,218	(16,218)
1991	36,000	45,176	(9,176)	1,392,199	1,410,529	(18,330)
1992	0	0	0	0	0	0
1993	50,000	35,013	14,987	1,455,461	1,221,895	233,566
1994	50,000	35,863	14,137	1,271,010	1,420,812	(149,802)
1995	40,000	36,457	3,543	1,442,095	1,436,084	6,011
1996	36,000	37,369	(1,369)	1,509,251	1,515,695	(6,444)
1997	37,000	35,444	1,556	1,471,816	1,439,761	32,055
1998	37,000	32,616	4,384	1,382,072	1,355,975	20,097
1999	37,000	35,010	1,990	1,309,310	1,339,798	(30,488)

Table A-2
Priority 1, 2 and 3 Depletion Projections

Column 1	2	3	4	5	6	7	8
CY	IID Base (af)	CVWD (af)	SUM (kaf)	Priority 1&2 (kaf)	Priority 1-3 (kaf)	CAPPED (kaf) (1)	Priority 3 (2) Base (kaf)
2002	2,915,621	334,046	3,252	478	3,730	3,730	3,252
2003	3,044,916	334,503	3,381	465	3,846	3,800	3,335
2004	3,064,253	336,665	3,403	467	3,870	3,800	3,333
2005	3,006,884	337,862	3,347	425	3,772	3,772	3,347
2006	2,915,621	342,708	3,260	456	3,716	3,716	3,260
2007	2,915,621	342,995	3,261	435	3,696	3,696	3,261
2008	2,772,663	344,174	3,119	437	3,556	3,556	3,119
2009	3,044,916	346,233	3,393	419	3,812	3,800	3,381
2010	2,915,621	346,414	3,264	421	3,685	3,685	3,264
2011	3,006,884	346,588	3,355	449	3,804	3,800	3,351
2012	2,772,663	346,760	3,121	361	3,482	3,482	3,121
2013	3,205,935	346,943	3,555	374	3,929	3,800	3,426
2014	3,205,935	347,116	3,555	372	3,927	3,800	3,428
2015	3,058,162	347,295	3,407	375	3,782	3,782	3,407
2016	2,896,071	347,470	3,246	388	3,634	3,634	3,246
2017	3,058,162	347,617	3,408	431	3,839	3,800	3,369
2018	2,896,071	347,732	3,246	407	3,653	3,653	3,246
2019	3,205,935	347,833	3,556	427	3,983	3,800	3,373
2020	2,915,621	347,934	3,266	411	3,677	3,677	3,266
2021	3,178,829	348,046	3,529	421	3,950	3,800	3,379
2022	2,772,663	348,156	3,123	420	3,543	3,543	3,123
2023	3,044,916	348,268	3,395	455	3,850	3,800	3,345
2024	3,006,884	348,380	3,357	431	3,788	3,788	3,357
2025	3,205,935	348,495	3,556	450	4,006	3,800	3,350
2026	3,058,162	348,607	3,409	439	3,848	3,800	3,361
2027	3,006,884	348,718	3,358	405	3,763	3,763	3,358
2028	3,064,253	348,829	3,415	369	3,784	3,784	3,415
2029	3,058,162	348,944	3,409	380	3,789	3,789	3,409
2030	3,006,884	349,071	3,358	396	3,754	3,754	3,358
2031	3,006,884	349,218	3,358	438	3,796	3,796	3,358
2032	3,178,829	349,364	3,530	409	3,939	3,800	3,391
2033	3,006,884	349,514	3,358	467	3,825	3,800	3,333
2034	2,772,663	349,671	3,124	414	3,538	3,538	3,124
2035	3,058,162	349,671	3,410	427	3,837	3,800	3,373
2036	3,058,162	349,671	3,410	445	3,855	3,800	3,355
2037	2,915,621	349,671	3,267	366	3,633	3,633	3,267
2038	3,058,162	349,671	3,410	396	3,806	3,800	3,404
2039	3,058,162	349,671	3,410	375	3,785	3,785	3,410
2040	3,178,829	349,671	3,531	361	3,892	3,800	3,439
2041	3,044,916	349,671	3,397	402	3,799	3,799	3,397
2042	2,772,663	349,671	3,124	363	3,487	3,487	3,124
2043	2,729,694	349,671	3,081	414	3,495	3,495	3,081
2044	2,896,071	349,671	3,248	373	3,621	3,621	3,248
2045	3,064,253	349,671	3,416	400	3,816	3,800	3,400
2046	2,772,663	349,671	3,124	400	3,524	3,524	3,124
2047	3,064,253	349,671	3,416	417	3,833	3,800	3,383
2048	3,044,916	349,671	3,397	464	3,861	3,800	3,336
2049	3,044,916	349,671	3,397	446	3,843	3,800	3,354
2050	3,058,162	349,671	3,410	470	3,880	3,800	3,330
2051	3,058,162	349,671	3,410	462	3,872	3,800	3,338
2052	2,729,694	349,671	3,081	453	3,534	3,534	3,081
2053	2,896,071	349,671	3,248	398	3,646	3,646	3,248
2054	3,127,806	349,671	3,480	439	3,919	3,800	3,361
2055	2,772,663	349,671	3,124	427	3,551	3,551	3,124
2056	3,044,916	349,671	3,397	462	3,859	3,800	3,338
2057	2,772,663	349,671	3,124	424	3,548	3,548	3,124
2058	3,058,162	349,671	3,410	516	3,926	3,800	3,284
2059	2,896,071	349,671	3,248	460	3,708	3,708	3,248
2060	2,896,071	349,671	3,248	345	3,593	3,593	3,248
2061	2,772,663	349,671	3,124	341	3,465	3,465	3,124
2062	3,178,829	349,671	3,531	404	3,935	3,800	3,396
2063	3,064,253	349,671	3,416	412	3,828	3,800	3,388
2064	2,729,694	349,671	3,081	428	3,509	3,509	3,081
2065	2,915,621	349,671	3,267	449	3,716	3,716	3,267
2066	3,006,884	349,671	3,259	456	3,815	3,800	3,344
2067	3,064,253	349,671	3,416	464	3,880	3,800	3,336
2068	2,896,071	349,671	3,248	421	3,669	3,669	3,248
2069	2,528,424	349,671	2,880	348	3,228	3,228	2,880
2070	2,772,663	349,671	3,124	349	3,473	3,473	3,124
2071	3,044,916	349,671	3,397	394	3,791	3,791	3,397
2072	3,058,162	349,671	3,410	434	3,844	3,800	3,366
2073	3,205,935	349,671	3,558	496	4,054	3,800	3,304
2074	3,178,829	349,671	3,531	426	3,957	3,800	3,374
2075	3,127,806	349,671	3,480	432	3,912	3,800	3,368
2076	3,064,253	349,671	3,416	472	3,888	3,800	3,328
Average	2,984,899	348,112	3,335	420			

(1.) Capped is equal to the lesser of the Projected Priority 1-3 depletion or 3,800 kaf (capped depletion for Priority 1-3).

(2.) Priority 3 Base is equal to Capped less Priority 1 & 2 amounts.

Table A-3
Priority 1, 2 and 3 Capped Depletions

Column 1	**2**	**3**	**4**	**5**	**6**	**6**	**7**
CY	**IIDbase (af)**	**CVWD (af)**	**SUM (kaf)**	**CAPPED 3.38 (kaf) (1)**	**Difference from 3800 (kaf) (2)**	**Priority 1&2 (kaf)**	**Available To MWD (kaf) (3)**
2002	2,915,621	334,046	3,252	3,252	548	478	128
2003	3,044,916	334,503	3,381	3,380	420	465	0
2004	3,064,253	336,665	3,403	3,380	420	467	0
2005	3,006,884	337,862	3,347	3,347	453	425	33
2006	2,915,621	342,708	3,260	3,260	540	456	120
2007	2,915,621	342,995	3,261	3,261	539	435	119
2008	2,772,663	344,174	3,119	3,119	681	437	261
2009	3,044,916	346,233	3,393	3,380	420	419	0
2010	2,915,621	346,414	3,264	3,264	536	421	116
2011	3,006,884	346,588	3,355	3,355	445	449	25
2012	2,772,663	346,760	3,121	3,121	679	361	259
2013	3,205,935	346,943	3,555	3,380	420	374	0
2014	3,205,935	347,116	3,555	3,380	420	372	0
2015	3,058,162	347,295	3,407	3,380	420	375	0
2016	2,896,071	347,470	3,246	3,246	554	388	134
2017	3,058,162	347,617	3,408	3,380	420	431	0
2018	2,896,071	347,732	3,246	3,246	554	407	134
2019	3,205,935	347,833	3,556	3,380	420	427	0
2020	2,915,621	347,934	3,266	3,266	534	411	114
2021	3,178,829	348,046	3,529	3,380	420	421	0
2022	2,772,663	348,156	3,123	3,123	677	420	257
2023	3,044,916	348,268	3,395	3,380	420	455	0
2024	3,006,884	348,380	3,357	3,357	443	431	23
2025	3,205,935	348,495	3,556	3,380	420	450	0
2026	3,058,162	348,607	3,409	3,380	420	439	0
2027	3,006,884	348,718	3,358	3,358	442	405	22
2028	3,064,253	348,829	3,415	3,380	420	369	0
2029	3,058,162	348,944	3,409	3,380	420	380	0
2030	3,006,884	349,071	3,358	3,358	442	396	22
2031	3,006,884	349,218	3,358	3,358	442	438	22
2032	3,178,829	349,364	3,530	3,380	420	409	0
2033	3,006,884	349,514	3,358	3,358	442	467	22
2034	2,772,663	349,671	3,124	3,124	676	414	256
2035	3,058,162	349,671	3,410	3,380	420	427	0
2036	3,058,162	349,671	3,410	3,380	420	445	0
2037	2,915,621	349,671	3,267	3,267	533	366	113
2038	3,058,162	349,671	3,410	3,380	420	396	0
2039	3,058,162	349,671	3,410	3,380	420	375	0
2040	3,178,829	349,671	3,531	3,380	420	361	0
2041	3,044,916	349,671	3,397	3,380	420	402	0
2042	2,772,663	349,671	3,124	3,124	676	363	256
2043	2,729,694	349,671	3,081	3,081	719	414	299
2044	2,896,071	349,671	3,248	3,248	552	373	132
2045	3,064,253	349,671	3,416	3,380	420	400	0
2046	2,772,663	349,671	3,124	3,124	676	400	256
2047	3,064,253	349,671	3,416	3,380	420	417	0
2048	3,044,916	349,671	3,397	3,380	420	464	0
2049	3,044,916	349,671	3,397	3,380	420	446	0
2050	3,058,162	349,671	3,410	3,380	420	470	0
2051	3,058,162	349,671	3,410	3,380	420	462	0
2052	2,729,694	349,671	3,081	3,081	719	453	299
2053	2,896,071	349,671	3,248	3,248	552	398	132
2054	3,127,806	349,671	3,480	3,380	420	439	0
2055	2,772,663	349,671	3,124	3,124	676	427	256
2056	3,044,916	349,671	3,397	3,380	420	462	0
2057	2,772,663	349,671	3,124	3,124	676	424	256
2058	3,058,162	349,671	3,410	3,380	420	516	0
2059	2,896,071	349,671	3,248	3,248	552	460	132
2060	2,896,071	349,671	3,248	3,248	552	345	132
2061	2,772,663	349,671	3,124	3,124	676	341	256
2062	3,178,829	349,671	3,531	3,380	420	404	0
2063	3,064,253	349,671	3,416	3,380	420	412	0
2064	2,729,694	349,671	3,081	3,081	719	428	299
2065	2,915,621	349,671	3,267	3,267	533	449	113
2066	3,006,884	349,671	3,359	3,359	441	456	21
2067	3,064,253	349,671	3,416	3,380	420	464	0
2068	2,896,071	349,671	3,248	3,248	552	421	132
2069	2,528,424	349,671	2,880	2,880	920	348	500
2070	2,772,663	349,671	3,124	3,124	676	349	256
2071	3,044,916	349,671	3,397	3,380	420	394	0
2072	3,058,162	349,671	3,410	3,380	420	434	0
2073	3,205,935	349,671	3,558	3,380	420	496	0
2074	3,178,829	349,671	3,531	3,380	420	426	0
2075	3,127,806	349,671	3,480	3,380	420	432	0
2076	3,064,253	349,671	3,416	3,380	420	472	0
AVG	**2,984,899**	**348,112**	**3,335**	**3,301**	**499**	**420**	**79**

(1.) Capped 3.38 is equal to the lesser of the Sum (IID base + CVWD) or 3,380 kaf (assumed capped depletion for Priority 3).
(2.) Difference from 3,800 is equal to 3,800 kaf less the amount calculated under the Capped 3,380 kaf column.
(3.) Available to MWD is equal to amount under “Difference from 3800” column and Priority 1&2 column.

Table A-4
MWD Projected Depletions and Inadvertent Overrun (PVID/YPRD) Accounting

Column 1	2	3
CY	**MWD OBLIGATION (kaf) [(1)]**	**MWD BASE (kaf)**
2002	350	620
2003	465	550
2004	467	550
2005	392	578
2006	336	634
2007	316	654
2008	176	794
2009	419	550
2010	305	665
2011	424	550
2012	102	868
2013	374	550
2014	372	550
2015	375	568
2016	254	716
2017	431	550
2018	273	697
2019	427	550
2020	297	673
2021	421	550
2022	163	807
2023	455	550
2024	408	562
2025	450	550
2026	439	550
2027	383	587
2028	369	566
2029	380	561
2030	374	596
2031	416	554
2032	409	550
2033	445	550
2034	158	812
2035	427	550
2036	445	550
2037	253	717
2038	396	550
2039	375	565
2040	361	550
2041	402	551
2042	107	863
2043	115	855
2044	241	729
2045	400	550
2046	144	826
2047	417	550
2048	464	550
2049	446	550
2050	470	550
2051	462	550
2052	154	816
2053	266	704
2054	439	550
2055	171	799
2056	462	550
2057	168	802
2058	516	550
2059	328	642
2060	213	757
2061	85	885
2062	404	550
2063	412	550
2064	129	841
2065	336	634
2066	435	550
2067	464	550
2068	289	681
2069	(152)	1,122
2070	93	877
2071	394	559
2072	434	550
2073	496	550
2074	426	550
2075	432	550
2076	472	550

(1.) MWD obligation is equal to Priority 1&2 (Table A-3) less amount "Available to MWD" (Table A-3).

Table A-5
CALIFORNIA AGRICULTURAL AGENCY OVER/UNDER RUN DIFFERENT FROM BASE CASE

Column 1	MWD (PVID+YPRD)				IID+CVWD			
	2	3	4	5	6	7	8	9
CY	3YR-PAY 10% MAX	1YR-PAY 10% MAX	3YR-PAY 5% MAX	1YR-PAY 5% MAX	3YR-PAY 10% MAX	1YR-PAY 10% MAX	3YR-PAY 5% MAX	1YR-PAY 5% MAX
2002	0	0	0	0	0	0	0	0
2003	0	45	0	45	46	46	46	46
2004	0	47	0	47	70	70	70	70
2005	(18)	(45)	(15)	(45)	(1)	(1)	(1)	(1)
2006	(36)	(47)	(30)	(47)	(23)	(23)	(23)	(23)
2007	(27)	0	(30)	0	0	0	0	0
2008	(11)	0	(15)	0	0	0	0	0
2009	1	0	(1)	0	12	12	12	12
2010	0	0	0	0	0	0	0	0
2011	0	4	0	4	(9)	(9)	(9)	(9)
2012	0	0	0	0	0	0	0	0
2013	42	(4)	42	(4)	129	129	129	129
2014	48	0	48	0	127	127	127	127
2015	27	0	27	0	(68)	(175)	(62)	(175)
2016	0	0	0	0	(136)	(175)	(118)	(175)
2017	0	11	0	11	(95)	12	(100)	12
2018	0	O	0	0	(39)	0	(58)	0
2019	(11)	(4)	(11)	(4)	155	155	155	155
2020	0	0	0	0	0	0	0	0
2021	(7)	(6)	(7)	(6)	82	(26)	87	(26)
2022	0	0	0	0	(68)	0	(56)	0
2023	(1)	34	(1)	34	(58)	(99)	(80)	(99)
2024	0	0	0	0	(68)	0	(37)	0
2025	(18)	(5)	(12)	(5)	188	191	152	191
2026	(17)	8	(12)	8	33	48	48	48
2027	(18)	(30)	(21)	(30)	(68)	(176)	(63)	(176)
2028	5	(19)	15	(19)	(68)	(29)	(85)	(29)
2029	28	0	lOO	(69)	0	(57)	0	
2030	0	0	0	0	(35)	(35)	(34)	(35)
2031	0	0	0	0	(29)	(29)	(30)	(29)
2032	11	0	11	0	139	139	139	139
2033	0	25	0	25	25	25	25	25
2034	0	0	0	0	(68)	(150)	(50)	(150)
2035	(18)	(18)	(10)	(18)	(31)	37	(13)	37
2036	(7)	25	(10)	25	41	55	5	55
2037	(7)	(7)	(12)	(7)	(30)	(30)	(30)	(30)
2038	6	(25)	14	(25)	(24)	(24)	(24)	(24)
2039	23	0	20	0	0	0	0	0
2040	59	0	54	0	62	62	62	62
2041	17	0	17	0	(30)	(30)	(30)	(30)
2042	0	0	0	0	(68)	(151)	(50)	(151)
2043	0	0	0	0	(68)	(17)	(67)	(17)
2044	0	0	0	0	(32)	0	(51)	0
2045	20	0	20	0	16	16	16	16
2046	0	0	0	0	0	0	0	0
2047	0	0	3	0	(3)	(3)	(3)	(3)
2048	0	44	0	44	61	61	61	61
2049	0	26	0	26	7	7	7	7
2050	(18)	6	(15)	6	63	63	63	63
2051	(36)	(14)	(25)	(14)	55	55	55	55
2052	(34)	(50)	(41)	(50)	(30)	(30)	(30)	(30)
2053	(30)	(12)	(33)	(12)	(30)	(30)	(30)	(30)
2054	(14)	19	(18)	19	119	119	119	119
2055	0	0	0	0	0	1	0	1
2056	(18)	23	(10)	23	(9)	(41)	25	(41)
2057	(1)	0	(9)	0	(32)	0	(34)	0
2058	(18)	54	(14)	54	109	109	77	109
2059	(18)	0	(14)	0	0	0	0	0
2060	(43)	(96)	(78)	(96)	(30)	(30)	(30)	(30)
2061	(32)	0	(16)	0	0	0	0	0
2062	(11)	0	0	0	135	135	135	135
2063	8	0	8	0	28	28	28	28
2064	0	0	0	0	(68)	(151)	(50)	(151)
2065	0	0	0	0	(104)	(36)	(84)	(36)
2066	0	15	0	15	0	15	(38)	15
2067	0	44	0	44	80	80	80	80
2068	(15)	(15)	(10)	(15)	0	0	0	0
2069	(18)	0	(20)	0	(36)	0	(36)	0
2070	(11)	0	(15)	0	0	0	0	0
2071	17	0	3	0	0	0	0	0
2072	0	14	0	14	44	44	44	44
2073	0	76	0	76	237	237	237	237
2074	(14)	(8)	(10)	(8)	127	127	127	127
2075	(25)	(64)	(48)	(64)	44	(66)	47	(66)
2076	(31)	46	(22)	46	20	(63)	(97)	(63)
AVG	**(4)**	**1**	**(4)**	**1**	**10**	**8**	**8**	**8**

Note: Negative numbers (in parenthesis "(#)") represent observed payback amounts and whole numbers represent overruns.
Individual IID/CVWD and MWD values reflect the values from the columns entitled - "Diff. From Base Case (kaf)" under the respective modeled condition (from the Tables B-1 to B-12 in Appendix B).

Table A-6
ID+CVWD OVER/UNDER RUN DIFFERENT FROM BASE CASE

Column 1	**2**	**3**	**4**	**5**		**6**	**7**	**8**	**9**	**10**
CY	**3YR-PAY 10% MAX**	**1YR-PAY 10% MAX**	**3YR-PAY 5% MAX**	**1YR-PAY 5% MAX**		**PERCENT LESS THAN OR EQUAL TO**	**RANKED 3YR-PAY 10% MAX**	**RANKED 1YR-PAY 10% MAX**	**RANKED 3YR-PAY 5% MAX**	**RANKED 1YR-PAY 5% MAX**
2002	0	0	0	0		1	(136)	(176)	(118)	(176)
2003	46	46	46	46		3	(104)	(175)	(100)	(175)
2004	70	70	70	70		4	(95)	(175)	(97)	(175)
2005	(1)	(1)	(1)	(1)		5	(69)	(151)	(85)	(151)
2006	(23)	(23)	(23)	(23)		7	(68)	(151)	(84)	(151)
2007	0	0	0	0		8	(68)	(150)	(80)	(150)
2008	0	0	0	0		9	(68)	(99)	(67)	(99)
2009	12	12	12	12		11	(68)	(66)	(63)	(66)
2010	0	0	0	0		12	(68)	(63)	(62)	(63)
2011	(9)	(9)	(9)	(9)		13	(68)	(41)	(58)	(41)
2012	0	0	0	0		15	(68)	(36)	(57)	(36)
2013	129	129	129	129		16	(68)	(35)	(56)	(35)
2014	127	127	127	127		17	(68)	(30)	(51)	(30)
2015	(68)	(175)	(62)	(175)		19	(58)	(30)	(50)	(30)
2016	(136)	(175)	(118)	(175)		20	(39)	(30)	(50)	(30)
2017	(95)	12	(100)	12		21	(36)	(30)	(50)	(30)
2018	(39)	0	(58)	0		23	(35)	(30)	(38)	(30)
2019	155	155	155	155		24	(32)	(29)	(37)	(29)
2020	0	0	0	0		25	(32)	(29)	(36)	(29)
2021	82	(26)	87	(26)		27	(31)	(26)	(34)	(26)
2022	(68)	0	(56)	0		28	(30)	(24)	(34)	(24)
2023	(58)	(99)	(80)	(99)		29	(30)	(23)	(30)	(23)
2024	(68)	0	(37)	0		31	(30)	(17)	(30)	(17)
2025	188	191	152	191		32	(30)	(9)	(30)	(9)
2026	33	48	48	48		33	(30)	(3)	(30)	(3)
2027	(68)	(176)	(63)	(176)		35	(29)	(1)	(30)	(1)
2028	(68)	(29)	(85)	(29)		36	(24)	0	(30)	0
2029	(69)	0	(57)	0		37	(23)	0	(24)	0
2030	(35)	(35)	(34)	(35)		39	(9)	0	(23)	0
2031	(29)	(29)	(30)	(29)		40	(9)	0	(13)	0
2032	139	139	139	139		41	(3)	0	(9)	0
2033	25	25	25	25		43	(1)	0	(3)	0
2034	(68)	(150)	(50)	(150)		44	0	0	(1)	0
2035	(31)	37	(13)	37		45	0	0	0	0
2036	41	55	5	55		47	0	0	0	0
2037	(30)	(30)	(30)	(30)		48	0	0	0	0
2038	(24)	(24)	(24)	(24)		49	0	0	0	0
2039	0	0	0	0		51	0	0	0	0
2040	62	62	62	62		52	0	0	0	0
2041	(30)	(30)	(30)	(30)		53	0	0	0	0
2042	(68)	(151)	(50)	(151)		55	0	0	0	0
2043	(68)	(17)	(67)	(17)		56	0	0	0	0
2044	(32)	0	(51)	0		57	0	0	0	0
2045	16	16	16	16		59	0	0	0	0
2046	0	0	0	0		60	0	0	0	0
2047	(3)	(3)	(3)	(3)		61	0	0	0	0
2048	61	61	61	61		63	0	1	0	1
2049	7	7	7	7		64	7	7	5	7
2050	63	63	63	63		65	12	12	7	12
2051	55	55	55	55		67	16	12	12	12
2052	(30)	(30)	(30)	(30)		68	20	15	16	15
2053	(30)	(30)	(30)	(30)		69	25	16	25	16
2054	119	119	119	119		71	28	25	25	25
2055	0	1	0	1		72	33	28	28	28
2056	(9)	(41)	25	(41)		73	41	37	44	37
2057	(32)	0	(34)	0		75	44	44	46	44
2058	109	109	77	109		76	44	46	47	46
2059	0	0	0	0		77	46	48	48	48
2060	(30)	(30)	(30)	(30)		79	55	55	55	55
2061	0	0	0	0		80	61	55	61	55
2062	135	135	135	135		81	62	61	62	61
2063	28	28	28	28		83	63	62	63	62
2064	(68)	(151)	(50)	(151)		84	70	63	70	63
2065	(104)	(36)	(84)	(36)		85	80	70	77	70
2066	0	15	(38)	15		87	82	8	80	80
2067	80	80	80	80		88	109	109	87	109
2068	0	0	0	0		89	119	119	119	119
2069	(36)	0	(36)	0		91	127	127	127	127
2070	0	0	0	0		92	127	127	127	127
2071	0	0	0	0		93	129	129	129	129
2072	44	44	44	44		95	135	135	135	135
2073	237	237	237	237		96	139	139	139	139
2074	127	127	127	127		97	155	155	152	155
2075	44	(66)	47	(66)		99	188	191	155	191
2076	20	(63)	(97)	(63)		100	237	237	237	237
						NegP	**0.2267**	**0.1867**	**0.2400**	**0.1867**
						AVG PAYBACK	**(48)**	**(63)**	**(47)**	**(63)**

Note: Negative numbers (in parenthesis "(#)") represent observed payback amounts and whole numbers represent overruns.
Individual IID/CVWD values reflect the values from the columns entitled - "Diff. From Base Case (kaf)" under the respective modeled condition (from the Tables B-1 to B-6 in Appendix B).

Table A7
IID+CVWD PROBABILITY OF AVERAGE DIFFERENCE FROM BASE CASE RIVER FLOWS

Column 1	2	3	4	5	6	7	8	9
CY	Probability	3YR-PAY 10% MAX	Probability	1YR-PAY 10% MAX	Probability	3YR-PAY 5% MAX	Probability	1YR-PAY 5% MAX
2002	0.3614	(48)	0.0000	(63)	0.3727	(47)	0.0000	(63)
2003	0.3062	(48)	0.0000	(63)	0.3158	(47)	0.0000	(63)
2004	0.2912	(48)	0.0000	(63)	0.3002	(47)	0.0000	(63)
2005	0.3163	(48)	0.0000	(63)	0.3261	(47)	0.0000	(63)
2006	0.3012	(48)	0.0041	(63)	0.3106	(47)	0.0041	(63)
2007	0.2861	(48)	0.0122	(63)	0.2951	(47)	0.0122	(63)
2008	0.2711	(48)	0.0286	(63)	0.2795	(47)	0.0286	(63)
2009	0.2510	(48)	0.0408	(63)	0.2588	(47)	0.0408	(63)
2010	0.2410	(48)	0.0489	(63)	0.2485	(47)	0.0489	(63)
2011	0.2460	(48)	0.0286	(63)	0.2536	(47)	0.0286	(63)
2012	0.2309	(48)	0.0367	(63)	0.2381	(47)	0.0367	(63)
2013	0.2008	(48)	0.0408	(63)	0.2071	(47)	0.0408	(63)
2014	0.2159	(48)	0.0286	(63)	0.2226	(47)	0.0286	(63)
2015	0.1506	(48)	0.0653	(63)	0.1553	(47)	0.0653	(63)
2016	0.1506	(48)	0.0612	(63)	0.1553	(47)	0.0612	(63)
2017	0.1456	(48)	0.0326	(63)	0.1501	(47)	0.0326	(63)
2018	0.1456	(48)	0.0082	(63)	0.1501	(47)	0.0082	(63)
2019	0.1456	(48)	0.0082	(63)	0.1501	(47)	0.0082	(63)
2020	0.1305	(48)	0.0041	(63)	0.1346	(47)	0.0041	(63)
2021	0.1355	(48)	0.0041	(63)	0.1398	(47)	0.0041	(63)
2022	0.1104	(48)	0.0122	(63)	0.1139	(47)	0.0122	(63)
2023	0.1255	(48)	0.0204	(63)	0.1294	(47)	0.0204	(63)
2024	0.1205	(48)	0.0122	(63)	0.1242	(47)	0.0122	(63)
2025	0.1104	(48)	0.0000	(63)	0.1139	(47)	0.0000	(63)
2026	0.1054	(48)	0.0000	(63)	0.1087	(47)	0.0000	(63)
2027	0.1104	(48)	0.0000	(63)	0.1139	(47)	0.0000	(63)
2028	0.1155	(48)	0.0000	(63)	0.1191	(47)	0.0000	(63)
2029	0.1205	(48)	0.0000	(63)	0.1242	(47)	0.0000	(63)
2030	0.0954	(48)	0.0000	(63)	0.0984	(47)	0.0000	(63)
2031	0.1104	(48)	0.0000	(63)	0.1139	(47)	0.0000	(63)
2032	0.1104	(48)	0.0000	(63)	0.1139	(47)	0.0000	(63)
2033	0.1155	(48)	0.0000	(63)	0.1191	(47)	0.0000	(63)
2034	0.1155	(48)	0.0000	(63)	0.1191	(47)	0.0000	(63)
2035	0.1104	(48)	0.0000	(63)	0.1139	(47)	0.0000	(63)
2036	0.1155	(48)	0.0000	(63)	0.1191	(47)	0.0000	(63)
2037	0.1255	(48)	0.0000	(63)	0.1294	(47)	0.0000	(63)
2038	0.1255	(48)	0.0000	(63)	0.1294	(47)	0.0000	(63)
2039	0.1054	(48)	0.0000	(63)	0.1087	(47)	0.0000	(63)
2040	0.1255	(48)	0.0000	(63)	0.1294	(47)	0.0000	(63)
2041	0.1054	(48)	0.0000	(63)	0.1087	(47)	0.0000	(63)
2042	0.1205	(48)	0.0000	(63)	0.1242	(47)	0.0000	(63)
2043	0.1104	(48)	0.0000	(63)	0.1139	(47)	0.0000	(63)
2044	0.1104	(48)	0.0000	(63)	0.1139	(47)	0.0000	(63)
2045	0.1205	(48)	0.0000	(63)	0.1242	(47)	0.0000	(63)
2046	0.1155	(48)	0.0000	(63)	0.1191	(47)	0.0000	(63)
2047	0.1205	(48)	0.0000	(63)	0.1242	(47)	0.0000	(63)
2048	0.1205	(48)	0.0000	(63)	0.1242	(47)	0.0000	(63)
2049	0.1255	(48)	0.0000	(63)	0.1294	(47)	0.0000	(63)
2050	0.1205	(48)	0.0000	(63)	0.1242	(47)	0.0000	(63)

Table A-8
MWD (PVID/YPRD) OVER/UNDER RUN DIFF FROM BASE CASE

Column 1	**2**	**3**	**4**	**5**		**6**	**7**	**8**	**9**	**10**
CY	**3YR-PAY 10% MAX**	**1YR-PAY 10% MAX**	**3YR-PAY 5% MAX**	**1YR-PAY 5% MAX**		**PERCENT LESS THAN OR EQUAL TO**	**RANKED 3YR-PAY 10% MAX**	**RANKED 1YR-PAY 10% MAX**	**RANKED 3YR-PAY 5% MAX**	**RANKED 1YR-PAY 5% MAX**
2002	0	0	0	0		1.33	(43)	(96)	(78)	(96)
2003	0	45	O	45		2.67	(36)	(64)	(48)	(64)
2004	0	47	0	47		4.00	(36)	(50)	(41)	(50)
2005	(18)	(45)	(15)	(45)		5.33	(34)	(47)	(33)	(47)
2006	(36)	(47)	(30)	(47)		6.67	(32)	(45)	(30)	(45)
2007	(27)	0	(30)	0		8.00	(31)	(30)	(30)	(30)
2008	(11)	0	(15)	0		9.33	(30)	(25)	(25)	(25)
2009	1	0	(1)	0		10.67	(27)	(19)	(22)	(19)
2010	0	0	0	0		12.00	(25)	(18)	(21)	(18)
2011	0	4	0	4		13.33	(18)	(15)	(20)	(15)
2012	0	0	0	0		14.67	(18)	(14)	(18)	(14)
2013	42	(4)	42	(4)		16.00	(18)	(12)	(16)	(12)
2014	48	0	48	0		17.33	(18)	(8)	(15)	(8)
2015	27	0	27	0		18.67	(18)	(7)	(15)	(7)
2016	0	0	0	0		20.00	(18)	(6)	(15)	(6)
2017	0	11	0	11		21.33	(18)	(5)	(15)	(5)
2018	0	0	0	0		22.67	(18)	(4)	(14)	(4)
2019	(11)	(4)	(11)	(4)		24.00	(18)	(4)	(14)	(4)
2020	0	0	0	0		25.33	(17)	0	(12)	0
2021	(7)	(6)	(7)	(6)		26.67	(15)	0	(12)	0
2022	0	0	0	0		28.00	(14)	0	(12)	0
2023	(1)	34	(1)	34		29.33	(14)	0	(11)	0
2024	0	0	0	0		30.67	(11)	0	(10)	0
2025	(18)	(5)	(12)	(5)		32.00	(11)	0	(10)	0
2026	(17)	8	(12)	8		33.33	(11)	0	(10)	0
2027	(18)	(30)	(21)	(30)		34.67	(11)	0	(10)	0
2028	5	(19)	15	(19)		36.00	(7)	0	(10)	0
2029	28	0	10	0		37.33	(7)	0	(9)	0
2030	0	0	0	0		38.67	(7)	0	(7)	0
2031	0	0	0	0		40.00	(1)	0	(1)	0
2032	11	0	11	0		41.33	(1)	0	(1)	0
2033	0	25	0	25		42.67	0	0	0	0
2034	0	0	0	0		44.00	0	0	0	0
2035	(18)	(18)	(10)	(18)		45.33	0	0	0	0
2036	(7)	25	(10)	25		46.67	0	0	0	0
2037	(7)	(7)	(12)	(7)		48.00	0	0	0	0
2038	6	(25)	14	(25)		49.33	0	0	0	0
2039	23	0	20	0		50.67	0	0	0	0
2040	59	0	54	0		52.00	0	0	0	0
2041	17	0	17	0		53.33	0	0	0	0
2042	0	0	0	0		54.67	0	0	0	0
2043	0	0	0	0		56.00	0	0	0	0
2044	0	0	0	0		57.33	0	0	0	0
2045	20	0	20	0		58.67	0	0	0	0
2046	0	0	0	0		60.00	0	0	0	0
2047	0	0	3	0		61.33	0	0	0	0
2048	0	44	0	44		62.67	0	0	0	0
2049	0	26	0	26		64.00	0	0	0	0
2050	(18)	6	(15)	6		65.33	0	0	0	0
2051	(36)	(14)	(25)	(14)		66.67	0	0	0	0
2052	(34)	(50)	(41)	(50)		68.00	0	0	0	0
2053	(30)	(12)	(33)	(12)		69.33	0	0	0	0
2054	(14)	19	(18)	19		70.67	0	0	0	0
2055	0	0	0	0		72.00	0	0	0	0
2056	(18)	23	(10)	23		73.33	0	0	0	0
2057	(1)	0	(9)	0		74.67	0	0	0	0
2058	(18)	54	(14)	54		76.00	0	4	0	4
2059	(18)	0	(14)	0		77.33	0	6	0	6
2060	(43)	(96)	(78)	(96)		78.67	0	8	0	8
2061	(32)	0	(16)	0		80.00	0	11	0	11
2062	(11)	0	0	0		81.33	0	14	0	14
2063	8	0	8	0		82.67	1	15	3	15
2064	0	0	0	0		84.00	5	19	3	19
2065	0	0	0	0		85.33	6	23	8	23
2066	0	15	0	15		86.67	8	25	10	25
2067	0	44	0	44		88.00	11	25	11	25
2068	(15)	(15)	(10)	(15)		89.33	17	26	14	26
2069	(18)	0	(20)	0		90.67	17	34	15	34
2070	(11)	0	(15)	0		92.00	20	44	17	44
2071	17	0	3	0		93.33	23	44	20	44
2072	0	14	0	14		94.67	27	45	20	45
2073	0	76	0	76		96.00	28	46	27	46
2074	(14)	(8)	(10)	(8)		97.33	42	47	42	47
2075	(25)	(64)	(48)	(64)		98.67	48	54	48	54
2076	(31)	46	(22)	46		100.00	59	76	54	76
						NegP	**0.2267**	**0.1333**	**0.2267**	**0.1333**
						AVG PAYBACK	**(19)**	**(26)**	**(19)**	**(26)**

Note: Negative numbers (in parenthesis "(#)") represent observed payback amounts and whole numbers represent overruns.
Individual MWD (PVID/YPRD) values reflect the values from the columns entitled - "Diff. From Base Case (kaf)" under the respective modeled condition (from the Tables B-7 to B-12 in Appendix B).

Table A-9
MWD + IID/CVWD OVER/UNDER RUN DIFFERENT FROM BASE CASE

	SUM (MWD + IID/CVWD)				RANKED SUM (MWD + IID/CVWD)			
Column 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CY	**3YR-PAY 10% MAX**	**1YR-PAY 10% MAX**	**3YR-PAY 5% MAX**	**1YR-PAY 5% MAX**	**3YR-PAY 10% MAX**	**1YR-PAY 10% MAX**	**3YR-PAY 5% MAX**	**1YR-PAY 5% MAX**
2002	0	0	0	0	(136)	(206)	(119)	(206)
2003	46	91	46	91	(104)	(175)	(118)	(175)
2004	70	117	70	117	(95)	(175)	(108)	(175)
2005	(19)	(46)	(16)	(46)	(86)	(151)	(100)	(151)
2006	(59)	(70)	(53)	(70)	(73)	(151)	(84)	(151)
2007	(27)	0	(30)	0	(68)	(150)	(84)	(150)
2008	(11)	0	(15)	0	(68)	(130)	(81)	(130)
2009	13	12	11	12	(68)	(126)	(71)	(126)
2010	0	0	0	0	(68)	(80)	(70)	(80)
2011	(9)	(5)	(9)	(5)	(68)	(70)	(67)	(70)
2012	0	0	0	0	(68)	(65)	(63)	(69)
2013	171	125	171	125	(64)	(57)	(58)	(65)
2014	175	127	175	127	(63)	(49)	(56)	(49)
2015	(41)	(175)	(35)	(175)	(60)	(48)	(56)	(48)
2016	(136)	(175)	(118)	(175)	(59)	(46)	(53)	(46)
2017	(95)	23	(100)	23	(59)	(42)	(51)	(42)
2018	(39)	0	(58)	0	(54)	(37)	(50)	(37)
2019	144	151	144	151	(49)	(36)	(50)	(36)
2020	0	0	0	0	(41)	(35)	(50)	(35)
2021	75	(32)	80	(32)	(39)	(32)	(43)	(32)
2022	(68)	0	(56)	0	(37)	(30)	(42)	(30)
2023	(59)	(65)	(81)	(65)	(35)	(29)	(38)	(29)
2024	(68)	0	(37)	0	(33)	(18)	(37)	(18)
2025	170	186	140	186	(32)	(17)	(35)	(17)
2026	16	56	36	56	(32)	(17)	(34)	(17)
2027	(86)	(206)	(84)	(206)	(29)	(15)	(30)	(15)
2028	(63)	(48)	(70)	(48)	(27)	(5)	(30)	(5)
2029	28	(57)	100	(69)	(27)	(3)	(23)	(3)
2030	(35)	(35)	(34)	(35)	(19)	0	(16)	0
2031	(29)	(29)	(30)	(29)	(18)	0	(16)	0
2032	150	139	150	139	(18)	0	(15)	0
2033	25	50	25	50	(15)	0	(15)	0
2034	(68)	(150)	(50)	(150)	(13)	0	(14)	0
2035	(49)	19	(23)	19	(11)	0	(13)	0
2036	34	80	(5)	80	(11)	0	(10)	0
2037	(37)	(37)	(42)	(37)	(11)	0	(10)	0
2038	(18)	(49)	(10)	(49)	(9)	0	(9)	0
2039	23	0	20	0	(3)	0	(5)	0
2040	121	62	116	62	0	0	(1)	0
2041	(13)	(30)	(13)	(30)	0	0	0	0
2042	(68)	(151)	(50)	(151)	0	0	0	0
2043	(68)	(17)	(67)	(17)	0	0	0	0
2044	(32)	0	(51)	0	0	0	0	0
2045	36	16	36	16	0	0	0	0
2046	0	0	0	0	0	0	0	0
2047	(3)	(3)	0	(3)	7	0	0	0
2048	61	105	61	105	13	1	3	1
2049	7	33	7	33	16	12	7	12
2050	45	69	48	69	17	16	11	16
2051	19	41	30	41	19	19	15	19
2052	(64)	(80)	(71)	(80)	19	23	20	23
2053	(60)	(42)	(63)	(42)	23	28	25	28
2054	105	138	101	138	25	30	30	30
2055	0	1	0	1	28	33	36	33
2056	(27)	(18)	15	(18)	34	41	36	41
2057	(33)	0	(43)	0	36	50	36	50
2058	91	163	63	163	36	56	44	56
2059	(18)	0	(14)	0	44	58	46	58
2060	(73)	(126)	(108)	(126)	45	62	48	62
2061	(32)	0	(16)	0	46	69	61	69
2062	124	135	135	135	61	80	63	80
2063	36	28	36	28	70	91	70	91
2064	(68)	(151)	(50)	(151)	75	105	80	105
2065	(104)	(36)	(84)	(36)	80	117	80	117
2066	0	30	(38)	30	91	119	100	119
2067	80	124	80	124	105	124	101	124
2068	(15)	(15)	(10)	(15)	113	125	116	125
2069	(54)	0	(56)	0	121	127	117	127
2070	(11)	0	(15)	0	124	135	135	135
2071	17	0	3	0	144	138	140	138
2072	44	58	44	58	150	139	144	139
2073	237	313	237	313	170	151	150	151
2074	113	119	117	119	171	163	171	163
2075	19	(130)	(1)	(130)	175	186	175	186
2076	(11)	(17)	(119)	(17)	237	313	237	313
AVG	6	9	4	9				
Average Payback					**(47)**	**(71)**	**(47)**	**(72)**
Average Overrun					**77**	**90**	**79**	**90**

Note: Negative numbers (in parenthesis "(#)") represent observed payback amounts and whole numbers represent overruns.
Individual MWD (PVID/YPRD) values reflect the values from the columns entitled - "Diff. From Base Case (kaf)" under the respective modeled condition (from the Tables B-7 to B-12 in Appendix B).

Table A-10
SUMMARY OF INDIVIDUAL AND TOTAL END-OF-YEAR OVERRUN ACCOUNT BALANCES FOR IID/CVWD PLUS MWD

	10% Overrun with 3-Year Payback			10% Overrun with 1-Year Payback			5% Overrun with 3-Year Payback			5% Overrun with 1-Year Payback		
Column 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
CY	**IID/CVWD**	**MWD**	**Sum (IID/CVWD+ MWD)**	**IID/CVWD**	**MWD**	**Sum (IID/CVWD+ MWD)**	**IID/CVWD**	**MWD**	**Sum (IID/CVWD+ MWD)**	**IID/CVWD**	**MWD**	**Sum (IID/CVWD+ MWD)**
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	1	45	46	1	45	46	1	45	46	1	45	46
2005	23	74	97	23	47	70	23	77	100	23	47	70
2006	0	38	38	0	0	0	0	47	47	0	0	0
2007	0	11	11	0	0	0	0	17	17	0	0	0
2008	0	0	0	0	0	0	0	2	2	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	13	0	13	13	0	13	13	0	13	13	0	13
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	4	4	0	4	4	0	4	4	0	4	4
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	175	0	175	175	0	175	175	0	175	175	0	175
2015	282	0	282	175	0	175	288	0	288	175	0	175
2016	173	0	173	27	0	27	197	0	197	27	0	27
2017	39	0	39	0	0	0	58	0	58	0	0	0
2018	28	11	39	28	11	39	28	11	39	28	11	39
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	176	7	183	176	7	183	176	7	183	176	7	183
2021	108	0	108	0	0	0	113	0	113	0	0	0
2022	189	1	190	149	1	150	206	1	207	149	1	150
2023	81	0	81	0	0	0	76	0	76	0	0	0
2024	28	35	63	15	35	50	54	35	89	15	35	50
2025	15	17	32	0	11	11	0	23	23	0	11	11
2026	176	30	206	176	30	206	176	41	217	176	30	206
2027	137	31	168	29	19	48	142	39	181	29	19	48
2028	40	1	41	0	0	0	57	19	76	0	0	0
2029	35	0	35	35	0	35	35	0	35	35	0	35
2030	29	0	29	29	0	29	30	0	30	29	0	29
2031	0	0	0	0	0	0	0	0	0	0	0	0
2032	0	0	0	0	0	0	0	0	0	0	0	0
2033	150	0	150	150	0	150	150	0	150	150	0	150
2034	82	25	107	0	25	25	100	25	125	0	25	25
2035	14	7	21	0	0	0	50	15	65	0	0	0
2036	30	7	37	30	7	37	30	12	42	30	7	37
2037	30	25	55	30	25	55	30	25	55	30	25	55
2038	0	7	7	0	0	0	0	15	15	0	0	0
2039	30	0	30	30	0	30	30	5	35	30	0	30
2040	30	0	30	30	0	30	30	0	30	30	0	30
2041	151	0	151	151	0	151	151	0	151	151	0	151
2042	100	0	100	17	0	17	118	0	118	17	0	17
2043	15	0	15	0	0	0	51	0	51	0	0	0
2044	0	0	0	0	0	0	0	0	0	0	0	0
2045	0	0	0	0	0	0	0	0	0	0	0	0
2046	36	0	36	36	0	36	36	0	36	36	0	36
2047	0	0	0	0	0	0	0	0	0	0	0	0
2048	36	0	36	36	0	36	36	0	36	36	0	36
2049	17	44	61	17	44	61	17	44	61	17	44	61
2050	17	52	69	17	26	43	17	55	72	17	26	43
2051	30	66	96	30	50	80	30	80	110	30	50	80
2052	30	44	74	30	12	42	30	51	81	30	12	42
2053	0	14	14	0	0	0	0	18	18	0	0	0
2054	0	0	0	0	0	0	0	0	0	0	0	0
2055	100	19	119	100	19	119	100	19	119	100	19	119
2056	32	1	33	0	0	0	66	9	75	0	0	0
2057	17	42	59	17	42	59	49	42	91	17	42	59
2058	0	24	24	0	0	0	0	28	28	0	0	0
2059	30	102	132	30	96	126	30	110	140	30	96	126
2060	0	59	59	0	0	0	0	32	32	0	0	0
2061	0	27	27	0	0	0	0	16	16	0	0	0
2062	0	0	0	0	0	0	0	0	0	0	0	0
2063	151	0	151	151	0	151	151	0	151	151	0	151
2064	119	0	119	36	0	36	137	0	137	36	0	36
2065	15	0	15	0	0	0	53	0	53	0	0	0
2066	0	0	0	0	0	0	0	0	0	0	0	0
2067	0	15	15	0	15	15	0	15	15	0	15	15
2068	36	29	65	0	0	0	36	49	85	0	0	0
2069	0	11	11	0	0	0	0	29	29	0	0	0
2070	0	0	0	0	0	0	0	14	14	0	0	0
2071	0	0	0	0	0	0	0	0	0	0	0	0
2072	17	0	17	17	0	17	17	0	17	17	0	17
2073	30	14	44	30	14	44	30	14	44	30	14	44
2074	178	76	254	178	76	254	178	80	258	178	76	254
2075	261	57	318	151	6	157	264	38	302	151	6	157
2076	225	106	331	100	12	112	179	28	207	100	12	112

Note: Individual IID/CVWD and MWD values reflect the values from the columns entitled - “Diff. From Base Case (kaf)” for each respective modeled condition (from Tables B-1 to B-12 in Appendix B).

Table A-11
CALIFORNIA TOTAL END-OF-YEAR OVERRUN ACCOUNT BALANCES (KAF)

Column 1	**2**	**3**	**4**	**5**		**6**	**7**	**8**	**9**	**10**
CY	**3YR-PAY 10% MAX**	**1YR-PAY 10% MAX**	**3YR-PAY 5% MAX**	**1YR-PAY 5% MAX**		**PERCENT LESS THAN OR EQUAL TO**	**RANKED 3YR-PAY 10% MAX**	**RANKED 1YR-PAY 10% MAX**	**RANKED 3YR-PAY 5% MAX**	**RANKED 1YR-PAY 5% MAX**
2002	0	0	0	0		1.33	331	254	302	254
2003	0	0	0	0		2.67	318	206	288	206
2004	46	46	46	46		4.00	282	183	258	183
2005	97	70	100	70		5.33	254	175	217	175
2006	38	0	47	0		6.67	206	175	207	175
2007	11	0	17	0		8.00	190	157	207	157
2008	0	0	2	0		9.33	183	151	197	151
2009	0	0	0	0		10.67	175	151	183	151
2010	13	13	13	13		12.00	173	150	181	150
2011	0	0	0	0		13.33	168	150	175	150
2012	4	4	4	4		14.67	151	126	151	126
2013	0	0	0	0		16.00	151	119	151	119
2014	175	175	175	175		17.33	150	112	150	112
2015	282	175	288	175		18.67	132	80	140	80
2016	173	27	197	27		20.00	119	70	137	70
2017	39	0	58	0		21.33	119	61	125	61
2018	39	39	39	39		22.67	108	59	119	59
2019	0	0	0	0		24.00	107	55	118	55
2020	183	183	183	183		25.33	100	50	113	50
2021	108	0	113	0		26.67	97	48	110	48
2022	190	150	207	150		28.00	96	46	100	46
2023	81	0	76	0		29.33	81	44	91	44
2024	63	50	89	50		30.67	74	43	89	43
2025	32	11	23	11		32.00	70	42	85	42
2026	206	206	217	206		33.33	69	39	81	39
2027	168	48	181	48		34.67	65	37	76	37
2028	70	0	76	0		36.00	63	36	76	36
2029	35	35	35	35		37.33	61	36	75	36
2030	29	29	30	29		38.67	59	36	72	36
2031	0	0	0	0		40.00	59	35	65	35
2032	0	0	0	0		41.33	55	30	61	30
2033	150	150	150	150		42.67	46	30	58	30
2034	107	25	125	25		44.00	44	29	55	29
2035	21	0	65	0		45.33	39	27	53	27
2036	37	37	42	37		46.67	39	25	51	25
2037	55	55	55	55		48.00	38	17	47	17
2038	7	0	15	0		49.33	37	17	46	17
2039	30	30	35	30		50.67	36	15	44	15
2040	30	30	30	30		52.00	36	13	42	13
2041	151	151	151	151		53.33	35	11	39	11
2042	100	17	118	17		54.67	33	4	36	4
2043	32	0	51	0		56.00	32	0	36	0
2044	0	0	0	0		57.33	32	0	35	0
2045	0	0	0	0		58.67	30	0	35	0
2046	36	36	36	36		60.00	30	0	32	0
2047	0	0	0	0		61.33	29	0	30	0
2048	36	36	36	36		62.67	27	0	30	0
2049	61	61	61	61		64.00	24	0	29	0
2050	69	43	72	43		65.33	21	0	28	0
2051	96	80	110	80		66.67	17	0	23	0
2052	74	42	81	42		68.00	15	0	18	0
2053	14	0	18	0		69.33	15	0	17	0
2054	0	0	0	0		70.67	14	0	17	0
2055	119	119	119	119		72.00	13	0	16	0
2056	33	0	75	0		73.33	11	0	15	0
2057	59	59	91	59		74.67	11	0	15	0
2058	24	0	28	0		76.00	7	0	14	0
2059	132	126	140	126		77.33	4	0	13	0
2060	59	0	32	0		78.67	0	0	4	0
2061	27	0	16	0		80.00	0	0	2	0
2062	0	0	0	0		81.33	0	0	0	0
2063	151	151	151	151		82.67	0	0	0	0
2064	119	36	137	36		84.00	0	0	0	0
2065	15	0	53	0		85.33	0	0	0	0
2066	0	0	0	0		86.67	0	0	0	0
2067	15	15	15	15		88.00	0	0	0	0
2068	65	0	85	0		89.33	0	0	0	0
2069	11	0	29	0		90.00	1	0	0	0
2070	0	0	14	0		92.00	0	0	0	0
2071	0	0	0	0		93.33	0	0	0	0
2072	17	17	17	17		94.67	0	0	0	0
2073	44	44	44	44		96.00	0	0	0	0
2074	254	254	258	254		97.33	0	0	0	0
2075	318	157	302	157		98.67	0	0	0	0
2076	331	112	207	112		**100.00**	**0**	**0**	**0**	**0**
						AVERAGE	**66**	**42**	**70**	**42**

Note: Values in column nos. 2, 3, 4 and 5 above reflect values in column nos. 4, 7, 10 and 13 in Table A-10, respectively.

Table A-12
AVERAGE OVERRUN ACCOUNT FORGIVEN

Column 1	2	3	4	5	6
CY	PROB	3YR-PAY 10% MAX	1YR-PAY 10%MAX	3YR-PAY 5% MAX	1YR-PAY 5% MAX
2002	0.1295	66	42	70	42
2003	0.1857	66	42	70	42
2004	0.1927	66	42	70	42
2005	0.1831	66	42	70	42
2006	0.1910	66	42	70	42
2007	0.1815	66	42	70	42
2008	0.1644	66	42	70	42
2009	0.1315	66	42	70	42
2010	0.1129	66	42	70	42
2011	0.1221	66	42	70	42
2012	0.1146	66	42	70	42
2013	0.1052	66	42	70	42
2014	0.1012	66	42	70	42
2015	0.0747	66	42	70	42
2016	0.0664	66	42	70	42
2017	0.0763	66	42	70	42
2018	0.0803	66	42	70	42
2019	0.0642	66	42	70	42
2020	0.0720	66	42	70	42
2021	0.0635	66	42	70	42
2022	0.0579	66	42	70	42
2023	0.0623	66	42	70	42
2024	0.0565	66	42	70	42
2025	0.0518	66	42	70	42
2026	0.0436	66	42	70	42
2027	0.0548	66	42	70	42
2028	0.0541	66	42	70	42
2029	0.0531	66	42	70	42
2030	0.0473	66	42	70	42
2031	0.0518	66	42	70	42
2032	0.0518	66	42	70	42
2033	0.0509	66	42	70	42
2034	0.0573	66	42	70	42
2035	0.0548	66	42	70	42
2036	0.0509	66	42	70	42
2037	0.0484	66	42	70	42
2038	0.0450	66	42	70	42
2039	0.0494	66	42	70	42
2040	0.0484	66	42	70	42
2041	0.0436	66	42	70	42
2042	0.0399	66	42	70	42
2043	0.0426	66	42	70	42
2044	0.0426	66	42	70	42
2045	0.0399	66	42	70	42
2046	0.0414	66	42	70	42
2047	0.0432	66	42	70	42
2048	0.0365	66	42	70	42
2049	0.0415	66	42	70	42
2050	0.0432	66	42	70	42

ATTACHMENT B

MODELING SIMULATION RESULTS

MODELING SIMULATIONS

Table No.	User(s)	Maximum Allowed Overrun Account Balance	Payback Period (years)	
B-1	IID/CVWD	10%	3	Priority 3 Entitlement = 3.38 kafy
B-2	IID/CVWD	10%	1	Priority 3 Entitlement = 3.38 kafy
B-3	IID/CVWD	10%	0	Priority 3 Entitlement = 3.38 kafy
B-4	IID/CVWD	5%	3	Priority 3 Entitlement = 3.38 kafy
B-5	IID/CVWD	5%	1	Priority 3 Entitlement = 3.38 kafy
B-6	IID/CVWD	5%	0	Priority 3 Entitlement = 3.38 kafy
B-7	PVID/YPRD	10%	3	Priority 1&2 Target = 0.42 kafy
B-8	PVID/YPRD	10%	1	Priority 1&2 Target = 0.42 kafy
B-9	PVID/YPRD	10%	0	Priority 1&2 Target = 0.42 kafy
B-10	PVID/YPRD	5%	3	Priority 1&2 Target = 0.42 kafy
B-11	PVID/YPRD	5%	1	Priority 1&2 Target = 0.42 kafy
B-12	PVID/YPRD	5%	0	Priority 1&2 Target = 0.42 kafy

Explanation of contents of columns in Tables B-1 to B-12.

Column	Title	Content Description
1	Year	Modeled calendar year, starting with 02 or 2002.
2	Estimated Consumptive Use	Estimated consumptive use based on projections developed by Reclamation or as provided by the respective agency.
3	Measured Consumptive Use	Represents the "Measured" Consumptive Use assuming that variable extraordinary Conservation is taking place. Measured Consumptive use is therefore equal to historic minus the Extraordinary Conservation.
4	Entitlement Minus the Payback Target	Entitlement less payback amount (Column 9)
5	Over/Under	Amount of Over-Run exceeding entitlement or entitlement minus payback amount.
6	Overrun Account Reported	Amount of Over-run that occurred last year, but was reported this year.
7	% of Entitlement	Maximum Overrun Account Amount
8	20% of Maximum	Minimum payback = greater of 20% of Maximum or 1/3 of Account
9	Extraordinary Conservation Required	Amount of Extra Ordinary Conservation district implementing (required payback).
10	End of Year Account	Amount in Over-run Account including paybacks and any additional overruns
11	Base Case	The base case data for each respective agency or priority right group as developed and presented in Table A-2, Appendix A.
12	Difference from Base Case	Estimated Consumptive Use (Column 3) less Base Case Amount (Column 11)

Modeling Conditions for
Table Nos. B-1, B-2 and B-3 (IID/CVWD)

Conditions:

1. Inadvertent Overruns are limited to a maximum of 10% of entities' entitlement.

Rules:

1. Minimum Payback = greater of 20% maximum allowed Inadvertent Overrun or 1/3 of Account Balance.
2. Accounts which exceed 10% of entitlement - Strict enforcement 1 yr payback
3. First Year of payback not strictly enforced, except that exceeding maximum account will not be allowed during a payback year.
4. Second Year of payback - strict enforcement and balancing of Account
5. Inadvertent Overrun Account balances are forgiven when flood releases occur.
6. Under 1 year payback (normal, or overage greater than 10%)
7. For 1 year delay in reporting, as long as entity has not exceeded its 10% overrun allowance and they are meeting their payback schedule, the second year overrun, which was not reported prior to implementation of the first year of payback, would be treated as a separate overrun, with the payback amount criteria applying to the second amount. The full payback would be the sum of the two paybacks occurring together.

Table B-1
IID and Coachella Baselines Added Together - 10% Overrun with 3-Year Payback
(Assume base entitlement of 3.38 maf)

Column 1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Year	**Estimated Consumptive Use**	**Measured Consumptive Use**	**Entitlement Minus Payback Target**	**Over / Under Runs**	**Overrun Account Reported**	**10% of Entitlement**	**20% of Maximum Entitlement**	**Extraordinary Conservation Required**	**End of Year Overrun Account**	**Base Case**	**Difference From Base Case**
2002	3,252	3,252		0		338	68			3,252	0
2003	3,381	3,381		1	0	338	68		0	3,335	46
2004	3,403	3,403		23	1	338	68		1	3,333	70
2005	3,347	3,346	3,379	0	23	338	68	1	23	3,347	(1)
2006	3,260	3,237	3,357	0	0	338	68	23	0	3,260	(23)
2007	3,261	3,261		0	0	338	68		0	3,261	0
2008	3,119	3,119		0	0	338	68		0	3,119	0
2009	3,393	3,393		13	0	338	68		0	3,381	12
2010	3,264	3,264		0	13	338	68		13	3,264	0
2011	3,355	3,342	3,367	0	0	338	68	13	0	3,351	(9)
2012	3,121	3,121		0	0	338	68		0	3,121	0
2013	3,555	3,555		175	0	338	68		0	3,426	129
2014	3,555	3,555		175	175	338	68		175	3,428	127
2015	3,407	3,339	3,312	27	175	338	68	68	282	3,407	(68)
2016	3,246	3,110	3,244	0	27	338	68	136	173	3,246	(136)
2017	3,408	3,274	3,246	28	0	338	68	134	39	3,369	(95)
2018	3,246	3,207	3,341	0	28	338	68	39	28	3,246	(39)
2019	3,556	3,528	3,352	176	0	338	68	28	0	3,373	155
2020	3,266	3,266		0	176	338	68		176	3,266	0
2021	3,529	3,461	3,312	149	0	338	68	68	108	3,379	82
2022	3,123	3,055	3,312	0	149	338	68	68	189	3,123	(68)
2023	3,395	3,287	3,272	15	0	338	68	108	81	3,345	(58)
2024	3,357	3,289	3,312	0	15	338	68	68	28	3,357	(68)
2025	3,556	3,528	3,352	176	15	338	68	28	15	3,350	178
2026	3,409	3,394	3,365	29	176	338	68	15	176	3,361	33
2027	3,358	3,290	3,312	0	29	338	68	68	137	3,358	(68)
2028	3,415	3,318	3,283	35	0	338	68	97	40	3,415	(97)
2029	3,409	3,369	3,340	29	35	338	68	40	35	3,409	(40)
2030	3,358	3,323	3,345	0	29	338	68	35	29	3,358	(35)
2031	3,358	3,329	3,351	0	0	338	68	29	0	3,358	(29)
2032	3,530	3,530		150	0	338	68		0	3,391	139
2033	3,358	3,358		0	150	338	68		150	3,333	25
2034	3,124	3,056	3,312	0	0	338	68	68	82	3,124	(68)
2035	3,410	3,342	3,312	30	0	338	68	68	14	3,373	(31)
2036	3,410	3,396	3,366	30	30	338	68	14	30	3,355	41
2037	3,267	3,237	3,350	0	30	338	68	30	30	3,267	(30)
2038	3,410	3,380	3,350	30	0	338	68	30	0	3,404	(24)
2039	3,410	3,410	3,380	30	30	338	68		30	3,410	0
2040	3,531	3,501	3,350	151	30	338	68	30	30	3,439	62
2041	3,397	3,367	3,350	17	151	338	68	30	151	3,397	(30)
2042	3,124	3,056	3,312	0	17	338	68	68	100	3,124	(68)
2043	3,081	2,996	3,295	0	0	338	68	85	15	3,081	(85)
2044	3,248	3,233	3,365	0	0	338	68	15	0	3,248	(15)
2045	3,416	3,416		36	0	338	68		0	3,400	16
2046	3,124	3,124		0	36	338	68		36	3,124	0
2047	3,416	3,380	3,344	36	0	338	68	36	0	3,383	(3)
2048	3,397	3,397		17	36	338	68		36	3,336	61
2049	3,397	3,361	3,344	17	17	338	68	36	17	3,354	7
2050	3,410	3,393	3,363	30	17	338	68	17	17	3,330	63
2051	3,410	3,393	3,363	30	30	338	68	17	30	3,338	55
2052	3,081	3,051	3,350	0	30	338	68	30	30	3,081	(30)
2053	3,248	3,218	3,350	0	0	338	68	30	0	3,248	(30)
2054	3,480	3,480		100	0	338	68		0	3,361	119
2055	3,123	3,123		0	100	338	68		100	3,123	0
2056	3,397	3,329	3,312	17	0	338	68	68	32	3,338	(9)
2057	3,124	3,092	3,348	0	17	338	68	32	17	3,124	(32)
2058	3,410	3,393	3,363	30	0	338	68	17	0	3,284	109
2059	3,248	3,248		0	30	338	68		30	3,248	0
2060	3,248	3,218	3,350	0	0	338	68	30	0	3,248	(30)
2061	3,124	3,124		0	0	338	68		0	3,124	0
2062	3,531	3,531		151	0	338	68		0	3,396	135
2063	3,416	3,416	3,380	36	151	338	68		151	3,388	28
2064	3,081	3,013	3,312	0	36	338	68	68	119	3,081	(68)
2065	3,267	3,163	3,276	0	0	338	68	104	15	3,267	(104)
2066	3,359	3,344	3,365	0	0	338	68	15	0	3,344	0
2067	3,416	3,416		36	0	338	68		0	3,336	80
2068	3,248	3,248		0	36	338	68		36	3,248	0
2069	2,880	2,844	3,344	0	0	338	68	36	0	2,880	(36)
2070	3,124	3,124		0	0	338	68		0	3,124	0
2071	3,397	3,397	3,380	17	0	338	68		0	3,397	0
2072	3,410	3,410	3,380	30	17	338	68		17	3,366	44
2073	3,558	3,541	3,363	178	30	338	68	17	30	3,304	237
2074	3,531	3,501	3,350	151	178	338	68	30	178	3,374	127
2075	3,480	3,412	3,312	100	151	338	68	68	261	3,368	44
2076	3,416	3,280	3,244	36	100	338	68	136	225	3,328	(48)
							Maximum	**178**			
							Average	**47**			

Table B-2
IID and Coachella Baselines Added Together - 10% Overrun with 1-Year Payback
(Assume base entitlement of 3.38 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	Estimated Consumptive Use	Measured Consumptive Use	Entitlement Minus Payback Target	Over / Under Runs	Overrun Account Reported	10% of Entitlement	20% of Maximum Entitlement	Extraordinary Conservation Required	End of Year Overrun Account	Base Case	Difference From Base Case
2002	3,252	3,252		0		338	68			3,252	0
2003	3,381	3,381		1	0	338	68		0	3,335	46
2004	3,403	3,403		23	1	338	68		1	3,333	70
2005	3,347	3,346	3,379	0	23	338	68	1	23	3,347	(1)
2006	3,260	3,237	3,357	0	0	338	68	23	0	3,260	(23)
2007	3,261	3,261		0	0	338	68		0	3,261	0
2008	3,119	3,119		0	0	338	68		0	3,119	0
2009	3,393	3,393		13	0	338	68		0	3,381	12
2010	3,264	3,264		0	13	338	68		13	3,264	0
2011	3,355	3,342	3,367	0	0	338	68	13	0	3,351	(9)
2012	3,121	3,121		0	0	338	68		0	3,121	0
2013	3,555	3,555		175	0	338	68		0	3,426	129
2014	3,555	3,555		175	175	338	68		175	3,428	127
2015	3,407	3,232	3,205	27	175	338	68	175	175	3,407	(175)
2016	3,246	3,071	3,205	0	27	338	68	175	27	3,246	(175)
2017	3,408	3,381	3,353	28	0	338	68	27	0	3,369	12
2018	3,246	3,246		0	28	338	68		28	3,246	0
2019	3,556	3,528	3,352	176	0	338	68	28	0	3,373	155
2020	3,266	3,266		0	176	338	68		176	3,266	0
2021	3,529	3,353	3,204	149	0	338	68	176	0	3,379	(26)
2022	3,123	3,123		0	149	338	68		149	3,123	0
2023	3,395	3,246	3,231	15	0	338	68	149	0	3,345	(99)
2024	3,357	3,357		0	15	338	68		15	3,357	0
2025	3,556	3,541	3,365	176		338	68	15	0	3,350	191
2026	3,409	3,409		29	176	338	68		176	3,361	48
2027	3,358	3,182	3,204	0	29	338	68	176	29	3,358	(176)
2028	3,415	3,386	3,351	35	0	338	68	29	0	3,415	(29)
2029	3,409	3,409	3,380	29	35	338	68		35	3,409	0
2030	3,358	3,323	3,345	0	29	338	68	35	29	3,358	(35)
2031	3,358	3,329	3,351	0	0	338	68	29	0	3,358	(29)
2032	3,530	3,530		150	0	338	68		0	3,391	139
2033	3,358	3,358		0	150	338	68		150	3,333	25
2034	3,124	2,974	3,230	0	0	338	68	150	0	3,124	(150)
2035	3,410	3,410		30	0	338	68		0	3,373	37
2036	3,410	3,410		30	30	338	68		30	3,355	55
2037	3,267	3,237	3,350	0	30	338	68	30	30	3,267	(30)
2038	3,410	3,380	3,350	30	0	338	68	30	0	3,404	(24)
2039	3,410	3,410	3,380	30	30	338	68		30	3,410	0
2040	3,531	3,501	3,350	151	30	338	68	30	30	3,439	62
2041	3,397	3,367	3,350	17	151	338	68	30	151	3,397	(30)
2042	3,124	2,973	3,229	0	17	338	68	151	17	3,124	(151)
2043	3,081	3,064	3,363	0	0	338	68	17	0	3,081	(17)
2044	3,248	3,248		0	0	338	68		0	3,248	0
2045	3,416	3,416		36	0	338	68		0	3,400	16
2046	3,124	3,124		0	36	338	68		36	3,124	0
2047	3,416	3,380	3,344	36	0	338	68	36	0	3,383	(3)
2048	3,397	3,397		17	36	338	68		36	3,336	61
2049	3,397	3,361	3,344	17	17	338	68	36	17	3,354	7
2050	3,410	3,393	3,363	30	17	338	68	17	17	3,330	63
2051	3,410	3,393	3,363	30	30	338	68	17	30	3,338	55
2052	3,081	3,051	3,350	0	30	338	68	30	30	3,081	(30)
2053	3,248	3,218	3,350	0	0	338	68	30	0	3,248	(30)
2054	3,480	3,480		100	0	338	68		0	3,361	119
2055	3,124	3,124		0	100	338	68		100	3,123	1
2056	3,397	3,297	3,280	17	0	338	68	100	0	3,338	(41)
2057	3,124	3,124		0	17	338	68		17	3,124	0
2058	3,410	3,393	3,363	30	0	338	68	17	0	3,284	109
2059	3,248	3,248		0	30	338	68		30	3,248	0
2060	3,248	3,218	3,350	0	0	338	68	30	0	3,248	(30)
2061	3,124	3,124		0	0	338	68		0	3,124	0
2062	3,531	3,531		151	0	338	68		0	3,396	135
2063	3,416	3,416	3,380	36	151	338	68		151	3,388	28
2064	3,081	2,930	3,229	0	36	338	68	151	36	3,081	(151)
2065	3,267	3,231	3,344	0	0	338	68	36	0	3,267	(36)
2066	3,359	3,359		0	0	338	68		0	3,344	15
2067	3,416	3,416		36	0	338	68		0	3,336	80
2068	3,248	3,248		0	0	338	68		0	3,248	0
2069	2,880	2,880		0	0	338	68		0	2,880	0
2070	3,124	3,124		0	0	338	68		0	3,124	0
2071	3,397	3,397	3,380	17	0	338	68		0	3,397	0
2072	3,410	3,410	3,380	30	17	338	68		17	3,366	44
2073	3,558	3,541	3,363	178	30	338	68	17	30	3,304	237
2074	3,531	3,501	3,350	151	178	338	68	30	178	3,374	127
2075	3,480	3,302	3,202	100	151	338	68	178	151	3,368	(66)
2076	3,416	3,265	3,229	36	100	338	68	151	100	3,328	(63)

Table B-3
IID and Coachella Baselines Added Together - Baseline and Shortage Years w/ 10% Overrun
(Assume base entitlement of 3.38 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	**Estimated Consumptive Use**	**Measured Consumptive Use**	**Entitlement Minus Payback Target**	**Over / Under Runs**	**Overrun Account Reported**	**10% of Entitlement**	**20% of Maximum Entitlement**	**Extraordinary Conservation Required**	**End of Year Overrun Account**	**Base Case**	**Difference From Base Case**
2002	3,252	3,252		0		338	68			3,252	0
2003	3,335	3,335		0	0	338	68		0	3,335	0
2004	3,333	3,333		0	0	338	68		0	3,333	0
2005	3,347	3,347		0	0	338	68		0	3,347	0
2006	3,260	3,260		0	0	338	68		0	3,260	0
2007	3,261	3,261		0	0	338	68		0	3,261	0
2008	3,119	3,119		0	0	338	68		0	3,119	0
2009	3,381	3,380		0	0	338	68		0	3,380	0
2010	3,264	3,264		0	0	338	68		0	3,264	0
2011	3,351	3,351		0	0	338	68		0	3,351	0
2012	3,121	3,121		0	0	338	68		0	3,121	0
2013	3,426	3,380		0	0	338	68		0	3,380	0
2014	3,428	3,380		0	0	338	68		0	3,380	0
2015	3,407	3,380		0	0	338	68		0	3,380	0
2016	3,246	3,246		0	0	338	68		0	3,246	0
2017	3,369	3,369		0	0	338	68		0	3,369	0
2018	3,246	3,246		0	0	338	68		0	3,246	0
2019	3,373	3,373		0	0	338	68		0	3,373	0
2020	3,266	3,266		0	0	338	68		0	3,266	0
2021	3,379	3,379		0	0	338	68		0	3,379	0
2022	3,123	3,123		0	0	338	68		0	3,123	0
2023	3,345	3,345		0	0	338	68		0	3,345	0
2024	3,357	3,357		0	0	338	68		0	3,357	0
2025	3,350	3,350		0		338	68		0	3,350	0
2026	3,361	3,361		0	0	338	68		0	3,361	0
2027	3,358	3,358		0	0	338	68		0	3,358	0
2028	3,415	3,380		0	0	338	68		0	3,380	0
2029	3,409	3,380		0	0	338	68		0	3,380	0
2030	3,358	3,358		0	0	338	68		0	3,358	0
2031	3,358	3,358		0	0	338	68		0	3,358	0
2032	3,391	3,380		0	0	338	68		0	3,380	0
2033	3,333	3,333		0	0	338	68		0	3,333	0
2034	3,124	3,124		0	0	338	68		0	3,124	0
2035	3,373	3,373		0	0	338	68		0	3,373	0
2036	3,355	3,355		0	0	338	68		0	3,355	0
2037	3,267	3,267		0	0	338	68		0	3,267	0
2038	3,404	3,380		0	0	338	68		0	3,380	0
2039	3,410	3,380		0	0	338	68		0	3,380	0
2040	3,439	3,380		0	0	338	68		0	3,380	0
2041	3,397	3,380		0	0	338	68		0	3,380	0
2042	3,124	3,124		0	0	338	68		0	3,124	0
2043	3,081	3,081		0	0	338	68		0	3,081	0
2044	3,248	3,248		0	0	338	68		0	3,248	0
2045	3,400	3,380		0	0	338	68		0	3,380	0
2046	3,124	3,124		0	0	338	68		0	3,124	0
2047	3,383	3,380		0	0	338	68		0	3,380	0
2048	3,336	3,336		0	0	338	68		0	3,336	0
2049	3,354	3,354		0	0	338	68		0	3,354	0
2050	3,330	3,330		0	0	338	68		0	3,330	0
2051	3,338	3,338		0	0	338	68		0	3,338	0
2052	3,081	3,081		0	0	338	68		0	3,081	0
2053	3,248	3,248		0	0	338	68		0	3,248	0
2054	3,361	3,361		0	0	338	68		0	3,361	0
2055	3,123	3,123		0	0	338	68		0	3,123	0
2056	3,338	3,338		0	0	338	68		0	3,338	0
2057	3,124	3,124		0	0	338	68		0	3,124	0
2058	3,284	3,284		0	0	338	68		0	3,284	0
2059	3,248	3,248		0	0	338	68		0	3,248	0
2060	3,248	3,248		0	0	338	68		0	3,248	0
2061	3,124	3,124		0	0	338	68		0	3,124	0
2062	3,396	3,380		0	0	338	68		0	3,380	0
2063	3,388	3,380		0	0	338	68		0	3,380	0
2064	3,081	3,081		0	0	338	68		0	3,081	0
2065	3,267	3,267		0	0	338	68		0	3,267	0
2066	3,344	3,344		0	0	338	68		0	3,344	0
2067	3,336	3,336		0	0	338	68		0	3,336	0
2068	3,248	3,248		0	0	338	68		0	3,248	0
2069	2,880	2,880		0	0	338	68		0	2,880	0
2070	3,124	3,124		0	0	338	68		0	3,124	0
2071	3,397	3,380		0	0	338	68		0	3,380	0
2072	3,366	3,366		0	0	338	68		0	3,366	0
2073	3,304	3,304		0	0	338	68		0	3,304	0
2074	3,374	3,374		0	0	338	68		0	3,374	0
2075	3,368	3,368		0	0	338	68		0	3,368	0
2076	3,328	3,328		0	0	338	68		0	3,328	0

Modeling Conditions for
Table Nos. B-4, B-5 and B-6 (IID/CVWD)

Conditions:

1. Inadvertent Overruns are limited to a maximum of 5% of entities entitlement.

Rules:

1. Minimum Payback = greater of 20% maximum allowed Inadvertent Overrun or 1/3 of Account Balance.
2. Accounts which exceed 5% of entitlement - Strict enforcement 1 yr payback
3. First Year of payback not strictly enforced, except that exceeding maximum account will not be allowed during a payback year.
4. Second Year of payback - strict enforcement and balancing of Account
5. Inadvertent Overrun Account balances are forgiven when flood releases occur.
6. Under 1 year payback (normal, or overage greater than 5%)
7. For 1 year delay in reporting, as long as entity has not exceeded its 5% overrun allowance and they are meeting their payback schedule, the second year overrun, which was not reported prior to implementation of the first year of payback, would be treated as a separate overrun, with the payback amount criteria applying to the second amount. The full payback would be the sum of the two paybacks occurring together.

Table B-4
IID and Coachella Baselines Added Together - 5% Overrun with 3-Year Payback
(Assume base entitlement of 3.38 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	**Estimated Consumptive Use**	**Measured Consumptive Use**	**Entitlement Minus Payback Target**	**Over / Under Runs**	**Overrun Account Reported**	**5% of Entitlement**	**20% of Maximum Entitlement**	**Extraordinary Conservation Required**	**End of Year Overrun Account**	**Base Case**	**Difference From Base Case**
2002	3,252	3,252		0		169	34			3,252	0
2003	3,381	3,381		1	0	169	34		0	3,335	46
2004	3,403	3,403		23	1	169	34		1	3,333	70
2005	3,347	3,346	1,689	0	23	169	34	1	23	3,347	(1)
2006	3,260	3,237	1,667	0	0	169	34	23	0	3,260	(23)
2007	3,261	3,261		0	0	169	34		0	3,261	0
2008	3,119	3,119		0	0	169	34		0	3,119	0
2009	3,393	3,393		13	0	169	34		0	3,381	12
2010	3,264	3,264		0	13	169	34		13	3,264	0
2011	3,355	3,342	1,677	0	0	169	34	13	0	3,351	(9)
2012	3,121	3,121		0	0	169	34		0	3,121	0
2013	3,555	3,555		175	0	169	34		0	3,426	129
2014	3,555	3,555		175	175	169	34		175	3,428	127
2015	3,407	3,345	3,318	27	175	169	34	62	288	3,407	(62)
2016	3,246	3,128	3,262	0	27	169	34	118	197	3,246	(118)
2017	3,408	3,269	3,241	28	0	169	34	139	58	3,369	(100)
2018	3,246	3,188	3,322	0	28	169	34	58	28	3,246	(58)
2019	3,556	3,528	3,352	176	0	169	34	28	0	3,373	155
2020	3,266	3,266		0	176	169	34		176	3,266	0
2021	3,529	3,466	3,317	149	0	169	34	63	113	3,379	87
2022	3,123	3,067	3,324	0	149	169	34	56	206	3,123	(56)
2023	3,395	3,265	3,250	15	0	169	34	130	76	3,345	(80)
2024	3,357	3,320	3,343	0	15	169	34	37	54	3,357	(37)
2025	3,556	3,502	3,326	176	0	169	34	54	0	3,350	152
2026	3,409	3,409		29	176	169	34		176	3,361	48
2027	3,358	3,295	1,627	0	29	169	34	63	142	3,358	(63)
2028	3,415	3,330	1,605	35	0	169	34	85	57	3,415	(85)
2029	3,409	3,352	1,633	29	35	169	34	57	35	3,409	(57)
2030	3,358	3,324	1,656	0	29	169	34	34	30	3,358	(34)
2031	3,358	3,328	1,660	0	0	169	34	30	0	3,358	(30)
2032	3,530	3,530		150	0	169	34		0	3,391	139
2033	3,358	3,358		0	150	169	34		150	3,333	25
2034	3,124	3,074	1,640	0	0	169	34	50	100	3,124	(50)
2035	3,410	3,360	1,640	30	0	169	34	50	50	3,373	(13)
2036	3,410	3,360	1,640	30	30	169	34	50	30	3,355	5
2037	3,267	3,237	3,350	0	30	169	34	30	30	3,267	(30)
2038	3,410	3,380	3,350	30	0	169	34	30	0	3,404	(24)
2039	3,410	3,410	3,380	30	30	169	34		30	3,410	0
2040	3,531	3,501	3,350	151	30	169	34	30	30	3,439	62
2041	3,397	3,367	3,350	17	151	169	34	30	151	3,397	(30)
2042	3,124	3,074	3,330	0	17	169	34	50	118	3,124	(50)
2043	3,081	3,014	3,313	0	0	169	34	67	51	3,081	(67)
2044	3,248	3,197	3,329	0	0	169	34	51	0	3,248	(51)
2045	3,416	3,416		36	0	169	34		0	3,400	16
2046	3,124	3,124		0	36	169	34		36	3,124	0
2047	3,416	3,380	3,344	36	0	169	34	36	0	3,383	(3)
2048	3,397	3,397		17	36	169	34		36	3,336	61
2049	3,397	3,361	3,344	17	17	169	34	36	17	3,354	7
2050	3,410	3,393	3,363	30	17	169	34	17	17	3,330	63
2051	3,410	3,393	3,363	30	30	169	34	17	30	3,338	55
2052	3,081	3,051	3,350	0	30	169	34	30	30	3,081	(30)
2053	3,248	3,218	3,350	0	0	169	34	30	0	3,248	(30)
2054	3,480	3,480		100	0	169	34		0	3,361	119
2055	3,123	3,123		0	100	169	34		100	3,123	0
2056	3,397	3,363	3,346	17	0	169	34	34	66	3,338	25
2057	3,124	3,090	3,346	0	17	169	34	34	49	3,124	(34)
2058	3,410	3,361	3,331	30	0	169	34	49	0	3,284	77
2059	3,248	3,248		0	30	169	34		30	3,248	0
2060	3,248	3,218	3,350	0	0	169	34	30	0	3,248	(30)
2061	3,124	3,124		0	0	169	34		0	3,124	0
2062	3,531	3,531		151	0	169	34		0	3,396	135
2063	3,416	3,416	3,380	36	151	169	34		151	3,388	28
2064	3,081	3,031	3,330	0	36	169	34	50	137	3,081	(50)
2065	3,267	3,183	3,296	0	0	169	34	84	53	3,267	(84)
2066	3,359	3,306	3,327	0	0	169	34	53	0	3,344	(38)
2067	3,416	3,416		36	0	169	34		0	3,336	80
2068	3,248	3,248		0	36	169	34		36	3,248	0
2069	2,880	2,844	3,344	0	0	169	34	36	0	2,880	(36)
2070	3,124	3,124		0	0	169	34		0	3,124	0
2071	3,397	3,397	3,380	17	0	169	34		0	3,397	0
2072	3,410	3,410	3,380	30	17	169	34		17	3,366	44
2073	3,558	3,541	3,363	178	30	169	34	17	30	3,304	237
2074	3,531	3,501	3,350	151	178	169	34	30	178	3,374	127
2075	3,480	3,415	3,315	100	151	169	34	65	264	3,368	47
2076	3,416	3,231	3,195	36	100	169	34	185	179	3,328	(97)
								119			

Table B-5
IID and Coachella Baselines Added Together - 5% Overrun with 1-Year Payback
(Assume base entitlement of 3.38 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	Estimated Consumptive Use	Measured Consumptive Use	Entitlement Minus Payback Target	Over / Under Runs	Overrun Account Reported	5% of Entitlement	20% of Maximum Entitlement	Extraordinary Conservation Required	End of Year Overrun Account	Base Case	Difference From Base Case
2002	3,252	3,252		0		169	34			3,252	0
2003	3,381	3,381		1	0	169	34		0	3,335	46
2004	3,403	3,403		23	1	169	34		1	3,333	70
2005	3,347	3,346	3,379	0	23	169	34	1	23	3,347	(1)
2006	3,260	3,237	3,357	0	0	169	34	23	0	3,260	(23)
2007	3,261	3,261		0	0	169	34		0	3,261	0
2008	3,119	3,119		0	0	169	34		0	3,119	0
2009	3,393	3,393		13	0	169	34		0	3,381	12
2010	3,264	3,264		0	13	169	34		13	3,264	0
2011	3,355	3,342	3,367	0	0	169	34	13	0	3,351	(9)
2012	3,121	3,121		0	0	169	34		0	3,121	0
2013	3,555	3,555		175	0	169	34		0	3,426	129
2014	3,555	3,555		175	175	169	34		175	3,428	127
2015	3,407	3,232	3,205	27	175	169	34	175	175	3,407	(175)
2016	3,246	3,071	3,205	0	27	169	34	175	27	3,246	(175)
2017	3,408	3,381	3,353	28	0	169	34	27	0	3,369	12
2018	3,246	3,246		0	28	169	34		28	3,246	0
2019	3,556	3,528	3,352	176	0	169	34	28	0	3,373	155
2020	3,266	3,266		0	176	169	34		176	3,266	0
2021	3,529	3,353	3,204	149	0	169	34	176	0	3,379	(26)
2022	3,123	3,123		0	149	169	34		149	3,123	0
2023	3,395	3,246	3,231	15	0	169	34	149	0	3,345	(99)
2024	3,357	3,357		0	15	169	34		15	3,357	0
2025	3,556	3,541	3,365	176		169	34	15	0	3,350	191
2026	3,409	3,409		29	176	169	34		176	3,361	48
2027	3,358	3,182	3,204	0	29	169	34	176	29	3,358	(176)
2028	3,415	3,386	3,351	35	0	169	34	29	0	3,415	(29)
2029	3,409	3,409	3,380	29	35	169	34		35	3,409	0
2030	3,358	3,323	3,345	0	29	169	34	35	29	3,358	(35)
2031	3,358	3,329	3,351	0	0	169	34	29	0	3,358	(29)
2032	3,530	3,530		150	0	169	34		0	3,391	139
2033	3,358	3,358		0	150	169	34		150	3,333	25
2034	3,124	2,974	3,230	0	0	169	34	150	0	3,124	(150)
2035	3,410	3,410		30	0	169	34		0	3,373	37
2036	3,410	3,410		30	30	169	34		30	3,355	55
2037	3,267	3,237	3,350	0	30	169	34	30	30	3,267	(30)
2038	3,410	3,380	3,350	30	0	169	34	30	0	3,404	(24)
2039	3,410	3,410	3,380	30	30	169	34		30	3,410	0
2040	3,531	3,501	3,350	151	30	169	34	30	30	3,439	62
2041	3,397	3,367	3,350	17	151	169	34	30	151	3,397	(30)
2042	3,124	2,973	3,229	0	17	169	34	151	17	3,124	(151)
2043	3,081	3,064	3,363	0	0	169	34	17	0	3,081	(17)
2044	3,248	3,248		0	0	169	34		0	3,248	0
2045	3,416	3,416		36	0	169	34		0	3,400	16
2046	3,124	3,124		0	36	169	34		36	3,124	0
2047	3,416	3,380	3,344	36	0	169	34	36	0	3,383	(3)
2048	3,397	3,397		17	36	169	34		36	3,336	61
2049	3,397	3,361	3,344	17	17	169	34	36	17	3,354	7
2050	3,410	3,393	3,363	30	17	169	34	17	17	3,330	63
2051	3,410	3,393	3,363	30	30	169	34	17	30	3,338	55
2052	3,081	3,051	3,350	0	30	169	34	30	30	3,081	(30)
2053	3,248	3,218	3,350	0	0	169	34	30	0	3,248	(30)
2054	3,480	3,480		100	0	169	34		0	3,361	119
2055	3,124	3,124		0	100	169	34		100	3,123	1
2056	3,397	3,297	3,280	17	0	169	34	100	0	3,338	(41)
2057	3,124	3,124		0	17	169	34		17	3,124	0
2058	3,410	3,393	3,363	30	0	169	34	17	0	3,284	109
2059	3,248	3,248		0	30	169	34		30	3,248	0
2060	3,248	3,218	3,350	0	0	169	34	30	0	3,248	(30)
2061	3,124	3,124		0	0	169	34		0	3,124	0
2062	3,531	3,531		151	0	169	34		0	3,396	135
2063	3,416	3,416	3,380	36	151	169	34		151	3,388	28
2064	3,081	2,930	3,229	0	36	169	34	151	36	3,081	(151)
2065	3,267	3,231	3,344	0	0	169	34	36	0	3,267	(36)
2066	3,359	3,359		0	0	169	34		0	3,344	15
2067	3,416	3,416		36	0	169	34		0	3,336	80
2068	3,248	3,248		0	0	169	34		0	3,248	0
2069	2,880	2,880		0	0	169	34		0	2,880	0
2070	3,124	3,124		0	0	169	34		0	3,124	0
2071	3,397	3,397	3,380	17	0	169	34		0	3,397	0
2072	3,410	3,410	3,380	30	17	169	34		17	3,366	44
2073	3,558	3,541	3,363	178	30	169	34	17	30	3,304	237
2074	3,531	3,501	3,350	151	178	169	34	30	178	3,374	127
2075	3,480	3,302	3,202	100	151	169	34	178	151	3,368	(66)
2076	3,416	3,265	3,229	36	100	169	34	151	100	3,328	(63)

Table B-6
IID and Coachella Baselines Added Together - Baseline and Shortage Years w/ 5% Overrun
(Assume base entitlement of 3.38 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	Estimated Consumptive Use	Measured Consumptive Use	Entitlement Minus Payback Target	Over / Under Runs	Overrun Account Reported	5% of Entitlement	20% of Maximum Entitlement	Extraordinary Conservation Required	End of Year Overrun Account	Base Case	Difference From Base Case
2002	3,252	3,252		0		169	34			3,252	0
2003	3,335	3,335		0	0	169	34		0	3,335	0
2004	3,333	3,333		0	0	169	34		0	3,333	0
2005	3,347	3,347		0	0	169	34		0	3,347	0
2006	3,260	3,260		0	0	169	34		0	3,260	0
2007	3,261	3,261		0	0	169	34		0	3,261	0
2008	3,119	3,119		0	0	169	34		0	3,119	0
2009	3,381	3,380		0	0	169	34		0	3,380	0
2010	3,264	3,264		0	0	169	34		0	3,264	0
2011	3,351	3,351		0	0	169	34		0	3,351	0
2012	3,121	3,121		0	0	169	34		0	3,121	0
2013	3,426	3,380		0	0	169	34		0	3,380	0
2014	3,428	3,380		0	0	169	34		0	3,380	0
2015	3,407	3,380		0	0	169	34		0	3,380	0
2016	3,246	3,246		0	0	169	34		0	3,246	0
2017	3,369	3,369		0	0	169	34		0	3,369	0
2018	3,246	3,246		0	0	169	34		0	3,246	0
2019	3,373	3,373		0	0	169	34		0	3,373	0
2020	3,266	3,266		0	0	169	34		0	3,266	0
2021	3,379	3,379		0	0	169	34		0	3,379	0
2022	3,123	3,123		0	0	169	34		0	3,123	0
2023	3,345	3,345		0	0	169	34		0	3,345	0
2024	3,357	3,357		0	0	169	34		0	3,357	0
2025	3,350	3,350		0		169	34		0	3,350	0
2026	3,361	3,361		0	0	169	34		0	3,361	0
2027	3,358	3,358		0	0	169	34		0	3,358	0
2028	3,415	3,380		0	0	169	34		0	3,380	0
2029	3,409	3,380		0	0	169	34		0	3,380	0
2030	3,358	3,358		0	0	169	34		0	3,358	0
2031	3,358	3,358		0	0	169	34		0	3,358	0
2032	3,391	3,380		0	0	169	34		0	3,380	0
2033	3,333	3,333		0	0	169	34		0	3,333	0
2034	3,124	3,124		0	0	169	34		0	3,124	0
2035	3,373	3,373		0	0	169	34		0	3,373	0
2036	3,355	3,355		0	0	169	34		0	3,355	0
2037	3,267	3,267		0	0	169	34		0	3,267	0
2038	3,404	3,380		0	0	169	34		0	3,380	0
2039	3,410	3,380		0	0	169	34		0	3,380	0
2040	3,439	3,380		0	0	169	34		0	3,380	0
2041	3,397	3,380		0	0	169	34		0	3,380	0
2042	3,124	3,124		0	0	169	34		0	3,124	0
2043	3,081	3,081		0	0	169	34		0	3,081	0
2044	3,248	3,248		0	0	169	34		0	3,248	0
2045	3,400	3,380		0	0	169	34		0	3,380	0
2046	3,124	3,124		0	0	169	34		0	3,124	0
2047	3,383	3,380		0	0	169	34		0	3,380	0
2048	3,336	3,336		0	0	169	34		0	3,336	0
2049	3,354	3,354		0	0	169	34		0	3,354	0
2050	3,330	3,330		0	0	169	34		0	3,330	0
2051	3,338	3,338		0	0	169	34		0	3,338	0
2052	3,081	3,081		0	0	169	34		0	3,081	0
2053	3,248	3,248		0	0	169	34		0	3,248	0
2054	3,361	3,361		0	0	169	34		0	3,361	0
2055	3,123	3,123		0	0	169	34		0	3,123	0
2056	3,338	3,338		0	0	169	34		0	3,338	0
2057	3,124	3,124		0	0	169	34		0	3,124	0
2058	3,284	3,284		0	0	169	34		0	3,284	0
2059	3,248	3,248		0	0	169	34		0	3,248	0
2060	3,248	3,248		0	0	169	34		0	3,248	0
2061	3,124	3,124		0	0	169	34		0	3,124	0
2062	3,396	3,380		0	0	169	34		0	3,380	0
2063	3,388	3,380		0	0	169	34		0	3,380	0
2064	3,081	3,081		0	0	169	34		0	3,081	0
2065	3,267	3,267		0	0	169	34		0	3,267	0
2066	3,344	3,344		0	0	169	34		0	3,344	0
2067	3,336	3,336		0	0	169	34		0	3,336	0
2068	3,248	3,248		0	0	169	34		0	3,248	0
2069	2,880	2,880		0	0	169	34		0	2,880	0
2070	3,124	3,124		0	0	169	34		0	3,124	0
2071	3,397	3,380		0	0	169	34		0	3,380	0
2072	3,366	3,366		0	0	169	34		0	3,366	0
2073	3,304	3,304		0	0	169	34		0	3,304	0
2074	3,374	3,374		0	0	169	34		0	3,374	0
2075	3,368	3,368		0	0	169	34		0	3,368	0
2076	3,328	3,328		0	0	169	34		0	3,328	0

Modeling Conditions for
Table Nos. B-7, B-8 and B-9 (PVID/YPRD)

Conditions:

1. Inadvertent Overruns are limited to a maximum of 10% of entities entitlement.

Rules:

1. Minimum Payback = greater of 20% maximum allowed Inadvertent Overrun or 1/3 of Account Balance.
2. Accounts which exceed 10% of entitlement - Strict enforcement 1 yr payback
3. First Year of payback not strictly enforced, except that exceeding maximum account will not be allowed during a payback year.
4. Second Year of payback - strict enforcement and balancing of Account
5. Inadvertent Overrun Account balances are forgiven when flood releases occur.
6. Under 1 year payback (normal, or overage greater than 10%)
7. For 1 year delay in reporting, as long as entity has not exceeded its 10% overrun allowance and they are meeting their payback schedule, the second year overrun, which was not reported prior to implementation of the first year of payback, would be treated as a separate overrun, with the payback amount criteria applying to the second amount. The full payback would be the sum of the two paybacks occurring together.

Table B-7
PVID and YPRD Baselines Added Together – 10% Overrun with 3-Year Payback
(Assume base entitlement of 0.42 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	**Estimated Consumptive Use**	**Measured Consumptive Use**	**Entitlement Minus Payback Target**	**Over / Under Runs**	**Overrun Account Reported**	**10% of Entitlement**	**20% of Maximum Entitlement**	**Extraordinary Conservation Required**	**End of Year Overrun Account**	**Base Case**	**Difference From Base Case**
2002	350	620		0		42/ 97	18			620	0
2003	465	550		45	0	42/ 97	18		0	550	0
2004	467	550		47	45	42/ 97	18		45	550	0
2005	392	560	402	0	47	42/ 97	18	18	74	578	(18)
2006	336	598	384	0	0	42/ 97	18	36	38	634	(36)
2007	316	627	393	0	0	42/ 97	18	27	11	654	(27)
2008	176	783	409	0	0	42/ 97	18	11	0	794	(11)
2009	419	551		0	0	42/ 97	18		0	550	1
2010	305	665		0	0	42/ 97	18		0	665	0
2011	424	550		4	0	42/ 97	18		0	550	0
2012	102	868		0	4	42/ 97	18		4	868	0
2013	374	592	416	0	0	42/ 97	18	4	0	550	42
2014	372	598		0	0	42/ 97	18		0	550	48
2015	375	595		0	0	42/ 97	18		0	568	27
2016	254	716		0	0	42/ 97	18		0	716	0
2017	431	550		11	0	42/ 97	18		0	550	0
2018	273	697		0	11	42/ 97	18		11	697	0
2019	427	539	409	7	0	42/ 97	18	11	0	550	(11)
2020	297	673		0	7	42/ 97	18		7	673	0
2021	421	543	413	1	0	42/ 97	18	7	0	550	(7)
2022	163	807		0	1	42/ 97	18		1	807	0
2023	455	549	419	35	0	42/ 97	18	1	0	550	(1)
2024	408	562		0	35	42/ 97	18		35	562	0
2025	450	532	402	30	0	42/ 97	18	18	17	550	(18)
2026	439	533	403	19	30	42/ 97	18	17	30	550	(17)
2027	383	569	402	0	19	42/ 97	18	18	31	587	(18)
2028	369	571	390	0	0	42/ 97	18	30	1	566	5
2029	380	589	419	0	0	42/ 97	18	1	0	561	28
2030	374	596		0	0	42/ 97	18		0	596	0
2031	416	554		0	0	42/ 97	18		0	554	0
2032	409	561		0	0	42/ 97	18		0	550	11
2033	445	550	420	25	0	42/ 97	18		0	550	0
2034	158	812		0	25	42/ 97	18		25	812	0
2035	427	532	402	7	0	42/ 97	18	18	7	550	(18)
2036	445	543	413	25	7	42/97	18	7	7	550	(7)
2037	253	710	413	0	25	42/ 97	18	7	25	717	(7)
2038	396	556	402	0	0	42/ 97	18	18	7	550	6
2039	375	588	413	0	0	42/97	18	7	0	565	23
2040	361	609		0	0	42/ 97	18		0	550	59
2041	402	568		0	0	42/97	18		0	551	17
2042	107	863		0	0	42/ 97	18		0	863	0
2043	115	855		0	0	42/ 97	18		0	855	0
2044	241	729		0	0	42/97	18		0	729	0
2045	400	570		0	0	42/97	18		0	550	20
2046	144	826		0	0	42/ 97	18		0	826	0
2047	417	553		0	0	42/ 97	18		0	550	3
2048	464	550		44	0	42/ 97	18		0	550	0
2049	446	550		26	44	42/ 97	18		44	550	0
2050	470	532	402	50	26	42/ 97	18	18	52	550	(18)
2051	432	514	384	12	50	42/ 97	18	36	66	550	(36)
2052	154	782	386	0	12	42/ 97	18	34	44	816	(34)
2053	266	674	390	0	0	42/ 97	18	30	14	704	(30)
2054	439	536	406	19	0	42/ 97	18	14	0	550	(14)
2055	171	799		0	19	42/ 97	18		19	799	0
2056	462	532	402	42	0	42/ 97	18	18	1	550	(18)
2057	168	801	419	0	42	42/ 97	18	1	42	802	(1)
2058	516	532	402	96	0	42/ 97	18	18	24	550	(18)
2059	328	624	402	0	96	42/ 97	18	18	102	642	(18)
2060	213	714	390	0	0	42/ 97	18	43	59	757	(43)
2061	85	853	370	0	0	42/ 97	18	32	27	885	(32)
2062	404	539	370	0	0	42/ 97	18	27	0	550	(11)
2063	412	558	420	0	0	42/ 97	18		0	550	8
2064	129	841		0	0	42/ 97	18		0	841	0
2065	336	634		0	0	42/ 97	18		0	634	0
2066	435	550		15	0	42/ 97	18		0	550	0
2067	464	550		44	15	42/ 97	18		15	550	0
2068	289	666	405	0	44	42/ 97	18	15	29	681	(15)
2069	(152)	1,104	405	0	0	42/ 97	18	18	11	1,122	(18)
2070	93	866	404	0	0	42/ 97	18	11	0	877	(11)
2071	394	576	420	0	0	42/ 97	18		0	559	17
2072	434	550	420	14	0	42/ 97	18		0	550	0
2073	496	550		76	14	42/ 97	18		14	550	0
2074	426	536	406	6	76	42/ 97	18	14	76	550	(14)
2075	432	525	395	12	6	42/ 97	18	25	57	550	(25)
2076	472	519	389	52	12	42/ 97	18	31	38	550	(31)

Table B-8
PVID and YPRD Baselines Added Together – 10% Overrun with 1-Year Payback
(Assume base entitlement of 0.42 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	Estimated Consumptive Use	Measured Consumptive Use	Entitlement Minus Payback Target	Over / Under Runs	Overrun Account Reported	10% of Entitlement	20% of Maximum Entitlement	Extraordinary Conservation Required	End of Year Overrun Account	Base Case	Difference From Base Case
2002	350	350		0		42/ 92	18			350	0
2003	465	465		45	0	42/ 92	18		0	420	45
2004	467	467	420	47	45	42/ 92	18		45	420	47
2005	392	347	375	0	47	42/ 92	18	45	47	392	(45)
2006	336	289	373	0	0	42/ 92	18	47	0	336	(47)
2007	316	316		0	0	42/ 92	18		0	316	0
2008	176	176		0	0	42/ 92	18		0	176	0
2009	419	419		0	0	42/ 92	18		0	419	0
2010	305	305		0	0	42/ 92	18		0	305	0
2011	424	424		4	0	42/ 92	18		0	420	4
2012	102	102		0	4	42/ 92	18		4	102	0
2013	374	370	416	0	0	42/ 92	18	4	0	374	(4)
2014	372	372	409	0	0	42/ 92	68		0	372	0
2015	375	375		0	0	42/ 92	68		0	375	0
2016	254	254		0	0	42/ 92	68		0	254	0
2017	431	431		11	0	42/ 92	68		0	420	11
2018	273	273		0	11	42/ 92	68		11	273	0
2019	427	416	409	7	0	42/ 92	68	11	0	420	(4)
2020	297	297		0	7	42/ 92	68		7	297	0
2021	421	414	413	1	0	42/ 92	68	7	0	420	(6)
2022	163	163		0	1	42/ 92	68		1	163	0
2023	455	454	419	35	0	42/ 92	68	1	0	420	34
2024	408	408		0	35	42/ 92	68		35	408	0
2025	450	415	385	30	11	42/ 92	18	35	11	420	(5)
2026	439	428	392	19	30	42/ 92	18	11	30	420	8
2027	383	353	390	0	19	42/ 92	18	30	19	383	(30)
2028	369	350	401	0	0	42/ 92	18	19	0	369	(19)
2029	380	380		0	0	42/ 92	18		0	380	0
2030	374	374		0	0	42/ 92	18		0	374	0
2031	416	416		0	0	42/ 92	18		0	416	0
2032	409	409		0	0	42/ 92	18		0	409	0
2033	445	445		25	0	42/ 92	18		0	420	25
2034	158	158		0	25	42/ 92	18		25	158	0
2035	427	402	395	7	0	42/ 92	18	25	0	420	(18)
2036	445	445		25	7	42/ 92	18		7	420	25
2037	253	246	413	0	25	42/ 92	18	7	25	253	(7)
2038	396	371	395	0	0	42/ 92	18	25	0	396	(25)
2039	375	375		0	0	42/ 92	18		0	375	0
2040	361	361		0	0	42/ 92	18		0	361	0
2041	402	402	420	0	0	42/ 92	18		0	402	0
2042	107	107		0	0	42/ 92	18		0	107	0
2043	115	115		0	0	42/ 92	18		0	115	0
2044	241	241		0	0	42/ 92	18		0	241	0
2045	400	400		0	0	42/ 92	18		0	400	0
2046	144	144		0	0	42/ 92	18		0	144	0
2047	417	417		0	0	42/ 92	18		0	417	0
2048	464	464		44	0	42/ 92	18		0	420	44
2049	446	446		26	44	42/ 92	18		44	420	26
2050	470	426	376	50	26	42/ 92	18	44	26	420	6
2051	432	406	394	12	50	42/ 92	18	26	50	420	(14)
2052	154	104	370	0	12	42/ 92	18	50	12	154	(50)
2053	266	254	408	0	0	42/ 92	18	12	0	266	(12)
2054	439	439		19	0	42/ 92	18		0	420	19
2055	171	171		0	19	42/ 92	18		19	171	0
2056	462	443	401	42	0	42/ 92	18	19	0	420	23
2057	168	168		0	42	42/ 92	18		42	168	0
2058	516	474	378	96	0	42/ 92	18	42	0	420	54
2059	328	328		0	96	42/ 92	18		96	328	0
2060	213	117	324	0	0	42/ 92	18	96	0	213	(96)
2061	85	85		0	0	42/ 92	18		0	85	0
2062	404	404		0	0	42/ 92	18		0	404	0
2063	412	412		0	0	42/ 92	18		0	412	0
2064	129	129		0	0	42/ 92	18		0	129	0
2065	336	336		0	0	42/ 92	18		0	336	0
2066	435	435		15	0	42/ 92	18		0	420	15
2067	464	464		44	15	42/ 92	18		15	420	44
2068	289	274	405	0	15	42/ 92	18	15	0	289	(15)
2069	(152)	(152)		0	0	42/ 92	18		0	(152)	0
2070	93	93		0	0	42/ 92	18		0	93	0
2071	394	394		0	0	42/ 92	18		0	394	0
2072	434	434		14	0	42/ 92	18		0	420	14
2073	496	496		76	14	42/ 92	18		14	420	76
2074	426	412	406	6	76	42/ 92	18	14	76	420	(8)
2075	432	356	344	12	6	42/ 92	18	76	6	420	(64)
2076	472	466	414	52	12	42/ 92	18	6	12	420	46

Table B-9
PVID and YPRD Baselines Added Together - Baseline and Shortage Years with 10% Overrun
(Assume base entitlement of 0.42 maf)

Column 1 Year	2 Estimated Consumptive Use	3 Measured Consumptive Use	4 Entitlement Minus Payback Target	5 Over / Under Runs	6 Overrun Account Reported	7 10% of Entitlement	8 20% of Maximum Entitlement	9 Extraordinary Conservation Required	10 End of Year Overrun Account	11 Base Case	12 Difference From Base Case
2002	350	350		0		42/ 92	18			350	0
2003	465	420		0	0	42/ 92	18		0	420	0
2004	467	420		0	0	42/ 92	18		0	420	0
2005	392	392		0	0	42/ 92	18		0	392	0
2006	336	336		0	0	42/ 92	18		0	336	0
2007	316	316		0	0	42/ 92	18		0	316	0
2008	176	176		0	0	42/ 92	18		0	176	0
2009	419	419		0	0	42/ 92	18		0	419	0
2010	305	305		0	0	42/ 92	18		0	305	0
2011	424	420		0	0	42/ 92	18		0	420	0
2012	102	102		0	0	42/ 92	18		0	102	0
2013	374	374		0	0	42/ 92	18		0	374	0
2014	372	372		0	0	42/ 92	18		0	372	0
2015	375	375		0	0	42/ 92	18		0	375	0
2016	254	254		0	0	42/ 92	18		0	254	0
2017	431	420		0	0	42/ 92	18		0	420	0
2018	273	273		0	0	42/ 92	18		0	273	0
2019	427	420		0	0	42/ 92	18		0	420	0
2020	297	297		0	0	42/ 92	18		0	297	0
2021	421	420		0	0	42/ 92	18		0	420	0
2022	163	163		0	0	42/ 92	18		0	163	0
2023	455	420		0	0	42/ 92	18		0	420	0
2024	408	408		0	0	42/ 92	18		0	408	0
2025	450	420		0		42/ 92	18		0	420	0
2026	439	420		0	0	42/ 92	18		0	420	0
2027	383	383		0	0	42/ 92	18		0	383	0
2028	369	369		0	0	42/ 92	18		0	369	0
2029	380	380		0	0	42/ 92	18		0	380	0
2030	374	374		0	0	42/ 92	18		0	374	0
2031	416	416		0	0	42/ 92	18		0	416	0
2032	409	409		0	0	42/ 92	18		0	409	0
2033	445	420		0	0	42/ 92	18		0	420	0
2034	158	158		0	0	42/ 92	18		0	158	0
2035	427	420		0	0	42/ 92	18		0	420	0
2036	445	420		0	0	42/ 92	18		0	420	0
2037	253	253		0	0	42/ 92	18		0	253	0
2038	396	396		0	0	42/ 92	18		0	396	0
2039	375	375		0	0	42/ 92	18		0	375	0
2040	361	361		0	0	42/ 92	18		0	361	0
2041	402	402		0	0	42/ 92	18		0	402	0
2042	107	107		0	0	42/ 92	18		0	107	0
2043	115	115		0	0	42/ 92	18		0	115	0
2044	241	241		0	0	42/ 92	18		0	241	0
2045	400	400		0	0	42/ 92	18		0	400	0
2046	144	144		0	0	42/ 92	18		0	144	0
2047	417	417		0	0	42/ 92	18		0	417	0
2048	464	420		0	0	42/ 92	18		0	420	0
2049	446	420		0	0	42/ 92	18		0	420	0
2050	470	420		0	0	42/ 92	18		0	420	0
2051	432	420		0	0	42/ 92	18		0	420	0
2052	154	154		0	0	42/ 92	18		0	154	0
2053	266	266		0	0	42/ 92	18		0	266	0
2054	439	420		0	0	42/ 92	18		0	420	0
2055	171	171		0	0	42/ 92	18		0	171	0
2056	462	420		0	0	42/ 92	18		0	420	0
2057	168	168		0	0	42/ 92	18		0	168	0
2058	516	420		0	0	42/ 92	18		0	420	0
2059	328	328		0	0	42/ 92	18		0	328	0
2060	213	213		0	0	42/ 92	18		0	213	0
2061	85	85		0	0	42/ 92	18		0	85	0
2062	404	404		0	0	42/ 92	18		0	404	0
2063	412	412		0	0	42/ 92	18		0	412	0
2064	129	129		0	0	42/ 92	18		0	129	0
2065	336	336		0	0	42/ 92	18		0	336	0
2066	435	420		0	0	42/ 92	18		0	420	0
2067	464	420		0	0	42/ 92	18		0	420	0
2068	289	289		0	0	42/ 92	18		0	289	0
2069	(152)	(152)		0	0	42/ 92	18		0	(152)	0
2070	93	93		0	0	42/ 92	18		0	93	0
2071	394	394		0	0	42/ 92	18		0	394	0
2072	434	420		0	0	42/ 92	18		0	420	0
2073	496	420		0	0	42/ 92	18		0	420	0
2074	426	420		0	0	42/ 92	18		0	420	0
2075	432	420		0	0	42/ 92	18		0	420	0
2076	472	420		0	0	42/ 92	18		0	420	0

Modeling Conditions for

Table Nos. 10, 11 and 12 (PVID/YPRD)

Conditions:

1. Inadvertent Overruns are limited to a maximum of 5% of entities entitlement.

Rules:

1. Minimum Payback = greater of 20% maximum allowed Inadvertent Overrun or 1/3 of Account Balance.
2. Accounts which exceed 5% of entitlement - Strict enforcement 1 yr payback
3. First Year of payback not strictly enforced, except that exceeding maximum account will not be allowed during a payback year.
4. Second Year of payback - strict enforcement and balancing of Account
5. Inadvertent Overrun Account balances are forgiven when flood releases occur.
6. Under 1 year payback (normal, or overage greater than 5%)
7. For 1 year delay in reporting, as long as entity has not exceeded its 5% overrun allowance and they are meeting their payback schedule, the second year overrun, which was not reported prior to implementation of the first year of payback, would be treated as a separate overrun, with the payback amount criteria applying to the second amount. The full payback would be the sum of the two paybacks occurring together.

Table B-10
PVID and YPRD Baselines Added Together – 5% Overrun with 3-Year Payback
(Assume base entitlement of 0.42 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	**Estimated Consumptive Use**	**Measured Consumptive Use**	**Entitlement Minus Payback Target**	**Over / Under Runs**	**Overrun Account Reported**	**5% of Entitlement**	**20% of Maximum Entitlement**	**Extraordinary Conservation Required**	**End of Year Overrun Account**	**Base Case**	**Difference From Base Case**
2002	350	620		0		42/ 48	10			620	0
2003	465	550		45	0	42/ 48	10		0	550	0
2004	467	550		47	45	42/48	10		45	550	0
2005	392	563	405	0	47	42/48	10	15	77	578	(15)
2006	336	604	390	0	0	42/ 48	10	30	47	634	(30)
2007	316	624	390	0	0	42/ 48	10	30	17	654	(30)
2008	176	779	405	0	0	42/ 48	10	15	2	794	(15)
2009	419	549	418	0	0	42/ 48	10	2	0	550	(1)
2010	305	665		0	0	42/ 48	10		0	665	0
2011	424	550		4	0	42/ 48	10		0	550	0
2012	102	868		0	4	42/ 48	10		4	868	0
2013	374	592	416	0	0	42/ 48	10	4	0	550	42
2014	372	598		0	0	42/ 48	10		0	550	48
2015	375	595		0	0	42/ 48	10		0	568	27
2016	254	716		0	0	42/ 48	10		0	716	0
2017	431	550		11	0	42/ 48	10		0	550	0
2018	273	697		0	11	42/ 48	10		11	697	0
2019	427	539	409	7	0	42/ 48	10	11	0	550	(11)
2020	297	673		0	7	42/ 48	10		7	673	0
2021	421	543	413	1	0	42/ 48	10	7	0	550	(7)
2022	163	807		0	1	42/ 48	10		1	807	0
2023	455	549	419	35	0	42/ 48	10	1	0	550	(1)
2024	408	562		0	35	42/ 48	10		35	562	0
2025	450	538	408	30	0	42/ 48	10	12	23	550	(12)
2026	439	538	408	19	30	42/ 48	10	12	41	550	(12)
2027	383	566	399	0	19	42/48	10	21	39	587	(21)
2028	369	581	400	0	0	42/ 48	10	20	19	566	15
2029	380	571	401	0	0	42/ 48	10	19	0	561	10
2030	374	596		0	0	42/ 48	10		0	596	0
2031	416	554		0	0	42/ 48	10		0	554	0
2032	409	561		0	0	42/ 48	10		0	550	11
2033	445	550	420	25	0	42/ 48	10		0	550	0
2034	158	812		0	25	42/ 48	10		25	812	0
2035	427	540	410	7	0	42/ 48	10	10	15	550	(10)
2036	445	540	410	25	7	42/ 48	10	10	12	550	(10)
2037	253	705	408	0	25	42/ 48	10	12	25	717	(12)
2038	396	564	410	0	0	42/ 48	10	10	15	550	14
2039	375	585	410	0	0	42/ 48	10	10	5	565	20
2040	361	604	415	0	0	42/ 48	10	5	0	550	54
2041	402	568		0	0	42/ 48	10		0	551	17
2042	107	863		0	0	42/ 48	10		0	863	0
2043	115	855		0	0	42/ 48	10		0	855	0
2044	241	729		0	0	42/ 48	10		0	729	0
2045	400	570		0	0	42/ 48	10		0	550	20
2046	144	826		0	0	42/ 48	10		0	826	0
2047	417	553		0	0	42/ 48	10		0	550	3
2048	464	550		44	0	42/ 48	10		0	550	0
2049	446	550		26	44	42/ 48	10		44	550	0
2050	470	535	405	50	26	42/ 48	10	15	55	550	(15)
2051	432	525	395	12	50	42/ 48	10	25	80	550	(25)
2052	154	775	379	0	12	42/ 48	10	41	51	816	(41)
2053	266	671	387	0	0	42/ 48	10	33	18	704	(33)
2054	439	532	402	19	0	42/ 48	10	18	0	550	(18)
2055	171	799		0	19	42/ 48	10		19	799	0
2056	462	540	410	42	0	42/ 48	10	10	9	550	(10)
2057	168	793	411	0	42	42/ 48	10	9	42	802	(9)
2058	516	536	406	96	0	42/ 48	10	14	28	550	(14)
2059	328	628	402	0	96	42/ 48	10	14	110	642	(14)
2060	213	679	390	0	0	42/ 48	10	78	32	757	(78)
2061	85	869	370	0	0	42/ 48	10	16	16	885	(16)
2062	404	550	370	0	0	42/ 48	10	16	0	550	0
2063	412	558	420	0	0	42/ 48	10		0	550	8
2064	129	841		0	0	42/ 48	10		0	841	0
2065	336	634		0	0	42/ 48	10		0	634	0
2066	435	550		15	0	42/ 48	10		0	550	0
2067	464	550		44	15	42/ 48	10		15	550	0
2068	289	671	410	0	44	42/ 48	10	10	49	681	(10)
2069	(152)	1,102	405	0	0	42/ 48	10	20	29	1,122	(20)
2070	93	862	404	0	0	42/ 48	10	15	14	877	(15)
2071	394	562	406	0	0	42/ 48	10	14	0	559	3
2072	434	550	420	14	0	42/ 48	10		0	550	0
2073	496	550		76	14	42/ 48	10		14	550	0
2074	426	540	410	6	76	42/ 48	10	10	80	550	(10)
2075	432	502	372	12	6	42/ 48	10	48	38	550	(48)
2076	472	528	398	52	12	42/ 48	10	22	28	550	(22)
								28			

Table B-11
PVID and YPRD Baselines Added Together – 5% Overrun with 1-Year Payback
(Assume base entitlement of 0.42 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	**Estimated Consumptive Use**	**Measured Consumptive Use**	**Entitlement Minus Payback Target**	**Over / Under Runs**	**Overrun Account Reported**	**5% of Entitlement**	**20% of Maximum Entitlement**	**Extraordinary Conservation Required**	**End of Year Overrun Account**	**Base Case**	**Difference From Base Case**
2002	350	350		0		42/ 92	18			350	0
2003	465	465		45	0	42/ 92	18		0	420	45
2004	467	467	420	47	45	42/ 92	18		45	420	47
2005	392	347	375	0	47	42/ 92	18	45	47	392	(45)
2006	336	289	373	0	0	42/ 92	18	47	0	336	(47)
2007	316	316		0	0	42/ 92	18		0	316	0
2008	176	176		0	0	42/ 92	18		0	176	0
2009	419	419		0	0	42/ 92	18		0	419	0
2010	305	305		0	0	42/ 92	18		0	305	0
2011	424	424		4	0	42/ 92	18		0	420	4
2012	102	102		0	4	42/ 92	18		4	102	0
2013	374	370	416	0	0	42/ 92	18	4	0	374	(4)
2014	372	372	409	0	0	42/ 92	68		0	372	0
2015	375	375		0	0	42/ 92	68		0	375	0
2016	254	254		0	0	42/ 92	68		0	254	0
2017	431	431		11	0	42/ 92	68		0	420	11
2018	273	273		0	11	42/ 92	68		11	273	0
2019	427	416	409	7	0	42/ 92	68	11	0	420	(4)
2020	297	297		0	7	42/ 92	68		7	297	0
2021	421	414	413	1	0	42/ 92	68	7	0	420	(6)
2022	163	163		0	1	42/ 92	68		1	163	0
2023	455	454	419	35	0	42/ 92	68	1	0	420	34
2024	408	408		0	35	42/ 92	68		35	408	0
2025	450	415	385	30	11	42/ 92	18	35	11	420	(5)
2026	439	428	392	19	30	42/ 92	18	11	30	420	8
2027	383	353	390	0	19	42/ 92	18	30	19	383	(30)
2028	369	350	401	0	0	42/ 92	18	19	0	369	(19)
2029	380	380		0	0	42/ 92	18		0	380	0
2030	374	374		0	0	42/ 92	18		0	374	0
2031	416	416		0	0	42/ 92	18		0	416	0
2032	409	409		0	0	42/ 92	18		0	409	0
2033	445	445		25	0	42/ 92	18		0	420	25
2034	158	158		0	25	42/ 92	18		25	158	0
2035	427	402	395	7	0	42/ 92	18	25	0	420	(18)
2036	445	445		25	7	42/ 92	18		7	420	25
2037	253	246	413	0	25	42/ 92	18	7	25	253	(7)
2038	396	371	395	0	0	42/ 92	18	25	0	396	(25)
2039	375	375		0	0	42/ 92	18		0	375	0
2040	361	361		0	0	42/ 92	18		0	361	0
2041	402	402	420	0	0	42/ 92	18		0	402	0
2042	107	107		0	0	42/ 92	18		0	107	0
2043	115	115		0	0	42/ 92	18		0	115	0
2044	241	241		0	0	42/ 92	18		0	241	0
2045	400	400		0	0	42/ 92	18		0	400	0
2046	144	144		0	0	42/ 92	18		0	144	0
2047	417	417		0	0	42/ 92	18		0	417	0
2048	464	464		44	0	42/ 92	18		0	420	44
2049	446	446		26	44	42/ 92	18		44	420	26
2050	470	426	376	50	26	42/ 92	18	44	26	420	6
2051	432	406	394	12	50	42/ 92	18	26	50	420	(14)
2052	154	104	370	0	12	42/ 92	18	50	12	154	(50)
2053	266	254	408	0	0	42/ 92	18	12	0	266	(12)
2054	439	439		19	0	42/ 92	18		0	420	19
2055	171	171		0	19	42/ 92	18		19	171	0
2056	462	443	401	42	0	42/ 92	18	19	0	420	23
2057	168	168		0	42	42/ 92	18		42	168	0
2058	516	474	378	96	0	42/ 92	18	42	0	420	54
2059	328	328		0	96	42/ 92	18		96	328	0
2060	213	117	324	0	0	42/ 92	18	96	0	213	(96)
2061	85	85		0	0	42/ 92	18		0	85	0
2062	404	404		0	0	42/ 92	18		0	404	0
2063	412	412		0	0	42/ 92	18		0	412	0
2064	129	129		0	0	42/ 92	18		0	129	0
2065	336	336		0	0	42/ 92	18		0	336	0
2066	435	435		15	0	42/ 92	18		0	420	15
2067	464	464		44	15	42/ 92	18		15	420	44
2068	289	274	405	0	15	42/ 92	18	15	0	289	(15)
2069	(152)	(152)		0	0	42/ 92	18		0	(152)	0
2070	93	93		0	0	42/ 92	18		0	93	0
2071	394	394		0	0	42/ 92	18		0	394	0
2072	434	434		14	0	42/ 92	18		0	420	14
2073	496	496		76	14	42/ 92	18		14	420	76
2074	426	412	406	6	76	42/ 92	18	14	76	420	(8)
2075	432	356	344	12	6	42/ 92	18	76	6	420	(64)
2076	472	466	414	52	12	42/ 92	18	6	12	420	46

Table B-12
PVID and YPRD Baselines Added Together – Baseline and Shortage Years with 5% Overrun
(Assume base entitlement of 0.42 maf)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Year	Estimated Consumptive Use	Measured Consumptive Use	Entitlement Minus Payback Target	Over / Under Runs	Overrun Account Reported	5% of Entitlement	20% of Maximum Entitlement	Extraordinary Conservation Required	End of Year Overrun Account	Base Case	Difference From Base Case
2002	350	350		0		42/ 92	18			350	0
2003	465	420		0	0	42/ 92	18		0	420	0
2004	467	420		0	0	42/ 92	18		0	420	0
2005	392	392		0	0	42/ 92	18		0	392	0
2006	336	336		0	0	42/ 92	18		0	336	0
2007	316	316		0	0	42/ 92	18		0	316	0
2008	176	176		0	0	42/ 92	18		0	176	0
2009	419	419		0	0	42/ 92	18		0	419	0
2010	305	305		0	0	42/ 92	18		0	305	0
2011	424	420		0	0	42/ 92	18		0	420	0
2012	102	102		0	0	42/ 92	18		0	102	0
2013	374	374		0	0	42/ 92	18		0	374	0
2014	372	372		0	0	42/ 92	18		0	372	0
2015	375	375		0	0	42/ 92	18		0	375	0
2016	254	254		0	0	42/ 92	18		0	254	0
2017	431	420		0	0	42/ 92	18		0	420	0
2018	273	273		0	0	42/ 92	18		0	273	0
2019	427	420		0	0	42/ 92	18		0	420	0
2020	297	297		0	0	42/ 92	18		0	297	0
2021	421	420		0	0	42/ 92	18		0	420	0
2022	163	163		0	0	42/ 92	18		0	163	0
2023	455	420		0	0	42/ 92	18		0	420	0
2024	408	408		0	0	42/ 92	18		0	408	0
2025	450	420		0		42/ 92	18		0	420	0
2026	439	420		0	0	42/ 92	18		0	420	0
2027	383	383		0	0	42/ 92	18		0	383	0
2028	369	369		0	0	42/ 92	18		0	369	0
2029	380	380		0	0	42/ 92	18		0	380	0
2030	374	374		0	0	42/ 92	18		0	374	0
2031	416	416		0	0	42/ 92	18		0	416	0
2032	409	409		0	0	42/ 92	18		0	409	0
2033	445	420		0	0	42/ 92	18		0	420	0
2034	158	158		0	0	42/ 92	18		0	158	0
2035	427	420		0	0	42/ 92	18		0	420	0
2036	445	420		0	0	42/ 92	18		0	420	0
2037	253	253		0	0	42/ 92	18		0	253	0
2038	396	396		0	0	42/ 92	18		0	396	0
2039	375	375		0	0	42/ 92	18		0	375	0
2040	361	361		0	0	42/ 92	18		0	361	0
2041	402	402		0	0	42/ 92	18		0	402	0
2042	107	107		0	0	42/ 92	18		0	107	0
2043	115	115		0	0	42/ 92	18		0	115	0
2044	241	241		0	0	42/ 92	18		0	241	0
2045	400	400		0	0	42/ 92	18		0	400	0
2046	144	144		0	0	42/ 92	18		0	144	0
2047	417	417		0	0	42/ 92	18		0	417	0
2048	464	420		0	0	42/ 92	18		0	420	0
2049	446	420		0	0	42/ 92	18		0	420	0
2050	470	420		0	0	42/ 92	18		0	420	0
2051	432	420		0	0	42/ 92	18		0	420	0
2052	154	154		0	0	42/ 92	18		0	154	0
2053	266	266		0	0	42/ 92	18		0	266	0
2054	439	420		0	0	42/ 92	18		0	420	0
2055	171	171		0	0	42/ 92	18		0	171	0
2056	462	420		0	0	42/ 92	18		0	420	0
2057	168	168		0	0	42/ 92	18		0	168	0
2058	516	420		0	0	42/ 92	18		0	420	0
2059	328	328		0	0	42/ 92	18		0	328	0
2060	213	213		0	0	42/ 92	18		0	213	0
2061	85	85		0	0	42/ 92	18		0	85	0
2062	404	404		0	0	42/ 92	18		0	404	0
2063	412	412		0	0	42/ 92	18		0	412	0
2064	129	129		0	0	42/ 92	18		0	129	0
2065	336	336		0	0	42/ 92	18		0	336	0
2066	435	420		0	0	42/ 92	18		0	420	0
2067	464	420		0	0	42/ 92	18		0	420	0
2068	289	289		0	0	42/ 92	18		0	289	0
2069	(152)	(152)		0	0	42/ 92	18		0	(152)	0
2070	93	93		0	0	42/ 92	18		0	93	0
2071	394	394		0	0	42/ 92	18		0	394	0
2072	434	420		0	0	42/ 92	18		0	420	0
2073	496	420		0	0	42/ 92	18		0	420	0
2074	426	420		0	0	42/ 92	18		0	420	0
2075	432	420		0	0	42/ 92	18		0	420	0
2076	472	420		0	0	42/ 92	18		0	420	0

ATTACHMENT C

Results of Additional Analysis of Potential Impacts to Excess Flows Below Mexico Diversion at Morelos Dam

This attachment provides the results of additional analyses performed to evaluate the potential impacts that the Inadvertent Overrun and Payback Policy (IOP) combined with the other action alternatives may have on excess flows that occur below the Mexico diversion at Morelos Dam. Specifically, the results included herein consists of an evaluation of the probability of occurrence of excess flows greater than 250 kaf and 1.0 maf below the Mexico diversion at Morelos Dam. Figures C-1 through C-4 compare the results of the Implementation Agreement (IA) to the No Action (NA) modeled conditions. Figures C-5 through C-8 compare the results of the Cumulative Analysis (CA) to the Baseline for Cumulative Analysis (Baseline) modeled conditions. A total of eight figures are presented herein. The modeled conditions represented by each of figure is as follows:

Figure No.	**Probability of Occurrence of Excess Flows Greater than**	**Comparison of Modeled Conditions**	**Overrun Account Balance Considered**	**Payback Period and Maximum Allowed Overrun**
C-1	250 kaf	NA to IA-IOP	Average (66 kafy)	3- Year / 10%
C-2	250 kaf	NA to IA-IOP	Maximum (331 kafy)	3- Year / 10%
C-3	1.0maf	NA to IA-IOP	Average (66 kafy)	3- Year / 10%
C-4	1.0maf	NA to IA-IOP	Maximum (331 kafy)	3- Year / 10%
C-5	250 kaf	Baseline to CA-IOP	Average (66 kafy)	3- Year / 10%
C-6	250 kaf	Baseline to CA-IOP	Maximum (331 kafy)	3- Year / 10%
C-7	1.0maf	Baseline to CA-IOP	Average (66 kafy)	3- Year / 10%
C-8	1.0maf	Baseline to CA-IOP	Maximum (331 kafy)	3- Year / 10%

A summary of the results in tabular format follows:

Table C-1
Probability Of Occurrence Of Excess Flows Greater Than 250 Kaf And 1.0 Maf
Below The Mexico Diversion At Morelos Dam

	Differences in Probability of Excess Flows Greater than 250 kaf		**Differences in Probability of Excess Flows Greater than 1.0 maf**	
Differences in Probability	**NA to IA-IOP w/ Overrun Account Balance of 66 kaf**	**NA to IA-IOP w/ Overrun Account Balance of 331 kaf**	**NA to IA-IOP w/ Overrun Account Balance of 66 kaf**	**NA to IA-IOP w/ Overrun Account Balance of 331 kaf**
No. of Years w/ Observed Differences	10	45	22	33
No. of Years w/ Observed Increases	5	8	4	4
No. of Years w/ Observed Decreases	5	37	18	29
Average Difference	**0.0%**	**-0.7%**	**-0.2%**	**-0.5%**
Maximum Increase	1.2%	2.4%	1.2%	1.2%
Maximum Decrease	-1.2%	-3.5%	-2.4%	-3.5%
Differences in Probability	**Baseline to CA-IOP w/ Average Account Balance of 66 kaf**	**Baseline to CA-IOP w/ Average Account Balance of 331 kaf**	**Baseline to CA--IOP w/ Average Account Balance of 66 kaf**	**Baseline to CA--IOP w/ Average Account Balance of 331 kaf**
No. of Years w/ Observed Differences	34	48	37	43
No. of Years w/ Observed Increases	4	3	7	2
No. of Years w/ Observed Decreases	30	45	30	41
Average Difference	**-0.8%**	**-1.4%**	**-0.6%**	**-1.1%**
Maximum Increase	1.2%	1.2%	2.4%	1.2%
Maximum Decrease	-4.7%	-5.9%	-3.5%	-3.5%

Figure C-1
Probability of Occurrence of Excess Flows Greater than 250 KAF Below Mexico Diversion at Morelos Dam Comparison of No Action to IA-IOP w/ Average Lower Basin Overrun Account Balance of 66 kafy 10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

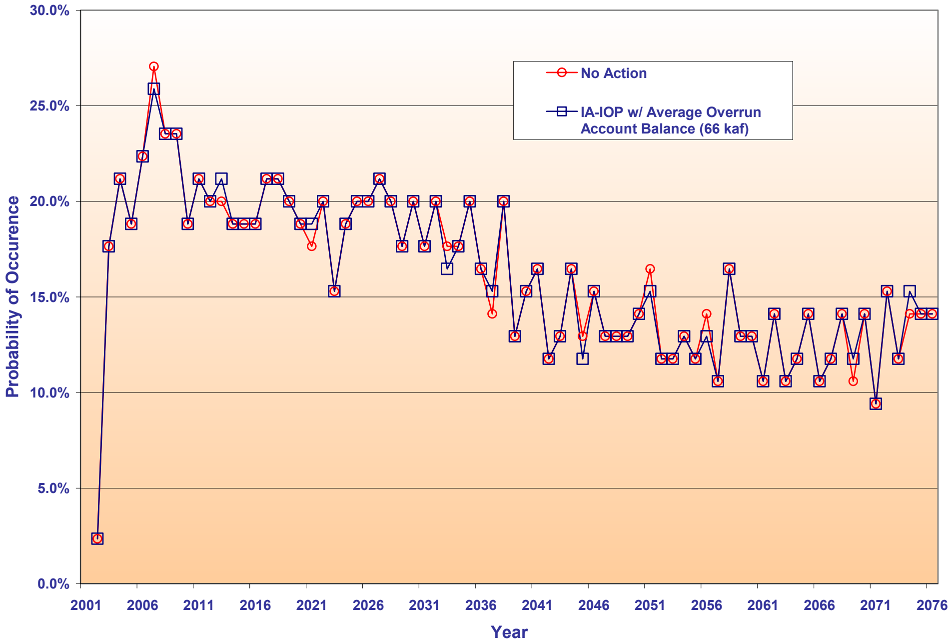


Figure C-2
Probability of Occurrence of Excess Flows Greater than 250,000 KAF Below Mexico Diversion at Morelos Dam Comparison of No Action to IA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy 10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

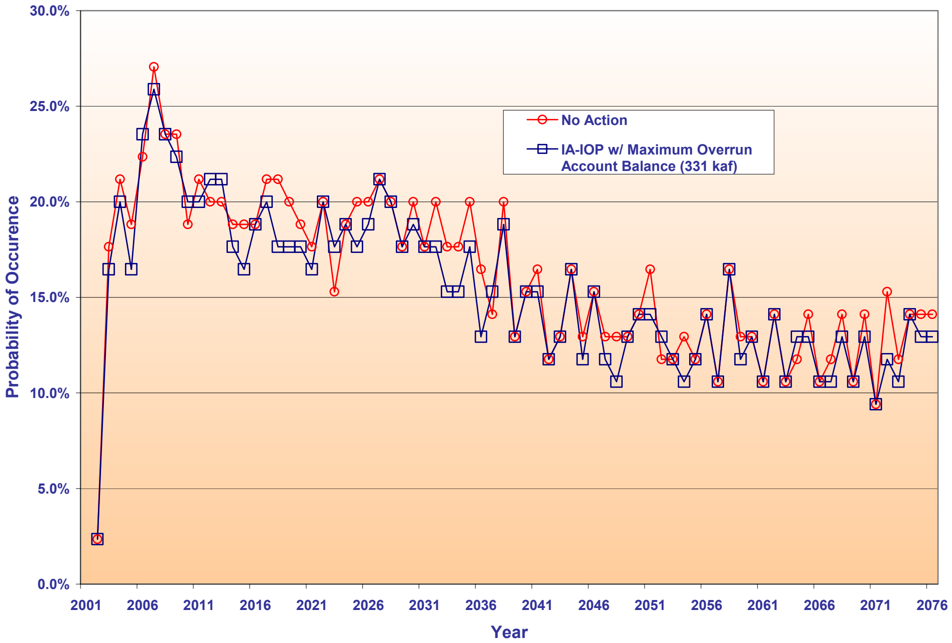


Figure C-3
Probability of Occurrence of Excess Flows Greater than 1,000,000 KAF Below Mexico Diversion at Morelos Dam
Comparison of No Action to IA-IOP w/ Average Lower Basin Overrun Account Balance of 66 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

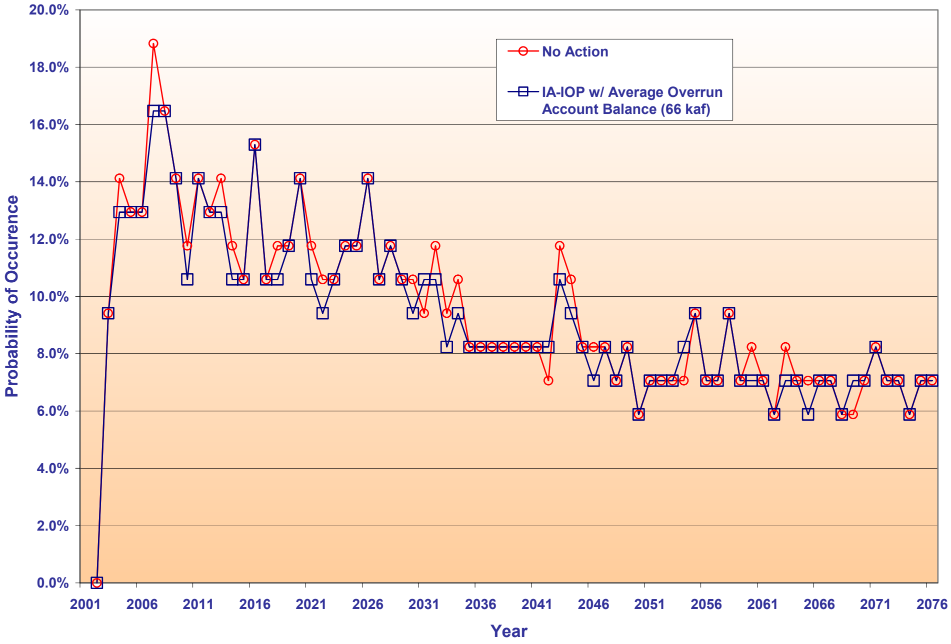


Figure C-4
Probability of Occurrence of Excess Flows Greater than 1,000,000 KAF Below Mexico Diversion at Morelos Dam
Comparison of No Action to IA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

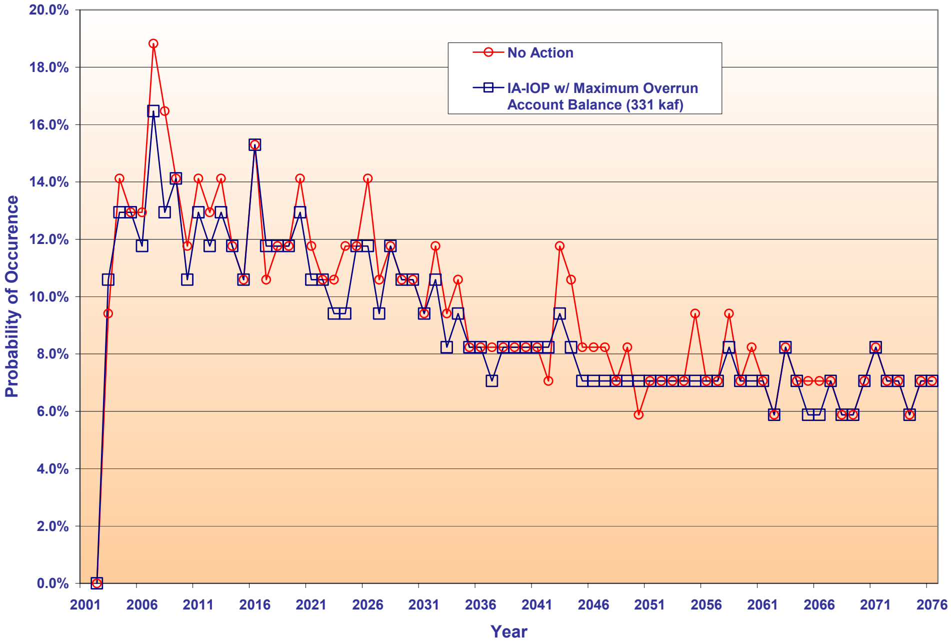


Figure C-5
Probability of Occurrence of Excess Flows Greater than 250,000 KAF Below Mexico Diversion at Morelos Dam
Comparison of Baseline to CA-IOP w/ Average Lower Basin Overrun Account Balance of 66 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

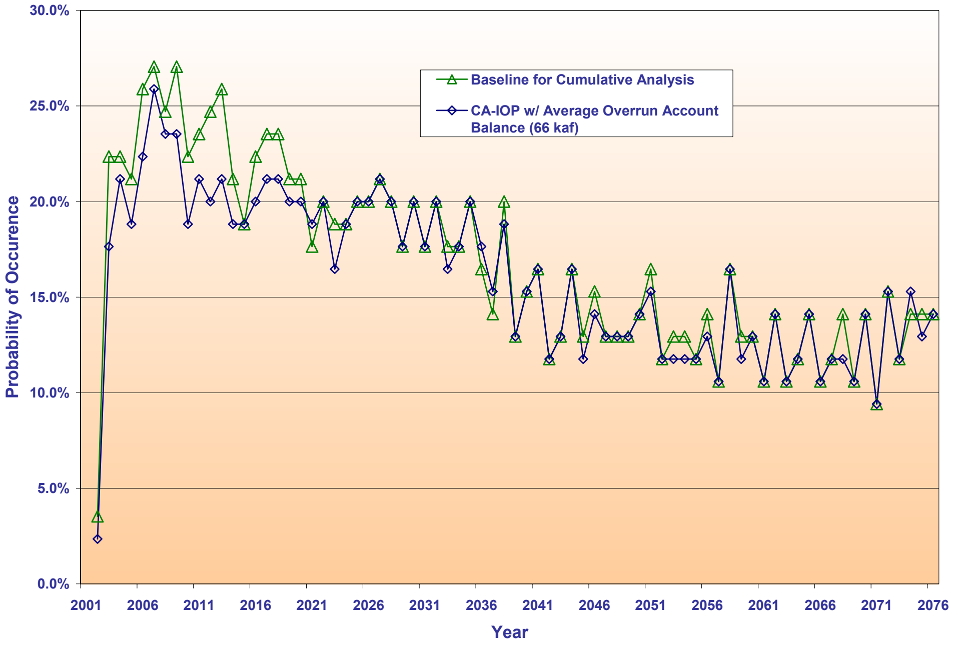


Figure C-6
Probability of Occurrence of Excess Flows Greater than 250,000 KAF Below Mexico Diversion at Morelos Dam
Comparison of Baseline to CA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

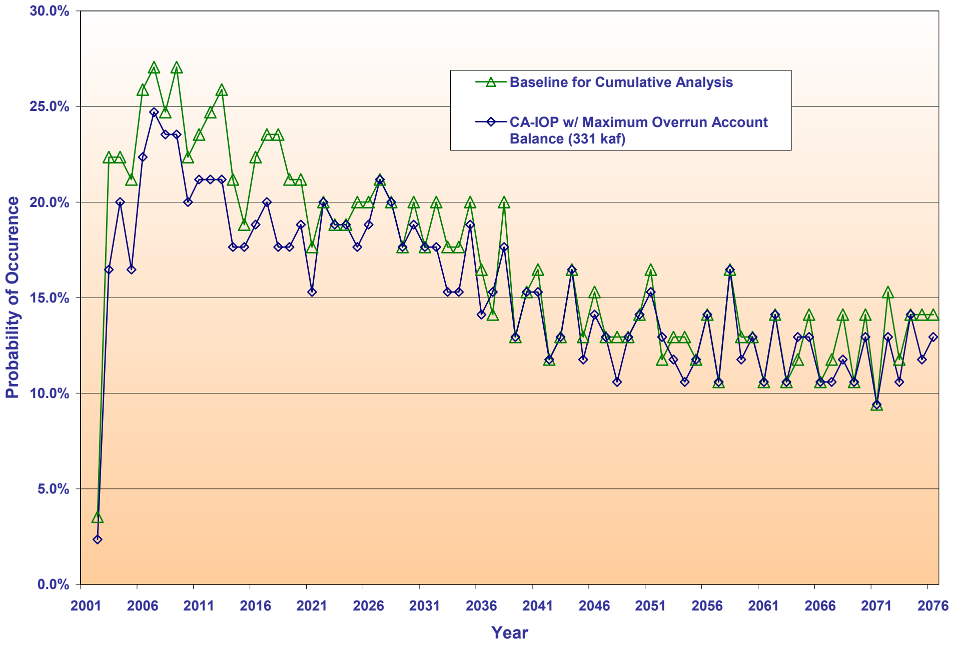


Figure C-y
Probability of Occurrence of Excess Flows Greater than 1,000,000 KAF Below Mexico Diversion at Morelos Dam
Comparison of No Action to IA-IOP w/ Average Lower Basin Overrun Account Balance of 66 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule

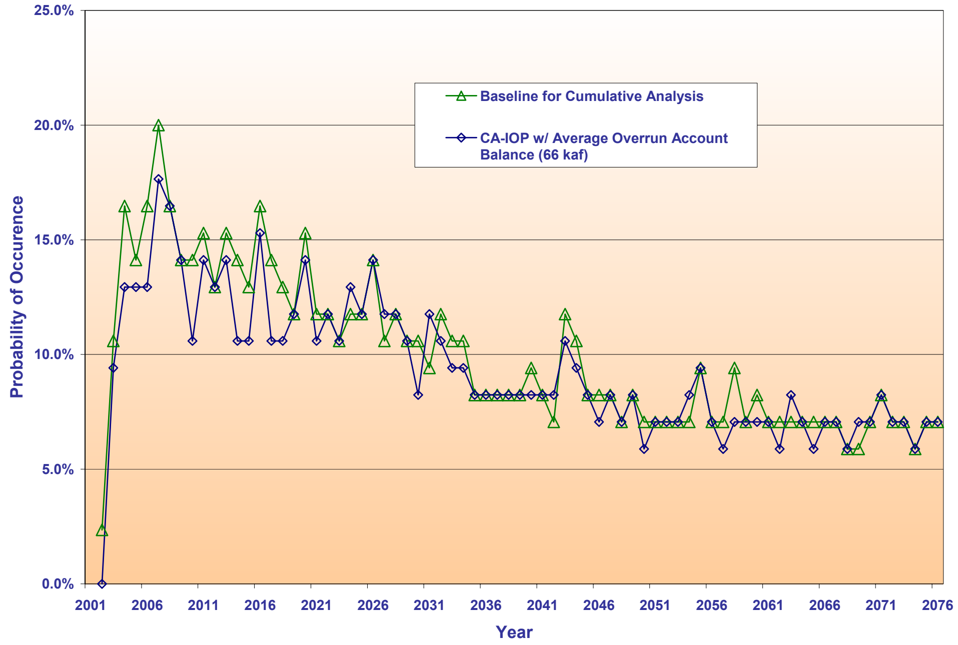
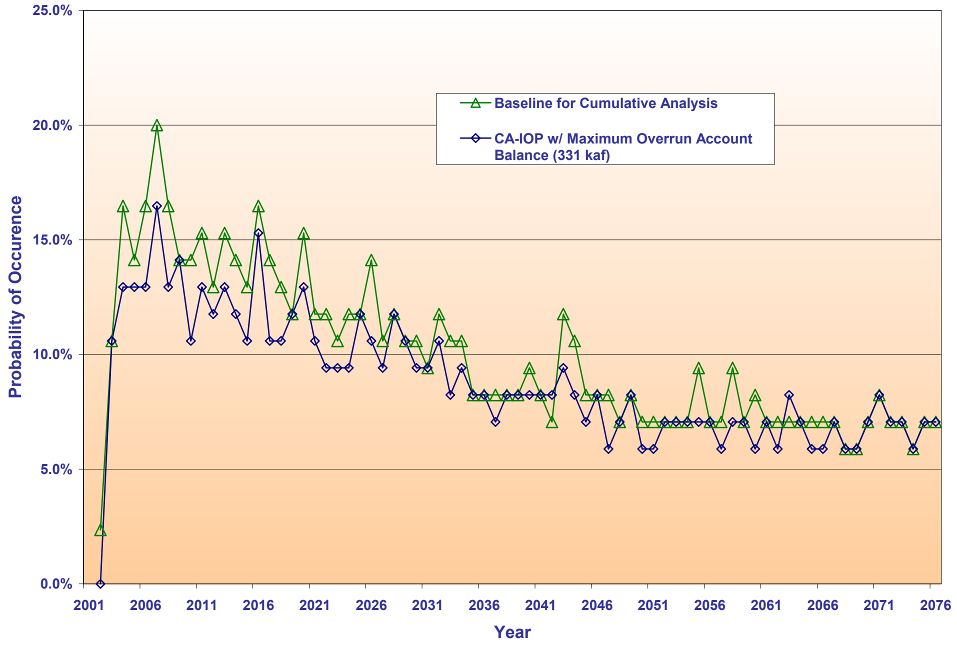


Figure C-8
Probability of Occurrence of Excess Flows Greater than 1,000,000 KAF Below Mexico Diversion at Morelos Dam
Comparison of No Action to IA-IOP w/ Maximum Lower Basin Overrun Account Balance of 331 kafy
10 Percent Maximum Allowed Overrun w/ 3-Year Payback Schedule



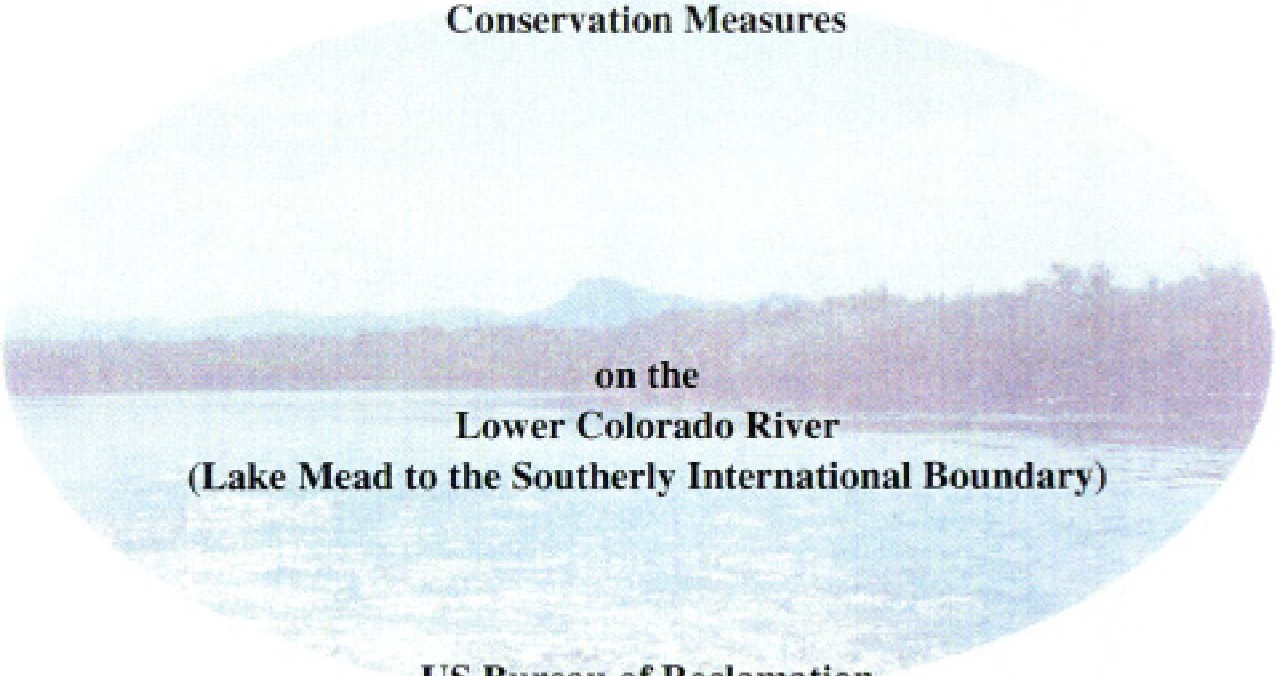
Appendix D

Biological Assessment/
Supplemental Biological Assessment

Biological Assessment

for

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



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

US Bureau of Reclamation
Lower Colorado Region

08/30/00
Final

Biological Assessment
for

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

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

US Bureau of Reclamation
Lower Colorado Region

08/30/00
Final

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I. INTRODUCTION

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

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

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

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

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

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

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

II. BIOLOGICAL ASSESSMENT OVERVIEW

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

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

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

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

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

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

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

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

III. FEDERAL ENVIRONMENTAL COMPLIANCE FOR PROPOSED ACTIONS

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

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

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

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

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

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

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

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

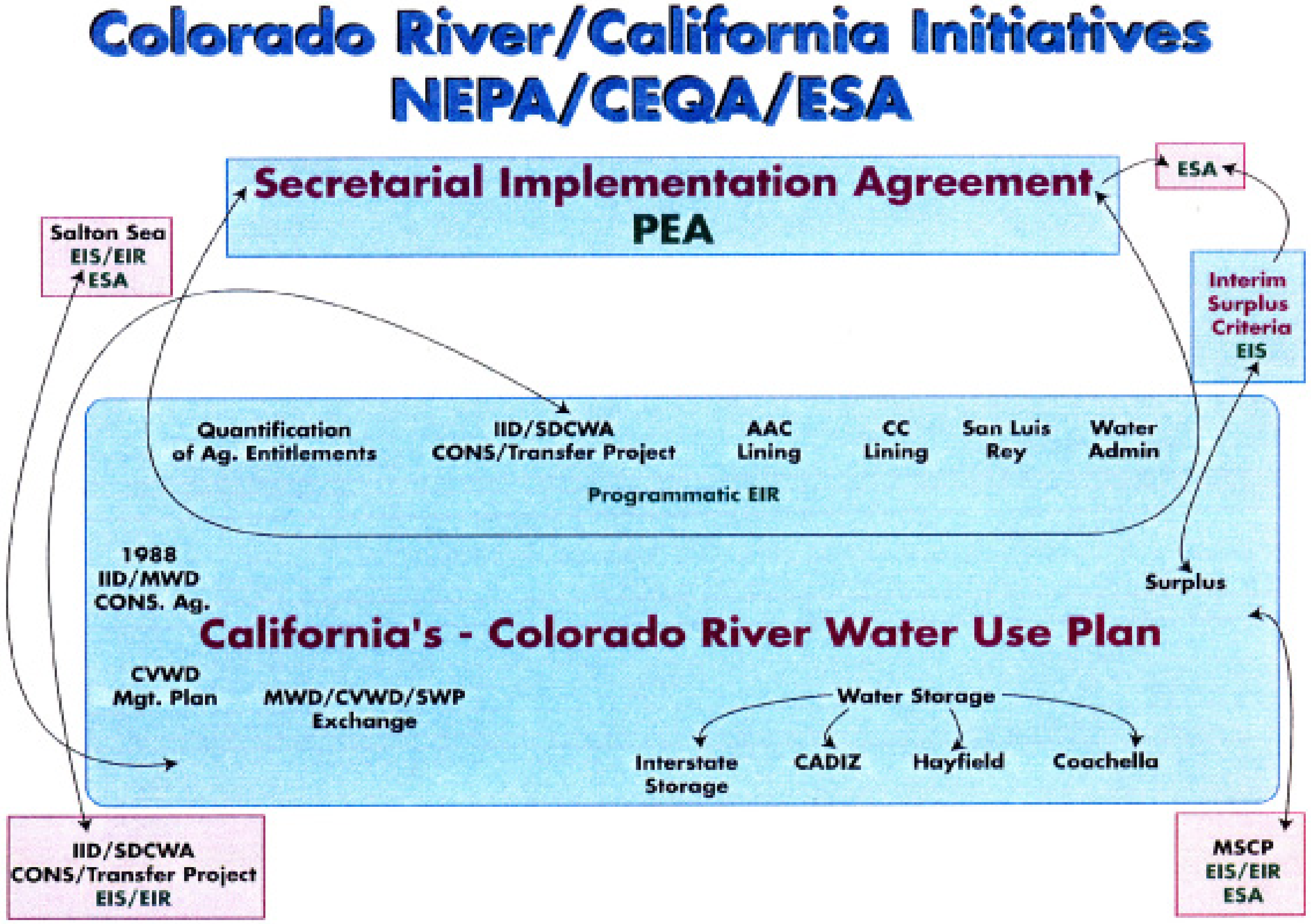

Figure 2. Relationships of Various components of California's Colorado River Water Use Plan covered by this Biological Assessment and Reclamation NEPA documents.

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

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

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

IV. DESCRIPTION OF ACTIONS

A. Interim Surplus Criteria.

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

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

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

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

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

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

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

1. No Action (Baseline)

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

2. California Alternative

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

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

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

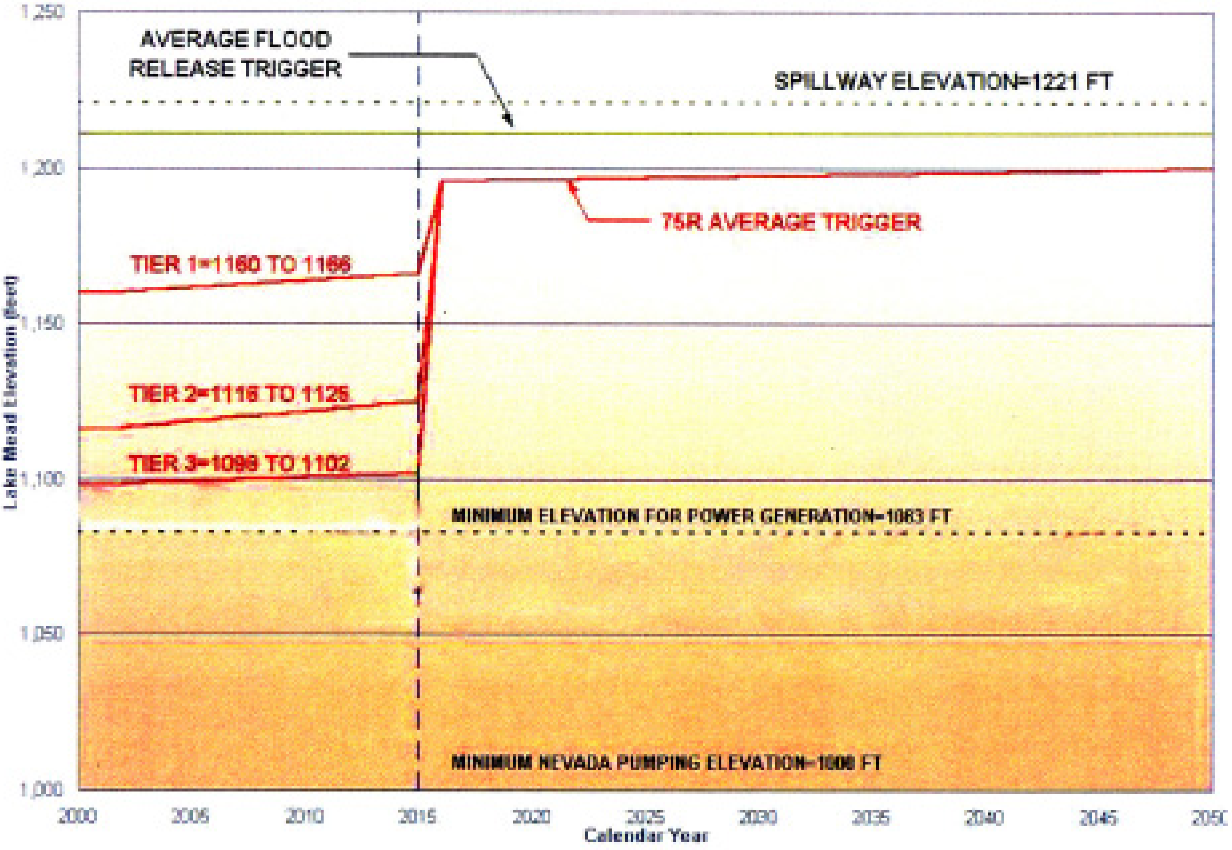

Figure 3. California surplus alternative showing tier elevations for Lake Mead.

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

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

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

B. Secretarial Implementation Agreements (SIAs).

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

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

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

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

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

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

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

Table 3 - Secretarial Implementation Agreements Water Transfers

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

Table 4 - Secretarial Implementation Agreements / Canal Lining Projects

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

C. Conservation Measures

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

Table 5. Conservation Measures

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

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

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

V. ENVIRONMENTAL BASELINE

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

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

1. Historic

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

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

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

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

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

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

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

2. Chronology of development along the lower Colorado River

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

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

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

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

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

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

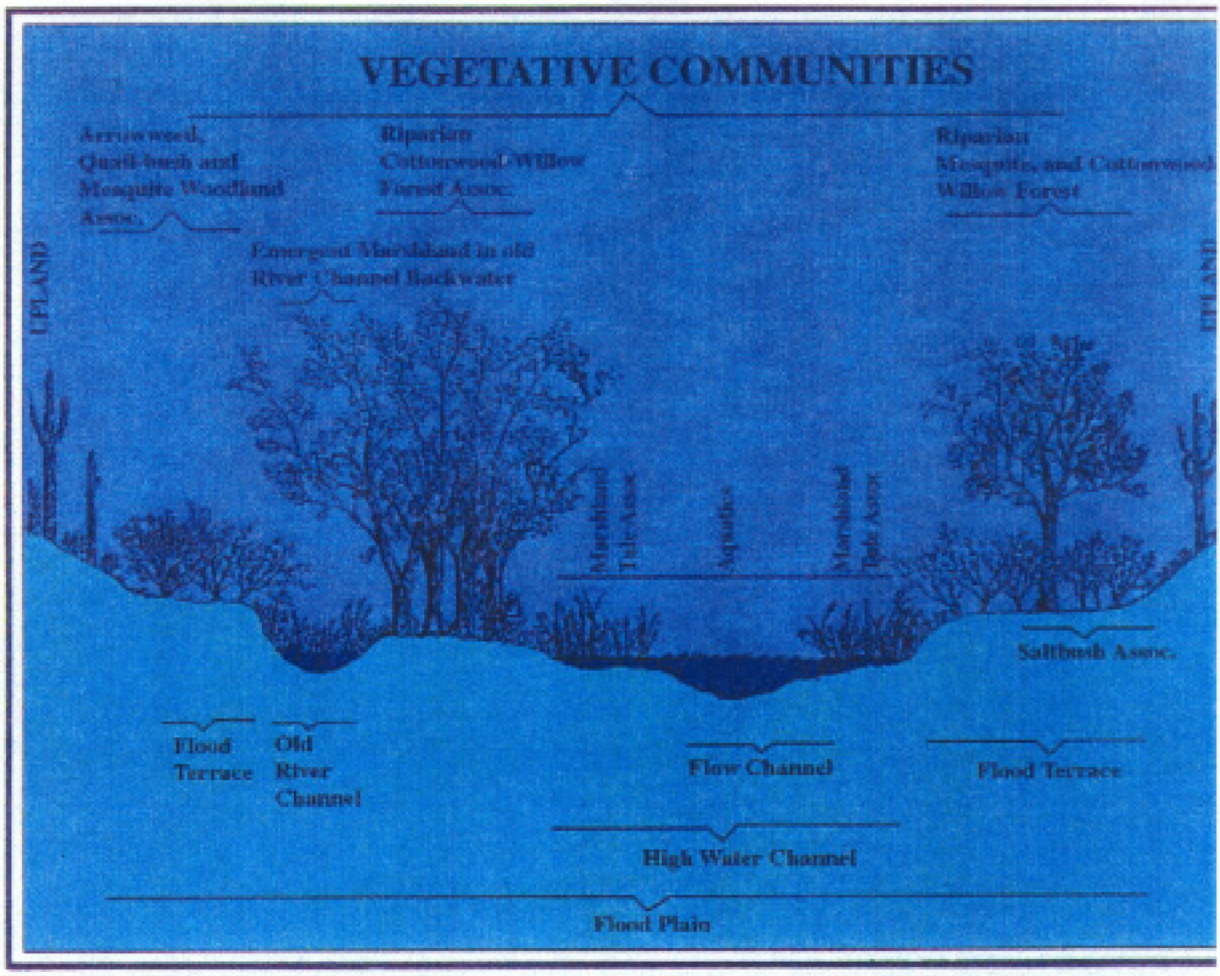

Figure 4. Historic lower Colorado River flood plain and associated vegetation communities

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

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

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

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

Table 6. Chronology of Lower Colorado River Development.

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

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

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

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

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

2. Present

a. Riparian Communities

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

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

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

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

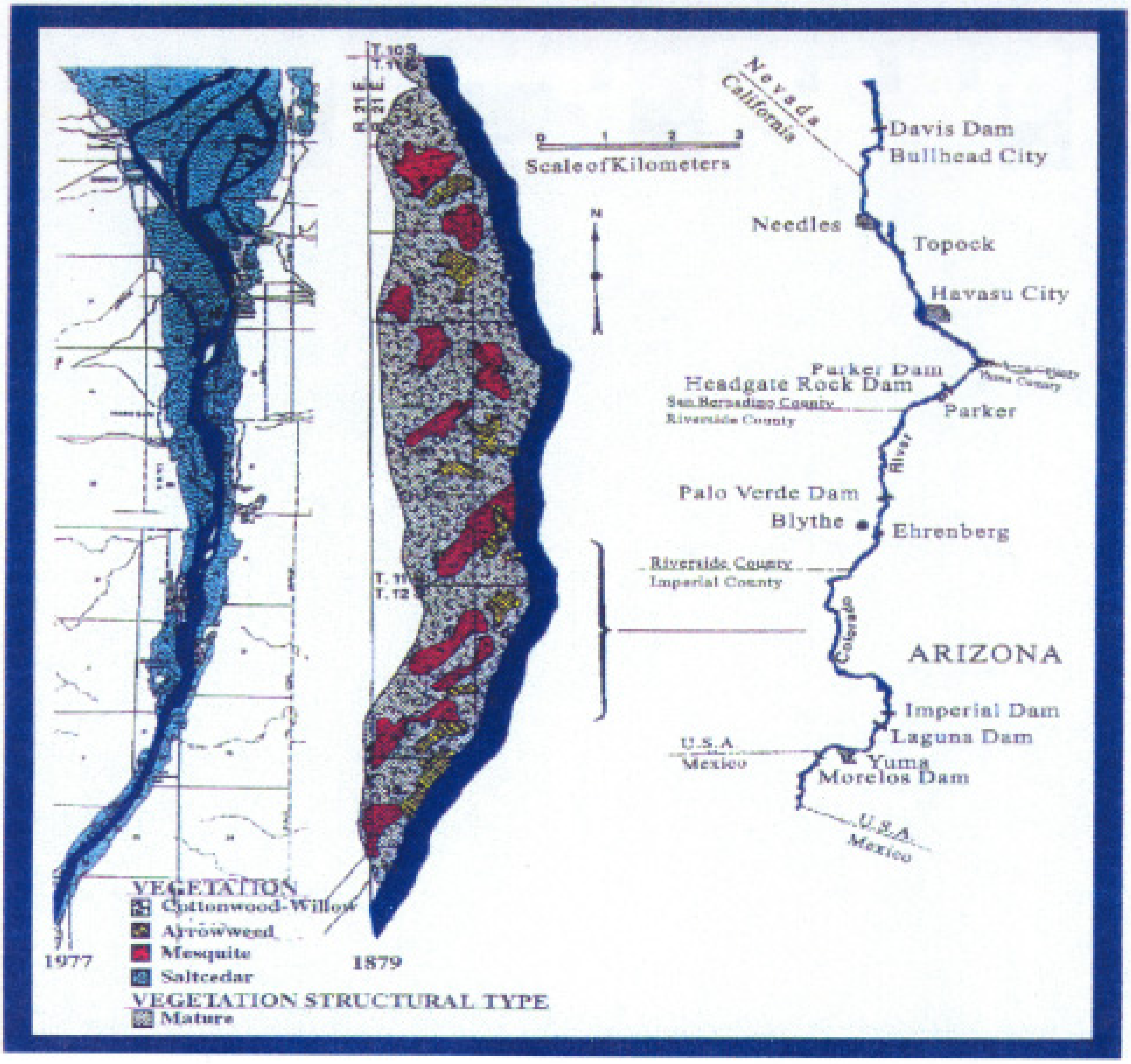

Figure 6. 1879 - 1977 comparison of vegetation communities along same stretch of lower Colorado River near Blythe, California (1879 Reconstruction; Ohmart et. al., 1977)

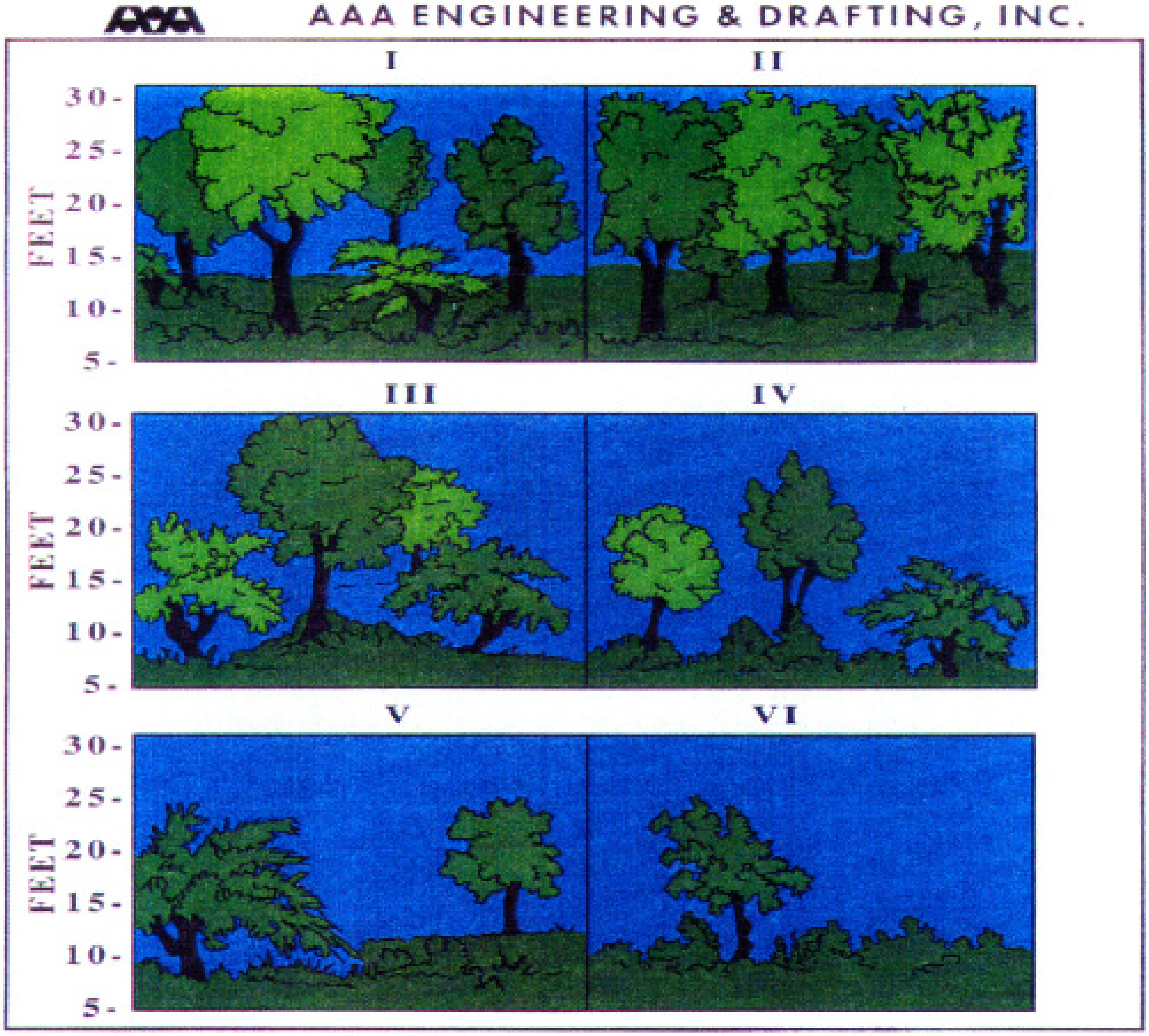

Figure 7. Examples of vertical configurations for the vegetation structural types (from the 1984 Anderson/Ohmart report).

Table 7. Description of Vegetation Structural Types.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

b. Marsh

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

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

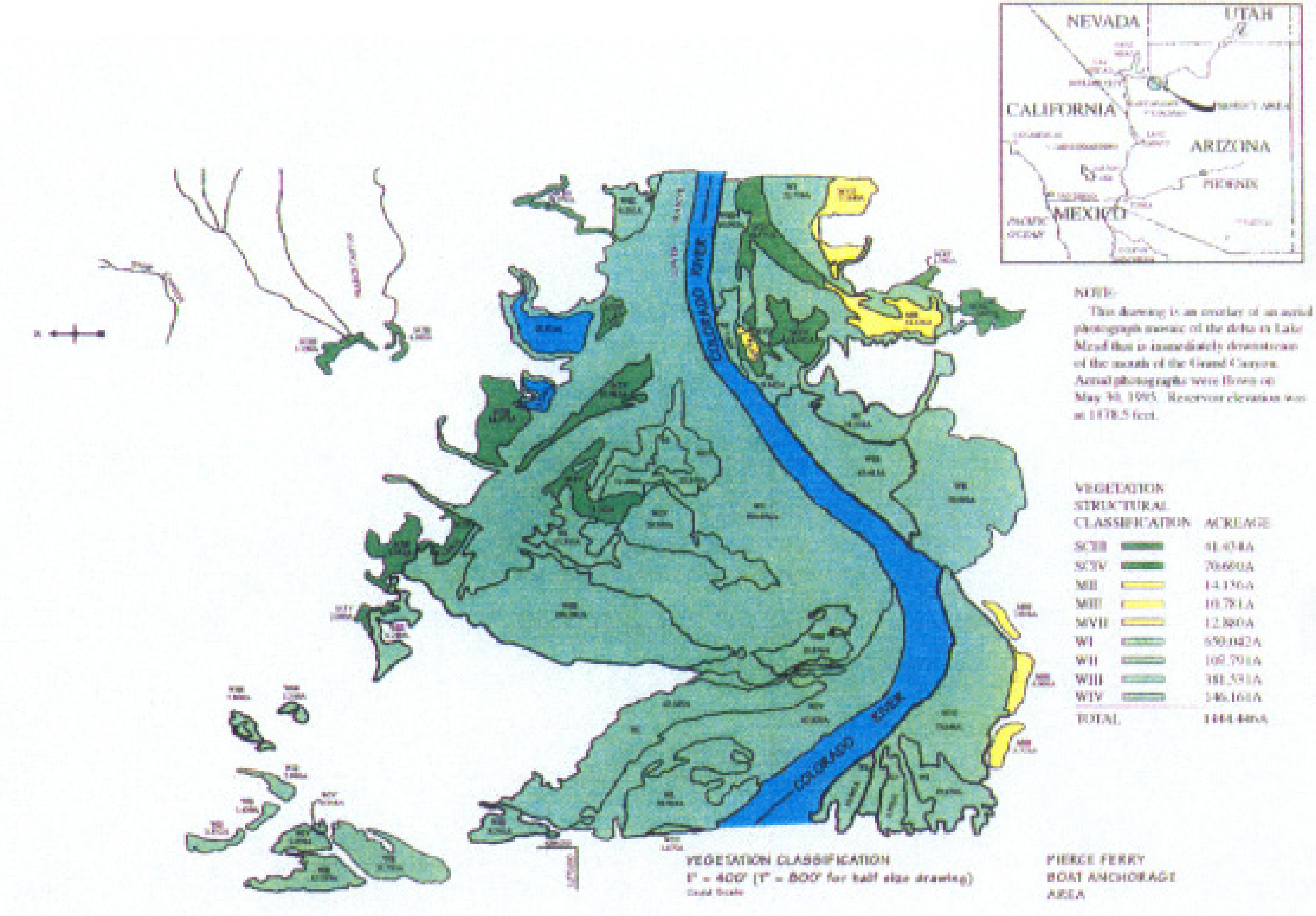

Figure 8. 1995 Colorado River Delta at Lake Mead Vegetation Classification.

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

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

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

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

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

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

c. Aquatic

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

(USBR, 1996).

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

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

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

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

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

> "...it seems probable that the native fish populations have undergone alternate periods of

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

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

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

> "Destruction of the native fauna of the lower Colorado River has been attributed to physical modifications of the environment, such as channelization and construction of dams.... Considering the great age of the Colorado River, and correspondingly great ages of at least some of the genera of fishes inhabiting it..., sufficient time has been available for them to have experienced far more change than has recently been effected by man.
>
> Excluding special cases..., almost all declines in native fish populations are directly attributable to predation by small adults or juveniles of introduced kinds upon early life-history stages of indigenous forms. Shoreline and backwater habitats once exclusively available to non-piscivorous juveniles of suckers and minnows now are inhabited by mosquitofish and young centrachids, and cropping by those animals destroys the native fauna."

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

B. Previous and On-Going Section 7 Consultations

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

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

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

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

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

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

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

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

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

C. Indirect and Cumulative Actions

1. Indirect Effects

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

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

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

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

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

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

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

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

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

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

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

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

- diversion of state entitlement waters

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

- trash accumulation

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

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

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

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

- trash accumulation:
  - solid waste disposal (landfills)

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

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

<u>Affecting areas away from the lower Colorado River and its floodplain</u>

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

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

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

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

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

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

A. Impacts on riparian/terrestrial habitat

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

1. Interim Surplus Criteria

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

<u>Lower Grand Canyon and Lake Mead</u>

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

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

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

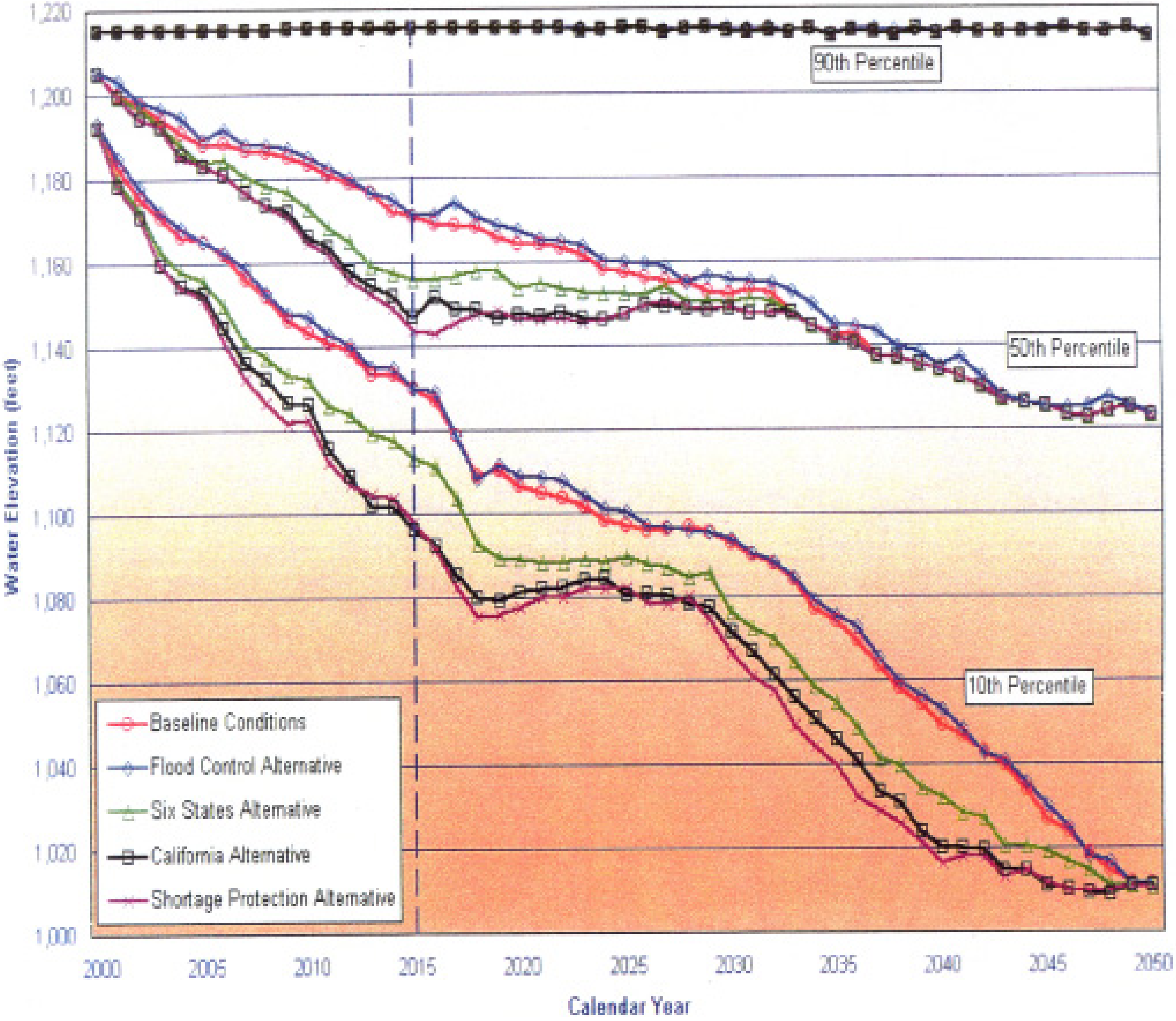

Figure 9. Lake Mead End-of-Year Water Elevations Comparison of Surplus Alternatives and Baseline Conditions 90th, 50th, and 10th Percentile Values.

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

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

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

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

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

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

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

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

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

Hoover Dam to Parker Dam

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

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

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

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

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

Parker Dam to Imperial Dam

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

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

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

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

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

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

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

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

2. Secretarial Implementation Agreement

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

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

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

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

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

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

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

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

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

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

Imperial National Wildlife Refuge near Picacho and Imperial Dam.

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

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

Estimate of Potential Willow Flycatcher Habitat

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

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

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

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

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

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

Estimate of Occupied Willow Flycatcher Habitat

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

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

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

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

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

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

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

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

* Site Deleted from analysis, water depth > 1.55'

** Saturated soil criteria is based on rankings of substrate samples taken within the SWWF survey area.

Observers sample multiple areas (n=30) of each surveyed site at 0 to 3cm soil depth every two weeks between 15 May and 15 August.

B. Impacts on aquatic and backwater habitat

1. Interim Surplus Criteria

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

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

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

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

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

2. Secretarial Implementation Agreements

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

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

Table 14. Open Water and Emergent Vegetation Reductions*

<table>
<tr><td colspan="5">April Acreage Reduction</td></tr>
<tr><td>Acre Feet (1000s)</td><td>Backwater Open Water</td><td>Backwater Emergent</td><td>River Channel Open Water</td><td>Total Open Water</td></tr>
<tr><td>200</td><td>12</td><td>19</td><td>24</td><td>36</td></tr>
<tr><td>300</td><td>18</td><td>29</td><td>35</td><td>53</td></tr>
<tr><td>400</td><td>~~24~~ 17</td><td>~~38~~ 28</td><td>~~47~~ 35</td><td>~~71~~ 52</td></tr>
<tr><td colspan="5">August Acreage Reduction</td></tr>
<tr><td>Acre Feet (1000s)</td><td>Backwater Open Water</td><td></td><td>River Channel Open Water</td><td>Total Open Water</td></tr>
<tr><td>200</td><td>5</td><td></td><td>7</td><td>12</td></tr>
<tr><td>300</td><td>7</td><td></td><td>11</td><td>18</td></tr>
<tr><td>400</td><td>10</td><td></td><td>14</td><td>24</td></tr>
<tr><td colspan="5">December Acreage Reduction</td></tr>
<tr><td>Acre Feet (1000s)</td><td>Backwater Open Water</td><td></td><td>River Channel Open Water</td><td>Total Open Water</td></tr>
<tr><td>200</td><td>4</td><td></td><td>6</td><td>10</td></tr>
<tr><td>300</td><td>6</td><td></td><td>9</td><td>15</td></tr>
<tr><td>400</td><td>8</td><td></td><td>12</td><td>20</td></tr>
</table>

* Proportional to 1.574 maf reduction

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

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

VII. SPECIES DESCRIPTIONS

A. Terrestrial

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

Description and Life Requisites

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

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

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

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

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

Distribution and Abundance

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

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

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

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

Effects Analysis

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

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

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

Bald Eagle (Haliaeetus leucocephalus)
Federally Threatened

Description and Life Requisites

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

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

Distribution and Abundance

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Effects Analysis

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

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

Description and Life Requisites

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

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

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

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

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

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

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

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

Distribution and Abundance

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

Sonoran Population:

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

Mojave Population:

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

Effect Analysis

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

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

Description and Life Requisites

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

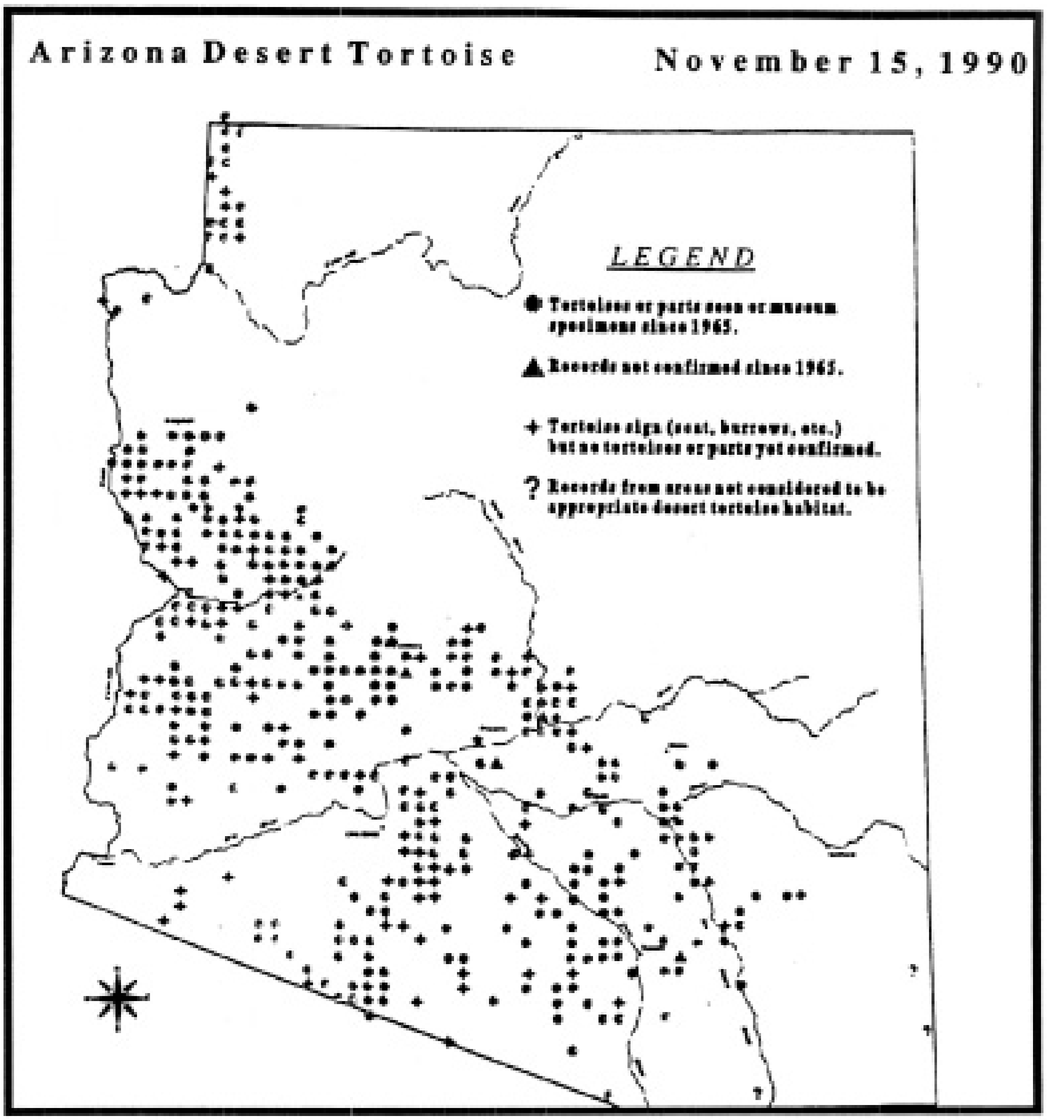

Figure 10. Known Sonoran Tortoise Sites

Distribution and Abundance

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

Table 15. Cuckoos detected from 1993-2000

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

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

Effects Analysis

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

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

B. Marsh

Brown Pelican (Pelecanus occidentalis)
Federally Endangered

Description and Life Requisites

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

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

Distribution and Abundance

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

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

Effect Analysis

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

Yuma Clapper Rail (Rallus longirostris yumanensis)
Federally Endangered

Description and Life Requisites

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

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

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

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

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

Distribution and Abundance

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

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

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

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

Table 16. Yuma Clapper Rail Survey Data 1990-1999

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

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

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

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

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

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

Effect Analysis

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

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

Description and Life Requisites

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

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

Distribution and Abundance

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

Effect Analysis

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

C. Aquatic

Razorback Sucker (Xyrauchen texanus)
Federally Endangered

Description and Life Requisites

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

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

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

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

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

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

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

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

Distribution and Abundance

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

As stated in Minckley et al. (1991):

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

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

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

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

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

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

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

Effect Analysis

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

1) Mainstem Reservoirs:

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

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

2) Riverine Reaches:

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

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

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

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

Effect Summary:

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

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

Bonytail (Gila elegans)
Federally Endangered

Description and Life Requisites

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

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

Distribution and Abundance

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

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

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

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

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

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

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

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

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

Effects Analysis

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

1. Critical Habitat Description - Razorback Sucker and Bonytail

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

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

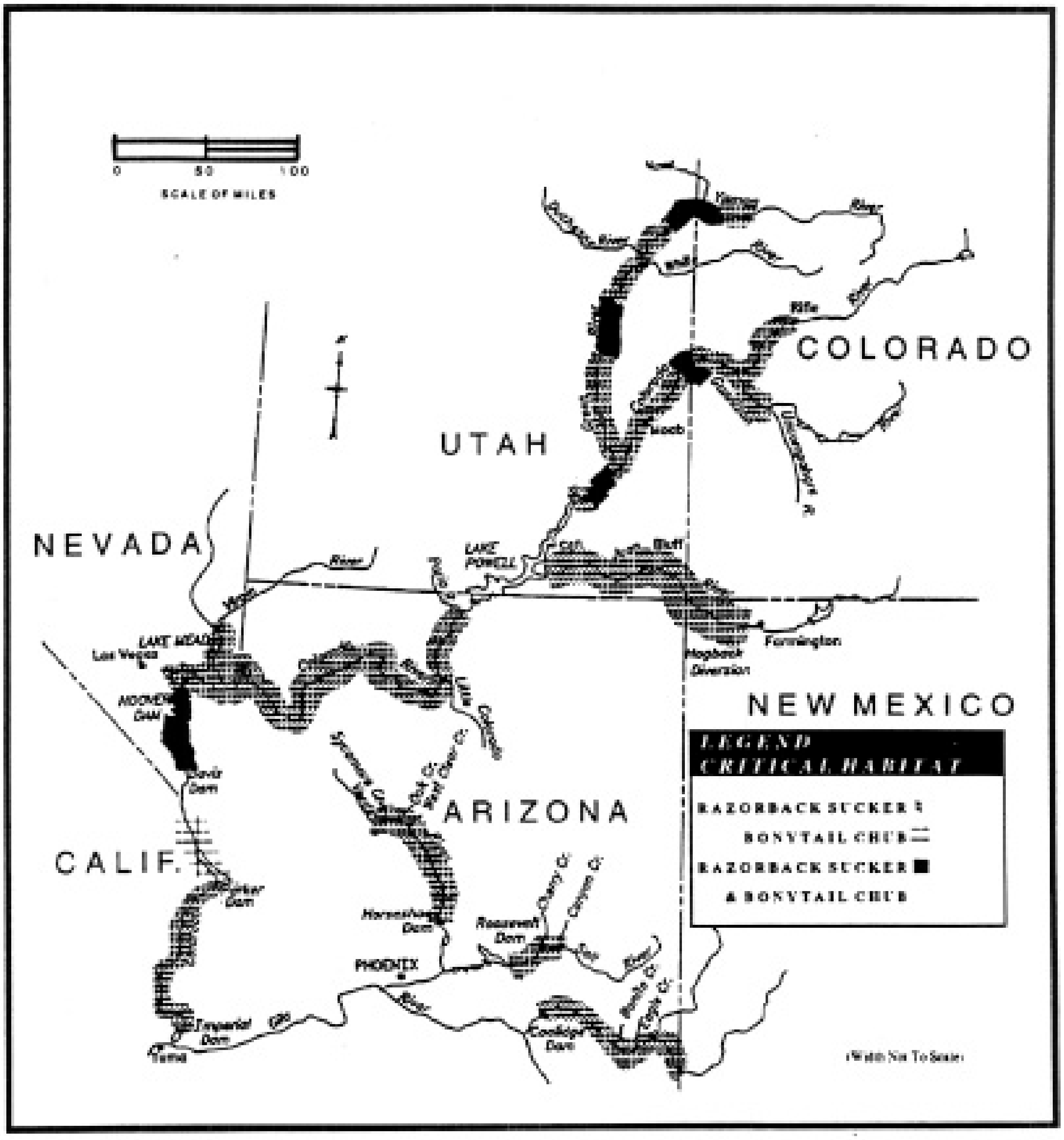

Figure 11. Location of Critical Habitat for Bonytail Chub and Razorback Sucker.

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

> Water - A quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, contaminants, nutrients, turbidity etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life-stage of each species.
>
> Physical Habitat - Areas of the Colorado River system that are inhabited or potentially habitable for use in spawning, nursery, feeding and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats.
>
> Biological Environment - Food supply, predation, and competition are important elements of the biological environment. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation, although considered a normal component of this environment, may be out of balance due to introduced fish species in some areas.
>
> Each aspect of a critical habitat may, in and of itself, explain some changes in the population status of the big-river fishes, but the interactions between, and cumulative effects of, the combined elements are also of important concern.

Effects Analysis

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

Water:

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

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

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

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

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

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

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

Physical Habitat:

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

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

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

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

Desert pupfish (Cyprinodon macularius)
Federally Endangered

Description and Life Requisites

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

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

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

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

Distribution and Abundance

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

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

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

Effects Analysis

Desert pupfish will not be affected by the ISC.

D. Summary of Effects Analysis

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

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

Table 17. Summary of Effect Analyses

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

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

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

Introduction

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

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

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

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

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

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

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

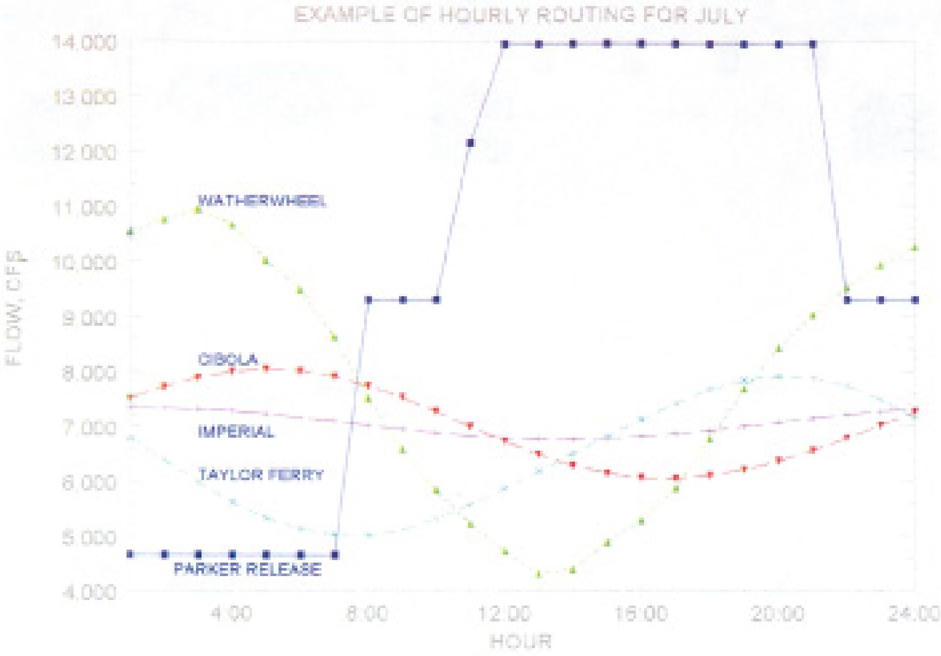

Figure A-1

USBR 08-17-2000

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

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

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

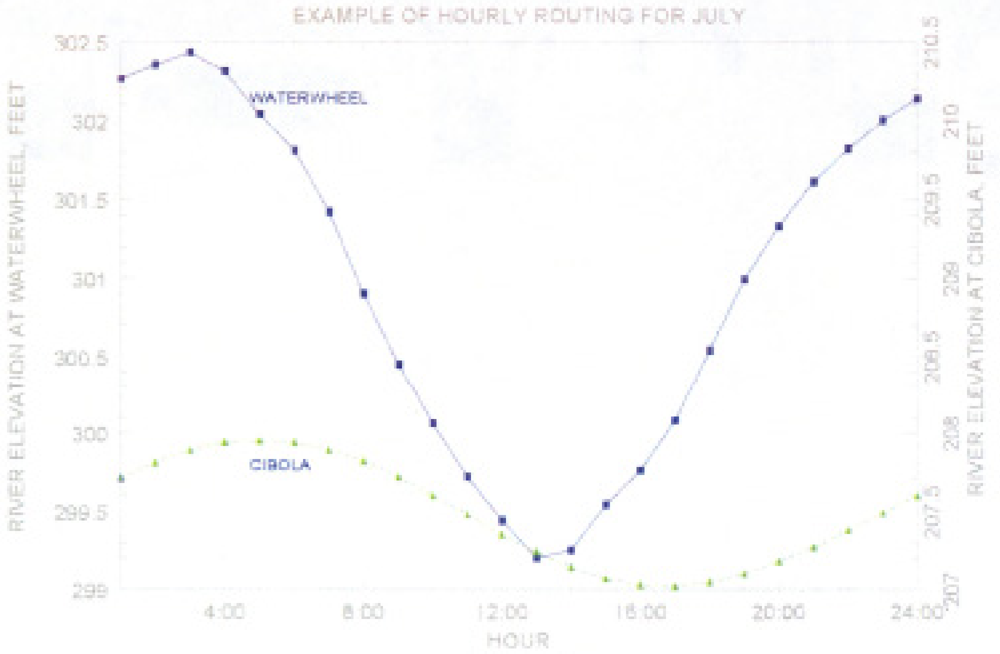

Figure A-2

USBR 08-17-2000

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

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

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

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

			ww	ww	ww	ww	ww	ww	tf	tf	tf
Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
Baseline	10083	Flow:	8474	8474	8474	8474	8474	8474	7796	7796	7796
		Elev:	334.12	327.66	316.12	298.96	295.52	283.83	248.26	241.93	239.50
200K AF Reduction	9808	Flow:	8199	8199	8199	8199	8199	8199	7521	7521	7521
		Elev:	333.98	327.51	315.98	298.81	295.41	283.81	248.12	241.75	239.33
Change	-275	dElev:	-0.14	-0.15	-0.14	-0.14	-0.11	-0.02	-0.14	-0.18	-0.17
300K AF Reduction	9669	Flow:	8060	8060	8060	8060	8060	8060	7382	7382	7382
		Elev:	333.91	327.44	315.91	298.74	295.35	283.80	248.05	241.65	239.24
Change	-414	dElev:	-0.21	-0.22	-0.22	-0.22	-0.17	-0.03	-0.21	-0.28	-0.26
400K AF Reduction	9531	Flow:	7922	7922	7922	7922	7922	7922	7244	7244	7244
		Elev:	333.84	327.36	315.83	298.67	295.29	283.80	247.98	241.56	239.15
Change	-552	dElev:	-0.28	-0.30	-0.29	-0.29	-0.22	-0.04	-0.28	-0.37	-0.34
500K AF Reduction	9393	Flow:	7784	7784	7784	7784	7784	7784	7106	7106	7106
		Elev:	333.77	327.28	315.76	298.59	295.24	283.79	247.91	241.46	239.07
Change	-690	dElev:	-0.35	-0.38	-0.36	-0.36	-0.28	-0.04	-0.35	-0.47	-0.43
675K AF Reduction	9152	Flow:	7543	7543	7543	7543	7543	7543	6865	6865	6865
		Elev:	333.64	327.15	315.63	298.46	295.13	283.77	247.78	241.29	238.91
Change	-932	dElev:	-0.47	-0.51	-0.50	-0.50	-0.38	-0.06	-0.48	-0.63	-0.59
948K AF Reduction	8775	Flow:	7166	7166	7166	7166	7166	7166	6488	6488	6488
		Elev:	333.45	326.94	315.42	298.25	294.97	283.75	247.58	241.02	238.66
Change	-1308	dElev:	-0.67	-0.72	-0.70	-0.71	-0.55	-0.08	-0.68	-0.90	-0.84
1,553K AF Reduction	7940	Flow:	6331	6331	6331	6331	6331	6331	5653	5653	5653
		Elev:	333.00	326.45	314.94	297.75	294.59	283.70	247.11	240.40	238.07
Change	-2143	dElev:	-1.12	-1.21	-1.18	-1.20	-0.93	-0.13	-1.15	-1.53	-1.43
1.574K AF Reduction	7911	Flow:	6302	6302	6302	6302	6302	6302	5624	5624	5624
		Elev:	332.98	326.43	314.92	297.74	294.57	283.70	247.09	240.38	238.05
Change	-2172	dElev:	-1.14	-1.23	-1.20	-1.22	-0.95	-0.13	-1.17	-1.55	-1.45

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

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

			ww	ww	ww	ww	ww	ww	tf	tf	tf
Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
Baseline	14234	Flow:	10437	10437	10437	10437	10437	10437	10004	10004	10004
		Elev:	335.05	328.67	317.09	299.89	296.24	283.97	249.29	243.28	240.75
200K AF Reduction	13405	Flow:	9245	9245	9245	9245	9245	9245	9360	9360	9360
		Elev:	334.49	328.07	316.51	299.34	295.82	283.88	249.00	242.91	240.40
Change	-829	dElev:	-0.56	-0.60	-0.57	-0.55	-0.43	-0.08	-0.29	-0.38	-0.34
300K AF Reduction	13219	Flow:	9185	9185	9185	9185	9185	9185	9236	9236	9236
		Elev:	334.46	328.04	316.48	299.31	295.79	283.88	248.94	242.83	240.33
Change	-1015	dElev:	-0.59	-0.63	-0.60	-0.58	-0.45	-0.09	-0.34	-0.45	-0.41
400K AF Reduction	13034	Flow:	9141	9141	9141	9141	9141	9141	9132	9132	9132
		Elev:	334.44	328.01	316.46	299.29	295.78	283.88	248.90	242.77	240.28
Change	-1200	dElev:	-0.61	-0.66	-0.63	-0.60	-0.47	-0.09	-0.39	-0.51	-0.47
500K AF Reduction	12849	Flow:	9092	9092	9092	9092	9092	9092	9019	9019	9019
		Elev:	334.42	327.99	316.44	299.27	295.76	283.87	248.84	242.70	240.21
Change	-1385	dElev:	-0.63	-0.68	-0.65	-0.63	-0.49	-0.10	-0.44	-0.58	-0.53
675K AF Reduction	12364	Flow:	8678	8678	8678	8678	8678	8678	8530	8530	8530
		Elev:	334.22	327.77	316.23	299.06	295.60	283.84	248.62	242.40	239.94
Change	-1870	dElev:	-0.83	-0.90	-0.86	-0.83	-0.64	-0.12	-0.67	-0.88	-0.81
948K AF Reduction	11608	Flow:	6565	6565	6565	6565	6565	6565	7359	7359	7359
		Elev:	333.12	326.59	315.08	297.90	294.70	283.71	248.04	241.64	239.23
Change	-2626	dElev:	-1.93	-2.08	-2.01	-2.00	-1.55	-0.26	-1.25	-1.65	-1.52
1,553K AF Reduction	9932	Flow:	4988	4988	4988	4988	4988	4988	5441	5441	5441
		Elev:	332.23	325.63	314.11	296.87	293.90	283.63	246.99	240.23	237.92
Change	-4302	dElev:	-2.82	-3.04	-2.97	-3.03	-2.34	-0.34	-2.30	-3.05	-2.83
1.574K AF Reduction	9874	Flow:	4978	4978	4978	4978	4978	4978	5395	5395	5395
		Elev:	332.22	325.62	314.11	296.86	293.89	283.62	246.96	240.20	237.88
Change	-4360	dElev:	-2.83	-3.05	-2.98	-3.03	-2.35	-0.34	-2.33	-3.09	-2.86

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

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

			ww	ww	ww	ww	ww	ww	tf	tf	tf
Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
Baseline	14234	Flow:	15864	15864	15864	15864	15864	15864	12353	12353	12353
		Elev:	337.29	331.09	319.33	301.95	297.83	284.42	250.24	244.54	241.89
200K AF Reduction	13405	Flow:	14504	14504	14504	14504	14504	14504	11389	11389	11389
		Elev:	336.77	330.53	318.82	301.49	297.48	284.30	249.87	244.04	241.44
Change	-829	dElev:	-0.52	-0.56	-0.51	-0.46	-0.35	-0.13	-0.38	-0.50	-0.45
300K AF Reduction	13219	Flow:	14034	14034	14034	14034	14034	14034	11110	11110	11110
		Elev:	336.58	330.33	318.63	301.32	297.35	284.26	249.75	243.89	241.30
Change	-1015	dElev:	-0.71	-0.76	-0.70	-0.62	-0.48	-0.17	-0.49	-0.64	-0.59
400K AF Reduction	13034	Flow:	13559	13559	13559	13559	13559	13559	10854	10854	10854
		Elev:	336.39	330.12	318.44	301.15	297.22	284.22	249.65	243.76	241.18
Change	-1200	dElev:	-0.90	-0.97	-0.89	-0.80	-0.62	-0.21	-0.60	-0.78	-0.71
500K AF Reduction	12849	Flow:	12888	12888	12888	12888	12888	12888	10587	10587	10587
		Elev:	336.12	329.82	318.17	300.90	297.02	284.16	249.53	243.61	241.05
Change	-1385	dElev:	-1.17	-1.26	-1.16	-1.05	-0.81	-0.26	-0.71	-0.93	-0.85
675K AF Reduction	12364	Flow:	12300	12300	12300	12300	12300	12300	10118	10118	10118
		Elev:	335.87	329.56	317.92	300.67	296.85	284.11	249.33	243.35	240.81
Change	-1870	dElev:	-1.42	-1.53	-1.41	-1.28	-0.99	-0.31	-0.91	-1.19	-1.09
948K AF Reduction	11608	Flow:	11984	11984	11984	11984	11984	11984	9779	9779	9779
		Elev:	335.74	329.41	317.78	300.55	296.75	284.09	249.19	243.15	240.63
Change	-2626	dElev:	-1.55	-1.68	-1.55	-1.40	-1.08	-0.34	-1.06	-1.39	-1.26
1,553K AF Reduction	9932	Flow:	11579	11579	11579	11579	11579	11579	8328	8328	8328
		Elev:	335.56	329.22	317.61	300.38	296.62	284.05	248.52	242.27	239.82
Change	-4302	dElev:	-1.73	-1.87	-1.73	-1.57	-1.21	-0.37	-1.72	-2.27	-2.07
1.574K AF Reduction	9874	Flow:	11530	11530	11530	11530	11530	11530	8264	8264	8264
		Elev:	335.54	329.20	317.58	300.36	296.61	284.05	248.49	242.23	239.78
Change	-4360	dElev:	-1.75	-1.89	-1.75	-1.59	-1.23	-0.37	-1.76	-2.31	-2.11

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

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

			ww	ww	ww	ww	ww	ww	tf	tf	tf
Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
Baseline	10818	Flow:	5412	5412	5412	5412	5412	5412	6853	6853	6853
		Elev:	332.48	325.89	314.38	297.16	294.13	283.65	247.78	241.29	238.90
200K AF Reduction	10502	Flow:	5251	5251	5251	5251	5251	5251	6490	6490	6490
		Elev:	332.38	325.79	314.28	297.05	294.04	283.64	247.58	241.03	238.66
Change	-316	dElev:	-0.09	-0.10	-0.10	-0.11	-0.09	-0.01	-0.20	-0.26	-0.24
300K AF Reduction	10344	Flow:	5204	5204	5204	5204	5204	5204	6351	6351	6351
		Elev:	332.36	325.76	314.25	297.02	294.02	283.64	247.50	240.92	238.57
Change	-474	dElev:	-0.12	-0.13	-0.13	-0.14	-0.11	-0.01	-0.27	-0.36	-0.34
400K AF Reduction	10186	Flow:	5132	5132	5132	5132	5132	5132	6204	6204	6204
		Elev:	332.32	325.72	314.21	296.97	293.98	283.63	247.42	240.82	238.46
Change	-632	dElev:	-0.16	-0.18	-0.18	-0.19	-0.15	-0.01	-0.35	-0.47	-0.44
500K AF Reduction	10028	Flow:	5038	5038	5038	5038	5038	5038	6066	6066	6066
		Elev:	332.26	325.66	314.15	296.90	293.93	283.63	247.35	240.71	238.37
Change	-790	dElev:	-0.22	-0.24	-0.24	-0.26	-0.20	-0.02	-0.43	-0.57	-0.53
675K AF Reduction	9752	Flow:	4941	4941	4941	4941	4941	4941	5841	5841	5841
		Elev:	332.20	325.60	314.08	296.83	293.87	283.62	247.22	240.54	238.21
Change	-1067	dElev:	-0.28	-0.30	-0.30	-0.33	-0.25	-0.02	-0.56	-0.74	-0.69
948K AF Reduction	9320	Flow:	4784	4784	4784	4784	4784	4784	5557	5557	5557
		Elev:	332.11	325.50	313.98	296.72	293.79	283.61	247.05	240.32	238.00
Change	-1498	dElev:	-0.37	-0.40	-0.40	-0.44	-0.34	-0.03	-0.72	-0.96	-0.90
1,553K AF Reduction	8364	Flow:	5123	5123	5123	5123	5123	5123	5352	5352	5352
		Elev:	332.31	325.71	314.20	296.96	293.97	283.63	246.93	240.16	237.85
Change	-2454	dElev:	-0.17	-0.18	-0.18	-0.20	-0.15	-0.02	-0.84	-1.12	-1.05
1.574K AF Reduction	8331	Flow:	5051	5051	5051	5051	5051	5051	5302	5302	5302
		Elev:	332.27	325.67	314.15	296.91	293.93	283.63	246.90	240.12	237.81
Change	-2487	dElev:	-0.21	-0.23	-0.23	-0.25	-0.19	-0.02	-0.87	-1.16	-1.09

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

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

			ww	ww	ww	ww	ww	ww	tf	tf	tf
Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
Baseline	10818	Flow:	12101	12101	12101	12101	12101	12101	9786	9786	9786
		Elev:	335.79	329.46	317.83	300.59	296.78	284.10	249.19	243.16	240.63
200K AF Reduction	10502	Flow:	11950	11950	11950	11950	11950	11950	9481	9481	9481
		Elev:	335.72	329.39	317.77	300.53	296.74	284.08	249.05	242.98	240.47
Change	-316	dElev:	-0.06	-0.07	-0.07	-0.06	-0.05	-0.01	-0.14	-0.18	-0.16
300K AF Reduction	10344	Flow:	11896	11896	11896	11896	11896	11896	9332	9332	9332
		Elev:	335.70	329.37	317.75	300.51	296.72	284.08	248.99	242.89	240.39
Change	-474	dElev:	-0.09	-0.10	-0.09	-0.08	-0.06	-0.02	-0.20	-0.27	-0.24
400K AF Reduction	10186	Flow:	11721	11721	11721	11721	11721	11721	9159	9159	9159
		Elev:	335.62	329.29	317.67	300.44	296.67	284.07	248.91	242.79	240.29
Change	-632	dElev:	-0.16	-0.18	-0.17	-0.15	-0.12	-0.03	-0.28	-0.37	-0.34
500K AF Reduction	10028	Flow:	11685	11685	11685	11685	11685	11685	8982	8982	8982
		Elev:	335.61	329.27	317.65	300.43	296.65	284.06	248.83	242.68	240.19
Change	-790	dElev:	-0.18	-0.19	-0.18	-0.17	-0.13	-0.03	-0.36	-0.48	-0.44
675K AF Reduction	9752	Flow:	11383	11383	11383	11383	11383	11383	8649	8649	8649
		Elev:	335.47	329.13	317.52	300.30	296.56	284.04	248.67	242.47	240.00
Change	-1067	dElev:	-0.31	-0.34	-0.31	-0.29	-0.23	-0.06	-0.52	-0.68	-0.63
948K AF Reduction	9320	Flow:	10894	10894	10894	10894	10894	10894	8076	8076	8076
		Elev:	335.26	328.89	317.30	300.09	296.40	284.00	248.40	242.11	239.67
Change	-1498	dElev:	-0.53	-0.57	-0.54	-0.50	-0.39	-0.09	-0.79	-1.05	-0.96
1,553K AF Reduction	8364	Flow:	7764	7764	7764	7764	7764	7764	6378	6378	6378
		Elev:	333.76	327.27	315.75	298.58	295.23	283.79	247.52	240.94	238.58
Change	-2454	dElev:	-2.03	-2.19	-2.09	-2.01	-1.56	-0.31	-1.67	-2.21	-2.05
1.574K AF Reduction	8331	Flow:	7760	7760	7760	7760	7760	7760	6361	6361	6361
		Elev:	333.76	327.27	315.74	298.58	295.23	283.79	247.51	240.93	238.57
Change	-2487	dElev:	-2.03	-2.19	-2.09	-2.01	-1.56	-0.31	-1.68	-2.23	-2.06

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

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

			ww	ww	ww	ww	ww	ww	tf	tf	tf
Location (RM)	ParkerDam Avg Flow		171.3	167.6	160.9	149.5	146.9	135.8	119.7	116.5	114.6
Baseline	4986	Flow:	2424	2424	2424	2424	2424	2424	3530	3530	3530
		Elev:	330.60	323.87	312.30	294.74	292.25	283.50	245.77	238.59	236.35
200K AF Reduction	4849	Flow:	2334	2334	2334	2334	2334	2334	3373	3373	3373
		Elev:	330.54	323.80	312.23	294.65	292.18	283.50	245.66	238.44	236.21
Change	-137	dElev:	-0.06	-0.07	-0.07	-0.09	-0.07	-0.00	-0.11	-0.15	-0.14
300K AF Reduction	4780	Flow:	2328	2328	2328	2328	2328	2328	3313	3313	3313
		Elev:	330.54	323.80	312.22	294.65	292.18	283.50	245.62	238.38	236.15
Change	-206	dElev:	-0.07	-0.07	-0.08	-0.09	-0.07	-0.00	-0.15	-0.21	-0.20
400K AF Reduction	4712	Flow:	2324	2324	2324	2324	2324	2324	3235	3235	3235
		Elev:	330.53	323.80	312.22	294.64	292.17	283.50	245.56	238.31	236.08
Change	-274	dElev:	-0.07	-0.07	-0.08	-0.10	-0.08	-0.00	-0.21	-0.28	-0.27
500K AF Reduction	4643	Flow:	2224	2224	2224	2224	2224	2224	3157	3157	3157
		Elev:	330.46	323.72	312.14	294.54	292.09	283.50	245.51	238.23	236.01
Change	-343	dElev:	-0.14	-0.15	-0.16	-0.20	-0.15	-0.01	-0.26	-0.36	-0.34
675K AF Reduction	4523	Flow:	2171	2171	2171	2171	2171	2171	3042	3042	3042
		Elev:	330.43	323.68	312.10	294.49	292.05	283.49	245.42	238.12	235.90
Change	-463	dElev:	-0.17	-0.19	-0.20	-0.25	-0.20	-0.01	-0.35	-0.47	-0.45
948K AF Reduction	4336	Flow:	2136	2136	2136	2136	2136	2136	2882	2882	2882
		Elev:	330.40	323.66	312.07	294.45	292.02	283.49	245.31	237.96	235.74
Change	-650	dElev:	-0.20	-0.21	-0.23	-0.29	-0.22	-0.01	-0.46	-0.63	-0.61
1,553K AF Reduction	3921	Flow:	2008	2008	2008	2008	2008	2008	2537	2537	2537
		Elev:	330.31	323.56	311.97	294.32	291.92	283.49	245.05	237.60	235.40
Change	-1065	dElev:	-0.29	-0.31	-0.33	-0.42	-0.33	-0.02	-0.72	-0.98	-0.95
1.574K AF Reduction	3906	Flow:	2007	2007	2007	2007	2007	2007	2525	2525	2525
		Elev:	330.31	323.56	311.97	294.32	291.92	283.49	245.04	237.59	235.39
Change	-1080	dElev:	-0.29	-0.31	-0.33	-0.42	-0.33	-0.02	-0.73	-1.00	-0.96

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

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

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

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

APPENDIX B.
Description of the Interim Surplus Criteria Alternatives

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX D.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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APPENDIX E.

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

Backwater and Aquatic Analysis

Introduction

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

Purpose

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

Data from this analysis were used to determine the following:

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

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

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

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

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

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

Data Sources

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

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

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

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

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

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

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

Data Analysis

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

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

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

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

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

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

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

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

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

7. *GIS Modeling and Analysis*

General Strategy

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

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

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

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

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

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

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

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

Riparian Analysis

Summary

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

Losing Reaches

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

Gaining Reaches

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

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

Measured "Near-River" Groundwater Levels

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

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

Typical Groundwater Response

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

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

Estimated River Elevation Drop

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

Estimate of Riparian Acreage Influenced by River Flow Reductions

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

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

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APPENDIX F.
Historical Total Selenium - Lower Colorado River

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

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

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

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

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

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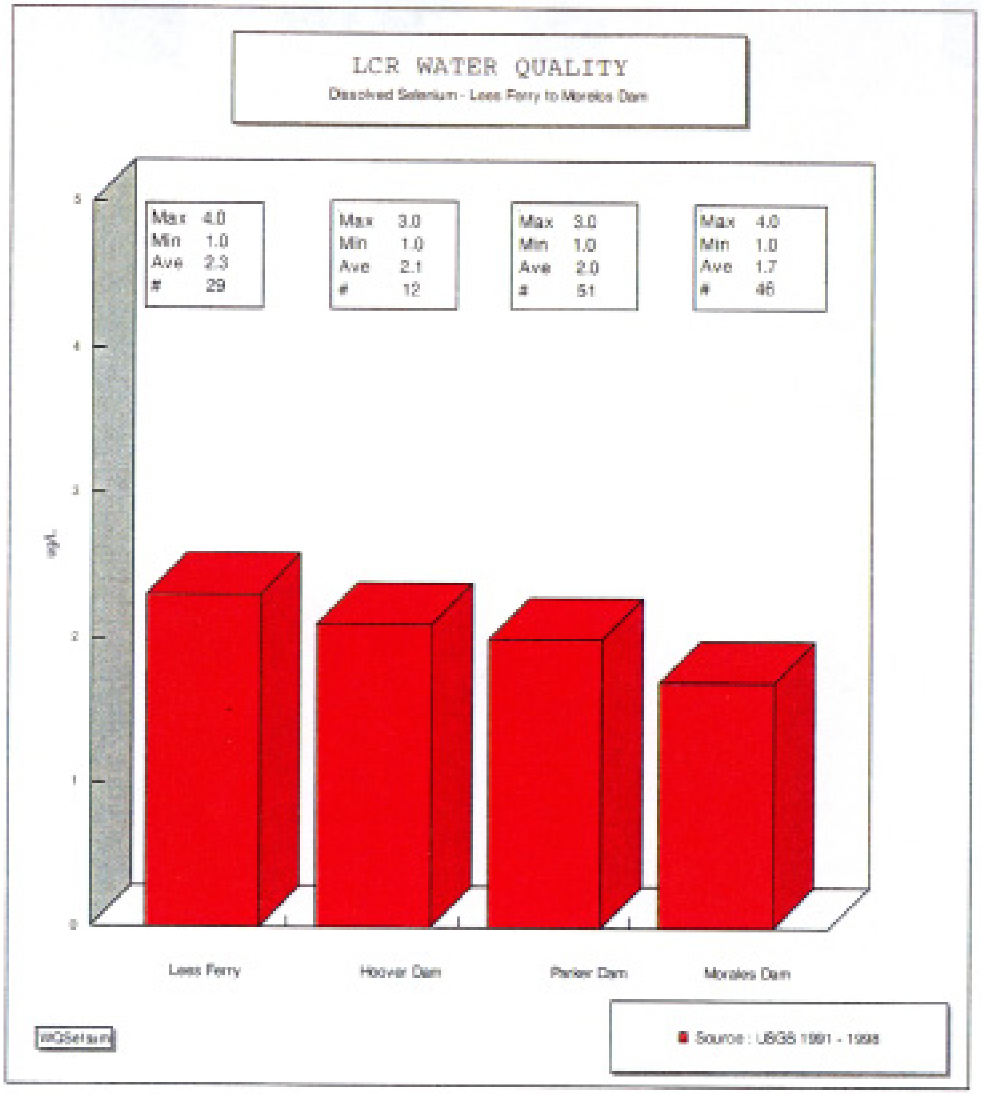
A USGS Water Resources Reconnaissance Investigation Report (88- 4002),1986-87, indicated similar findings (3.4 or less ug/l) for dissolved Selenium concentrations at several sites in the lower Colorado River.

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

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

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


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

APPENDIX G.
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SUPPLEMENTAL
BIOLOGICAL ASSESSMENT ON TRANSBOUNDARY EFFECTS IN MEXICO
FOR
PROPOSED INTERIM SURPLUS CRITERIA

January 9, 2001

INTRODUCTION

This consultation is conducted to consider the impacts on species in Mexico listed as endangered or threatened in the U.S. under Section 7 (a)(1) of the Endangered Species Act of 1967, as amended. This document addresses impacts in Mexico and supplements the Biological Assessment (BA) on the Interim Surplus Criteria (ISC) and Secretarial Implementation Agreements (SIA) (U.S. Bureau of Reclamation, 2000a) which is incorporated by reference. Project descriptions and background for the SIA are found in the main body of the BA. Project descriptions and background for the ISC are found in the Final EIS, Colorado River Interim Surplus Criteria EIS (U.S. Bureau of Reclamation, 2000b)

This consultation does not reflect any conclusion on Reclamation's part that consultation is required, as a matter of law or regulation, on any possible impact the adoption of interim surplus criteria may have on U.S. listed species in Mexico. Rather, consultation on these effects has proceeded with the express understanding that it may exceed what is required under applicable Federal law and regulations and does not establish a legal or policy precedent.

Several interim surplus criteria (ISC) have been proposed and are described in the EIS. For the purposes of this analysis, however, the criteria selected are known as the Basin States Alternative, which is presently proposed for use by Reclamation for the Preferred Alternative in the EIS. The Basin States Alternative specifies ranges of Lake Mead water surface elevations to be used through 2015 for determining the availability of surplus water through 2016. The elevation ranges are coupled with specific amounts of surplus water in such a way that, if Lake Mead's surface elevation were to decline, the amount of surplus water would be reduced. Surplus water would be available only to holders of valid contracts for surplus water delivery. The interim criteria would be reviewed at five-year intervals with the Long-Range Operating Criteria and as needed based upon actual operational experience. This plan is described further in Appendix A of this document. This alternative was developed with input and consensus from the seven Colorado River Basin states.

This document discusses the potential effects that extend across the international border below the Northerly International Boundary (NIB). Reclamation distinguishes between impacts resulting from the ISC and the SIA. Reclamation does not believe the SIA has any potential effect on any U.S. listed species in Mexico. Potential effects on resources could occur from potential changes in flows to Mexico as a result of adoption of ISC. The potential changes in flow to Mexico as a result of the ISC are discussed in this document. Details of how the changes in flow were derived are further detailed in the EIS and are also incorporated by reference.

U.S. Federally Endangered Species analyzed in this assessment include the desert pupfish (*Cyprinodon macularius*), vaquita (*Phocaena sinus*), totoaba (*Totoaba macdonaldi*), southwestern willow flycatcher (*Empidonax traillii extimus*), and the Yuma clapper rail (*Rallus longirostris yumanensis*).

METHODOLOGY

The analytical approach used to evaluate potential impacts below the NIB is the same as that used for other resources and is fully consistent with the other documents pertaining to this subject. The incremental hydrological change between the baseline conditions and the Basin States Alternative was determined by modeling the Colorado River system. Environmental baseline conditions are those expected to result from the full development of the U.S. waters reserved by treaty. This includes the full development of the water allocated to the lower Colorado River Basin and up to 5.9 maf development of the upper Colorado River Basin allocation as recognized by the Colorado River Compact.

The potential effects on Mexico's resources cannot be specifically determined due to the uncertainty of water use once it flows across the NIB into Mexico. The waters of the Colorado River, once delivered to Mexico, as agreed upon in the Mexican Water Treaty of 1944, are under the jurisdiction of Mexico. This treaty contains no provisions requiring Mexico to provide water for environmental protection, nor any requirements relating to Mexico's use of that water. It is reasonably foreseeable that Mexico will continue to maximize consumptive use of its Colorado River water apportionment for agricultural, municipal and industrial purposes.

For Clarification it is necessary to distinguish between Mexico's receipt of up to 200,000 acre feet (af) of scheduled surplus water from that of additional water, which this analysis refers to as "excess flows." The 200,000 af of flood control surplus to Mexico is in addition to the amount necessary to supply uses in the United States and the more assured quantity of 1.5 maf to Mexico. This 200,000 af is scheduled by Mexico and is spread over the entire year as outlined in Article 15 of the Treaty of 1944, and are not related to the surplus water that will be generated from the Basin States Alternative implementation under the surplus criteria. Excess flows result from flood control operations, unanticipated contributions from events such as flooding along the Gila River and/or other factors resulting in canceled water orders by water users below Parker Dam. The change in probability of these excess flows is the subject of this analysis. Mexico has complete autonomy as to how they choose to manage apportioned (scheduled surplus water) and excess Colorado River flows.

AFFECTED ENVIRONMENT

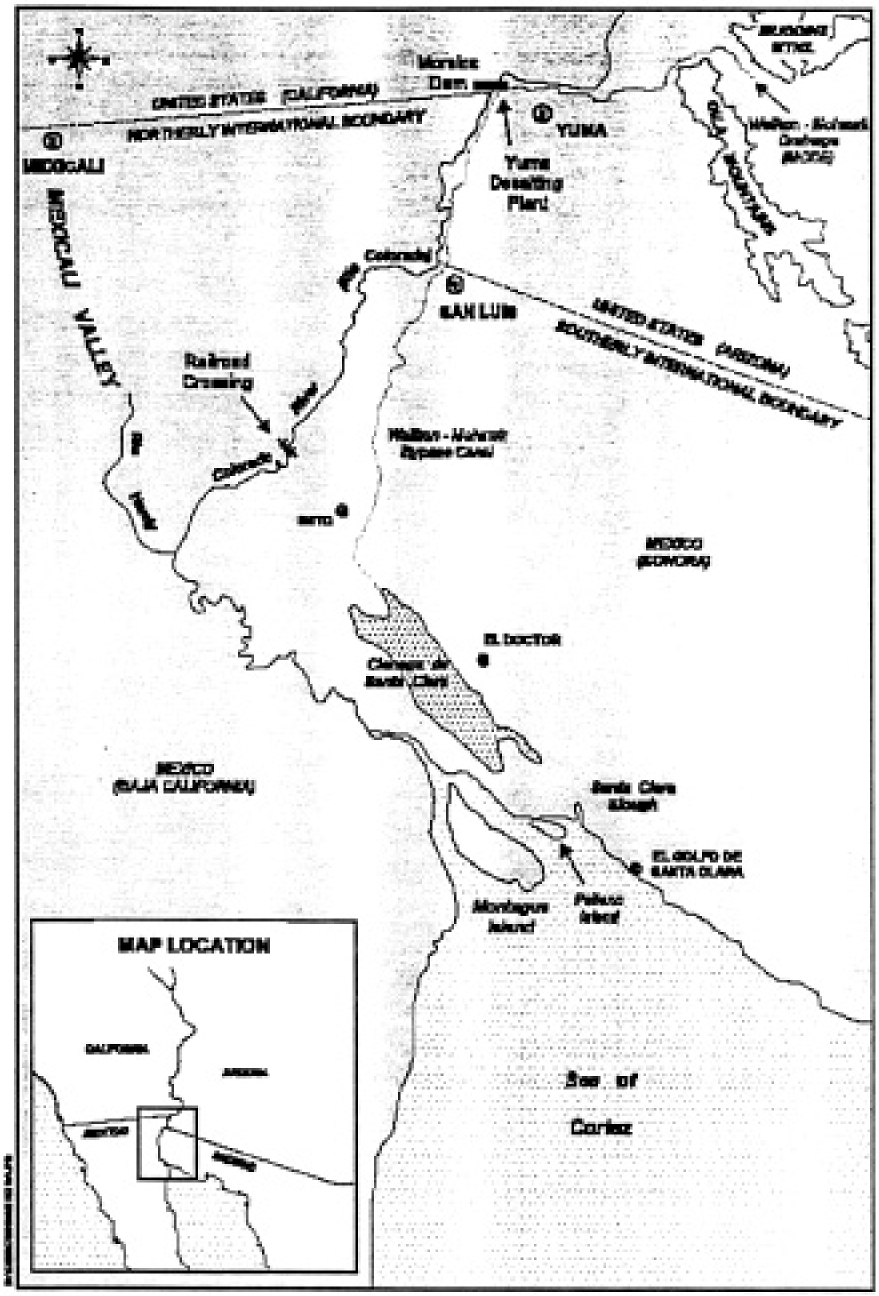
HISTORICAL COLORADO RIVER BETWEEN THE NORTHERLY INTERNATIONAL BOUNDARY AND THE GULF OF CALIFORNIA

Historically, the Colorado River flowed approximately 1,440 miles from its headwaters in the Rocky Mountains to its mouth at the Gulf of California. Although the section of the river between the Southerly International Boundary (SIB) with Mexico and the Sea of Cortez is less than 50 air miles in length, the river meandered as much as 175 miles through this stretch (Browne, 1869; Rudkin, 1953). This section of the river from the SIB to the Sea of Cortez could be divided into two reaches: the upper reach, which was influenced mainly by flood events; and the lower reach, which was influenced mainly by tidal fluctuations in the Gulf of California. A third reach of the river, stretching from the NIB to the SIB, is analyzed in this section that acts as the east-west boundary between Baja California and the State of Arizona. This section of the river is known as the Limitrophe Division. Map 1 illustrates the Colorado River location in Mexico.

The upper reach of the Colorado River in Mexico between the NIB, including the Limitrophe Division, and the Gulf of California, extends from the international boundary to approximately the confluence of the Rio Hardy and the Colorado (Mearns, 1907). The plant community found in this reach of the Colorado was similar to that found in the Yuma Valley. Large cottonwoods and dense willow thickets lined the river channel and oxbows within the floodplain (Johnson, 1869; Mearns, 1907) Honey and screwbean mesquites formed large dense thickets in areas that were subject to occasional overbank flooding (Bolton, 1930; Thwaites, 1905). Dense stands of arrowweed were noted in many historical journals throughout this reach of the river (Bolton, 1930; Mearns, 1907). Unlike the portion of the Colorado River that lies within the United States, large marshes were common within this stretch of the river. Several journals note expanses of cattails, rushes, and cane (Thwaites, 1905; Mearns, 1907; Bolton, 1930). Large grass savannas were present within the floodplain that supported a cattle industry from the late 1800's through the early 1900's (Mearns, 1907; Kniffen, 1929 *in* Ohmart, 1982; Bolton, 1930).

The ecosystem found in the lower reach of the Colorado River, below the mouth of the Rio Hardy to the Gulf of California, was heavily influenced by tidal fluctuations in the Gulf of California and by heavy soil deposition from annual flood events. As the river meandered south of its confluence with the Rio Hardy, cottonwoods became scarce. Dense thickets of mesquite and arrowweed were still recorded on the upper terraces within this reach of the river. Dense stands of willows formed on newly deposited sediments. Large marshes, comprised mainly of cattails, rushes, and cane, dominated this stretch of the river (United States War Department, 1852; Mearns, 1907). Saltgrass became prevalent at the mouth of the river (Kniffen, 1929 *in* Ohmart, 1982).

Map 1
Colorado River Location In Mexico



Present Status of the Colorado River in Mexico

Human activities have significantly changed the lower Colorado River ecosystem since the early 1900's. The most current information available on the vegetation composition present along the upper reach of the Colorado River floodplain between the SIB and the Rio Hardy comes from a 1999 study conducted by the University of Monterrey (Guaymas), the University of Arizona, the Environmental Defense Fund, and the Sonoran Institute (Glenn, unpub. data and Luecke et al, 1999). Aerial and remote sensing methods, combined with ground surveys to check accuracy, were used to estimate acreages of each habitat type. Habitat types were separated into two broad categories: (1) areas where Fremont cottonwood and Goodding willow comprised greater than 10 percent of the stand (determined by measuring percent vegetation cover by using remote sensing techniques); and (2) areas where Fremont cottonwood and Goodding willow comprised less than 10 percent of the stand. In stands where cottonwoods and willows comprised greater than 10 percent of the vegetative cover, the stands were further subdivided by height class and density (Open Gallery Forest, Closed Gallery Forest, and Shrub Dominated). In stands where cottonwoods and willows comprised less than 10 percent of the vegetative cover, the stands were further divided by species composition (saltcedar/arrowweed and saltcedar/mesquite).

The University of Monterrey study estimated approximately 9,545 acres of >10 percent cottonwood-willow habitat, 4,492 acres classified as open gallery forest and 5,053 acres classified as shrub dominated. Analysis of tree ring data indicated that the majority of these cottonwood-willow stands had been regenerated during high flow events over the past twenty years, including the high flows from 1983-1985 and the 1993 Gila River flood event along with the high flows in the Gila River during 1997. This study also identified 25,829 acres of saltcedar/arrowweed habitat. Although the study does not specify, it is likely that these stands were actually monotypic saltcedar and monotypic arrowweed stands or clumps as arrowweed does not usually grow as a mixed stand with other vegetation types. Interestingly, this study did not identify any saltcedar/mesquite acreage within the entire study area (E. Glenn, University of Arizona, Tucson, unpub. report; CH2MHill, 1997).

In December, 1998, biologists from the Bureau of Reclamation, San Bernardino County Museum, and the Upper Gulf of California and Colorado River Delta Biosphere Preserve conducted an aerial survey of the Rio Hardy and the Colorado River to determine potentially suitable Southwestern willow flycatcher breeding habitat. This survey noted the vegetation at the confluence of the Rio Hardy and Colorado River was mostly narrow, dry stands of saltcedar. Northeast of the town of Venustiano Carranza, patches of Goodding willow and Fremont cottonwood were evident. Approximately 5 kilometers north of the Mexican Railroad crossing of the Colorado River, the river contained long, linear stands of Goodding willow with a few cottonwoods also present. Approximately 15 kilometers south of San Luis, Sonora, the Colorado River begins to broaden out and, from this point north to the NIB, a variety of habitats believed to be suitable breeding habitat for Southwestern willow flycatcher were present (McKernan, pers. comm.). The majority of those latter habitats occurs in the Limitrophe Division between Morelos Dam and San Luis.

SEA OF CORTEZ ESTUARY

The lower Colorado River supported a large estuary at its mouth in the Sea of Cortez. The historic lower Colorado River exhibited the typical annual fluctuations in flow with the peak flows generally occurring in the spring to early summer. These flows carried nutrients and sediments into the estuary, creating the conditions suited for various phases of the life history of the endemic species.

The current condition of the upper end of the Sea is remarkably changed due to the lack of annual inflow from the lower Colorado River, following the construction of dams and water diversions upstream. In recent years there have been only three events of note that have resulted in large quantities of water reaching this estuary from the lower Colorado River. High flows were experienced on the lower Colorado River during flood control operations from 1983 through 1987, and flows from the Gila River through the lower Colorado River reached the estuary in 1993. There were space building flows in the fall of 1997 and fall of 1998, and flood control releases in January 1998. All but the flows of 1983-85 and 1993 probably had little effect on the Sea of Cortez. Therefore, the hydrology of the estuary is primarily dominated by tidal processes, and sediment contribution to the estuary is a result of erosion of the delta itself (Carriquiry and Sanchez, 1999).

In spite of the reduced inflow from the lower Colorado River the estuary is extremely rich in nutrients, with the corresponding richness of plankton, leading to rich amounts of organisms on up the food chain. High chlorophyll values are found in the estuary typical of very rich coastal waters (Santamaria-Del-Angel, et. al. (1994). Zooplankton biomass values are similar to those of the rich central Sea of Cortez, and the values for the channels around Montague Island at the mouth of the Colorado River are as high as those of estuaries and coastal lagoons (Farfan and Alvarez-Borrego, 1992). The nutrient inflow is primarily a result of agricultural drainage into the Rio Hardy, which joins the lower Colorado River immediately above the Sea.

FLOWS IN MEXICO

Currently, water can flow past Morelos Dam under three circumstances; (1) as a result of canceled water orders that Mexico is unable to divert at Morelos Dam; (2) during a Gila River flood event; and (3) during flood control releases along the mainstream Colorado River.

Water released from Parker Dam to meet U.S. 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, result in irrigation districts canceling these water delivery orders after the water has been released at Parker Dam. Usually, the water is diverted at Morelos Dam for use in Mexico; however, some of this water may flow past Morelos Dam. The volume of water passing by Morelos Dam due to cancelled water orders by contract users is rarely enough to have much effect on species and habitat in Mexico below the NIB. Mexico has the capability to divert up to 200 kaf monthly over its normal water order. Adoption of interim surplus criteria will not affect water that flows past the NIB as a result of canceled water orders.

As stated earlier in the discussion on the upper end of the Sea of Cortez there have been only three events of note in recent years that have resulted in large quantities of excess water reaching Mexico. Gila River flood events are extremely rare. Only once has flow been recorded over 4000 cfs at the Dome, Arizona, gaging station since 1941. In 1993, up to 27,500 cfs flowed past the Dome gaging station as a result of the 1993 Gila River flood. The 1993 flood created much of the riparian habitat presently found along the Gila River and Colorado River below its confluence with the Gila (Glenn, per. comm.).

BASELINE CONDITION

Excess flows below Morelos Dam 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 dependent upon hydrologic conditions. Mexico can schedule up to 200 kaf annually during years when flood control releases occur; however, it is important to remember that water which flows beyond the NIB are managed by Mexico and may be used for beneficial human uses and therefore, may not reach the affected areas. As flood flows arrive at Morelos Dam, Mexico has the discretion to divert more water than their water order, or allow all the additional flows to flow downstream of Morelos Dam. In the past, Mexico has generally chosen to increase their diversion for use in agriculture for increased crop production and soil salinity improvement, or for diluting flows delivered at the Southerly International Boundary, municipal and industrial uses, or to recharge groundwater aquifers in the Mexicali Valley.

Both the frequency and magnitude of excess flows are important factors in restoring and maintaining riparian and estuary habitat below Morelos Dam and the Sea and are analyzed in more detail in this section. It should be emphasized that Mexico's management decisions at and below Morelos Dam are not modeled. This is due to the uncertainty of what Mexico chooses to do with excess water; therefore, the hydrologic analyses assume that any water in excess of Mexico's scheduled normal or surplus deliveries are those flows that would occur below Morelos Dam.

The potential for future excess flows of any magnitude to Mexico is shown in Figure 1. The frequency of occurrence is computed by counting the number of modeled traces for each year that have excess annual flows and dividing by the total number of traces (85). As shown in Figure 1, under baseline conditions, the probability is a maximum of 35 percent in 2007 and then follows a gradually declining trend. The gradual decline in the trend can be attributed to increasing Upper Basin depletions. Under baseline conditions, the frequency of occurrence of any magnitude of flows declines to about 16 percent in 2050.

Predicting what magnitudes of flows could be expected from 2002 until 2050 is problematic at best. One way is to examine the probability of occurrence of flows greater than specified volumes. It is generally believed that periodic flows of 250 kaf or greater are necessary for maintaining the health of the Colorado River corridor in Mexico and the upper end of the Sea of Cortez (Leuke et al, 1999). Figure 4 shows the potential for excess flows of 250 kaf or greater to Mexico under baseline conditions. As illustrated, the probability of excess flows exceeding 250 kaf is a maximum of 32% in 2007 and gradually declining to about 13% in 2050. Similarly, Figure 5 shows the probability of excess flows of 1000 kaf or greater.

Alternatively, one can examine the probability of occurrence versus the magnitude of the flows for specified years. Figures 2 and 3 present the cumulative distribution of the annual flows for years 2016 and 2050. Figure 6, shows the probability of magnitude of excess flows at the 75th and 90th percentile levels. The probability magnitude of excess flows at the 50th percentile level is essentially zero.

Figure 1. Frequency of Excess Flows to Mexico

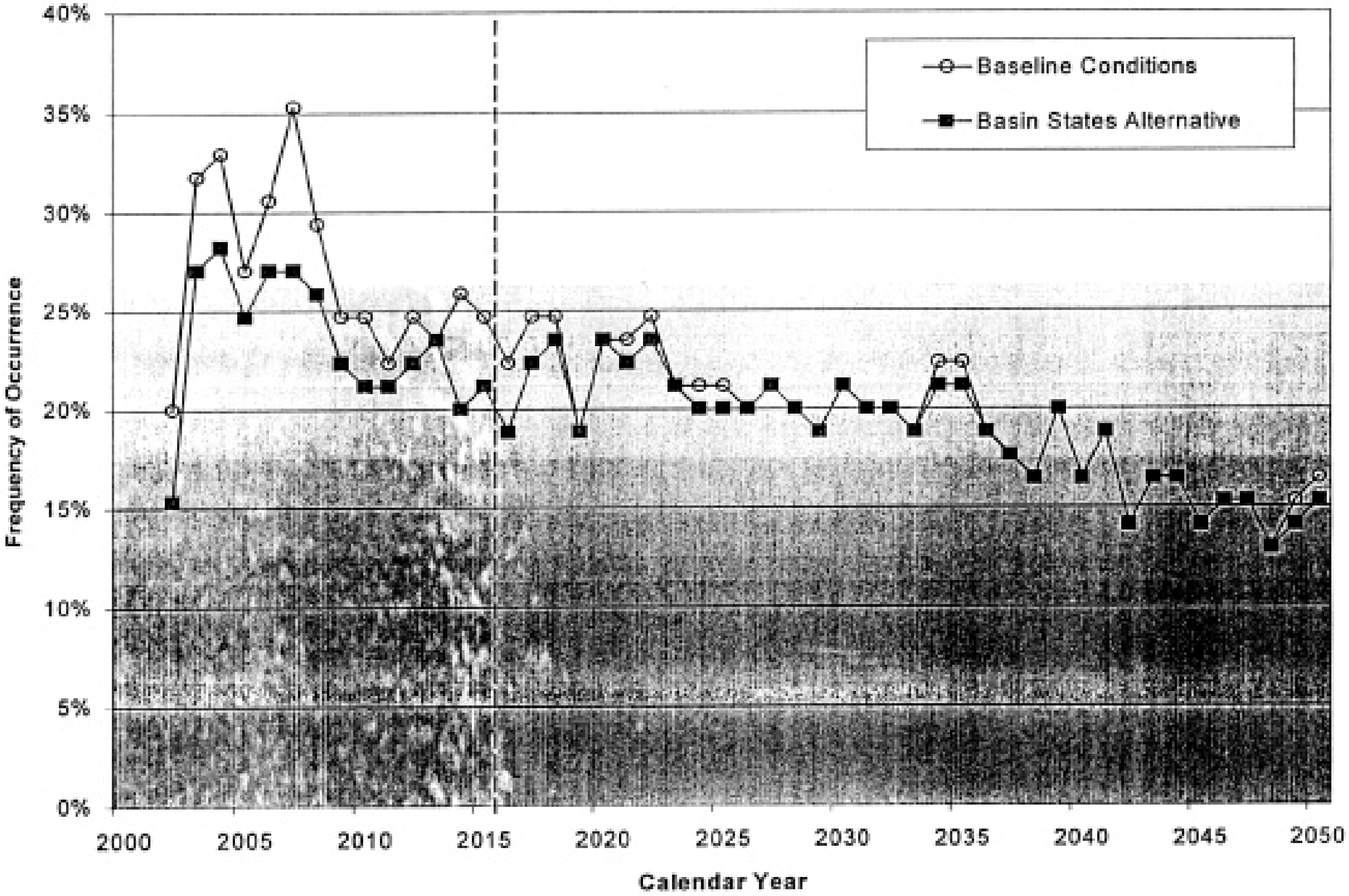


Figure 2. Excess Flows To Mexico, Comparison of Basin States Alternative to Baseline Conditions for Modeled Year 2016

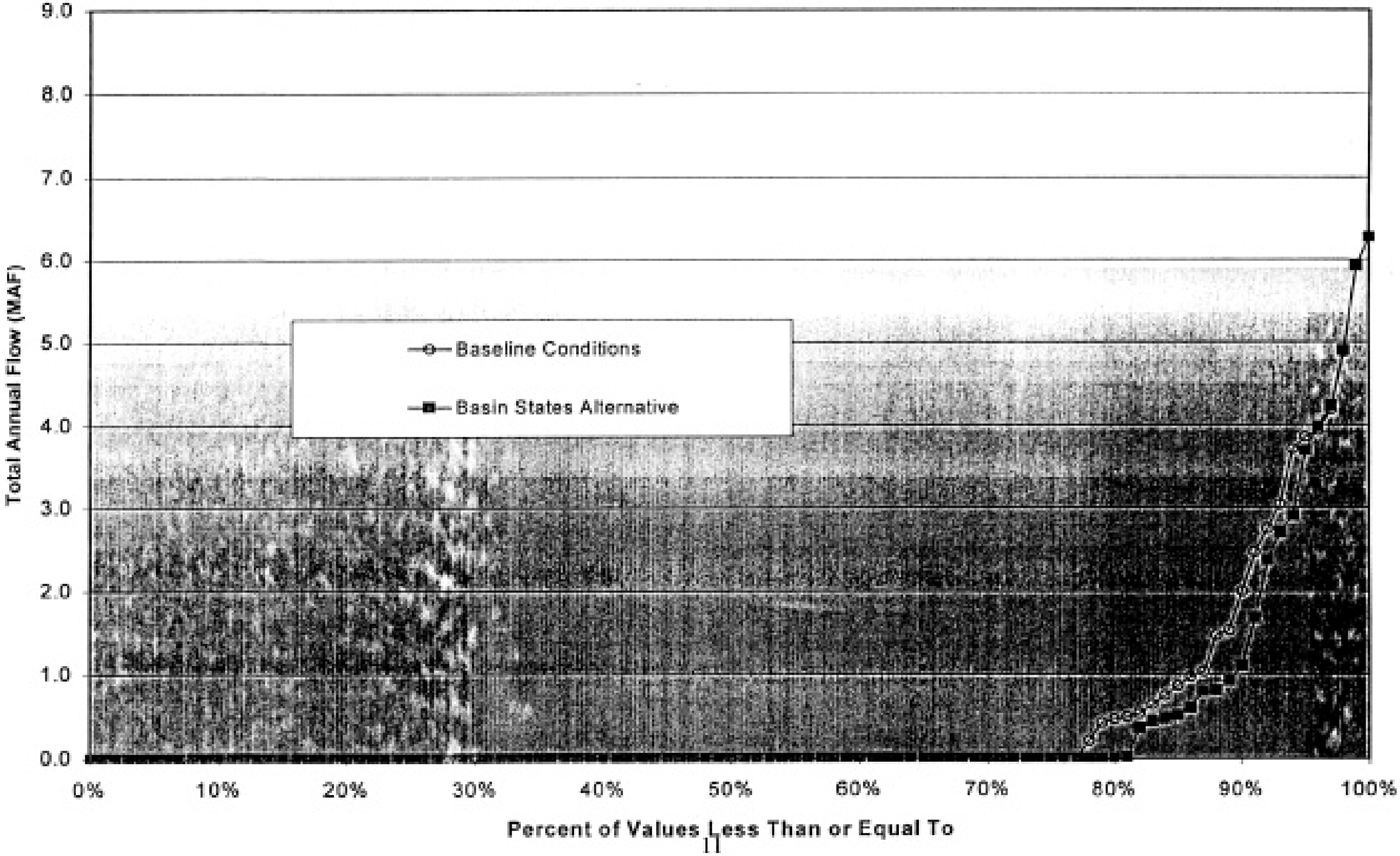


Figure 3. Excess Flows to Mexico. Comparison of Basin States Alternative to Baseline Conditions for Modeled Year 2050

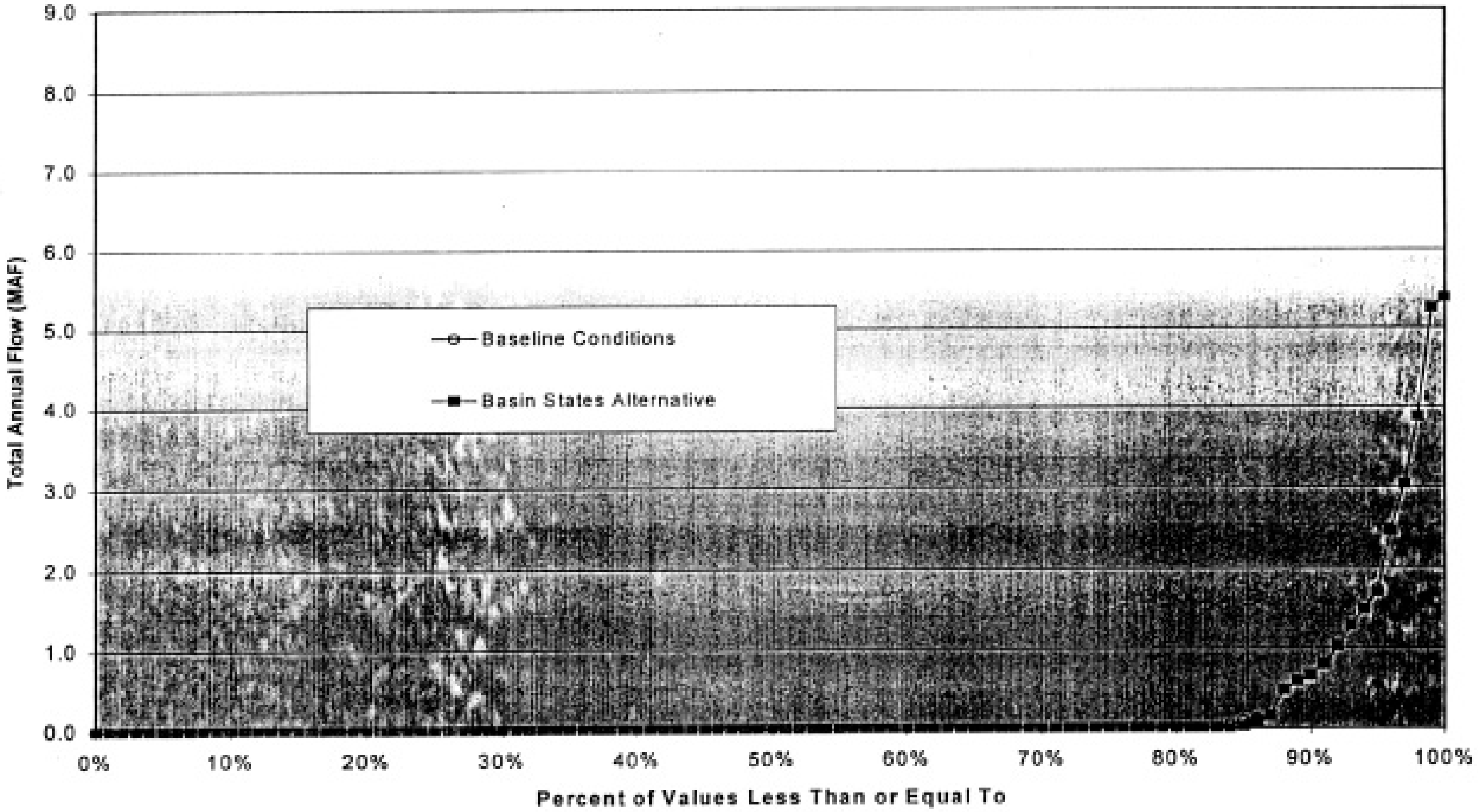


Figure 4. Excess Flows to Mexico Greater than 250 KAF

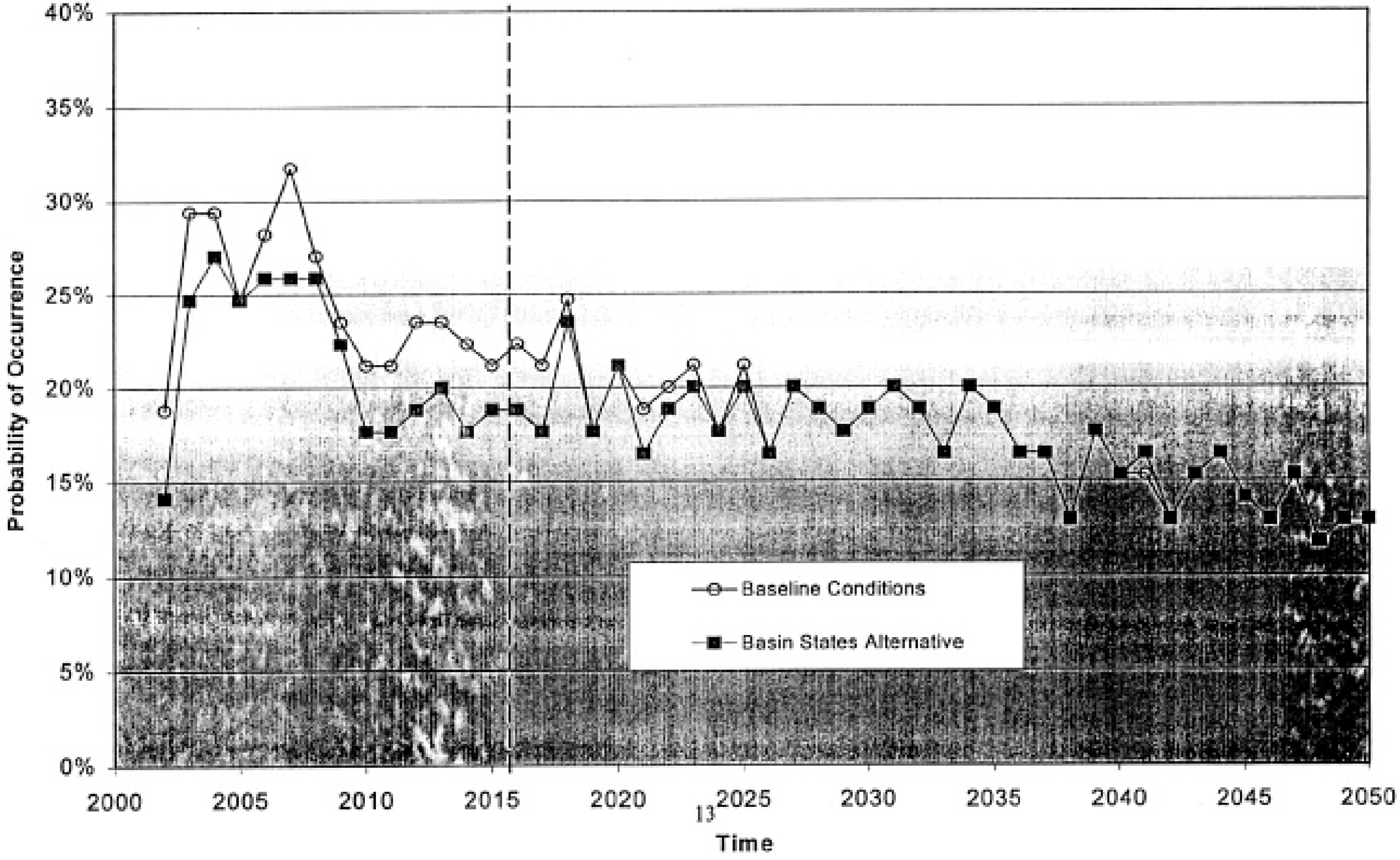
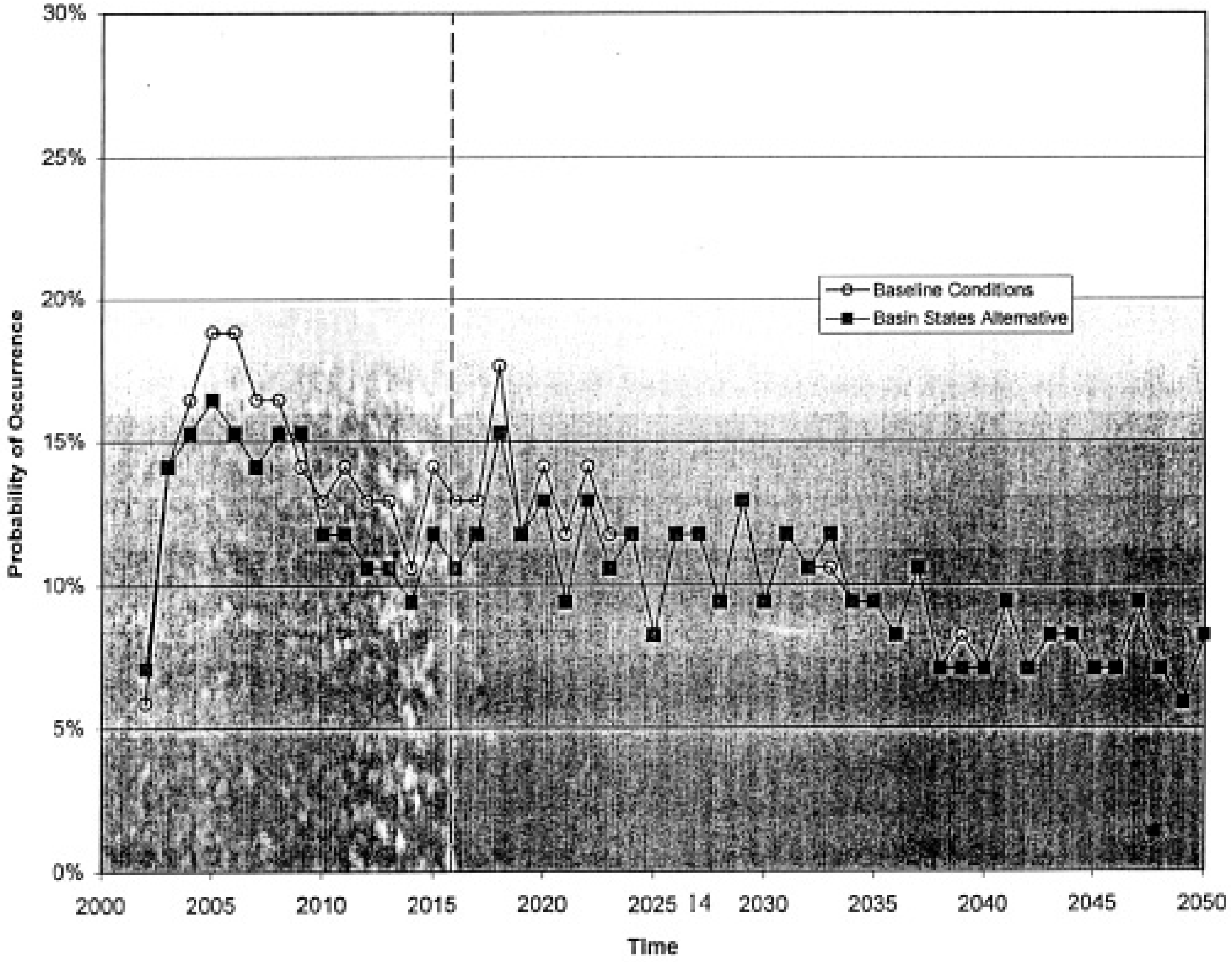


Figure 5. Excess Flows to Mexico Greater than 1,000 kaf



COMPARISON OF THE BASIN STATES ALTERNATIVE TO THE BASELINE CONDITION

Figure 1 presented a graphical comparison of future frequency of excess flows of any magnitude to Mexico under the Basin States Alternative to those under the baseline conditions. The probability of excess flows of any magnitude to Mexico for the Basin States Alternative are compared to baseline conditions for selected years in Table 1. The Basin States Alternative shows slightly less probability of occurrence compared to the baseline through 2018. After 2018, the probability of occurrence of excess flows of any magnitude is essentially the same for the baseline and Basin States Alternative.

Table 1

Colorado River Flows to Mexico
Frequency of Occurrence of Excess Flows

Year	Baseline Conditions	Basin States Alternative
2002	20%	15%
2003	31%	26%
2004	33%	28%
2005	27%	25%
2006	31%	27%
2007	35%	27%
2008	28%	26%
2009	25%	22%
2010	24%	20%
2011	22%	21%
2012	25%	21%
2013	24%	22%
2014	25%	20%
2015	25%	21%
2016	22%	19%
2017	25%	22%
2018	25%	24%
2019	19%	19%
2020	24%	24%
2021	21%	20%
2022	24%	22%
2023	21%	21%
2024	20%	20%
2025	21%	20%
2026	19%	18%
2050	16%	15%

The potential magnitudes of excess flows for the surplus alternatives are compared to baseline conditions for the 75th and 90th percentiles as shown in Figure 6. The 75th percentile values also detailed for years 2002 through 2026 in Table 2 and the 90th percentile value is shown in Table 3. The 75th percentile flow is defined as the flow that would not be exceeded 75 percent of the time (i.e., the minimum flow that could be expected to occur 25 percent of the time). The 75th and 90th percentile values are illustrated to show two of the various probabilities. In general, the volume of flow is reduced somewhat with implementation of the Basin States Alternative, but not in amounts that are large enough to appear significant.

Figure 2 and Table 4 shows the probability of excess flows to Mexico that would exceed 250 kaf annually. This volume was selected for analysis because it is near the amount generally believed to be required to the scouring action needed for regeneration of riparian habitat in the river corridor in Mexico (Leucke, et al. 1999). This volume of flow would also be expected to reach the Sea of Cortez, with attendant benefits to the estuary at the mouth of the lower Colorado River. Flows exceeding 250 kaf annually are likely to go past Morelos Dam. As stated before, Mexico had complete discretion over use of the water once it reaches Morelos Dam. Mexico has the capacity to divert up to 200 kaf monthly above its normal water order. Therefore, lesser flows on an annual basis are expected to be diverted in their entirety, unless those flows exceed 200 kaf over the normal diversion. The volume of flow of 250 kaf annually was suggested by Luecke, et al., at four year intervals, apparently based on flows experienced over the past 20 years.

The data displayed in Figure 2 and table 4 for excess flows exceeding 250 kaf annually show the same trends as the probability of excess flow of any magnitude. That is, there would be a slightly less probability until 2018, from that point on the probabilities are essentially the same between the Basin States Alternative and the Baseline Conditions. The overall probability of flows exceeding 250 kaf until 2018 under the Basin States Plan is about once every five years. After 2018, the probability of flows exceeding 250 kaf is approximately once in every 6 years. The reduced probability after 2018 is a result of the Upper Basin States developing their Colorado River resources. These probabilities indicate periodic flows of 250 kaf will continue under the Basin States Plan at about the same expected recurrence level as currently experienced.

Table 2
Excess Flows To Mexico

75th Percentile Values

Year	Baseline Conditions (kaf)	Basin States Alternative (kaf)
2002	0	0
2003	406	109
2004	645	536
2005	153	0
2006	534	500
2007	545	386
2008	318	282
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	0	0
2021	0	0
2022	0	0
2023	0	0
2024	0	0
2025	0	0
2026	0	0

Table 3
Excess Flows To Mexico

90th Percentile Values

Year	Baseline Conditions (kaf)	Basin States Alternative (kaf)
2002	870	429
2003	2510	2068
2004	2112	2550
2005	2560	2274
2006	2918	2481
2007	2495	2489
2008	2157	2227
2009	2230	2175
2010	1641	1583
2011	1458	1881
2012	1378	1438
2013	1680	1049
2014	1368	857
2015	1464	1611
2016	1999	1114
2017	2034	1957
2018	1492	1201
2019	1630	1358
2020	1276	1032
2021	1167	876
2022	1136	1112
2023	1130	981
2024	1338	1338
2025	823	823
2026	1422	1422

Figure 6. Excess Flows to Mexico. Comparison of Basin States Alternative to Baseline Conditions 90th and 75th Percentile Values.

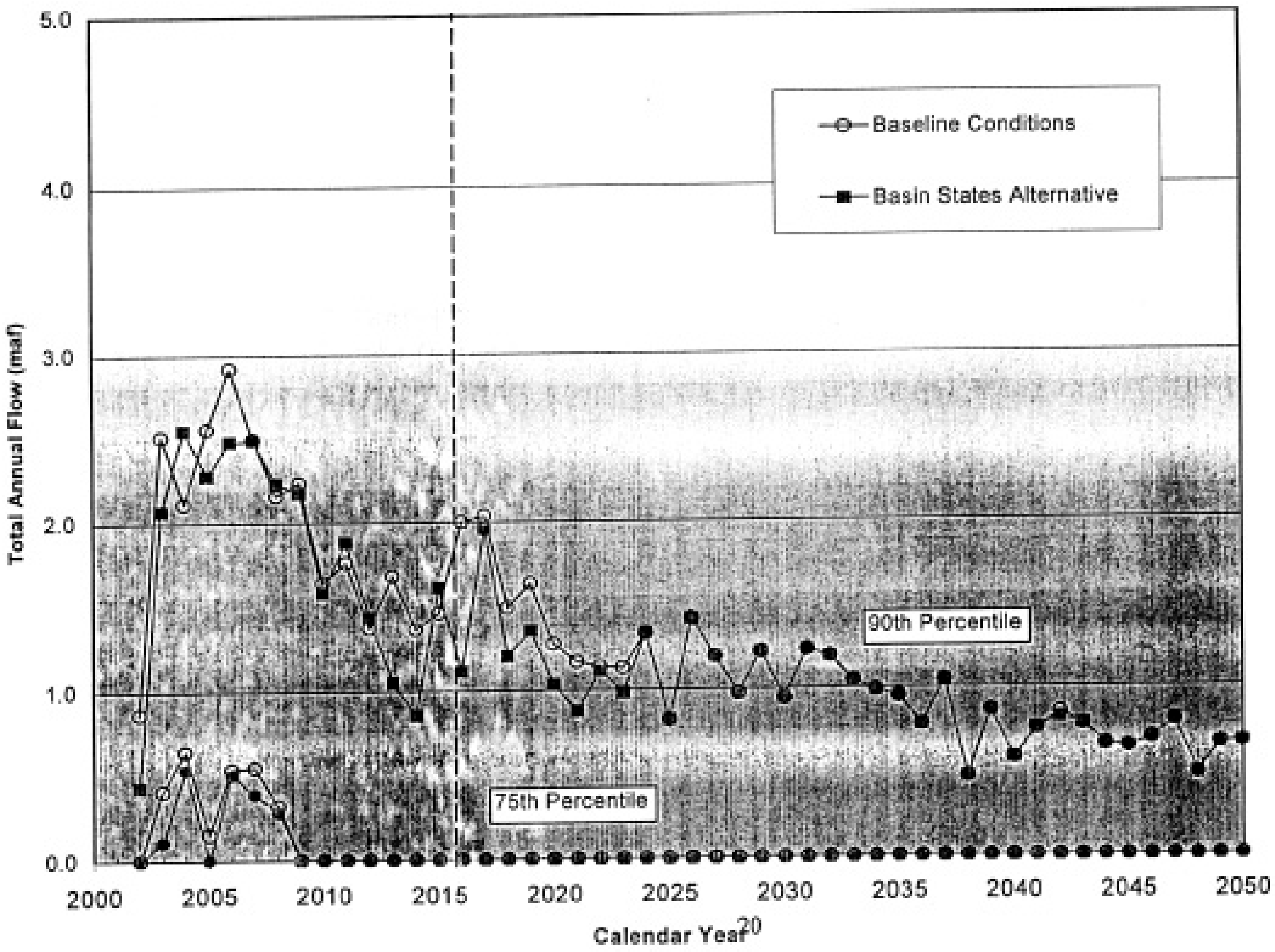


Table 4
Probability of Occurrence of Excess Flows to Mexico Greater than 250 KAF

Year	Baseline	Proposed Action
2002	19%	14%
2003	29%	25%
2004	29%	27%
2005	25%	25%
2006	28%	26%
2007	32%	26%
2008	27%	26%
2009	24%	22%
2010	21%	18%
2011	21%	18%
2012	24%	19%
2013	24%	20%
2014	22%	18%
2015	21%	19%
2016	22%	19%
2017	20%	18%
2018	24%	24%
2019	18%	18%
2020	20%	21%
2021	16%	16%
2022	18%	19%
2023	20%	20%
2024	18%	18%
2025	19%	20%
2026	16%	16%
2027	20%	20%
2028	16%	19%
2029	18%	18%
2030	18%	19%
2031	19%	20%
2032	16%	19%
2033	16%	16%
2034	18%	20%
2035	16%	19%
2036	16%	16%
2037	16%	16%
2038	13%	13%
2039	14%	18%
2040	15%	15%
2041	14%	16%
2042	13%	13%
2043	14%	15%
2044	16%	16%
2045	12%	14%
2046	13%	13%
2047	15%	15%
2048	12%	12%
2049	13%	13%
2050	13%	13%

In summary, there are only minor differences in the potential magnitudes and potential frequencies of excess flows between baseline conditions and the Basin States Alternative. These differences are not expected to be significant. Probable frequency of beneficial flows exceeding 250 kaf under the Basin States Alternative are one year in five through 2017 and after that are one year in six from 2018 through 2050 (Figure 5 and Table 4). This compares to a probable frequency of 250 kaf or greater flows for the baseline condition of one in four through 2017 and one in 5 through 2050.

The above probabilities indicate conditions below Morelos Dam would be similar to those presumed to be beneficial. Leucke, et al, 1999 states it is not yet possible to quantify with certainty the required volume and frequency of these high flows. While the probable frequency of once in four years under the baseline would change to a probable frequency of once in five years under the Basin States Alternative, the change in benefits to species and habitat would likely be insignificant. The riparian vegetation existing along the Colorado River corridor in Mexico is extremely resilient.

Mexico has complete discretion over the use of water entering that country. As stated before, excess flows are generally diverted when possible and used for other than species and habitat. It is only when the amount of water arriving at Mexico is in excess of what can be diverted can benefits to species and habitat be realized.

SUMMARY OF POTENTIAL EFFECTS TO HABITAT AND SPECIAL-STATUS SPECIES IN MEXICO

POTENTIAL EFFECTS TO HABITAT IN MEXICO

RIPARIAN CORRIDOR

The historic reduction in Colorado River flows below the NIB has had an affect on the ecosystem of the delta. Except for periods of high flow or flood control operations, little Colorado River water reaches the delta and the upper Gulf. It is not within Reclamation's discretionary authority to make unilateral adjustments to water deliveries to the international border. As discussed previously, the potential magnitude of these excess flows is little affected by interim surplus criteria. Under baseline conditions, the frequency of excess flows of any magnitude declines over the next 25 years. Those frequencies under the Basin States Alternative follow this trend, with the maximum difference of 8% occurring in 2007.

Riparian habitat, along the Colorado River between the NIB and the Gulf of California, requires scouring flood events for regeneration. Both the frequency and magnitude of excess flows are important for this regeneration. As discussed previously, the potential magnitude of these excess flows is little affected by interim surplus criteria. Under baseline conditions, modeling indicates that the frequency of excess flows to Mexico will decrease over the next 25 years. The probable frequencies for flows under the Basin States Plan are one year in five through 2017 and one year in six thereafter.

The majority of the existing cottonwood-willow habitat regenerated during the 1983-87 Colorado River and 1993 Gila River flood events. This habitat has been sustained by a variety of potential water sources, including high groundwater and agricultural runoff. Probabilities of future magnitude and frequencies of excess flows indicate little or no change to habitat in Mexico resulting from implementing the Basin States Alternative.

The reaches of the riparian corridor would be expected to benefit differentially from flows of lesser magnitude. The Limitrophe Division (lower Colorado River between Morelos Dam and the SIB) would benefit from any excess flows past Morelos Dam, however slight. This is where the majority of the habitat for the southwestern willow flycatcher is known to occur. The reach from a few miles below the SIB to the mouth of the Rio Hardy would benefit less than the Limitrophe Division from lesser flows past Morelos Dam due to percolation effects in the riverbed. Data is lacking to adequately model flows in this reach of the river. Primarily ground water, or adjacent agricultural practices maintain the riparian vegetation in these reaches of the river.

Special status species that utilize riparian habitat along the Mexican reach of the Colorado River are not likely to be affected by the decrease in frequency of flood control releases and amounts of flow past Morelos Dam. Existing habitat in Mexico will be threatened by wildfire, agricultural clearing, and clearing for channel maintenance and flood control. These events are likely to occur whether surplus criteria are implemented or not. U.S. actions in the Limitrophe Division including clearing for flood control and channel maintenance are subject to existing U.S. Environmental regulations. Both the Basin States Alternative and baseline indicate a decrease in frequency of flood control releases and flow amounts. These potential effects of the Basin States Alternative for interim surplus criteria are negligible compared to the decreases stated above.

The Cienega de Santa Clara is the largest wetland in the delta. This action will not affect the habitat occurring there, as the Cienega is sustained by irrigation return flows from the United States. The Rio Hardy wetlands occurring at the confluence of the Rio Hardy are also not expected to be affected by the action. These wetlands are also sustained by agricultural runoff from the west side of the Mexicali Valley.

SEA OF CORTEZ ESTUARY

Effects to the estuary at the mouth of the lower Colorado River in the Sea of Cortez from implementing the Basin States Plan would result from the change in frequency of flows greater than 250 kaf annually. These flows would change from a probability under the baseline condition of one in four through 2017 and one in five thereafter to one in five through 2017 and one in six thereafter under the Basin States Plan.

During periods when flows from the lower Colorado River do not reach the Sea of Cortez the estuary is a negative estuary and behaves like a fertile coastal lagoon. This is because, throughout the year, salinity in the estuarine basin is always higher than in the adjacent ocean (Carriquiry and Sanchez, 1999). It is only during periods of flows from the mainstem Colorado River that the conditions characteristic of an estuary occur.

When these flows occur there is a benefit to the estuary because salinity is reduced which favors certain species for growth and reproduction. There is a strong correlation between flows from the lower Colorado River reaching the Sea of Cortez and shrimp landings (Galindo-Bect and Glenn, 2000), for instance. Cisnereos-Mata et al. (1995) suggests fresh water inflow to the estuary may be a factor in the reproduction of the totoaba (*Totoaba macdonaldi*).

The interface between fresh water and salt water in the estuary is controlled by two factors. The primary factor influencing the interface is the tides that occur in the upper end of the Sea of Cortez. The tidal range occurs up to 36 feet at the mouth of the Colorado River. The second factor influencing the interface is the inflow from the Rio

Hardy River, which is primarily agricultural return flow. This flow is presumed to be relatively constant. This interface would be affected to some degree (by moving south) during periods when flows from the lower Colorado River reach the estuary.

POTENTIAL EFFECTS TO SPECIAL STATUS SPECIES IN MEXICO

Desert pupfish (*Cyprinodon macularius*)

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

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

Desert pupfish are adapted to harsh desert environments and are extremely hardy. They routinely occupy water of too poor quality for other fishes, most notably too warm and too salty. They can tolerate temperatures in excess of 110 F; oxygen levels as low as 0.1 ppm; and salinity nearly twice that of sea water (over 70,000 ppm). In addition to their absolute tolerance of these parameters, they are able to adjust and tolerate rapid, extreme changes to these same parameters (Marsh and Sada 1993). Pupfish have a short life span, usually only 2 years, but they mature rapidly and can reproduce as many as three times during the year.

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

One of the natural populations in Mexico is in the Cienega de Santa Clara, a 100,000 acre bowl on the Colorado River delta 60 miles south of the U.S./Mexico border. The area is about 90 percent unvegetated salt flats with a number of small marsh complexes along the eastern edge of the bowl where it abuts an escarpment. The area is disconnected from both the Colorado River and the Gulf (Sea of Cortez), however extreme high tides result in the lower half of the bowl becoming inundated to a level of one foot or less of salt water from the gulf. The marsh areas on the east side are small and are spring fed. The largest marsh complex is on the northeast side where two agricultural drains provide relatively fresh water inflows. The desert pupfish occur in a number of these marsh complexes.

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

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

Desert pupfish would not be affected by the Basin States Alternative. The main population exists in the Cienega de Santa Clara, which is not dependent on flows in the lower Colorado River. The other populations of desert pupfish are not found in the Colorado River in Mexico. Any populations that may have existed have been extirpated due to baseline conditions.

Vaquita (*Phocaena sinus*)

The Vaquita is a small porpoise and is widely believed to be the most endangered marine cetacean in the world (Klinowska 1991; Taylor and Gerrodette 1993). It is also the only endemic species of marine mammal from the Gulf.

The vaquita was listed as "Vulnerable" in 1978 by IUCN-The World Conservation Union [formerly the International Union for Conservation of Nature and Natural Resources (IUCN)] in their Red Data Book and also in the Mexican list of wild vertebrates in danger of extinction. The vaquita was also listed in Appendix I of the Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora on 28 June 1979, and in February 1985 as an endangered species under the U.S. Endangered Species Act. Recently, this porpoise was classified as "Endangered" in the IUCN Cetacean Red Data Book. The Vaquita is very similar in external morphology to the harbor porpoise (Phocaena phocaena). Based on a very small sample and a maximum recorded total length of about 5 feet, the Vaquita may be the smallest of all the delphinoids (Brownell et al. 1987). The pectoral fins are larger and the dorsal fin is higher proportionally to the body length than in any other extant porpoise species (Brownell et al. 1987). The coloration of adult vaquitas is unique. On the dorsal portion, the color is dark gray, the sides are pale gray, and the ventral surface is white with some pale-gray elongated spots. The porpoise has a large, dark eye spot and lip patches that contrast with the gray background (Ramirez 1993).

The life history of the vaquita appears, in many ways, to be similar to its better-studied congener, the harbour porpoise, *Phocoena phocoena*, from the Bay of Fundy, Canada and the Gulf of Maine. Both species have a maximum longevity of about 20 years (Hohn, et al, 1996). Little is known about the reproductive biology of the species. It has been suggested that calving occurs in the spring and mating in late spring or soon thereafter (Vidal 1990). Food habits are also practically unknown; Fitch and Brownell (1968) reported small fish such as grunt (*Orthopristis reddingi*) and croaker (*Bairdiella icistia*) from stomach contents and Brownell (1982) also reported squid. More details regarding the life history of the vaquita are documented in Vidal (1995) and Hohn, et al. (1996).

The range of the Vaquita is restricted to the northwestern corner of the Gulf of California, Mexico (Jaramillo-Legorreta, et al, 1999), representing the most restricted range for any cetacean species (Ramirez 1993). Stranding data, mortalities in fishing nets and sightings of live animals all confirm that the present distribution of vaquita is concentrated in a small area rear Rocas Consag in the northwestern Gulf of California (Gerrodette, et al, 1995). Sightings outside of this region (south of 30E 45' N latitude) may represent occasional departures by some individuals from the center of distribution (Silber and Norris 1991) or temporary extensions in distribution due to climatic changes (Vidal 1990). The region south of Puerto Penasco, Sonora, Mexico, remains insufficiently monitored to further increase the accuracy of population estimates and to establish the southern limit of the geographic range of the species (Ramirez 1993). The range of the Vaquita overlaps that of the endangered totoaba, to which it may be linked ecologically (Ramirez 1993).

A number of factors make the Vaquita an extremely difficult species to survey; habitat characteristics such as turbid water, fraction of the time spent at the surface, elusive behavior, and its erratic surfacing mode (Ramirez 1993). Despite these difficulties, and biases in collection of survey data, it is clear that the species is rare. The total population size is estimated to be 567 animals, with a 95% confidence interval from 177 to 1,073 (Jaramillo-Legorreta, et al, 1999).

The vaquita is particularly vulnerable to incidental mortality in gillnets. The vaquita has probably been incidentally caught in gillnets since the mid-1920's. It can be assumed the significant expansion of the fishing industry during the early 1940's further reduced the population (Vidal, 1995). Vaquita bycatch in gillnet fisheries was identified as a defining factor which may drive the species to extinction. The total estimated incidental mortality caused by the fleet of El Golfo de Santa Clara was 39 vaquitas per year, over 17% of the most recent estimate of population size. El Golfo de Santa Clara is one of three main ports that support gillnet fisheries throughout the range of the vaquita. The fishing effort for San Felipe, Baja California appears to be similar to that of El Golfo de Santa Clara, suggesting that this estimate of incidental mortality of vaquitas represents a minimum (D'Agrosa, et al, 2000).

Ramirez (1993) identified three actual and potential impacts to the Vaquita: incidental mortality caused by fishery activities including recreational, commercial and shrimping; reduced Colorado River flows into the Gulf of California; and pollution from various sources associated with Colorado River flows into the Gulf.

Rojas-Bracho and Taylor (1999) concluded habitat alteration from reduced flow of the Colorado River does not currently appear to be a risk factor because productivity remains high in vaquita habitat. Pollutant loads are low and pose low to no risk. Reduced fitness from inbreeding depression and loss of genetic variability are unlikely to pose high risk currently, though risk will increase if vaquitas remain at low abundance over long periods of time. Mortality resulting from fisheries is the greatest immediate risk for vaquitas. As a result, Reclamation concludes the Basin States Alternative will have no effect on the vaquita.

Totoaba (*Totoaba macdonaldi*)

The totoaba is a fish endemic to the Gulf of California. In 1976 the species was listed as threatened under the Convention on International Trade in Endangered Species (CITES). On May 21, 1979, the totoaba was listed in the U.S. as endangered pursuant to the Endangered Species Act (44 FR 99).

Totoaba are large schooling fish that undertake a seasonal migration within the Gulf and may live to 25 years of age (Cisneros-Mata et al. 1995). Totoaba are the largest of the sciaenid fish, with a maximum reported weight of over 100 kg and a length of over 2 meters (Flanagan and Hendrickson 1976). Adults spawn in the shallow waters of the Colorado River delta in the upper Gulf where they remain for several weeks before migrating south. Spawning originally occurred from February to June. More recently, it has been determined that spawning takes place from February through April (Cisnereo-Mata, et al, 1995). Juveniles are thought to emigrate south after spending 2 years in the upper Gulf, which is considered their nursery ground (Flanagan and Hendrickson 1976).

Juvenile fish eat small benthic organisms, mainly crabs and fish, amphipods, and shrimp; adults eat larger more pelagic items, such as sardines and adult crabs (Flanagan and Hendrickson 1976, Cisneros-Mata et al. 1995). Many aspects of the biology and ecology of this species are unknown.

The totoaba is thought to have ranged from the mouth of the Colorado River to Bahia Concepcion on the west coast of the Gulf and to the mouth of the El Fuerte River in the east (Jordan and Everman 1896 cited in Berdegue 1955). Historically, millions of totoaba migrated north in the spring to spawn at the mouth of the Colorado River (Gause 1969). A more thorough description of the life history of the totoaba is found in Cisneros-Mata, et al, 1995.

The first commercial harvesting of totoaba began in the early 1890s and by 1942, annual catches peaked at 2.3 million kg. In 1975, the catch had declined to 59,142 kg (Lagomarsino 1991). Beginning as early as 1940, the Mexican government imposed restrictions on the commercial fishery for totoaba, and in 1975, the government designated totoaba as endangered and declared an indefinite prohibition on all types of commercial and recreational fishing (Flanagan and Hendrickson 1976).

In April-June 1994, the School of Marine Sciences of the Autonomous University of Baja California developed a field technique that permitted successful capture and transport of totoaba broodstock from the Upper Gulf to the laboratory at Ensanada (True et al. 1997). They were able to keep these specimens of totoaba alive and successfully spawned them. In October of 1997 they released 250 juveniles, back into the upper gulf. These were four months old and 20-25 cm long.

Despite conservation efforts the totoaba population has continued to decline. Cisneros-Mata et al. (1995) reviewed a variety of human activities that may have affected the totoaba population. Prerecruits (egg to 1 year) may have been affected by decreased fresh-water input from the Colorado River, juveniles (1 to 2 years of age) by shrimp harvesting, preadults (3 to 5 years) by sport fisherman, and adults (6 years of age and older) by commercial fishing and poaching.

Despite the closure of the fishery, illegal exploitation continues. It is believed that the incidental catch of juvenile totoaba in the shrimp trawling fishery is the principal factor effecting the recovery of the species (Barrera-Buevara, 1990). Much of the illegal gillnetting for totoaba occurs during the spawning migration. As a result, gravid fish are being fished out of the population. Current knowledge indicates that decrease of the adult stock may be responsible for the decline experienced by the totoaba population (Cisneros-Mata, et al, 1995).

Cisneros-Mata, et al, (1995) concluded that a negative impact on totoaba due to decreased flow from the Colorado River may be questionable because the claimed effects would have caused extinction of totoaba over 40 years time. Flanagan and Hendrickson (1976) concluded that recruitment and over-fishing explained the decline better than habitat alteration. It is estimated that a steady flow of water reaching an annual total of 1.6 million acre-feet would be necessary to restore the brackish water conditions that historically occurred in the estuary (US Bureau of Reclamation file data and pers. com. Dave Hemphill, USBR, Boulder City, NV). Estimations were based on salinity factors in both the Sea of Cortez and the Lower Colorado River along with the estimated area of impact. A static condition was assumed, and tidal currents and other influences were not factored, thus the estimated amount may be conservative (Carriquiry and Sanchez, 1999). Even if that amount of water were available at present, releases of such a nature would be impractical, and Reclamation has no control over Colorado River water once it reaches the Northerly International Boundary.

Therefore, based on the minor, insignificant reduction in the probable magnitude and probability of flows past Morelos Dam until 2018; the continued exploitation of the species and inadvertent mortality resulting from commercial fishing as described above; and Reclamation's lack of discretion over Colorado River water in Mexico; Reclamation concludes that the Basin States Alternative may affect but is not likely to adversely affect the totoaba.

Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

Willow flycatchers are found throughout North America and are further divided taxonomically into four subspecies, *E.t. brewseri, E.t. adastus, E. t. traillii,* and *E.t. extimus.* The latter, *E.t. extimus*, the southwestern willow flycatcher, breeds on the Lower Colorado River and its tributaries (McKernan and Braden, 1997, 1998, 1999). In January 1992, the Service was petitioned to list the southwestern willow flycatcher, *Empidonax traillii extimus* as an endangered species. In July 1993, the species was proposed as endangered with critical habitat (58FR39495). On February 27, 1995, the Service listed the southwestern willow flycatcher as an endangered species

(60FR10694). There are no recovery plans to date and the designated critical habitat does not include the lower Colorado River (60FR10694).

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

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

A long-distance migrant, the southwestern willow flycatcher winters in Mexico from Nayarit and southwestern Oaxaca south to Panama and possibly extreme northwestern Columbia. The flycatcher migrates widely through the southern U.S. occurring as a regular migrant south to the limits of the wintering range (Peterson 1990; Sogge et al. 1997, AOU 1998). Recent field studies in Costa Rica by Koronkiewicz and Whitfield (1999) and studies of museum specimens by Phil Unitt (1999) collaborate previous information on the species' range. One specimen of willow flycatcher captured in Costa Rica during the winter of 1999 was banded at the Ash Meadows National Wildlife Refuge (NWR) in southern Nevada in July 1998 (Koronkiewicz and Whitfield 1999). The Ash Meadows NWR is within the identified breeding range of this southwestern subspecies and thus the capture in Costa Rica is the most recent confirmed wintering site of *E.t. extimus*. Breeding range for the species as a whole extends as far south as northern Sonora, and northern Baja California (AOU 1998) and north into Canada.

Breeding range for the southwestern subspecies of the willow flycatcher, *E. t. extimus*, extends from extreme southern Utah and Nevada, through Arizona, New Mexico, and southern California, but records from west Texas and extreme northern Baja California and Sonora, Mexico remain lacking to date (Unitt 1987). Molina (1998) observed the species in exotic plantings in the El Golfo de Santa Clara fishing village, and in the saltcedar-mesquite-acacia woodland corridor along the pozos near El Doctor in 1997. The species has also been documented at El Doctor wetlands, Colorado River delta, Sonora, Mexico June 7 and 8, 1999 (Huerta, University of Arizona, pers. comm.). These sightings confirm the area is used for migration, but does not confirm breeding. The presence of the subspecies after June 15 is required to confirm breeding (Sogge et al 1997; Braden and McKernan 1998). A survey for southwestern willow flycatcher was conducted on the Copopah Indian Reservation in the Limitrophe Division on the Colorado River near Yuma, Arizona in 2000. Twenty six birds were detected on May 22 and June 6, 2000, and none later. It was concluded the riparian habitat on the Reservation was being used as a stopover area during the migration (Garcia-Hernandez, et al, 2000).

The majority of southwestern willow flycatchers found during the past five years of surveys on the Lower Colorado River have been found in saltcedar, *Tamarix rammosissima*, or a mixture of saltcedar and native cottonwood and willow, especially Gooddings willow, *Salix gooddingii*, coyote willow, *S. exigua* and Fremont cottonwood, *Populus fremontii*. Based on available information at the time of this writing, aside from the presence of water and dense structure of vegetation, no clear distinctions can be made based on perennial species composition or foliage height profiles, as to what constitutes appropriate southwestern willow flycatcher habitat.

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

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

In 1993, the U.S. Fish and Wildlife Service estimated that only 230 to 500 nesting pairs existed throughout its entire range (58FR39495). However, since extensive surveying has been implemented, this number has likely increased, especially on the lower

Colorado River where the species was thought to have been extirpated (Hunter et al. 1987; Rosenberg et al. 1991; McKernan and Braden, 1999). Sixty-four nesting attempts were documented on the lower Colorado River from southern Nevada to Needles, California in 1998 (McKernan and Braden, 1999).

Several factors have caused the decline in southwestern willow flycatcher populations. Extensive areas of suitable riparian habitat have been lost due to river regulation and channelization, agricultural and urban development, mining, road construction, and overgrazing (Phillips et al. 1964; Johnson and Haight 1984; Unitt 1987; Rosenberg et al. 1991; Sogge et al. 1997). The total acreage of riparian vegetation has changed little in the last 20 years (Anderson and Ohmart 1976; Younker and Anderson 1986.), although there is less native vegetation and more non-native present (Rosenberg et al. 1991). The most recent estimate of historical, potentially suitable willow flycatcher habitat as delineated from 1938 aerial photography from the Grand Canyon to Mexico is 89, 203 acres (USBR 1999). Only some portion of this potentially suitable habitat can be assumed to have been suitable habitat for the flycatcher, as the microclimate and other factors required which existed at the time are undeterminable. The total amount of occupied habitat along the lower Colorado River in the U.S. today is estimated to be slightly over 6,000 acres (USBR 1999). A certain amount of habitat that exists along the lower Colorado River in the U.S. apparently has the necessary components to be utilized as breeding habitat by southwestern willow flycatchers is not always being used (McKernan and Braden, 1998). This could indicate that lack of breeding habitat may not be what is limiting the southwestern willow flycatcher's population.

In December, 1998, biologists from the Bureau of Reclamation, San Bernardino County Museum, and the Upper Gulf of California and Colorado River delta Biosphere Preserve conducted an aerial survey of the Rio Hardy and the Colorado River to determine potentially suitable southwestern willow flycatcher breeding habitat. Results of this survey indicate suitable habitat is present in the vicinity of Campo Mosqueda and Cucapa El Mayor and San Luis, Sonora along the Rio Colorado. Southwestern willow flycatchers utilize dense riparian habitat with moist soil or standing water present.

Flood control releases and Gila River flows are the primary condition under which riparian habitats are established in the delta, and a high ground water table is needed to maintain this habitat. Therefore, the potential impacts resulting from the Basin States Alternative would be due to the minor decrease in the frequency and magnitude of excess flows into the Gulf compared to the baseline conditions. These decreases are not expected to significantly reduce the opportunity for regeneration of riparian habitat on the Colorado River in Mexico. The probability of the average magnitudes of flows greater than 250 kaf over time indicates there will not be a significantly less probability for excess flows to Mexico than what exists currently under baseline conditions. Also, due to the uncertainty of what discretionary actions Mexico may take with excess flows, impacts of implementing the Basin States Plan are uncertain. Therefore, Reclamation concludes the Basin States Alternative may affect but is not likely to adversely affect the southwestern willow flycatcher.

Yuma Clapper Rail (*Rallus longirostris yumanensis*)

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

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

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

One issue of concern with the Yuma clapper rail is selenium. Eddleman (1989) reported selenium levels in Yuma clapper rails and eggs and in crayfish used as food were well within levels that will cause reproductive effects in mallards. Rusk (1991) reported a mean of 2.24 ppm dry weight selenium in crayfish samples from six lower Colorado River backwaters from Havasu National Wildlife Refuge, near Needles, CA to Mittry

Lake, near Yuma, AZ. Over the past decade, there has been an apparent two to five fold increase in selenium concentrations in crayfish, the primary prey species for the Yuma clapper rail (King et al 2000). Elevated concentrations of selenium (4.21- 15.5 ppm dry weight) were present in 95 percent of the samples collected from known food items of rails. Crayfish from the Cienega de Santa Clara in Mexico contained 4.21 ppm selenium, a level lower than those in the U. S., but still above the concern threshold. Recommendations from this latest report on the subject conclude that if selenium concentrations continue to rise, invertebrate and fish eating birds could experience selenium induced reproductive failure and subsequent population declines (King et al 2000).

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

This subspecies is found along the Colorado River from Needles, California, to the Gulf, at the Salton Sea and other localities in the Imperial Valley, California, along the Gila River from Yuma to at least Tacna, Arizona, and several areas in central Arizona, including Picacho Reservoir (Todd 1986; Rosenberg et al. 1991). In 1985, Anderson and Ohmart (1985) estimated a population size of 750 birds along the Colorado River north of the International Boundary. Current estimates of Yuma clapper rail in Mexico were made in 1999 (Hinojosa-Huerta, et al., 2000). These indicate over 6,000 Yuma clapper rail occur in Mexico, with the majority of the population (6,294) occurring in the Cienega de Santa Clara. Based on call count surveys, the population of Yuma clapper rail in the United States appears to be holding steady (U.S. Fish and Wildlife Service, Phoenix, Arizona, unpublished data). Due to the variation in surveying over time, these estimates can only be considered the minimum number of birds present (Eddleman 1989; Todd 1986).

The range of the Yuma clapper rail has expanded in the past 25 years and continues to do so (Ohmart and Smith 1973; Monson and Phillips 1981; Rosenberg et al. 1991, SNWA 1998, McKernan And Braden, 1999), so there is a strong possibility that population size may increase. Yuma clapper rails are known to expand into desired habitat when it becomes available. This is evidenced by the colonization of the California Department of Fish and Game Department Finne-Ramer habitat management unit in Southern California. This unit was modified to provide marsh habitat specifically for Yuma clapper rail and a substantial resident population exists there. There is also recent documentation of the species in Las Vegas Wash, Virgin River and the lower Grand Canyon (McKernan and Braden, 1999).

A substantial population of Yuma clapper rail exists proximate to the Colorado River delta in Mexico. Eddleman (1989) estimated a total of 450 to 970 Yuma clapper rails were present there in 1987. The birds were located in the Cienega de Santa Clara, Sonora, Mexico (200-400 birds), along a dike road on the delta proper (35-140 birds), and at the confluence of the Rio Hardy and Colorado River (200-400 birds). Piest and Campoy (Arizona Game and Fish Dept, Yuma, Arizona and Upper Gulf of California and Colorado River delta Biosphere Reserve, unpublished report) detected a total of 240 birds responding to taped calls in the Cienega. From these data, they estimate a total population of approximately 5,000 rails in the cattail habitat the Cienega. As mentioned earlier, 1999 estimates of the Yuma clapper rail in the Cienega are 6,249. Other Yuma clapper rail were detected at Laguna del Indio, the eastern drains at Ayala-Aacatecas, Rio El Mayor, the Cupapa Wetland Complex at the confluence of the Rio Hardy and Colorado River, and along the Rio Hardy. Interestingly enough, no Yuma clapper rail were detected along the riparian corridor of the Colorado River in Mexico (Hinojosa-Huerta, et. al., 2000).

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

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

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

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

Currently, not all of the above recovery actions had been met, and the Service recommends the Yuma clapper rail remain classified as endangered.

Yuma clapper rail use dense stands of cattail marsh habitat in the delta. Changes in water availability that helps to maintain this habitat would have the potential for impacting the species by slightly lowering the groundwater and surface water and possibly altering the prey availability. The currently known populations of Yuma clapper rail in Mexico are found in areas supported primarily by agricultural drainage and are expected to be affected little, if any by implementing the Basin States Alternative. Therefore, Reclamation concludes Yuma clapper will not be affected by the Basin States Alternative.

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APPENDIX A. BASIN STATES ALTERNATIVE

BASIN STATES ALTERNATIVE (PREFERRED ALTERNATIVE)

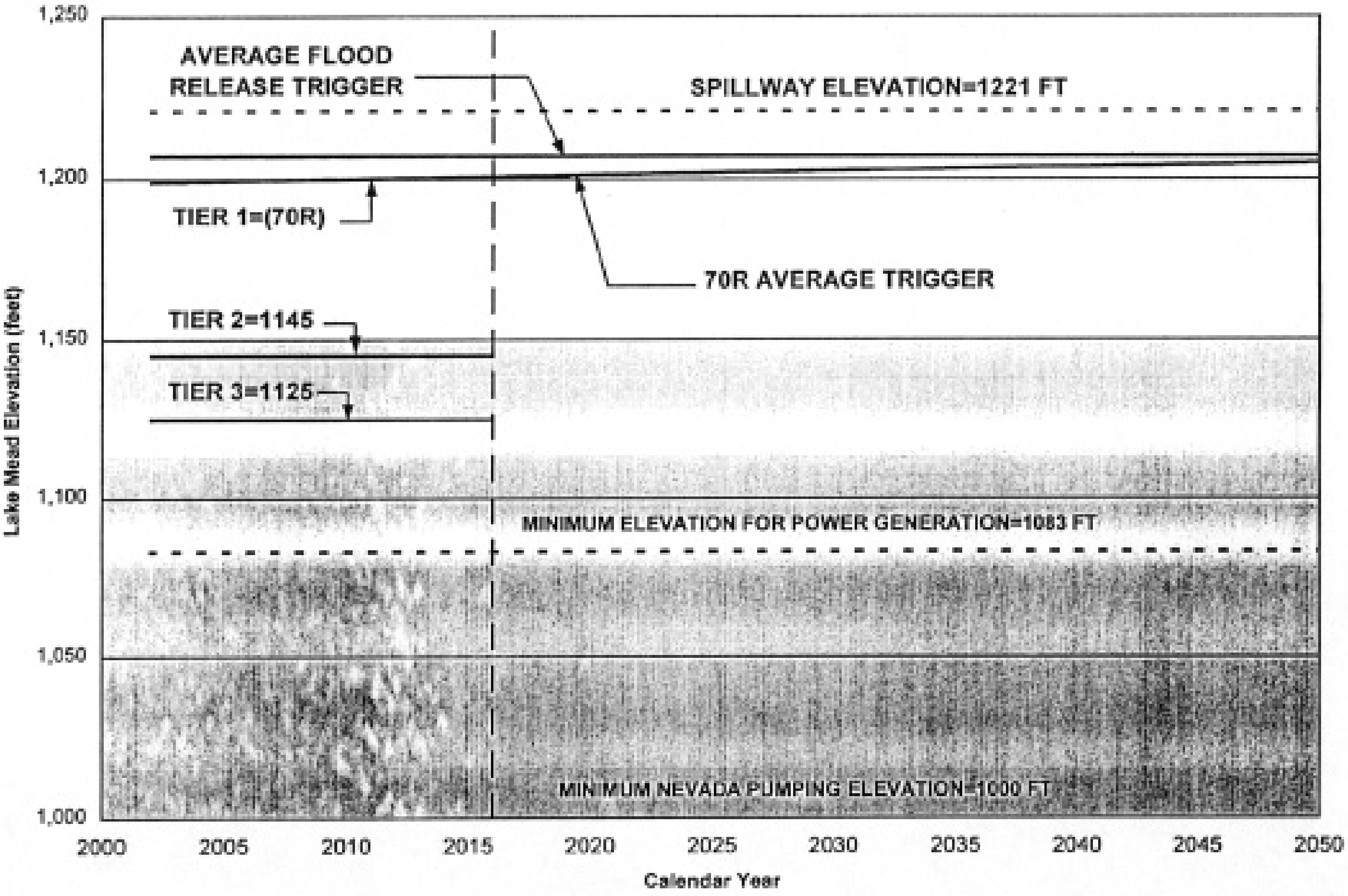
The Basin States Alternative specifies ranges of Lake Mead water surface elevations to be used through 2015 for determining the availability of surplus water through 2016. The elevation ranges are coupled with specific amounts of surplus water in such a way that, if Lake Mead's surface elevation were to decline, the amount of surplus water would be reduced. Surplus water would be available only to holders of valid contracts for surplus water delivery.The interim criteria would be reviewed at five-year intervals with the Long Range Operating Criteria and as needed based upon actual operational experience.

BASIN STATES ALTERNATIVE SURPLUS TRIGGERS

The surplus determination elevations under the preferred alternative consist of the tiered Lake Mead water surface elevations listed below, each of which is associated with certain amounts of surplus water. The tiered elevations are shown on Figure 1. They are as follows, proceeding from higher to lower water levels:

Tier 1 - 70R Line (1199 to 1201 feet msl)
Tier 2 - 1145 feet msl
Tier 3 - 1125 feet msl

Figure 1



Basin States Alternative Surplus Trigger Elevations

Basin States Alternative Tier 1

The Basin States Alternative Tier 1 Lake Mead surplus trigger elevations are based on the 70R strategy and range from approximately 1199 feet msl to 1201 feet msl. In years when the Secretary determines that water should be released for beneficial consumptive use to reduce the risk of potential flood control releases based on the 70R operating strategy, the Secretary would determine the quantity of surplus water available and allocate it as follows: 50 percent to California, 46 percent to Arizona and 4 percent to Nevada.
Table A-1 lists the estimated maximum annual amounts of surplus water that would be available to the Lower Division states under the Basin States Alternative, when Lake Mead is at or above the Tier 1 trigger. The table also lists the estimated amounts of surplus water that would be available to the Lower Division states when flood control releases are required.

Table A-1
Basin States Alternative Potential Surplus Water Supply
Thousand Acre Feet

Year	Flood Control	Tier 1	Tier 2	Tier 3
2002	1350	1100	650	200
2003	1300	950	600	200
2004	1200	850	500	150
2005	1250	900	550	150
2006	1200	850	500	150
2007	1250	900	500	150
2008	1250	900	450	150
2009	1300	950	450	150
2010	1300	1000	450	150
2011	1300	1000	400	200
2012	1350	1000	450	200
2013	1350	1050	450	250
2014	1350	1050	450	250
2016	1350	1050	450	300
2017	1350	1050	450	150

Regardless of the quantity of surplus water determined under Tier 1, surplus deliveries under Tier 2 (discussed below) would be met.

Basin States Alternative Tier 2

The Basin States Alternative Tier 2 Lake Mead surplus trigger elevation is 1145 feet msl. At or above this Tier 2 elevation (and below the Tier 1 elevation), surplus water would be available for use by the Lower Division states in the estimated amounts on Table A-1.

Basin States Alternative Tier 3

The Basin States Alternative Tier 3 Lake Mead surplus trigger elevation is 1125 feet msl. At or above this Tier 3 elevation (and below the Tier 2 elevation), surplus water would be available for use by the Lower Division states in the estimated amounts on Table A-1. At Lake Mead Levels below the Tier 3 trigger surplus water would not be available.

Appendix E

Biological Opinion

United States Department of the Interior
U.S. Fish and Wildlife Service
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AESO/SE
2-21-00-F-273 January 12, 2001

Memorandum

To: Regional Director, Lower Colorado Region, Bureau of Reclamation, Boulder City, Nevada (Attention: Area Manager, Boulder Canyon Operations Office)

From: Field Supervisor

Subject: Biological Opinion for Interim Surplus Criteria, Secretarial Implementation Agreements, and Conservation Measures on the Lower Colorado River, Lake Mead to the Southerly International Boundary Arizona, California and Nevada

This document transmits the U.S. Fish and Wildlife Service's (Service's) biological opinion (BO) based on our review of effects of the proposed Interim Surplus Criteria (ISC), Secretarial Implementation Agreements (SIAs) for change in point of diversion for up to 400,000 acre-feet (af) of California apportionment waters within California, and implementation of certain conservation measures on the endangered razorback sucker (*Xyrauchen texanus*), bonytail chub (*Gila elegans*), desert pupfish (*Cyprinodon macularius*), Yuma clapper rail (*Rallus longirostris yumanensis*), brown pelican (*Pelecanus occidentalis*) and southwestern willow flycatcher (*Empidonax traillii extimus*); the threatened desert tortoise (*Gopherus agassizii*) and bald eagle (*Haliaeetus leucocephalus*); and designated critical habitat for the razorback sucker and bonytail chub in accordance with section 7 of the Endangered Species Act (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). There are five designated applicants for this consultation: Metropolitan Water District of Southern California (MWD), San Diego County Water Authority (SDCWA), Imperial Irrigation District (IID), Coachella Valley Water District (CVWD) and the San Luis Rey Tribe (SLR).

The Bureau of Reclamation (Reclamation) and the applicants have requested our concurrence that the action may affect, but is not likely to adversely affect the bald eagle. The Service concurs with this determination. Reclamation has also made findings of no effect for the desert pupfish, brown pelican, and desert tortoise and critical habitat for the bonytail chub.

This BO is based on information provided in the August 2000, biological assessment (BA) (USBR 2000a), the draft Environmental Impact Statement (DEIS) for the ISC (USBR 2000b), the final conservation measures provided in a memorandum from Reclamation on January 8, 2001 (USBR 2001), information from the 1996 Operations and Maintenance BA (USBR 1996) for the lower Colorado River (LCR), the 1997 BO on Operations and Maintenance (USFWS 1997); meetings with Reclamation with and without the applicants, technical information provided by Reclamation on computer simulation models and results of modeling, telephone and personal conversations, e-mails, and other sources of information. A complete administrative record of this consultation is on file at the Arizona Ecological Services Office in Phoenix. We have assigned log number 2-21-00-F-273 to this consultation. Please refer to that number in future correspondence on this consultation.

Consultation History

The Service met several times with Reclamation during 2000 and twice with the applicants regarding this consultation. Because of Reclamation's schedule to complete all environmental compliance on this project by December 31, 2000, the Service and Reclamation agreed to a time line that provided 60 days to prepare a biological opinion, provided that the BA was of sufficient detail that additional information would not be needed to prepare the BO. Informal consultation was initiated in March. A May 22, 2000 memorandum from Reclamation asked the Service for concurrence with a list of species. The Service replied on June 5, 2000 requesting the bald eagle and desert pupfish be added to the list of species. A draft BA was provided by Reclamation to the Service and applicants on August 15, 2000. The Service provided comments on the draft BA in a memorandum dated August 22, 2000. Formal consultation was requested by Reclamation on August 31, 2000. The Service requested additional information on the BA in a memorandum acknowledging that request on September 5, 2000. The Service stated the information contained in the BA was sufficient to initiate consultation as of August 31, 2000, but that the additional information was needed by September 12, 2000 in order to maintain the 60-day schedule. For unknown reasons, Reclamation did not get a copy of the memorandum until October 2, 2000 at a scheduled coordination meeting. Contents of the memorandum were discussed, and Reclamation was sent another official copy. Responses to the questions raised in the September 5, 2000 memorandum were received from Reclamation in a memorandum dated November 30, 2000. Extensive discussions on the final form of the conservation measures were held in December, 2000 and January, 2001. The final conservation measures were provided to the Service by Reclamation in a memorandum dated January 9, 2001.

In discussions with Reclamation, the Service will provide separate memoranda on findings for the effects of the proposed actions to listed species in the Grand Canyon and Mexico. This decision is necessary in light of changes to the findings for Grand Canyon species after the BA was provided, and the supplemental BA for species in Mexico used a different project and baseline than in the original BA. This biological opinion does not contain information on effects to listed species in those two areas.

BIOLOGICAL OPINION

I. DESCRIPTION OF THE PROPOSED ACTION

The proposed action would take place on the Colorado River in Arizona, California and Nevada. Figure 1 is a map of the area showing important features of the river. The proposed action is comprised of several connected yet independent actions that involve apportioned and designated surplus waters of the lower Colorado River (LCR). Although Reclamation has now selected a preferred alternative, this consultation is based on the California Plan alternative described in the DEIS (USBR 2000b) and in the BA (USBR 2000a). The preferred alternative Basin States Plan has less severe effects to Lake Mead than the California Plan considered in this consultation. The baseline "no-action" alternative is also slightly different for the preferred alternative, but not outside the bounds considered in this biological opinion. The changes in points of diversion for 400,000 af of California allocation water for which SIAs are needed are described in the draft California's Colorado River Water Use Plan (4.4 Plan) (Colorado River Board of California 2000), and in the BA. The information contained in the above documents is herein incorporated by reference.

ISC

The DEIS for the ISC contained four alternatives and a no-action alternative. The ISC eventually implemented will be in effect for the years 2001-2015 only. Beyond that time, the no-action alternative will be put into place. This alternative is essentially the same as the method used in the 1996-2000 water years to declare surplus conditions. The California Plan alternative was developed by California water users to meet the needs of implementation of the 4.4 Plan. In terms of the other ISC alternatives, its effects fall between the Flood Control Alternative and the Shortage Protection Alternative.

The California Plan is described in considerable detail in the DEIS and more generally in the BA. These descriptions are incorporated herein by reference. The critical points of the alternative are summarized in this document to provide for the focus of the BO analysis.

The California Plan has three Tiers or trigger elevation levels that provide for surplus declaration (Figure 2). These elevation levels would be determined using the August-24 month study projections for the January 1 system storage, which is not at the lowest point in Lake Mead's yearly elevation cycle. Lake Mead elevations vary 10-20 feet per year with maximum monthly increases or decreases of up to 3 feet (USBR 1996). Actual water surface elevations in Lake Mead are the result of water releases from Hoover Dam and inflows from Glen Canyon Dam and the Grand Canyon tributaries. An effort to reduce monthly reservoir level fluctuations by timing high Glen Canyon Dam releases with high Hoover Dam releases is made by Reclamation. All Tier elevations increase over the 15 year life of the ISC to provide the same degree of protection for Lake Mead water storage amounts as depletions in the Upper Colorado River

Basin States (Colorado, New Mexico, Utah and Wyoming) increase from approximately 3.96 maf in 2000 to 4.46 million af (maf) in 2015 (USBR 2000b). As the Upper Basin uses more of its water, there is less available to be stored in Lake Mead or Lake Powell. Most of the surplus water goes to California, with smaller amounts to Arizona and Nevada. Information in the DEIS Attachment G (USBR 2000b) contains the assumed depletion schedules for the three States used to run the models for Lake Mead elevations and contains surplus water amounts assumed for those years. Other information on depletion schedules is also in the DEIS.

Please refer to Figure 2 for this discussion. The Tier 1 elevation changes from 1160 to 1166 feet from 2001-2015. For surpluses declared at Tier 1, Arizona, California and Nevada divide up between 770,000 and 835,000 af for any beneficial purposes. For Tier 2 (1116 to 1125 feet), the States would still get surplus water, dividing up between 564,000 and 620,000 af. Agricultural uses for surplus and storage other than for future municipal uses would not be allowed. At Tier 3 (1098 to 1102 feet) the usage restrictions are much more severe and essentially restrict the use of surplus water to active municipal and industrial uses. The amount available is between 464,000 and 520,000 af. The amount of water designated for surplus in each year does not require that the Tier level be protected. No surplus water would be available at Lake Mead levels below 1098-1102 feet. These amounts result from a more liberal interpretation of what qualifies as a surplus year.

Use of more liberal surplus criteria would also result in changes to how space-building in Lake Mead is accomplished. The flood control plans require a certain amount of storage space be available at a specific time of the year to accommodate runoff. Reclamation has traditionally released water in excess of normal apportionment demands when necessary to provide for this space. With additional releases in the form of surplus water, the need for space-building releases will change.

Changes to the elevations of Tier lines would be made at 5-year intervals based on the review of the Long-Range Operating Criteria (LROC) for the LCR and actual operating experience. It is not clear if the changes to Tier water surface elevations could be made more liberal as well as more conservative during the review. In the case of more liberal criteria (lower water surface elevations would provide for surplus declarations), additional effects not covered by this BO or the EIS process may occur and additional consultation be required at that time. Decisions on when a surplus would be declared, and at what level, would be made for the Annual Operating Plan (AOP). Water deliveries for a surplus year would be made in such a way that the States could put to beneficial use all the water provided. The Law of the River prevents Reclamation from releasing any water that cannot be beneficially used by a water user with a valid water service or surplus contract except under flood conditions. Unlike normal water contracts for basic apportionments, surplus contracts are not permanent. This is an important distinction, as it provides for the continuing discretion of Reclamation in the matter of declaring surpluses.

4.4 Plan

The 4.4 Plan is a very complex, multi-component plan to maintain existing levels of water supplies to the Southern California urban areas while providing that the State will not use more than its apportionment of Colorado River flows. There are numerous features of the 4.4 Plan that are not the subject of this consultation. An EIS/EIR and ESA section 10 program are ongoing to address issues within California resulting from parts of the 4.4 Plan. There are also some possible connections to the Colorado River in the form of delivery overruns, water accounting, actual delivery of the transferred water, conjunctive use, storage projects and offstream interstate water banking that are not covered by this consultation. Some of these activities have a Federal nexus, but sufficient information was not provided for them to be included in this consultation.

California's apportionment is 4.4 maf of the total 7.5 maf for the Lower Colorado River Basin States (Arizona, California and Nevada). It has used up to 5.4 maf per year in the past, relying on unused apportionment from Arizona and Nevada to provide the excess water. Those States are now, or will be by 2004, using their entire apportionments, leaving none extra to provide to California. This shortfall will affect the Southern California urban areas, since the entities that supply water to those areas, like MWD, have been the ones using the unused apportionment of Arizona and Nevada. The MWD aqueduct from Lake Havasu can carry approximately 1.25 maf of water per year. The MWD has a water right for approximately 550,000 af, and has another 100,000 af that is part of an ongoing agreement between MWD and IID and will continue to be delivered to the MWD aqueduct. MWD thus needs to find 600,000 af of water to maintain existing supplies. The surplus water generated from the ISC will make up some of this water over the short-term. Approximately 400,000 af of California's Colorado River water proposed for changes in point of diversion from below Parker Dam to above Parker Dam will be part of long-term replacement water. This water has a variety of sources and eventual destinations, specifics of which are in the BA and DEIS. These transfers will take several years to accomplish, and will increase incrementally to the full amount. The completion of the transfers still leaves a 200,000 af deficit for MWD's aqueduct capacity that is not explained in the DEIS or BA. This water will have to be made up from in-state supplies, future surplus declarations (if any) or other sources. What is important for this analysis is that the total volume of water released from Hoover Dam will not change due to the SIAs. What will change is the timing of that release and where it will be taken from the river. Because diversions to IID and CVWD do not provide return flows to the river, the changing of flow patterns below Parker Dam will not be further complicated by elimination of those flows as the water now moves to the coastal plain instead of the Imperial Valley. The 4.4 Plan will be in effect for a maximum of 75 years. Once Reclamation, as Watermaster and representative of the Secretary of the Interior, signs the SIAs, there is no future or continuing discretion on delivery of the 400,000 af of water. It is also important to note that the diversion of the 400,000 af is not the subject of this consultation, only the delivery of the water by Reclamation to the point of diversion. Diversion is a State discretionary action and this BO has no section 10 component. Effects of the existing diversion are part of the baseline and cumulative effects.

As part of the 4.4 Plan, there are other actions that are not part of this consultation that may result in changes in points of diversion to Lake Havasu from other locations on the LCR below Parker Dam. For the purposes of this consultation, those changes in points of diversion may be included within the total 400,000 af of transfer water provided that they do not increase the total amount of water transferred beyond the 400,000 af. Any effects to listed species from these other types of transfers that are not covered in this analysis would require additional consultation.

Conservation Measures

Reclamation has provided conservation measures that would be part of the proposed action once one is selected. These measures are designed to reduce the significance of the effects of the action on the listed species and critical habitat. These measures were listed in the BA (Table 5) in very general form. Final conservation measures for this project were provide by Reclamation in a memorandum dated January 9, 2001 (USBR 2001).

The conservation measures for the ISC are:

1. Reclamation will continue to provide funding and support for the ongoing Lake Mead Razorback Sucker study. The focus will be on locating populations of razorbacks in Lake Mead from the lower Grand Canyon (Separation Canyon) area downstream to Hoover Dam, documenting use and availability of spawning areas at various water elevations, clarifying substrate requirements, monitoring potential nursery areas, continuing ageing studies and confirming recruitment events that may be tied to physical conditions in the lake. The expanded program will be developed within 9 months of signing the BO and implemented by January 2002. Initial studies will extend for 5 years, followed by a review and determination of the scope of studies for the remaining 10 years of the ISC. Reclamation will use the bathymetric surveys, to be conducted in fiscal year 2001, to gather data in the areas of the identified spawning habitat, if not already available.

2. Reclamation will to the maximum extent practicable provide rising spring (February through April) water surface elevations of 5-10 feet on Lake Mead, to the extent hydrologic conditions allow. Hydrologic studies indicate that such conditions could occur once in 6 years, although no guarantee of frequency can be made. This operation plan will be pursued through Beach/Habitat Building Flows (BHBF) and/or equalization and achieved through the Adaptive Management and Annual Operating Plan processes, as needed for spawning razorback suckers.

3. Reclamation will continue existing operations on Lake Mohave that benefit native fish during the 15-year ISC period and will explore additional ways to provide benefits to native fish.

4. Reclamation will monitor water levels of Lake Mead from February through April of each year during the 15 years ISC are in place. Should water levels reach 1160 feet because of the

implementation of ISC, Reclamation will implement a program to collect and rear larval razorbacks in Lake Mead the spawning season following this determination. If larvae cannot be captured from Lake Mead, wild larvae will be collected from Lake Mohave.

The implementation of ISC is not likely to produce a condition resulting in a minimum February through April Lake Mead elevation at or below 1130 feet for more than 2 consecutive years during which surplus is being declared. Therefore, this condition has not been evaluated as an effect of the proposed action.

The conservation measures for the 4.4 Plan are:

1. Reclamation will stock 20,000 razorback suckers, 25 centimeters (cm) or greater in length, into the Colorado River between Parker and Imperial dams. This effort would be a continuation of present effort and bring the total number of razorbacks of that size stocked below Parker Dam to 70,000. This will be completed by 2006.

2. Reclamation will restore or create 44 acres of backwaters along the LCR between Parker Dam and Imperial Dam. This effort could include restoring existing decadent backwaters for which no ongoing effort provides funding or responsibility for restoration, or the creation of new backwaters where water availability, access and other issues can be met. Maintenance of these backwaters for native fish and wildlife will be ensured for the life of the water transfers. This will be completed within 5 years of the first water transfers.

3. Reclamation will provide funding of $50,000 for the capture of wild-born or F1 generation bonytails from Lake Mohave to be incorporated into the broodstock for this species and/or to support rearing efforts at Achii Hanyo, a satellite rearing facility of Willow Beach National Fish Hatchery. These efforts will be funded for 5 years (2001-2006).

4. A two-tiered conservation plan has been developed to minimize potential effects to willow flycatcher habitat that could result because of reduced flows on the Colorado River between Parker and Imperial dams as water transfers and associated changes in point of delivery are implemented. The plan is also illustrated in a decision driven flow chart.

   Tier One

   The primary strategy of this tier is to use management actions to prevent changes in the existing micro-habitat and prey base of occupied willow flycatcher habitat. Reclamation will identify and monitor 372 acres of currently occupied habitat (monitored habitat) that may be affected by water transfers and changes in point of delivery of up to 400,000 af of Colorado River water between Parker and Imperial dams (water transfer actions). Soil moisture will be monitored and if levels decrease as a result of implementation of water transfer actions under consultation, management actions will be taken to maintain the monitored habitat. Initially, monitoring efforts will be at a level of effort similar to Reclamation’s monitoring program under the existing interim biological opinion for river operations and maintenance. The monitoring program will be reviewed every five years to determine whether this level of effort is appropriate to monitor effects of water transfer actions or can be reduced for the remainder of the period that water transfer actions are occurring. Monitoring will continue for up to five years after implementation of all water transfer actions unless it becomes part of a broader effort associated with recovery actions.

In addition, Reclamation will restore and maintain 372 acres of new replacement willow flycatcher habitat along the lower Colorado River. All 372 acres of replacement habitat will be in place within five years of the effective date of the Implementation Agreement that provides Federal approval for water transfer actions.

Tier Two

A two step contingency strategy has been developed and will be initiated if Reclamation, in consultation with the Service, determines that management actions to prevent adverse changes to monitored habitat are no longer viable or will not be successful in maintaining “baseline” soil moisture conditions. (Note: baseline soil moisture conditions will be evaluated using criteria that will be developed within one year of the acceptance of the biological opinion).

The contingency strategy emphasizes replacement of the monitored habitat in Tier One that is impacted as a result of the water transfer actions under consultation. The status of willow flycatchers relative to success of recovery efforts along the Lower Colorado River between Parker and Imperial dams will form the primary basis for determining the level of habitat replacement implemented under this strategy using the following approach:

Flycatcher Status Improving:

If willow flycatchers along the lower Colorado River, when compared to data collected as of the year 2000 are exhibiting an appreciable upward trend, then one acre will be restored and maintained for every one acre of monitored habitat that is adversely impacted. In combination with the 372 acres of habitat established under Tier One, the maximum acreage conserved would be 744 acres and no further replacement of acreage is required.

Flycatcher Status is Stable or Decreasing:

Step 1 - If the willow flycatchers population along the Lower Colorado River is exhibiting an appreciable downward trend that is likely attributable to habitat factors along the lower Colorado River, then two acres will be restored and maintained for every one acre of monitored habitat that is adversely impacted for the first 186 acres (acres 1-186). Under this step, Reclamation will replace up to a maximum of 372 additional acres.

Step 2 - If after implementing step 1, additional acreage (acres 187-372) of the monitored habitat is affected, Reclamation will answer two questions:

a) Are flycatchers occupying the 372 acres of replacement habitat already being maintained under Tier One?

b) Are the flycatchers along the lower Colorado River exhibiting an appreciable upward trend?

If the answer to question a or b is yes, Reclamation will have no further requirement to restore acreage. However, if the answer to both questions are no, Reclamation will restore and maintain two acres for every one acre of monitored habitat that is adversely affected by the water transfer actions for the remaining 186 acres (acres 187-372) of monitored habitat. Under this step, Reclamation will replace and maintain up to a maximum of 372 additional acres.

Note: Should it be necessary to implement all of the Tier Two steps (744 acres) in addition to Tier One actions, Reclamation will have replaced the monitored habitat at an overall 3:1 ratio (a maximum of 1116 acres).

Reclamation will continue voluntary conservation efforts along the lower Colorado River and its tributaries to restore and maintain riparian habitat primarily for willow flycatchers. Reclamation may use this habitat as credit towards replacement of willow flycatcher habitat as long as they are not previously counted to support any other Reclamation Section 7(a)(2) obligation.

If the willow flycatcher is downlisted to threatened, then Reclamation can replace at an overall rate of 2:1 instead of 3:1 regardless of current trend in population numbers in the lower Colorado River recovery unit, and regardless of whether the first 372 restored acres is occupied by willow flycatchers.

Reclamation did not provide any conservation measures to offset the effects to 5404 acres of potential willow flycatcher habitat that is within the area of effect to groundwater levels from the water transfers. These effects will be addressed within the context of the MSCP or, if the MSCP is not developed, during reinitiation on operations and maintenance.

Description of the Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR §402.02). In the BA, Reclamation has defined the geographic area as the Colorado River from Lake Powell to the Southern International Boundary (SIB). In accordance with the CFR requirements, the Service is defining the action area to be the Colorado River from the full pool elevation of Lake Mead beyond Pierce Ferry to the Gulf of California and the 100-year floodplain of the river, plus all land areas in the three states (Arizona, California and Nevada) in which waters from the Colorado River involved in this consultation are used now and in the future under the proposed action.

The initial area of potential effects of the ISC included Lake Powell and the Colorado River through Grand Canyon. These areas are discussed in the DEIS, and are included in the geographic area covered by the BA. The effects to listed species in the Grand Canyon are not included in this BO because the BA did not contain the necessary analysis.

Although Reclamation's BA does not conclude that the proposed actions may contribute to growth, the Service believes it is necessary to include the water use areas in the United States within the action area. These areas may have indirect effects attributable to the proposed actions. Indirect effects outside of the immediate project area are determined using the dual requirements of causation and reasonable certainty of occurring. Causation need not be exclusive, that is, the Federal action under consultation does not need to be the only means by which the indirect effect could occur. It only has to be one way the effects could be generated. Reasonable certainty can be difficult to document because of the nature of future growth and development projects. In this case, there are other factors to consider.

It is very important to understand that no new permanent water supplies based on the lower Colorado River will be developed under the proposed actions. Water provided under the ISC will only be available for a 15-year period. Under the SIA water transfers, water now used in one location would be redirected to another location within the same State. The need to implement the ISC and 4.4 Plan is based on having water to support existing uses and future needs within the MWD and SDCWA service areas. We do not need to know what or where those uses are for this consultation, only that there are present and future uses for this water within the service areas. The areas of present use for the 400,000 af are also included since they will have effects of reduced water availability as a result of the proposed actions. Effects in existing use areas are being covered under an on-going ESA section 10 process.

The Colorado River and 100-year floodplain in Mexico are part of the action area. Effects to species in Mexico have been detailed in a supplemental BA and are not included in this BO. Appropriate consultation with the National Marine Fisheries Service (NMFS) will be accomplished by Reclamation for the totoaba (*Totoaba macdonaldi*) and vaquita (*Phocoena sinus*) in the Gulf of California.

II. STATUS OF THE SPECIES/CRITICAL HABITAT

This section provides brief summaries of the status of the listed species and critical habitat that would be adversely affected by the proposed actions. Recovery plans, if one exists, are cited for each species in the appropriate section. Biological information on species for which a finding of "no effect" or "may affect, not likely to adversely affect" has been made by Reclamation and concurred with by the Service is not provided in this BO. Please refer to the BA for that information.

Species/Critical Habitat Description

Bonytail chub and razorback sucker

The bonytail chub was listed as an endangered species on April 24, 1980, with an effective date of May 23, 1980. Critical habitat for the bonytail was designated on March 21, 1994, with an effective date of April 20, 1994. Critical habitat in the action area is the mainstem Colorado River from Hoover Dam to Davis Dam including Lake Mohave to its full pool elevation and the river and 100-year floodplain between the northern boundary of the Havasu National Wildlife Refuge to Parker Dam, including Lake Havasu to its full pool elevation. The Bonytail Chub Recovery Plan was most recently updated in 1990 (USFWS 1990).

The razorback sucker was listed as an endangered species October 23, 1991, with an effective date of November 22, 1991. Critical habitat for the razorback was designated on March 21, 1994, with an effective date of April 20, 1994. Critical habitat in the action area is Lake Mead to its full pool elevation, the river between Hoover Dam to Davis Dam including Lake Mohave to its full pool elevation, and the river and 100-year floodplain between Parker Dam and Imperial Dam. The Razorback Sucker Recovery Plan was released in 1998 (USFWS 1998).

Yuma clapper rail

The Yuma clapper rail was listed on March 11, 1967, under endangered species legislation enacted in 1966 (Public Law 89-669). Only populations in the United States are protected under the ESA. Those in Mexico are not. Critical habitat has not been designated for this species. The Yuma Clapper Rail Recovery Plan was released in 1983 (USFWS 1983).

Southwestern willow flycatcher

The willow flycatcher was listed as endangered, without critical habitat on February 27, 1995. Critical habitat was later designated on July 22, 1997. A correction notice was published in the Federal Register on August 20, 1997, to clarify the lateral extent of the designation. Eighteen critical habitat units totaling 599 river miles in Arizona, California, and New Mexico were designated. Knowledge of important or "critical" habitat areas for willow flycatchers has improved since 1997, thus what was designated as critical habitat then, may not be the most accurate description of the most critical areas for willow flycatchers (i.e., Roosevelt Lake in Arizona, Colorado River main stem below Hoover Dam, etc.). No draft or final recovery plan has been released for this species.

Life History

Bonytail chub and razorback sucker

Life history information on the bonytail and razorback can be obtained in documents previously incorporated by reference into this BO (USBR 1996, USBR 2000a, USFWS 1997), the biological support document for the critical habitat designation (USFWS 1993a) and in the recovery plans (USFWS 1990, 1998). In the time period since 1997, new information on the number of founders for the bonytail broodstock (Hedrick *et al.* 2000) and on recruitment of razorbacks in Lake Mead (Holden *et al.* 1999) has been developed.

Yuma clapper rail

Life history information on the clapper rail can be obtained in documents previously incorporated by reference into this BO (USBR 1996, USBR 2000a, USFWS 1997), in the recovery plan (USFWS 1983) and other life history summaries (Eddleman 1989, Todd 1986). In the time period since 1997, no new significant biological information on life history for this species has been obtained, although information on the potential for selenium poisoning via food sources has been developed (Roberts 1996, King *et al.* 2000).

Southwestern willow flycatcher

Life history information on the willow flycatcher is also contained in documents previously incorporated by reference into this BO (USBR 1996, USBR 2000a, USFWS 1997). Since the 1997 critical habitat designation, significant new information on life history and habitat preferences have been obtained and are included in this document.

Declining willow flycatcher numbers have been attributed to loss, modification, and fragmentation of riparian breeding habitat, loss of wintering habitat, and brood parasitism by the brown-headed cowbird (Sogge *et al.* 1997, McCarthey *et al.* 1998). Habitat loss and degradation are caused by a variety of factors, including urban, recreational, and agricultural development, water diversion and groundwater pumping, channelization, dams, and livestock grazing. Fire is an increasing threat to willow flycatcher habitat (Paxton *et al.* 1996), especially in monotypic saltcedar vegetation (DeLoach 1991) and where water diversions and/or groundwater pumping desiccates riparian vegetation (Sogge *et al.* 1997). The presence of livestock and range improvements such as watering facilities and corrals, large scale agriculture, urban areas such as golf courses, bird feeders, and trash areas, may provide feeding sites for cowbirds. These feeding areas, coupled with habitat fragmentation, facilitate cowbird parasitism of willow flycatcher nests (Hanna 1928, Mayfield 1977, Tibbitts *et al.* 1994).

The willow flycatcher breeds in dense riparian habitats from sea level in California to just over 7000 feet in Arizona and southwestern Colorado. Historic egg/nest collections and species' descriptions throughout its range document the willow flycatcher's widespread use of willow (*Salix* spp.) for nesting (Phillips 1948, Phillips *et al.* 1964, Hubbard 1987, Unitt 1987, T. Huels *in litt.* 1993, San Diego Natural History Museum 1995). Currently, willow flycatchers primarily use Geyer willow, Gooddings willow, boxelder (*Acer negundo*), saltcedar (*Tamarix* sp.), Russian olive (*Elaeagnus angustifolio*) and live oak (*Quercus agrifolia*) for nesting. Other plant species less commonly used for nesting include: buttonbush (*Cephalanthus* sp.), black twinberry (*Lonicera involucrata*), cottonwood (*Populus* spp.), white alder (*Alnus rhombifolia*), blackberry (*Rubus ursinus*), and stinging nettle (*Urtica spp.*). Based on the diversity of plant species composition and complexity of habitat structure, four basic habitat types can be described for the willow flycatcher: monotypic willow, monotypic exotic, native broadleaf dominated, and mixed native/exotic (Sogge *et al.*1997).

Open water, cienegas, marshy seeps, or saturated soil are typically in the vicinity of willow flycatcher territories and nests; willow flycatchers sometimes nest in areas where nesting substrates were in standing water (Maynard 1995, Sferra *et al.* 1995, 1997). However, hydrological conditions at a particular site can vary remarkably in the arid Southwest within seasons and between years. At some locations, particularly during drier years, water or saturated soil is only present early in the breeding season (i.e., May and part of June). However, the total absence of water or visibly saturated soil has been documented at several sites where the river channel has been modified (e.g., creation of pilot channels), where modification of subsurface flows has occurred (e.g., agricultural runoff), or as a result of changes in river channel configuration after flood events (Spencer *et al.* 1996).

Throughout its range the willow flycatcher arrives on breeding grounds in late April and May (Sogge and Tibbitts 1992, Sogge *et al.* 1993, Sogge and Tibbitts 1994, Muiznieks *et al.* 1994, Maynard 1995, Sferra *et al.* 1995, 1997). Nesting begins in late May and early June and young fledge from late June through mid-August (Willard 1912, Ligon 1961, Brown 1988a,b, Whitfield 1990, Sogge and Tibbitts 1992, Sogge *et al.* 1993, Muiznieks *et al.* 1994, Whitfield 1994, Maynard 1995).

Willow flycatcher nests are fairly small (3.2 inches tall and 3.2 inches wide) and its placement in a shrub or tree varies throughout its range (2.0 to 59.1 feet off the ground). Nests are open cup structures, and are typically placed in the fork of a branch. Nests have been found against the trunk of a shrub or tree (in monotypic saltcedar and mixed native broadleaf/saltcedar habitats) and on limbs as far away from the trunk as 10.8 feet (Spencer *et al.* 1996). Willow flycatchers using predominantly native broadleaf riparian habitats nest low to the ground (5.9 to 6.9 feet on average), whereas birds using mixed native/exotic and monotypic exotic riparian habitats nest higher (14.1 to 24.3 feet on average).

The willow flycatcher is an insectivore, foraging in dense shrub and tree vegetation along rivers, streams, and other wetlands. The bird typically perches on a branch and makes short direct flights, or sallies to capture flying insects. Drost *et al.* (1998) found that the major prey items of the willow flycatcher (in Arizona and Colorado), consisted of true flies (Diptera); ants, bees, and wasps (Hymenoptera); and true bugs (Hemiptera). Other insect prey taxa included leafhoppers (Homoptera: Cicadellidae); dragonflies and damselflies (Odonata); and caterpillars (Lepidoptera larvae). Non-insect prey included spiders (Araneae), sowbugs (Isopoda), and fragments of plant material.

Brown-headed cowbird (*Molothrus ater*) parasitism of willow flycatcher broods has been documented throughout its range (Brown 1988a,b, Whitfield 1990, Muiznieks *et al.* 1994, Whitfield 1994, Hull and Parker 1995, Maynard 1995, Sferra *et al.* 1995, Sogge 1995b). Where studied, high rates of cowbird parasitism have coincided with willow flycatcher population declines (Whitfield 1994, Sogge 1995a,c, Whitfield and Strong 1995) or, at a minimum, resulted in reduced or complete nesting failure at a site for a particular year (Muiznieks *et al.* 1994, Whitfield 1994, Maynard 1995, Sferra *et al.* 1995, Sogge 1995a,c, Whitfield and Strong 1995). Cowbird eggs hatch earlier than those of many passerine hosts, thus giving cowbird nestlings a competitive advantage (Bent 1960, McGeen 1972, Mayfield 1977a,b, Brittingham and Temple 1983). Willow flycatchers can attempt to renest, but renesting often results in reduced clutch sizes, delayed fledging, and reduced nest success (Whitfield 1994). In one study, cowbird parasitism was often the cause of delayed fledging and nestlings that fledged later than July 20th had a significantly lower return rate than those fledging earlier (Whitfield and Strong 1995).

Willow flycatcher territory size likely fluctuates with population density, habitat quality, and nesting stage. Estimated territory sizes are 0.59 to 3.21 acres for monogamous males and 2.72 to 5.68 acres for polygynous males at the Kern River (Whitfield and Enos 1996), 0.15 to 0.49 acres for birds in a 1.48 to 2.22 acre patch on the Colorado River (Sogge 1995c), and 0.49 to 1.24 acres in a 3.71 acre patch on the Verde River (Sogge 1995a).

Species Status and Distribution Range-Wide

Bonytail chub and razorback sucker

Range-wide status and distribution information on the bonytail and razorback can be obtained in documents previously incorporated by reference into this BO (USBR 1996, USBR 2000a, USFWS 1997) and in the recovery plans (USFWS 1990, 1998). In the time period since 1997, species status has been affected by other Federal actions that have received informal and formal section 7 consultations, implementation of recovery and conservation actions, and implementation of reasonable and prudent alternatives (RPAs) from the 1997 BO.

The status of the bonytail in 2000 is also summarized in draft documents dealing with development of recovery goals (SWCA 2000a). No bonytails have been captured in the Upper

Colorado River Basin since 1988, although individuals are believed to persist in Desolation/Gray Canyons, Cataract Canyon, and Black Rocks areas.

In the Lower Colorado River Basin, bonytails persist in Lakes Havasu and Mohave. No natural recruitment has been documented. There is one broodstock being maintained at Dexter National Fish Hatchery and Technology Center (Dexter NFH&TC) in New Mexico. Recent information on the genetics of this broodstock state that as few as 3.5 of the 11 adults involved in the creation of the F1 generation actually contributed genetic material (Hedrick *et al.* 2000). Information on the genetics of the F2 indicate these fish were genetically acceptable to use in reintroductions (Minckley *et al.* 1989). However, for the long-term benefit of the species, additional fish must be incorporated into the broodstock.

Augmentation using hatchery born young bonytails is occurring in the Green and Colorado Rivers in the Upper Basin using 3 to 9 inch length fish. There have been 71,332 stocked between 1997 and September 2000 (Table 1) (Pat Nelson, FWS, pers. comm.). In the Lower Basin, bonytails are being stocked to augment the Havasu and Mohave populations. Fish 10 to 12 inches in length are stocked into the reservoirs as part of the implementation of previous BO actions (USFWS 1993b, 1994). Between 1997 and September 2000, 1,507 fish were put into Havasu (Al Doelker, BLM, pers. comm.) and 18,089 into Mohave (Chester Figiel, FWS, pers. comm). Another 8,379 will be stocked in October, 2000 and another 4,000 in November, 2000 (Manuel Ulibarri, FWS, pers. comm). Some of the 166,000 small bonytails stocked in the 1981-1991 period by the Service to Lake Mohave have recruited to the wild adult population and have been captured along with the wild adults.

The status of the razorback in 2000 is also summarized in draft documents dealing with development of recovery goals (SWCA 2000b). In the Upper Basin, razorbacks are found in the middle Green River (estimated at 524 adults in Modde *et al.* 1996) with very small (unquantified) numbers of wild fish in the upper Colorado, Gunnison, White, Duchesne and Yampa Rivers (SWCA 2000b). A small population of wild fish persists in the San Juan River (Jim Brooks, FWS, pers. comm.). The one significant population remaining in the Upper Basin, that in the Green River, has signs of limited recruitment (based on changes in length frequency data at 17.6-19.2 inch total length of captured fishes) with the population considered stable or slowly declining (Modde et al. 1996). Recruitment within the other Upper Basin populations has not been observed. Augmentation using hatchery born young fish is occurring in the Green, Gunnison and Colorado Rivers in the Upper Basin using 1-17 inch length fish. There have been 96,693 stocked between 1997 and September 2000 (Table 2) (Pat Nelson, FWS, pers. comm). Stocking also occurs in the San Juan River and Lake Powell.

In the Lower Basin, razorbacks persist on the Colorado River in Lakes Mead, Mohave and Havasu and in the mainstem between the reservoirs and downstream of Lake Havasu. In the Gila, Salt and Verde Rivers of interior Arizona, stocking activities have created small populations but no recruitment of wild-born young has been observed to these populations. One broodstock being maintained at Dexter NFH&TC in New Mexico, however, most fish for augmentation come from wild larvae caught in Lake Mohave or from paired matings with wild adults from Mohave. The wild adults in the Mohave population were estimated at 9,087 individuals in 1999 with and additional 3,104 repatriated sub-adults captured on the spawning grounds with the adults (Pacey and Marsh 1999). Population estimates of wild or stocked individuals for other Colorado River sites are not available, but populations are very small.

In the Lower Basin, populations in both Mohave and Havasu are being augmented with sub-adult fish raised in hatcheries or in semi-natural rearing ponds while the population below Parker Dam is being augmented through implementation of an RPA from the 1997 BO on BOR operations (USFWS 1997) and by adults being used in radio or sonic tracking studies. Fish 10-12 inches in length are stocked into the reservoirs as part of the implementation of previous BO actions (USFWS 1993b, 1994) and efforts of the Native Fish Work Group in Lake Mohave. Between 1997 and September 2000, 20,296 fish have been put into Havasu (Al Doelker, BLM, pers. comm.) and 33,708 into Mohave (Tom Burke, BOR, pers. comm; Chester Figiel, FWS, pers. comm). An additional 2300 razorbacks were stocked into Havasu in October, 2000 (Al Doelker, BLM, pers. comm.). Reclamation has stocked 4,596, razorbacks with an average length of 10 inches below Parker Dam under RPA 1 from the 1997 BO.

Spawning by razorback suckers has been documented in Lakes Mead and Mohave. Large recruitment events after Lakes Mead and Mohave filled (in the 1930's and 1950's respectively), created the adult populations found there (summarized in Minckley *et al.* 1991). Recruitment into the Lake Mohave population has not occurred since that time, resulting in the decline from an estimated 60,000 adults in the 1980's to the present 9,000 adults as fish age and die (Pacey and Marsh 1999). The normal pattern seen for razorback populations in reservoirs is to die out approximately 40-50 years after formation of the reservoir as fish reach the end of their life span. This decline in razorback populations was observed in Lake Mead. The Lake Mead population was rapidly disappearing from the lake in the late 1970's, as would be expected, since Lake Mead began to fill in the mid-1930's. Although there are many records in the literature on razorbacks in Lake Mead, none provide a population estimate beyond saying they were "common" or "abundant" (Minckley *et al.* 1991). No razorbacks were taken from Lake Mead in the 1980's (Sjoberg 1995).

In 1990, Nevada Division of Wildlife (NDOW) was advised by anglers that razorbacks were still present in Lake Mead and the Las Vegas Wash/Blackbird Point and Echo Canyon populations were confirmed. NDOW surveyed these areas in 1990, 1992-1994 capturing a total of 49 razorbacks (Sjoberg 1995). These razorbacks did not have the physical characteristics of old, senescent fish. They were, based on size and physical condition, estimated to be 20-30 years old, therefore born between the early 1960's-early 1970's. Arizona Game and Fish Department (AGFD) did capture six razorbacks averaging 231 mm in length in 1967 (cited in Sjoberg 1995), and using available growth curves, these may have been 3-5 years old at the time and may be part of the 20- 30 year old cohort now in the lake. Partial surveys of other likely spawning areas in the lake have not documented any other populations. Additional surveys are planned.

In addition to surveys, NDOW stocked a total of 97 razorbacks into Lake Mead since 1994. Of these, 57 were 1984 year class razorbacks from Dexter NFH&TC held at Floyd Lamb State Park and 40 were fish raised from captured wild larvae (Jon Sjoberg, NDOW, pers comm., Holden *et al.* 1997). Stocking information on these fish is given in Table 3. These stocked fish were all marked for later identification as stocked individuals to differentiate them from the wild-born and recruited individuals.

Since 1996, BioWest has been funded by Southern Nevada Water Authority (SNWA) and later with contributions from Reclamation, to examine the razorback population in Lake Mead. Their reports (Holden *et al.* 1997, 1999, 2000) were reviewed and used in this summary. The current population in Lake Mead is estimated at 400 in Las Vegas Wash and 50-60 in Echo Bay. Partial surveys in other parts of the lake have not located any additional populations, and more extensive surveys are planned for 2001. Based in sonic tracking data, the two populations do not seem to interact (Holden *et al.* 1999, 2000). Importantly, four subadults were captured in Echo Bay in the 1997-98 study year. One of these died and was aged at 4-5 years. An adult that also died that year was aged at 7-10 years. None of these were stocked fish (all stocked fish were tagged), indicating that recruitment events were still happening in the lake. Because of the limited data available, it is not clear if the present level of recruitment can sustain the population at its current level. The size of the current population is also too small to be genetically viable over the long term, however if additional recruitment opportunities are provided the population is likely to expand from its present size.

There is also a small spawning razorback population below Parker Dam that utilizes the Colorado River Indian Tribe (CRIT) canal system below Parker Dam. Capture records from 1980-1998 (Table 4) on approximately 80 individuals exist (Chuck Minckley and Mitch Thorson, FWS, pers. comm.). In addition, 5 adults were found and removed from the CRIT Main Canal in January, 1993 (Marsh 1993). Many of the captured fish were sub-adult sizes. There was a stocking of 60,000 average 2 inch razorbacks into the Parker Strip area on May 21, 1986 that may have produced some of these individuals. However, while razorbacks are known for growing quickly and at widely varying rates, and many of the sub-adults were found in January of 1987 (7-8 months after the known stocking), the lengths of these captured fish were up to 3 times the length of the stocked fish. This rate of growth would be extremely high even for razorbacks. Razorbacks of the same size range were found in 1986 in the canals before the stocking. It is therefore difficult to know how many of these fish were wild spawned and recruited and how many were from the stocking. It is important to note that success in stocking razorbacks below 10-12 inches in length has been extremely poor, and if some of the small stocked fish did live to grow to sub-adult size in the canals or somewhere else in the Parker Strip, this would be important to understanding how recruitment can be facilitated. Recruitment of young razorbacks in the canals may be related to cyclical maintenance and draining the canals that reduces the predator load. During the 1990's, several other razorbacks were found in the canals (Chuck Minckley, FWS, pers. comm) so there may be additional recruitment occurring. A spawning site has not been located in the Parker Strip reach of the LCR.

Ongoing research on the habitat preferences of the razorback sucker is being funded by Reclamation in the Imperial Division. Since 1995, Arizona Game and Fish Department has stocked 160 adult and sub-adult fish in the Division and followed them using sonic transmitters. Stocked razorbacks show a preference for backwaters over the main channel habitats (Gurtin and Bradford 2000).

Critical habitat for the razorback will be affected under the proposed action. Two of the areas, Lake Mead and the river reach below Parker Dam, have been the sites of the only known recruitment in the Lower Basin in the last 10 years or more and represent two thirds of the known recruitment areas range-wide. Information on exactly where, why and how this recruitment occurred is not available at the present time. Since lack of recruitment is the primary reason for the continued downward trend for the razorback, information on recruitment events is critical to future management. Changes to constituent elements that reduce or eliminate potential recruitment events are significant adverse effects to survival and recovery.

Yuma clapper rail

The status of the clapper rail in 2000 is provided by the results of annual surveys since 1997 (Table 5). These surveys do not provide estimates for the entire population, but provide information on the minimum number of birds present at survey sites. Survey data covers the LCR populations and also those found around the Salton Sea.

New information that may affect the life history of the clapper rail involves selenium levels in prey species (Roberts 1996, King *et al.* 2000). Levels in crayfish were high enough to cause concern for potential reproductive effects in clapper rails. No adverse effects have been noted, but because of the clapper rail's secretive nature, nests are difficult to find and a concentrated effort has not yet been made. Additional research and monitoring are under consideration at this time.

Southwestern willow flycatcher

Unitt (1987) documented the loss of more than 70 willow flycatcher breeding locations range-wide (peripheral and core drainages within its range) and estimated the range-wide population at 500 to 1000 pairs. There are currently 99 known willow flycatcher breeding sites (in CA, NV, AZ, UT, NM, and CO) holding approximately 712 territories (Table 6). Sampling errors may bias population estimates positively or negatively (e.g., incomplete survey effort, double-counting males/females, composite tabulation methodology) and random events, it is likely that the total breeding population of willow flycatchers fluctuates annually. Unpublished data from USGS (M. Sogge, USGS pers. com.) indicate that after the 1999 breeding season, just over 900 territories at 143 sites were known throughout the bird's range.

Seventy percent of the breeding sites where willow flycatchers have been found are comprised of five or fewer territorial birds. The distribution of breeding groups is highly fragmented, with groups often separated by considerable distances (e.g. in Arizona, approximately 55 miles straight-line distance between breeding willow flycatchers at Roosevelt Lake, Gila County, and the next closest breeding groups known on either the San Pedro River, Pinal County or Verde River, Yavapai County). To date, survey results reveal a consistent pattern range-wide; the willow flycatcher population is comprised of extremely small, widely-separated breeding groups including unmated individuals. Movement data indicates that willow flycatchers can disperse to areas as much as 200 kilometers away from past recorded locations.

Intensive nest monitoring efforts in California, Arizona, and New Mexico have shown that cowbird parasitism and/or predation can often result in failure of the nest; reduced fecundity in subsequent nesting attempts; delayed fledging; and reduced survivorship of late-fledged young. Cowbirds have been documented at more than 90 percent of sites surveyed (Sogge and Tibbitts 1992, Sogge *et al.* 1993, Camp Pendleton 1994, Muiznieks *et al.* 1994, Sogge and Tibbitts 1994, T. Ireland 1994 *in litt.*, Whitfield 1994, C. Tomlinson 1995 *in litt.*, Griffith and Griffith 1995, Holmgren and Collins 1995, Kus 1995, Maynard 1995, McDonald *et al.* 1995, Sferra *et al.* 1995, Sogge 1995a,b, San Diego Natural History Museum 1995, Stransky 1995, Whitfield and Strong 1995, Griffith and Griffith 1996, Skaggs 1996, Spencer *et al.* 1996, Whitfield and Enos 1996, Sferra *et al.* 1997, McCarthey *et al.*1998). The probability of a willow flycatcher successfully fledging its own young from a cowbird parasitized nest is low (<5%). Also, nest loss due to predation appears consistent from year to year and across sites, generally in the range of 30 to 50 percent. Documented predators of willow flycatcher nests identified to date include common king snake (*Lampropeltis getulus*), gopher snake (*Pituophis melanoleucos affinis*), and Cooper′s hawk (*Accipiter cooperii*) (Paxton *et al.* 1997, McCarthey *et al.* 1998, Paradzick *et al.* 2000).

Cowbird trapping has been demonstrated to be an effective management strategy for increasing reproductive success for the willow flycatcher as well as for other endangered passerines (e.g., least Bell's vireo [*Vireo bellii pusillus*], black-capped vireo [*V. atricapillus*], golden-cheeked warbler [*Dendroica chrysoparia*]). It may also benefit juvenile survivorship by increasing the probability that parents fledge birds early in the season. Expansion of cowbird management programs has the potential to not only increase reproductive output and juvenile survivorship at source populations, but also to potentially convert small, sink populations into breeding groups that contribute to population growth and expansion.

Arizona Distribution and Abundance

As reported by Paradzick *et al.* (2000), the greatest concentrations of willow flycatchers in Arizona in 1999 were near the confluence of the Gila and San Pedro rivers (236 willow flycatchers, 134 territories); at the inflows of Roosevelt Lake (140 willow flycatchers, 76 territories); between Fort Thomas and Solomon on the middle Gila River (9 willow flycatchers, 6 territories); Topock Marsh on the Lower Colorado River (30 willow flycatchers, 16 territories); Verde River at Camp Verde (7 willow flycatchers, 5 territories); Alpine/Greer on the San

Francisco River/Little Colorado River (11 willow flycatchers, 8 territories); Alamo Lake on the Bill Williams River (includes Santa Maria and Big Sandy river sites) (43 willow flycatchers, 23 territories); and Lower Grand Canyon on the Colorado River (21 willow flycatchers, 11 territories).

Unitt (1987) concluded that "probably the steepest decline in the population level of *E.t. extimus* has occurred in Arizona...". Historic records for Arizona indicate the former range of the willow flycatcher included portions of all major river systems (Colorado, Salt, Verde, Gila, Santa Cruz, and San Pedro) and major tributaries, such as the Little Colorado River and headwaters, and White River. As of 1999, 289 territories were known from 47 sites along 12 drainages statewide (Table 6). The lowest elevation where territorial pairs were detected was 197 feet at Adobe Lake on the Lower Colorado River; the highest elevation was at the Greer town site (8300 feet). The majority of breeding groups in Arizona are extremely small. Of the 47 sites where willow flycatchers have been documented, 70 percent (n=33) contain 5 or fewer territorial willow flycatchers.

California Distribution and Abundance

The historic range of *E.t. extimus* in California apparently included all lowland riparian areas in the southern third of the State. It was considered a common breeder where suitable habitat existed (Wheelock 1912, Willett 1912, 1933, Grinnell and Miller 1944). Unitt (1984, 1987) concluded that it was once common in the Los Angeles basin, the San Bernardino/Riverside area, and San Diego County. Specimen and egg/nest collections confirm its former distribution in all coastal counties from San Diego County north to San Luis Obispo County, as well as in the inland counties, i.e., Kern, Inyo, Mohave, San Bernardino, and Imperial. Unitt (1987) documented that the willow flycatcher had been extirpated, or virtually extirpated (i.e., few territories remaining) from the Santa Clara River (Ventura County), Los Angeles River (Los Angeles County), Santa Ana River (Orange and Riverside counties), San Diego River (San Diego County), lower Colorado River (Imperial and Riverside counties and adjacent counties in Arizona), Owen's River (Inyo County), and the Mohave River (San Bernardino County). Its former abundance in California is evident from the 72 egg and nest sets collected in Los Angeles County between 1890 and 1912, and from Herbert Brown's 34 nests and nine specimens taken in June of 1902 from the LCR near Yuma.

Survey and monitoring efforts since the late 1980s have confirmed the willow flycatcher's presence at a minimum of 11 sites on 8 drainages in southern California (including the Colorado River). Current known willow flycatcher breeding sites are restricted to coastal southern California from Santa Barbara to San Diego, and California's Great Basin near the towns of Kernville, Bishop, Victorville, the San Bernardino Mountains and along the lower Colorado River. The largest populations exist along the San Luis Rey, Santa Margarita, Santa Ynez, Kern and Owen's rivers. Combining survey data for all sites surveyed since the late 1980's for a composite population estimate, the total known willow flycatcher population in southern California is 95 territories, with possibly as many as 178 (M. Sogge, USGS, pers. com.).

Nevada Distribution and Abundance

Unitt (1987) documented three locations in Clark County from which *E.t. extimus* had been found prior to 1970. Current survey efforts have documented breeding birds along the Amargosa, Pahranagat, Muddy, and Virgin Rivers (McKernan and Braden 1997, 1998, 1999) in southern Nevada.

Federal Actions Throughout Subspecies Range

Since listing in 1995, at least 46 Federal agency actions have undergone (or are currently under) formal section 7 consultation throughout the bird's range (Table 7). Six actions have resulted in jeopardy determinations. Many activities continue to adversely affect the distribution and extent of occupied and potential breeding habitat throughout its range (development, grazing, recreation, dam operations, etc.). Stochastic events also continue to adversely affect the distribution and extent of occupied and potential breeding habitat. A catastrophic fire in June of 1996, destroyed approximately one half mile of occupied habitat on the San Pedro River in Pinal County. That fire resulted in the forced dispersal or loss of up to eight pairs of willow flycatchers (Paxton *et al.* 1996).

Range-Wide Trend

Bonytail chub and razorback sucker

Lack of recruitment to aging adult populations is resulting in increasingly smaller natural populations of bonytail and razorback as fish die and are not replaced by young fish. Extirpation and extinction from the wild for razorbacks and bonytails is being forestalled by the ongoing augmentation efforts, which have proved successful in re-establishing young adult populations into some areas of historic habitats. Use of wild larvae from razorbacks in Lake Mohave provides a vehicle to perpetuate this species' remarkable level of genetic variation to provide the most options for future reintroductions and augmentations. With the scarcity of wild bonytail adults left alive, adding diversity to this broodstock may be difficult, but every avenue must be exploited to provide the maximum retention of genetic variability. Efforts to capture additional wild bonytails from Lake Mohave are undertaken each year and increased efforts are needed.

Yuma clapper rail

Yuma clapper rail populations appear to be reasonably stable with no significant population declines or increases related to effects of activities within their habitats. Population changes on a local level have been noted, but these may be based on changes in habitat quality. Management actions such as burning old cattail stands and selected dredging to open up too-dense patches are under consideration in several areas to improve habitat conditions. The populations in Mexico, while not protected under the ESA, are critical to the ultimate survival of the species. These populations are mostly in the Cienega de Santa Clara, which is not directly connected to the

Colorado River but is supplied by water discharged from the US via the Main Outlet Drain from the Wellton-Mohawk Irrigation and Drainage District. Future operation of the Yuma Desalting Plant could have significant adverse effects on this water source. The Mexico rail populations were estimated at 6,400 individuals in 1999 (Hinojosa-Huerta *et al.* 2000).

Southwestern willow flycatcher

More intensive and widespread surveys and monitoring efforts have documented the presence of a greater number of willow flycatchers than known at the time of listing. However, this does not imply an increase in the actual population, or that the status of the species has remarkably improved. Continuing losses of occupied habitats and degradation of other areas precludes the possibility of population increases. Recovery actions may take many years to implement and decades for habitat to be restored. Protection of occupied habitats as a consequence of section 7 consultation does provide some stability for those populations, but the net result is still a declining population.

Analysis of the Species/Critical Habitat Likely to be Affected

The proposed action would take place in occupied habitats for the bonytail, razorback, clapper rail and willow flycatcher, and within designated critical habitat for the bonytail and razorback. The Colorado River within the vicinity of the proposed action has the largest populations of bonytails and razorbacks remaining in the wild, supports half of the clapper rail population in the United States, and is an important breeding and recovery habitat area for the willow flycatcher. The Salton Sea supports the other half of the clapper rail population in the US, and effects to this area are being covered by 4.4 Plan internal California compliance actions. Recovery of all these species will require these habitats to be able to support these species at current or higher levels.

III. ENVIRONMENTAL BASELINE

The environmental baseline is the analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area. For the lower Colorado River, the 1997 BO (USFWS 1997) provided an extensive environmental baseline. This has since been augmented by a discussion of the losses of riparian habitat (USBR 1999) prepared as part of RPA 11 for the 1997 BO. The information in these documents is herein incorporated by reference. The environmental baseline for areas outside of the river and 100-year floodplain has not been previously described. Because little has physically changed on the LCR for the bonytail, razorback and clapper rail since 1997, the description of the baseline is provided in very broad terms. Additional information is provided for the willow flycatcher because of the magnitude of new information developed.

The Colorado River and 100-Year Floodplain

Reclamation has been working to accomplish the short-term RPAs contained in the 1997 BO. For razorback and bonytail, the review of fish and wildlife programs (RPA 2), and research into conflicts between native and non-native fish (RPA 4) have been accomplished. Augmentation of razorback populations (RPA 1) is underway with 4,596 fish stocked to date, and development of the isolated impoundments (RPA 3) is underway. For willow flycatchers, approximately half of the 1400 acres of habitat protection/restoration (RPA 5) has been completed, and reviews of ongoing programs (RPA 6), protective management (RPA 7) and study funding (RPA 8) have been accomplished.

Under the long-term RPAs, Reclamation has stated it will support the reintroduction of bonytail to the lower river below Parker Dam (RPA 9) and has contributed to the study of razorbacks in Lake Mead (RPA 10). The alternative compensation habitat (RPA 11) implementation has generated an estimate of how much habitat for willow flycatchers was present along the river (USBR 1999), and some sites have been identified for inclusion in the compensation program. No lands have been protected to date, but most of this compensation was focused on implementation through the Lower Colorado River Multi-Species Habitat Conservation Program (MSCP). Potential areas for restoration on the river have been identified along with constraints (RPA 14). Reclamation has been an active participant in the MSCP (RPA 12), has provided the Service with a detailed description of their discretion in river operations (RPA 13), and has met with the Service in 1998-2000 to discuss progress (RPA 16). Implementation of RPA 15 involves Reclamation's use of its discretion to enable implementation and this is occurring. The last RPA, RPA 17, only comes into play if the MSCP efforts do not result in a section 10 permit by May 2002. At which time Reclamation must reinitiate on all of its operations. The Service believes that reinitiation should also include the ISC, because it will play a major role in how the river is operated and to not include it would make analysis of the system incomplete.

Since 1997, the lower Colorado River has also been the site of conservation and recovery actions, research and monitoring, population augmentations and additional development actions requiring consultation. Most of the development actions have been small and localized in extent of effects.

Table 7 provides information on willow flycatcher consultations within the action area. Despite the numerous Federal agencies and actions involved, only the1997 BO with Reclamation, and this current opinion has been initiated to look at the overall management of the LCR and its effects to willow flycatchers. The broad scope of interrelated and interdependent actions, or those that would not be possible but for the management of water on the LCR, has also had a significant and widespread impact on the willow flycatcher. For example, the availability of irrigation water spawned wide-scale agricultural development on private lands in the Colorado River valley. More than 75 percent of Mohave, Parker, Palo Verde, and Yuma valleys has been converted to agriculture (USFWS 1986). These areas formerly contained vast riparian forests and were captured in early photographs of the area. This riparian habitat probably comprised the most important riparian corridor in the Southwest and provided significant stands of habitat suitable for the willow flycatcher. The effect of these losses on the willow flycatcher has also been great; today, nowhere on the Colorado River could an individual look within a two-mile stretch and find 34 willow flycatcher nests as was done by Herbert Brown in June of 1902.

Only 3 BOs have been written since May 1997 on projects along the river (Table 8). Also included is a BO written just before the 1997 Reclamation BO was issued. In addition, the Service agreed that a dredging project in the Imperial Division was included under the 1997 BO. In addition to formal consultations, important informals where findings of "may affect, not likely to adversely affect" (NLAA) were made are listed in Table 9. There were many other small projects with the same findings. These types of projects were for recreational events such as boat races and waterski events, small 404 permits for docks and minor dredging at marinas, minor changes to recreational sites, and similar types of activities. Physical effects due to these projects were not significant and no take was foreseen for the bonytail, razorback and clapper rail.

Two findings of NLAA were for control activities for giant salvinia (*Salvinia molesta*), an invasive non-native, aquatic fern discovered entering the LCR from the West Side/Outfall Drain of the Palo Verde Irrigation District near Blythe, California, in 1999 (Science Advisory Panel 1999). At least 70 miles of the LCR have been infested with propagules (small survival stage clumps or individual plants) from the Drain. Requests for consultation from the Bureau of Land Management (BLM) and the Service addressed use of herbicides (Reward, a commercial formulation of diquat), barriers and physical removal of plants on Service and BLM lands along the LCR (USFWS 1999, BLM 2000). This infestation of giant salvinia threatens aquatic and marshland habitats along the river. In quiet waters, giant salvinia can form mats over 2 feet thick, blocking sunlight and oxygen circulation as well as replacing native aquatic plant species and decreasing macroinvertebrate biomass (Salvinia Task Force Action Plan Sub-Committee 1999). Giant salvinia prefers warm, still or very slow moving waters with high nitrogen concentrations. The LCR backwaters and impounded areas behind low dams would be the likeliest places for heavy infestation. The LCR is not heavily eutrophic, but sufficient nitrogen is present in the system to allow for at least localized problems. The presence of this plant in the LCR backwaters will restrict availability and quality of these desired razorback sucker habitats and may also affect clapper rail foraging areas or the ability of birds to use them. Efforts to control this plant in other parts of the US and in foreign countries have not been completely successful (Salvinia Task Force Action Plan Sub-Committee 1999). Some of the herbicides used are toxic to aquatic organisms, although diquat has very low toxicity when used properly (USFWS 1999). Biological controls are under evaluation but the effects and effectiveness are not fully understood.

Also during the 1997-2000 period, river management activities covered under the 1997 BO for Reclamation have continued to occur. These include maintenance of Front Work and Levee System improvements, generation of power, determinations of surplus water availability, flood control releases, and water delivery to Mexico. All Federal discretionary activities are covered by the 1997 BO until May 2002. After that time, the MSCP will be in place to address Federal and non-Federal activities along the river. If the MSCP is not completed by that time, additional consultation on Reclamation activities, including ISC, will be required.

There is currently no consultation or section 10 permit in place to cover the non-Federal actions along the river. Although Reclamation is the Watermaster for the LCR, there is limited Federal discretion in the release of the 7.5 maf of Lower Basin apportioned water. Reclamation can only not release water to a qualified contract holder if it is determined that the amount of water requested is in excess of that needed for beneficial uses. There is also some discretion in offering unused apportionment water to other States for use. Otherwise, the release of water from Hoover Dam and subsequent diversion for offstream use is entirely a discretionary action by the water rights holders. Over the 1997-2000 period, the water rights holders have requested and received their water and additional waters provided by unused apportionment and surplus declarations. Other non-Federal actions along the river and floodplain since 1997 include urban development, continuation of farming activities, and recreational use of the river and associated facilities.

The end result of the past, ongoing and present actions of water and land management along the LCR has been a maintenance of currently degraded habitat conditions for listed species. Because of the wide range of activities, jurisdictions and amount of discretion held by the various entities, it is very difficult to make any significant changes to the management of the system.

Action Areas Within the Three States

Lands where Colorado River waters are currently used have been developed for agriculture and also contain extensive areas urban/suburban development. The metropolitan areas of southern California (including Los Angeles and San Diego), Las Vegas, Phoenix and Tucson all rely to some extent on Colorado River waters included in the proposed action. The farmlands of the Imperial and Coachella valleys in California depend on Colorado River water. These areas have already been developed.

Status of Species in Action Area

Razorback sucker

The status of this species within the action area has been described as part of the range-wide status discussion earlier in this BO. However, additional information on known spawning areas and the operations of Lake Mead from 1935 to 2000 is needed for evaluations of effects of the action.

The Las Vegas Bay spawning site is on Blackbird Point facing the channel between the point and the marina (Figure 3). Elevations from topographic maps of this area show that the deepest area between the two sites is contained in the 1120 foot contour. Based on data from Holden *et al.* (1997, 1999, 2000), the spawning area is at approximately 1120-1150 feet elevation for an average of 1135 feet. The Bay is less than a mile wide and slowly deepens to 1080 feet within a mile to the east, continuing a shallow drop beyond that point but widening out.

The Echo Bay spawning area is at the western end of the bay in shallow water (Figure 4). Videotape data of spawning razorbacks was taken in 1999 with the area being used at elevation 1192. Holden *et al.* (1997) show a use area between 2013 and 1181 feet on the south shore of the bay. This use area is considerably smaller than the Las Vegas Bay site, and is in much shallower water. It may have been dry during the 1995 spawning season. There is a site with similar characteristics around the next bend of the bay also on the south side that may provide spawning habitats at slightly lower elevations, since the slope falls off to an elevation of 1148. Further east, the bay becomes deeper and wider and joins into the Overton Arm of the lake. Below elevation 1148, the Bay is essentially dry above the launch ramp at the campground, which includes most of the area used by the razorbacks during the spawning season (Holden *et al*. 1999, 2000). Given that there does not appear to be much interchange between the two populations in Lake Mead, the four sub-adults captured in Echo Bay in 1997-1998 were likely all spawned and recruited in this area.

Lake Mead was constructed in the early 1930's and began to fill in 1935. Over the 66-year period of record, water levels have fluctuated in response to inflows, outflows and operation of new dams on the Colorado River (Figure 5). Reclamation maintains exacting records of Lake Mead elevations on a monthly basis from February 1935 to the present. That information is available from Reclamation on its website and was used to develop the analysis presented here.

Including the 1935-1939 filling period, Lake Mead water levels during the spring spawning period (February-April) of the razorback have been over 1150 feet elevation in 44 of 66 years. This increases to 50 of 66 years if we include years where more than one but less than 3 months met this condition. Lake levels did not first reach 1150 until 1939, so the first 4 years of record do not provide anything to the analysis. Years when lake levels did not reach 1150 are concentrated in the 1952-1957 and 1964-1969 periods. The filling of Lake Powell in the 1960's had an effect on Lake Mead water levels. Water surface elevations dropped significantly as less water was reached Lake Mead. Figure 5 shows this pattern very clearly.

The second parameter of interest is whether water levels are increasing or decreasing during the spawning period. Using the Reclamation data, including the 1935-1939 period, there are 20 of 66 years where water levels were rising over the 3 month period (Table 10). Fifteen of those years are post 1939 and are important to the discussion. Of those 15 years, the average rise in water levels was 4.28 feet with a median of 3.50 feet (range 0.12-11.41 feet) during this period. As shown in Table 10, rising water levels have occurred in the 1940's, 1960's, 1980's and 1990's. Although the evidence is unclear, rising water levels may have played a role in post-1930's razorback recruitment in Lake Mead.

Razorback sucker populations in Lake Mead were first formed by the capture of fish living in the river reach that became the lake. As has been discussed earlier, those fish reproduced during the first years of lake formation to provide the population observed through the 1970's. The present adult population is hypothesized to be 20-30 years old (as of the early 1990's) and represent at least one year of recruitment. Based on the 1967 capture of sub-adult razorbacks, estimated at 3-5 years old using growth curves, this event may have occurred in the 1962-1964 window. Table 10 shows that 1960, 1962 and 1965 were all years of rising water levels, and two were over 1,150 elevation. The 7-10 year old captured in 1998 does not correlate to a rising water level year, but water levels were very high during this period. The 4-5 year old also captured in 1998 does correlate to the 1993 rising water year. Additional research and monitoring are needed to evaluate this population and its recruitment events.

Yuma clapper rail

The clapper rail appears to be expanding its range up into southern Nevada, including Lake Mead. Rails have been found in the lake and in wetlands habitats only recently and are still in small numbers. Since these habitats have existed for many years, it is unclear as to why they are just now being occupied. In some cases, surveys have not been done for clapper rails in those areas until very recently, or they were found during other bird surveys. Populations on the LCR and in the Salton Sea have not shown any large increases that would encourage dispersal into new habitats, but some areas of historic use have shown a decrease in habitat quality that may affect dispersal of rails from these areas.

Southwestern willow flycatcher

Unitt (1987) believed that the willow flycatcher had been extirpated, or virtually extirpated (i.e. few territories remaining) along the lower Colorado River. Its former abundance along the Colorado River was evident by Herbert Brown's 34 nests (93 eggs) and 9 specimens taken in June of 1902 near Yuma (Unitt 1987). Local collections of this magnitude suggest both a keen understanding of willow flycatcher habitat and use on the part of the collector, and that this subspecies was locally very abundant. However, subsequent to this collection, the distribution and abundance was not tracked well in the literature until declines were reported from the 1960's to present day (Phillips *et al.* 1964, Unitt 1987, Rosenberg *et al.* 1991).

Growing concern for the status of the willow flycatcher and its new status as a federally endangered species, prompted more survey effort along the lower Colorado River throughout the 1990's. Concurrently, more survey methodology was developed with species specific criteria for determining resident status (Sogge *et al.* 1997, USFWS 2000).

The Colorado River from Lake Mead down to the Southerly International Border separates Nevada and California from Arizona. Therefore, it is difficult, without extreme clarification, to describe populations along the Colorado River by state. As a result, populations will be described by reaches, near cities, or below dams, etc.

1993-1996

From 1993-1996 (Muizneiks *et al.* 1994, Sferra *et al.* 1995, Spencer *et al.* 1996, McKernan and Braden 1997), approximately 60 locations were surveyed on the lower Colorado River for willow flycatchers. McKernan and Braden (1997, 1998, 1999) continued to refine their search effort along the lower Colorado River in the late 1990's. Results from those surveys reveal a pattern of widely-separated and small breeding groups, similar to what is found throughout the subspecies' range (Table 6). Only two territories were discovered (Ehrenberg) between Parker and Imperial dams from 1993 to 1995 (Muizneiks *et al.* 1994, Sferra *et al.* 1995, Spencer *et al.* 1996).

Migrant willow flycatchers, probably including *E.t. extimus*, were documented along the length of the lower Colorado River (Muizneiks *et al.* 1994, Sferra *et al.* 1995, Spencer *et al.* 1996, McKernan and Braden 1997, 1998, 1999, Paradzick *et al.* 1999, Paradzick *et al.* 2000). Many sites had small, but relatively constant, numbers of willow flycatchers remaining on site early in the season for up to several weeks, but then disappear around mid-June. Sogge and Tibbitts (1992), Sogge *et al.* (1993), Sogge and Tibbitts (1994), and Sogge *et al.* (1995), also documented widespread use of the Colorado River through Grand Canyon National Park by migrant willow flycatchers. Records from Grand Canyon and the LCR downstream from the Grand Canyon combined with historical records demonstrate that this system is an important migratory corridor for this species.

1996-2000

Beginning in 1996, more extensive surveys began along the lower Colorado River and its tributaries from Lake Mead down to Yuma, Arizona (McKernan and Braden 1997, 1998, 1999). Tributaries examined were the lower Virgin, Bill Williams, and Gila rivers. Through this effort, more territories were located than previously known and, as a result, more was learned about the distribution of willow flycatchers along the length of lower Colorado River (Table 11). Most birds were found above Hoover Dam at the Colorado River Delta of Lake Mead (whose nesting habitat was subsequently inundated), the lower Virgin River, and Topock Marsh. McKernan and Braden (1999) attempted to survey all locations that they assessed as being suitable for nesting willow flycatchers. Reports for McKernan and Braden’s work exist for 1996 through 1998, and the data from 2000 used in this opinion were received by personal communication and are currently being compiled into a report.

In 1996, a concentration of nesting willow flycatchers were found at the inflow of the Colorado River to Lake Mead where 10 territories (8 confirmed pairs) were documented (McKernan and Braden 1997) in a random sample of plots within a 1219 acre area dominated by Goodding willow. An additional 15 to 20 territories were suspected in unsurveyed portions of the Lake Mead inflow and another eight to twelve territories were suspected in adjacent habitat in Grand Canyon National Park.

Seven nests were found at the Lake Mead inflow (McKernan and Braden 1997). None of the willow flycatcher nests at Lake Mead inflow were parasitized by cowbirds or depredated. However, three willow flycatcher nests at the inflow were lost due to treefall resulting from willows that were saturated from prolonged inundation of root crowns. All nests at Lake Mead inflow were located in Goodding willow. These Colorado River Delta nest areas and approximately 20 acres of occupied habitat at the Virgin River delta were subsequently lost due to inundation from Lake Mead by 1999 (McKernan and Braden 1999, USBR 2000) and consulted upon by Reclamation (USFWS 1997).

In 2000, McKernan (San Bernardino County Museum (SBCM), pers. comm.) examined 8 study areas from Lake Mead to Parker Dam, each consisting of numerous survey sites along the lower Virgin River (n=18), Colorado River in lower Grand Canyon (n=18), below Hoover Dam along the Colorado River (n=48), and on the lower Bill Williams River (n=12). Along the Virgin River from Littlefield, Arizona down to Lake Mead, 21 to 25 pairs were discovered. Also, 14 resident pairs of willow flycatchers were discovered on the Colorado River in the Grand Canyon. Below Hoover Dam 30 resident pairs were present this past season at Topock Marsh (n=44). Study sites (with no resident birds detected) were also surveyed at Topock Gorge (n=3) and Lake Havasu (n=1). Along the Bill Williams River on the Bill Williams National Wildlife Refuge, 4 resident pairs were discovered.

Between Parker and Imperial Dam, 16 study areas exist that contain 20 study sites (B. McKernan, SBCM, pers. comm.). Suitable habitat is not as abundant as sites above Parker Dam, thus the few number of sites within each area. All but three study areas have had a resident pair of willow flycatchers present during a season at least once since 1996 (B. McKernan, SBCM, pers. com.). In 2000, resident pairs were found at Big Hole (n=2), Ehrenberg (n=2), Walker Lake (n=2), Adobe Lake (n=2), Picacho West (n=2), Picacho/Camp Store (n=2), and Ferguson Lake (n=1). No nesting attempts were discovered at any of these sites.

Below Imperial Dam, McKernan (pers. com.) looked at 9 study areas which contained 21 survey sites. Again, while resident willow flycatchers have been detected at nearly all study areas at some time in the recent past, only two areas had resident birds in 2000. Resident willow flycatcher pairs were detected at the Gila River/Colorado River confluence (n=2), and along the lower Gila River (n=2).

Along the LCR, nest searches were conducted in most areas where resident birds were found, but in many areas nests were not found (B. McKernan, SBCM, pers. com.). That does not necessarily indicate that birds did not reproduce; but simply that no nests were found. Intensive searches were done in most areas, but some areas were not thoroughly searched (B. McKernan, SBCM, pers. com.). In 2000, nesting was documented along the lower Virgin River where approximately 38 attempts were recorded and in the Grand Canyon where 1 attempt was observed. Nesting attempts were also recorded at Topock Marsh (n≅19) and at the Bill Williams River (n=1). Downstream of Parker Dam, no nesting attempts were discovered.

The review of historic and current data on the distribution and abundance of the willow flycatcher, as well as data on productivity throughout this subspecies' range, presented under Status of the Species provides part of the baseline necessary to evaluate the effects of the proposed action. Other components of the baseline include the anthropogenic activities affecting the species and its habitat, the overall pattern and trend of habitat gains and losses, and the effects of Federal actions that have undergone formal section 7 consultation to individual birds from management and research activities, specific training in standardized survey and monitoring procedures (Sogge *et al.* 1997) are required throughout its range.

Change in aquatic and riparian systems

The development of limited and sparsely-distributed water resources in the Southwest has resulted in large-scale changes to aquatic and riparian systems. Those changes include losses of perennial aquatic ecosystems due to dams, diversions, and groundwater pumping; conversion of alluvial-influenced riparian areas to lacustrine-influenced reservoirs; loss and fragmentation of riparian and aquatic habitats due to residential, commercial, and agricultural development, overgrazing in riparian areas and in watersheds; modifications to stream systems from bank stabilization efforts and channelization; and invasion of remaining riparian areas by exotic species such as saltcedar. These activities and impacts are common among major stream systems in the Southwest.

The LCR has been transformed from a dynamic system prone to scouring, deposition, and meandering channels that leave floodplain forests in their wake, to one where human modifications have greatly reduced or eliminated these factors. This is described in the 1997 BO on Reclamation operations on the LCR (USFWS 1997). Historically, where the water table was relatively close to the surface, cottonwood-willow forests formerly extended away from the river for up to several miles (USBR 1996). Most of this habitat no longer exists (Ohmart 1979, USBR 1996). Ohmart *et al.* (1988) documented an 80 percent decrease between 1938 and 1960 in the areal extent of cottonwood-willow habitat in the Parker II Division. In that case, the loss amounted to more than 4,000 ha (9,880 ac) of cottonwood-willow. Historic photos compiled by Ohmart (1979) demonstrate the magnitude of loss of not only cottonwood-willow, but also of mesquite habitat. In addition to invasion by saltcedar, much of the native habitat loss resulted from agricultural expansion in floodplain terraces (Ohmart *et al.* 1988).

Riparian Restoration Along Lower Colorado River

Reclamation continues to sponsor a riparian restoration program along the river, including native plant nurseries and demonstration projects. Reclamation’s BA for their operations on the lower Colorado River (USBR 1996) described that several areas were under restoration and will contribute approximately 220 acres of new or restored riparian habitats. Several other projects were in the planning stage, including a 22 acre wetland restoration project at the lower end of Las Vegas Wash and a 30-year cost-share project to restore 2,964 acres of native riparian habitat along a 9.3 mile stretch through the Imperial Division. As a result of the 1997 BO with

Reclamation on their operations along the LCR, Reclamation will establish no more than 1400 acres of riparian habitat for the willow flycatcher in order to replace habitat lost around Lake Mead. Some, but not all of these 1400 acres will be established on the lower Colorado River. The potential for these projects to successfully establish habitat suitable for the willow flycatcher is not known. However, because plantings are comprised mostly of cottonwood, and are typically spaced in an open plantation style, in small areas (i.e., 24.7 acre or less), the probability that these areas will develop into suitable willow flycatcher habitat in the near future is low.

To date, willow flycatchers have not been documented at locations where previous or on-going planting efforts have occurred. Other factors such as habitat extent and the presence of water must be considered when evaluating the probability that a planting effort will be successful for the willow flycatcher. Areas well away from river channels that have no standing or flowing water during the willow flycatcher's breeding season have a low probability of attracting nesting willow flycatchers. Similarly, plantings done in narrow strips only a few trees wide also have a low probability of attracting willow flycatchers.

Contaminants

Water management operations on the lower Colorado River exacerbate potential effects to willow flycatcher reproduction by concentrating naturally occurring selenium. During 1996, monitoring efforts in southwestern Colorado, a willow flycatcher fledgling was found with a crossed bill, a symptom of selenium poisoning in birds (Beyer *et al.* 1996, Heinz *et al.* 1987, Heinz *et al.* 1989, Ohlendorf *et al.* 1986a). The deformity prevented this bird from normal foraging. This willow flycatcher was reared in the Escalante State Wildlife Area, which drains agricultural lands where high levels of selenium have been detected in past monitoring (M. Sogge, USGS, pers. comm.). Portions of the lower Colorado River are also known to have high levels of selenium.

Recovery

Recovery of the willow flycatcher depends upon reversing the current population status of the bird. Therefore, throughout the subspecies range, it is important to increase the abundance of, and decrease the distance between sub-populations. To accomplish this task, watersheds must be improved, suitable riparian habitat developed, and in many cases, natural hydrologic processes restored (especially where dams and/or diversions occur along streams).

As described in the Environmental Baseline of the 1997 BO, the flow of water has dramatically changed due to damming, diversion, channelization, dredging, levee construction, and development (i.e. agriculture) within the floodplain. As a result, lakes replaced former river channels, recycling floods are largely prevented, sediment flow is limited, the groundwater table has significantly dropped, and river beds are incised.

Through these changes to the LCR, riparian habitat has changed in quantity, quality, and plant species composition. Disturbances to the flow regime and prevention of river flooding, combined with the introduction of non-native salt cedar, caused this exotic species to become the dominant plant along the river. Salt cedar has not entirely, but has largely replaced native cottonwood and willow trees (historic native plant species used/needed for nesting willow flycatchers). In most instances, native species, even if planted, could not grow naturally because of the lowered groundwater table, and increased soil salinity and compaction. The large fuel load that salt cedar creates, the oils from its leaves, and dry river channel has greatly elevated the occurrence and risk of fire along the LCR. The increased risk of fire not only threatens willow flycatcher salt cedar habitat, but also remnant stands of native trees.

The most notable change in plant communities along the lower Colorado River is the conversion of native cottonwood/willow forests to salt cedar and loss of mesquite. This change is characteristic of the dramatic interruption of the natural hydrologic regime. Reclamation (2000a) described the continuing changes over the last 20 years (1976 to 1997) where monotypic salt cedar has increased from 35,461 to 55,437 acres, and cottonwood/willow trees have decreased from 8,288 to 5,044 acres. An additional 27,000 acres were classified as mixed-salt cedar/mesquite types in 1997. Monotypic honey mesquite (16,207 to 3,258 acres) and screwbean mesquite (20,783 to 8,966 acres) have also declined.

The willow flycatcher has found salt cedar useful for nesting (Paradzick *et al.* 2000), but a variety of specific vegetation structure and micro-climate features still need to be met before it (or native species) will be used (Sogge *et al.*1997). The specific habitat conditions are not completely understood. Possibly more so than in other less harsh environments, moist soils and/or standing water are needed at nesting sites along the lower Colorado River. Therefore it is not surprising that moist soils are a common component in occupied willow flycatcher habitat along the LCR (Table 12). Additionally, the salt cedar (or native plants) are typically expansive in size, with a dense interior, and largely vegetated from the ground to the canopy (Sogge *et al.*. 1997, McKernan and Braden 1997, 1998, 1999). It is believed that these larger tracts of habitat with moist soils and closed canopies contribute to the desired vegetation structure, solar protection, humidity, and possibly the insect populations for successful nesting. Thus, due to the changes to the river and riparian habitat, only a fraction of all salt cedar (and/or native trees) is appropriate habitat for nesting willow flycatchers. And while the prevention of flood flows and lowered groundwater table certainly prevent native plants from being established, the same conditions are also prevent salt cedar from growing into suitable willow flycatcher nesting habitat.

While known willow flycatcher populations have increased throughout the bird's range since the bird was listed (primarily as a result of increased survey effort), most populations on the LCR remain very small with great distances between them. For example, below Hoover Dam, 66 percent of all willow flycatcher pairs (n=30) exist at Topock Marsh. This is a key issue, because recovery is dependent upon maintaining a well balanced distribution of birds and bringing breeding populations closer together. Increasing the stability of breeding populations allows birds to withstand stochastic events (flooding, fires), prevents isolation and associated threats (cowbird parasitism/predation), and allows exchange of material to promote genetic heterozygosity. The LCR is an important location to maintain distribution and abundance of breeding birds, because it is the common thread between five states (Arizona, California, Nevada, Utah, and Colorado) and other rivers/populations (Pahranagat, Muddy, Virgin, Gila, Bill Williams, Big Sandy, and Santa Maria rivers). Its central geographic location in the birds range likely increases its importance as breeding habitat and a migratory corridor.

The willow flycatcher's current status along the LCR, was considered by Lamberson *et al.* (2000) to be one of the least stable populations in the subspecies' range. Lamberson *et al.* (2000) used existing survey data to provide information on spatial patterns and colonization and extinction rates for individual sites, which in turn were used to simulate the dynamics of the population. In general, the model found that the species may be in jeopardy in areas where the occupied sites are small and widely distributed. This was the conclusion for the willow flycatcher on the LCR and to prevent local extirpation, territories must increase in number and proximity.

IV. EFFECTS OF THE ACTION

In 50 CFR § 402.02, effects of the action are defined as "...the direct and indirect effects of the action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action...." Further, indirect effects are defined as "...those that are caused by the proposed action and are later in time, but are still reasonably certain to occur."

Because the models used by Reclamation are not predictive but are based on past inflow events, it must be cautioned that any of the details on flows and changes in lake elevation are not actual events that will occur at certain years. If runoff patterns are significantly different from those in the past, either because of drought or high precipitation years, the actual outcome in terms of lake elevations and flows will be quite different. It may be possible to have fewer or more surplus declarations, at different Tier levels, than the BA presumed based on the model results. The "certainty" shown in the following discussions should be understood to be based on the model results showing differences between the no-action and California Plan alternatives given the same inflow data and not on any actual future levels. Implementation of the Basin States alternative in place of the California Plan will also affect actual future reservoir levels since the tiers and amounts available as surplus are not the same between the two plans. Please note that all Reclamation model runs are in feet, not metric measure, and have been kept as described in the DEIS and BA.

Changes to Upper Basin development of their water resources will also have an effect on the actual Lake Mead elevations seen over the life of the project and beyond. Reclamation has included all those increases as baseline, however, some portion of those increases may be more correctly interpreted as cumulative or future Federal actions. Because these increases cannot be separated out of the model runs, this discussion includes the Upper Basin depletions under direct and indirect effects. This should not be interpreted as acceptance by the Service of these depletions as part of the baseline, but as a consequence of the type of model data provided in the BA by Reclamation.

Direct and Indirect Effects: River and 100-Year Floodplain

ISC

Implementation of the California Plan will have effects to water levels in Lake Mead, normal contracted releases from Hoover and Davis Dams, flows below Davis Dam to Lake Havasu, and the frequency and volume of flood control releases and space-building releases from Hoover Dam. The latter will affect flows downstream of Davis and Parker dams to the Colorado River Delta in Mexico. Normal contracted releases will not change below Parker Dam because the surplus water provided to the States will be taken from Lake Mead directly (Nevada's share), or out of Lake Havasu (Arizona's and California's share).

Lake Mead

Lake Mead's elevations result from the pattern of yearly inflows (from Lake Powell and the Grand Canyon tributaries) and outflows (releases from Hoover Dam and the Southern Nevada Water Authority diversion). Over the course of a year, elevations will vary by 10-20 feet on average (USBR 1996) as water enters and leaves the reservoir. The median levels generated by the models for the 2000 to 2050 period are for January 1 water elevations. In most recent years, lake elevations are falling from January through May which includes the spawning period of the razorback sucker (February-April). Water levels may fall as much as 3 feet in a month during this period (USBR 1996). Because of past management direction and a series of wet years, Lake Mead's water levels were near capacity at the start of the planning process for this project. Figure 5 demonstrates that water levels over the last 20 years have been lower and higher than present levels.

Please refer to Figure 6 for this discussion. Under the no-action alternative, the median lake level of Lake Mead will fall from 1205 in 2000 to 1171 in 2015, a drop of 34 feet. This drop is a result of the increases in Upper Basin diversions of Colorado River water that reduces the inflows to Lake Powell and subsequently to Lake Mead. This drop in median water levels is gradual at an average of about 2 feet per year. The median water levels for the California Plan alternative fall from 1205 to 1147 feet in 2015, 24 feet more than under the no-action alternative, at an average of about 4 feet per year. The median water levels of the no-action alternative do not reach the 2015 California Plan levels until about the year 2032 and the medians are generally the same thereafter. Looking at the 10th percentile water levels, we see a decline from 1194 to 1130 feet in the no-action alternative, a change of 64 feet with an average drop of 4 feet per year. The California Plan goes from 1194 to 1098 feet in the same 2000-2015 period for a change of 96 feet with an average drop of 6 feet per year. Post-project, it is not until about 2027 that the no-action alternative reaches the 2015 level for the California Plan. Further, for the 10th percentile line, the California Plan has consistently lower elevations than the no-action plan until 2049. What we see in the effects of the action for the median is a doubling of the rate of decline of water levels during the 15 year project duration, a 17 year loss of those higher median water levels being available after the project ends, and an increase in the number of years at lower water levels over the no-action alternative. For the 10th percentile, the rate of decline increases 50% and the two lines retain a 15 to 25 foot difference in elevation until 2045 not coming together until 2049, indicating a longer period of lower elevations under the California Plan.

Another form of the data is in Table 13. This table was generated from the 85 model runs per year (traces) for various Lake Mead elevations. These elevations were chosen for analysis based on known spawning habitat for the razorback. These are the same data used to develop the medians shown in Figure 6. The baseline/no-action alternative (75R) is compared to the California Plan alternative (CP). The data show that the number of traces above the target elevations declines much more rapidly under the CP than the 75R, with the CP figures up to 34% lower than the corresponding 75R figures. While the CP does not show lower overall figures than the 75 R, in part because the lowest target elevation 1,120 is considerably above the 10th percentile range, it reaches these lower levels more quickly and more often in a comparison between years.

These changes translate into different probabilities of a particular water level or set of levels in Lake Mead being met or exceeded. For example, under the no-action alternative, a water level of 1171 in 2015 would be met or exceeded 50% of the time. The same 1171 foot elevation under the California Plan would be met less than 50% of the time in 2015 because there would be elevations above the 1147 median level that are below the 1171 level. An elevation of 1150 would be met more than 50% of the time under the no-action alternative, because it would always be met by the 50% of the points above the median and by that percentage of the below median points that were still greater than 1150. The 1147 median would not be able to meet the 1150 elevation 50% of the time because some of the points in that 50% would be between the 1150 and 1147 levels. Plus, the 50% of the points below 1147 would not be able to provide additional chances to meet the 1150 level because they are lower in elevation. The 10th percentile probability does not change for the 1150 level for either the no-action or California Plan, however, as this level drops, there is an decrease in the water level at which this 10% occurs. This translates to an increase in the range of the lowest 50% of possible levels, thus to more and lower levels being seen below the median level. There is also an increase in the lowest levels of the bottom 10th percentile, as is shown by that level dropping on Figure 6.

Reclamation predictions based on modeling and likely surplus releases over the life of the project do not foresee extended periods of low water levels in Lake Mead as a likely result of the action. The circumstance in question is water levels at or below 1130 feet for more than 2 consecutive years when a surplus is being declared. Thus, such a condition would not be covered under this biological opinion, and if it occurred, would constitute an effect of the action not previously considered.

Razorback sucker

For razorbacks in Lake Mead, these changes in the median and 10th percentile figures will have significant adverse effects to the two known spawning locations in Lake Mead, resulting in lower water levels at these sites and an increased potential for them to be completely dry in some years. If the known habitats are not available, spawning would likely still occur, but the quality of the replacement habitats is not certain.

Based on the 1171 median for the no-action alternative in 2015, the average important spawning elevations (1120-1150 feet) would be protected significantly over 50% of the time until 2025 and still at over 50% until 2040. Spawning habitat would not be entirely subject to the lowest 10th percentile levels until about 2016. Under the California Plan's median of 1147 feet, much less of the known spawning area remains above the median level each year from 2001-2040 and the median hovers at around 1150 for most of the 2015 to 2040 period, and the entire known location is below the 10th percentile by 2011. This would reduce the number of years that known spawning habitats would be available to the fish, which may adversely affect the combination of conditions needed to provide for recruitment. These habitats would not be lost permanently, but would be unavailable more often under the California Plan.

Of additional concern in the Las Vegas Bay area is access to Las Vegas Wash, upstream of the known spawning site. This area is between 1120 and 1200 feet elevation with a considerable portion at the 1160 contour. Spawning has not been documented in this habitat, but sonic-tagged razorbacks do use the area and larvae were found there (Holden *et al.* 1999), and it may be important habitat when it is available. Under the no-action alternative, much of this habitat would be available at above the median 1171 level. Under the California Plan, much of it would not be available at the 1147 median. This would reduce the number of years that known spawning habitats would be available to the fish, which may adversely affect the combination of conditions needed to provide for recruitment. Critical habitat constituent elements for spawning habitats would be compromised more often under the California Plan. These habitats would not be lost permanently, but would be unavailable more often.

Defining the Echo Bay spawning area as between 2013 and 1181, both the no-action and California Plan alternatives have significant adverse effects to water levels at the known spawning area. Under the no action alternative, the 1171 median is 9 feet below the bottom of the area, and there will be less than 50% of the time that the area would be usable. However, the area around the point to the east would remain partially available since the elevation goes to 1148. The situation for the 1147 median of the California Plan is that the known spawning sites would be available far less than 50% of the time with the eastern end availability perhaps at 50%. For the 10th percentile under the no-action alternative, the level is reached in about 2010 and for the California Plan in about 2007. This means that water levels will be lower sooner and this reduces the availability of known spawning habitats more often.

Declining lake elevations due to ISC may also affect potential nursery habitats. Razorback sucker larvae and juveniles use shallow waters in coves and other protected habitats for nursery areas. The waters here are warmer, and food resources more abundant than in deeper areas. These shallows also have an advantage during rising water levels, in that if there has been terrestrial vegetation growing, inundation of the vegetation provides cover for small fish and nutrient loading that benefits phyto- and zooplankton and benthic invertebrates. The amount and quality of nursery habitat is not known at most lake elevations. With reduced inflows to Lake Powell as Upper Basin depletions increase, there may not be the same level of equalization opportunities to offset the greater drain on Lake Mead. That could result in a decrease in the probability of rising spring water levels due to lower Lake Powell water levels, resulting in less opportunity to flood terrestrial vegetation.

A complicating factor at yearly elevations near the bottom of the spawning habitats is the usual pattern of falling lake elevations during the spring months. The median and 10th percentile figures are based on end-of-year figures, and data from Reclamation show declines of as much as 3 feet in March with lesser decreases in February and April (USBR 1996). This trend of declining levels was discussed in the baseline. Therefore, even at acceptable end-of-year elevations, spawning habitats may not be as available during the spawning season. Because additional water will be released from Lake Mead year round, during a surplus year the amount of monthly drawdown may increase.

Razorbacks in Lake Mead, as well as in Lake Mohave and in the Upper Basin, show a high degree of fidelity to spawning sites. The same sites are used year after year by the population. This trait has been used in Lake Mohave to assist in the monitoring of that population over the last 30 years and to direct efforts to locate larvae. Spawning bars in the Green River are similarly targeted by Upper Basin researchers. Known spawning areas in Lake Mohave are generally not subject to the degree of water level fluctuations seen in Lake Mead, and in the Green River, cobble and gravel spawning bars do shift somewhat in response to changes in flows, so it is difficult to assess how far razorbacks will relocate to suitable spawning areas near known sites that are not available in a particular year. A reasonable expectation would be that if suitable habitat was available, it would be used. What is unclear is if suitable habitats are available adjacent to existing sites at the lower water elevations that will be seen in Lake Mead. Razorbacks prefer gravel and cobble substrates, not ones with large amounts of fine sediments that may be present at deeper lake elevations. Further, razorback adults spend the immediate pre-reproductive season in shallow waters that are warmer and may provide benefits for sexual maturation, feeding and other behaviors (SWCA 2000b). Lower water elevations may reduce or eliminate those habitats in the vicinity of the spawning areas. There may be suitable spawning areas along the southern shore of Echo Bay where it reaches the main part of the Overton Arm, but fish have not been recorded using those areas (based on sonic tagging) for spawning at this time. Under different conditions, there may be use, but data are not available. In Las Vegas Bay, suitable spawning habitat in the vicinity of the existing area may not be as readily available due to the topography of the site.

Razorback sucker are long-lived fish, reaching 50 years of age. In the pre-development Colorado River Basin, with its large yearly water level fluctuations, successful spawning and recruitment likely did not occur every year. Water levels might be too high or too low at the proper time to provide suitable spawning and nursery habitats. With long-lived adults, yearly success was not as critical to the survival of the species. In the Upper Basin Rivers, razorbacks spawn on the rising arm of the spring hydrograph (SWCA 2000b). Spawning times in the Lower Basin are earlier in the year, perhaps reflecting a difference in when suitable temperature and rising water conditions were available. Recruitment of razorbacks to the initial Lake Mead and Lake Mohave populations took place at a time when reservoir levels were rising and non-native predator populations were low. Rising water levels inundate vegetated shorelines that may be important for providing food and cover for larval and juvenile fish. Rising water levels have occurred over the 61 years of record (excluding 1935-1939) 15 times, for an average occurrence of once every 4.4 years. Over the last 19 years, a rise in the spring water levels in Lake Mead can be seen in Table 10 for the years 1983, 1986, 1993 and 1997. The 1993 rise may correspond to the recruitment of the four sub-adults captured in 1998. The Echo Bay spawning area was flooded during the spawning season after having been dry the previous 2 years. We do not know if this rise in water elevation was a critical factor to that recruitment event, but it is an anomaly that should be considered. A smaller rise in water elevations is noted in 1986, which is before the other young fish (the 7-10 year old) was perhaps spawned. The existing adult population was thought to have been spawned between the early 1960's to 1970's (Sjoberg 1995), and there are two large water level increases in that period. Aging of razorback suckers becomes more difficult at older ages due to the numbers of false and incomplete annuli. Techniques to refine aging estimates, especially those that do not require killing the specimen, are under review (Holden *et al.* 2000) and may shed light on recruitment years.

This discussion has two relevant points. One, that perhaps ascending water levels during the spawning period is important for recruitment (perhaps through providing nursery habitat), and two, that the opportunity for such increases is limited by normal reservoir operations. Even historically, razorbacks likely did not have significant recruitment every year so conditions need not be perfect every year. The number of years that lake levels start at acceptable levels and can increase is reduced if the median water surface elevation for the lake is lower over time and there are fewer years where water levels start out at an adequate level. With less water reaching Lake Powell due to Upper Basin increased depletions, there is a reduced opportunity for equalization between the two lakes that reduces the opportunity for rising water levels in Mead. The result is that with the California Plan, there is a greater risk of not meeting the conditions for successful recruitment than there is under the no-action alternative. Further, because the California Plan drops the water levels sooner than under the no-action, researchers have less time to determine what the important parameters are before the changes to water elevations become critical.

Overall, fish habitat within Lake Mead will be adversely affected by the lower lake elevations. Depending upon topography of preferred habitat areas, there may be less or more habitats of particular types available. Reduced habitats may result in crowding of razorbacks and non-native competitors or predators into the same spaces. We know from literature reviews that there is a considerable overlap in habitat use and preferences between razorbacks and non-native fish species (Pacey and Marsh 1998). Competition for food and space may result in reduced growth and health of individual razorback suckers. Telemetry data indicate that razorbacks can be very sedentary (Holden *et al.* 1999, 2000; SWCA 2000b) and may rest on the bottom for extended periods. The presence of other fish species, or crayfish, may cause them to move more often if they are disturbed. This can affect feeding and resting behaviors. Parasites such as *Lernea* may be more prevalent in areas with denser populations of fish to act as hosts. Declining water levels will also affect production of benthic organisms, aquatic plants and other important components of the habitat (Ploskey 1983) to the detriment of the fish population as a whole. Given that both important areas for razorbacks in Lake Mead are near existing recreational sites, shallower waters in the area also concentrate the effects of boats and personal watercraft (which include noise disturbances, and wake damage to shallow spawning or nursery habitats), risks to the area from spills or releases of toxic materials and take by fishermen.

Lake Mead has been designated as critical habitat for the razorback sucker. Constituent elements of water, physical habitat, and biological environment are all adversely affected over the next 50 years by both the no-action and California Plan alternative. The additional effects that result from the California Plan alternative cause greater effects over the short- and long-term and increase the level of damage to the constituent elements, especially those associated with spawning and nursery habitat availability and quality.

The 1997 BO addressed the potential for razorback suckers to be transported from the river into canals and other diversion facilities and to pass through dam turbines. Increased diversions by Southern Nevada Water Authority at their Lake Mead pumping plant would occur during surplus years. Sonic telemetry has not shown any use of the pumping plant area by the razorbacks in the Las Vegas Bay area, so this risk may not be increased. If populations in Lake Mead expanded, there may be cause to review this issue. Similarly, increases in water going through the turbines at Hoover Dam would not be expected to result in higher razorback mortality under present conditions since individuals are not known to use the area. Additional information on distribution within the lake may change this; however, to date no concentrations of fish have been found in the vicinity of the dam.

Yuma clapper rail

Lake Mead has only recently been found to support clapper rails. Rails have been found in the Virgin River delta area (McKernan and Braden 1999) and in Las Vegas Wash (NDOW unpublished data). Increased fluctuations of water levels over time may dry up existing or create new marsh habitats, especially in the Virgin River delta. Parts of the Las Vegas Wash marsh habitats supported by high water levels in Lake Mead may also be adversely affected. Depending upon local conditions and the rate of change of water levels from year to year, there may be more or less habitat available in any particular year. Cattail and bulrush habitats can develop relatively quickly if they are near to existing marshes and both areas may continue to support habitat at lower lake elevations if there are sufficient mud flats for cattails to colonize. If there are significant yearly fluctuations that inundate newly formed marshes at the low water elevations, replacement of affected habitats could be questionable in some years. As water levels decline, cattail areas may be left on dry land and degrade. Depending on how fast the water levels decline, new habitats may not be formed at the edges of old areas to preserve habitat availability. This would result in a lack if breeding, feeding and sheltering habitat for the rails.

Southwestern willow flycatcher

Surplus criteria will lower the level of Lake Mead which may allow willow flycatcher habitat to develop in the Virgin, Muddy, and Colorado river inflows. However, the amount, type, quality, and longevity of this habitat will be in question depending on how much soil is exposed, the quality of the soil, when draw downs occur, and how long habitat is exposed and/or inundated. Hydrologic modeling conducted by Reclamation (USBR 2000b) predicts that Lake Mead elevations will fluctuate between full level and progressively lower levels during their 50-year period of analysis. Therefore, there may be a possible benefit from the proposed action, that by lowering Lake Mead, willow flycatcher habitat will develop at the Colorado, Muddy, and Virgin river deltas of Lake Mead. Yet, it is unknown how long this habitat will persist, if it develops at all. Reclamation has already consulted on the loss of willow flycatcher habitat within the influence of Lake Mead and those birds via the 1997 BO and provided replacement habitat to offset the periodic loss of this area. Thus, the willow flycatcher may obtain a temporary benefit from having this habitat occasionally available and at worst would not be worse off than at present if it is eliminated.

Hoover Dam to Parker Dam

Releases of water from Hoover Dam during a surplus year will be higher than in a non-surplus year. This would affect all species present in this reach. The amount of the increase would depend on the amount of surplus, estimated to be around 800,000 af during a Tier 1 year. This would add at most approximately 9% to the flows between Hoover and Parker Dams. Since these releases would be for municipal and industrial uses, it can be assumed that equal amounts would be released over the year to keep the MWD aqueduct full. This would mean an increase in releases of up to 1105 cubic feet per second (cfs) into Lake Mohave. Water levels in Lake Mohave may increase slightly, but there would not be meaningful changes since water would be released immediately to provide for this flow downstream. Water releases from Davis Dam are made to provide downstream demand and generate power. Thus, flows vary significantly over a 24-hour period. Water levels in the reach from Davis Dam to Lake Havasu may increase slightly or be at higher levels for longer periods. The specific release patterns are not detailed in the DEIS or BA. This change may be more noticeable in the winter low flow period when releases vary between 4,000 and 14,000 cfs over a day than the high flow periods when releases vary between 10,000 and 27,000 cfs (USBR 1996). Higher or more sustained high flows in the Davis Dam to Lake Havasu reach will result in higher water velocity in the main channel, and perhaps more movement of sediments within the unarmored sections of the river bed that may result in more scouring and channel deepening. Much of the upper end of this reach is armored and the channel is at equilibrium. Further downstream there is still considerable bedload and equilibrium has not been established. Anything that deepens the river channel will also affect the water level in marshes and backwaters as well as groundwater in the floodplain. Higher flows may also provide better circulation of water within the backwaters and marshes found along this river reach. Benefits due to refreshing flows may be negated if the river channel deepens, dropping the water level for these habitats and causing degradation. If new flow release patterns have greater fluctuations, greater oscillation of water elevations in the channel and backwaters will result. This effect would be attenuated as the water moves downstream toward the head of Lake Havasu but the attenuation may not occur as quickly. Maintaining oscillations causes shallow habitats to dry out and be temporarily lost.

Bonytail chub and Razorback sucker

Razorback sucker populations in this reach of the river are increasing, probably because of fish moving up from Lake Havasu. Mueller (2000a) has reported young adult razorbacks schooling with the adult flannelmouth suckers in this reach. Spawning has not yet been documented, but is likely as the young stocked fish mature. The flannelmouth population here has recruitment, and it is not known if the factors enabling that recruitment will also provide for razorback recruitment; however, there is a difference in spawning times that may be significant since razorbacks spawning earlier than flannelmouth suckers (Mueller 2000b). Razorback spawning and nursery habitats may be disrupted due to changes in flows and fluctuations, with losses to eggs and young fish. Drying of backwaters also interferes with adult cover and feeding since benthic areas are dried and inundated repeatedly which may reduce benthos and amount of time to utilize these resources.

Over time, as the Lake Havasu bonytail population increases, these fish may move into the reach between the reservoir and Davis Dam and be subject to the same effects as razorbacks. Wild bonytail chub were captured in this reach (USFWS 1990) until the 1970's and may be expected there in the future. There is no information on spawning habitats for the bonytail in the LCR outside of the reservoirs, so it is not clear if there could be effects to spawning in this reach during the 15-year project period.

Surplus water would be removed from the system at Lake Havasu, and effects to the reservoir elevations are not expected. Because the MWD aqueduct currently runs full with unused apportionment and other waters, the removal of surplus water via the aqueduct is not expected to increase the risk to fish of being transported out of the river to California because there is no increase in diversion. If the aqueduct is not filled by MDW apportionment and surplus, then there may even be a decreased risk to fish entrainment; however the project description has the aqueduct full. Increased diversions to Arizona of surplus water do increase the risk of fish being transported into the CAP canal. This may not be significant for razorback and bonytail until populations in the lake increase.

Yuma clapper rail

Marshes are equally susceptible to water oscillations and nesting clapper rails can only tolerate fluctuations that do not drown out nests. The primary clapper rail populations in this reach of the river are at the bottom end at Topock Marsh and Topock Gorge. Water level oscillations are generally flattened out by the time waters reach these areas, and the Marsh is protected from river effects by inlet and outlet structures. Effects to rail habitat in those areas are not expected to occur. Rails in the Laughlin Bay area, nearer to Davis Dam, may be subject to greater fluctuations and effects from daily oscillations and habitats may become less usable due to the fluctuations. Increased oscillations affect the availability of food and cover for the rails.

Southwestern willow flycatcher

Effects to the willow flycatcher habitat in this reach are not expected to be significant since groundwater levels are not expected to change unless there is additional channel incisement. If that does occur, there could be changes to groundwater levels that would affect riparian habitats and thus degrade willow flycatcher habitat.

Parker Dam to Imperial Dam

Normal water releases below Parker Dam would not be directly affected by surplus water releases unless some of the designated surplus is being used by a diverter in this reach. Under Tier 1 and Tier 2 releases, there is some availability of water for agricultural purposes and most of the major agricultural diversions are below Parker Dam. Since the ISC is primarily a tool for providing water to MWD, it is not likely that large amounts of water for agricultural uses will be available to cause an increase in river flows.

What will be affected by the ISC will be the probability of flood control and space building releases from Hoover Dam. Space building releases are those which provide the necessary amount of storage space that needs to be available in Lake Mead at certain times of the year. Currently, Reclamation attempts to match up contracted water releases with the need to maintain storage space, but higher than requested flows are sometimes needed to provide for required space. Since Reclamation cannot release water without a beneficial use, these excess releases are destined for some use within the system. The volume of Lake Mead needed for flood control will be within the area defined as containing the surplus under the California Plan, so what would have been space building releases will become surplus releases. Releases in excess of 19,500 cfs below Parker will be reduced 0.9% (13.9 to 13.0%), which is actually a 6% reduction from the no action under the California Plan over the 2000-2015 period and 1.8% (19.7 to 17.9%), which is actually a 9% reduction from the no action under the 2016-2050 period. The probabilities of such flows is not high even without the ISC so the reductions are more significant to the river environment than may first appear. Flood release criteria start at 19,500 cfs and go up to 73,000 cfs. Reclamation attempts to release these higher flows in concert with downstream water needs so no “excess” water is put into the system. Flood control releases also provide for diversion of water by water contract holders along the system. Thus, even at higher flood control releases, the river does not see uniformly high flows and determining the effects to the system of a reduction in the probability of those flows becomes very difficult. There are some general observations of the effects of higher flows that can provide insights for the analysis.

At relatively lower high-flow levels, there is a change in velocity and pattern of releases. There may be fewer hourly or daily oscillations due to the need to not back up water in the system. This causes changes to bedload transport and channel armoring/equilibrium. Erosion and deposition patterns experience local changes. Higher water levels provide additional water exchange to backwaters and marshes and sustained high flows increase groundwater levels near the river channel. If these flows occur at the proper time of the year for cottonwood or willow seeds to be present, then regeneration of native riparian plants may occur in saturated soils.

At very high flow levels, because of the effects of past channelization, the effects to the river ecosystem are generally adverse. Very high flows cause significant channel degradation and aggradation that may reach several feet. In lowered channel areas, backwaters and marshes are dried out and degraded. Groundwater levels in these areas decline as a result. In aggrading areas, marshes and backwaters may be filled and lost but groundwater may rise under the floodplain. This phenomenon was noted in the 1980's and early 1990's high water events. Although high flows were characteristic of the pre-development Colorado River, the maintenance of the managed river prevents the beneficial effects to habitat replacement and recreation from high flows from operating.

Bonytail chub, Razorback sucker, Yuma clapper rail

Under the ISC, there will be fewer high level flood releases, but the range of water levels that would occur will not change (as shown by the unchanging 90th percentile line). Within the US reaches of the river, there will be fewer opportunities for both lower high flows and higher high flows, thus there will be benefits (in terms of fewer destructive flows) and adverse effects (in terms of lower beneficial flows) as a result. For razorbacks, bonytails (once the population is established here), and clapper rails in this reach, there will be effects to habitat quality and quantity. Lower frequency of beneficial flood flows may result in reductions of water quality in backwaters as there is less opportunity for movement of water through them. This affects the quality of fish habitat, and the habitat for prey items of the clapper rail. The number of damaging floods may decrease, thus reducing the deposition of large amounts of sediments in backwaters that cause them to dry up. Less channel degradation from the high flows may also protect existing backwaters by protecting water levels that support them. Because of the magnitude of these changes, the effects to these species are not significant, however, this is predicated on the fact that the normal flood cycles have already been severely impacted by past actions.

Southwestern willow flycatcher

For willow flycatchers, the effects of ISC in this reach involve groundwater levels. Higher river flows during space-building or flood control releases translate into higher groundwater levels under the floodplain during those time periods. This provides more water and moist soils for riparian habitats and when they occur there are benefits to the trees and shrubs that may influence the suitability of these habitats for willow flycatcher breeding in those years. Lingering benefits to riparian vegetation may last past the decline in water levels if trees became better established and able to cope with drier conditions as a result. Because these higher than normal flows will be more curtailed under the ISC than at present, any beneficial effects would be reduced in scope until Lake Mead elevations recover from the additional releases.

Imperial Dam to Southerly International Border

Normal water deliveries past Imperial and Morelos Dam will occur as a result of this project. Reduction of flood flows from the Colorado River, which are currently reduced as a result of damming, are expected to be reduced even further, but at an insignificant amount (about 5%). This reduced percentage is not expected to have any noticeable change to habitat for the clapper rail or the willow flycatcher. Flood flows entering the Colorado River from the Gila River will not be affected from the proposed action and these exercise greater effects on this reach of the river.

Applicable Conservation Measures for ISC

As part of the proposed action, there are several conservation measures designed to reduce the adverse effects of the proposed action on listed species. For the ISC, the species of special concern is the razorback sucker. The conservation measures have been listed previously in this biological opinion. The effects are discussed in this section.

Continuing and expanding the ongoing research on the Lake Mead razorback population will assist in the survival and recovery of the species by answering questions about the recruitment and the events that may be controlling it. Providing for recruitment is the primary focus of razorback sucker recovery efforts. While in some portions of the historic range of the species flowing rivers remain, much of the habitat in other portions of the basin have been modified by dams. Adult razorback sucker populations do well in reservoir situations and, if factors that provide for recruitment to those populations can be identified, these reservoirs could make significant contributions to recovery.

Reclamation would use its discretion under existing programs to provide rising water levels during the spring in Lake Mead. Research into razorback recruitment needs to have years of rising water levels during the spawning period to assist in defining physical conditions during recruitment events. This effort to provide rising water levels may also offset to some extent the foreseen decrease in lake levels and number of rising water level years attributed to reduced inflows to Lake Powell from the increased uses in the Upper Basin.

Although Lake Mohave is not expected to be affected by the proposed ISC or 4.4 Plan, Reclamation will continue to operate Lake Mohave water levels for native fish conservation.

This will provide long term protection for the native fish propagation programs ongoing in Lake Mohave. These programs provide for the maintenance of genetic variability in the species that is needed for reintroduction and augmentation programs throughout the range of the species.

Loss of spawning and nursery habitat due to lowered lake elevation reduces the potential for recruitment by reducing the available physical habitat. Therefore, Reclamation will minimize the effects of that loss after years when the ISC would cause the lake elevation to be below 1160 feet by collecting wild born larvae the next spawning season after the event, rearing them to stocking size (25 cm), and returning them to the lake as sub-adults. These individuals would be tagged to distinguish them from the wild-born and recruited members of the population. Because of the uncertainty about numbers of recruitment events and the number of fish that result from such, the number of fish that might be lost cannot be quantified. Further, these losses of habitat make it more difficult for the research effort to study recruitment events because some critical feature may be lacking or reduced below viable levels. However, the population augmentation proposed by Reclamation would increase the number of potential spawners in the future, which would benefit the population and assist in monitoring. These additional sub-adults may actually augment the population in Lake Mead, provided that more fish are stocked than what would have recruited naturally. The Lake Mead and Lake Mohave razorback populations have been separated for 65 years and using Lake Mohave stock for these repatriations is not likely to have any adverse effects to the genetic variability or special adaptations in the Lake Mead fish.

Complete loss of spawning habitat in more than 2 consecutive years is not anticipated for the proposed action. Based on existing data, below the 1130 level most of the known spawning habitat is out of the water, resulting in displacement of spawning adults from the known spawning area. With the ISC, although reduced lake levels are anticipated, Reclamation does not believe that the effects of ISC would be severe enough to cause lake levels of or below 1130 to occur greater than 2 consecutive years, and therefore we did not include this case in this analysis. If this situation were to occur, it would be considered an effect of the action not considered in this biological opinion.

4.4 Plan

The implementation of the change in point of diversion for the 400,000 af of water under the 4.4 Plan will not affect overall releases from Hoover Dam, however, the timing of the releases will be different. Agricultural releases vary seasonally more than M&I uses therefore, as with ISC releases, it can be assumed the changed releases will be equalized over the year. This will result in a change of up to 552 cfs in Hoover Dam daily release levels. Summer releases may be less than under current conditions (because normal summer releases are high) and may be higher under the winter conditions (when releases are generally lower). Effects to the reservoir and river levels above Parker Dam are therefore going to be seasonally different and, due to the actual size of the change, difficult to detect in this reach. Below Parker Dam is where the effects of this change will be most apparent. These effects will occur over time, as the amount of water diverted at Lake Havasu is increased. This increase is seen in 20,000 af yearly increments.

The DEIS and BA contain tables showing the decrease in water levels for groundwater and river elevations based on the change in point of diversion below Parker Dam. The model results are based on 100,000 af increments of the total 1.574 maf that could have a change in point of diversion as part of the MSCP. The 400,000 af is a portion of this total and is the only part analyzed here.

Parker Dam-Imperial Dam

Bonytail chub, razorback sucker and Yuma clapper rail

Because of the seasonality of normal release levels, Reclamation has evaluated three release patterns (April, August and December). The greatest effect, as well as the greatest potential time for adverse effects to occur to razorbacks and clapper rails, was in the April time period. The change in point of diversion for 400,000 af of water will result in the loss of 35 surface acres of open water in the main channel, 17 surface acres of open water in backwaters and 28 acres of emergent vegetation in backwaters. These losses would occur incrementally over the implementation of the transfers. These losses would eliminate that amount of habitat from the system.

Changes in flows and water surface elevations resulting from those flows can affect habitat values for razorbacks and any future bonytail population. Increased fluctuations can strand fish or expose spawning areas causing death of eggs and just hatched young fish. This area is critical habitat for the razorback sucker, and changes to constituent elements of water and physical habitat are expected to occur due to declining water levels. Declining water levels force fish into deeper water where there may be less cover and protection from predators. Exposure of shallow areas also reduces the benthos and may affect the ability of fish to feed and remain healthy. Shallow waters also become very hot in the Colorado River, and reduced water quality may make preferred backwaters less able to support fish over the entire day or even the season.

Clapper rails nest and feed in shallow waters. They do not prefer areas with wide fluctuations, which damage nests and potentially injure eggs and young birds before they leave the nest within 48 hours of hatching (Rosenberg *et al.* 1991). Fluctuations may also make some habitats more susceptible to terrestrial predators. Shallow water is crucial for feeding, and clapper rails do not dive for prey. Depending upon the slope of the backwater or shoreline area, wide fluctuations may significantly reduce potential feeding habitats or make prey more difficult to catch.

Effects to razorbacks and clapper rails from the 4.4 Plan water transfers below Parker Dam are more significant than the changes in the same reach caused by ISC. The future reintroduction of bonytail chub to this portion of the LCR would also be affected if habitats were reduced or compromised. Additionally, one of the most successful rearing areas for bonytail is the High Levee Pond on the Cibola National Wildlife Refuge. The pond is kept filled by the adjacent river, and reductions in river elevation have an effect on this pond's water level. Reductions may have adverse effects to production of food resources and changes in water quality that affect health and growth of the fish present. Considering the difficulties that have been plaguing the bonytail reintroduction program, compromising the ability of High Levee Pond to contribute to the survival and recovery of the bonytail may reduce the ability of ongoing programs to meet their goals.

Southwestern willow flycatcher

Between Parker and Imperial dams, approximately 21,218 acres of riparian habitat (cottonwood/willow types I, II, III, IV, and saltcedar types III and IV) exist which have the structure to be, or develop into willow flycatcher habitat (USBR 2000a). Reclamation (B. Raulston, USBR, pers. comm.) indicates that all currently suitable habitat (1570 acres in 15 study areas) has been identified and surveyed for willow flycatchers.

The change in points of diversion (less water traveling between Parker and Imperial dams) will cause a drop in groundwater levels of 1.55 feet or less. It is uncertain how this drop in groundwater will affect existing occupied and potential willow flycatcher habitat. Experts agree (McKernan and Braden 1998, Sogge *et al.* 1997) that moist soils and standing water are important micro-habitat components of willow flycatcher nesting habitat, and are present at all occupied habitat between Parker and Imperial dams (Table 12). Moisture in the soils likely benefits the distribution, abundance, and success of willow flycatchers at a site by providing the proper humidity, ground cover, solar protection, and/or insect populations for food. In addition to soil moisture problems, newly established cottonwood and willow stands (classified as types V and VI) would also be adversely affected due to their recent establishment and shallow roots. There are 46 known acres of this type V and VI habitat which are expected to be influenced by the proposed action.

As a result of the proposed project, Reclamation (2000a) estimates that 372 acres of occupied willow flycatcher habitat could lose its moist soils. This could occur at 11 of the 15 study areas (Table 12). The BA assumed that the gross plant composition (cottonwood and willow trees) in occupied habitat will be affected by any change in groundwater level due to the groundwater table being relatively high in these areas (which is why moist soils are present). The changes in soil moisture will not occur immediately. Rather, it would likely occur at some point throughout the life of the project. Therefore, it is uncertain when a change may occur. But if moist soils are removed from the site, we expect this change will affect the distribution, abundance, occupancy, prey base, and breeding success of nesting willow flycatchers.

The potential impacts of the project and risk to the willow flycatcher are significant because a large proportion of the current willow flycatcher population along the LCR and nearly all the sites and birds between Parker and Imperial dams will be affected. In 2000, there were a total of 45 pairs along the LCR below Hoover Dam. Thirteen of these 45 pairs exist between Parker and Imperial dams, and 9 of these 13 resident willow flycatcher pairs could lose moist soils in their nest areas. Therefore, 20 percent (n=9) of all the pairs (n=45) below Hoover Dam and 70 percent (9/13) of all pairs between Parker and Imperial dams could be negatively affected by the project.

Additionally, 11 of the existing 15 areas where suitable habitat exists could be rendered partially or completely unsuitable.

Dropping the groundwater level is also expected to delay willow flycatcher recovery and cause recovery to be more difficult by further degrading potential riparian nesting habitat in the Colorado River floodplain. Groundwater levels have already been dramatically lowered along the floodplain, thus some mature existing plants (salt cedar, mesquite) are not expected to show any detrimental effects from the project due to their deep roots being established. However, cottonwoods and willows are most susceptible to changes in groundwater elevation.

Reclamation estimated that there are 5,404 acres of potential willow flycatcher habitat between Parker and Imperial dams that could be influenced by the drop in groundwater level. The nature, extent and timing of effects is difficult to determine. For some areas with established vegetation, the effect may be on the ability to sustain or develop moist soil conditions**.** Depending on how long the drop in groundwater takes, plants whose roots are barely established in groundwater may also be affected if the water escapes their reach.

It is clear than continuing to drop groundwater levels in the floodplain further reduces the ability to restore these 5,404 acres to suitability for nesting willow flycatchers. As described above, nesting habitat is dependent upon the density, vigor, structure of plant species and microclimate of sites. High groundwater levels are a key component of healthy and expansive riparian habitat for willow flycatchers. Continuing to drop groundwater levels reduces the restoration potential of this acreage and moves a large amount of habitat further away from suitability and eventual recovery. As stated in Reclamation’s analysis in their BA (2000a); “although this habitat is unsuitable at this time, it could be improved with appropriate management in the future.” Therefore, the proposed project will continue to degrade what is already a poorly functioning ecosystem along the LCR below Hoover Dam.

The Colorado River is an important location to maintain the distribution and abundance of breeding willow flycatchers, because it is the common thread between five states (Arizona, California, Nevada, Utah, and Colorado), other rivers/populations (Pahranagat, Muddy, Virgin, Gila, Bill Williams, Big Sandy, and Santa Maria rivers). It is a central geographic location for a breeding habitat and as a migratory corridor allowing birds to reach other portions of the range.

The primary effects to the willow flycatcher from Reclamation’s ISC and 4.4 plan are from lowering groundwater levels between Parker and Imperial Dams. Lowering of groundwater levels may remove the moist soils underneath occupied willow flycatcher habitat (372 acres), thus changing micro-habitat qualities at 70 percent of all the occupied sites between Parker and Imperial dams. This loss of moist soils could lead to a decrease in the occupancy, distribution, success and/or abundance of nesting willow flycatchers. Lowering the groundwater between Parker and Imperial dams may also reduce the quality of thousands (5,404) of acres of “potential” willow flycatcher habitat in the Colorado River floodplain by degrading, modifying, and fragmenting this habitat even further from its already poor condition.

The effects from the change in point of diversion on occupied and potential willow flycatcher habitat, for all practical purposes, will be permanent. As a result of the proposed project, recovery of these habitats to willow flycatcher suitability will be delayed even longer, cause recovery to be more difficult, and further degrade the lower Colorado River ecosystem.

Applicable Conservation Measures for 4.4 Plan

The loss of potential spawning habitat in the mainstem from the reduction in river flows is difficult to measure. Considerable areas of gravel bars exist and, with changing flows, erosion and deposition events will be affected as well. The existing razorback population in the affected reaches is very low, and spawning and nursery areas are not used to capacity by the existing population. Assuming the survival figures for razorbacks stocked into Lake Mohave are similar to those for the river, the 50,000 fish stocking commitment under the 1997 BO would result in a population of 17,000 adult fish. The stocking of 20,000 sub-adult razorbacks below Parker Dam would provide for a larger and more robust population in this reach. The additional 20,000 would bring that to approximately 24,000 adult fish. This larger population may be more efficient in fully utilizing available habitats and provide for more effective monitoring and management actions in the future.

Replacement of 44 acres of backwater and marsh habitats will offset the physical losses expected to those types of habitats from the change in point of diversion of 400,000 af of water and flood flow changes from ISC. These new habitats would be in place within 5 years, before adverse effects of the water transfers would be anticipated. Specific locations for the new habitats is not known at this time, but will be located in the LCR. There would be no net loss of habitat, however, existing habitats would be smaller and perhaps less suitable as a result of the lower flows and those effects are not offset by the new or restored habitats. These new areas would have to be designed so as not to be adversely affected by the future flow reductions that could render them unsuitable. These habitats will be used by razorback, bonytail and clapper rails.

The bonytail initiative is directed to capture more wild bonytail for inclusion in the broodstock and it’s importance cannot be understated. Our ability to capture such fish would be enhanced by understanding their behavior in the wild. We know that some stocked fish have survived to adulthood and been captured with wild born fish. Increasing our opportunities to locate and capture fish to maintain the genetic integrity of the species benefits both survival and recovery. This measure offsets effects to future potential bonytail spawning in the Davis Dam to Parker Dam reach and the Parker Dam to Imperial Dam reach of the LCR. The option to fund operations at Achii Hanyo Fish Hatchery instead of capture wild fish is equally valid for bonytail conservation. There is a bottleneck in rearing bonytails to stocking sizes that must be addressed for ongoing and future augmentation and reintroduction efforts to be successful.

For the willow flycatcher, the extent to which the proposed action will result in the loss of nesting habitat components between Parker and Imperial dams has been estimated using models and assumptions about effects to moist soils from declining water levels. This is further confounded by the long term implementation of the project (20-25 years) and the possibility that adverse effects may be seen only decades from now or possibly not appear at all. Should adverse effects never occur from the water transfers, the conservation measures proposed are expected to provide benefits to the willow flycatcher in the form of 372 acres of new habitat. If effects begin to appear, the monitoring and management strategy is expected to identify and reverse the problems associated with the loss of soil moisture in occupied willow flycatcher habitat. Should even these management efforts fail, additional habitat development will occur, with a maximum of 1116 acres of new habitat provided, to reduce and minimize the effects of habitat loss from the proposed action.

Because of the uncertainty in our knowledge of how to create habitat that will be occupied by willow flycatchers, and the uncertainty inherent in modeling of effects to soil moisture, the Service believes it is appropriate to also include a "worst-case" scenario as part of the incidental take statement. In the "worst-case" scenario, all 372 acres of occupied habitat are lost. We do not expect that, if the conservation measures are implemented, this would happen, but in making the assumption, are providing an option to cover any take that might occur.

The Service supports using the status of the LCR population below Lake Mead to determine which Tier Two conservation measures to implement. As indicated earlier in this opinion, this population is considered the least stable of all southwestern willow flycatcher populations (Lamberson *et al.* 2000) and must be improved. Additionally, recovery of the flycatcher is likely dependent upon increases in the number of flycatcher pairs, and proper distribution of breeding flycatchers. Thus, the LCR is important for the overall stability of flycatcher populations throughout its range.

The proposed conservation measures provide the road map, but not the details to implement an appropriate decision-driven monitoring and management strategy. For Reclamation and the Service to assure a mutual understanding of how the monitoring and management strategy will occur and when certain benchmarks are reached, our agencies need to agree to established standards and terms.

Direct and Indirect Effects: Delivery Areas

Defining the magnitude of indirect effects in the delivery areas does not require that the proposed action be the only causative factor in those effects, only that it be a factor. We understand that Reclamation and the applicants do not concur with our determination that the proposed actions may contribute to growth. However, we believe that these effects need to be mentioned in this BO. Given the level of existing growth that depends upon the presence of Colorado River water, and the documented future growth, there is a likelihood that these effects will exist.

ISC

There should be no direct effects of the ISC to areas outside of the river channel and 100-year floodplain of the Colorado River and its reservoirs. There will be indirect effects of providing this surplus water to the water delivery areas in the three states.

The area of Colorado River water use in Nevada is contained within Clark County. There is an ongoing Habitat Conservation Plan (HCP) (Regional Environmental Consultants 1995) that covers urban and suburban growth in the county that would address any developmental indirect effects of the additional surplus water provided for Nevada.

The Central Arizona Project (CAP) is the likely sole beneficiary of surplus water in Arizona. The majority of the CAP construction and operation has completed consultation under the ESA and the remaining portions are under consultation at this time. Providing surplus water over the 15 year period will increase the certainty of supply, as it is likely that Arizona will store much of the water it obtains to make up for post-2015 shortage year deliveries. Having this water in storage will provide respite for native groundwater supplies at those times since pumping needs would be reduced during shortage periods.

California is the primary beneficiary of the ISC. As noted in the BA, the surplus water is not additive over the amount of water currently available for municipal and industrial use, but it will ensure that current amounts do not decrease markedly in the future as they otherwise may have without the ISC. As such, surplus water may be viewed as serving the future growth that depends on maintenance of the current levels of water supply. Significant portions of the southern California delivery areas are already covered by existing HCP permits, and any growth in those areas will be authorized through those HCP permits. In other portions of the water delivery service area, HCPs (Riverside, Coachella Valley, the San Diego Multiple Habitat Conservation Program and Multiple Species Conservation Program North) are in preparation and are anticipated to be permitted within the next 3 years (in approximately 2004). Effects to listed species in the agencies' service areas would be covered by existing and developing HCPs and by other plans and consultations for projects in those service areas.

4.4 Plan

Only California is affected by the 4.4 Plan water transfers. Effects to MWD and SDCWA service areas would be covered by existing and developing HCPs and other plans and consultations for projects occurring in those service areas. Effects to the IID service area are being addressed in a HCP and EIS/EIR currently under development. The CVWD has begun discussions with the Service on effects in their delivery area which will be addressed by a separate HCP or by participation in the Coachella Valley Multiple Species Habitat Conservation Plan. The IID's and CVWD's efforts will cover effects to the clapper rails and desert pupfish at the Salton Sea that result from the proposed action. If the IID and Coachella Valley HCPs are completed as anticipated, we do not expect that this action will lead to effects on species that have not already been authorized at a regional level.

Interrelated and Interdependent Actions

Interrelated actions are part of the proposed action that depend on the action for their justification, and interdependent actions have no independent utility apart from the proposed action. The Service has not found any actions that qualify as interrelated and interdependent to the ISC and water transfers. The remainder of the 4.4 Plan not included in this consultation is more properly considered under cumulative effects and future Federal actions to be subject to future consultation.

Critical Habitat

Effects to constituent elements of designated critical habitat for the razorback sucker include changes to water quality and quantity and loss of physical habitat used for spawning, nursery areas, feeding and sheltering areas. The ISC will adversely affect the availability of known spawning habitats in Lake Mead through lowering the water levels that may leave these locations less available in significantly more years than under the no-action alternative. Shallow waters near the known spawning habitats that provide nursery areas would also be unavailable at these lower water elevations. The conservation measure for rising water levels would offset some of these effects. Unless the water levels go to below 1130, it is not expected that spawning and nursery habitats would completely be lost in any year or subsequent year. Water levels caused by ISC below those levels for over 2 consecutive years are not considered part of the proposed action under consultation.

Changes to flood flows downstream of Parker Dam due to the ISC would reduce water quality in backwaters, which affects the usability of these areas for feeding and sheltering as well as for nursery areas. Losses to backwaters from the 4.4 Plan would be offset by the creation of new areas under the conservation measures, thus there would not be a loss to constituent elements of physical habitat and water quality. However, the effects to spawning habitats in the main channel from the reduction in flows is not covered by the replacement habitat. Additional augmentation of the below Parker Dam population will offset some of the effects to spawning habitats.

V. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

The size of the action area for this consultation precludes having detailed discussions of the actions likely to occur in the foreseeable future. We can, however, discuss in general terms the types of activities that are likely to occur, based on continuation of existing actions and likely future development.

The primary cumulative effect to the LCR and its floodplain is the continuing diversion of 7.5 maf each year by the three Lower Basin States. Data provided by the States for the DEIS show the intent is to continue taking their full apportionments each year for the foreseeable future. The proposed depletion schedules and immediate need for this water to support existing development make these diversions a reasonable certainty. Uses for water along the river for M&I and agriculture, with their respective return flows, will continue to affect water quality in terms of salinity, selenium levels, nutrient loading and changing flow levels. Larger changes in river flows result from the major diversions to the use areas away from the river where no flows return at all. Because this 7.5 maf of water is removed from the system, it does not back up behind the dams requiring more frequent flood releases and precludes the natural hydrograph from occurring. Natural river processes of meandering, marsh and backwater creation and destruction, and development of riparian areas are largely precluded. Because the river channel must act as a conveyance structure and not a natural river, these natural processes must be precluded from re-developing riverine habitats as was the case before diversions took the water.

Water levels in Lake Mead are significantly affected by increasing depletions from the Upper Basin. Some of these depletions are baseline, having completed section 7 consultation. Some are not, but may also have a Federal nexus and be subject to individual consultation so do not qualify as cumulative actions for this analysis. Other depletions may occur based solely on State use of its apportionment and are cumulative in nature. Information is not available to separate the three types of future depletions for this consultation. Because of Reclamation's modeling inputs, the cumulative effects of these actions have already been included in the effects of the action. This consultation may represent the first time effects to Lake Mead are correlated with new depletions in the Upper Basin and how this issue is addressed in the future is unclear.

The MSCP for the LCR has completed a list of cumulative actions along the river and 100-year floodplain for their EIS development (Ogden 2000). The cumulative effects for ESA are likely a subset of these developed for NEPA compliance because of differences in projects and regulatory needs. This list includes many new housing developments, a landfill, bridges and roads, parks and recreation facilities, wastewater treatment facilities, power plants, fish and wildlife management actions, and other activities and is incorporated by reference. The effects of some of these projects is in the conversion of agricultural water uses to urban and suburban uses which changes the delivery amounts and timing. However, because these may involve changes to water service contracts, Reclamation may have some limited discretion, thus moving these changes to future Federal actions. Again, the discretion is in the delivery of water to a designated location, not in the actual diversion of that water from the river.

Within the three-State action area, urban and suburban development is going to increase. The limitation on water supplies from the Colorado River may eventually have an effect on this growth, however, we do not know when or how this will occur since there are a variety of other water sources available for use. Effects to endangered or threatened species in these areas may require future HCP development in areas where such programs do not currently exist.

The in-state components of the 4.4 Plan may have effects to existing water supplies and uses in California. The extent of these effects is not predictable at this time and will be addressed in future compliance actions. There are also some concepts in the 4.4 Plan that will require future Federal action and those will be handled under separate section 7 consultation as appropriate. These items include overruns, and delivery accounting methods.

VI. CONCLUSION

After reviewing the current status of the bonytail chub, razorback sucker, Yuma clapper rail and southwestern willow flycatcher, the environmental baseline for the action area, the effects of the proposed actions including conservation measures, and cumulative effects, it is the Service's biological opinion that the proposed actions are not likely to jeopardize the continued existence of the bonytail chub, razorback sucker, Yuma clapper rail, and southwestern willow flycatcher or result in the destruction or adverse modification of critical habitat for the razorback sucker in the LCR.

This conclusion is based on the level of adverse effects to the listed species and critical habitat that remain after conservation measures included in the proposed action are implemented. For the bonytail chub, provisions to enhance the broodstock and captive rearing facilities may even provide a net benefit to this species. For the razorback sucker, provisions to study and potentially assist recruitment events in Lake Mead will be important to future management of this species. Additional augmentation of the population below Parker Dam, replacement of backwater habitats lost, and the opportunity to maintain or enhance conditions in Lake Mohave for this species are also significant to the finding. Significant adverse effects to constituent elements of critical habitat, especially in Lake Mead do not occur within the scope of the proposed action under consultation. Effects to Yuma clapper rails are largely negated by the replacement of marsh habitats lost to changing water levels due to the changes in points of diversion. Under the terms of the conservation measures, effects to occupied southwestern willow flycatcher habitat are likely to be avoided, or lost habitat will be replaced.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such and extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be undertaken by Reclamation so that they become binding conditions of any grant or permit issued to the applicants, as appropriate, for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity covered by this incidental take statement. If Reclamation (1) fails to assume and implement the terms and conditions or (2) fails to require the applicants to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Reclamation and/or the applicant must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(i)(3)]

Amount or Extent of Take Anticipated

The Service has developed the following incidental take statement based on the premise that the amount of take will not jeopardize the continued existence of these species.

Bonytail chub and razorback sucker

The majority of incidental take for the proposed action is expected to be in the form of harm through habitat loss. The types of take likely to result from the implementation of the proposed action makes it unlikely that dead or injured individuals would be found. These species are generally wide-ranging, are rare in the system, and locating a dead fish in the Colorado River is extremely unlikely.

Take of individual fish via diversions of ISC and 4.4 Plan water will occur. Fish diverted into canals and pumping plants or going through the dams generally do not survive or return to the system. This type of take was addressed in the incidental take statement contained in the 1997 BO (USFWS 1997). ISC water taken by Nevada from Lake Mead would have an increased risk for razorbacks. ISC water taken by Arizona from Lake Havasu would have an increased risk to both razorbacks and bonytail. Risks to entrainment below Parker Dam for razorbacks would be reduced as less water was released for the IID to divert. The amount of this take cannot be given in known numbers of fish since population sizes, locations of fish versus diversion sites and amount diverted each year under these actions will vary. The one thing that can be said for certain is that as populations of fish rise (from augmentation and natural recruitment), the risk per unit of water diverted also rises.

This same situation for defining take was encountered in the 1997 BO. The incidental take statement in the 1997 BO did not specify numbers of fish likely to be taken as a result of Reclamation delivering water to the diversion points, but did provide figures under which take would be considered exceeded. Take would be exceeded if 2 or more bonytails and/or razorbacks were found dead over the first 2 years of the 5-year period covered. This level was increased over time by 1 fish per 1000 stocked into the river or the reservoirs. That level of take was not considered to jeopardize the species. If that level is translated to fish lost per unit of water diverted, it comes out to 1 fish per 7.5 maf for the first 2 years. The figure decreases per unit water as populations increase. There have been no reports of any dead fish found to date.

Using the same rationale as in 1997, the Service anticipates that the Arizona and Nevada portions of the increased water diversion, will increase the level of incidental take by 1 fish over the remaining life of the 1997 BO. Because California is not taking more water (since the Colorado River aqueduct will be maintained at present levels) there is no increase attributable to their ISC water. For the 4.4 Plan, the increase in risk in Lake Havasu is offset by the decrease in risk at Imperial Dam and no net change in take is expected from that established in 1997 for the period to 2002. It is important to note that actual diversion of fish into the canals or pipelines is take attributed to the water users, not to Reclamation.

The Service anticipates that up to 35 acres of river channel habitat of razorback sucker would be eliminated as habitat, causing harm through reduction in areas for spawning, nursery, feeding and sheltering. All razorbacks in these 35 acres would be taken. Loss of feeding, breeding and sheltering areas will result in injury to individuals through loss of eggs and young fish from stranding or reduction in available nursery habitats. Reduction in feeding areas due to changing water level effects on benthic organisms and detritus will adversely affect the health and growth of individuals. Changes to water quality (especially oxygen and temperature) in remaining backwaters due to the decreased flows may make the areas less usable to fish, and these habitats have been shown to be very important for razorbacks. There is no net loss of acreage of backwater habitats due to the conservation measure to replace the 17 acres that would be lost at 400,000 af, but adverse physical effects to habitats due to decreased size and flow in existing backwaters would continue even with the conservation measures.

There will also be harm to razorback suckers breeding in Lake Mead. Existing spawning and nursery areas will be unavailable somewhat more often under the ISC than at present and this may have effects on recruitment opportunities. These issues have been discussed previously in this biological opinion. The conservation measures included in the proposed action reduce the amount of this take to the extent practicable, although the potential for take to occur is not eliminated.

Yuma clapper rail

The loss of 28 acres of marsh habitat under the 4.4 Plan may cause harm to the clapper rail. Marshes provide breeding, feeding and shelter for clapper rails that would be eliminated by the change in flows resulting from the project. This could adversely affect the habitat use of all of the approximately 100 clapper rails within the Parker Dam to Imperial Dam reach of the LCR. Since the replacement of lost habitats by the conservation measures will be in specific areas and not spread evenly throughout the affected existing habitat, the amount of habitat may not be changed, but the quality of the remaining patches will be altered. This local habitat alteration causes harm to the resident birds, although the new habitats offset the total adverse effects to the population.

The conservation measures included in the proposed action reduce the amount of this take to the extent practicable, although the potential for take to occur is not eliminated.

Southwestern willow flycatcher

The Service anticipates that take of willow flycatchers will only occur in the unlikely event that implementation of the Tier One conservation measures are unsuccessful in maintaining occupied habitat. Only in a worst case scenario does the Service anticipate the take of willow flycatcher due to project-related activities in the form of riparian micro-habitat degradation and loss of suitable nesting habitat, and/or reduced nesting success in 372 acres of occupied habitat. Riparian micro-habitat degradation and loss of suitable nesting habitat is anticipated to occur by removing the moist soil component of the bird’s nesting habitat resulting in reduced occupancy and/or success of nesting birds. This habitat loss is also anticipated to result in displacement of adults, reduced productivity, and reduced survivorship of adults and/or young. Therefore, the Service anticipates that all willow flycatchers inhabiting those 372 acres may be taken. As stated previously in the effects section, this 372 acres supports 9 currently occupied territories. The Service has inadequate information to quantify actual take of nests, reduced productivity, occupancy, and/or nesting success. However, when habitat is rendered unsuitable, population maintenance and expansion are precluded. Thus, young and adults that return to breed in areas that have been lost or degraded are less likely to find suitable habitat or find mates.

Effect of the Take

In the accompanying BO, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize impacts of incidental take of razorback sucker, bonytail chub, and willow flycatcher:

1. Reduce the changes in water level fluctuations below Davis Dam to protect razorback and bonytail populations.

2. Reduce changes in water level fluctuations below Parker Dam to protect razorback populations.

3. Provide for suitable spawning and nursery habitats for razorback in the Parker Dam to Imperial Dam reach.

4. Ensure that all suitable willow flycatcher nesting habitat between Parker and Imperial dams and surrounding Lake Mead are annually surveyed, searched for nests, and nest monitored.

5. Minimize impacts to nesting willow flycatchers.

Terms and Conditions

In order the be exempt from the prohibition of section 9 of the ESA, Reclamation and/or the applicants, as appropriate, must comply with the following terms and conditions, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

To implement RPM 1 the following terms and conditions must be met:

a. Hourly, daily and weekly release schedules from Davis Dam will be reviewed for the new surplus water releases.

b. New release schedules will not increase the magnitude or range of fluctuations beyond what is seen under existing operating conditions as of January 2000.

c. Reclamation will provide the Service with documentation of the new schedules for water release from Davis Dam each year.

To implement RPM 2 the following terms and conditions must be met:

a. Hourly, daily and weekly release schedules from Parker Dam will be reviewed for the changes due to decreased water releases

b. New release schedules will not increase the magnitude or range of fluctuations beyond what is seen under existing operating conditions as of January 2000.

c. Reclamation will provide the Service with documentation of the new schedules for water release from Parker Dam each year.

To implement RPM 3 the following terms and conditions must be met:

a. Any future dredging of suitable spawning habitats will be focused on maintaining suitable area below the fluctuation zone to provide adequate spawning habitat area to offset declines in flows.

b. Shallow water areas that will not be dried out by changes in flows will be provided for in all replacement backwater and marsh habitats to provide for nursery habitats for razorbacks.

To implement RPM 4 the following terms and conditions must be met:

a. Reclamation will conduct presence and absence surveys for willow flycatchers in all suitable habitat between Parker and Imperial dams and surrounding Lake Mead (Virgin, Muddy, and Colorado River inflows) annually for up to 5 years after the implementation of all transfers. Once resident birds are found, nest searches and nest monitoring will occur to determine nesting distribution, abundance, success, and cowbird parasitism and predation rates. Detecting willow flycatcher presence/absence and nesting success, plus predation and cowbird parasitism rates are needed to implement management activities to reduce and minimize take described in RPM 5.

To implement RPM 5 the following terms and conditions must be met:

a. Reclamation will continue to protect occupied and unoccupied willow flycatcher habitat under their management between Parker and Imperial dams, and surrounding Lake Mead regardless of plant species composition. Protection actions will include, but not be limited to cowbird trapping in or near occupied habitat in coordination with ongoing research, protection of nesting willow flycatchers from predators, fire breaks, and measures such as road/lake closures to limit public access, the risk of fire, and/or habitat degradation.

b. In areas not under Reclamation management:

    1. Reclamation will continue to develop agreements and work with other agencies to develop closures, and protect sites from the effects of fire and recreation. For example, if willow flycatcher sites are found surrounding Lake Mead that can be accessed by watercraft, work with the National Park Service or other appropriate agencies to protect the area by closing the site with buoys.

    2. Based upon nest monitoring, if predation by mammals or reptiles is 25 percent or greater at willow flycatcher nests between Parker and Imperial dams, or surrounding Lake Mead, then seek out and if possible, initiate creative ways to lower predation with approval by the Service.

        3. Reclamation will continue to develop agreements with appropriate land management agencies to develop a cowbird trapping programs if necessary.

c. Triggers to initiate cowbird trapping:

1. Trapping would begin if monitoring of nesting willow flycatchers (all sites between Parker and Imperial dams) shows a 40 percent or greater parasitism rate in any one year, or averages more than 20 percent in any two or more consecutive years. Thus, if in year one there is greater than 40 percent parasitism, begin trapping in year two. If there was 20, 10, 25, and 0 percent parasitism in years one through four, no trapping is needed. If there was 20 and 25 percent parasitism in years one and two, begin trapping in year three.

2. Once trapping has been determined necessary based upon monitoring, Reclamation will continue with the cowbird trapping for 5 consecutive years and then evaluate (along with the Service) the need to continue.

3. If no nesting birds can be detected at occupied sites, then due to poor sub-population stability, trapping must be initiated at half of all occupied sites (those where residents have been detected at least once over the previous five years) and continued at an even rotation through all sites (i.e. trap at half the occupied sites in year one, the other half in year two, and repeat) for five years, or until monitoring can determine that less than 20 percent parasitism is occurring over an average of two or more years on all resident nesting pairs of birds. At the end of five years evaluate with the Service the effectiveness and the need to continue.

Reporting Requirements

Reclamation or the applicants, as appropriate, will provide the Service with annual reports on the implementation of the conservation measures and terms and conditions, on the amounts of water released under the surplus criteria and how it affected Lake Mead elevations and downstream flows, the amounts of water that have been successfully transferred to the new point of diversion, and the results of all biological monitoring for razorbacks and bonytails, groundwater and willow flycatcher habitat monitoring. These reports will be due to the Service on February 1 for the preceding calendar year. Willow flycatcher reporting deadlines (surveys and nest monitoring) are subject to dates determined in permit guidelines; typically September for survey data and October for nest monitoring information.

Disposition of Dead or Injured Listed Animals

Upon finding a dead or injured threatened or endangered animal, initial notification must be made to the Service's Division of Law Enforcement, Federal Building, Room 8, 26 North McDonald, Mesa, Arizona (602/261-6443) within three working days of its finding. Written notification must be made within five calendar days and include the date, time, and location of the animal, a photograph, and any other pertinent information. Care must be taken in handling injured animals to ensure effective treatment and care, and in handling dead specimens to preserve biological material in the best possible condition. If feasible, the remains of intact specimens of listed animal species shall be submitted as soon as possible to the nearest Fish and Wildlife Service or State game and fish office, or other institution holding the appropriate State and Federal permits. Arrangements regarding proper disposition of potential museum specimens shall be made with the institution before implementation of the action. A qualified biologist should transport injured animals to a qualified veterinarian or other suitable facility in the case of injured fish. Should any treated listed animal survive, the Service should be contacted regarding the final disposition of the animal.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of listed species. Conservation recommendations are discretionary agency activities to minimize or avoid effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information on listed species. The recommendations provided here do not represent complete fulfillment of Reclamation's section 2(c) or 7(a)(1). In furtherance of the purposes of the ESA, we recommend implementing the following actions:

1. Monitor development of cattail/bulrush marsh habitats around Lake Mead and survey appropriate areas for Yuma clapper rail occupancy.

2. Monitor CRIT canals yearly for presence of razorback suckers. Also provide surveys in the Parker Strip for potential spawning habitat.

3. Reduce the amount of maintenance dredging in the Parker Dam to Imperial Dam reach to maintain a variety of spawning habitats, especially at wash fans and other gravel/cobble areas.

4. Evaluate how the LCR could be operated to more closely imitate a natural hydrograph.

REINITIATION NOTICE

This concludes formal consultation on the proposed action. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is liste or critical habitat designated that may be affected by the action. Changes to the Tier lines at the 5 year reviews that result in lowering the level at which a surplus is declared would qualify for reinitiation under (3). In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

The Service appreciates the efforts of Reclamation in the development and preparation of this document. Any questions or comments on this BO should be directed to Tom Gatz, Lesley Fitzpatrick or Greg Beatty in our office.

/s/ David L. Harlow

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Regional Director, Fish and Wildlife Service, Albuquerque, NM (AES)
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Appendix

Tables

Figures

Table 1: Bonytail Stockings in the Upper Basin

Species	Date	River Section	Number	Size (mm)
Bonytail	10/98	Colorado	3,280	125
	10/98	Lower Green	3,000	125
	3/99	Colorado	15 (radio tags)	250
	4/99	Colorado	10,000	100
	4/99	Lower Green	10,000	100
	3/00	Lower Green	13	none given
	4/00	Lower Green	19,987	100-175
	4/00	Colorado	15,037	75
	7/00	Yampa	5,000	100
	7/00	Middle Green	5,000	100
Total			71,332	

Table 2: Razorback Sucker Stockings in the Upper Basin

Species	Date	River Section	Number	Size (mm)
Razorbacks	9/98	Gunnison	249	225
	10/98	Middle Green	125	150-200
	10/98	Gunnison	126	400
	4/99 and 8/99	Middle Green	6,659	100-200
	5/99	Middle Green	est. 57,900	<25
	5/99	Middle Green	35 (radio tags)	>250
	6/99	Middle Green	738	250-400
	5/99 and 11/99	Gunnison	2,772	200
	9/99 and 10/99	Colorado	3,498	200
	4/00	Colorado	3,875	100-150
	6/00	Old Charlie	9,599	<25
	6/00	Middle Green	79	425
	6/00	Stewart Lake	145	300
	6/00	Old Charlie	2,106	>150
	8/00	Colorado	3,845	100-325
	8/00	Gunnison	1,640	75-325
Total			96,693	

Table 3: Razorback Sucker Stockings into Lake Mead by NDOW

Year	Source	Location Stocked	Number
1994	FLSP	Las Vegas Bay	26
1995	FLSP	Echo Bay	14
1996	larvae	Las Vegas Bay	1
1997	FLSP	Las Vegas Bay	6
1998	FLSP	Las Vegas Bay	8
	FLSP	Echo Bay	3
1999	larvae	unspecified	39

(FLSP is Floyd Lamb State Park)

Table 4: Razorback suckers captured in the Parker Strip/CRIT Canals area, 1980-1998			
DATE	NUMBER	LENGTH RANGE (mm)	WEIGHT RANGE (gms)
1-12-80	1	323	339.6
1-26-80	1	371	567
?-?-80	2	323-371	n/a
9-9-81	2	300	n/a
1-16-86	1	375	680
1-19-86	1	343	566
1-19-86	1	318	454
1-28-86	1	368	680
11-5-87	2	350-450 (estimate)	n/a
1-10-87	3	n/a	n/a
1-11-87	7	234-330	145-455
1-12-87	11	245-310	141-286
1-15-87	4	285-331	270-468
1-23-87	13	211-320	109-409
1-11-88	1	438	900
1-13-88	1	450	1040
1-16-88	1	465	1360
1-10-89	28	425-536	1069-1757
1-6-93	5	522-615	794-1134
1-8-93	1	n/a	n/a
10-14-96	5	n/a	n/a
4-10-98	1	n/a	n/a

Table 5: Yuma Clapper Rail Survey Data 1997-2000

Year	Number of Rails Counted in USA
1997	716
1998	553
1999	607
2000	464

Table 6: Range-wide population status for the southwestern willow flycatcher based on 1996 survey data for New Mexico and California, 1997 survey data for Colorado and Utah, 1998 survey data from Nevada, 1999 survey data for Arizona, and personal communication of 1999 and 2000 survey data.[1]

State	Number of sites with resident WIFLs	Number of drainages with resident WIFLs	Number of territories within site			
			≤5	6-20	>20	Total number of territories
Arizona	47	12	33	11	3	289
California	11	8	7	2	2	91
Colorado	7	6	2	4	1	69
New Mexico	19	6	16	2	1	209
Nevada	10	4	8	2	-	46
Utah	5	4	5	0	0	8
Texas	?	?	?	?	?	?
Total	99	40	69	21	7	712 [2]

[1] Based on surveys conducted at >800 historic and new sites in AZ (Sogge and Tibbitts 1992, Sogge *et al.* 1993, Muiznieks *et al.* 1994, Sogge and Tibbitts 1994, Sferra *et al.* 1995, 1997, Sogge 1995a, Sogge *et al.* 1995, Spencer *et al.* 1996, McKernan 1997, McKernan and Braden 1998, Paradzick *et al.* 2000); CA (Camp Pendleton 1994, Whitfield 1994, Griffith and Griffith 1995, Holmgren and Collins 1995, Kus 1995, San Diego Natural History Museum 1995, Whitfield and Strong 1995, Griffith and Griffith 1996, M.Sogge pers. com.); CO (T. Ireland 1994 *in litt.*, Stransky 1995); NM (Maynard 1995, Cooper 1996, 1997, Parker 1997, Skaggs 1996, Williams 1997); NV (C. Tomlinson 1995 *in litt.*, 1997, M.Sogge pers. com, B.McKernan pers. com., McKernan and Braden 1999); UT (McDonald *et al.* 1995, 1997, Sogge 1995b). Systematic surveys have not been conducted in Texas.

[2] Personal communication from Mark Sogge (USES, unpubl. data) indicates that as of the end of the 1999 breeding season just over 900 willow flycatcher territories are found at 143 sites throughout it's range.

Table 7: Agency actions that have undergone formal section 7 consultation and levels of incidental take permitted for the southwestern willow flycatcher range-wide.

Action (County)	Year	Federal Agency[1]	Incidental Take Anticipated
Arizona			
Cedar Bench Allotment (Yavapai)	1995	Tonto NF	Indeterminable
Tuzigoot Bridge (Yavapai)	1995*	NPS	None
Windmill Allotment (Yavapai)	1995	Coconino NF	Loss of 1 nest annually/for 2 years
Solomon Bridge (Graham)	1995	FHWA	Loss of 2 territories
Tonto Creek Riparian Unit (Maricopa)	1995	Tonto NF	Indeterminable
Eastern Roosevelt Lake Watershed Allotment (Maricopa)	1995	Tonto NF	Indeterminable
Cienega Creek (Pima)	1996	BLM	1 nest annually by cowbird parasitism
Glen Canyon Spike Flow (Coconino)	1996	USBR	Indeterminable
Verde Valley Ranch (Yavapai)	1996*	Corps	Loss of 2 willow flycatcher territories
Modified Roosevelt Dam (Gila/Maricopa)	1996*	USBR	Loss of 45 territories; reduced productivity/ survivorship 90 birds
Lower Colorado River Operations (Mohave/Yuma)	1997*	USBR	Indeterminable
Blue River Road (Greenlee)	1997	A/S NF	Indeterminable
Skeleton Ridge (Yavapai)	1997	Tonto NF	Indeterminable
White Canyon Fire – Emergency Consultation (Final)	1997	BLM	Harassment of 4 pairs
U.S. Hwy 93 Wickenburg (Mohave/Yavapai)	1997	FHWA	Harassment of 6 birds in 3 territories and 1 bird killed/decade
Safford District Grazing Allotments (Greenlee, Graham, Final, Cochise & Pima)	1997	BLM	Indeterminable
Lower Gila Resource Plan Amend. (Maricopa, Yavapai, Pima, Final, La Paz & Yuma)	1997	BLM	Indeterminable
Storm Water Permit for Verde Valley Ranch (Yavapai)	1997	EPA	Indeterminable

Table 7: Agency actions that have undergone formal section 7 consultation and levels of incidental take permitted for the southwestern willow flycatcher range-wide.

Action (County)	Year	Federal Agency[1]	Incidental Take Anticipated
Gila River Transmission Structures (Graham)	1997	AZ Electric Power Coop. Inc.	Indeterminable
Arizona Strip Resource Mgmt Plan Amendment (Mohave)	1998	BLM	Harm of 1 nest every 3 years
CAP Water Transfer Cottonwood/Camp Verde (Yavapai/Maricopa)	1998	USBR	Indeterminable
Cienega Creek Stream Restoration Project (Pima)	1998	BLM	Harassment of 1 bird
Kearny Wastewater Treatment (Final)	1998	FEMA	Indeterminable
Fort Huachuca Programmatic (Cochise)	1998	US Army	None
SR 260 Cottonwood to Camp Verde (Yavapai)	1998	FHWA	Indeterminable
Wildlife Services (ADC) Nationwide consultation	1998	Wildlife Services	in consultation
Alamo Lake Reoperation (LaPaz, Mohave)	1998	ACOE	Loss of 1 nest w/2 eggs in 20 years due to projected inundation
Grazing on 25 allotments on the Tonto NF (Various)	1999	USFS	in consultation
Mingus Avenue Extension (Yavapai)	1999	ACOE	Indeterminable
The Homestead at Camp Verde Development	2000	Prescott NF/EPA	in informal consultation
Wikieup/Big Sandy Caithness power plant	2000	WAPA/BLM	in informal consultation
Interim Surplus Criteria, CA Water- lower Colorado River	2000	USBR	in consultation
Tonto Creek Crossing - Tonto NF (Gila County)	2000	USFS	in consultation
Big Sandy/Santa Maria Grazing Allotments (La Paz)	2000	BLM	in consultation
California			
Prado Basin (Riverside/San Bernardino)	1994	Corps	None
Orange County Water District (Orange)	1995	Corps	None
Temescal Wash Bridge (Riverside)	1995	Corps	Harm to 2 willow flycatchers

Table 7: Agency actions that have undergone formal section 7 consultation and levels of incidental take permitted for the southwestern willow flycatcher range-wide.

Action (County)	Year	Federal Agency[1]	Incidental Take Anticipated
Camp Pendleton (San Diego)	1995	DOD	Loss of 4 willow flycatcher territories
Lake Isabella Operations 1996 (Kern)	1996	Corps	Inundation 700 ac critical habitat; reduced productivity 14 pairs
Lake Isabella Long-Term Operations (Kern)	1997	Corps	Indeterminable
H.G. Fenton Sand Mine and Levee near Pala on the San Luis Rey River (San Diego)	1997	Corps	None
Colorado			
AB Lateral - Hydroelectric/Hydropower Facility, Gunnison River to Uncompahgre River (Montrose)	1996	USBR	None
TransColorado Gas Transmission Line Project, Meeker, Colorado to Bloomfield, New Mexico	1998	BLM	None
Nevada			
Gold Properties Resort (Clark)	1995	BIA	Harm to 1 willow flycatcher from habitat loss
Las Vegas Wash, Pabco Road Erosion Control Structure	1998	Corps	Harm to 2-3 pairs of willow flycatchers
New Mexico			
Corrales Unit, Rio Grande (Bernalillo)	1995	Corps	None
Rio Puerco Resource Area	1997	BLM	None
Farmington District Resource Management Plan	1997*	BLM	None
Mimbres Resource Area Management Plan	1997*	BLM	1 pair of willow flycatchers
Belen Unit, Rio Grande (Valencia)	1998	Corps	Consultation in progress

BIA = Bureau of Indian Affairs; BLM = Bureau of Land Management; Corps = Army Corps of Engineers; DOD = Dept. of Defense; EPA = Environmental Protection Agency; FEMA = Federal Emergency Management Agency; FHWA = Federal Highway Administration; NF = National Forest; NPS = National Park Service; USBR = U.S. Bureau of Reclamation; USFS = U.S. Forest Service.

* Jeopardy opinions.

Table 8: Biological Opinions Issued on Lower Colorado River since 1997

Number	Name of Project	Date BO Issued
2-21-96-F-161	Blue Water Resort, Casino and Marina	March 21, 1997
2-21-99-F-231	Desert Pupfish Refugium, Cibola NWR	June 25, 1999
2-21-99-F-205	Laughlin Lagoon Dredging Project	August 19, 1999
2-21-00-F-041	Desert Pupfish Refugium, Imperial NWR	December 16, 1999

Table 9: Significant Projects on Lower Colorado River with May Affect, not Likely to Adversely Affect Findings since 1997

Number	Name of Project	Date Finding Issued
2-21-98-I-436	Offstream Storage of Colorado R. Water	August 19, 1998
2-21-99-I-121	Beal Lake Improvement Project	February 2, 1999
2-21-99-I-301	Headgate Rock Tailrace Dredging	May 28, 1999
2-21-99-I-322	River Mile 33 Dredging	September 10, 1999
2-21-99-I-263	City of Yuma Riverfront Park	October 1, 1999
2-21-98-I-040	Phase II CRFRP-Morelos Dam	December 10, 1999
2-21-00-I-130	USFWS Giant Salvinia Control	February 8, 2000
2-21-00-I-156	BLM Giant Salvinia Control	February 25, 2000

Table 10: Years with Lake Mead Rising Water Elevations				
Year	February	March	April	Amount of Rise
1935	708.70	701.70	752.4	43.70 ft
1936	908.40	906.90	922.2	13.80 ft
1937	1026.20	1031.00	1044.60	18.40 ft
1938	1094.85	1100.20	1109.20	14.35 ft
1939	1157.40	1158.20	1162.90	5.50 ft
1941	1167.55	1170.35	1175.85	8.30 ft
1942	1176.75	1171.25	1182.9	6.15 ft
1943	1179.6	1177.00	1180.6	1.00 ft
1947	1130.10	1135.38	1134.49	4.39 ft
1960	1163.78	1164.26	1169.94	6.16 ft
1962	1156.51	1154.69	1165.75	9.24 ft
1965	1090.63	1088.31	1094.57	3.94 ft
1968	1132.54	1132.79	1134.15	2.61 ft
1969	1140.67	1139.34	1140.79	0.12 ft
1973	1174.73	1178.78	1186.14	11.41 ft
1983	1210.25	1211.59	1211.26	1.01 ft
1986	1202.72	1202.45	1204.78	2.06 ft
1992	1179.42	1180.31	1179.78	0.36 ft
1993	1189.88	1193.46	1193.04	3.16 ft
1997	1196.51	1199.10	1200.01	3.50 ft

Table 11. The relative abundance of southwestern willow flycatcher pairs along the lower Colorado River and its tributaries from 1996 to 2000 (McKernan and Braden 1997,1998,1999, pers. com.).

Study Area	1996 pairs	1997 pairs	1998 pairs	1999 pairs	2000 pairs
Pahranagat, Meadow Valley, NV	ns	ns	18	16	24
Littlefield, AZ, Virgin River	ns	0	0	ns	0
Mesquite, NV (old site), Virgin River	ns	6	4	0	0
Mesquite, NV, west (new site)	ns	ns	ns	ns	20-22
Riverside, NV, Virgin River	ns	2	0	0	0
Mormon Mesa, NV (north), Virgin River	ns	6	6	11	10-11
Mormon Mesa, NV (south), Virgin River	ns	6	12	11	10-11
Virgin River Delta, NV, Virgin River	ns	12	6	0	2
Muddy River	ns	4	ns	ns	2
Lake Mead Delta, CO River	10	6	ns	ns	ns
Grand Canyon, CO River	ns	2	16	17	14
Hoover Dam					
Topock Marsh, AZ, CO River	10	25	36	32	30
Topock Gorge, CA-AZ, CO River	2	1	0	0	0
Lake Havasu, AZ, CO River	2	0	0	2	0
Bill Williams River, AZ	2	2	6	2	4
Parker Dam					
**Headgate Dam, CA, CO River	ns	0	2	2	0
[1]Hall Island, CA, CO River	ns	0	1	0	[1]
Big Hole, CA, CO River	ns	ns	ns	2	2
**Ehrenberg, AZ, CO River	4	0	0	2	2
**Cibola Lake, AZ, CO River	0	0	0	0	0
Cibola NWR, AZ, CO River	2	0	0	0	0
**Walker Lake, CA, CO River	3	0	0	0	2
Draper Lake, CA, CO River	2	0	0	0	0
**Paradise Valley, CA, CO River	0	0	0	0	0
**Adobe Lake, AZ, CO River	4	2	0	0	2
Taylor Lake, CO River	2	0	0	0	0

Table 11. The relative abundance of southwestern willow flycatcher pairs along the lower Colorado River and its tributaries from 1996 to 2000 (McKernan and Braden 1997,1998,1999, pers. com.).

**The Alley (Island Lake/Mile Marker 65), CO River	0	0	0	0	0
Picacho west, CA, CO River	2	2	0	0	2
**Picacho Camp Store, CA, CO River	ns	0	1	0	2
**Ferguson Lake, CA, CO River	2	0	0	0	1
**Imperial NWR, AZ, CO River	1	0	0	0	0
Imperial Dam					
Mittry Lake, AZ, CO River	0	0	0	2	0
South of Laguna Dam, AZ, CO River	ns	0	0	0	0
South of Laguna Dam, AZ (old Colo. Riv), CO River	ns	ns	0	0	0
Gila R/Colorado R. Confluence, AZ, CO River	ns	0	0	4	2
Gila River, AZ	2	0	1	2	2
Morales Dam, CO River	ns	ns	ns	4	0
Hunters Hole, CO River	ns	ns	0	0	0
Gadsden Bend, CO River	ns	ns	2	2	0
Gadsden, CO River	ns	ns	0	0	0

[1] Habitat at Hall Island has degraded and was not suitable

** Areas that may be negatively affected by the proposed action

ns - not surveyed

Table 12: Hydrology at southwestern willow flycatcher study areas, Parker to Imperial Dams, lower Colorado River, 1996 to 1999 (Reclamation 2000).

Study area	% site w/ surface water	Average depth of surface water	Distance from surface water	% of site w/ saturated soils (excluding area with surface water)
	1996/97/98/99	1996/97/98/99	1996/97/98/99	1996/97/98/99
Ehrenberg (21.5 ac)	30/50/20/10	2cm/2cm/5cm/1cm	5m/5m/5m/5m	50/100/80/50
Headgate Rock (48 ac)	10/10/10/20	5cm/5cm/10cm/10cm	30m/30m/30m/30m	30/50/20/20
Imperial NWR (39.3 ac)	50/30/10/20	1cm/1cm/1cm/1cm	60m/60m/60m/60m	25/25/25/25
Lower Walker Lake (334 ac)	30/30/30/30	30cm/20cm/20cm/5cm	10m/10m/10m/10m	100/100/100/100
Cibola Lake (61 ac)	70/70/50/50	10cm/20cm/20cm/5cm	5m/5m/5m/5m	25/25/25/25
Adobe Lake (185.6 ac)	10/10/10/10	5cm/5cm/10cm/10cm	10m/10m/10m/10m	50/50/50/50
Paradise Valley (104.4 ac)	20/20/30/30	1cm/1cm/1cm/1cm	25m/25m/25m/25m	100/100/100/100
The Alley (244 ac)	70/70/50/50	30cm/20cm/20cm/5cm	5m/5m/5m/5m	100/100/100/100
Picacho/Camp Store (44.1 ac)	50/50/30/30	5cm/5cm/10cm/10cm	10m/10m/10m/10m	100/100/100/100
Draper Lake (248 ac)	20/20/30/30	30cm/20cm/20cm/5cm	25m/25m/25m/25m	100/100/100/100
Ferguson Lake (130.6 ac)	70/70/50/50	5cm/10cm/10cm/10cm	5m/5m/5m/5m	100/100/100/100

Table 13: Lake Mead Water Levels: Number of Runs over the Stated Elevation

Year	75R 1180	CP 1180	75R 1150	CP 1150	75R 1135	CP 1135	75R 1120	CP 1120
2000	85	85	85	85	85	85	85	85
2001	83	74	85	85	85	85	85	85
2002	72	65	85	85	85	85	85	85
2003	64	59	85	83	85	85	85	85
2004	66	54	85	78	85	85	85	85
2005	57	44	83	77	85	83	85	85
2006	52	43	82	69	85	82	85	85
2007	51	36	82	67	85	78	85	85
2008	50	35	77	62	84	75	85	83
2009	50	35	75	59	83	71	85	79
2010	50	34	79	56	80	67	85	77
2011	43	32	70	55	81	64	84	74
2012	39	31	69	48	77	62	84	71
2013	39	30	68	48	76	59	82	70
2014	38	30	68	45	74	55	81	66
2015	37	31	63	42	75	52	79	65
2016	37	30	63	43	74	53	77	64
2017	35	33	59	42	73	50	75	65
2018	35	33	59	43	70	54	75	65
2019	35	32	57	42	69	57	75	63
2020	36	32	57	41	69	58	73	64
2021	33	31	56	40	65	58	73	64
Year	75R 1180	CP 1180	75R 1150	CP 1150	75R 1135	CP 1135	75R 1120	CP 1120

Table 13: Lake Mead Water Levels: Number of Runs over the Stated Elevation

2022	30	31	56	39	62	57	70	63
2023	32	32	56	38	61	55	67	62
2024	31	32	54	39	61	53	65	62
2025	31	31	51	40	62	53	66	61
2026	29	30	50	41	61	52	65	59
2027	32	31	49	42	59	52	65	58
2028	33	31	48	42	58	51	65	58
2029	29	29	47	42	57	52	64	58
2030	31	31	46	42	54	52	64	58
2031	32	31	43	42	53	52	63	58
2032	31	31	43	42	51	49	62	58
2033	33	32	41	40	52	50	58	56
2034	32	34	40	41	49	50	57	58
2035	32	30	40	39	50	48	57	55
2036	32	30	40	41	49	47	56	53
2037	30	29	39	39	46	45	55	53
2038	31	31	38	38	44	44	52	51
2039	31	30	39	38	43	43	51	51
2040	30	30	37	38	41	42	51	51
2041	31	29	37	41	41	43	49	49
2042	31	30	37	37	40	41	48	48
2043	31	30	37	37	40	40	49	49
Year	75R 1180	CP 1180	75R 1150	CP 1150	75R 1135	CP 1135	75R 1120	CP 1120
2044	31	29	39	37	43	40	50	48
2045	29	30	35	36	38	40	46	47

Table 13: Lake Mead Water Levels: Number of Runs over the Stated Elevation								
2046	30	30	37	36	38	38	46	46
2047	28	29	36	36	40	40	44	44
2048	29	29	37	36	39	39	44	44
2049	29	29	37	36	39	39	45	45
2050	29	29	36	36	38	37	44	44

United States Department of the Interior
U.S. Fish and Wildlife Service
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Phoenix, Arizona 85021-4951
Telephone: (602) 640-2720 FAX: (602) 640-2730

JAN 2001

In Reply Refer To:
AESO/SE
2-21-00-I-273

January 11, 2001

BCOO 1000

Memorandum

To: Regional Director, Lower Colorado Region, Bureau of Reclamation, Boulder City, Nevada (Attn: Area Manager, Boulder Canyon Operations Office)

From: Field Supervisor

Subject: Supplemental Biological Assessment on Transboundary Effects in Mexico for Proposed Interim Surplus Criteria, dated January 9, 2001

The Fish and Wildlife Service has reviewed the subject supplemental biological assessment (SBA) for effects of the Basin States Alternative of the Interim Surplus Criteria (ISC). In your transmittal memorandum, you requested Service concurrence with a finding of "may affect, not likely to adversely affect" for the endangered southwestern willow flycatcher (*Empidonax traillii extimus*). Reclamation also made findings of "no effect" to the endangered desert pupfish (*Cyprinodon macularius macularius*), Yuma clapper rail (*Rallus longirostris yumanensis*), vaquita (*Phocaena sinus*) and totoaba (*Totoaba macdonaldi*). This response is provided pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) and under the terms contained in your memorandum of January 9, 2001 concerning the need for this concurrence.

The Service does not have jurisdiction in section 7 consultations for marine species such as the vaquita and totoaba. Therefore, they are not discussed further in this memorandum. The Yuma clapper rail is not listed under the Endangered Species Act of 1973 (as amended) outside of the United States. Therefore, Yuma clapper rails in Mexico are not protected or considered in section 7 consultation and they will not be discussed further in this memorandum.

Information provided in the SBA concerning effects to desert pupfish was reviewed for this concurrence. Populations of desert pupfish are not found in the mainstem or waters connected to the mainstem Colorado River where effects of the proposed ISC would occur. Although present historically, populations in these areas have been extirpated. The Service concurs with the finding of "no effect" for the desert pupfish.

Information provided in the SBA concerning effects to southwestern willow flycatcher was reviewed for this concurrence. The few surveys that have been done in the area have not documented any willow flycatcher breeding territories in the habitat present below Morelos Dam. Migrant individuals, which may or may not be the federally listed subspecies, have been recorded using these habitats, but breeding has not been confirmed. Riparian habitat that is used by migrating willow flycatchers is in the area of effect from the proposed action.

Implementation of the ISC will result in changes to the frequency and volume of water that passes Morelos Dam during flood releases from Hoover Dam. These changes are small and will not have significant adverse effects to the existing riparian vegetation. These flood flows are instrumental in establishing riparian habitats in the affected area, but are not the source of water to maintain these areas once established. Maintenance of these habitats is from agriculture returns and other groundwater sources that would not be affected by the proposed action. Groundwater levels would not be expected to change as a result of ISC implementation since the amount of water reaching Morelos Dam and the nearby agricultural fields would not change.

Habitat for willow flycatchers may be affected by other operations that are not part of the proposed action in the vicinity of and downstream of Morelos Dam. Changes in water delivery patterns, flood channel clearing, fire and other factors can destroy riparian habitats or drop groundwater levels that may damage physical characteristics of the habitat needed by willow flycatchers. Also, riparian habitat may grow out of the stage preferred by the willow flycatcher and become unusable. In the event of the elimination of this habitat, for whatever reason, the decrease in flood frequency for large events that influence riparian formation (over 250,000 af) becomes more of an issue of concern. However, the decrease is from 1 in 5 years under the baseline to 1 in 6 years under ISC and this is not a significant change.

The Service finds that the effects of the ISC are insignificant and concurs with your finding of "may affect, not likely to adversely affect" the southwestern willow flycatcher from the implementation of the preferred action ISC. If there are any questions regarding this concurrence, please contact Tom Gatz (x240), Lesley Fitzpatrick (x236), or Greg Beatty (x247).

David L. Harlow

David L. Harlow

cc: Director, Fish and Wildlife Service, Arlington, VA (AES)
Regional Director, Fish and Wildlife Service, Albuquerque, NM (AES)
Manager, California/Nevada Operations Office, Fish and Wildlife Service, Sacramento, CA
Field Supervisor, Carlsbad Field Office, Fish and Wildlife Service, Carlsbad, CA
Field Supervisor, Ventura Field Office, Fish and Wildlife Service, Ventura, CA
Field Supervisor, Las Vegas Field Office, Fish and Wildlife Service, Las Vegas, NV
SPOC, Lower Colorado River Ecoteam, Bill Williams River NWR, Fish and Wildlife Service, Parker, AZ

Director, Arizona Game and Fish Department, Phoenix, AZ

00-I-273 Mexico concurrence:LAF

Appendix F

Wildlife and Plant Species Occurring within the Project Area

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

(Page 1 of 9)

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
INVERTEBRATES						
Andrew's Dune Scarab Beetle (*Pseudocotalpa andrewsi*)	SC			X		
California Floater (*Anodonta californiensis*)	FS		X			
Cheeseweed Moth Lacewing (*Oliaroes dara*)	SC			X		
Coachella Giant Sand Treader Cricket (*Macrobaenetes valgum*)	SC			X		
Coachella Valley Jerusalem Cricket (*Stenopelmatus cahuilaensis*)	SC			X		
Mojave Desert Blister Beetle (*Lytta inseparata*)	SC			X		
AMPHIBIANS						
Arroyo Southwestern Toad (*Bufo microscaphus californicus*)	FE/CSC	Mainly west of the desert in Southern California		X	X	
Colorado River Toad (*Bufo alarius)*	CE	Mainly southeast of California. Temporary pools and irrigation ditches are favored breeding habitat.	X			
Arizona Toad (*Bufo microscaphus microscaphus)*	--/CDFG Protected	Headwaters and tributaries to Colorado River	X			
California Red-Legged Frog (*Rana aurora draytonii*)	FT/CSC			X		
Couch's Spadefoot Toad (*Scaphiopus couchii*)	--/CSC	Mesquite savanna, creosote bush desert	X		X	
Desert Slender Salamander (*Batrachoseps aridus*)	FE/CE	Palm oases		X	X	

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

(Page 2 of 9)

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
AMPHIBIANS						
Lowland Leopard Frog (*Rana yavapaiensis*)	--/CSC/ ASC	Usually found close to water	X	X	X	
Northern Leopard Frog (*Rana pipiens*)	--/CSC/ ASC	Found in a variety of habitats, more adapted to cold than other leopard frogs. Glen Canyon and Kanab Creek	X			
REPTILES						
Banded Gila Monster (*Heloderma suspectum cinctum*)	--/CSC	Shrubby, grassy areas of the desert	X			
Barefoot Banded Gecko (*Coelonyx switaki*)	--/CSC	Arid hillsides and canyons				X
Coachella Valley Fringe-Toed Lizard (*Uma inornata*)	FT/CE	Loose sand		X	X	
Colorado Fringed-Toed Lizard (*Uma notata notata*)	--/CSC/ AC	Loose sand		X		X
Desert Rosy Boa (*Lichanum trivirgata gracia*)	BLM sensitive	Arid habitats, such as Gila and Castle Dome	X			
Desert Tortoise (*Gopherus agassizii*)	FT/CT/AC	Widespread, but rapidly declining population densities	X	X	X	X
Flat-tailed Horned Lizard (*Phrynosoma mcalli*)	CDFG protected/ AT	Fine sand	X	X	X	
Mohave Fringe-Tailed Lizard (*Uma scoparia*)	AE	Loose sand	X			
Northern Red-Diamond Rattlesnake (*Crotalus ruber ruber*)	--/CSC			X		
Sandstone Night Lizard (*Xantusia henshawi gracilis*)	--/CSC			X		

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

(Page 3 of 9)

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
REPTILES						
Silvery Legless Lizard (*Anniella pulchra pulchra*)	--/CSC	Loose sand for burrowing		X		
Sonoran Mud Turtle (*Kinosternon sonoriense*)	--/CSC	Streams and ponds	X		X	
FISH						
Bonytail Chub (*Gila elegans*)	FE/CE/AE		X			
Desert Pupfish (*Cyprinodon macularius*)	FE/CE/AE		X	X	X	X
Speckled Dace (*Rhinichthys osculus)*	-/CSC		X			
Colorado Pikeminnow (*Ptychocheilus locius)*	FE/CE/AE	Favored in deep, slow moving water. Now extirpated from Colorado River	X			
Razorback Sucker (*Xyrauchen texanus*)	FE/CE/AE		X			X
BIRDS						
Aleutian Canada Goose (*Branta canadensis leucopareia*)	FT/—	Very rare in Southern California		X		
American Peregrine Falcon (*Falco peregrinus anatum*)	--/CE (Federally delisted in 1999)	Widely distributed, but scarce in desert habitats	X	X	X	X
Double Crested Cormorant (*Phalacrocorax auritus)*	--/CSC					X
American White Pelican (*Pelecanus erythrorhynchos*)	--/CSC	Shallow-water lakes	X	X	X	X

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

(Page 4 of 9)

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
BIRDS						
Arizona Bell's Vireo (*Vireo bellii arizonae*)	--/CE	Dense riparian habitat; Lower Portion of the Colorado River south of Needles	X			X
Bald Eagle (*Haliaeetus leucocephalus*)	FT/CE/AE	Large lakes and reservoirs	X	X	X	
Black Skimmer (*Rhinchops niger)* (*Rynchops niger*)	--/CSC	Breeds on low sandbars and dikes Forages over shallow water		X		
Black Tern (*Chlidonias niger*)	--/CSC	Freshwater ponds, marshes, and flooded agricultural fields		X		X
Black-Tailed Gnatcatcher (*Polioptila melanura*)	--/CSC	Coastal sage scrub		X	X	
Burrowing Owl (*Athene cunicularia*)	--/CSC	Flat grasslands, agricultural fields	X		X	X
California Black Rail (*Laterallus jamaicensis coturniculus*)	--/CT/AE	Cattail and bulrush marshes	X	X	X	X
California Brown Pelican (*Pelecanus occidentalis californicus*)	FE/CE	Significant numbers at the Salton Sea, especially in summer. Some recent breeding	X	X	X	
California Least Tern (*Sterna antillarum browni*)	FE/CE	Ponds		X		X
Clark's Grebe (*Aechomophorus clarki*)	--/--/AC	Marsh-bordered channel	X			
Cooper's Hawk (*Accipiter cooperii*)	--/CSC	Riparian woodlands, especially near water	X	X	X	X
Crissal Thrasher (*Toxostoma crissale*)	--/CSC	Dense desert scrub, mesquite			X	X
Double-Crested Cormorant (*Phalacrocorax auritus*)	--/CSC	Nesting colonies only		X		X
Elf Owl (*Micrathene whitneyi*)	--/CE	Desert oases, springs. Very rare in California	X			X

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

(Page 5 of 9)

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
BIRDS						
Ferruginous Hawk (*Buteo regalis*)	--/CSC	Grasslands, plains, valleys, and agricultural lands	X		X	X
Fulvous Whistling Duck (*Dendrocygna bicolor*)	--/CSC	Freshwater lakes, ponds, and rivers	X	X		X
Gila Woodpecker (*Melanerpes uropygialis*)	--/CE	Saguaro, date palm, cottonwood forests	X			X
Golden Eagle (*Aquila chrysaetos)*	-/CSC	Nesting habitat includes trees and cliffs. Range includes grasslands, valleys, meadowlands; all open areas.	x			
Gilded Flicker (*Colaptes auratus*)	--/CE	Joshua Trees, riparian woodlands	X			X
Gray Vireo (*Vireo vicinior*)	--/CSC	Juniper, dry chaparral			X	
Great Blue Heron (*Ardea herodias*)	CDFG sensitive	Rookeries only	X	X	X	X
Great Egret (*Casmerodius albus*)	CDFG sensitive	Rookeries only	X	X	X	X
Greater Sandhill Crane (*Grus canadensis tabida*)	--/CT	Agricultural land, grain and stubble fields				X
Gull-Billed Tern (*Sterna nilotica vanrossemi*)	--/CSC	Shorelines, agricultural lands		X		X
Harris' Hawk (*Parabuteo unicinctus*)	--/CSC	Cottonwood forests, mesquite, saguaro cactus	X			X
Large-Billed Savannah Sparrow (*Passerculus sandwichensis rostratus*)	--/CSC	Tamarisk scrub bordering canals and Salton Sea	X	X		X
Least Bell's Vireo (*Vireo bellii pusillus*)	FE/CE	Dense riparian			X	X

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

(Page 6 of 9)

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
BIRDS						
Le Conte's Thrasher (*Toxostoma lecontei*)	--/CSC	Widespread in desert habitats exclusive of agricultural land			X	X
Least Bittern (*Ixobrychus exilis*)	--/--/AC	Dense cattails	X			
Loggerhead Shrike (*Lanius ludovicianus*)	--/CSC	Oases, desert scrub, Joshua Trees, open mesquite fields	X	X	X	X
Long-Billed Curlew (*Numenius americanus*)	--/CSC	Shorelines, ponds, and agricultural land		X	X	X
Long-Eared Owl (*Asio otus*)	--/CSC	Dense stands of trees, such as tamarisk	X		X	X
Merlin (*Falco columbarius)*	--/CSC	Various habitats, especially near water	X		X	X
Mountain Plover (*Charadrius montanus*)	FPT/CSC	Plains, hills, agricultural land	X		X	X
Northern Harrier (*Circus cyaneus*)	--/CSC	Savannas, grasslands, agricultural areas	X	X	X	X
Osprey (*Pandion haliaetus*)	--/CSC/AT	Lakes, rivers	X	X	X	X
Prairie Falcon (*Falco mexicanus*)	--/CSC	Widespread throughout desert areas	X	X	X	X
Purple Martin (*Progne subis*)	--/CSC	Rare, probably only transients				X
Sharp-Shinned Hawk (*Accipiter striatus*)	--/CSC	Woodlands	X	X	X	X
Short-Eared Owl (*Asio flammeus*)	--/CSC	Marshes, grasslands, agricultural land	X		X	X
Snowy Egret (*Egretta thule*)	--/--/A	Breeding colonies in new sites near Bullhead City	X			

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
BIRDS						
Southwestern Willow Flycatcher (*Empidonax traillii extimus*)	FE/CE/AE	Dense willow riparian, tamarisk	X		X	X
Summer Tanager (*Piranga rubra*)	--/CSC	Cottonwoods, tamarisks, oases	X		X	X
Swainson's Hawk (*Buteo swainsoni*)	--/CT	Savannas, agricultural land, Joshua Trees	X		X	X
Western Least Bittern (*Ixobrychus exilis*)	--/CSC	Densely vegetated freshwater marshes	X	X	X	X
Western Snowy Plover (inland population) (*Charadrius alexandrinus nivosus*)	--/CSC	Alkaline flats and shorelines	X	X	X	X
Western Yellow-Billed Cuckoo (*Coccyzus americanus occidentalis*)	--/CE/AT	Dense riparian areas	X		X	X
White-Faced Ibis (*Plegadis chihi*)	--/CSC	Marshes, flooded agricultural fields	X	X	X	X
White-tailed Kite (*Elanus leucurus*)	--/CFP	Grasslands, savannas			X	X
Wood Stork (*Mycteria americana*)	--/CSC	Sloughs, lagoons, and marshes		X		X
Yellow Warbler (*Dendroica petechia brewsteri*)	--/CSC	Riparian habitat		X	X	X
Yellow-breasted Chat (*Icteria virens*)	--/CSC	Dense riparian		X	X	X
Yuma Clapper Rail (*Rallus longirostris yumanensis*)	FE/CT/AT	Marshes	X	X	X	X
MAMMALS						
Big Free-Tailed Bat (*Nyctinomops [=Tadarida] macrotis*)	--/CSC	Upper Sonoran		X		X

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

(Page 8 of 9)

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
MAMMALS						
California Leaf-Nosed Bat (*Macrotus californicus*)	--/CSC/ AC	Hottest parts of Lower Sonoran Zone	X	X		X
Colorado River Cotton Rat (*Sigmodon arizonae plenus*)	--/CSC		X			X
Greater Western Mastiff Bat (*Eumops perotis*)	--/CSC	Arid and semi-arid lowlands	X	X		X
Jacumba Little Pocket Mouse (*Perognathus longimembris internationalis*)	--/CSC	Sandy soils, Lower Sonoran Zone		X		
Jaguar (*Felis onca arizonensis*)	FE/--/AE			X		
Mexican Long-Tongued Bat (*Choeronycteris mexicana*)	--/CSC	Sonoran Zone		X		X
Occult Little Brown Bat (*Myotis [lucifugus] occultus*)	--/CSC	Lower Sonoran Zone	X	X		X
Pale Townsend's Big-Eared Bat (*Plecotus townsendii pallescens*)	--/CSC	Sonoran Zone	X	X		X
Pale Western Big-eared Bat (*Corynorhinus townsendii pallesaens*)	SC			X		
Pallid Bat (*Antrozous pallidus*)	--/CSC	Sonoran Zone		X		X
Pallid San Diego Pocket Mouse (*Chaetodipus fallax pallidus*)	SC			X		
Palm Springs Ground Squirrel (*Spermophilus tereticaudis chlorus)*	CSC				X	
Palm Springs Pocket Mouse (*Perognathus longimembris bangsi*)	--/CSC	Lower Sonoran Zone		X	X	

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

(Page 9 of 9)

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
MAMMALS						
Palm Springs Round-Tailed ground squirrel (*Spermophilus tereticaudus chlorus*)	SC			X		
Peninsular Big Horned Sheep (*Ovis canadensis cremnobates*)	FE/CE	Mountain ranges; occasional movement into valleys		X	X	X
Pocketed Free-Tailed Bat (*Tadarida femorosacca*)	--/CSC	Lower Sonoran Zone		X		X
San Bernardino Northern Flying Squirrel (*Glaucomys sabrinus californicus*)	SC			X		
Southern Grasshopper Mouse (*Onychomys torridus ramona*)	--/CSC	Valley grasslands, Lower Sonoran Zone		X		
Southwestern Cave Myotis (*Myotis velifer brius*)	SC			X		
Spotted Bat (*Euderma maculatum*)	--/CSC/AC	Rare—Sonoran and Transition Zones	X	X		X
Western Small-Footed Myotis (*Myotis ciliolabrum*)	SC			X		
Yuma Hispid Cotton Rat (*Sigmodon hispidus eremicus*)	--/CSC	Cattail marshes, Lower Colorado River	X	X		
Yuma Myotis (*Myotis yumanensis*)	--/CSC	Open woods	X			X
Yuma Puma (*Felis concolor browni*)	SC/AE			X		

Table F-1. Sensitive Wildlife Species Occurring within the Project Area

Common Name (Scientific Name)	*Status* Federal/ California/ Arizona	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*

Notes: Abbreviations are as follows:
E = Endangered, in immediate danger of extinction
T = Threatened, likely to become endangered
SC = Species of Concern
NP = Nevada Protected
FS = U.S. Forest Service Sensitive
BLM = Bureau of Land Management Sensitive
LCR (Lower Colorado River) information as provided in the Lower Colorado River Multispecies Conservation Program.
Salton Sea information as provided in the Salton Sea Restoration Draft EIS/EIR
CVWD (Coachella Valley Water District) information as provided in Biological Analysis of Three Conservation Alternatives for the Coachella Valley Multiple Species HCP/NCCP (Dec. 1999).
IID (Imperial Irrigation District) information as provided in IID HCP Table 1.
Status information from the above sources or CNDDB January 2000 list.
MWD (Metropolitan Water District) and SDCWA (San Diego County Water Agency) are not included because no project effects are anticipated in those areas.

Table F-2. Special Status Plant Species Occurring within the Project Area

(Page 1 of 3)

Common Name/ Scientific Name	*Status* Federal/California/ CNPS	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
Abram's Spurge (*Chamaesyce abramsiana*)	-/-/2	Mohavean Desert Scrub, Sandy Areas in Sonoran Desert Scrub				X
Algodones Dunes Sunflower (*Helianthus niveus* ssp. *tephrodes*	-/E/1B	Desert Dunes	X	X		X
Ayenia (*Ayenia compacta*)	-/-/2	Mohavean Desert Scrub, Rocky Areas in Soronan Desert Scrub			X	
Brown Turbans (*Malperia tenuis*)	-/-/2	Sandy Areas in Sonoran Desert Scrub				X
Chaparral Sand-Verbena (*Abronia villosa* var. *aurita*)	-/-/1B	Sandy Areas in Chaparral and Coastal Scrub			X	
Cliff Spurge (*Euphorbia misera*)	-/-/2	Coastal Bluff Scrub, Rocky Areas			X	
Coachella Valley Milkvetch (*Astragalus lentiginosus* var. *coachellae*)	E/-/1B	Sandy Areas in Sonoran Desert Scrub		X	X	
Cove's Cassia (*Senna covesii*)	-/-/2	Sandy Areas in Sonoran Desert Scrub			X	
Creamy Blazing Star (*Mentzelia tridentata*)	-/-/1B	Mohavean Desert Scrub			X	
Crucifixion Thorn (*Castela emoryi*)	-/-/2	Mohavean Desert Scrub, Playas, and Gravelly Areas in Sonoran Desert Scrub				X
Deep Canyon Snapdragon (*Antirrhinum cyathiferum*)	-/-/2	Rocky Areas in Soronan Desert Scrub			X	
Elephant Tree (*Bursera microphylla*)	-/-/2	Rocky Areas in Sonoran Desert Scrub			X	
Fairyduster (*Calliandra eriophylla*)	-/-/2	Sandy and Rocky Areas in Sonoran Desert Scrub				X
Flat-Seeded Spurge (*Chamaesyce platysperma*)	-/-/1B	Desert Dunes and Sandy Areas in Sonoran Desert Scrub		X	X	X
Foxtail Cactus (*Escobaria vivipara* var. *alversonii*)	-/-/- Arizona salvage-restricted, protected native plant	Mohavean Desert Scrub, Sonoran Desert Scrub	X	X		X
Gander's Cryptantha (*Cryptantha ganderi*)	-/-/1B	Desert Dunes, Sonoran Desert Scrub		X		
Giant Spanish Needle	-/-/1B	Desert Dunes	X	X		X

Table F-2. Special Status Plant Species Occurring within the Project Area

(Page 2 of 3)

Common Name/ Scientific Name	*Status* Federal/California/ CNPS	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
(*Palafoxia arida* var. *gigantea*)						
Glandular Ditaxis (*Ditaxis clariana*)	-/-/2	Mohavean Desert Scrub, Sandy Areas in Sonoran Desert Scrub			X	X
Grand Canyon Evening-Primrose (*Camissonia specuicola* ssp. *hesperia*)	No official status	Washes and Dry Stream Beds, not known from California	X			
Hairy Evening-Primrose (*Camissonia boothii* ssp. *intermedia*)	-/-/2	Sandy Areas in Sonoran Desert Scrub		X	X	
Hairy Stickleaf (*Mentzelia hirsutissima*)	-/-/2	Rocky Areas in Sonoran Desert Scrub				X
Hardwood's Milk-Vetch (*Astragalus insularis* var. *harwoodii*)	-/-/2	Desert Dunes		X		X
Little San Bernardino Mountain Gilia (*Gilia maculata*)	-/-/1B	Desert Dunes, Joshua Tree Woodland, Mohavean Desert Scrub, and Sandy Areas in Sonoran Desert Scrub		X	X	
Mecca Aster (*Xylorhiza cognata*)	-/-/1B	Sonoran Desert Scrub		X	X	
Munz's Cactus (*Opuntia munzii*)	-/-/1B	Sandy or Gravelly Areas in Sonoran Desert Scrub		X		X
Orcutt's Woody-Aster (*Xylorhiza orcuttii*)	-/-/1B	Sonoran Desert Scrub		X	X	X
Orocopia Sage (*Salvia greatae*)	-/-/1B	Mohavean Desert Scrub, Sonoran Desert Scrub		X	X	X
Peirson's Milkvetch (*Astragalus magdalenae* var. *peirsonii*)	T/E/1B	Desert Dunes		X		X
Peirson's Pincushion (*Chaenactis carpholinia* var. *peirsonii*)	-/-/1B	Sandy Areas in Sonoran Desert Scrub			X	
Purple Stemodia (*Stemodia durantifolia*)	-/-/2	Sandy Areas in Sonoran Desert Scrub			X	
Rock Nettle (*Eucnide rupestris*)	-/-/2	Sonoran Desert Scrub				X
Sand Food (*Pholisma sonorae*)	-/-/1B Arizona highly safeguarded, protected	Desert Dunes	X	X		X

Table F-2. Special Status Plant Species Occurring within the Project Area

(Page 3 of 3)

Common Name/ Scientific Name	*Status* Federal/California/ CNPS	*Notes on Habitat and Occurrence*	*LCR*	*Salton Sea*	*CVWD*	*IID*
	native plant					
Shaggy-Haired Alumroot (*Huechera hirsutissima*)	-/-/1B	Subalpine Coniferous Forest, Rocky Areas in Upper Montane Coniferous Forest			X	
Slender-Stem Bean (*Phaseolus filiformis*)	-/-/2	Sonoran Desert Scrub			X	
Slender Wooly-Heads (*Nemacaulis denudata* var. *gracilis*)	-/-/2	Coastal Dunes, Desert Dunes, Sonoran Desert Scrub		X	X	
Sonoran Maiden Fern (*Thelypteris puberula* var. *sonorensis*)	-/-/2	Meadows			X	
Spearleaf (*Matelea parviflora*)	-/-/2	Mohavean Desert Scrub, Rocky Areas in Sonoran Desert Scrub			X	
Threecorner Milkvetch (*Astragalus geyeri* var. *triquetrus*)	-/-/- Nevada critically endangered	Sandy Soils in Flats, Dunes, Washes, Gullies, and Sandy Valley Floors, not known from California	X			
Triple-Ribbed Milkvetch (*Astragalus tricarinatus*)	E/-/1B	Joshua Tree Woodland, Sandy or Gravel areas in Sonoran Desert Scrub			X	
White-Bracted Spineflower (*Chorizanthe xanti* var. *luecotheca*)	-/-/1B	Mohavean Desert Scrub, Pinyon and Juniper Woodland			X	
Wiggin's Croton (*Croton wigginsii*)	-/R/2	Desert Dunes, Sonoran Desert Scrub		X		X

Notes : Abbreviations are as follows:

E = Endangered, in immediate danger of extinction
T = Threatened, likely to become endangered
R = Categorized as Rare by the State of California
1B = considered rare and endangered throughout its range by CNPS
2 = considered rare and endangered in California by CNPS, but also occurs outside of California

LCR (Lower Colorado River) information as provided in the Lower Colorado River Multispecies Conservation Program.
Salton Sea information as provided in the Salton Sea Restoration Draft EIS/EIR
CVWD (Coachella Valley Water District) information as provided in Biological Analysis of Three Conservation Alternatives for the Coachella Valley Multiple Species HCP/NCCP (Dec. 1999).
IID (Imperial Irrigation District) information as provided in IID HCP Table 1.
MWD (Metropolitan Water District) and SDCWA (San Diego County Water Agency) are not included because no project effects are anticipated in those areas.
Supplementary and updated information for IID, Salton Sea, and CVWD and habitat information from CNPS Electronic Inventory (updated June 2000).

Appendix G

Technical Memorandum No. 1
Analysis of River Operations and Water Supply

TECHNICAL MEMORANDUM NO. 1
ANALYSIS OF RIVER OPERATIONS AND WATER SUPPLY

Prepared as Part of the

ENVIRONMENTAL IMPACT STATEMENT FOR THE IMPLEMENTATION AGREEMENT, INADVERTENT OVERRUN AND PAYBACK POLICY, AND RELATED FEDERAL ACTIONS

October 18, 2002

TABLE OF CONTENTS

1.0 RIVER SYSTEM OPERATIONS

This section presents an overview of the operation of the Colorado River system, with particular emphasis on the operation of Glen Canyon and Hoover Dams. The term *operation of the Colorado River system* refers to how the water is managed once it enters the Colorado River system and includes operation of the system reservoirs, dams and other Colorado River system facilities.

1.1 OPERATION OF THE COLORADO RIVER SYSTEM OVERVIEW

Operation of the Colorado River system and delivery of Colorado River water to the seven Basin States and Mexico are conducted in accordance with a body of documents often referred to as the *Law of the River*, which is discussed in Section 1.2.2 of the Environmental Impact Statement for the Implementation Agreement, Inadvertent Overrun and Payback Policy, and Related Federal Actions (EIS). The *Law of the River* provides that 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 approved water delivery orders and to satisfy other stated purposes. 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 the Bureau of Reclamation (Reclamation) pursuant to the Long Range Operating Criteria (LROC) and the Annual Operating Plan (AOP). The AOP is required by the Colorado River Basin Project Act of 1968 (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 purchase of federal power, others interested in Colorado River operations, and the general public.

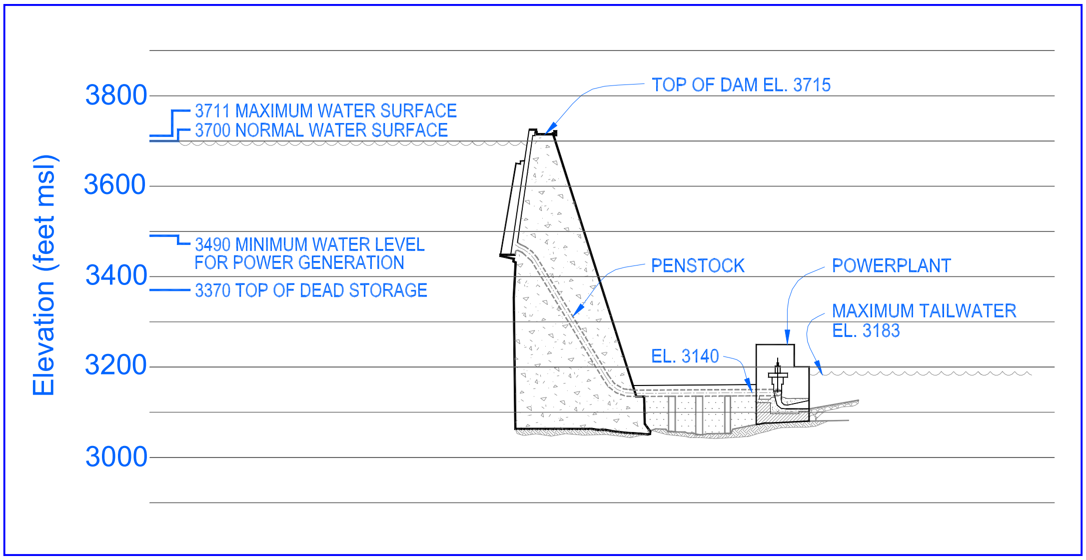
Prior to the beginning of the calendar year, Lower Basin diversion schedules are requested from major water users entitled to use Colorado River water as discussed in Section 4.4. These schedules are estimated monthly diversions and return flows that allow Reclamation to determine a tentative schedule of monthly releases through the Hoover Powerplant. Actual monthly releases are determined by the demand for water downstream of Hoover Dam. Daily changes in water releases are made to accommodate emergencies and weather.

A minimum of 1.5 million acre feet (maf) is delivered annually to Mexico in accordance with the US-Mexican Water Treaty of 1944. The Treaty contains provisions for delivery of up to 200,000 acre feet (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.

1.2 DESCRIPTION AND OPERATION OF GLEN CANYON DAM

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 1.2-1. Except during flood conditions, the "full reservoir" water level is 3700 feet above mean sea level (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 (Reclamation, 2000).

Figure 1.2-1
Lake Powell and Glen Canyon Dam Important Operating Elevations



Flows below Glen Canyon Dam are primary influenced by storage and release decisions that are scheduled and implemented on an annual, monthly and hourly basis at Glen Canyon Dam. Other sources of water below Glen Canyon Dam include inflows from the Paria and Little Colorado rivers.

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 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 forecasted 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 Colorado Basin River Forecast Center (CBRFC) provides the monthly forecasts of expected inflow into Lake Powell. 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. Regression and real-time conceptual computer models are used to forecast inflows that are then used by Reclamation to plan future release volumes. 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 forecasted inflow allows, Lake Powell is targeted 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 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.

Daily and hourly releases are made according to the parameters of the Record of Decision (ROD) for the Operation of Glen Canyon Dam Final Environmental Impact

Statement and published in the *Glen Canyon Dam Operating Criteria* (62 CFR 9447, Mar. 3, 1997), as shown in Table 1.2-1.

Table 1.2-1
Glen Canyon Dam Release Restrictions

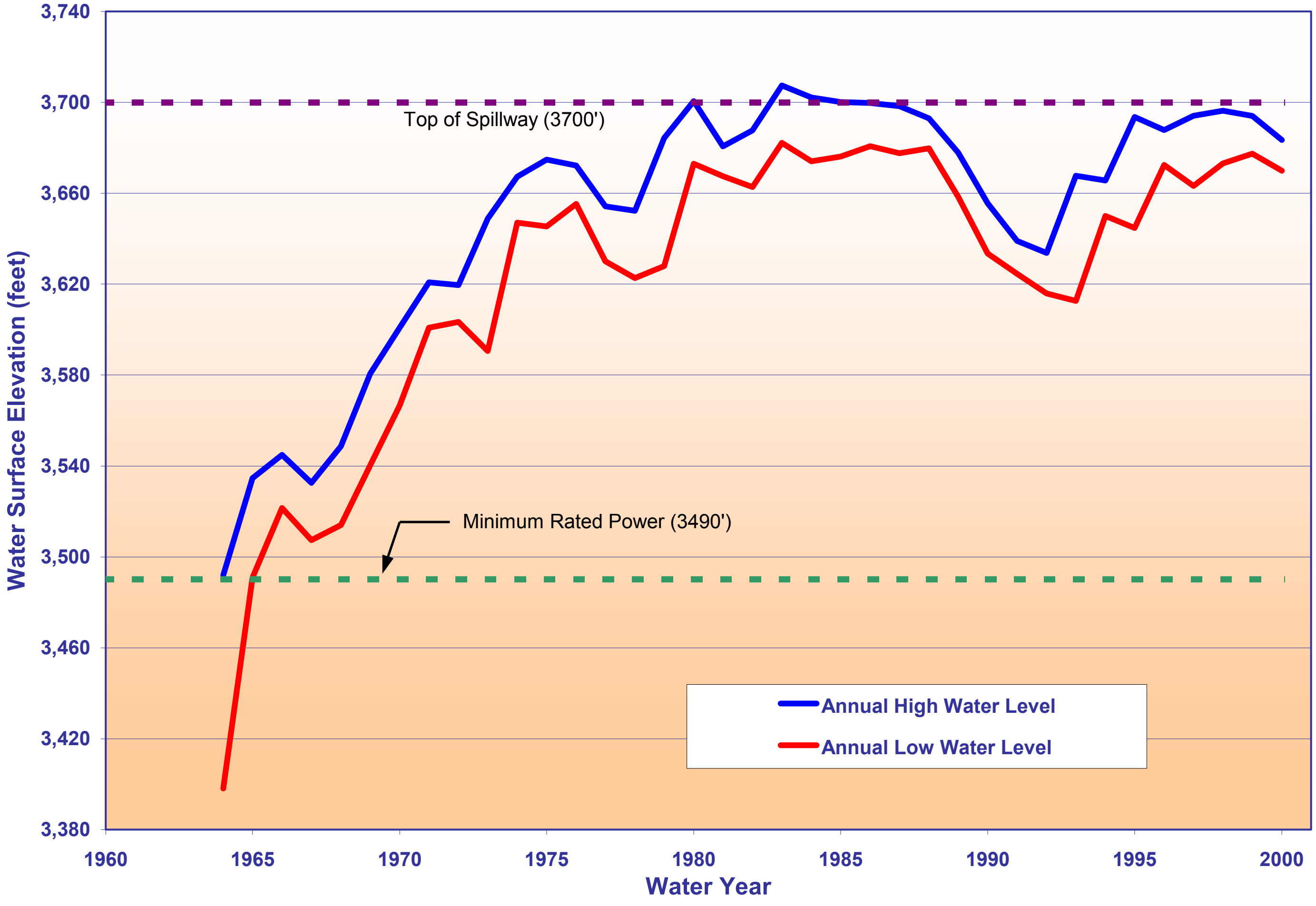
Parameter	Cubic Feet per Second	Conditions
Maximum Flow[1]	25,000	
Minimum Flow	5,000	Nighttime
	8,000	7:00 a.m. to 7:00 p.m.
Ramp Rates		
Ascending	4,000	Per hour
Descending	1,500	Per hour
Daily Fluctuations[2]	5,000 to 8,000	

[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.

Glen Canyon Dam and Lake Powell were designed to operate from a normal maximum water surface elevation of 3700 feet msl to a minimum elevation of 3490 feet msl, the minimum for hydropower production. During flood conditions, the water surface elevation of Lake Powell can exceed 3700 feet msl by raising 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 3612 feet msl, as shown on Figure 1.2-2. The “water year” is cited to correspond with Upper Basin water accounting.

Figure 1.2-2
Historic Lake Powell Water Levels



1.3 DESCRIPTION AND OPERATION OF HOOVER DAM

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 326 miles downstream of Lee Ferry. 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 27.38 maf at a maximum water surface 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 water surface elevation for efficient power generation is 1083 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 1221.0 feet, the top of the raised spillway gates. Figure 1.3-1 illustrates some of the important Hoover Dam and Lake Mead water surface elevations that are referenced in subsequent sections.

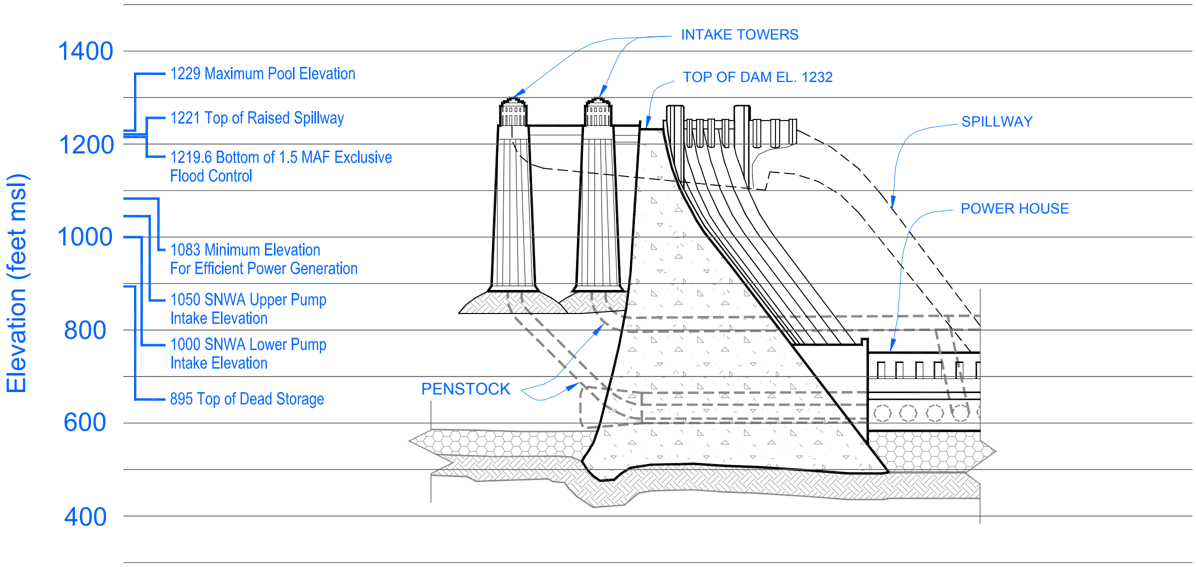
Lake Mead is usually at its maximum water level in November and December. If required, system storage space-building is achieved between August 1 and January 1. Hoover Dam storage space-building releases are limited to 28,000 cfs, while the mean daily releases to meet the water delivery orders of Colorado River water entitlement holders normally range between 8000 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 transmission facilities for treatment and further conveyance to the Las Vegas area. 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. SNWA recently constructed 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 new 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.

Hoover Dam is managed to provide at least 7.5 maf annually for consumptive use by the Lower Division states plus the United States' 1.5 maf obligation to Mexico. 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 cubic feet per second (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.

Figure 1.3-1
Lake Mead and Hoover Dam Important Operating Elevations



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 provided in the LROC. Another type of release includes flood control releases. For Hoover Dam, flood control releases are defined in this report as releases in excess of downstream demands.

Flood control was specified as a primary project purpose by the Boulder Canyon Project Act of 1928 (BCPA), the act authorizing Hoover Dam. The Corps is responsible for developing the flood control operation plan for Hoover Dam and Lake Mead as indicated in 33 CFR 208.11. The plan is the result of a coordinated effort by the Corps and Reclamation. However, the Corps 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 Corps. The Secretary is responsible for operating Hoover Dam in accordance with these regulations.

The 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 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 1.3-1 presents the amount of required flood storage space within the Colorado River system by date:

Table 1.3-1
Minimum Required Colorado River System Storage Space

Date	Storage Space (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 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 forecasted inflow may be required to prevent filling 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 Corps' regulations is based on increasing releases in six steps as shown on Table 1.3-2.

Table 1.3-2
Minimum Flood Control Releases at Hoover Dam

Step	Amount of Cubic Feet/Second
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. The fourth step in the Corps 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 nondamaging 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 forecasted inflow exceeds downstream demands, available storage space at lakes Mead and 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 Corps regulations set the procedures for releasing the volume that cannot be impounded, as discussed above.

Average monthly 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.

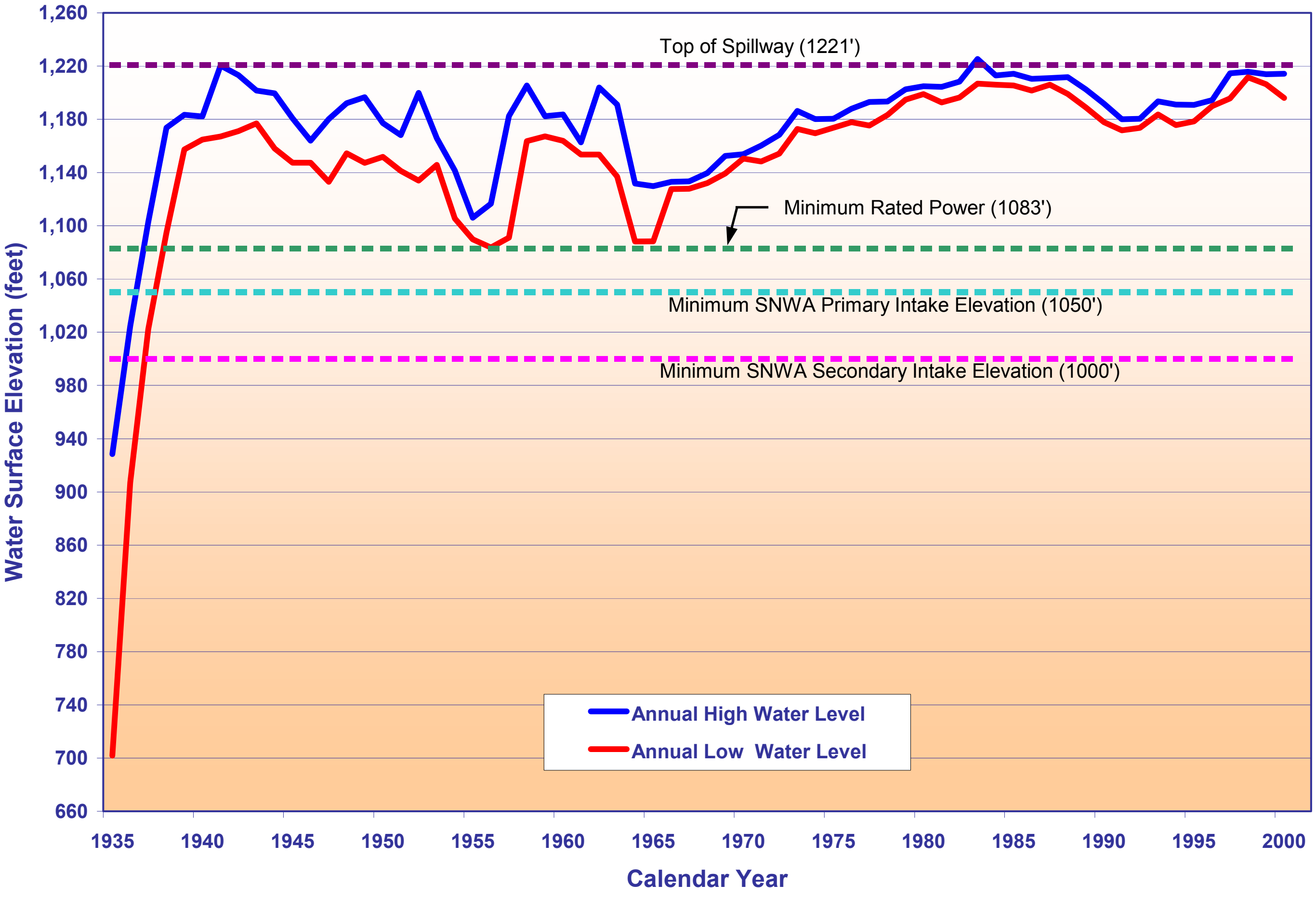
During non-flood operations, the end-of-month Lake Mead elevations are driven by consumptive use needs, Glen Canyon Dam releases and Treaty deliveries to Mexico. Lake Mead end-of-month target elevations are not fixed as are the end-of-month target elevations for Lake Mohave and Lake Havasu. Normally, Lake Mead elevations decline with increasing irrigation deliveries through June 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 International Boundary with Mexico. Figure

1.3-2 presents the historic annual water levels (annual maximum and minimum) of Lake Mead. The annual change in elevations of Lake Mead has ranged from less than ten feet to as much as 75 feet msl. The calendar year is cited to correspond with Lower Basin water accounting.

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 to the minimum rated power elevation (1083 feet msl) of the Hoover Powerplant during two periods (1954 to 1957 and 1965 to 1966). The maximum Lake Mead water surface elevation of approximately 1225.6 feet msl occurred in only one year, 1983.

Four Lake Mead water surface elevations of interest are also shown in Figure 1.3-2. The first elevation is 1221 feet msl, the top of the spillway gates. The second elevation is 1083 feet msl, the minimum elevation for the effective generation of power. The third elevation is 1050 feet msl, the minimum elevation required for the operation of SNWA's original intake facility. The final elevation is 1000 feet msl, the minimum elevation required for the operation of SNWA's second intake facility.

Figure 1.3-2
Historic Lake Mead Water Levels
(Annual Highs and Lows)



1.4 NATURAL RUNOFF AND STORAGE OF WATER

Most of the natural flow in the Colorado River system originates in the Upper Basin and is highly variable from year to year. The natural flow represents an estimate of runoff flows that would exist without storage or depletion by man and was used in the modeling of the baseline conditions and interim surplus criteria alternatives. 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 15.1 maf, annual flows in excess of 23.8 maf and as little as 5.0 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. The various reservoirs that provide storage in the Colorado River system and their respective capacities are discussed in Section 1.2.4 of the EIS.

Figure 1.4-1 presents the annual natural flow calculated at Lees Ferry for calendar years 1906 through 2000. The natural flow represents an estimate of the flows that would occur at Lees Ferry without storage or depletion by human activity. This is different than the recorded or historical stream flows that represent actual measured flows. Figure 1.4-2 presents the annual historical flows recorded at Lees Ferry for the period 1922 through 2000 (calendar year).

Figure 1.4-1
Natural Flow at Lees Ferry Stream Gage

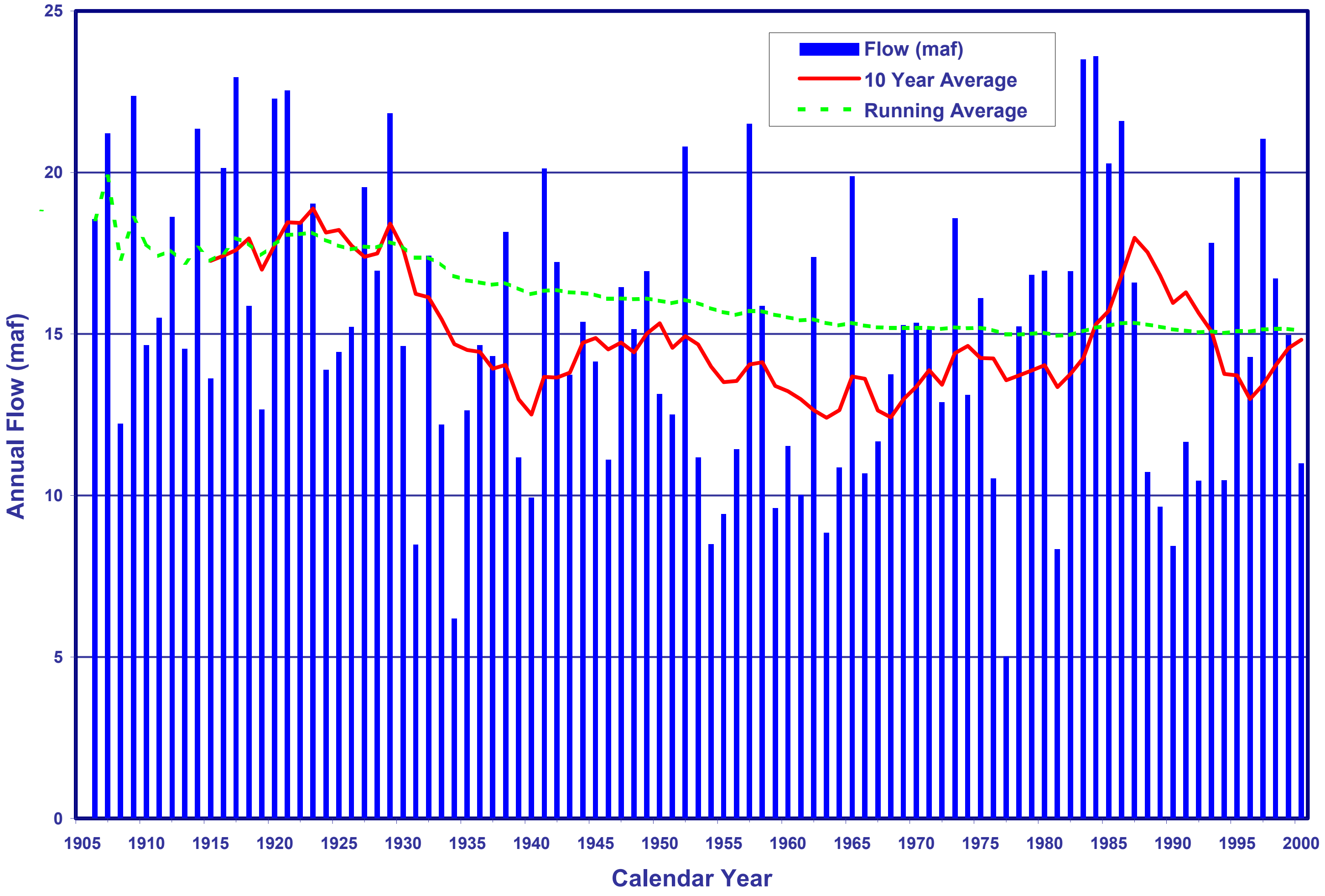
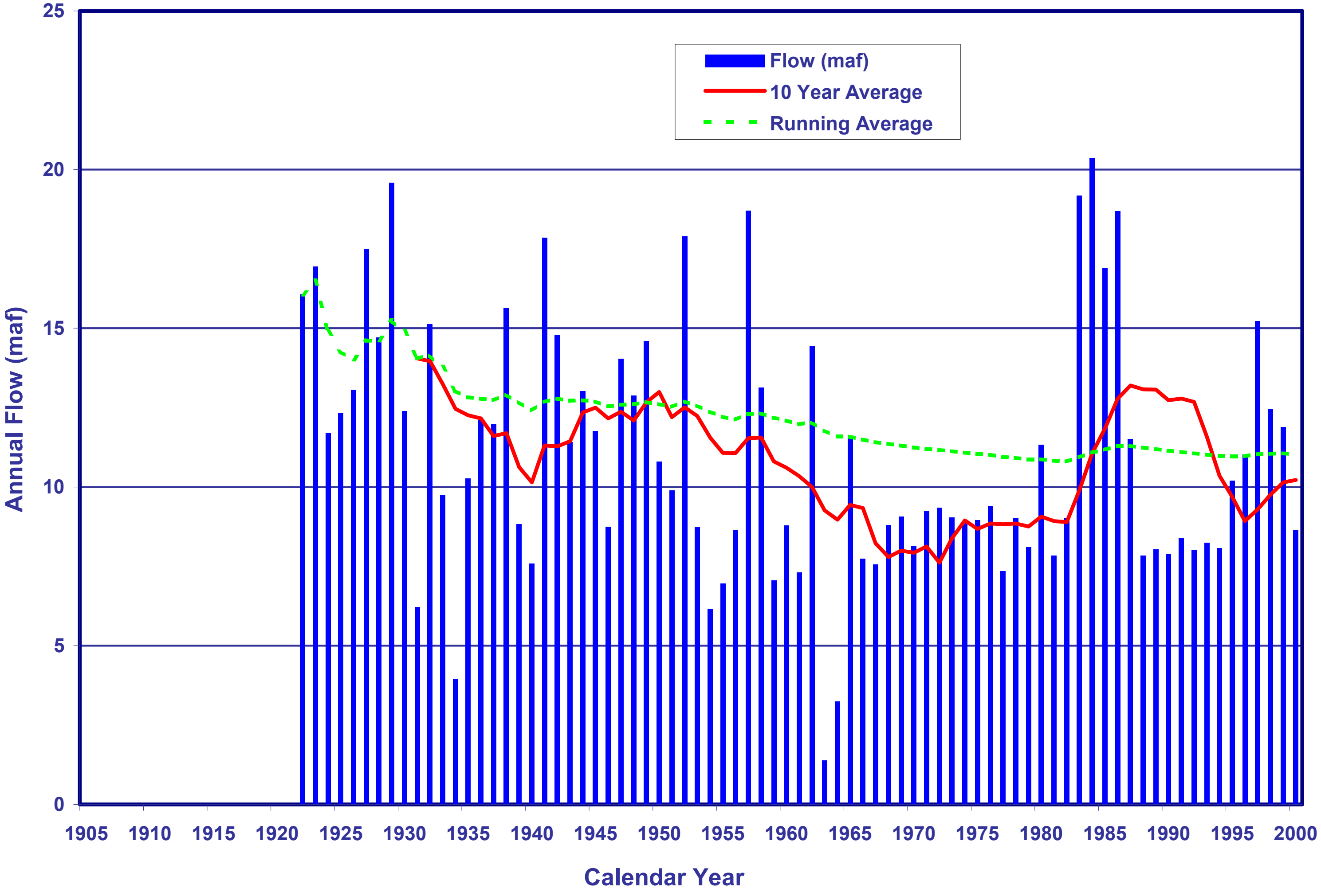


Figure 1.4-2
Historic Annual Flow at Lees Ferry Stream Gage



2.0 RIVER SYSTEM MODELING

This section addresses the modeling and analysis procedures used to simulate river system operation for various operational scenarios. The scenarios were chosen to analyze hydrologic changes that are likely to occur due to execution of the Secretarial Implementation Agreement (IA), which is necessary to implement the water transfers and exchanges proposed in the Quantification Settlement Agreement (QSA). Additional scenarios were modeled to analyze the cumulative effects of the combined Interim Surplus Guidelines (ISG) and QSA.

2.1 MODEL CONFIGURATION

Future river system conditions for each scenario were simulated using a computerized model. The model framework used for this process is the commercial river modeling software called RiverWare (Zagona et al, 2001). RiverWare was developed by the University of Colorado in cooperation with Reclamation and the Tennessee Valley Authority. RiverWare was configured to simulate the Colorado River System and its operation and integrates the Colorado River Simulation System (CRSS) model that was developed by Reclamation in the 1970s. River operation parameters modeled by CRSS on a monthly basis include the water entering the river system, storage in system reservoirs, releases from storage, river flows, and the water demands of and deliveries to the Basin States and Mexico. The water supply used by the model consists of the natural inflow in the river system over the 85-year period from 1906 through 1990, at 29 individual inflow points on the system.

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. Return flow credits are applied when a portion of the diverted water is returned to the river system. In cases where there are no return flow credits associated with the diversions, the depletion is equal to the diversion. The simulated operation of Glen Canyon Dam, Hoover Dam and other elements of the Colorado River system was consistent with the LROC, applicable requirements for storage and flood control management, water supply deliveries to contractors and federal establishments in the Basin States, Indian tribes, and Mexico, and flow regulation downstream of the system dams.

2.2 CRITERIA MODELED AND ANALYZED

Four Colorado River operational scenarios are considered in this report and are listed in Table 2.2-1. A more detailed description of the assumptions of the four operation scenarios can be found in Section 2.3.

Table 2.2-1
Colorado River Operational Scenarios Modeled

Operational Scenario	Assumptions
No Action (NA)	1988/89 agreement (110 kaf transfer from IID to MWD) No other California water transfers (i.e., no QSA) Interim Surplus Guidelines 2002-2016, 70R 2017-2076 MWD meets ISG ROD benchmarks, permitting the Interim Surplus Guidelines to remain in place.
Implementation Agreement (IA)	1988/89 agreement (110 kaf transfer from IID to MWD) QSA (388 kaf transfer by 2026) Interim Surplus Guidelines 2002-2016, 70R 2017-2076 ISG ROD benchmarks are met via QSA
Baseline for Cumulative Analysis (Baseline)	1988/89 agreement (110 kaf transfer from IID to MWD) No other California water transfers (i.e., no QSA) No Interim Surplus Guidelines (70R for entire period 2002-2076) No ISG ROD benchmarks to be met
Cumulative Analysis (CA)	1988/89 agreement (110 kaf transfer from IID to MWD) QSA (388 kaf transfer by 2026) Additional reduction in diversion by PVID of up to 111 kafpermitting the Secretary to make an equivalent amount of water available to MWD. Interim Surplus Guidelines 2002-2016, 70R 2017-2076 ISG Rod benchmarks are met via QSA

The 1988/89 agreement cited in Table 2.2-1 provides for a 110 kaf reduction in diversion by IID from water conservation to permit the Secretary to make an equivalent amount of water available to MWD.

The operational scenarios in Table 2.2-1 were used in two separate analyses as follows:

1. An analysis that evaluates the potential effects resulting from the implementation of the proposed water transfers (i.e., QSA). Under this analysis, the results of the modeled No Action and Implementation Agreement modeled operational scenarios were compared. The focus of this analysis was to ascertain the potential cumulative impacts to the river system and water deliveries to the Basin states and Mexico resulting from the implementation of the proposed water transfers.
2. An analysis that evaluates the potential cumulative effects from the implementation of the Interim Surplus Guidelines, water transfers proposed in the QSA, and the Palo Verde Irrigation District Land Management, Crop Rotation and Water Supply Program (PVID/MWD program). Under this analysis, the results of the modeled Baseline for Cumulative Analysis and Cumulative Analysis modeled operational scenarios were compared. The focus of this analysis was to ascertain the potential cumulative impacts to the

river system and water deliveries to the Basin states and Mexico resulting from the implementation of these water management programs.

2.3 MODELING ASSUMPTIONS

Due to the high degree of uncertainty in future inflows, projecting the future state of the Colorado River system is also highly uncertain. For this report, this uncertainty is dealt with in two ways. First, the uncertainty due to hydrologic variability is quantified by running many simulations, each with a different assumption of the future inflows. This technique is explained more fully in Section 2.5. Secondly, when comparing operational scenarios, the majority of modeling assumptions is kept consistent between the scenarios, and only those assumptions that are specific to the particular scenario are changed. This allows a relative comparison of the effects of one scenario to another.

The important modeling assumptions used for the scenarios studied are detailed below.

2.3.1 ASSUMPTIONS CONSISTENT FOR ALL OPERATIONAL SCENARIOS

For all scenarios, system conditions were simulated for the period 2002-2076, using the same initial reservoir elevations for January 1, 2002. Reclamation's 24 month study model (a model also implemented in RiverWare) was used to project these elevations, using actual elevations as of April 2001 (the month in which these studies began) and projected operations for the remainder of the 2001 calendar year. These elevations and the corresponding reservoir storage are shown on Table 2.3-1.

Table 2.3-1
Projected Jan 1, 2002 Reservoir Elevations Used
as Initial Conditions for Modeling Study

Reservoir	Elevation, feet msl	Storage, kaf
Fontenelle	6,484.89	197.32
Flaming Gorge	6,023.21	3,052.16
Taylor Park	9,309.50	62.79
Blue Mesa	7,486.72	582.68
Morrow Point	7,153.73	112.18
Crystal	6,746.05	15.00
Navajo	6,074.60	1,487.66
Powell	3,669.91	24,256.50
Mead	1,182.01	20,441.65
Mohave	638.71	1,582.96
Havasu	445.78	539.15
Total	**NA**	**52,330.05**

The operation of the Upper Basin reservoirs including Lake Powell, was consistent for all scenarios, as were the Upper Division States depletion projections. These projections were provided by the Upper Colorado River Commission (December 1999) and include new Indian tribe schedules as documented in the Interim Surplus Criteria FEIS. These schedules are detailed in Attachment B.

The operation of the Lower Basin reservoirs, including Lake Mead was consistent for all scenarios with the exception of the depletion schedules for specific California entities and the criteria under which surplus conditions were determined. These exceptions are discussed in detail in Section 2.3.2. Particular modeling assumptions for the Lower basin that were consistent for all scenarios include:

- Lake Mead is operated to meet downstream demand, (including Mexico), except when additional releases are necessary to meet the Corps flood control regulations.
- Lakes Mohave and Havasu are operated in accordance with their existing rule curves.
- Lower Basin shortage conditions are determined by the strategies detailed in Section 2.4.
- Water deliveries to Mexico are pursuant to the requirements of the US-Mexico Water Treaty of 1944, which provide annual deliveries of 1.5 maf to Mexico under normal conditions, up to 1.7 maf under Lake Mead flood control release conditions, and less than 1.5 maf under conditions of extreme shortage when California's delivery is also cut.

Several other modeling assumptions may be of interest. First, Mexico's principal diversion is at Morelos Dam where most of its Colorado River apportionment of 1.5 maf is diverted. In practice, up to 140 thousand acre-feet (kaf) is delivered to Mexico near the Southerly International Boundary (SIB). The model, however, extends to just south of the Northerly International Boundary (NIB) to include the diversion at Morelos Dam and accounts for the entire Treaty delivery at that point. Under normal conditions, the model sets the diversion and depletion schedule for the Mexican Treaty delivery at Morelos Dam to 1.515 mafy. The additional 15,000 af accounts for typical scheduling errors and over-deliveries.

Secondly, the Yuma Desalting Plant was assumed to remain in ready reserve status with 120,000 acre-feet per year (afy) bypassed to the Cienega de Santa Clara in Mexico from 2002-2004. For modeling purposes, this depletion is not counted as part of the Treaty delivery. The desalting plant is assumed to operate beginning in 2005, reducing the bypass to 52,000 afy. Similarly, for modeling purposes, this bypass is not counted as part of the Treaty delivery. It should be noted that the United States recognizes that it has an obligation to replace, as appropriate, the bypass flows and that 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 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.

Lastly, all Arizona shortages are assumed to be absorbed by the Central Arizona Project (CAP). Reclamation acknowledges that under the current priority framework, there would be some sharing of Arizona shortage between the Central Arizona Project and other Priority 4 users. However, the basis or formula for the sharing of Arizona shortages is the subject of current negotiations and thus could not be adequately modeled. The water supply conditions modeled were used to evaluate the relative differences in water deliveries to users in each state under each operational scenario. The normal, surplus and shortage condition water depletion schedules modeled are consistent with the depletion schedules prepared by the Basin states for this purpose.

2.3.2 MODELING ASSUMPTIONS SPECIFIC TO EACH OPERATIONAL SCENARIO

As previously mentioned, the differences in modeling assumptions between the operational scenarios involve the depletion schedules for specific California entities and the criteria used to determine surplus conditions. A description of these differences follows.

No Action Scenario

In this scenario, no water transfers specified in the QSA are in effect. However, the existing conservation program implemented by IID and funded by MWD (the 1988/89 Agreements) is assumed to continue throughout the study period (2002-2076) at 110 kaf per year. Detailed schedules for the Lower Division state entities under normal conditions for the No Action scenario are presented and discussed in Attachment A.

Surplus conditions are determined under the No Action Scenario using the Interim Surplus Guidelines for the period 2002-2016. For the period 2017-2076, surplus conditions are determined using the “70R” strategy. An overview of these strategies and the corresponding surplus depletion schedules are presented in Attachment C.

One additional assumption should be noted here. In the Interim Surplus Guidelines Record of Decision (ISG ROD), benchmarks for reductions of agricultural use of Colorado River water in California were specified. Since these benchmarks are not met from QSA water transfers under the No Action scenario, it was assumed that the Metropolitan Water District (MWD) would reduce its use to meet the benchmarks and therefore, keep the ISG in effect. Further explanation and the resulting MWD surplus schedules are detailed in Attachment C.

Implementation Agreement Scenario

In this scenario, water transfers consistent with the QSA are assumed under normal conditions. These transfers are in addition to the 110 kafy due to the 1988/89 Agreement between IID and MWD. Most of these transfers are assumed to "ramp up" over the first 25 years. The total amount of water transferred from California agricultural use to MWD is 388.2 kaf by the year 2026 and remains at that amount for the period 2027 – 2047.

In 2047, the total amount of water transferred to MWD is assumed to drop to 338.2 kaf per year and remain at that level through 2076. This 50 kaf drop is the result of assuming that the "Second 50 kafy" transfer (see section 2.2.1.1 of the EIS) from IID does not occur. This assumption was made to model the "worst case" with regard to reduced river flows in the Parker to Imperial reach.

Further details of the water transfers assumed under the IA scenario can be found in Attachment A.

Surplus conditions are determined under the IA scenario identical to those of the No Action Scenario (i.e., ISG 2002-2016, 70R 2017-2076). The surplus depletion schedules are also identical, with the exception of the MWD schedules, since the ISG ROD benchmarks are met with the QSA water transfers. These schedules are detailed in Attachment C.

Baseline for Cumulative Analysis Scenario

In this scenario, the normal depletion schedules are identical to those used for the No Action scenario (i.e., no water transfers except for the 1988/89 Agreements).

Surplus conditions are determined under this scenario using the 70R strategy for the entire period, 2002-2076. Interim Surplus Guidelines are not in effect, and therefore, there are no benchmark reductions to meet. A further explanation of this strategy and the corresponding surplus schedules are detailed in Attachment C.

Cumulative Analysis Scenario

In this scenario, the normal depletion schedules are identical to those used for the IA scenario (i.e., 388 kaf of transfers by 2026), but with the addition of approximately 110 kaf/year of transfers from PVID to MWD under the PVID/MWD program. These schedules are detailed in Attachment A.

Surplus conditions are determined under this scenario identical to those of the IA scenario. The surplus depletion schedules are also identical to those used for the IA scenario.

2.4 LAKE MEAD WATER LEVEL PROTECTION ASSUMPTIONS

There are no established shortage criteria for the operation of Lake Mead. However, it was necessary to include some shortage criteria in the model simulation to address concerns related to low Lake Mead water levels. Three important Lake Mead water elevations were selected for analysis. The significance of these selected elevations relates to known economic and/or socioeconomic impacts that would occur if Lake Mead water levels were lowered below the selected water levels. Elevation 1083 feet msl is the minimum water level for efficient power generation at the Hoover Powerplant based on its existing turbine configuration. Elevation 1050 feet msl is the minimum water level necessary for operation of SNWA's upper water intake. Water withdrawn from the Lake Mead through this intake is delivered to Las Vegas Valley, Boulder City and other parts of Clark County. Even though SNWA has constructed a second intake at a lower elevation, the original intake at elevation 1050 feet msl is needed to meet full SNWA summer diversions. Elevation 1000 feet msl is the minimum water level necessary for operation of SNWA’s lower water intake.

In the absence of specific shortage criteria, the Lake Mead level protection assumptions listed below were assumed for all operational scenarios modeled.

<u>First Level Shortage:</u>

- The Lake Mead water level of 1083 feet msl was designated as a level that should be protected. The “protection line” (to prevent the water level from declining below elevation 1083 feet msl with approximately an 80 percent probability) used for the Interim Surplus Criteria Final Environmental Impact statement (Reclamation, 2000) was extrapolated from 2050 through 2076 and used for this study. A graph of this protection line is presented in Attachment D. Sensitivity analysis of using a 1050-foot protection line is also discussed in Attachment D.
- A “first-level” shortage would be determined to exist for any year in which the Lake Mead water level was below the protection line at the beginning of the year.
- During first level shortage conditions, the annual water delivery to CAP was set to 1.0 maf, and the Southern Nevada Water Authority (SNWA) was assigned four percent of the total shortage.

<u>Second Level Shortage:</u>

- A second level shortage would be determined to exist for any year if the Lake Mead water surface elevation was projected at the beginning of the year to fall below 1000 feet msl by the end of the year.

- During second level shortage conditions, the CAP and SNWA consumptive use would be reduced as needed to maintain the Lake Mead water level at 1000 feet msl. Once the delivery to the CAP is reduced to zero, deliveries to MWD and to Mexico would be reduced to maintain the Lake Mead water level at 1000 feet msl.

2.5 COMPUTATIONAL PROCEDURES

As previously discussed, the model was used to simulate the future state of the Colorado River system on a monthly basis, in terms of reservoir levels, releases from the dams, hydroelectric energy generation, flows at various points along the system and diversions to and return flows from various water users. The input data for the model included the monthly tributary inflows, various physical process parameters (such as the evaporation rates for each reservoir) and the diversion and depletion schedules for entities in the Basin States and Mexico. The common and specific modeling assumptions were also input for each scenario being studied.

Despite the differences in the modeling assumptions for each scenario, the future state of the Colorado River system (i.e., water levels at Lake Mead and Lake Powell) is most sensitive to the future inflows. As discussed in Section 1.4, observations over the period of historical record (1906–present) show that inflow into the system has been highly variable from year to year. Predictions of the future inflows, particularly for long-range studies, are highly uncertain. Although the model does not predict future inflows, it can be used to analyze a range of possible future inflows and to quantify the probability of particular events (i.e., lake levels being below or above certain levels).

Several methods are available for ascertaining the range of possible future inflows. On the Colorado River, a particular technique (called the Indexed Sequential Method) has been used since the early 1980s and involves a series of simulations, each applying a different future inflow scenario (USBR, 1985; Ouarda, *et al.,* 1997). Each future inflow scenario is generated from the historical natural flow record by "cycling" through that record. Currently, the natural flow record from water years 1906-1990 is utilized, although work is on-going to compute the natural flows for all 29 inflow points from 1991 to present. For example, the first simulation assumes that the inflows for 2002 through 2076 will be the 1906 through 1980 record, the second simulation assumes the inflows for 2002 through 2076 will be the 1907 through 1981 record, and so on. As the method progresses, the historical record is assumed to "wrap-around" (i.e., after 1990, the record reverts back to 1906), yielding a possible 85 different inflow scenarios. The result of the Indexed Sequential Method is a set of 85 separate simulations (referred to as "traces") for each operating criterion that is analyzed. This enables an evaluation of the respective criteria over a broad range of possible future hydrologic conditions using standard statistical techniques.

2.6 POST-PROCESSING AND DATA INTERPRETATION PROCEDURES

The various hydrologic, environmental and socioeconomic analyses in the EIS requires the sorting and arranging of various types of model output data into tabulations or plots of specific operational conditions, or parameters, at various points on the system. This was done through the use of statistical methods and other numerical analyses.

The model generates data on a monthly time step for some 300 points (or nodes) on the river system. Furthermore, through the use of the Indexed Sequential Method, the model generates 85 possible outcomes for each node for each month over the time period 2002 through 2076. These very large data sets are generated for each surplus alternative and baseline conditions and 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 are typically aggregated to reduce the volume of data and to facilitate comparing the operational scenarios. The type of aggregation varies depending upon the needs of the particular resource analysis. The post-processing techniques used for this report fall into two basic categories: those that aggregate in time, space or both, and those that aggregate the 85 possible outcomes.

For aggregation in time and space, simple techniques are employed. For example, deliveries of Colorado River water to all California diversion nodes in the model are summed to produce the total delivery to the state for each calendar year. Similarly, lake elevations may be chosen on an annual basis (i.e., end of December) to show long-term lake level trends as opposed to short-term fluctuations. For comparison purposes, three time periods are routinely used in this analysis. They are the 15-year period that coincides with the interim surplus guidelines period (2002 through 2016), the 60 year period of time that follows (2017 through 2076), and the entire 75-year period of analysis. The particular time period used will be noted in the methodology section for each resource.

Once the appropriate temporal and spatial aggregation is chosen, standard statistical techniques are used to analyze the 85 possible outcomes for a fixed time. Statistics that may be generated include the mean and standard deviation. However, the most common technique simply ranks the outcomes at each time (from highest to lowest) and uses the ranked outcomes to compute other statistics of interest. For example, if end-of-calendar year Lake Mead elevations are ranked for each year, the median outcome for a given year is the elevation for which half of the values are below and half are above the median value, which is also referred to as the 50th percentile value. Similarly, the elevation for which 10 percent of the values are less than or equal to, is the 10th percentile outcome.

Several presentations of the ranked data are then possible. A graph (or table) may be produced that compares the 90th percentile, 50th percentile, and 10th percentile outcomes from 2002 through 2076 for the cases analyzed. 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).

3.0 RIVER SYSTEM MODELING RESULTS

This section presents general and specific discussions of the Colorado River System operation modeling results. The following sequence of topics is used to address the potentially affected river system components:

- Lake Powell water levels,
- River flows between Glen Canyon Dam and Lake Mead,
- Lake Mead water levels, and
- River flows below Hoover Dam.

Two separate analyses are presented in this section, each covering the four topics listed above. These analyses are as follows:

- An analysis of the Implementation Agreement. This analysis compares conditions under the Implementation Agreement with No Action.
- A cumulative analysis of the Implementation Agreement and other projects affecting river operation. This analysis compares conditions under the Cumulative Analysis with a specific Baseline for Cumulative Analysis.

The operational scenarios used for these two analyses were described in Section 2.2.

As noted previously, the focus of this analysis is the potentially affected portion of the Colorado River system extending from Lake Powell to the SIB. Although lakes Mohave and Havasu are within the potentially affected area, it has been determined that the Implementation Agreement would have no effect on the operation of these facilities. Lakes Mohave and Havasu are operated pursuant to monthly target elevations that are used to manage the storage, water release, and power production at these facilities. Under the respective target elevations, the annual water level fluctuation is approximately 14 feet for Lake Mohave and approximately four feet for Lake Havasu. Under all future operating scenarios considered under this analysis, lakes Mohave and Havasu would continue to be operated under their current respective monthly target elevations.

3.1 GENERAL OBSERVATIONS CONCERNING MODELING RESULTS

The following general observations apply to the results of operational modeling of the Implementation Agreement and the cumulative analysis:

- Future water levels of Lakes Powell and Mead will probably be lower than historical levels due to increasing Upper Basin depletions under the No Action conditions and the Implementation Agreement.

- Median Lake Mead water levels decline throughout the period of analysis for the No Action conditions and the Implementation Agreement because Lower Division depletions and evaporation exceed long-term inflow. Median Lake Powell levels decline for a number of years and then stabilize under the No Action conditions as well as under the Implementation Agreement. The declining median trend in Lake Powell levels under the No Action and Implementation Agreement conditions is due to increasing Upper Division depletions. Lake Powell water levels eventually stabilize under the No Action and Implementation Agreement conditions. This behavior is caused by less frequent equalization releases from Lake Powell to Lake Mead (due to the 602(a) storage requirements) as the Upper Division states continue to increase their use of Colorado River water.
- Under normal conditions, deliveries to the Lower Basin users are always equal to the normal depletion schedules, including those for the Indian tribes. Under shortage conditions, only CAP and SNWA share in the shortage until CAP goes to zero. All tribes in the 10 Tribe Partnership in the Lower Basin receive their scheduled depletion, with the exception of the Cocopah Tribe which holds a right to some Arizona Priority 4 water. As discussed above, as a modeling assumption, all Arizona shortages were assigned to CAP for this FEIS.

- As expected, changes in storage in Lakes Powell and Mead due to the IA are minor. The IA allows transfers of water between California entities within the State’s total apportionment of 4.4 MAF. Therefore under normal conditions, these transfers would have no impact on Lake Mead’s storage. However, under surplus conditions, the total delivery to California would be somewhat less under the IA compared to baseline conditions, the result of reduced agricultural use due to transfers and the ISG, which do not provide surplus water to the agricultural entities at the “full” and “Partial Domestic” surplus levels (see attachment C). The impact of the reduced California deliveries under these surplus levels would be a slight increase in Lake Mead’s contents, and under equalization conditions, a corresponding minor increase in Lake Powell.

The Cumulative Analysis covers the effects of the recently implemented interim surplus guidelines, the proposed Implementation Agreement, and the certain other proposed water transfers within California. The modeling study indicated that the cumulative effects would be as follows, when measured at the median of the values produced (50th percentile) unless otherwise noted.

- The water levels of lakes Powell and Mead would be lower during and immediately after the interim surplus period but after several decades water levels would be the same as those under baseline conditions.

- The probability of minimum releases from Lake Powell during the interim surplus period would be lower under Cumulative Analysis conditions than under Baseline for Cumulative Analysis.

- The annual river flows below the Havasu National Wildlife Refuge would be greater under Cumulative Analysis conditions than under the Baseline for Cumulative Analysis through 2016, after which flow conditions would be essentially the same as under the baseline.

- The annual river flows below Parker Dam and below the Palo Verde Irrigation District diversion would be lower under Cumulative Analysis conditions than under the Baseline for Cumulative Analysis through 2016, after which flow conditions would remain lower than under the baseline.

- The flows in the Colorado River below Morelos Dam, which lie in the realm of the 90th percentile of annual flow, would be approximately the same under Cumulative Analysis conditions as under the Baseline for Cumulative Analysis, although the cumulative values would vary above and below the baseline from year to year.

3.2 ANALYSIS OF WATER TRANSFERS

3.2.1 LAKE POWELL WATER LEVELS

3.2.1.1 MODELING RESULTS OF NO ACTION

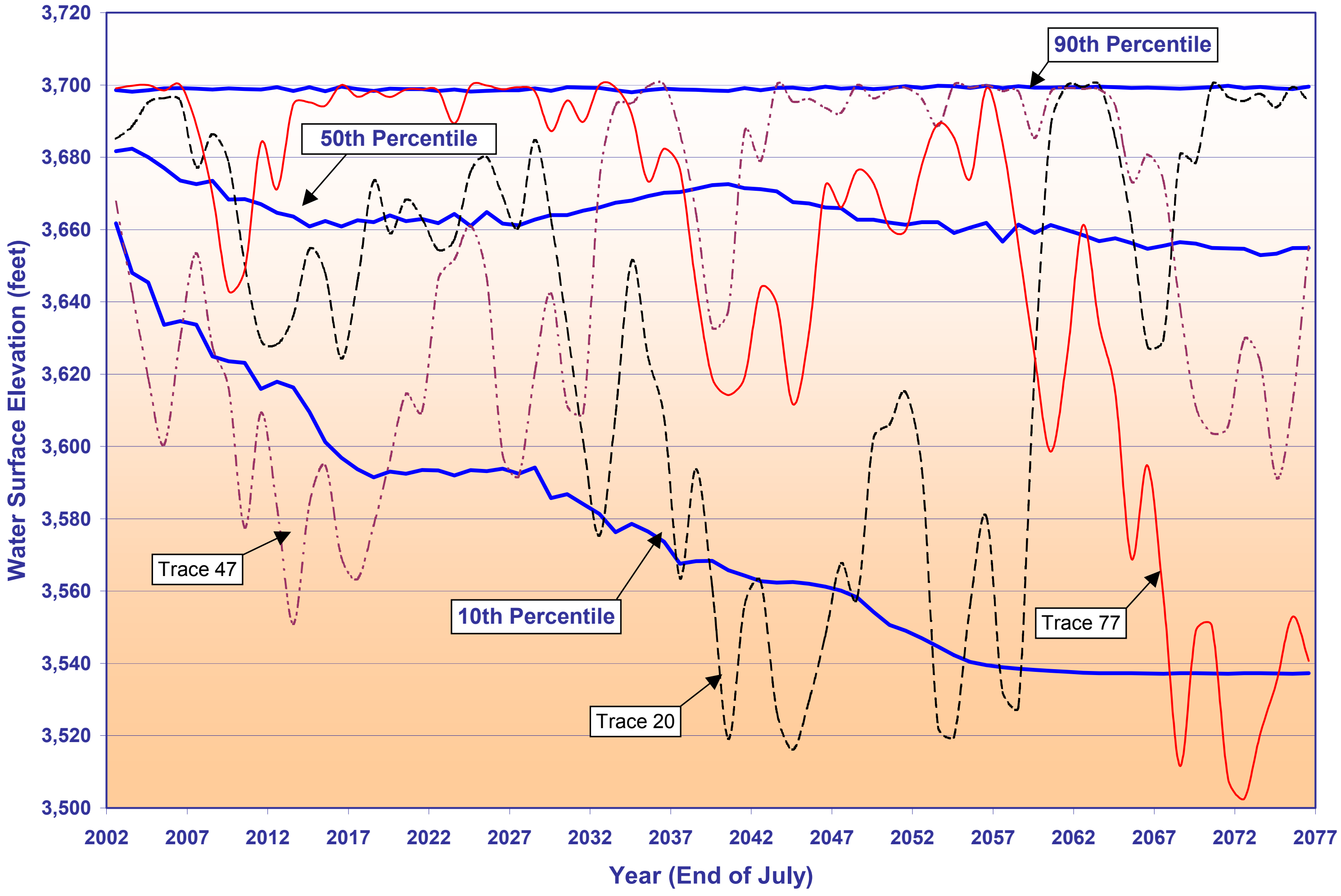
Under the No Action conditions, the water surface elevation of Lake Powell is projected to fluctuate between full level and decreasingly lower levels during the period of analysis (2002 to 2076). Figure 3.2-1 illustrates the range of water levels by three lines, labeled 90th Percentile, 50th Percentile and 10th Percentile. The 50th percentile line shows the median water level for each future year. The median water level under No Action conditions is shown to decline to approximately 3665 feet msl by 2016 and then vary gradually between approximately 10 feet higher and lower than that elevation through 2076. The 10th percentile line shows there is a 10 percent probability that the water level would drop to 3597 feet msl by 2016 and to 3537 feet msl by 2076.

Generally, there is about a 20-foot difference between the annual high and low water levels at Lake Powell. It should also be noted that the Lake Powell elevations depicted in Figure 3.2-1 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 low occurs at the end of the year. The high summer levels were analyzed because of their importance to water-based recreation at Lake Powell.

Figure 3.2-1

Lake Powell End-of-July Water Elevations Under No Action

90th, 50th and 10th Percentile Values and Representative Traces



Three distinct traces were added to Figure 3.2-1 to illustrate what was actually simulated under the various traces and respective hydrologic sequences and to highlight that the 90th, 50th and 10th percentile lines do not represent actual traces, but rather the ranking of the data from the 85 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 10th percentile line. The trace identified as Trace 20 represents the hydrologic sequence that begins in year 1925. The trace identified as Trace 47 represents the hydrologic sequence that begins in year 1952. The trace identified as Trace 77 represents the hydrologic sequence that begins in year 1982.

In Figure 3.2-1, the 90th and 10th percentile lines bracket the range where 80 percent of the water levels simulated for the No Action conditions occur. 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 between the highs and the lows, nor the length of time the water level would remain high or low can be predicted. These events would depend on the future variation in basin runoff conditions.

Figure 3.2-2 presents a comparison of the 90th, 50th and 10th percentile plots under No Action conditions and those under the Implementation Agreement. This figure is best used for comparing the relative differences in the general lake level trends that result from the simulation of No Action and Implementation Agreement conditions.

Figure 3.2-3 shows the frequency that future Lake Powell end-of-July water elevations would exceed elevation 3695 feet msl under the No Action and Implementation Agreement conditions. When the Lake Powell water level is at or exceeds 3695 feet msl, the reservoir is considered to be essentially full. In year 2016, under No Action conditions, the percentage of values greater than or equal to elevation 3695 feet msl is 19 percent. After 2016 the annual percentages of values equal to or greater than elevation 3695 feet msl increase gradually to 29 percent and then decrease to 24 percent in 2076 under No Action conditions.

Figure 3.2-2
Lake Powell End-of-July Water Elevations
Comparison of Implementation Agreement to No Action Conditions
90th, 50th and 10th Percentile Values

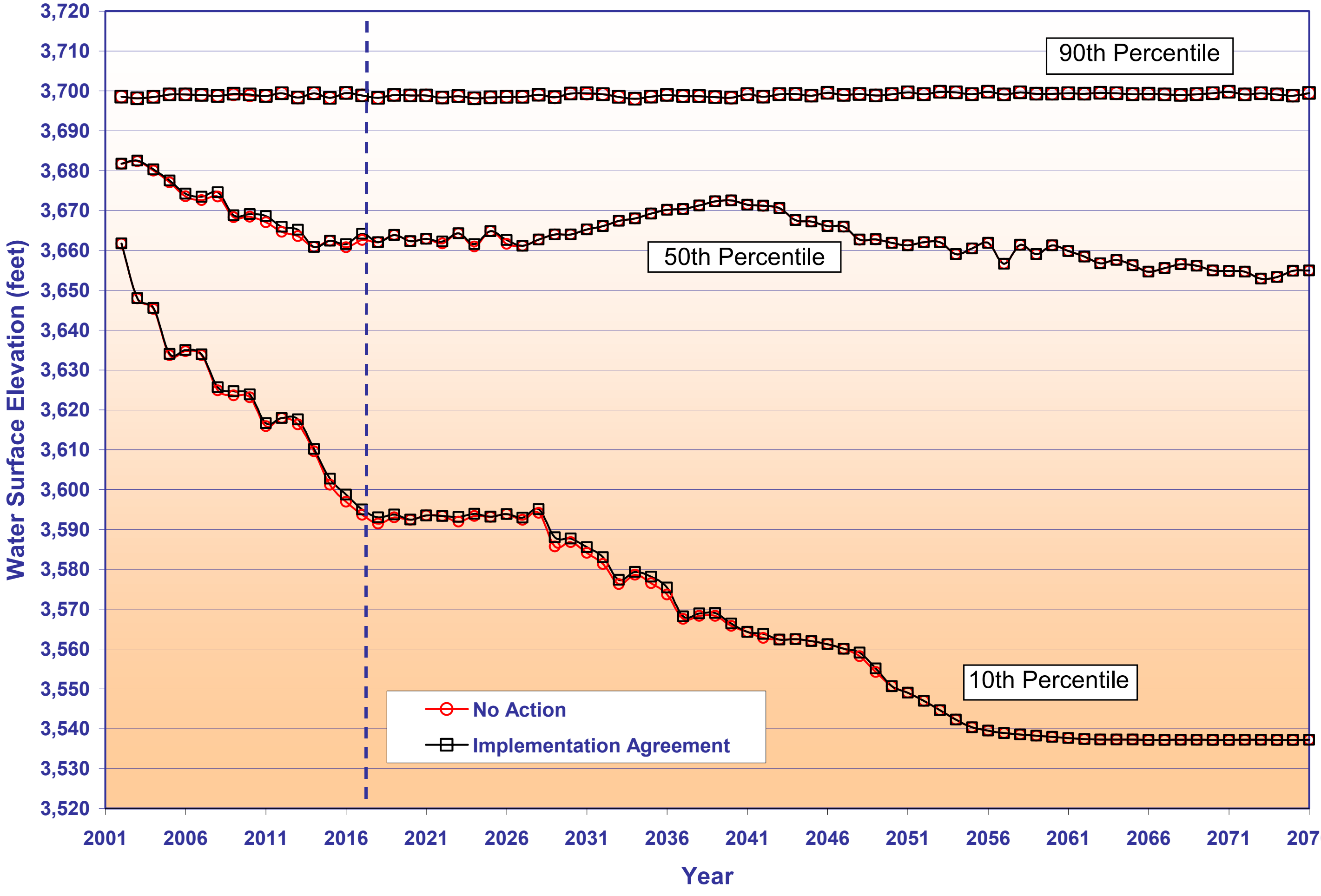


Figure 3.2-3
Lake Powell End-of-July Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 3695 Feet

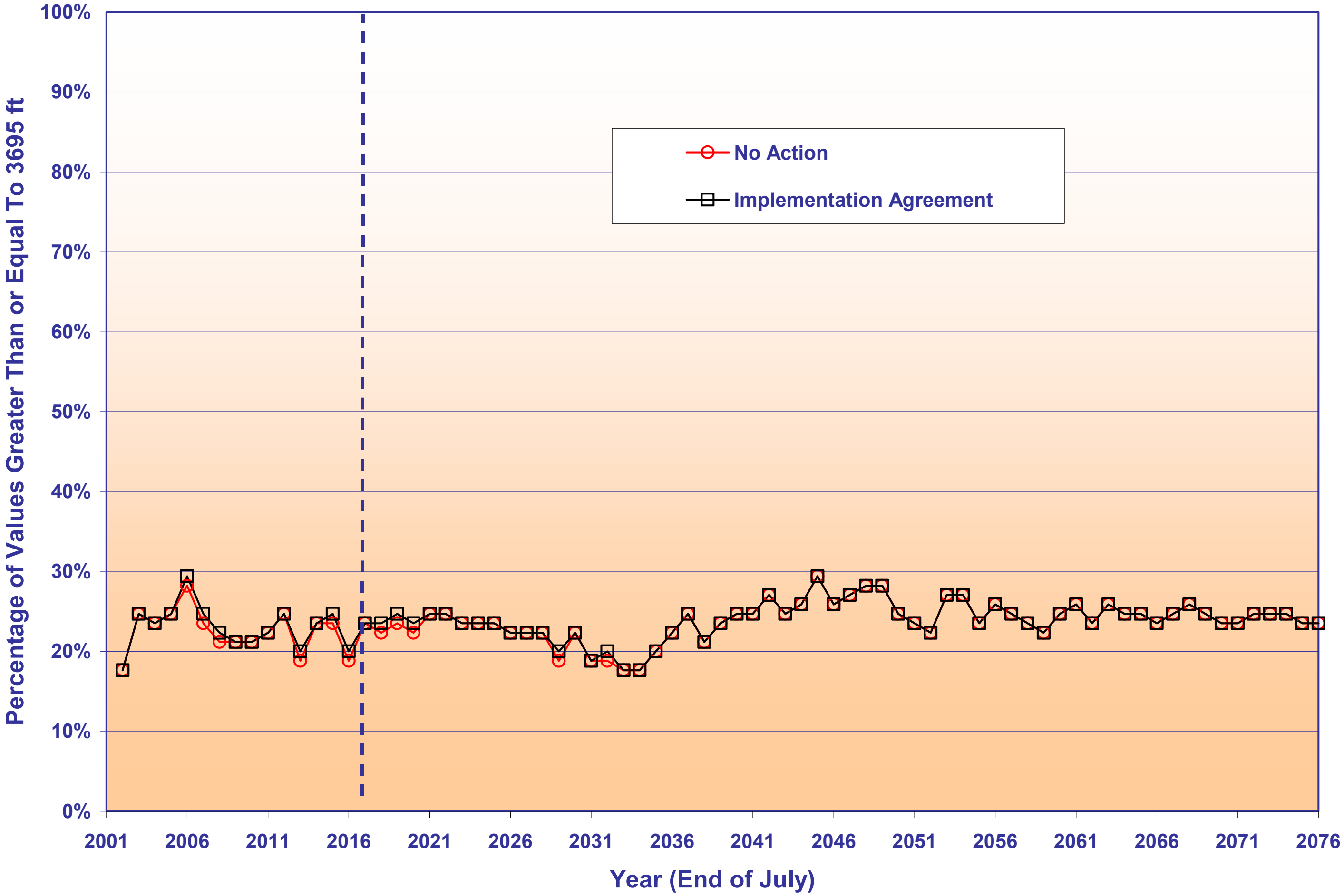


Figure 3.2-4 shows the frequency that future Lake Powell end-of-July water elevations under No Action conditions and the Implementation Agreement would be at or exceed a lake water elevation of 3612 feet msl. Lake Powell water surface elevation 3612 feet msl is used in this analysis as the low threshold elevation for marina and boat ramps at Lake Powell. This threshold elevation of 3612 feet msl is used to evaluate the No Action conditions and the effects of the Implementation Agreement on shoreline facilities at Lake Powell. The lines represent the percentage of values greater than or equal to the lake water elevation of 3612 feet msl under the No Action conditions and the Implementation Agreement. In year 2016, under the No Action conditions, the percentage of values greater than or equal to elevation 3612 feet msl is 88 percent. Between 2016 and 2076, the annual percentages of values greater than or equal to elevation 3612 feet msl decrease gradually to 68 percent.

3.2.1.2 COMPARISON OF IMPLEMENTATION AGREEMENT TO NO ACTION CONDITIONS

Figure 3.2-2 compared the 90th, 50th and 10th percentile water levels under the Implementation Agreement to those under No Action conditions. As discussed above, under No Action conditions, future Lake Powell water levels at the upper and lower 10th percentiles would likely be temporary and the water level would fluctuate between them in response to multi-year variations in basin runoff conditions. The same would apply to Implementation Agreement conditions.

Table 3.2-1 presents a comparison of the 90th percentile, median (50th percentile) and 10th percentile values of the Implementation Agreement to those of the No Action conditions. The values presented in this table are for years 2016, 2026, 2036, 2046 and 2076.

Table 3.2-1
Lake Powell End-of-July Water Elevations
Comparison of Implementation Agreement to No Action Conditions
90th, 50th and 10th Percentile Values

Year	No Action			Implementation Agreement		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
2016	3700	3661	3597	3699	3662	3599
2026	3699	3662	3594	3699	3663	3594
2036	3699	3670	3574	3699	3670	3575
2046	3700	3666	3561	3699	3666	3561
2076	3700	3655	3537	3699	3655	3537

Figure 3.2-3 compared the percentage of Lake Powell elevations that exceeded 3695 feet msl for the Implementation Agreement and No Action conditions. Table 3.2-2 provides a summary of that comparison for years 2016, 2026, 2036, 2046 and 2076.

Figure 3.2-4
Lake Powell End-of-July Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 3612 Feet

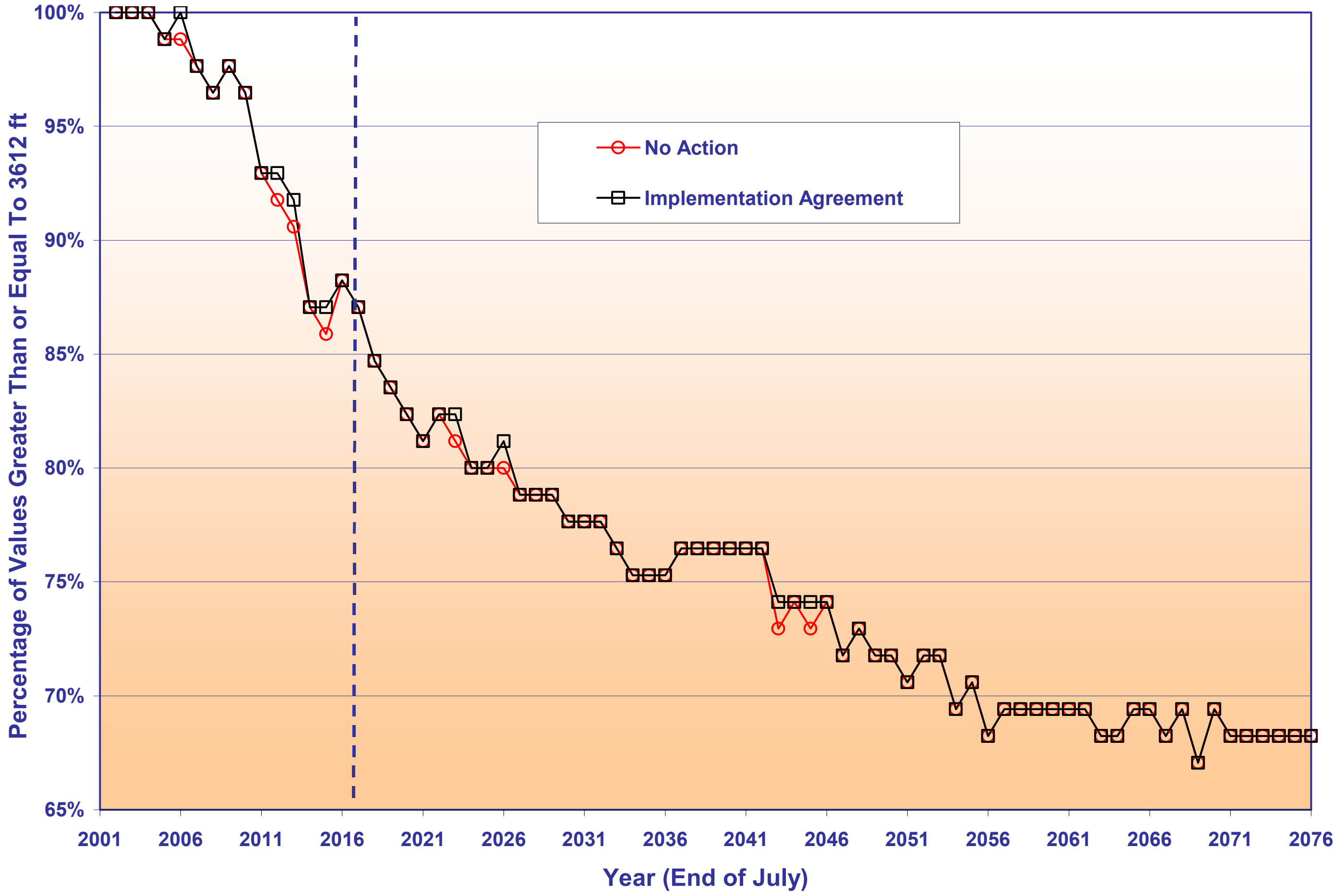


Table 3.2-2
Lake Powell End-of-July Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 3695 Feet

Year	No Action	Implementation Agreement
2016	18%	20%
2026	22%	22%
2036	22%	22%
2046	26%	26%
2076	24%	24%

Figure 3.2-4 compared the percentage of Lake Powell elevations that exceeded 3612 feet msl under the Implementation Agreement and No Action conditions. Table 3.2-3 provides a summary of that comparison for years 2016, 2026, 2036, 2046 and 2076.

Table 3.2-3
Lake Powell End-of-July Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 3612 Feet

Year	No Action	Implementation Agreement
2016	88%	88%
2026	80%	81%
2036	75%	75%
2046	74%	74%
2076	68%	68%

3.2.1.3 SENSITIVITY ANALYSIS

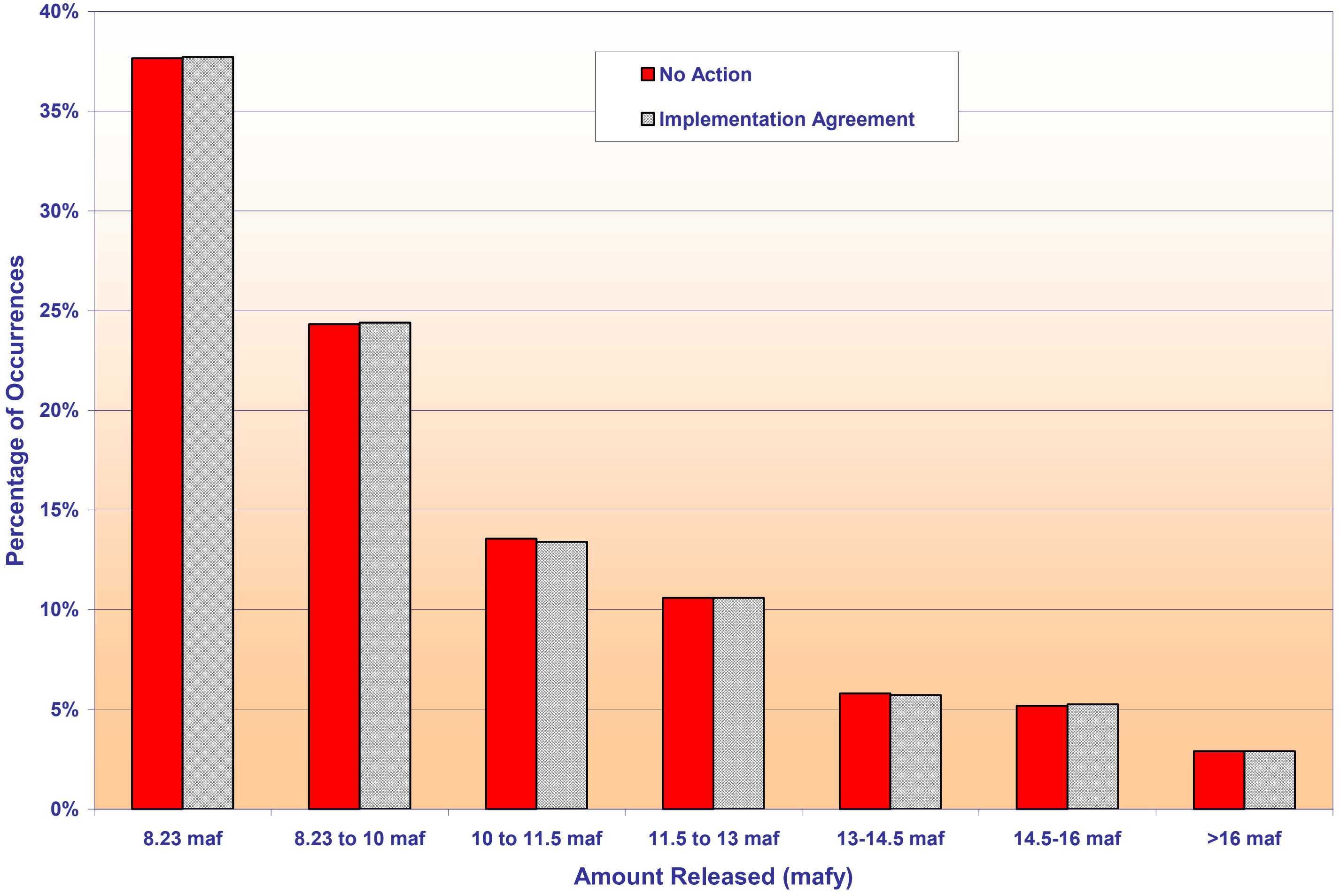
The water surface elevations of Lake Powell presented above are based on model operations in which the Lake Mead water surface elevation of 1083 feet msl was assumed to be the shortage protection level. In order to test the sensitivity of that assumption on the results of the model operation, model runs were also conducted with an assumed Lake Mead protection level of 1050 feet msl. With the 1050-foot protection level on Lake Mead, the water levels on Lake Powell were essentially the same as those based on the 1083-foot protection level under Implementation Agreement Conditions. Lake Mead water levels were observed to be lower under the 1050-foot level protection criteria. However, the relative differences between the Action and No Action alternatives were similar. A discussion of the results of this sensitivity analysis is presented in Attachment D.

3.2.2 RIVER FLOWS BETWEEN LAKE POWELL 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 1.1.1. The most significant gains from perennial streams include inflow from the Little Colorado River and Paria 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.

Figure 3.2-5 provides a comparison of the relative frequency of occurrence of annual releases from Lake Powell under the No Action conditions and Implementation Agreement, during the interim surplus guidelines period (through 2016). Releases between 8.23 and 11.5 maf generally correspond to years where equalization releases are being made from Lake Powell. The surplus water deliveries from Lake Mead associated with the interim surplus guidelines tend to increase the relative frequency of equalization during that period compared to No Action conditions.

Figure 3.2-5
Histogram of Modeled Lake Powell Annual Releases (Water Years)
2002 to 2016 (85 Traces)



3.2.3 LAKE MEAD WATER LEVELS

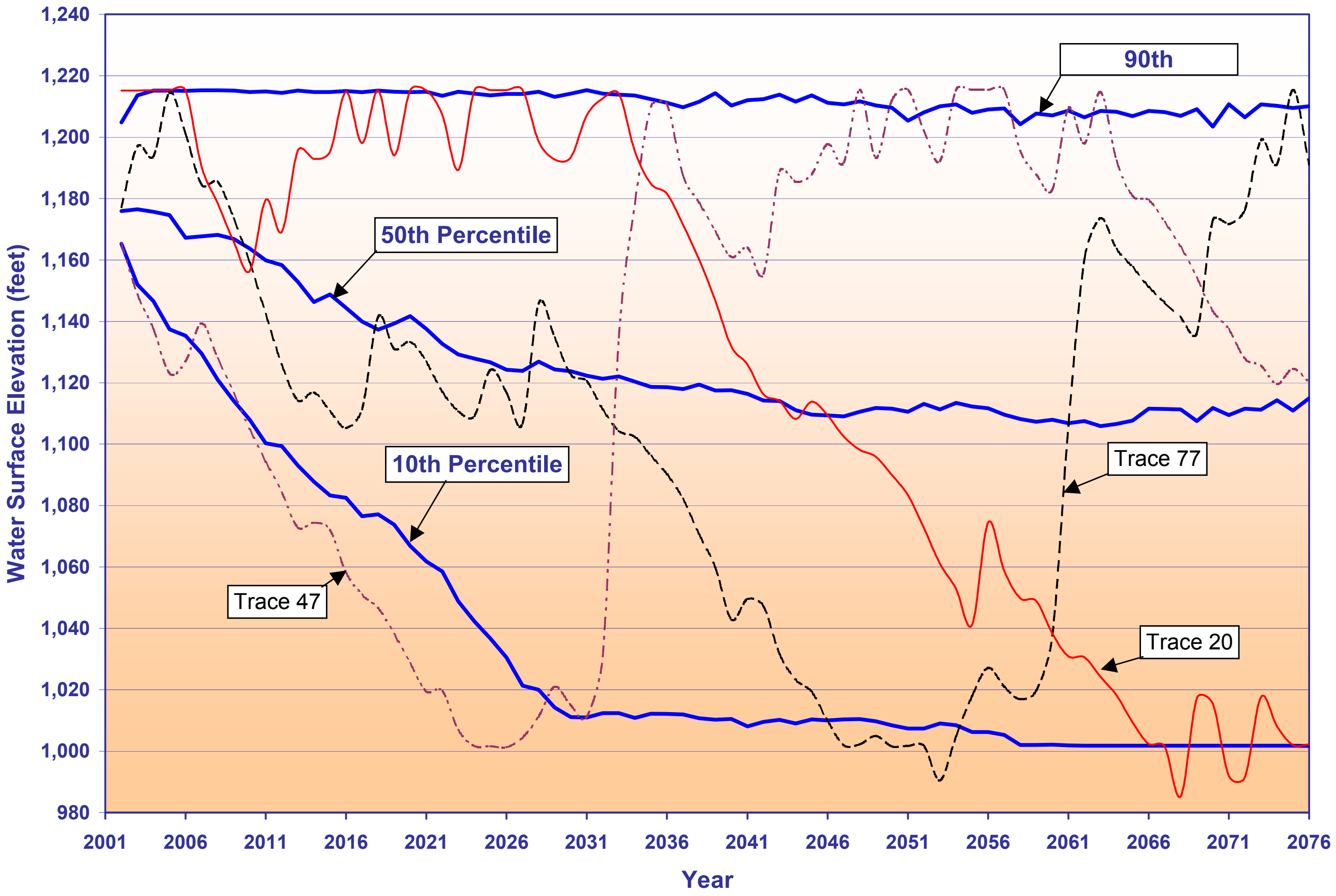
This section summarizes the results of the future Lake Mead water level simulations under No Action conditions and Implementation Agreement conditions.

3.2.3.1 MODELING RESULTS OF NO ACTION

Under the No Action conditions, the water surface elevation of Lake Mead is projected to fluctuate between full level and decreasingly lower levels during the period of analysis (2002 to 2076). Figure 3.2-6 illustrates the range of water levels (end of December) by three lines, labeled 90th Percentile, 50th Percentile and 10th Percentile. The 50th percentile line shows the median water level for each future year. The median water level under No Action conditions is shown to decline to 1144 feet msl by 2016 and to 1115 feet msl by 2076. The 10th percentile line shows there is a 10 percent probability that the water level would decline to 1082 feet msl by 2016 and to 1002 feet msl by 2076. It should also be noted that the Lake Mead elevations depicted in Figure 3.2-6 represent water levels at the end of December which is when lake levels are at a seasonal high. Conversely, the Lake Mead water level generally reaches its annual low in July.

Three distinct traces are added to Figure 3.2-6 to illustrate what was actually simulated under the various traces and respective hydrologic sequences and to highlight that the 90th, 50th and 10th percentile lines do not represent actual traces, but rather the ranking of the data from the 85 traces for the conditions modeled. The three traces illustrate the variability among the different traces and that the reservoir levels could temporarily decline below the 10th percentile line. The trace identified as Trace 20 represents the hydrologic sequence that begins in year 1925. The trace identified as Trace 47 represents the hydrologic sequence that begins in year 1952. The trace identified as Trace 77 represents the hydrologic sequence that begins in year 1982.

Figure 3.2-6
Lake Mead End-of-December Water Elevations Under No Action Conditions
90th, 50th and 10th Percentile Values and Representative Traces



In Figure 3.2-6, the 90th and 10th percentile lines bracket the range where 80 percent of future Lake Mead water levels simulated for the No Action conditions occur. The highs and lows shown on the three traces would likely be temporary conditions. The reservoir level would tend to fluctuate through multi-year periods of above average and below average inflows. Neither the timing of water level variations between the highs and the lows, nor the length of time the water level would remain high or low can be predicted. These events would depend on the future variation in basin runoff conditions.

Figure 3.2-7 presents the 90th, 50th and 10th percentile plots obtained for the No Action conditions and those obtained for the Implementation Agreement. This figure is best used for comparing the relative differences in the general lake level trends between the simulated No Action and Implementation Agreement conditions.

Figure 3.2-8 shows the frequency at which future Lake Mead end of December water surface elevations under No Action conditions would be at or exceed 1200 feet msl. The corresponding frequency with the Implementation Agreement is also plotted. The lines represent the percentage of values of all 85 traces that are equal to or greater than elevation 1200 feet msl. In year 2016, under the No Action conditions, the percentage of values greater than or equal to elevation 1200 feet msl is 19 percent. After 2016 the annual percentages of values equal to or greater than elevation 1200 feet msl vary around 20 percent for a decade and then decrease gradually to 13 percent in 2076 under No Action conditions.

Figure 3.2-9 provides a comparison of the frequency that future Lake Mead end of December water levels would be at or above elevation 1083 feet msl under No Action and Implementation Agreement conditions. In year 2016, under the No Action conditions, the percentage of values greater than or equal to elevation 1083 feet msl is 89 percent. After 2016 the annual percentages of values equal to or greater than elevation 1083 feet msl decline to 56 percent in 2076 under No Action conditions.

Figure 3.2-7
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement and No Action Conditions
90th, 50th and 10th Percentile Values

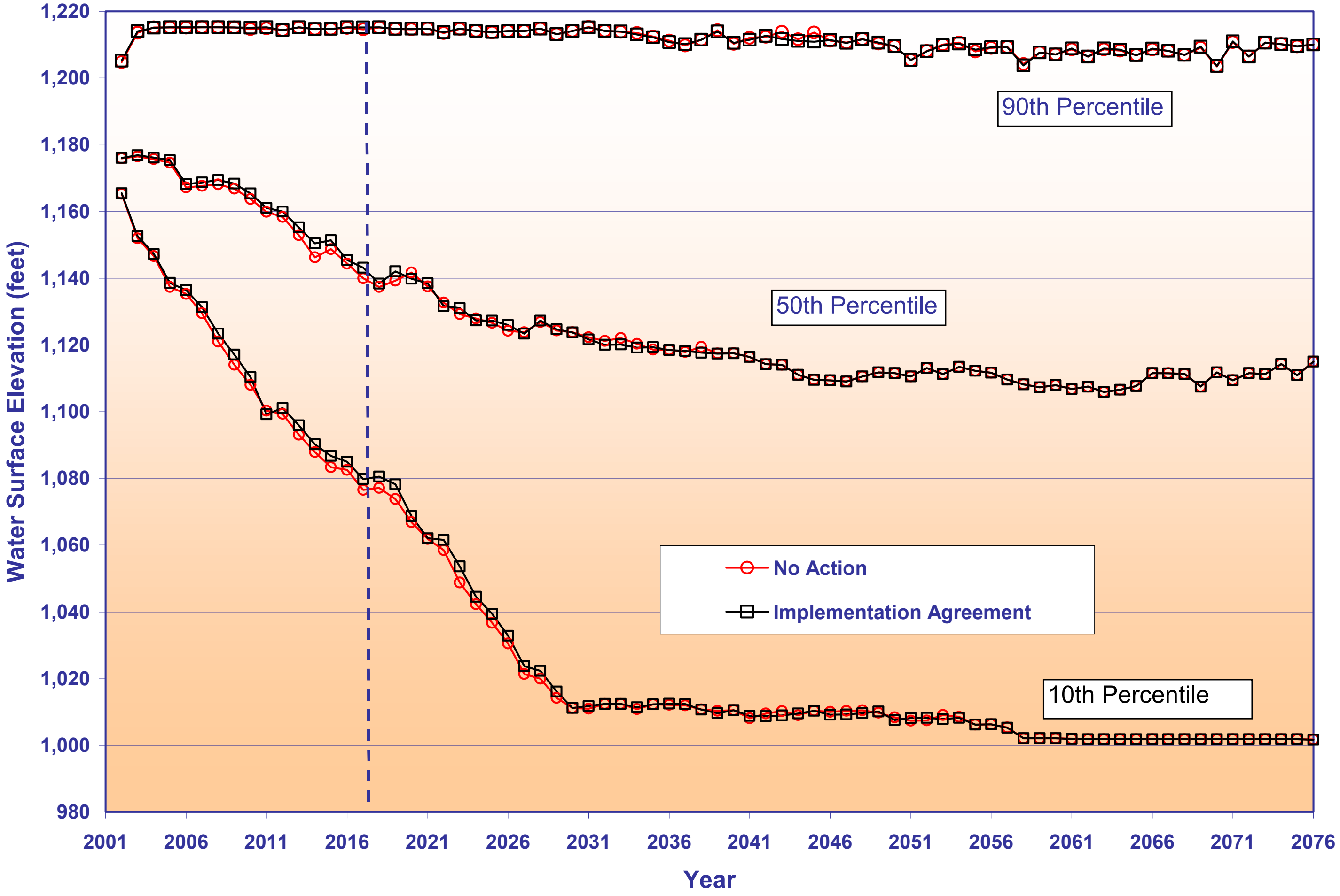


Figure 3.2.8
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement and No Action Conditions
Percentage of Values Greater than or Equal to Elevation 1200 Feet

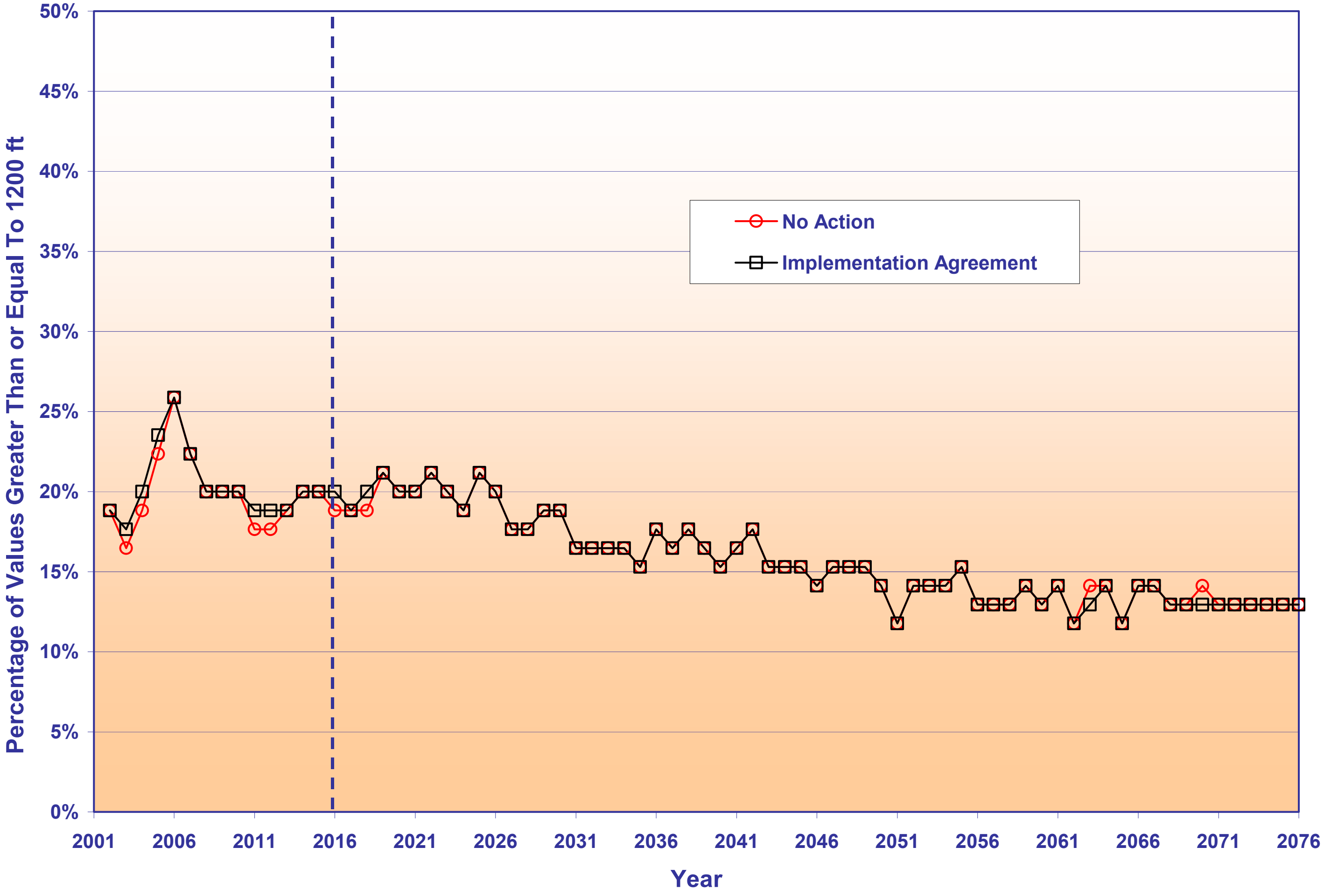


Figure 3.2-9
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 1083 Feet

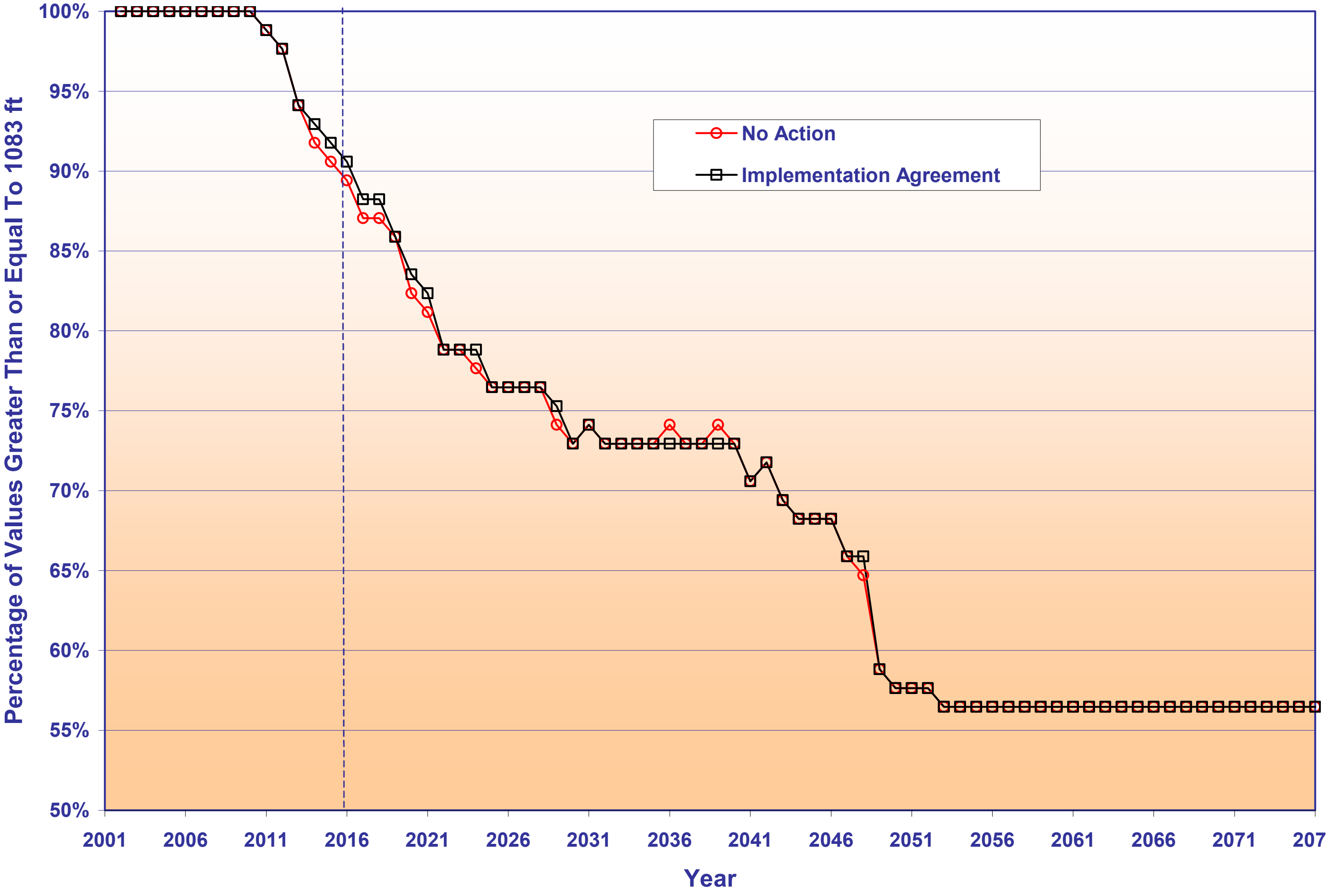


Figure 3.2-10 provides a comparison of the frequency that future Lake Mead end of December water levels would be at or above elevation 1050 feet msl under No Action and Implementation Agreement conditions. Between 2002 and 2016, under No Action conditions, the percentage of values greater than or equal to elevation 1050 feet msl is 100 percent. After 2016 the annual percentages of values equal to or greater than elevation 1050 feet msl decline to 60 percent in 2071 under No Action conditions.

Figure 3.2-11 provides a comparison of the frequency that future Lake Mead end of December water elevations under No Action conditions and the Implementation Agreement would be at or exceed a lake water elevation of 1000 feet msl. Between 2002 and 2016, under the No Action conditions, the percentage of values greater than or equal to elevation 1000 feet msl is 100 percent. After 2016 the annual percentages of values equal to or greater than elevation 1000 feet msl remain at 100 percent for several decades before declining to 94 percent in 2076 under No Action conditions.

3.2.3.2 COMPARISON OF IMPLEMENTATION AGREEMENT TO NO ACTION

Figure 3.2-7 compared the 90th, 50th and 10th percentile water levels of the Implementation Agreement to those of the No Action conditions. As discussed above, under No Action conditions, future Lake Mead water levels at the upper and lower 10th percentiles would likely be temporary and the water levels are expected to fluctuate between them in response to multi-year variations in basin runoff conditions. The same would apply to the Implementation Agreement.

The 90th percentile, median (50th percentile) and 10th percentile values of the Implementation Agreement are compared to those of the No Action conditions in Table 3.2-4. The values presented in this table are for years 2016, 2026, 2036, 2046, and 2076. There are no significant differences between the values under Implementation Agreement and No Action Conditions.

Table 3.2-4
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement to No Action Conditions
90th, 50th and 10th Percentile Values

Year	No Action			Implementation Agreement		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
2016	1215	1144	1083	1215	1146	1085
2026	1214	1124	1031	1214	1126	1033
2036	1213	1119	1012	1211	1119	1013
2046	1211	1109	1010	1211	1109	1009
2076	1210	1115	1002	1210	1115	1002

Figure 3.2-10
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 1050 Feet

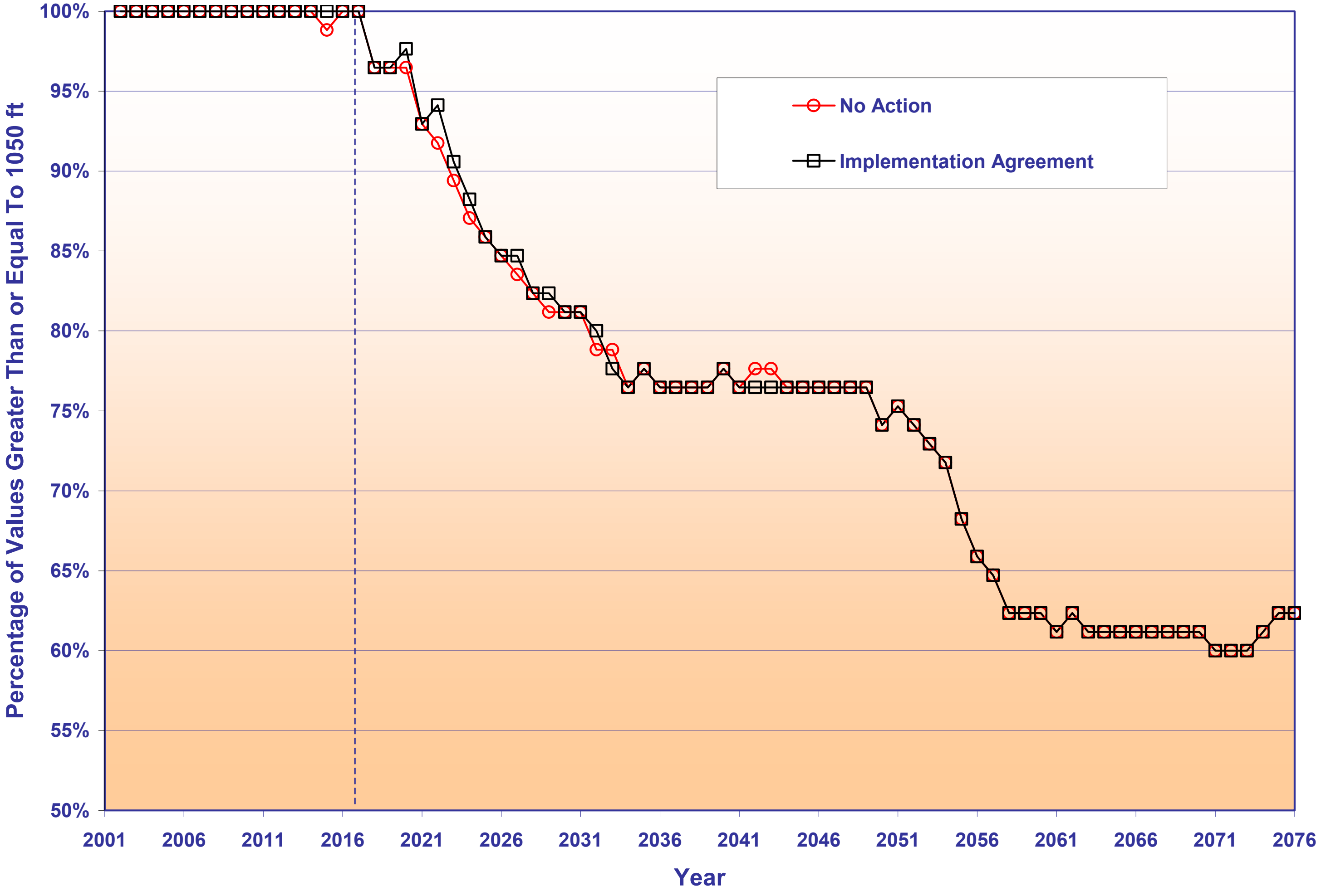


Figure 3.2-11
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 1000 Feet

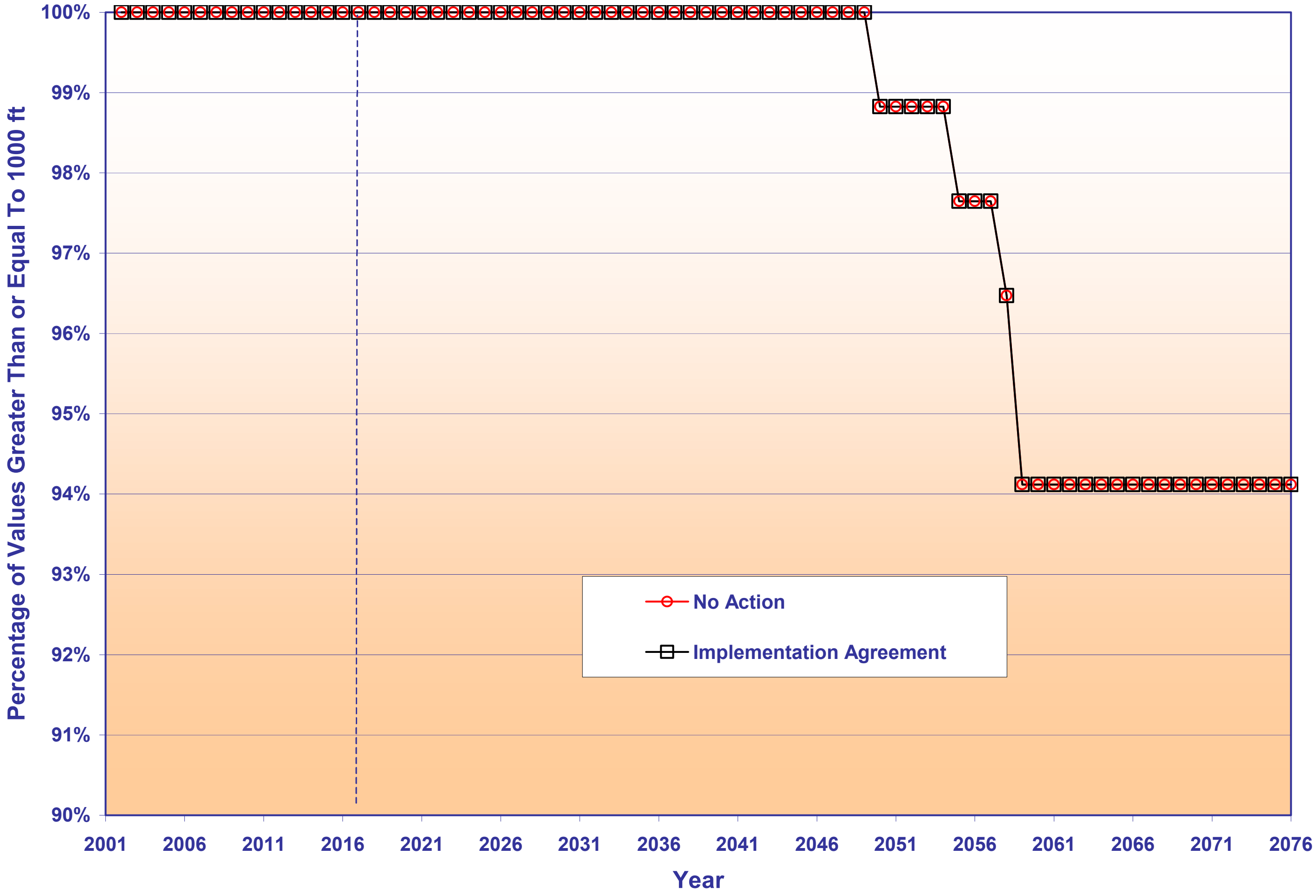


Figure 3.2-8 compared the percentage of Lake Mead elevations that were at or above 1200 feet msl for the Implementation Agreement and No Action conditions. Table 3.2-5 provides a summary of that comparison for years 2016, 2026, 2036, 2046, and 2076.

Table 3.2-5
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 1200 Feet

Year	No Action	Implementation Agreement
2016	19%	20%
2026	20%	20%
2036	18%	18%
2046	14%	14%
2076	13%	13%

Figure 3.2-9 compared the percentage of Lake Mead elevations that were at or above 1083 feet msl for the Implementation Agreement and No Action conditions. Table 3.2-6 provides a summary of that comparison for years 2016, 2026, 2036, 2046, and 2076.

Table 3.2-6
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 1083 Feet

Year	No Action	Implementation Agreement
2016	89%	91%
2026	76%	76%
2036	74%	73%
2046	68%	68%
2076	56%	56%

Figure 3.2-10 compared the percentage of Lake Mead elevations that were at or above 1050 feet msl for the Implementation Agreement and No Action conditions. Table 3.2-7 provides a summary of that comparison for years 2016, 2026, 2036, 2046, and 2076.

Table 3.2-7
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 1050 Feet

Year	No Action	Implementation Agreement
2016	100%	100%
2026	85%	85%
2036	76%	76%
2046	76%	76%
2076	62%	62%

Figure 3.2-11 compared the percentage of Lake Mead elevations that were at or above 1000 feet msl for the Implementation Agreement and No Action conditions. Table 3.2-8 provides a summary of that comparison for years 2016, 2026, 2036, 2046, and 2076.

Table 3.2-8
Lake Mead End-of-December Water Elevations
Comparison of Implementation Agreement to No Action Conditions
Percentage of Values Greater than or Equal to Elevation 1000 Feet

Year	No Action	Implementation Agreement
2016	100%	100%
2026	100%	100%
2036	100%	100%
2046	100%	100%
2076	94%	94%

3.2.3.3 SENSITIVITY ANALYSIS

The water surface elevations of Lake Mead presented above are based on model operations in which the Lake Mead water surface elevation of 1083 feet msl was assumed to be the shortage protection level. In order to test the sensitivity of that assumption on the results of the model operation, model runs were also conducted with an assumed Lake Mead protection level of 1050 feet msl. With the 1050-foot protection level, the resulting water levels on Lake Mead range up to approximately 13 feet lower than those based on the 1083-foot protection level under Implementation Agreement Conditions, after 2010 for the 50th and 10th percentiles. Lake Mead water level plots based on the use of the 1050-foot protection level are included in Attachment D.

3.2.4 RIVER FLOWS BELOW HOOVER DAM

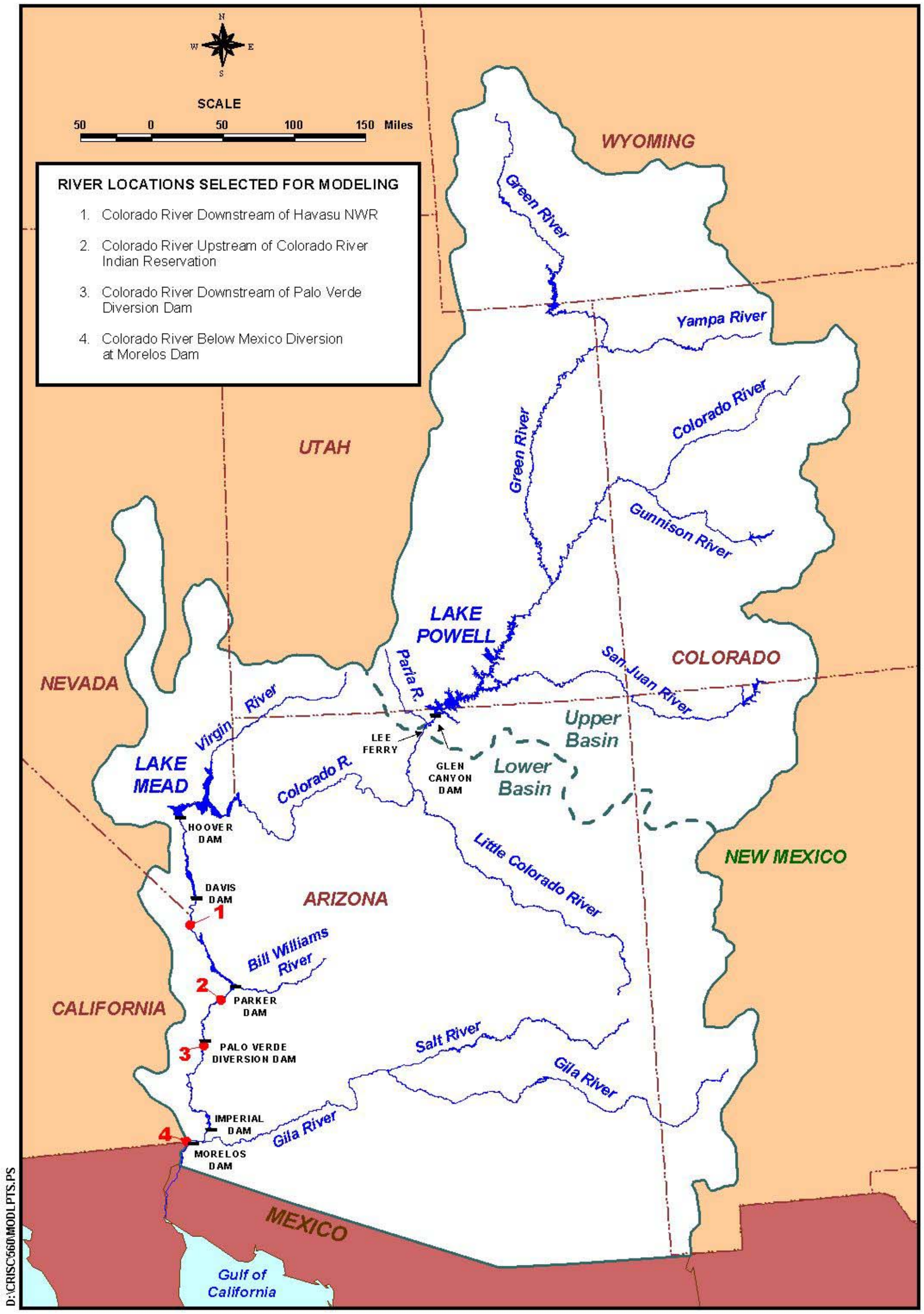
This section describes results of the analysis of the simulated Colorado River flows below Hoover Dam. The model of the Colorado River system was used to simulate future mean monthly flows under No Action and Implementation Agreement conditions. Four specific river locations were selected to represent flows within selected river reaches below Hoover Dam. The river reaches and corresponding flow locations are listed in Table 3.2-9 and shown on Map 3.2-1.

Table 3.2-9
Colorado River Flow Locations Identified for Evaluation

	Selected River Flow Locations	
Colorado River Reach	**Description**	**Approximate River Mile [1]**
Between Hoover Dam and Parker Dam	Havasu National Wildlife Refuge (NWR)	242.3
Between Parker Dam and Palo Verde Diversion Dam	Upstream of Colorado River Indian Reservation	180.8
Between Palo Verde Diversion and Imperial Dam	Downstream of the Palo Verde Diversion Dam	133.8
Between Imperial Dam and SIB	Below the Mexico Diversion at Morelos Dam	23.1

[1] River miles as measured from the southerly international boundary with Mexico

Map 3.2-1
Colorado River Locations Selected for Modeling



Two types of analysis of the potential of Implementation Agreement to affect river flows were conducted. In the first analysis, the potential effects on the total annual volume of flow in each reach were evaluated. In this analysis, the mean monthly flows were first summed over each calendar year. The 90th, 50th, and 10th percentiles of the annual volumes were then computed for each year. Plots of these percentiles for No Action and Implementation Agreement conditions are included in this section for each of the four river points. Cumulative distributions of the annual flow volumes are also presented for 2016 to aid in the understanding of the effects.

The second analysis investigated the potential effects on seasonal flows. Cumulative distributions of mean monthly flows (in cfs) were produced for specific years and selected months representative of each season. The mean monthly flows for January were used to represent the winter season flows and likewise for April, July, and October to represent spring, summer, and fall, respectively. The specific years analyzed included 2006, 2016, 2026, and 2050. The data and graphs for 2016 are presented in this section to illustrate the process.

It should be noted that the monthly demand schedules used in the model are based on a distribution of the total annual demand (a percentage for each month). Although each diversion point may use a different distribution, those percentages do not change from year to year, and cannot reflect potential future changes in the system that might affect the monthly distributions. Therefore, the seasonal differences are primarily governed by the overall changes in annual flow volumes, coupled with the effect of each diversion's distribution upstream of the point of interest.

Daily and hourly releases from Hoover Dam reflect the short-term demands of Colorado River water users with diversions located downstream, storage management in Lakes Mohave and Havasu, and power production at Hoover, Davis and Parker Dams. The close proximity of Lake Mohave to Hoover Dam effectively dampens the short-term fluctuations below Hoover Dam. The scheduling and subsequent release of water through Davis and Parker Dams create short-term fluctuations in river flows, depths, and water surface elevations downstream of these structures. These fluctuations of water surface elevations in the river are most noticeable in the river reaches located immediately downstream of the dams and lessen as the downstream distance increases. The Implementation Agreement, however, will have no effect on the short-term operations of Hoover, Davis and Parker Dam, and therefore, short-term fluctuations in river reaches downstream of Hoover Dam were not evaluated.

3.2.4.1 RIVER FLOWS BETWEEN HOOVER DAM AND PARKER DAM

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

A point on the Colorado River downstream of Davis Dam was used to evaluate the river flows for this reach, located immediately downstream of the Havasu National Wildlife Refuge (NWR). The 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 3.2-12. As shown by the 50th percentile values, annual flow volumes in this reach would be more uniform under the Implementation Agreement conditions than under the No Action conditions during the 15-year interim surplus guidelines period. The plot indicates that the Implementation Agreement would reduce the No Action highs during this period by up to approximately 10 percent. This is attributable to the reduction in California's mainstem depletions by MWD resulting from the conservation measures and water transfers implemented in California. Beyond the 15-year interim period, the annual flow volumes under the Implementation Agreement are essentially the same (within one percent) as those under the No Action conditions.

At the 90th and 10th percentile levels the flows under Implementation Agreement conditions are essentially the same as those under the No Action conditions. Figure 3.2-13 shows the distribution of annual flow volumes for year 2016.

Figures 3.2-14(a-d) present comparisons of the representative seasonal flows under No Action conditions and the Implementation Agreement for 2016. As expected, the largest flows occur in the spring and summer seasons for No Action conditions and all alternatives due to downstream irrigation demands. For flows that are due primarily to flood control releases from Lake Mead (flows in the 80th - 100th percentile range), the range of mean monthly flows is generally unchanged by the Implementation Agreement, except during the winter season where the Implementation Agreement would cause higher flows in the 80th to 85th percentile range. In the lower percentiles, the seasonal flows with the Implementation Agreement vary slightly higher or lower than the flows under No Action conditions. The approximate departure of Implementation Agreement from No Action varied from 15 percent higher (January) to 3 percent lower (April) in 2016.

A numerical comparison of the 70th percentile seasonal flow values is shown on Table 3.2-10. The values representing the seasons are the mean monthly flows in January, April, July and October.

Table 3.2-10
Comparison of Mean Monthly Flow (cfs) – Implementation Agreement to No Action Conditions
Colorado River Downstream of Havasu NWR (River Mile = 242.3)
70th Percentile Values for Year 2016

Season (Representative Month)	Mean Monthly Flows (cfs) for Year 2016 at the 70th Percentile	
	No Action	**Implementation Agreement**
Winter (January)	8,171	8,314
Spring (April)	16,198	16,041
Summer (July)	15,921	15,887
Fall (October)	11,781	11,170

Figure 3.2-12
Colorado River Downstream of Havasu NWR Annual Flow Volume (af)
Comparison of Implementation Agreement to No Action Conditions
90th, 50th and 10th Percentile Values

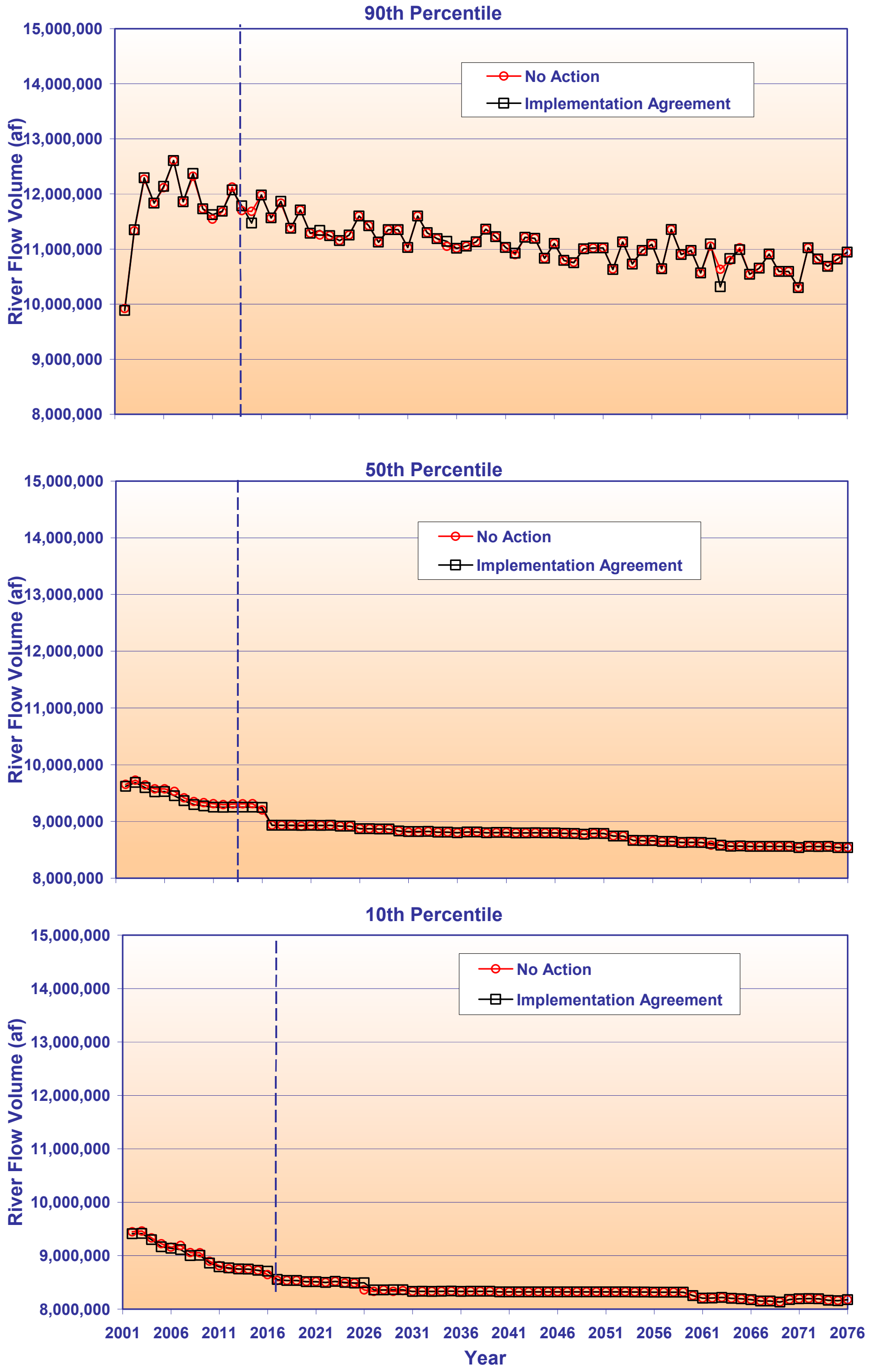


Figure 3.2-13
Colorado River Annual Flow Volume Downstream of Havasu NWR
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

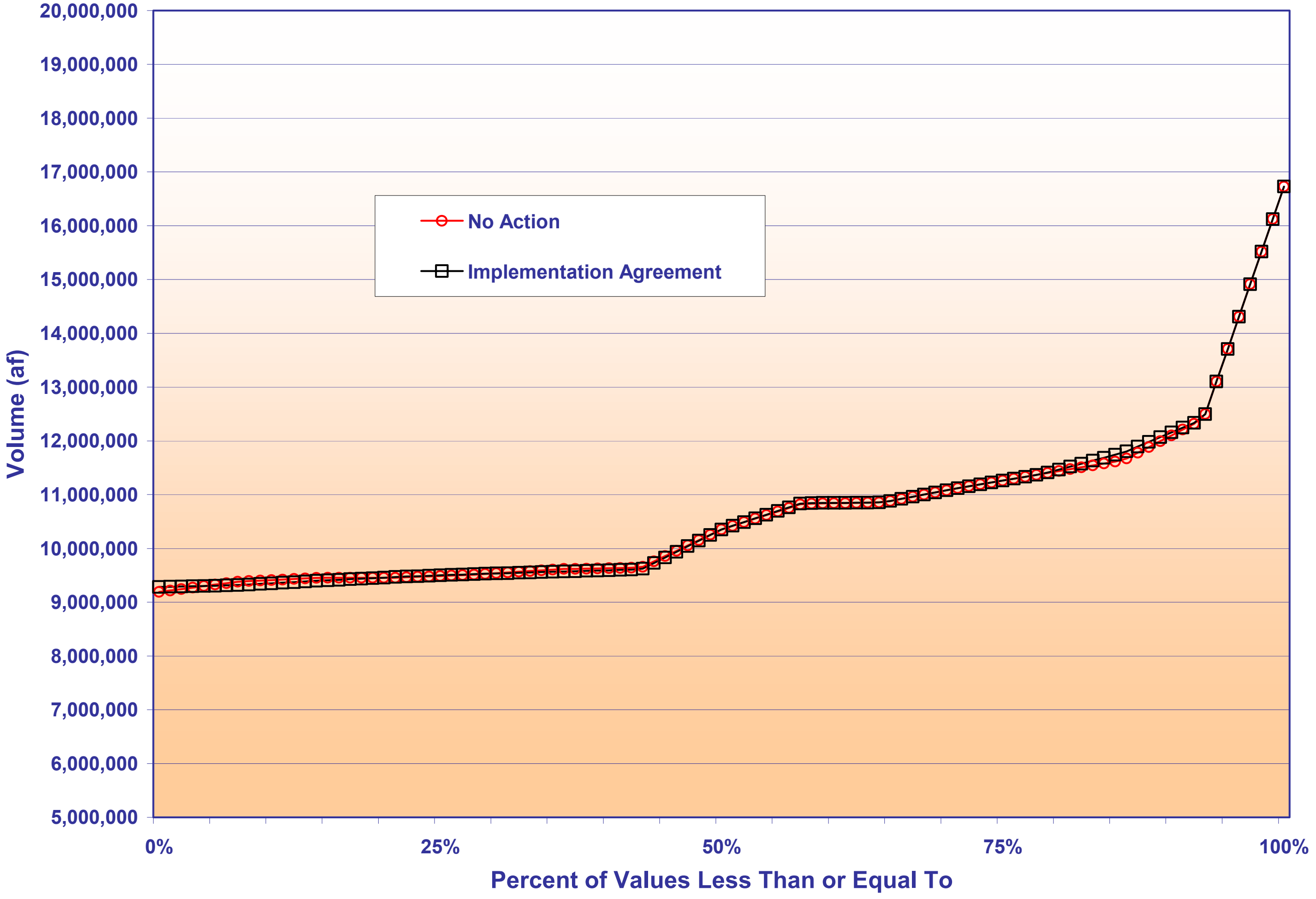


Figure 3.2-14a
Colorado River Seasonal Flows Downstream of Havasu NWR
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

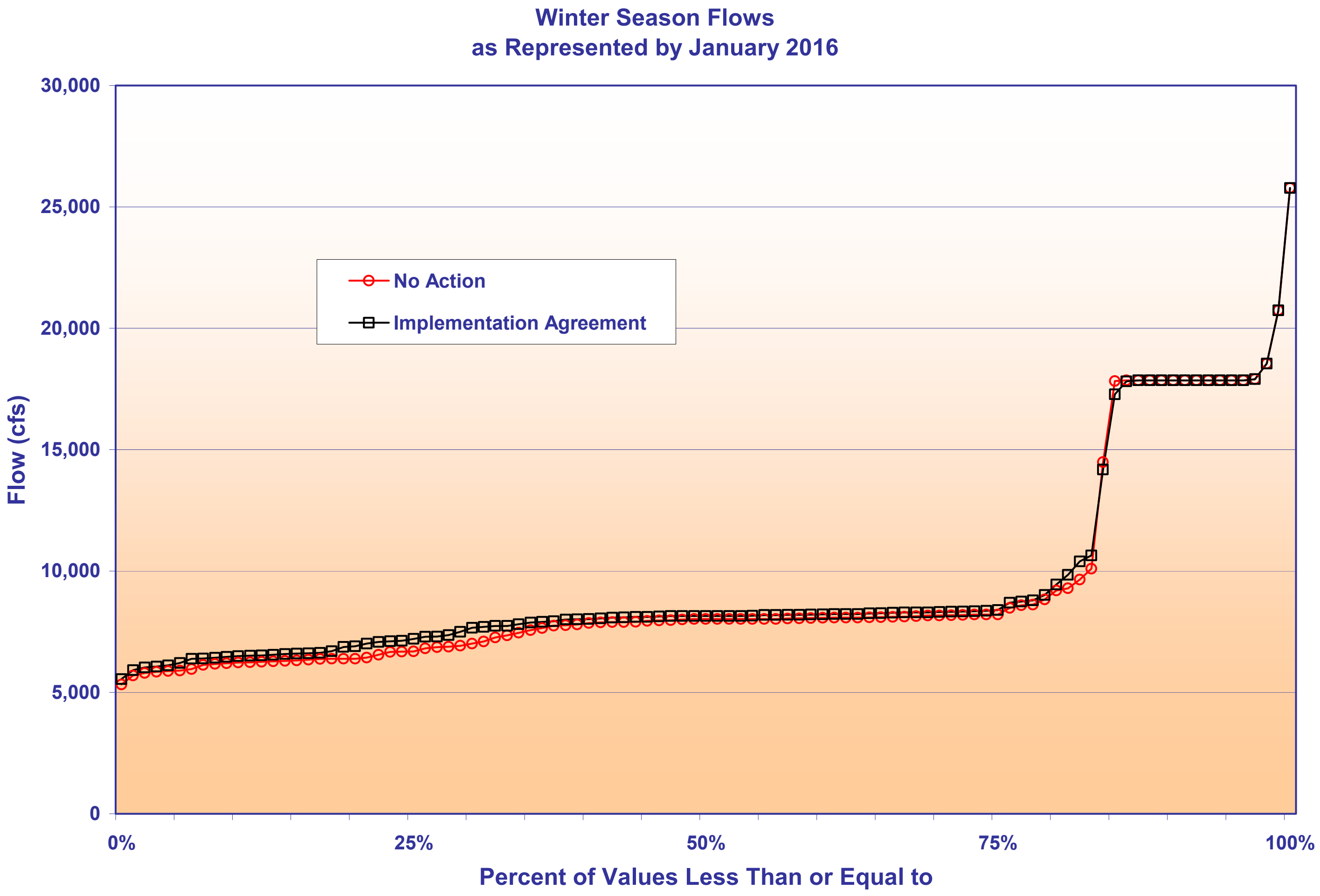


Figure 3.2-14b
Colorado River Seasonal Flows Downstream of Havasu NWR
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

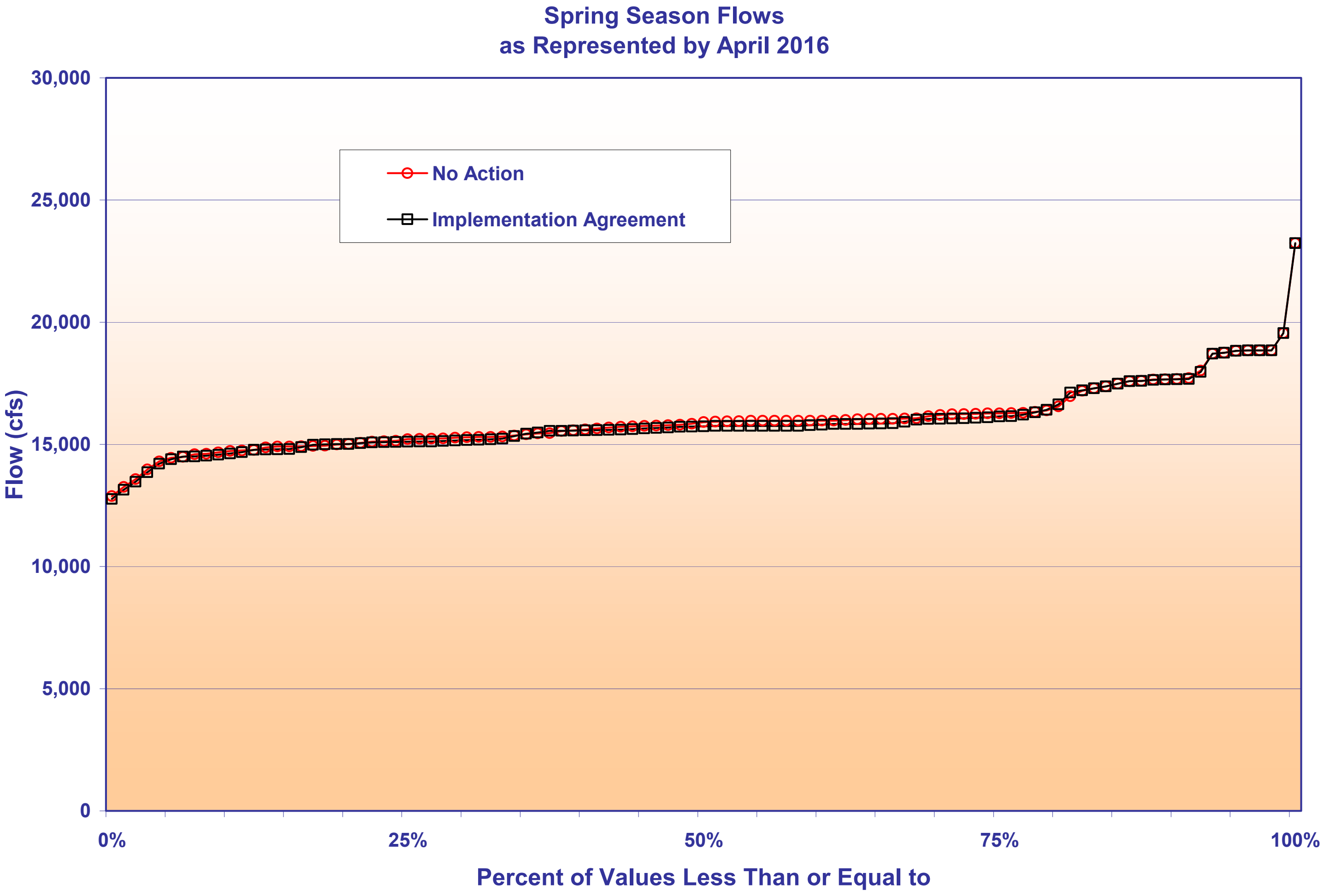


Figure 3.2-14c
Colorado River Seasonal Flows Downstream of Havasu NWR
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

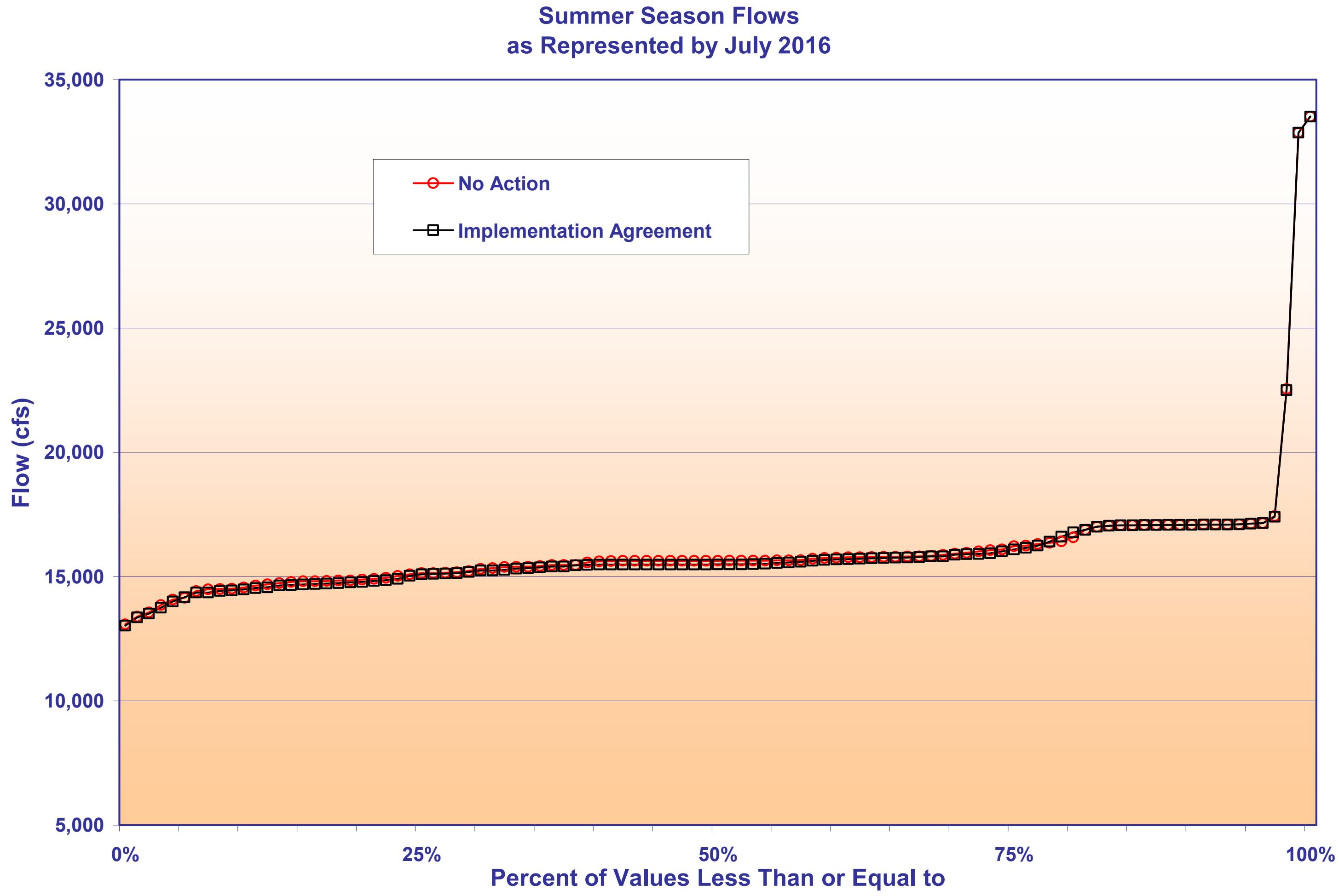
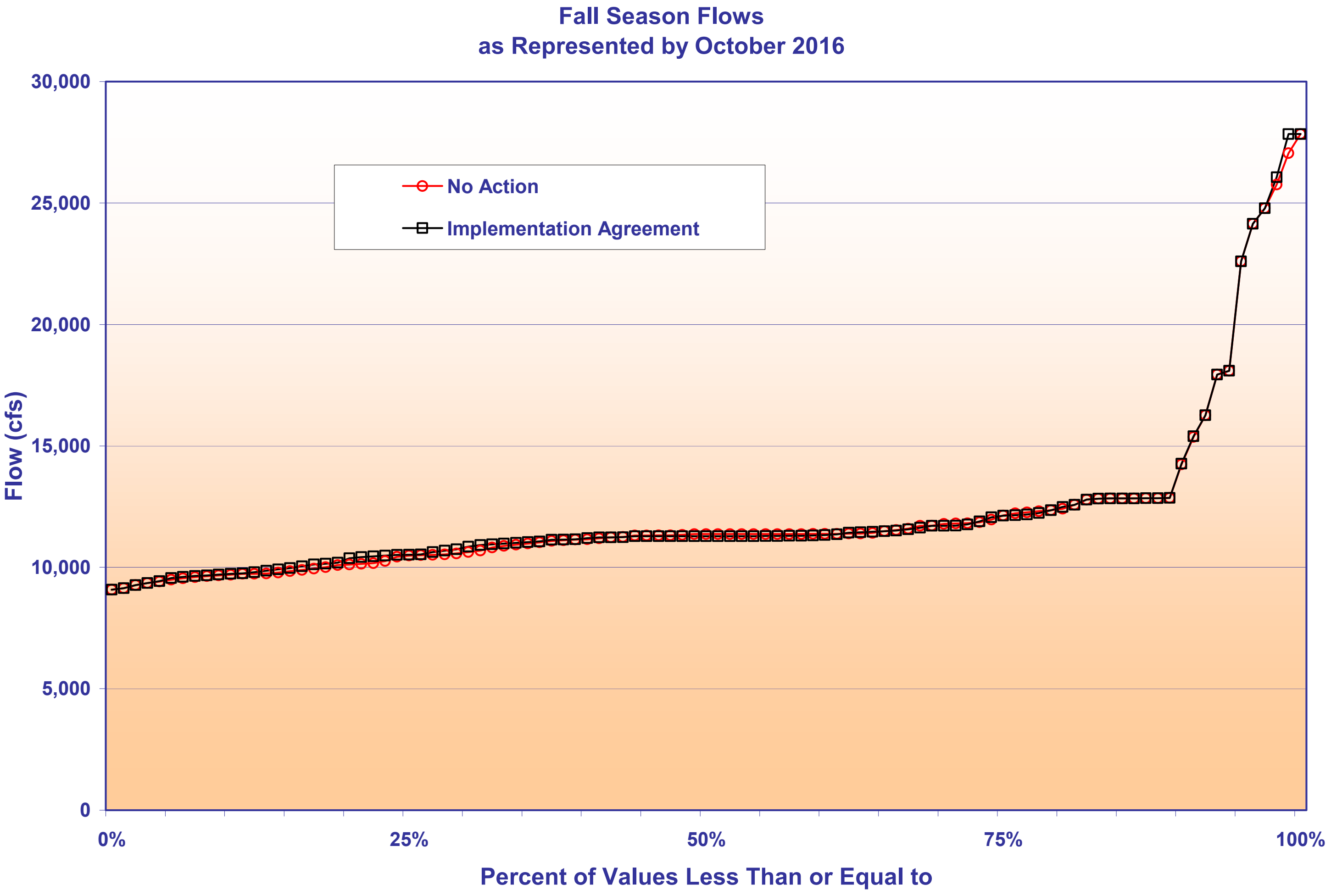


Figure 3.2-14d
Colorado River Seasonal Flows Downstream of Havasu NWR
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016



3.2.4.2 RIVER FLOWS BETWEEN PARKER DAM AND PALO VERDE DIVERSION DAM

The point on the Colorado used to evaluate the river flows in the reach of the river located between Parker Dam and the Palo Verde Diversion Dam is located immediately upstream of the Colorado River Indian Reservation (CRIR) diversion. The CRIR diversion is located at Headgate Rock Dam, approximately 14 miles below Parker Dam. Flows in this reach of the river result from primarily from releases from Parker Dam (Lake Havasu).

Future flows in this reach would be affected by the Implementation Agreement because the proposed water transfers and exchanges between the California agricultural water agencies and MWD would change the point of diversion from the river. 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 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 3.2-15. As shown by the 50th percentile values, the modeled annual flow volumes in this reach under the Implementation Agreement decline gradually between 2002 and 2016, as the water transfers take effect and certain amounts of California's water are diverted from Lake Havasu rather than at Imperial Dam. After 2016 the annual flow reduction continues. At the 10th percentile level, the same comparative annual flow patterns occur. Flows at the 90th percentile level are dominated by surplus water deliveries and flood flows, and do not exhibit a significant difference between the Implementation Agreement and No Action conditions.

Figure 3.2-16, shows the cumulative distribution of annual flow volumes is for year 2016.

A numerical comparison of the 70th percentile seasonal flow values is shown on Table 3.2-11. The values representing the seasons are the mean monthly flows in January, April, July and October.

Table 3.2-11
Comparison of Mean Monthly Flow (cfs) – No Action Conditions and Implementation Agreement
Colorado River Upstream of CRIR Diversion (River Mile = 180.8)
70th Percentile Values for Year 2016

Season (Representative Month)	Mean Monthly Flows (cfs) for Year 2016 at the 70th Percentile	
	No Action	Implementation Agreement
Winter (January)	4,087	3,819
Spring (April)	12,009	11,315
Summer (July)	13,282	12,604
Fall (October)	8,120	7,838

Figures 3.2-17 (a-d) present comparisons of the representative seasonal flows under No Action conditions and the Implementation Agreement for 2016. As expected, the largest flows occur in the spring and summer seasons under the No Action and

Implementation Agreement conditions due to downstream irrigation demands. As on the 90th, 50th, and 10th percentile plots, the seasonal flows under the Implementation Agreement are slightly lower than those under No Action conditions. For flows that are due primarily to flood control releases from Lake Mead (flows in the 90th - 100th percentile range), the range of mean monthly flows is not affected by the Implementation Agreement, since these magnitudes are dictated by the flood control regulations.

Figure 3.2-15
Colorado River Upstream of CRIR Diversion Annual Flow Volume (af)
Comparison of Implementation Agreement to No Action Conditions
90th, 50th and 10th Percentile Values

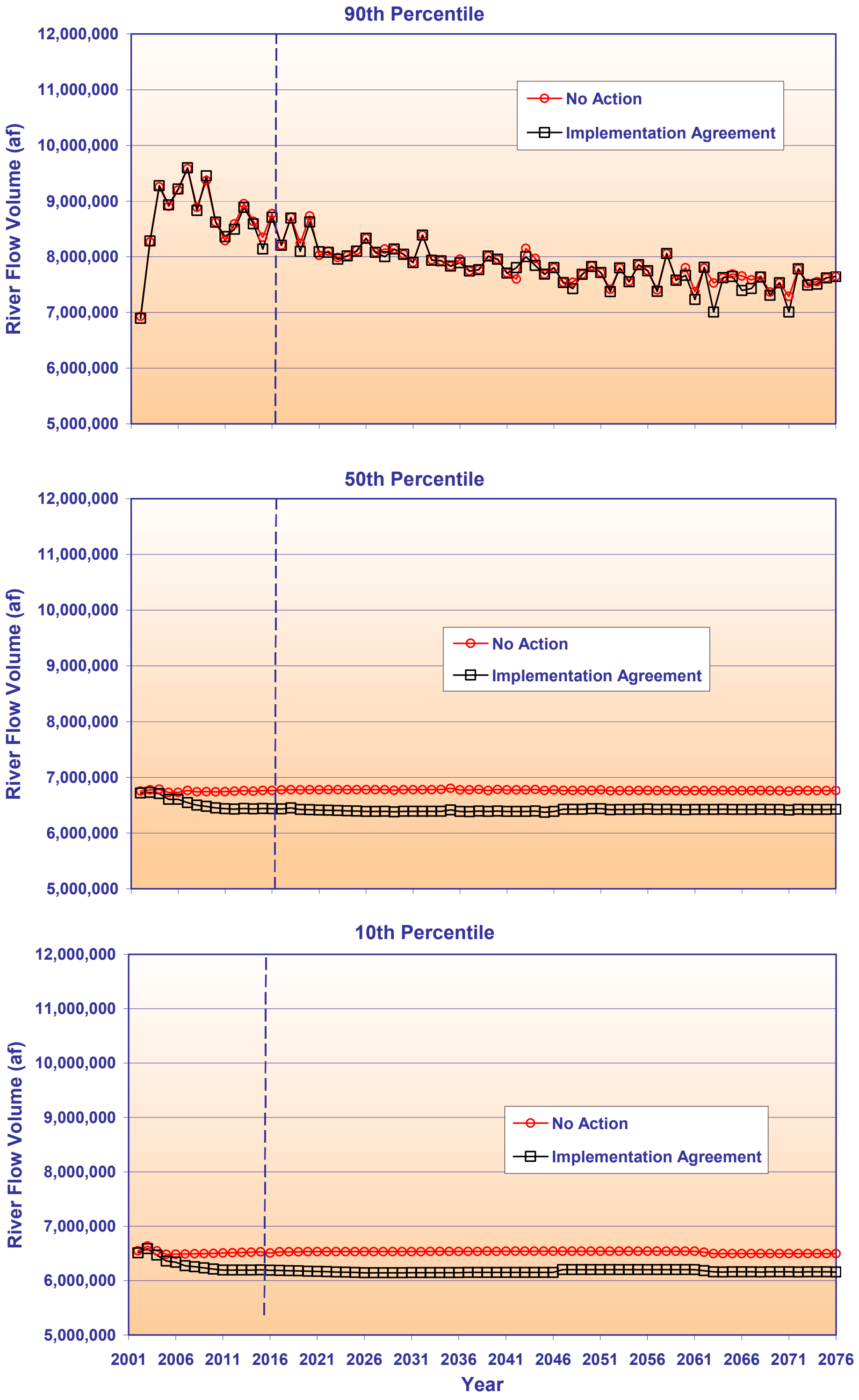


Figure 3.2-16
Colorado River Annual Flow Volumes Upstream of Colorado River Indian Reservation
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

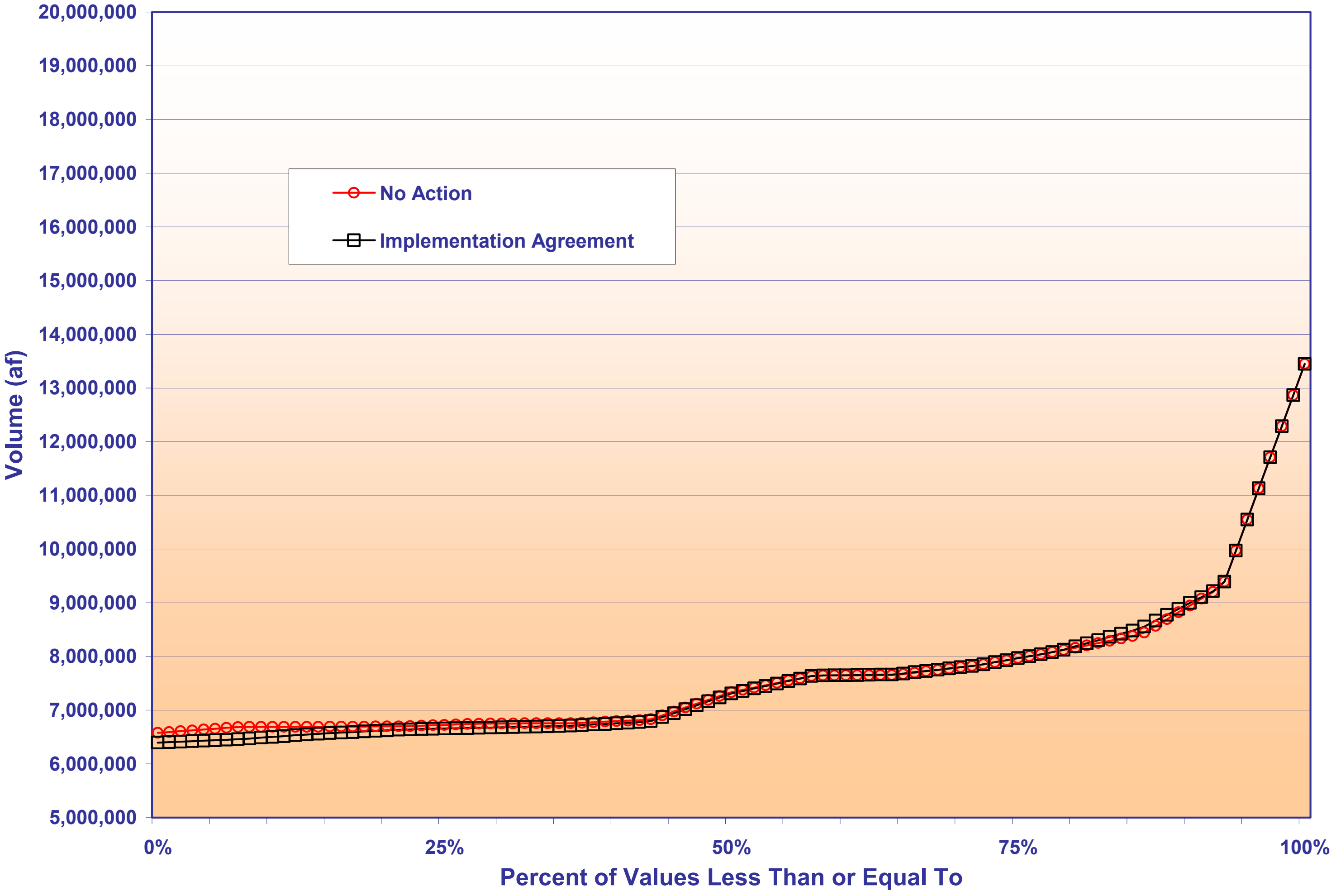


Figure 3.2-17a

Colorado River Seasonal Flows Upstream of Colorado River Indian Reservation

Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

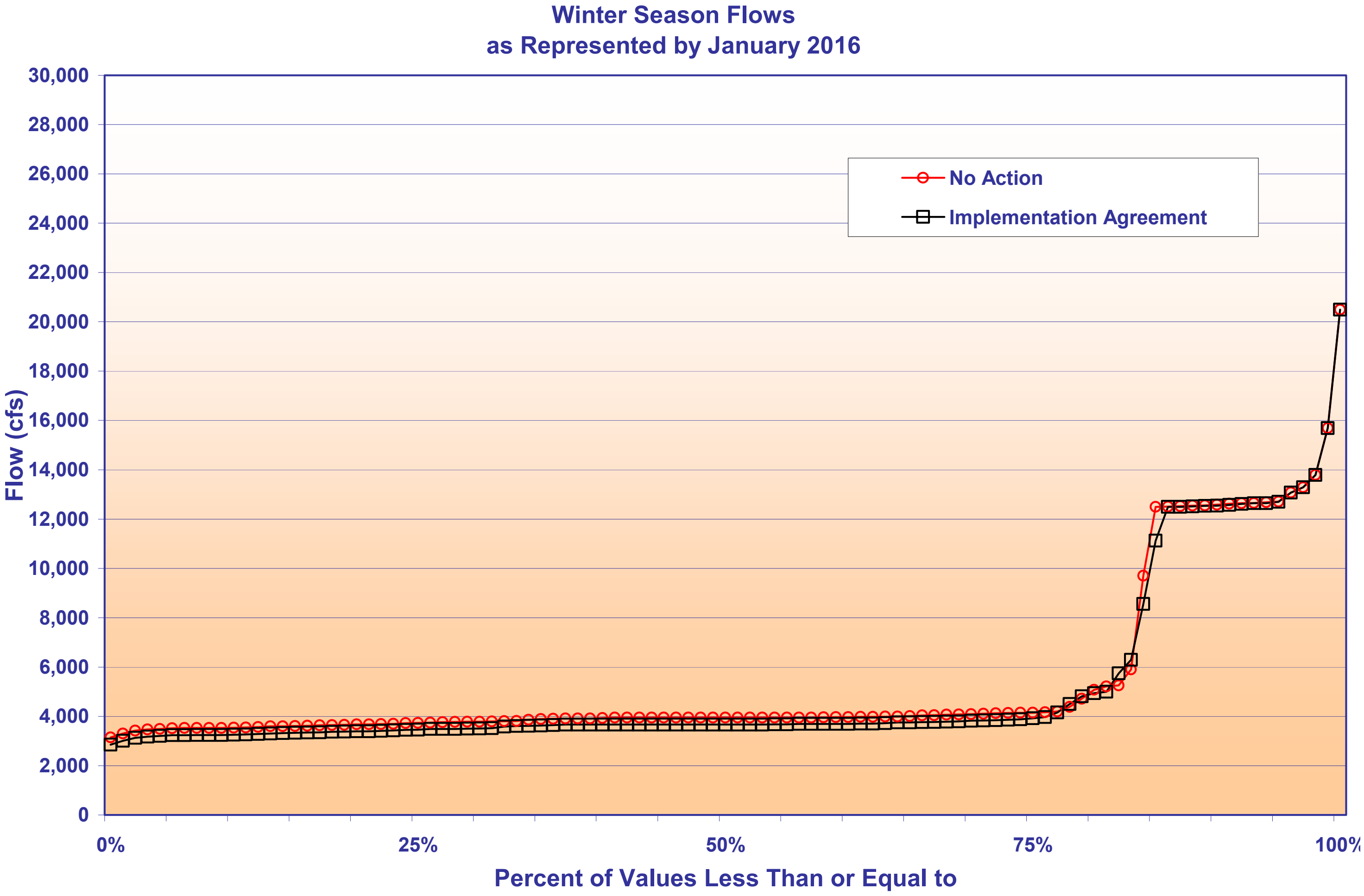


Figure 3.2-17b
Colorado River Seasonal Flows Upstream of Colorado River Indian Reservation
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

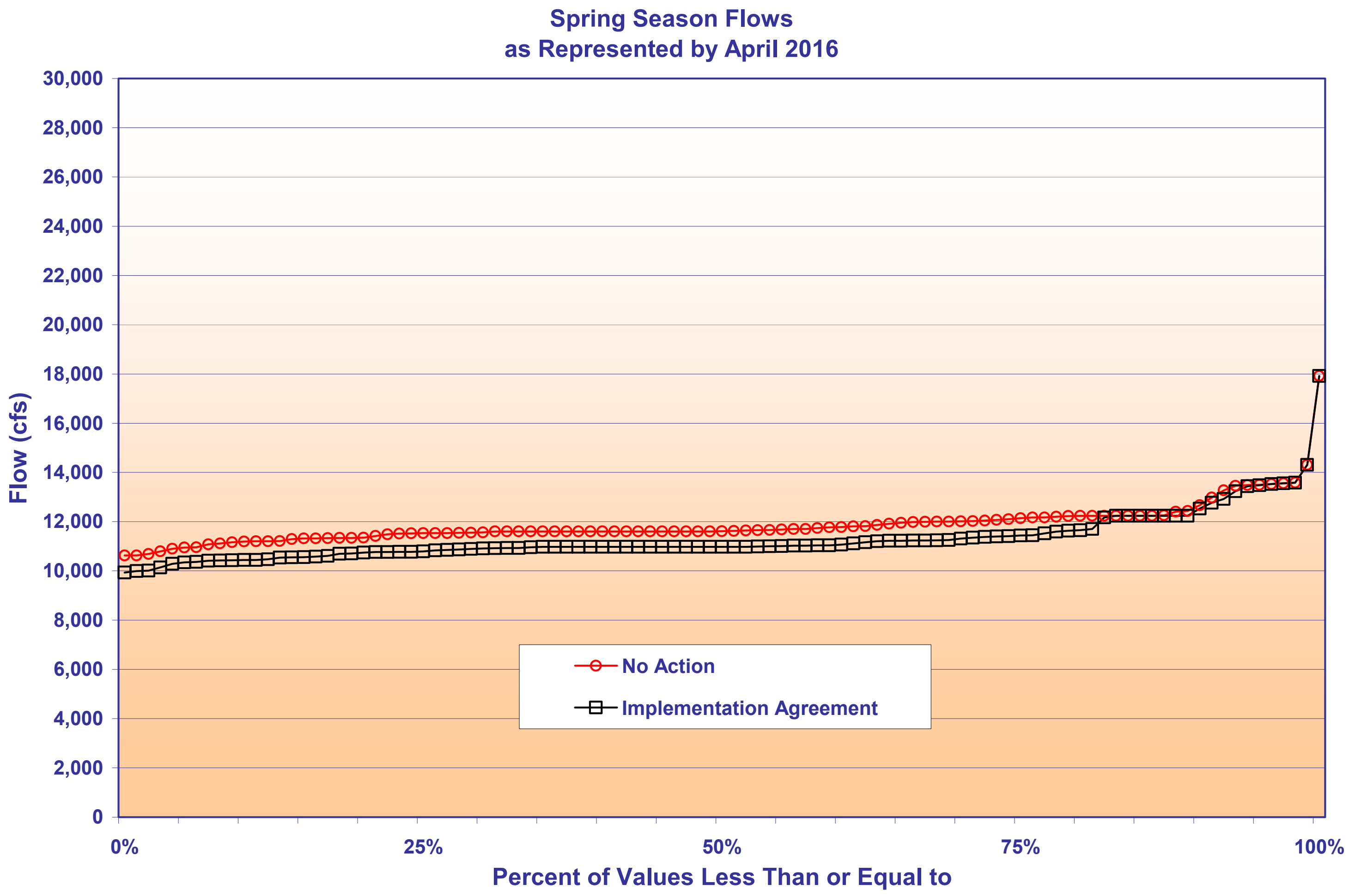


Figure 3.2-17c
Colorado River Seasonal Flows Upstream of Colorado River Indian Reservation
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

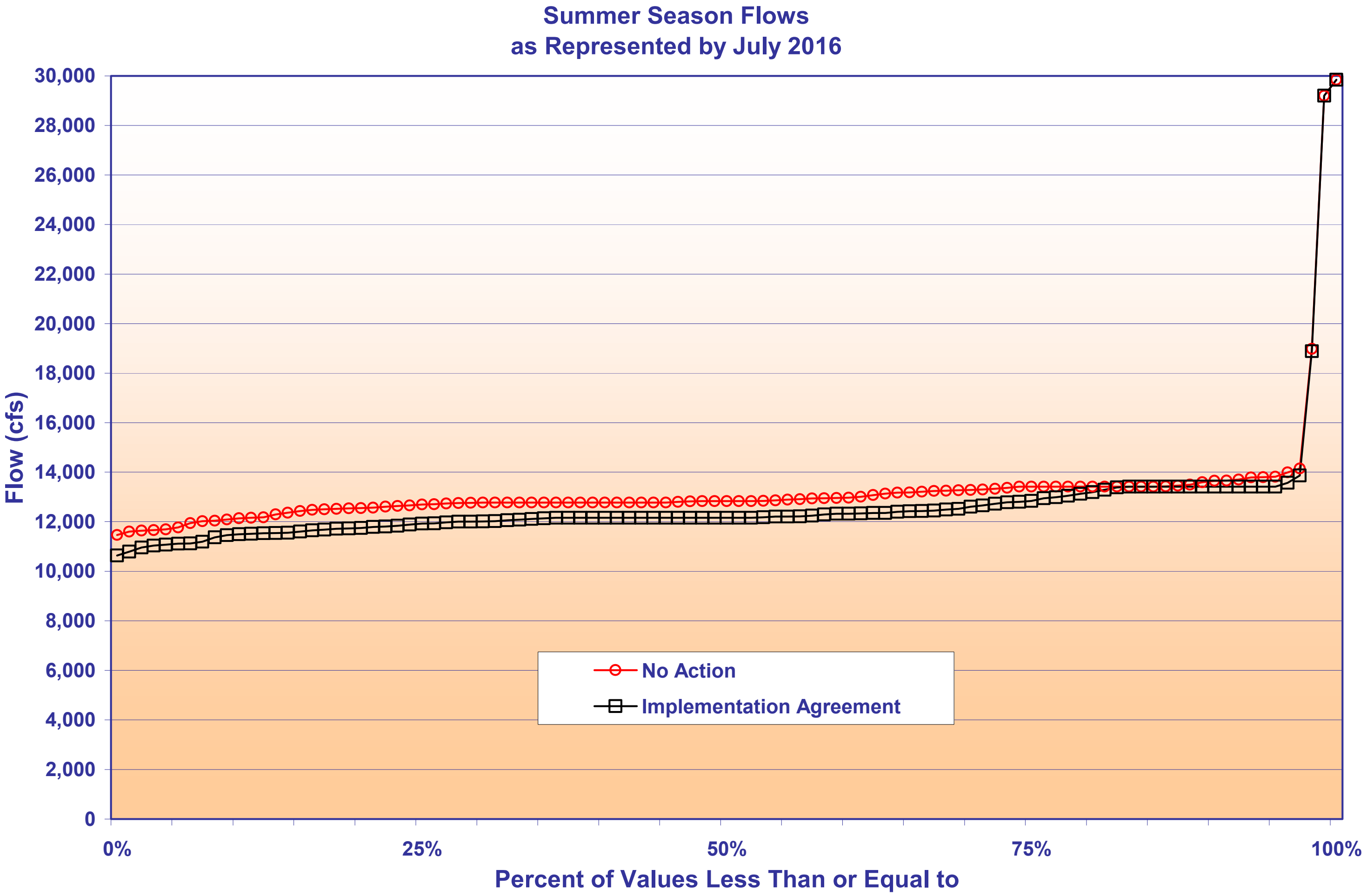
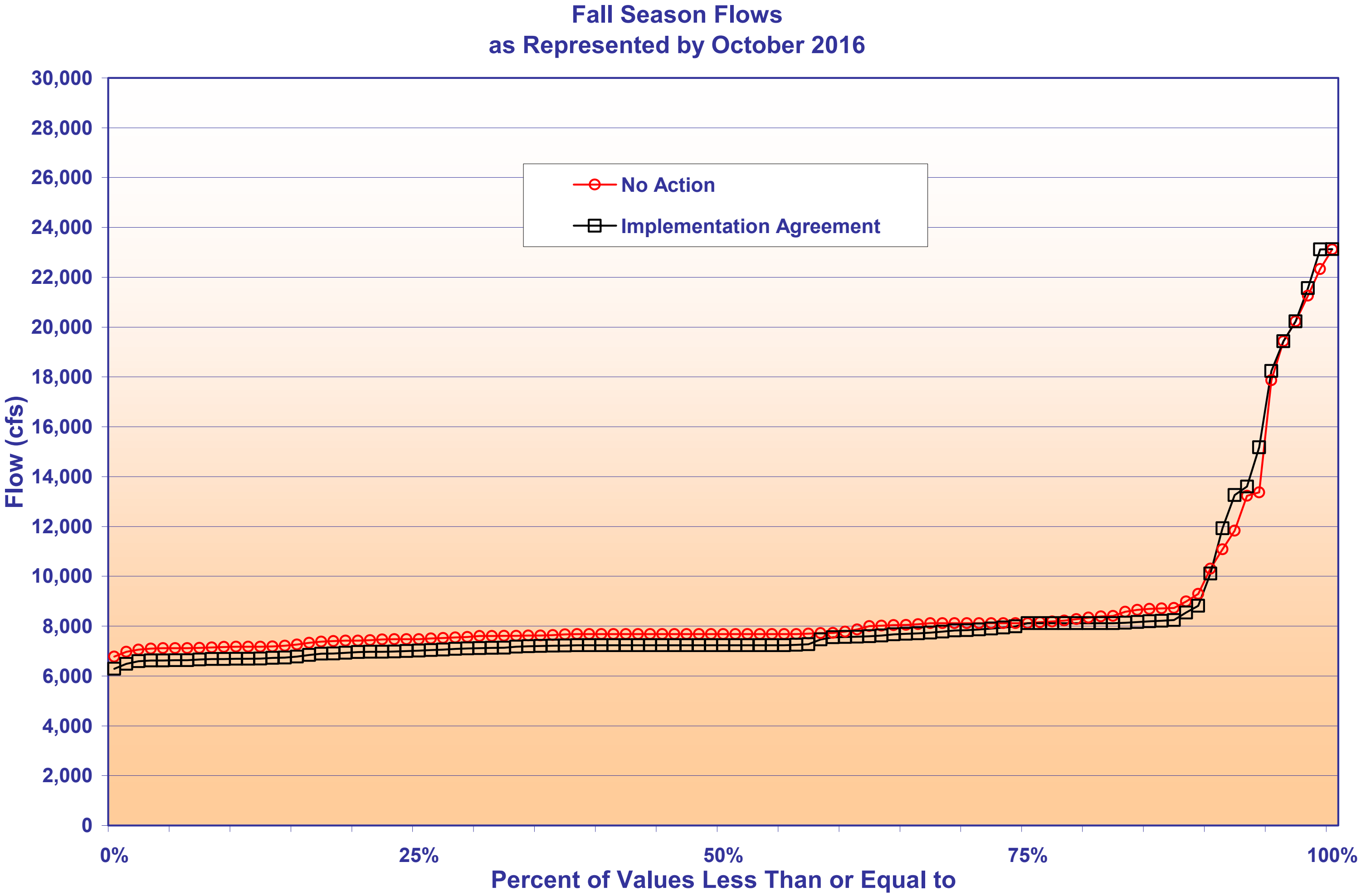


Figure 3.2-17d
Colorado River Seasonal Flows Upstream of Colorado River Indian Reservation
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016



3.2.4.3 RIVER FLOWS BETWEEN PALO VERDE DIVERSION DAM AND IMPERIAL DAM

The flow of the Colorado River between Palo Verde Diversion Dam and Imperial Dam is normally set at the amount needed to meet the United States diversion requirements downstream of the Palo Verde Diversion plus deliveries to Mexico. The river location that was modeled for this reach of the river is located immediately downstream of the Palo Verde Diversion Dam.

Future flows in this reach would be affected by the Implementation Agreement because the proposed water transfers and exchanges between the California agricultural water agencies and MWD would change the point of diversion from the river. 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 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 3.2-18. As shown by the 50th percentile values, the modeled annual flow volumes in this reach under the Implementation Agreement decline gradually between 2002 and 2016, as the water transfers take effect and certain amounts of California's water are diverted from Lake Havasu rather than at Imperial Dam. After 2016 the annual flow reduction continues. At the 10th percentile level, the same comparative annual flow patterns occur. Flows at the 90th percentile level are dominated by surplus water deliveries and flood flows, and do not exhibit a significant difference between the Implementation Agreement and No Action conditions.

Figure 3.2-19, shows the cumulative distribution of annual flow volumes for year 2016.

Figures 3.2-20 (a-d) present comparisons of the representative seasonal flows under No Action conditions and the Implementation Agreement for 2016. As expected, the largest flows occur in the spring and summer seasons under the No Action and Implementation Agreement conditions due to downstream irrigation demands. As on the 90th, 50th, and 10th percentile plots, the seasonal flows under the Implementation Agreement are slightly lower than those under No Action conditions. For flows that are due primarily to flood control releases from Lake Mead (flows in the 85th - 100th percentile range), the range of mean monthly flows is not affected by the Implementation Agreement, since these magnitudes are dictated by the flood control regulations. In the lower percentiles, the seasonal flows with the Implementation Agreement are slightly lower than the flows under No Action conditions (from six to 11 percent lower in various seasons in 2016).

A numerical comparison of the 70th percentile seasonal flow values is shown on Table 3.2-12. The values representing the seasons are the mean monthly flows in January, April, July and October.

Table 3.2-12
Comparison of Mean Monthly Flow (cfs) – No Action Conditions and Implementation Agreement
Colorado River Downstream of Palo Verde Diversion Dam (River Mile = 133.8)
70th Percentile Values for Year 2016

Season (Representative Month)	Mean Monthly Flows (cfs) for Year 2016 at the 70th Percentile	
	No Action	Implementation Agreement
Winter (January)	3,695	3,420
Spring (April)	10,202	9,633
Summer (July)	11,008	10,458
Fall (October)	7,444	7,003

Figure 3.2-18
Colorado River Downstream Palo Verde Diversion Dam Annual Flow Volume (af)
Comparison of Implementation Agreement to No Action Conditions
90th, 50th and 10th Percentile Values

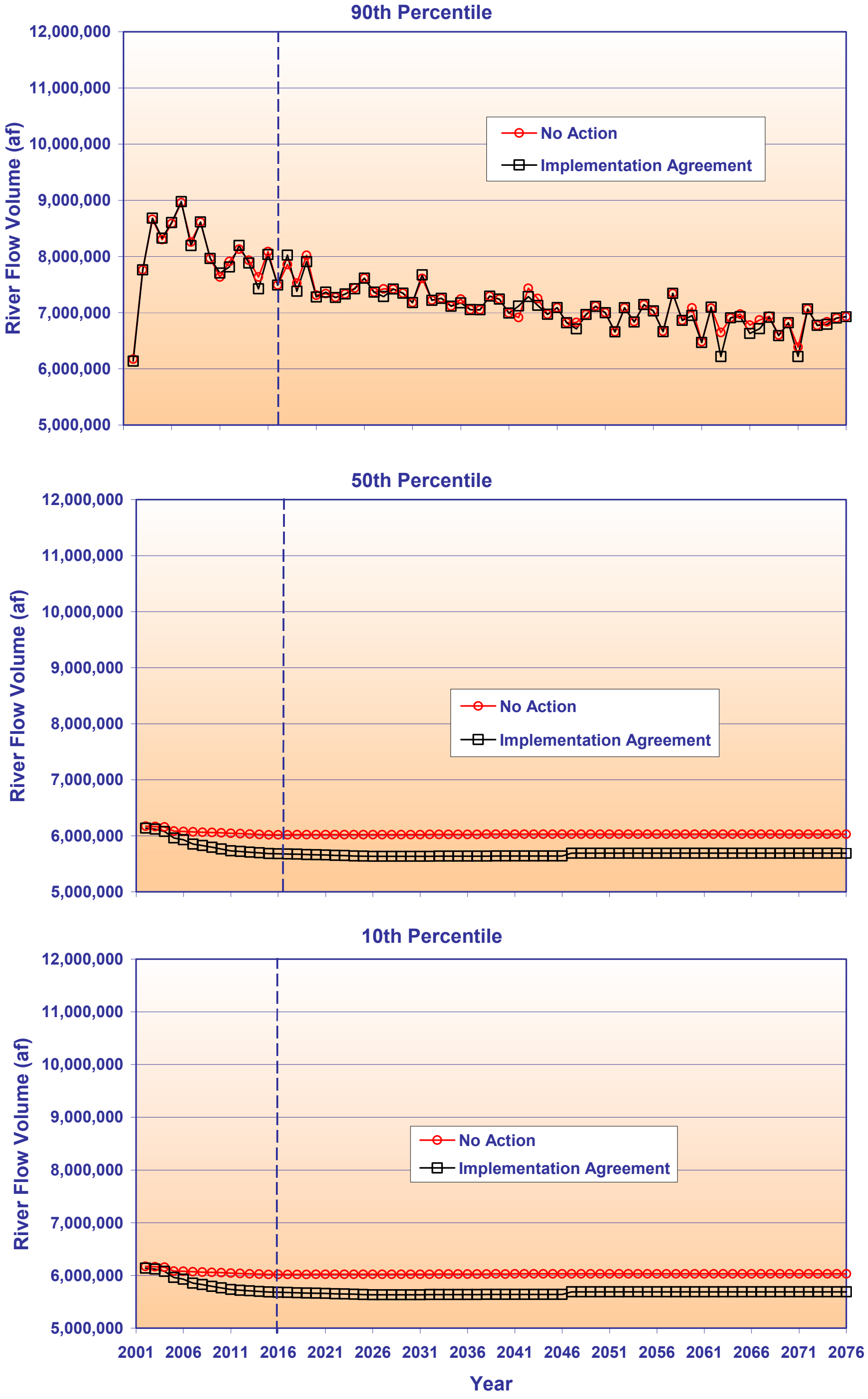


Figure 3.2-19
Colorado River Annual Flow Volumes Downstream of Palo Verde Irrigation Diversion
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

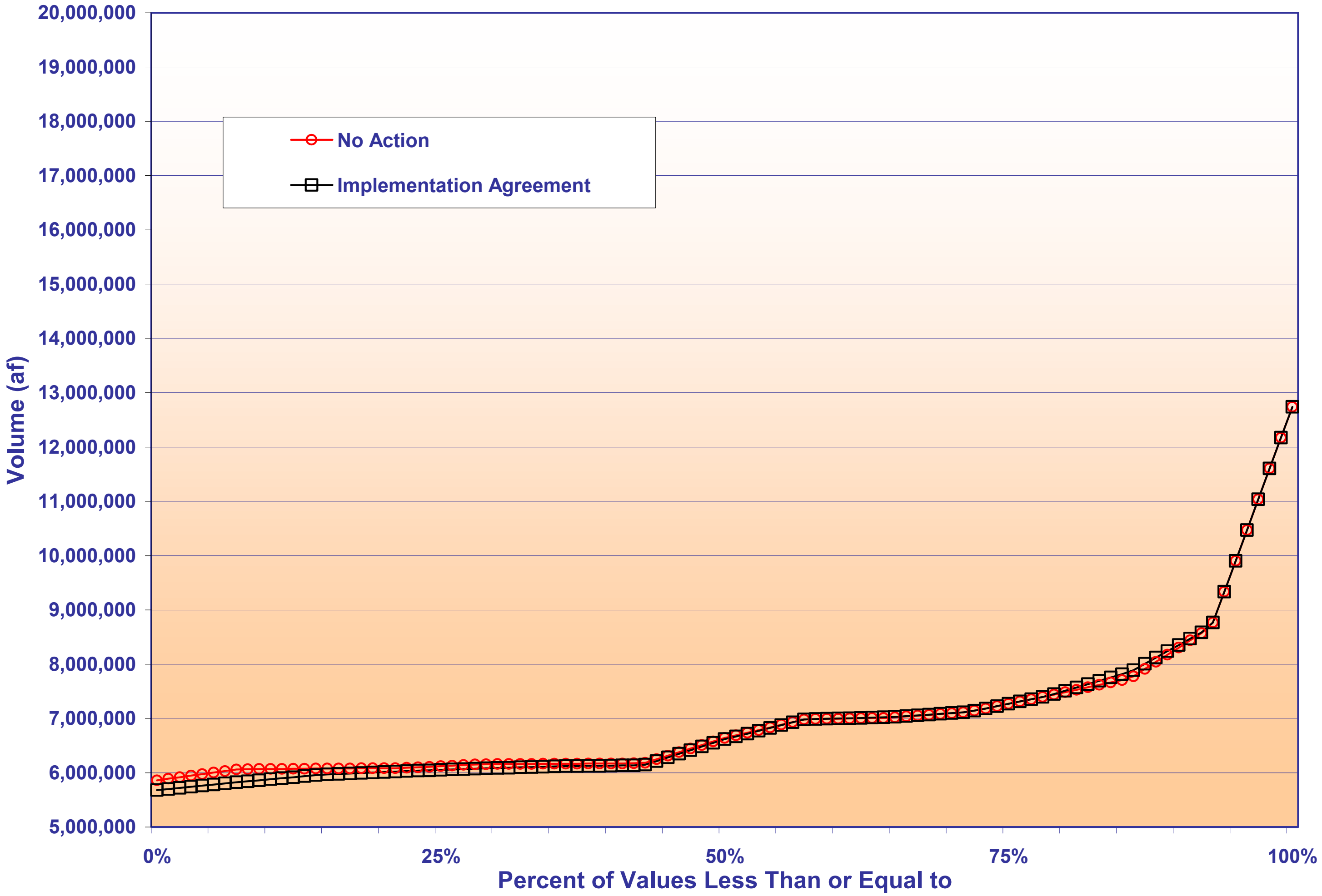


Figure 3.2-20a
Colorado River Seasonal Flows Downstream of Palo Verde Diversion Division
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

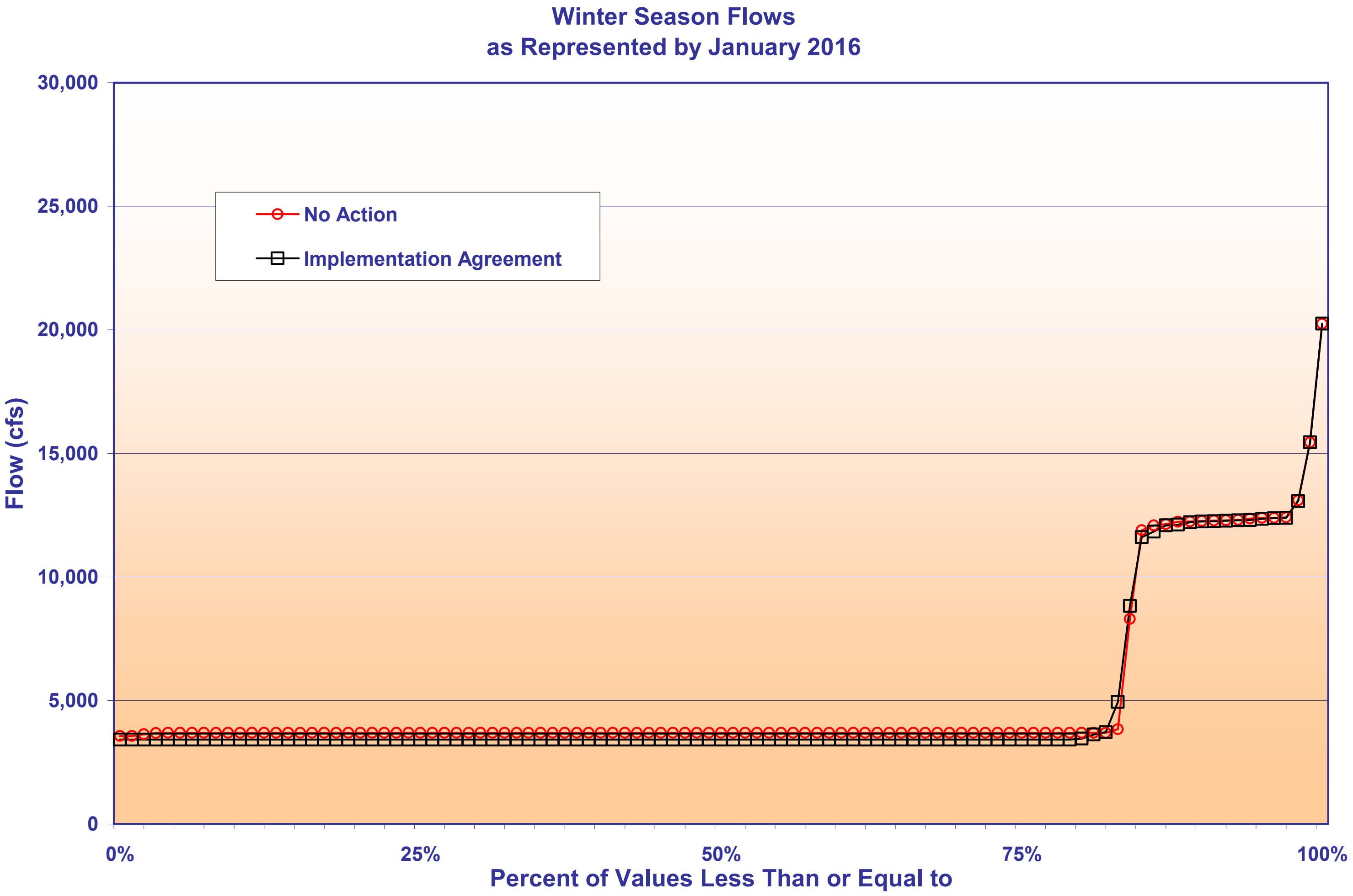


Figure 3.2-20b
Colorado River Seasonal Flows Downstream of Palo Verde Diversion Division
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

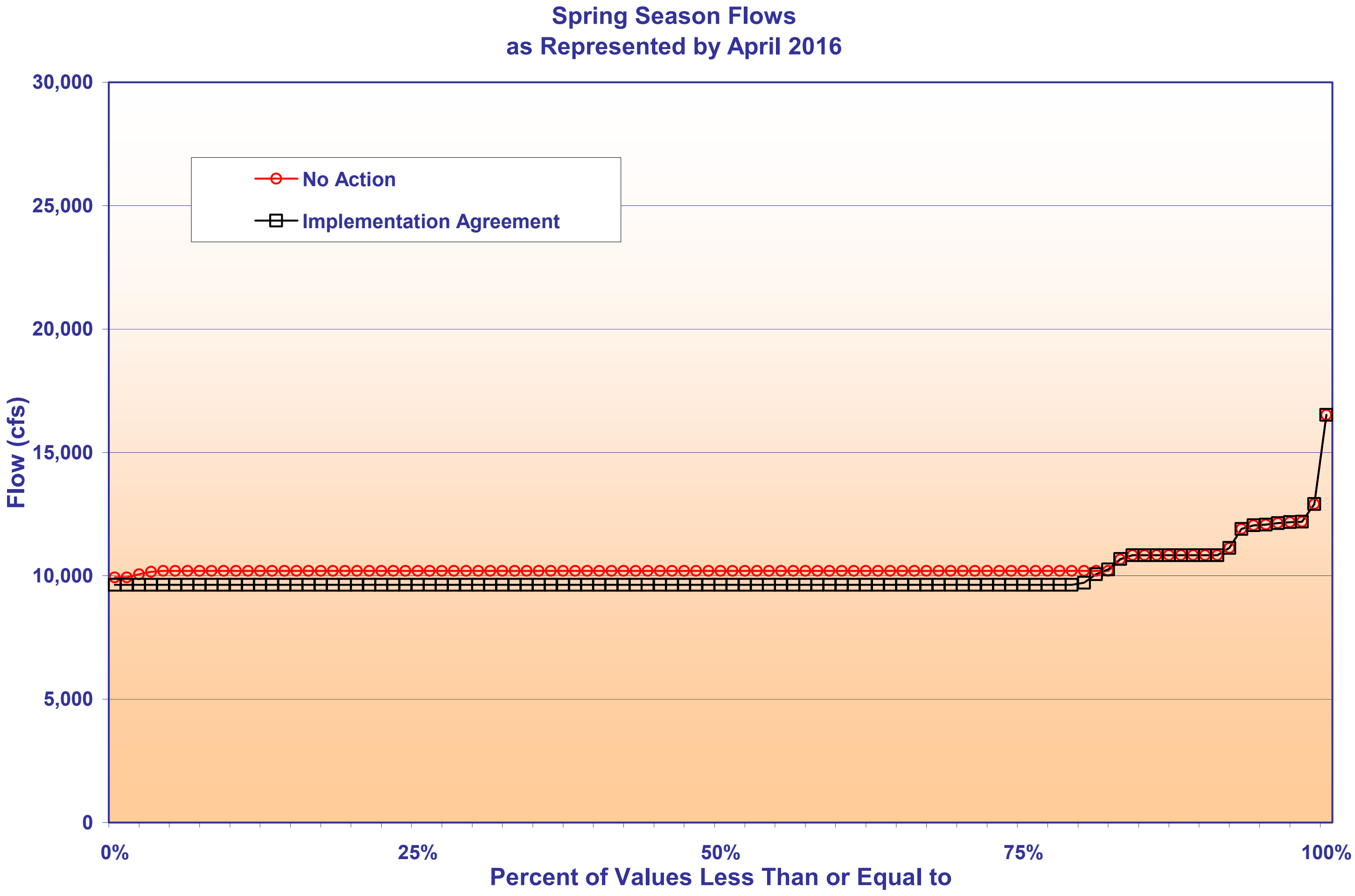


Figure 3.2-20c
Colorado River Seasonal Flows Downstream of Palo Verde Diversion Division
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

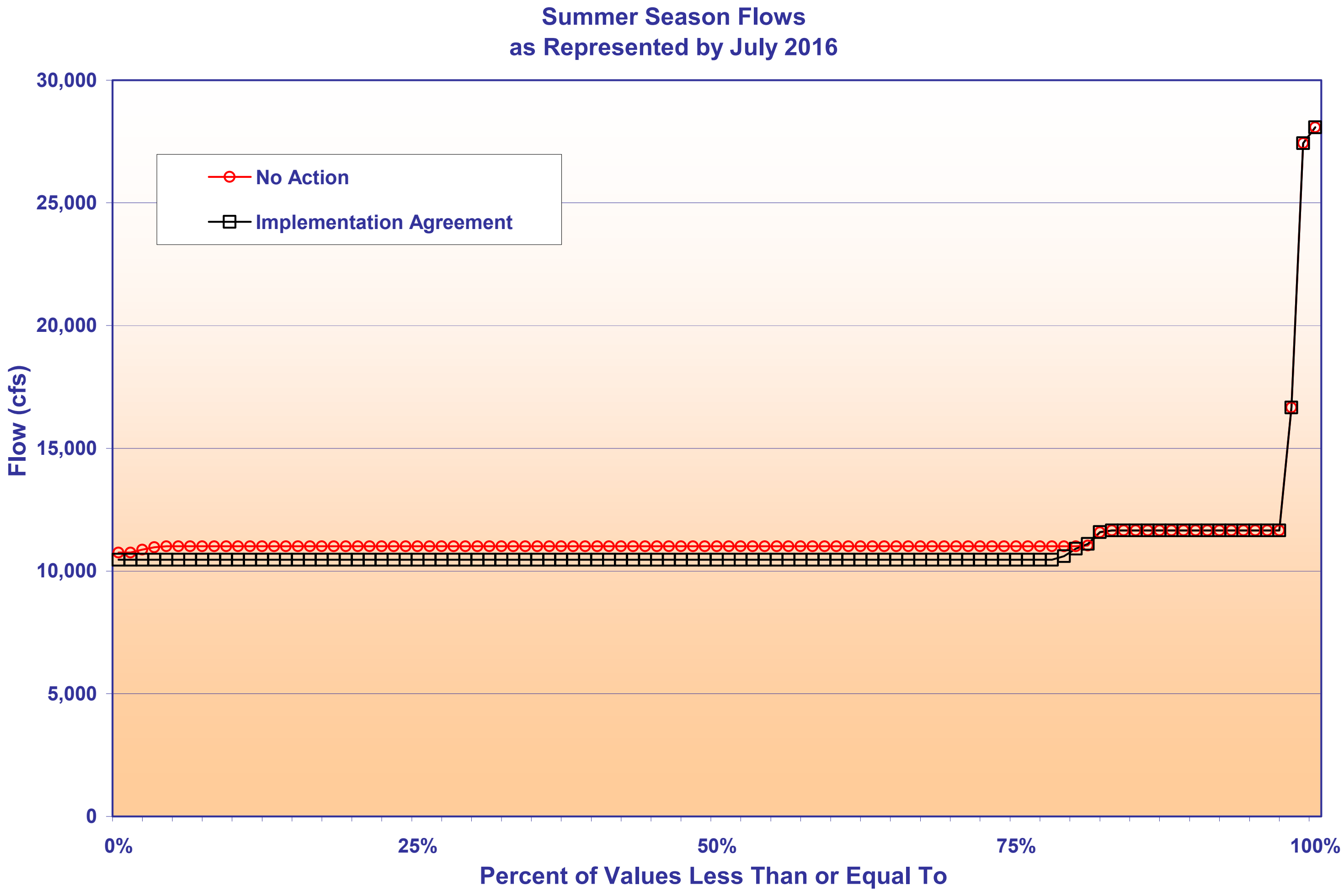
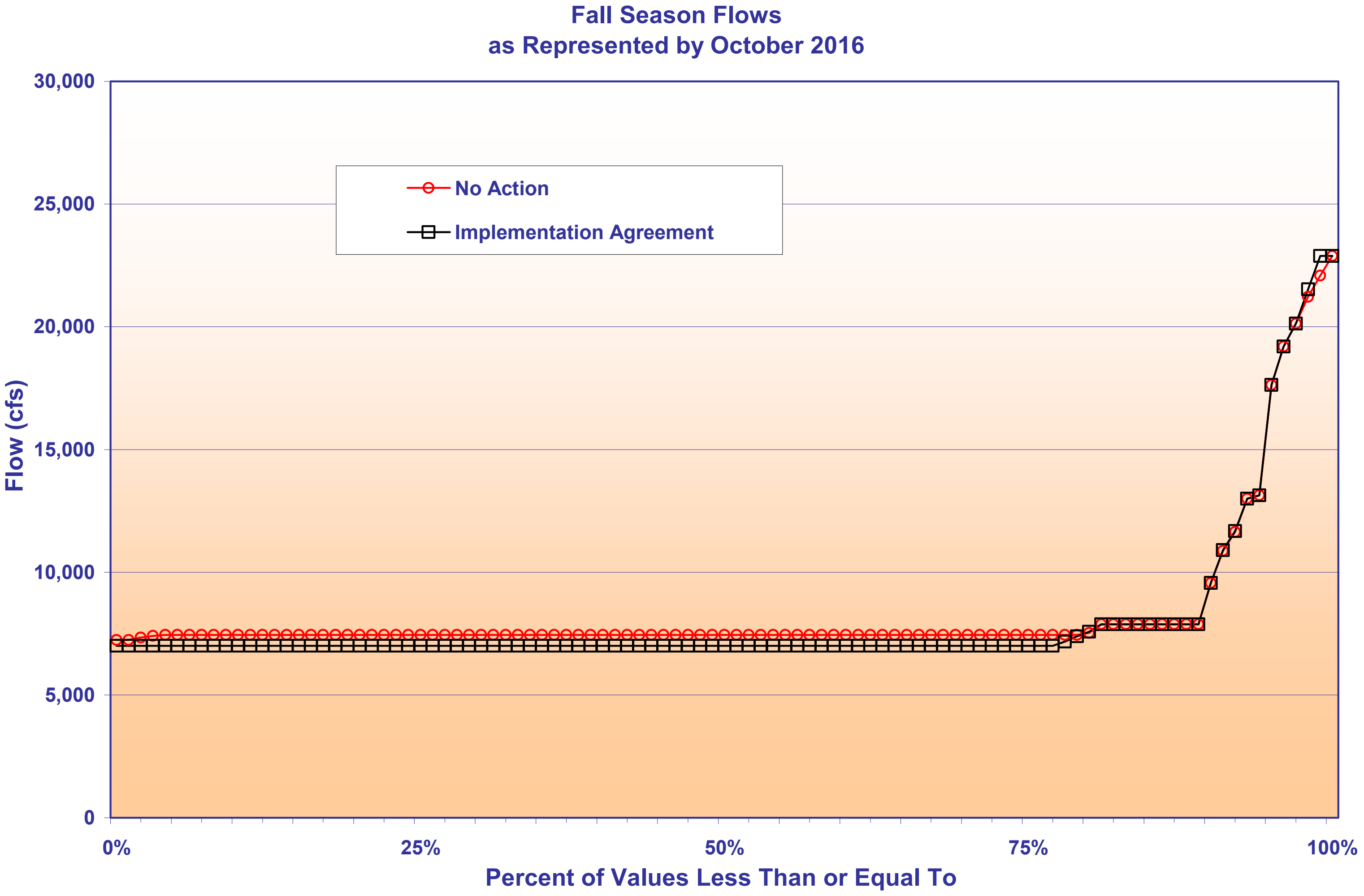


Figure 3.2-20d
Colorado River Seasonal Flows Downstream of Palo Verde Diversion Division
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016



3.2.4.4 RIVER FLOWS BETWEEN IMPERIAL DAM AND MORELOS DAM

The flows in the Colorado River below Imperial Dam are primarily comprised of the water delivered to Mexico in accordance with the US-Mexico Water Treaty of 1944. Mexico's principal diversion is at Morelos Dam, which is located, approximately nine miles southwest of Yuma, Arizona. Mexico owns, operates, and maintains Morelos Dam.

The reach of river between Morelos Dam and the SIB is commonly referred to by Reclamation as the Limitrophe Division. 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. Under International Treaty the United States Section of the IBWC is obligated to maintain the river channel within this division. Reclamation provides assistance to the IBWC, when requested, for maintenance needs in this reach of the river.

Minute 242 of the Mexican Water Treaty of 1944 provide requirements for deliveries at the NIB and SIB near Yuma and San Luis, Arizona, respectively (Note: Minutes are defined as decisions of IBWC and signed by the Mexican and United States commissioners of IBWC). Up to 140,000 af annually of agricultural drainage water can be delivered to Mexico at the SIB. The remaining 1,360,000 af of water is to be delivered to Mexico at the NIB annually and diverted at Morelos Dam for use in Mexico. For several years after the United States Bypass Drain was completed in 1978, the Colorado River Channel downstream of Morelos Dam was normally dry. Flows below Morelos Dam now occur only when water in excess of Mexico's requirement arrives at the NIB.

Much of the NIB water 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 Dam.

Water in excess of Mexico's water order at the NIB is normally passed through Morelos Dam, through the Limitrophe Division, and into the original Colorado River channel downstream. Water in excess of Mexico's water order occurs primarily when flood releases are made from Lake Mead. Excess water arriving at the NIB may also result from flooding on the Gila River, and from operational activities upstream (i.e., cancelled water orders in the United States, maintenance activities, etc.).

In December of each year, Mexico provides to the United States an advance monthly water order for the following calendar year. Normally, this water order can only be changed by providing the United States with written notice, 30 days in advance and each monthly water order can be increased or decreased by no more than 20 percent of the original monthly water order. The Treaty further stipulates that Mexico's total water order must be no less than 900 cfs and no more than 5500 cfs during the months of January, February, October, November and December. During the remainder of the year, Mexico's water order must be no less than 1500 cfs and no more than 5500 cfs. Daily water orders are usually not allowed to increase or decrease by more than 500 cfs.

As discussed in Section 2.3, the model accounts for all the deliveries to Mexico through diversions at the NIB (Morelos Dam). Flows that are modeled downstream of Morelos Dam represent mean monthly flows that are excess flows in the Colorado River due to Lake Mead flood control releases. These excess flows may reach the Colorado River Delta, although Mexico has the authority to divert them for other uses. Such decisions by Mexico are not modeled, as they are not known. The excess flows are over and above Mexico's normal 1.5 mafy water entitlement, plus the 200,000 afy for surplus deliveries.

The 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 3.2-21. These flows are dependent solely upon infrequent flood control releases, hence no flows are observed at either the 10th or 50th percentiles. At the 90th percentile level, the Implementation Agreement scenario produces annual flow volumes slightly above and below the No Action values to 2016, and annual flow volumes equal to or slightly above No Action flows after 2016.

Figure 3.2-22 shows the cumulative distribution of annual flow volumes for year 2016.

Figures 3.2-23 (a-d) present comparisons of the representative seasonal flows under No Action conditions and the Implementation Agreement for 2016. As expected, the only differences seen for flows are due to flood control releases from Lake Mead (flows in the 80th – 100th percentile range). As seen in the figures, where the Implementation Agreement flows differ from the No Action flows, the Implementation Agreement flows are higher (up to approximately 40 percent higher between the 85th and 90th percentiles for January 2016).

A numerical comparison of the 90th percentile seasonal flow values is shown on Table 3.2-13. The values representing the seasons are the mean monthly flows in January, April, July and October.

Table 3.2-13
Comparison of Mean Monthly Flow Data – No Action Conditions and Implementation Agreement
Colorado River Downstream of Morelos Dam (River Mile = 23.1)
90th Percentile Values (cfs) for Year 2016

Season (Representative Month)	Mean Monthly Flows (cfs) for Year 2016 at the 90th Percentile	
	No Action	Implementation Agreement
Winter (January)	8,361	8,346
Spring (April)	0	0
Summer (July)	0	0
Fall (October)	1,679	1,679

Figure 3.2-21
Colorado River Below Mexico Diversion at Morelos Dam Annual Flow Volume (af)
Comparison of Implementation Agreement to No Action Conditions
90^{th}, 50^{th} and 10^{th} Percentile Values

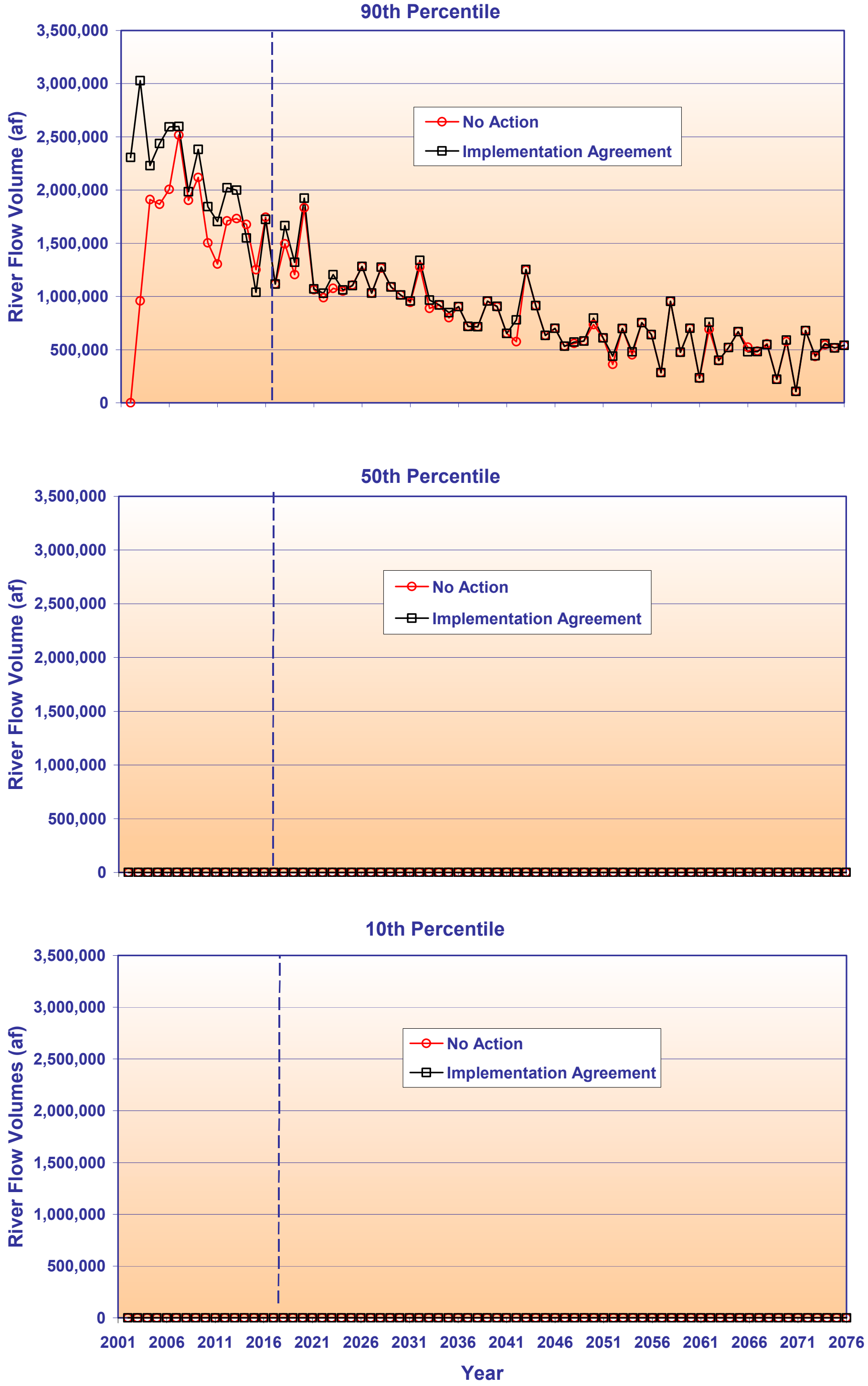


Figure 3.2-22
Colorado River Annual Flow Volumes Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

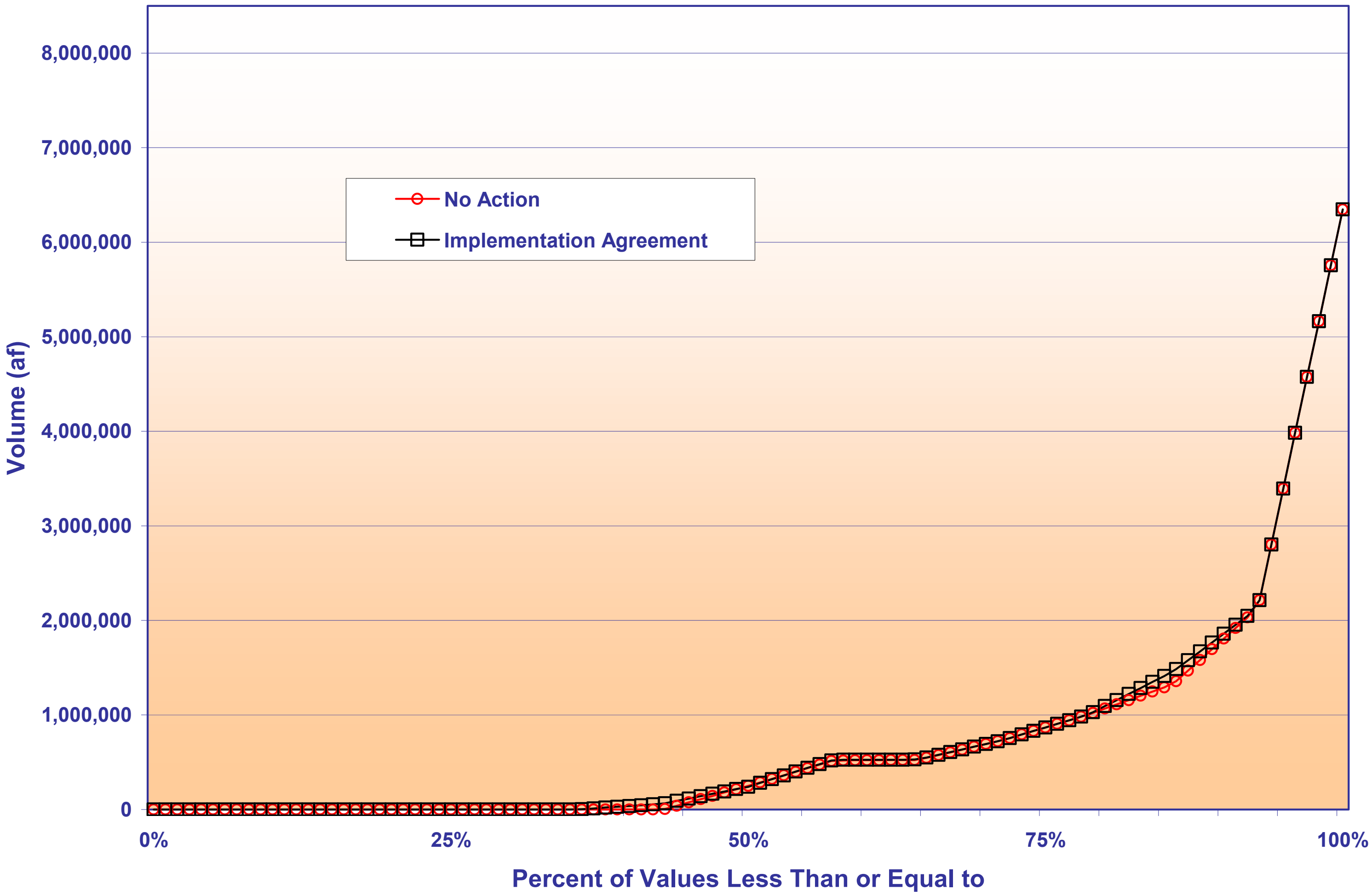


Figure 3.2-23a
Colorado River Seasonal Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

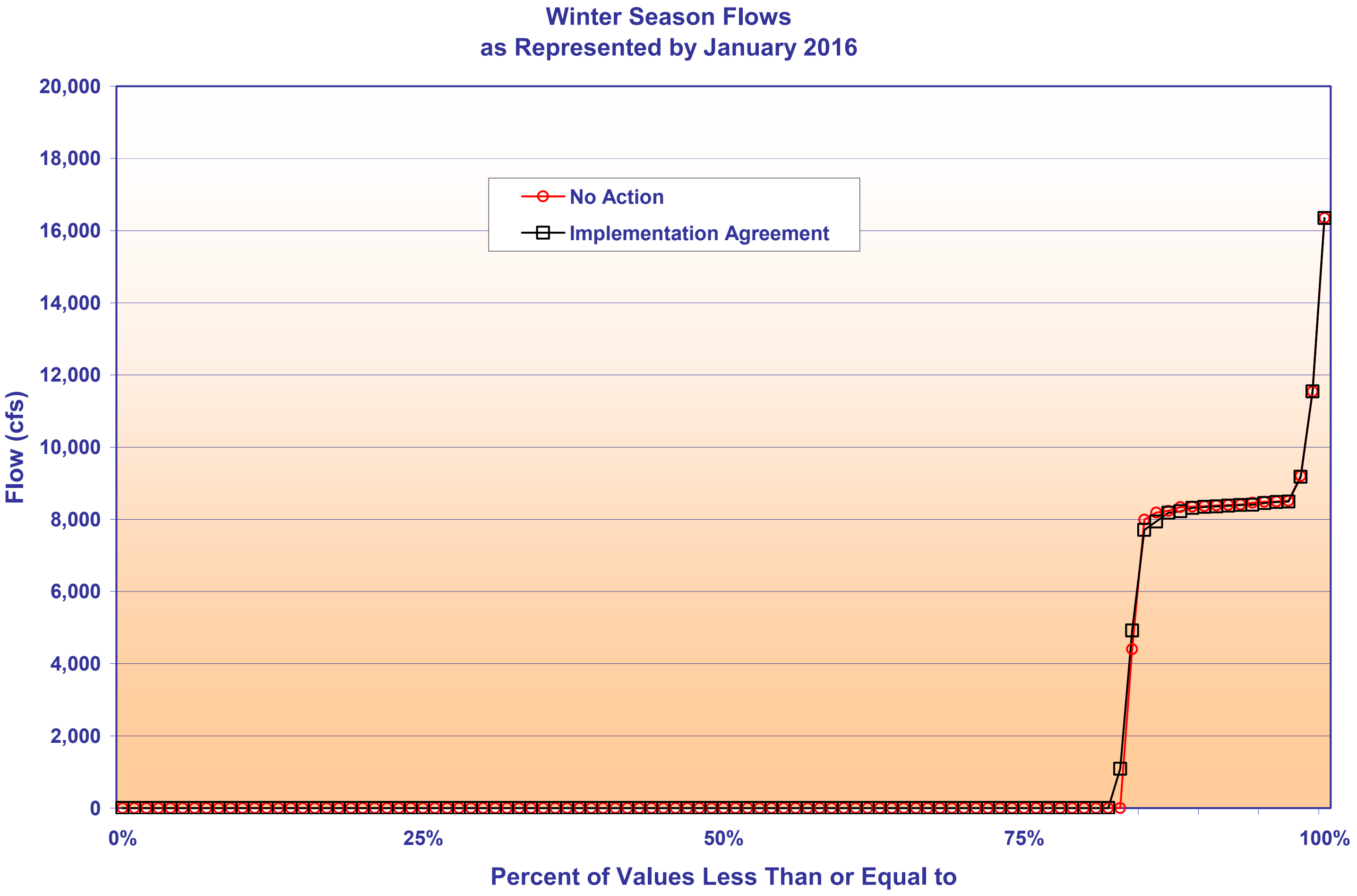


Figure 3.2-23b
Colorado River Seasonal Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

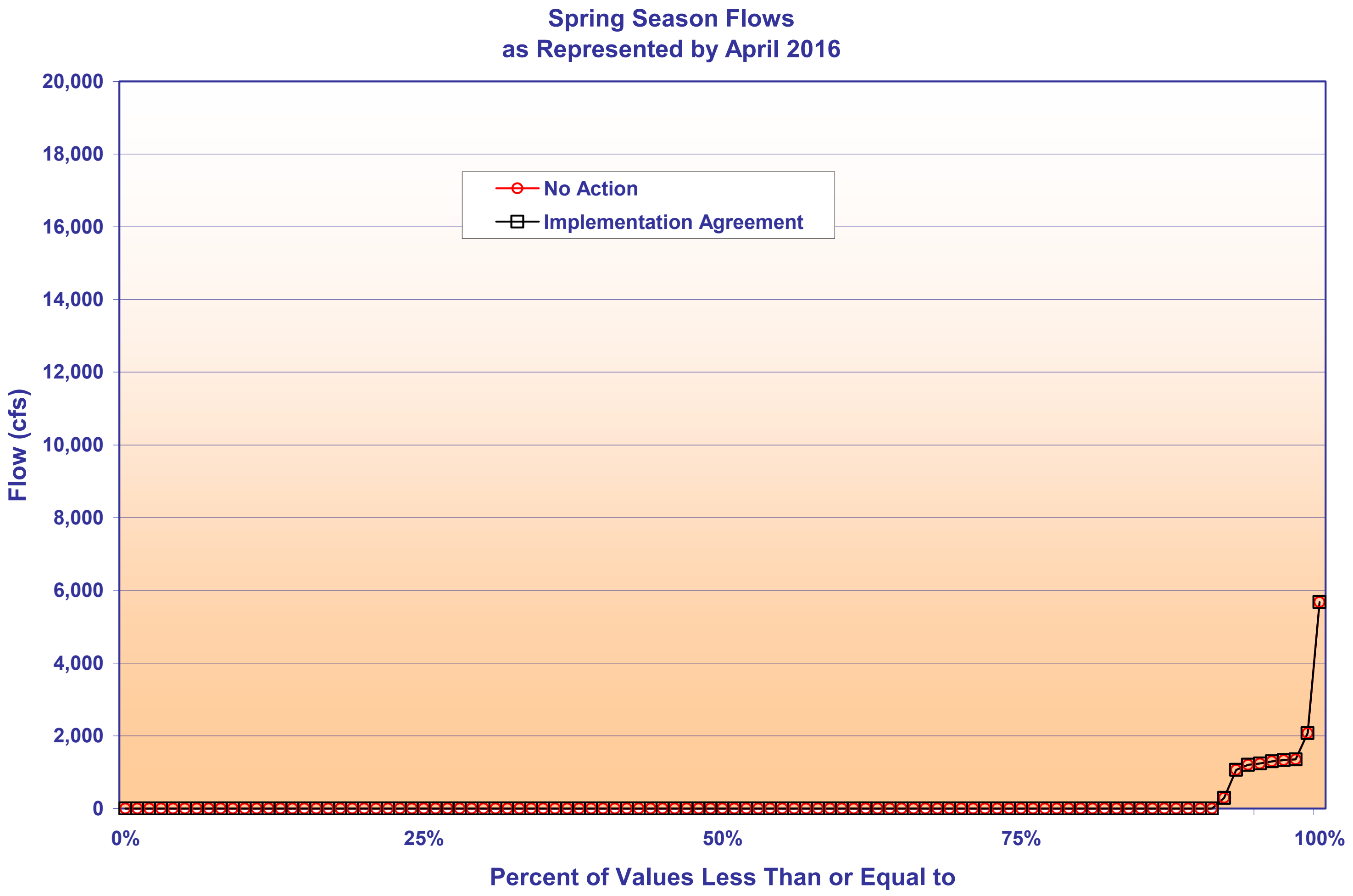


Figure 3.2-23c
Colorado River Seasonal Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

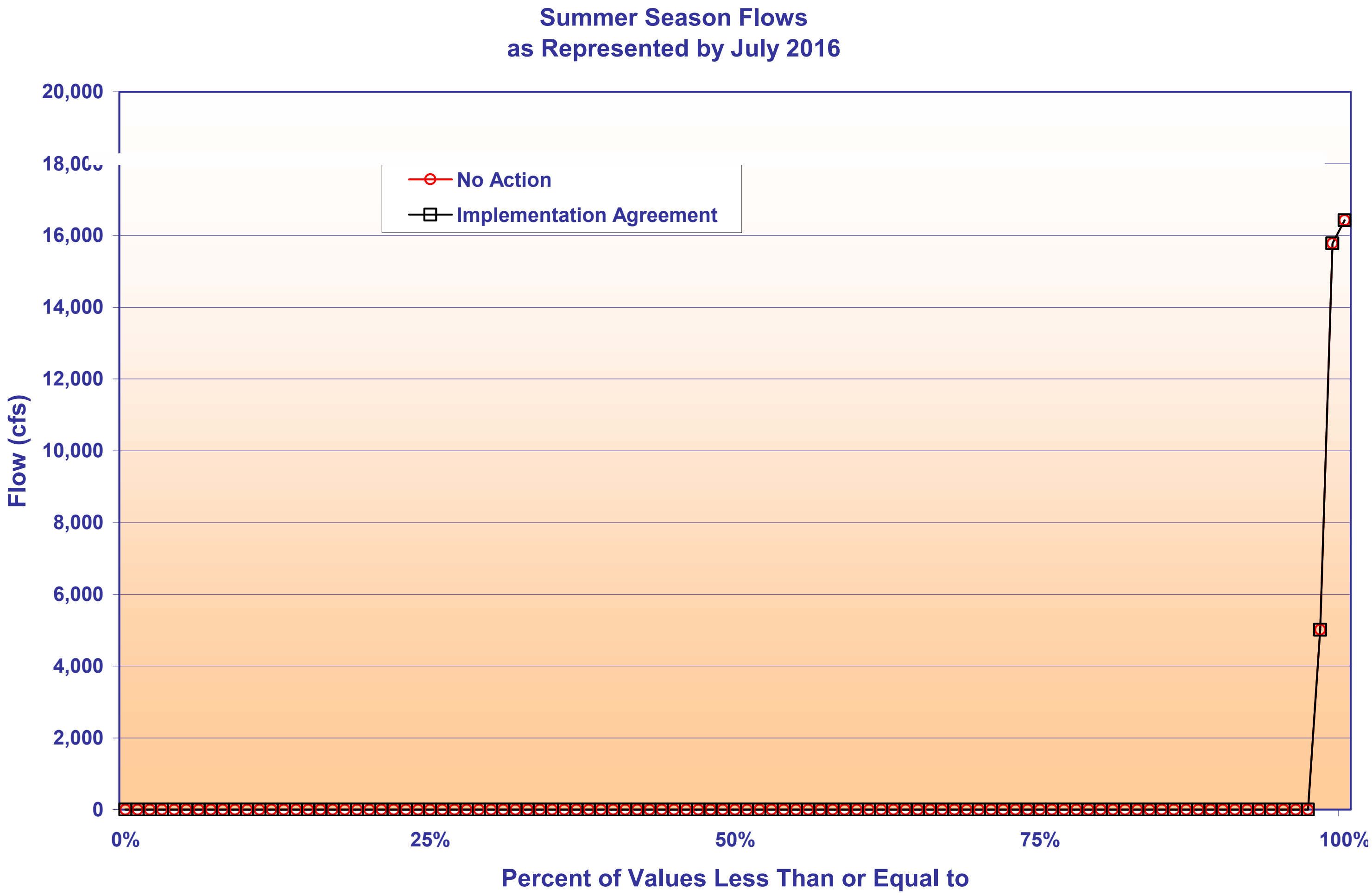
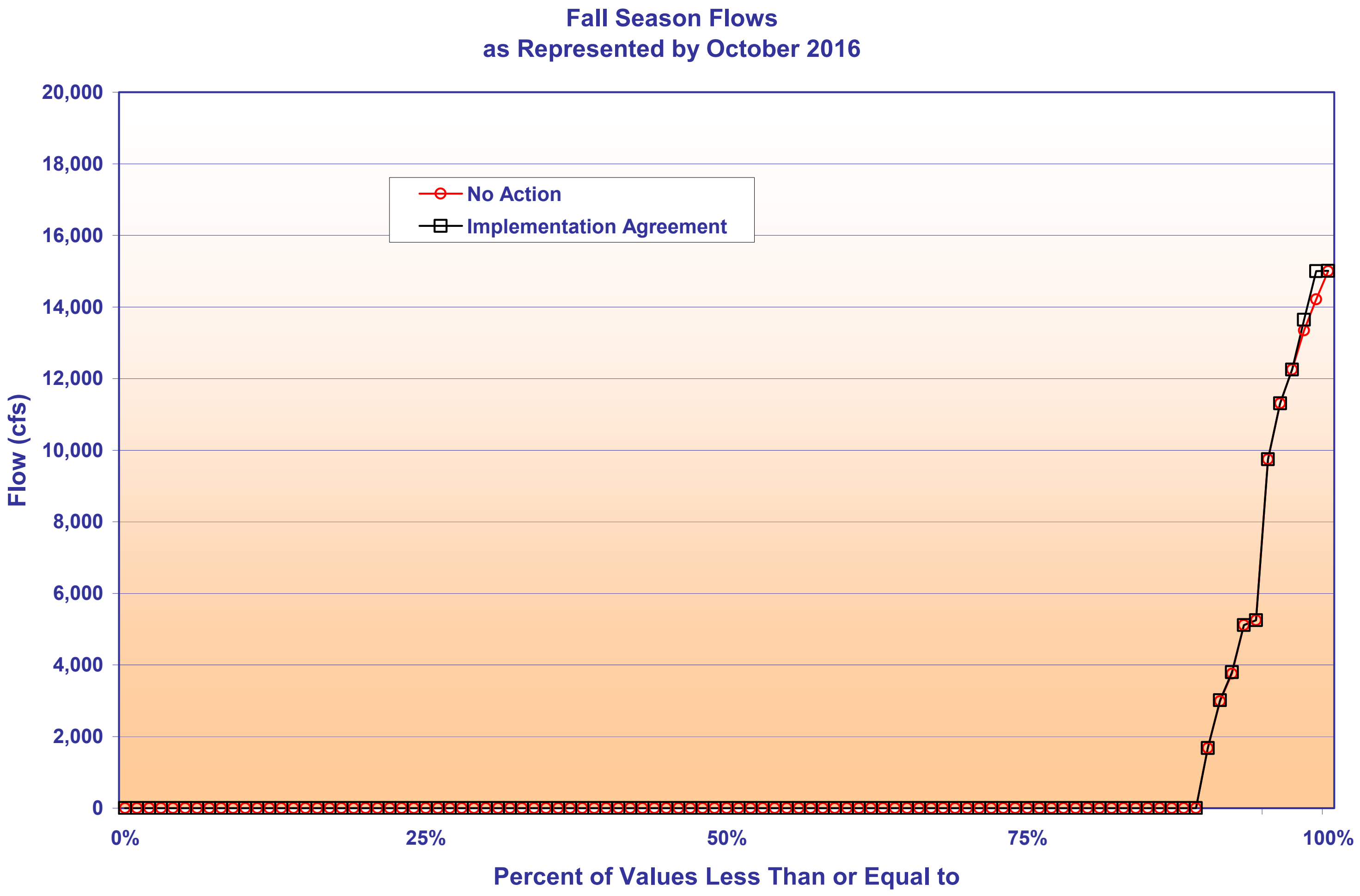


Figure 3.2-23d
Colorado River Seasonal Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016



3.3 ANALYSIS OF CUMULATIVE EFFECTS

This section describes the results of the analysis that evaluates the potential cumulative impacts to the levels of Lakes Powell and Mead and riverflows resulting from the proposed implementation of all the water management programs contemplated under this Technical Memorandum**.** The modeled operational scenarios that are used to evaluate the cumulative effects of the various water management programs in this section consist of the Baseline for the Cumulative Analysis (Baseline Conditions) and the Cumulative Analysis Conditions, which are defined in Section 2.2. The period of analysis is 75 years.

3.3.1 LAKE POWELL WATER LEVELS

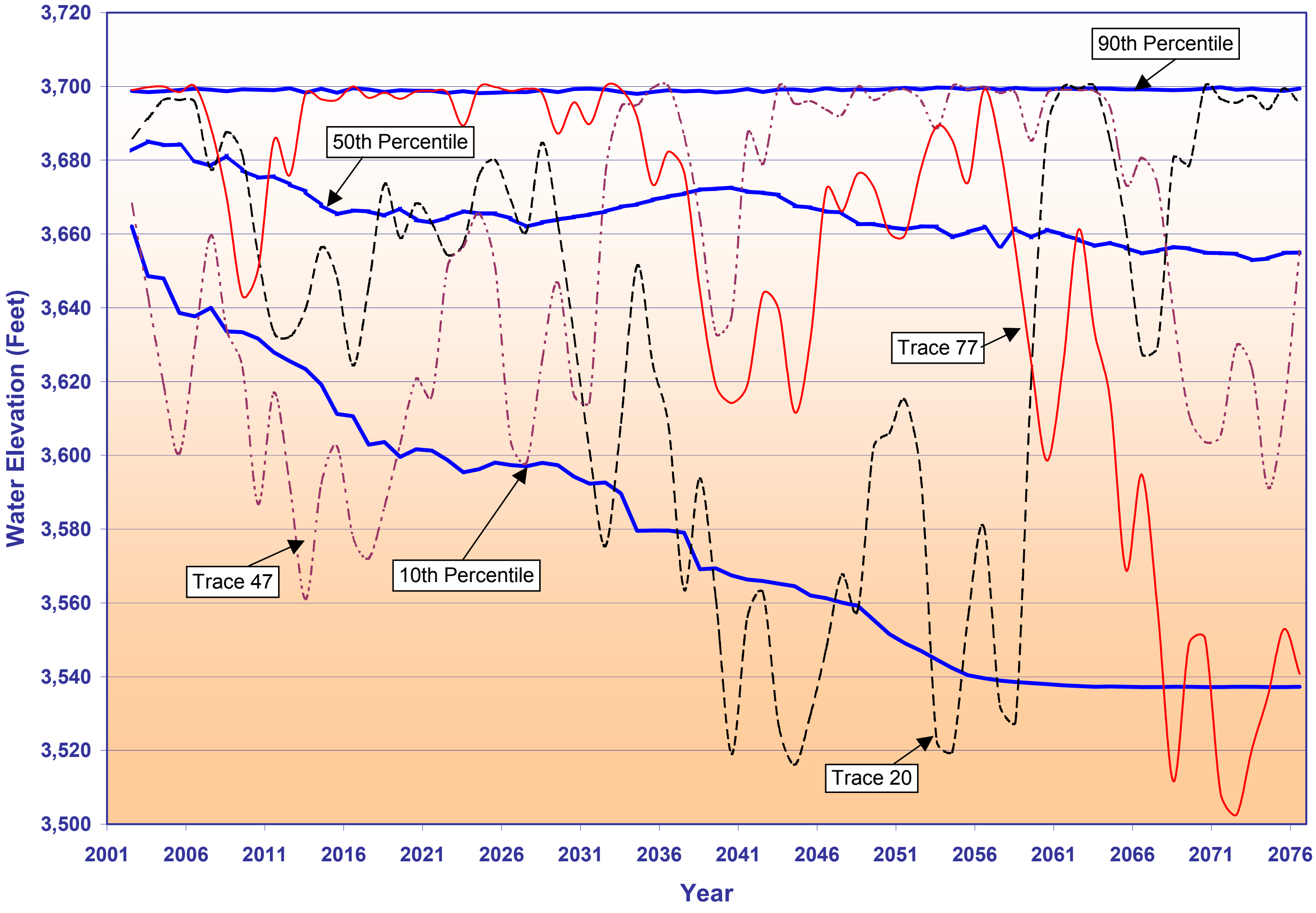
3.3.1.1 MODELING RESULTS OF BASELINE FOR CUMULATIVE ANALYSIS

Under the Baseline for Cumulative Analysis conditions, the water surface elevation of Lake Powell is projected to fluctuate between full level and decreasingly lower levels during the period of analysis (2002 to 2076). Figure 3.3-1 illustrates the range of water levels by three lines, labeled 90th Percentile, 50th Percentile and 10th Percentile. The 50th percentile line shows the median water level for each future year. The median water level under Baseline for Cumulative Analysis conditions is shown to decline to approximately 3666 feet msl by 2016 and remaining at this or slightly higher levels through 2076. The 10th percentile line shows there is a 10 percent probability that the water level would drop to 3611 feet msl by 2016 and to 3537 feet msl by 2076.

Generally, there is about a 20-foot difference between the annual high and low water levels at Lake Powell. It should also be noted that the Lake Powell elevations depicted in Figure 3.3-1 are for modeled lake water levels at the end of July, which influence recreation at the reservoir. The Lake Powell water level generally reaches its seasonal high in July whereas the seasonal low occurs at the end of the year.

Three distinct traces were added to Figure 3.3-1 to illustrate what was actually simulated under the various traces and respective hydrologic sequences and to highlight that the 90th, 50th and 10th percentile lines do not represent actual traces, but rather the ranking of the data from the 85 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 10th percentile line. The trace identified as Trace 20 represents the hydrologic sequence that begins in year 1926. The trace identified as Trace 47 represents the hydrologic sequence that begins in year 1953. The trace identified as Trace 77 represents the hydrologic sequence that begins in year 1983.

Figure 3.3-1
Lake Powell End-of-July Water Elevations Under Baseline for Cumulative Analysis
90th, 50th and 10th Percentile Values and Representative Traces



In Figure 3.3-1, the 90th and 10th percentile lines bracket the range where 80 percent of the water levels simulated for the Baseline for Cumulative Analysis conditions occur. 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 between the highs and the lows, nor the length of time the water level would remain high or low can be predicted. These events would depend on the future variation in basin runoff conditions.

Figure 3.3-2 presents a comparison of the 90th, 50th and 10th percentile plots under Baseline for Cumulative Analysis conditions and those under the Cumulative Analysis Conditions. This figure is best used for comparing the relative differences in the general lake level trends that result from the simulation of Baseline for Cumulative Analysis and Cumulative Analysis Conditions.

Figure 3.3-3 shows the frequency that future Lake Powell end-of-July water elevations would exceed elevation 3695 feet msl under the Baseline for Cumulative Analysis and Cumulative Analysis conditions. When the Lake Powell water level is at or exceeds 3695 feet msl, the reservoir is considered to be essentially full. In year 2016, under Baseline for Cumulative Analysis conditions, the percentage of values greater than or equal to elevation 3695 feet msl is 21 percent. After 2016 the annual percentages of values equal to or greater than elevation 3695 feet msl increase gradually to 29 percent and then decrease to 24 percent in 2076 under Baseline for Cumulative Analysis conditions.

Figure 3.3-4 shows the frequency that future Lake Powell end-of-July water elevations under Baseline for Cumulative Analysis conditions and the Cumulative Analysis would be at or exceed a lake water elevation of 3612 feet msl. Lake Powell water surface elevation 3612 feet msl is used in this analysis as the low threshold elevation for marina and boat ramps at Lake Powell. This threshold elevation of 3612 feet msl is used to evaluate the Baseline for Cumulative Analysis conditions and the effects of the Cumulative Analysis on shoreline facilities at Lake Powell. The lines represent the percentage of values greater than or equal to the lake water elevation of 3612 feet msl under the Baseline for Cumulative Analysis conditions and the Cumulative Analysis. In year 2016, under the Baseline for Cumulative Analysis conditions, the percentage of values greater than or equal to elevation 3612 feet msl is 89 percent. Between 2016 and 2076, the annual percentages of values greater than or equal to elevation 3612 feet msl decrease gradually to 68 percent.

Figure 3.3-2
Lake Powell End-of-July Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
90th, 50th and 10th Percentile Values

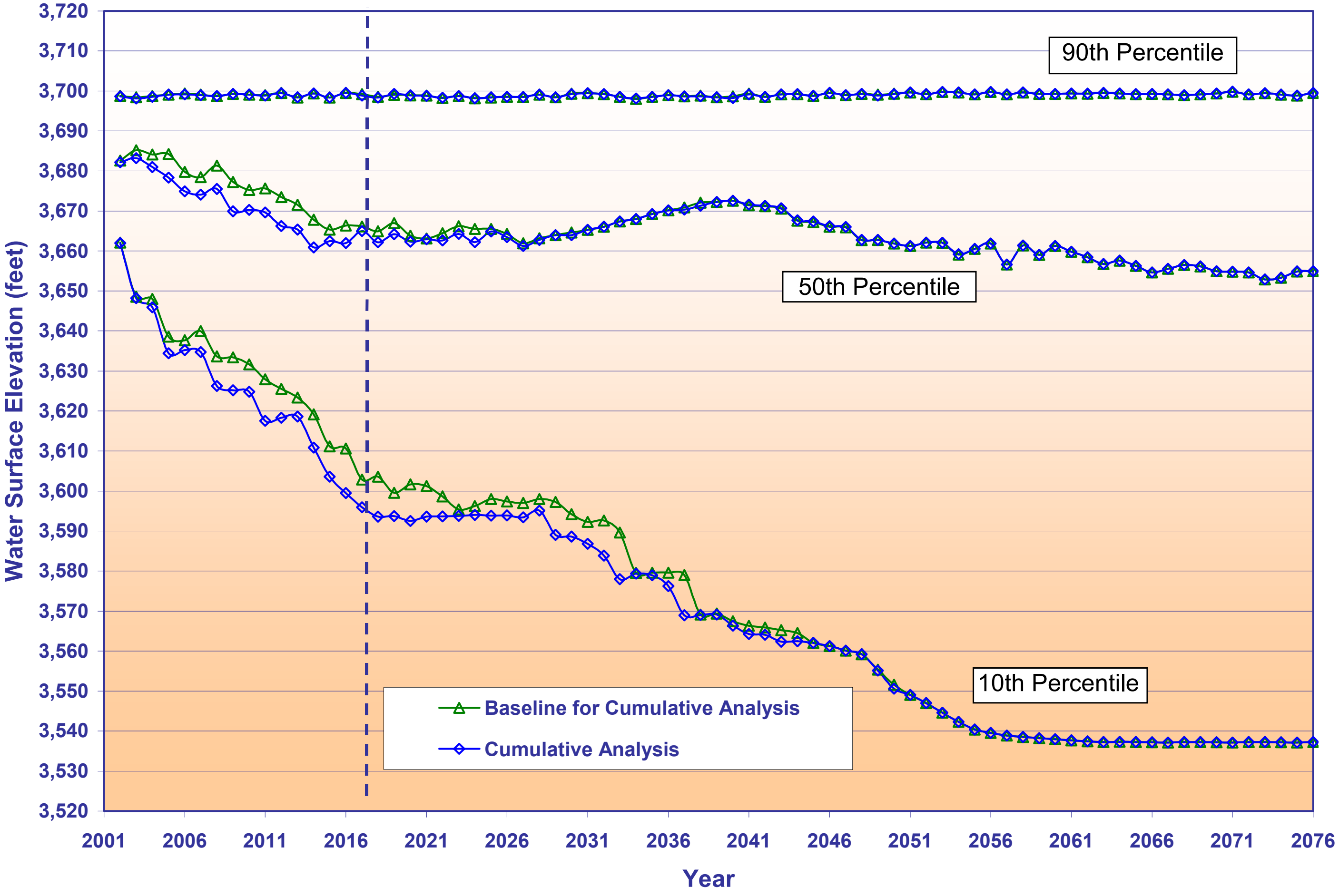
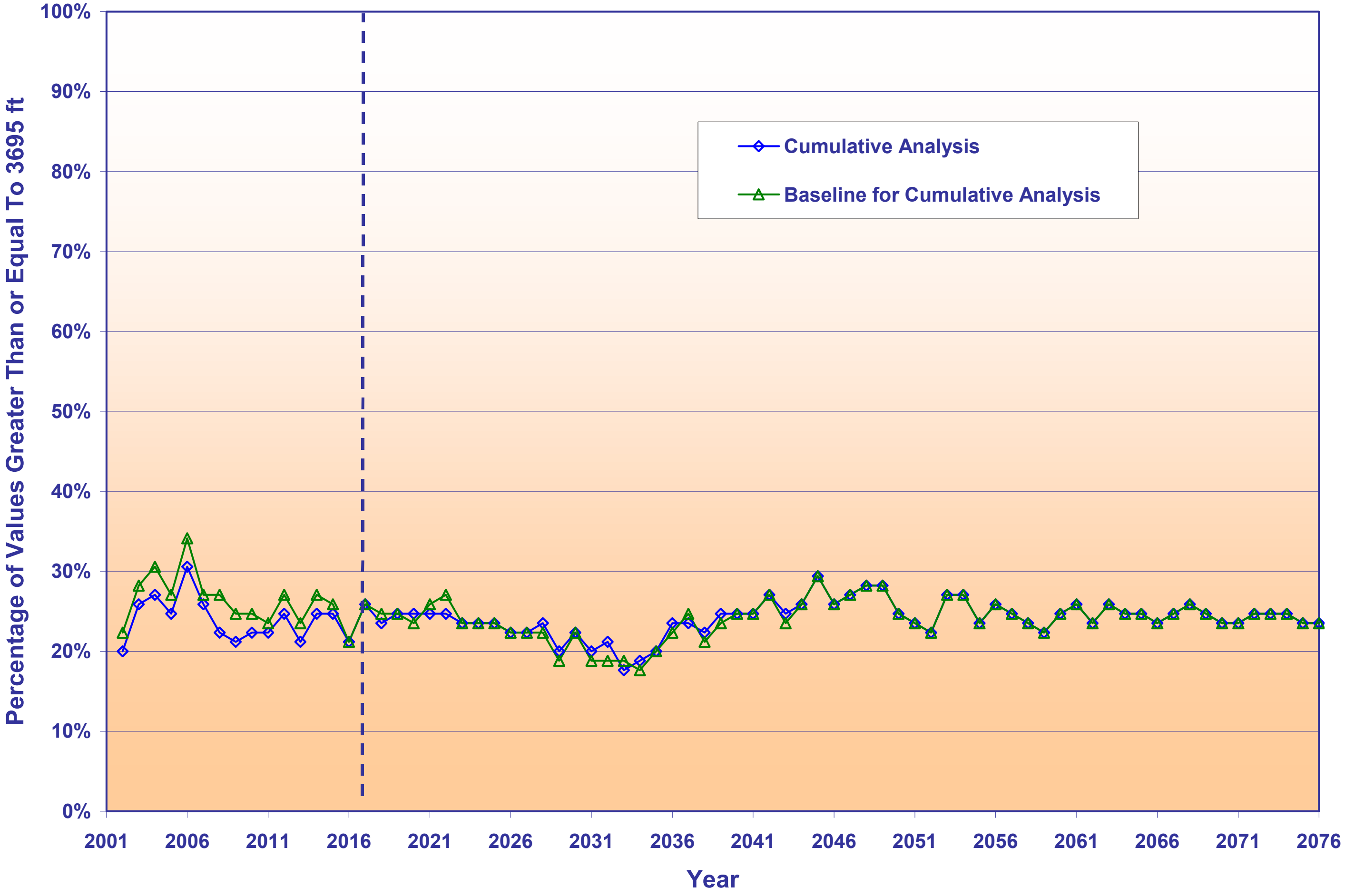


Figure 3.3-3
Lake Powell End-of-July Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
Percentage of Values Greater than or Equal to Elevation 3695 Feet



3.3.1.2 COMPARISON OF CUMULATIVE ANALYSIS TO BASELINE FOR CUMULATIVE ANALYSIS CONDITIONS

Figure 3.3-2 compared the 90th, 50th and 10th percentile water levels under the Cumulative Analysis to those under Baseline for Cumulative Analysis conditions. The median (50th percentile) water level of Lake Powell would be lower during and immediately after the interim surplus period but after several decades water levels would be the same as those under baseline conditions. These changes are primarily the result of the interim surplus guidelines on the river system [Ref. ISC FEIS, Page 3.3-23], offset to a minor degree by the effect of the changes anticipated under the Implementation Agreement (see Section 3.2.1).

As discussed above, under Baseline for Cumulative Analysis conditions, future Lake Powell water levels at the upper and lower 10th percentiles would likely be temporary and the water level would fluctuate between them in response to multi-year variations in basin runoff conditions. The same would apply to Cumulative Analysis conditions.

Table 3.3-1 presents a comparison of the 90th percentile, median (50th percentile) and 10th percentile values of the Cumulative Analysis to those of the Baseline for Cumulative Analysis conditions. The values presented in this table are for years 2016, 2026, 2036, 2046 and 2076.

Table 3.3-1
Lake Powell End-of-July Water Elevations
Comparison of Cumulative Effects to Cumulative Analysis Baseline
90th, 50th and 10th Percentile Values

Year	Baseline for Cumulative Analysis			Cumulative Analysis		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
2016	3699	3666	3611	3699	3662	3599
2026	3699	3664	3597	3699	3663	3594
2036	3699	3670	3580	3699	3670	3576
2046	3699	3666	3561	3699	3666	3561
2076	3699	3655	3537	3699	3655	3537

Figure 3.3-3 compared the percentage of Lake Powell elevations that exceeded 3695 feet msl for the Cumulative Analysis and Baseline for Cumulative Analysis conditions. Table 3.3-2 provides a summary of that comparison for years 2016, 2026, 2036, 2046 and 2076.

Figure 3.3-4
Lake Powell End-of-July Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
Percentage of Values Greater than or Equal to Elevation 3612 Feet

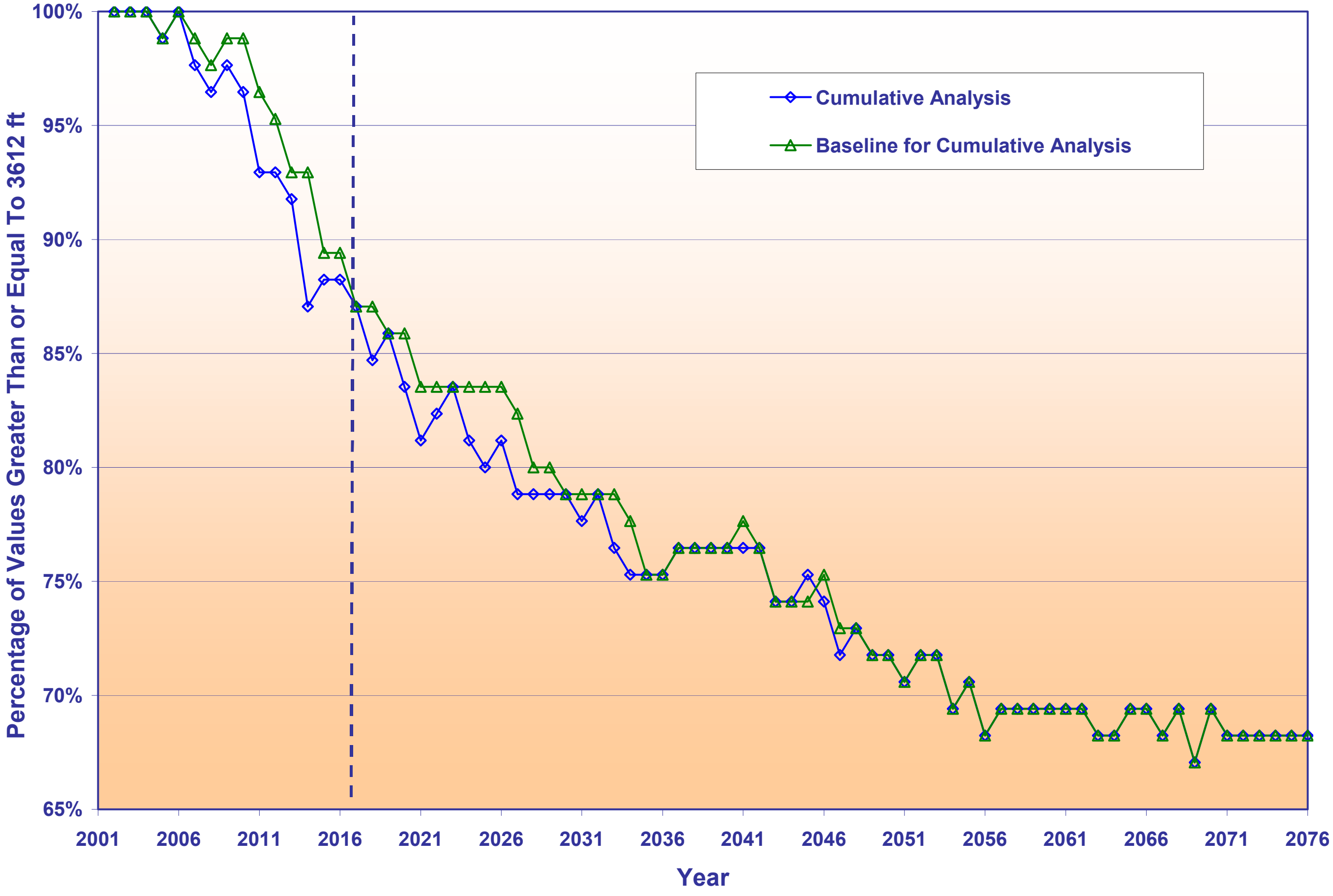


Table 3.3-2
Lake Powell End-of-July Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis
Percentage of Values Greater than or Equal to Elevation 3695 Feet

Year	Baseline For Cumulative Analysis	Cumulative Analysis
2016	21%	21%
2026	22%	22%
2036	22%	24%
2046	26%	26%
2076	24%	24%

Figure 3.3-4 compared the percentage of Lake Powell elevations that exceeded 3612 feet msl under the Cumulative Analysis and Baseline for Cumulative Analysis conditions. Table 3.3-3 provides a summary of that comparison for years 2016, 2026, 2036, 2046 and 2076.

Table 3.3-3
Lake Powell End-of-July Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis
Percentage of Values Greater than or Equal to Elevation 3612 Feet

Year	Baseline For Cumulative Analysis	Cumulative Analysis
2016	89%	88%
2026	84%	81%
2036	75%	75%
2046	75%	74%
2076	68%	68%

3.3.1.3 SENSITIVITY ANALYSIS

The water surface elevations of Lake Powell presented above are based on model operations in which the Lake Mead water surface elevation of 1083 feet msl was assumed to be the shortage protection level. In order to test the sensitivity of that assumption on the results of the model operation, model runs were also conducted with an assumed Lake Mead protection level of 1050 feet msl. With the 1050-foot protection level on Lake Mead, the water levels on Lake Powell were essentially the same as those based on the 1083-foot protection level under Cumulative Analysis Conditions. Lake Mead water level plots based on the use of the 1050-foot protection level are included in Attachment D.

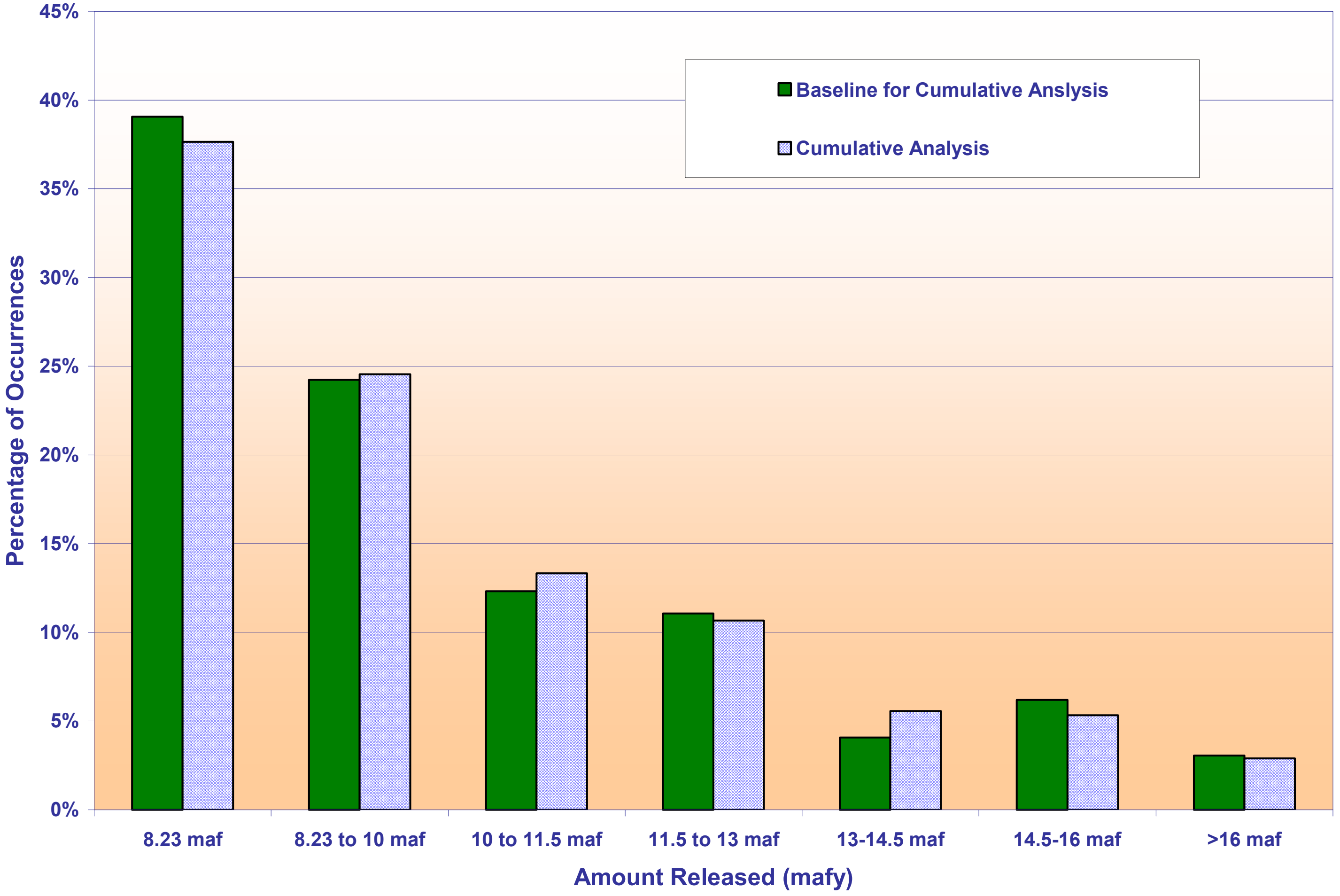
3.3.2 RIVER FLOWS BETWEEN LAKE POWELL AND LAKE MEAD

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 Section 1.2 The most significant gains from perennial streams include inflow from the Little Colorado River and Paria 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.

Figure 3.3-5 provides a comparison of the relative frequency of occurrence of annual releases from Lake Powell under the Baseline for Cumulative Analysis and Cumulative Analysis conditions, during the interim surplus guidelines period (through 2016). The probability of minimum releases from Lake Powell (8.23 maf) during the interim surplus period would be lower under Cumulative Analysis conditions than under Baseline for Cumulative Analysis. This change is primarily the result of the interim surplus guidelines on the river system, offset to a minor degree by the effect of the changes anticipated under the Implementation Agreement (See Section 3.2.2).

Releases between 8.23 and 11.5 maf generally correspond to years where equalization releases are being made from Lake Powell. The relative frequency of equalization during that period tends to decrease the probability of low releases under Cumulative Analysis conditions, compared to the Baseline for Cumulative Analysis. The decrease is associated with surplus water delivery from Lake Mead under the interim surplus guidelines, partially offset by the reduction in Lake Mead releases associated with the Implementation Agreement.

Figure 3.3-5
Histogram of Modeled Lake Powell Annual Releases (Water Years)
2002 to 2016 (85 Traces)



3.3.3 LAKE MEAD WATER LEVELS

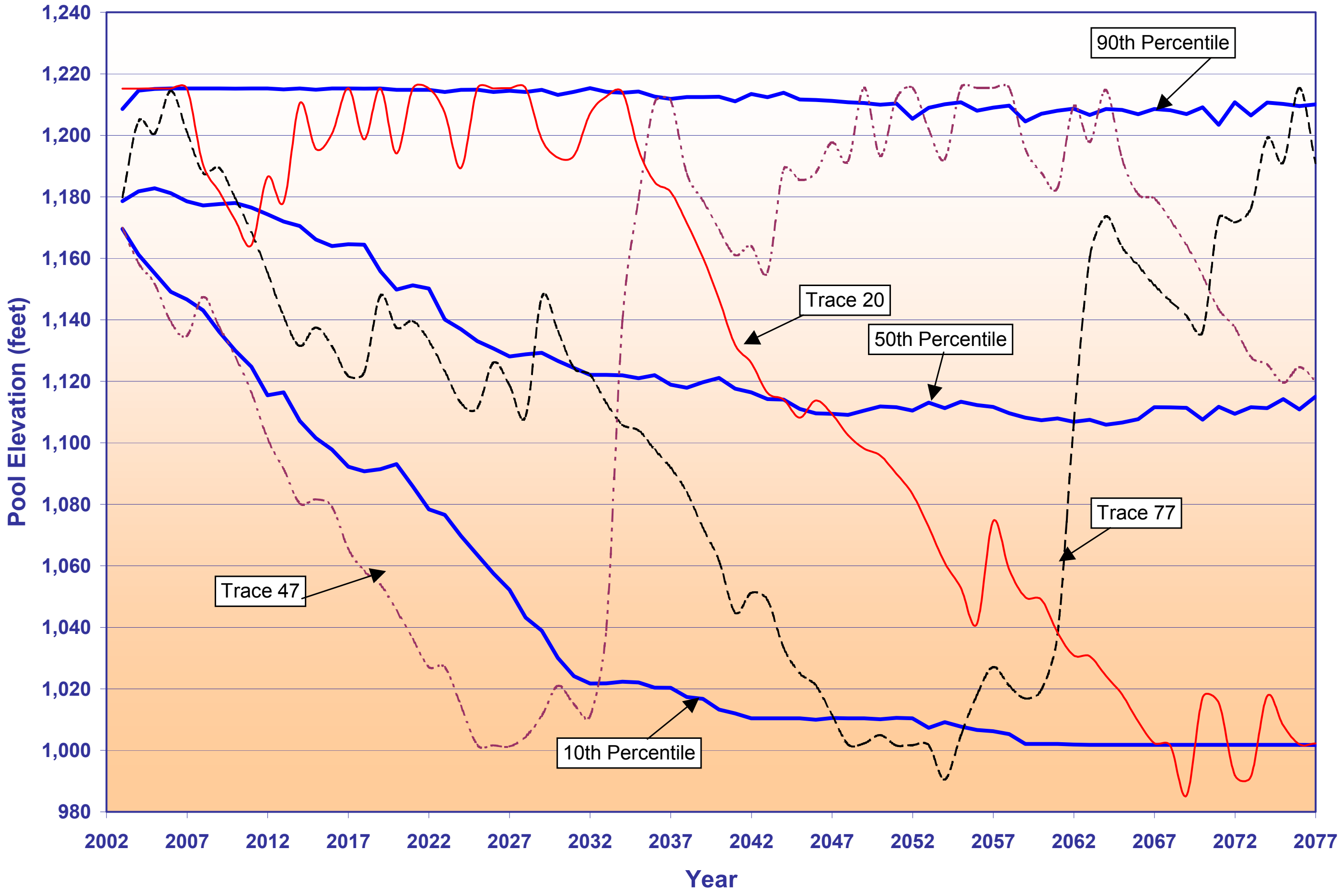
This section summarizes the results of the future Lake Mead water level simulations under Baseline for Cumulative Analysis conditions and Cumulative Analysis conditions.

3.3.3.1 MODELING RESULTS OF BASELINE FOR CUMULATIVE ANALYSIS

Under the Baseline for Cumulative Analysis conditions, the water surface elevation of Lake Mead is projected to fluctuate between full level and decreasingly lower levels during the period of analysis (2002 to 2076). Figure 3.3-6 illustrates the range of water levels (end of December) by three lines, labeled 90th Percentile, 50th Percentile and 10th Percentile. The 50th percentile line shows the median water level for each future year. The median water level under Baseline for Cumulative Analysis conditions is shown to decline to 1165 feet msl by 2016 and to 1115 feet msl by 2076. The 10th percentile line shows there is a 10 percent probability that the water level would decline to 1092 feet msl by 2016 and to 1002 feet msl by 2076. It should also be noted that the Lake Mead elevations depicted in Figure 3.3-6 represent water levels at the end of December which is when lake levels are at a seasonal high. Conversely, the Lake Mead water level generally reaches its annual low in July.

Three distinct traces are added to Figure 3.3-6 to illustrate what was actually simulated under the various traces and respective hydrologic sequences and to highlight that the 90th, 50th and 10th percentile lines do not represent actual traces, but rather the ranking of the data from the 85 traces for the conditions modeled. The three traces illustrate the variability among the different traces and that the reservoir levels could temporarily decline below the 10th percentile line. The trace identified as Trace 20 represents the hydrologic sequence that begins in year 1926. The trace identified as Trace 47 represents the hydrologic sequence that begins in year 1953. The trace identified as Trace 77 represents the hydrologic sequence that begins in year 1983.

Figure 3.3-6
Lake Mead End-of-December Water Elevations Under Baseline for Cumulative Analysis Conditions
90th, 50th and 10th Percentile Values and Representative Traces



In Figure 3.3-6, the 90th and 10th percentile lines bracket the range where 80 percent of future Lake Mead water levels simulated for the Baseline for Cumulative Analysis conditions occur. The highs and lows shown on the three traces would likely be temporary conditions. The reservoir level would tend to fluctuate through multi-year periods of above average and below average inflows. Neither the timing of water level variations between the highs and the lows, nor the length of time the water level would remain high or low can be predicted. These events would depend on the future variation in basin runoff conditions.

Figure 3.3-7 presents the 90th, 50th and 10th percentile plots obtained for the Baseline for Cumulative Analysis conditions and those obtained for the Cumulative Analysis. This figure is best used for comparing the relative differences in the general lake level trends between the simulated Baseline for Cumulative Analysis and Cumulative Analysis conditions.

Figure 3.3-8 shows the frequency at which future Lake Mead end of December water surface elevations under Baseline for Cumulative Analysis conditions would be at or exceed 1200 feet msl. The corresponding frequency with the Cumulative Analysis is also plotted. The lines represent the percentage of values of all 85 traces that are equal to or greater than elevation 1200 feet msl. In year 2016, under the Baseline for Cumulative Analysis conditions, the percentage of values greater than or equal to elevation 1200 feet msl is 21 percent. After 2016 the annual percentages of values equal to or greater than elevation 1200 feet msl increase slightly to 22 percent and then decrease gradually to 13 percent in 2076 under Baseline for Cumulative Analysis conditions.

Figure 3.3-9 provides a comparison of the frequency that future Lake Mead end of December water levels would be at or above elevation 1083 feet msl under Baseline for Cumulative Analysis and Cumulative Analysis conditions. In year 2016, under the Baseline for Cumulative Analysis conditions, the percentage of values greater than or equal to elevation 1083 feet msl is 95 percent. After 2016 the annual percentages of values equal to or greater than elevation 1083 feet msl decline gradually to 56 percent in 2076 under Baseline for Cumulative Analysis conditions.

Figure 3.3-7
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis and Baseline for Cumulative Analysis Conditions 90th, 50th and 10th Percentile Values

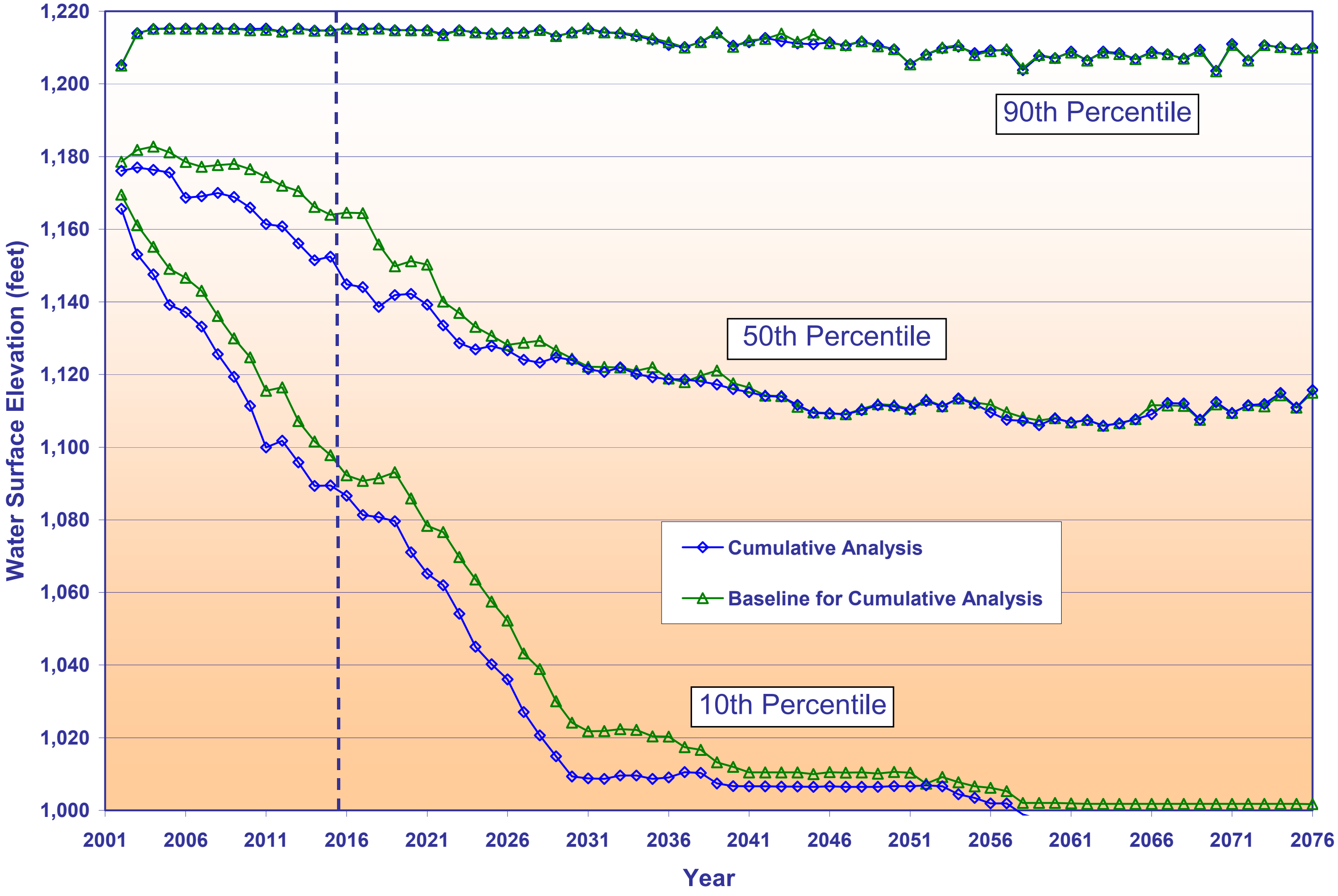


Figure 3.3.8
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis and Baseline for Cumulative Analysis Conditions
Percentage of Values Greater than or Equal to Elevation 1200 Feet

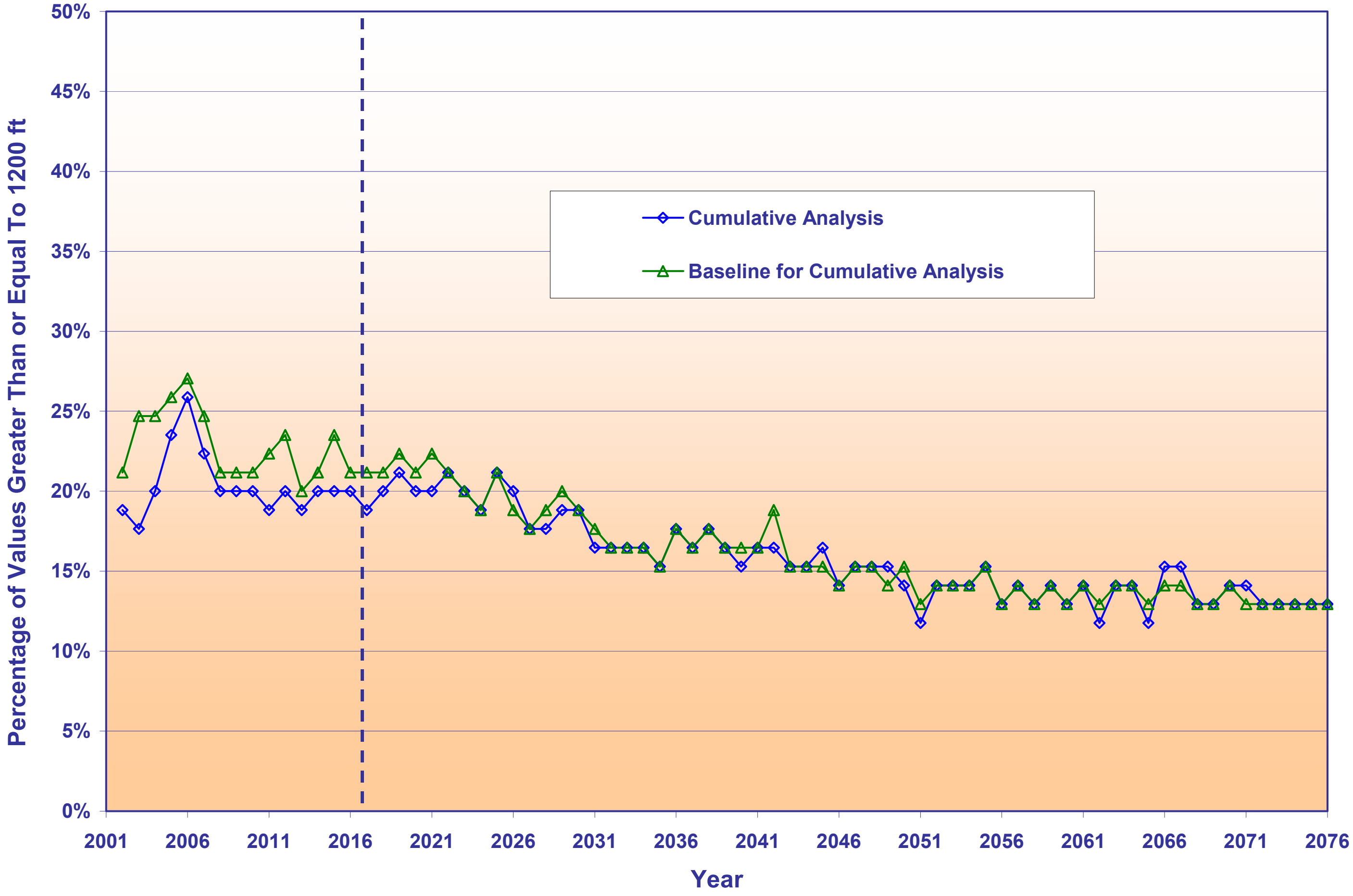


Figure 3.3-10 provides a comparison of the frequency that future Lake Mead end of December water levels would be at or above elevation 1050 feet msl under Baseline for Cumulative Analysis and Cumulative Analysis conditions. In year 2016, under the Baseline for Cumulative Analysis conditions, the percentage of values greater than or equal to elevation 1050 feet msl is 100 percent. After 2016 the annual percentages of values equal to or greater than elevation 1200 feet msl decline gradually to 62 percent in 2076 under Baseline for Cumulative Analysis conditions.

Figure 3.3-11 provides a comparison of the frequency that future Lake Mead end of December water elevations under Baseline for Cumulative Analysis conditions and the Cumulative Analysis would be at or exceed a lake water elevation of 1000 feet msl. In year 2016, under the Baseline for Cumulative Analysis conditions, the percentage of values greater than or equal to elevation 1000 feet msl is 100 percent. After 2016 the annual percentages of values equal to or greater than elevation 1200 feet msl remain at 100 percent for over three decades before declining gradually to 94 percent in 2076 under Baseline for Cumulative Analysis conditions.

3.3.3.2 COMPARISON OF CUMULATIVE ANALYSIS TO BASELINE FOR CUMULATIVE ANALYSIS

Figure 3.3-7 compared the 90th, 50th and 10th percentile water levels of the Cumulative Analysis to those of the Baseline for Cumulative Analysis conditions. The median (50th percentile) water level of Lake Mead would be lower during and immediately after the interim surplus period but after several decades water levels would be the same as those under baseline conditions. These changes are primarily the result of the Interim surplus guidelines on the river system [Ref. ISC FEIS, Page 3.3-35], offset to a minor degree by the effect of the changes anticipated under the Implementation Agreement (see Section 3.2.3).

As discussed previously, under Baseline for Cumulative Analysis conditions, future Lake Mead water levels at the upper and lower 10th percentiles would likely be temporary and the water levels are expected to fluctuate between them in response to multi-year variations in basin runoff conditions. The same would apply to the water levels under Cumulative Analysis conditions.

The 90th percentile, median (50th percentile) and 10th percentile values of the Cumulative Analysis are compared to those of the Baseline for Cumulative Analysis conditions in Table 3.3-4. The values presented in this table are for years 2016, 2026, 2036, 2046, and 2076.

Table 3.3-4
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Effects to Cumulative Analysis Baseline
90th, 50th and 10th Percentile Values

Year	Baseline for Cumulative Analysis			Cumulative Analysis		
	90th Percentile	50th Percentile	10th Percentile	90th Percentile	50th Percentile	10th Percentile
2016	1215	1165	1092	1215	1145	1087
2026	1215	1128	1052	1214	1127	1036
2036	1212	1119	1020	1211	1119	1009
2046	1211	1109	1011	1211	1109	1007
2076	1210	1115	1002	1210	1116	997

Figure 3.3-9
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
Percentage of Values Greater than or Equal to Elevation 1083 Feet

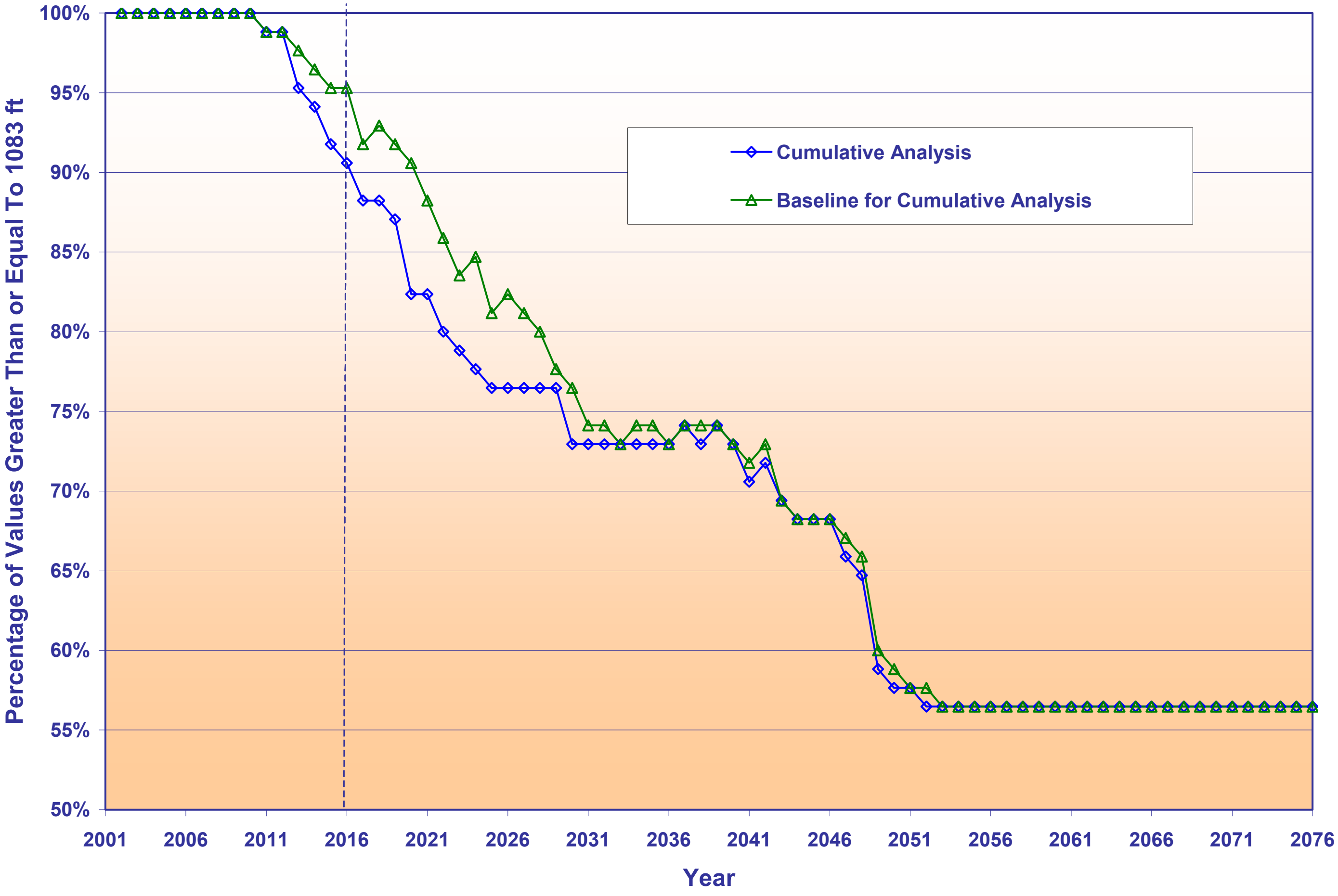


Figure 3.3-10
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
Percentage of Values Greater than or Equal to Elevation 1050 Feet

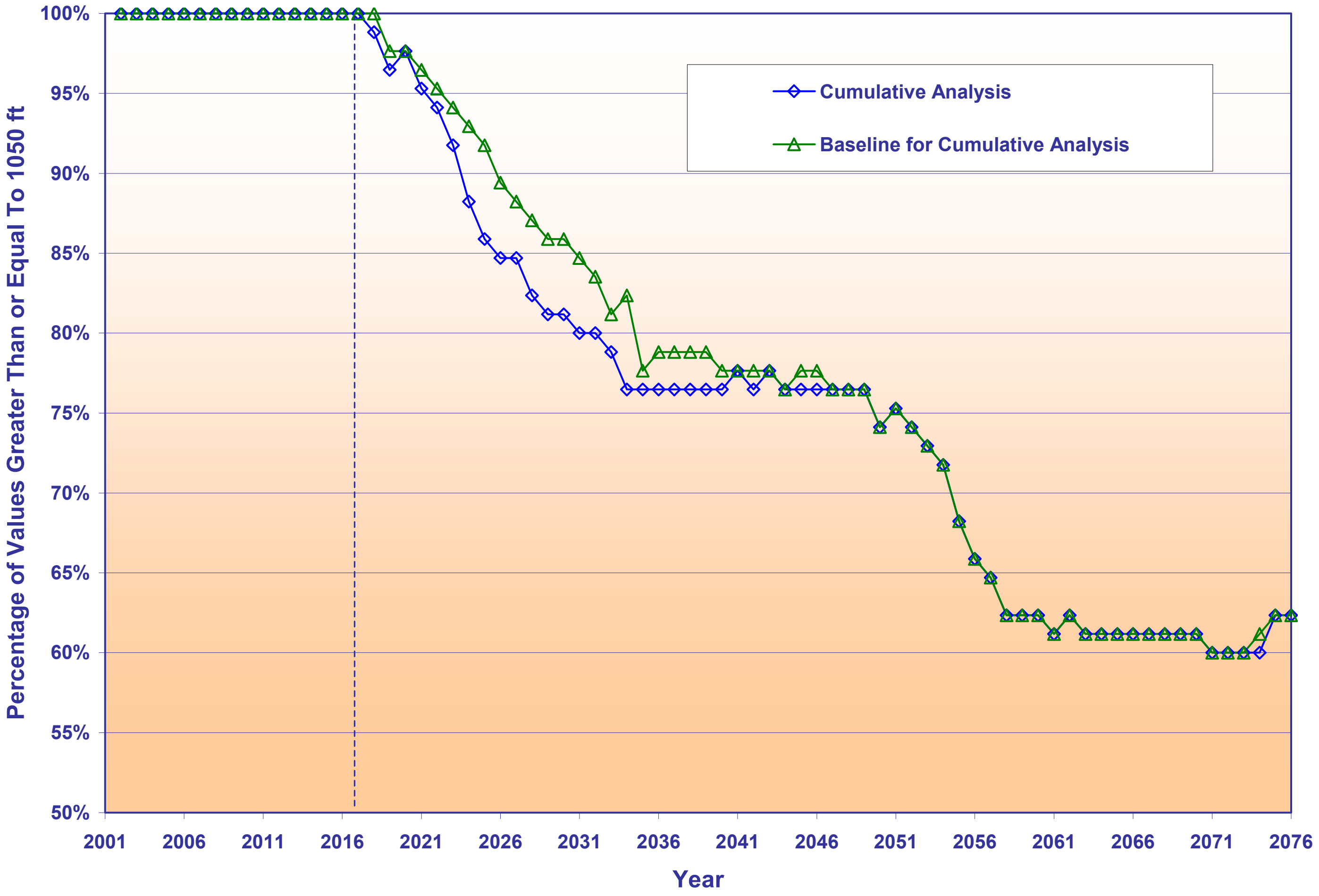


Figure 3.3-11
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
Percentage of Values Greater than or Equal to Elevation 1000 Feet

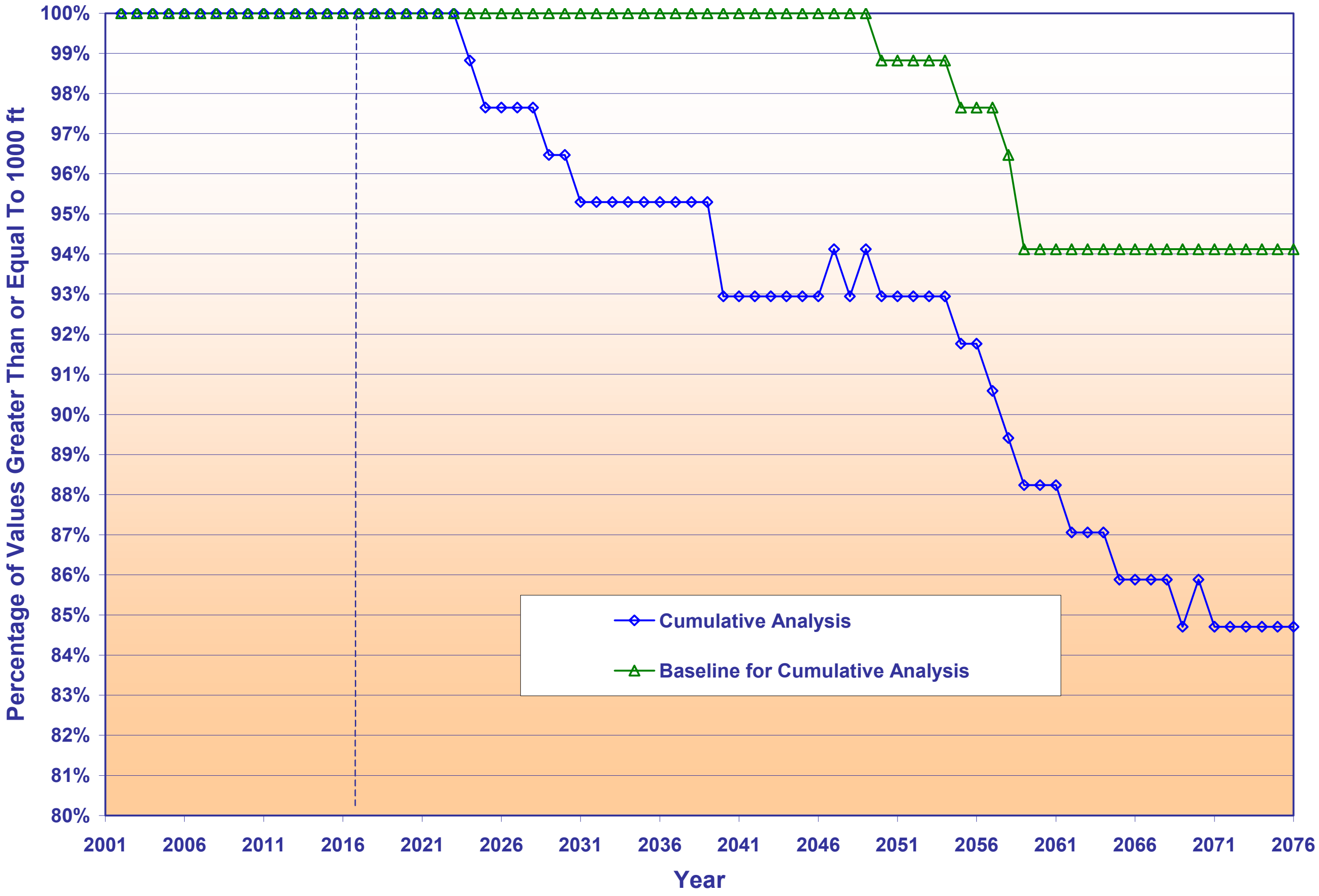


Figure 3.3-8 compared the percentage of Lake Mead elevations that were at or above 1200 feet msl for the Cumulative Analysis and Baseline for Cumulative Analysis conditions. Table 3.3-5 provides a summary of that comparison for years 2016, 2026, 2036, 2046, and 2076.

Table 3.3-5
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis
Percentage of Values Greater than or Equal to Elevation 1200 Feet

Year	Baseline for Cumulative Analysis	Cumulative Analysis
2016	21%	20%
2026	19%	20%
2036	18%	18%
2046	14%	14%
2076	13%	13%

Figure 3.3-9 compared the percentage of Lake Mead elevations that were at or above 1083 feet msl for the Cumulative Analysis and Baseline for Cumulative Analysis conditions. Table 3.3-6 provides a summary of that comparison for years 2016, 2026, 2036, 2046, and 2076.

Table 3.3-6
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis
Percentage of Values Greater than or Equal to Elevation 1083 Feet

Year	Baseline for Cumulative Analysis	Cumulative Analysis
2016	95%	91%
2026	82%	76%
2036	73%	73%
2046	68%	68%
2076	56%	56%

Figure 3.3-10 compared the percentage of Lake Mead elevations that were at or above 1050 feet msl for the Cumulative Analysis and Baseline for Cumulative Analysis conditions. Table 3.3-7 provides a summary of that comparison for years 2016, 2026, 2036, 2046, and 2076.

Table 3.3-7
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis
Percentage of Values Greater than or Equal to Elevation 1050 Feet

Year	Baseline for Cumulative Analysis	Cumulative Analysis
2016	100%	100%
2026	89%	85%
2036	78%	76%
2046	78%	76%
2076	62%	62%

Figure 3.3-11 compared the percentage of Lake Mead elevations that were at or above 1000 feet msl for the Cumulative Analysis and Baseline for Cumulative Analysis conditions. Table 3.3-8 provides a summary of that comparison for years 2016, 2026, 2036, 2046, and 2076.

Table 3.3-8
Lake Mead End-of-December Water Elevations
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis
Percentage of Values Greater than or Equal to Elevation 1000 Feet

Year	Baseline for Cumulative Analysis	Cumulative Analysis
2016	100%	100%
2026	100%	98%
2036	100%	95%
2046	100%	93%
2076	94%	85%

3.3.3.3 SENSITIVITY ANALYSIS

The water surface elevations of Lake Mead presented above are based on model operations in which the Lake Mead water surface elevation of 1083 feet msl was assumed to be the shortage protection level. In order to test the sensitivity of that assumption on the results of the model operation, model runs were also conducted with an assumed Lake Mead protection level of 1050 feet msl. With the 1050-foot protection level, the resulting water levels on Lake Mead range up to 15 feet lower than those based on the 1083-foot protection level under Cumulative Impact Conditions, at the 50th percentile, after 2016. Lake Mead water level plots based on the use of the 1050-foot protection level are included in Attachment D.

3.3.4 RIVER FLOWS BELOW HOOVER DAM

This section describes results of the analysis of the simulated Colorado River flows below Hoover Dam. The model of the Colorado River system was used to simulate future mean monthly flows under Baseline for Cumulative Analysis and Cumulative Analysis conditions. Four specific river locations were selected to represent flows within selected river reaches below Hoover Dam. The river reaches and corresponding flow locations are listed in Table 3.3-9 and their locations were shown on Map 3.2-1 in Section 3.2.

Table 3.3-9
Colorado River Flow Locations Identified for Evaluation

Colorado River Reach	Selected River Flow Locations	
	Description	Approximate River Mile [1]
Between Hoover Dam and Parker Dam	Havasu National Wildlife Refuge (NWR)	242.3
Between Parker Dam and Palo Verde Diversion Dam	Upstream of Colorado River Indian Reservation	180.8
Between Palo Verde Diversion and Imperial Dam	Downstream of the Palo Verde Diversion Dam	133.8
Between Imperial Dam and SIB	Below the Mexico Diversion at Morelos Dam	23.1

[1] River miles as measured from the southerly international boundary with Mexico

Two types of model data analysis were used to portray cumulative impacts on river flows. In the first analysis, the potential effects on the total annual volume of flow in each reach were evaluated. In this analysis, the mean monthly flows were first summed over each calendar year. The 90th, 50th, and 10th percentiles of the annual volumes were then computed for each year. Plots of these percentiles for the Baseline for the Cumulative Analysis and the Cumulative Analysis conditions are included in this section for each of the four river points listed above.

The second analysis investigated the potential effects on seasonal flows. The mean monthly flows for January were used to represent the winter season flows and likewise for April, July, and October to represent spring, summer, and fall, respectively. The specific years analyzed for seasonal flows included 2006, 2016, 2026, and 2050. Only the data and graphs for 2016 are presented in this section.

It should be noted that the monthly demand schedules used in the model are based on a distribution of the total annual demand (a specific percentage for each month). Although each diversion point may use a different distribution, those percentages do not change from year to year in the model, and thus can not reflect potential future changes in the system that might affect the monthly distributions. Therefore, the seasonal differences are primarily governed by the overall changes in annual flow volumes, coupled with the effect of each diversion's distribution upstream of the point of interest.

Daily and hourly releases from Hoover Dam reflect the short-term demands of Colorado River water users with diversions located downstream, storage management in Lakes Mohave and Havasu, and power production at Hoover, Davis and Parker Dams. The close proximity of Lake Mohave to Hoover Dam effectively dampens the short-term fluctuations below Hoover Dam. The scheduling and subsequent release of water through Davis and Parker Dams create short-term fluctuations in river flows, depths, and water surface elevations downstream of these structures. These fluctuations of water surface elevations in the river are most noticeable in the river reaches located immediately downstream of the dams and lessen as the downstream distance increases.

3.3.4.1 RIVER FLOWS BETWEEN HOOVER DAM AND PARKER DAM

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

A point on the Colorado River downstream of Davis Dam was used to evaluate the river flows for this reach, located immediately downstream of the Havasu National Wildlife Refuge (NWR).

The 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 3.3-12. As shown by the 50th percentile values, annual flow volumes in this reach would be greater under the Cumulative Analysis conditions than under the Baseline for Cumulative Analysis conditions during the 15-year interim surplus guidelines period through 2016. The plot indicates that the Cumulative Analysis conditions would increase flows above the Baseline during this period by up to approximately six percent. The difference is primarily the result of the interim surplus guidelines on the river system [Ref. ISC FEIS, Page 3.3-46], offset to a minor degree by the effect of the changes anticipated under the Implementation Agreement (See Section 3.2.4.1). Beyond the 15-year interim period, the annual flow volumes under the Cumulative Analysis are essentially the same (within one percent) as those under the Baseline for Cumulative Analysis conditions.

At the 90th percentile level the annual flow pattern under Cumulative Analysis is generally similar that of the Baseline for the Cumulative Analysis, with the Cumulative Analysis flows tending to exceed Baseline flows intermittently. The 10th percentile level exhibits a relationship similar to that described for the 50th percentile level until 2016. Beyond 2016 the 10th percentile flows under Cumulative Analysis conditions are essentially the same as those under the Baseline for Cumulative Analysis conditions.

Figure 3.3-13 shows the cumulative distribution of annual flow volumes for year 2016.

Figures 3.2-14(a-d) present comparisons of the representative seasonal flows under Baseline for Cumulative Analysis conditions and the Cumulative Analysis for 2016. As expected, the largest flows occur in the spring and summer seasons for Baseline for Cumulative Analysis conditions and Cumulative Analysis conditions due to downstream irrigation demands. For flows that are due primarily to flood control releases from Lake Mead (flows in the 80th - 100th percentile range), the seasonal flows under the Cumulative Analysis conditions vary higher or lower than the flows under the Baseline for Cumulative Analysis during the fall and winter seasons. In the lower percentiles, the seasonal flows under the Cumulative Analysis conditions varied from being approximately the same as Baseline flows (within one percent) to being approximately eight percent higher (January).

A numerical comparison of the 70th percentile seasonal flow values is shown on Table 3.3-10. The values tabulated are the mean monthly flows in January, April, July and October.

Table 3.3-10
Comparison of Mean Monthly Flow Data – Baseline for Cumulative Analysis and Cumulative Analysis
Colorado River Downstream of Havasu NWR (River Mile = 242.3)
70th Percentile Values for Year 2016

Season (Representative Month)	Mean Monthly Flows (cfs) for Year 2016 at the 70th Percentile	
	Baseline for Cumulative Analysis	Cumulative Analysis
January (January)	8,035	8,399
Spring (April)	16,038	15,979
Summer (July)	15,855	15,704
Fall (October)	12,091	11,880

Figure 3.3-12
Colorado River Downstream of Havasu NWR Annual Flow Volume (af)
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
90th, 50th and 10th Percentile Values

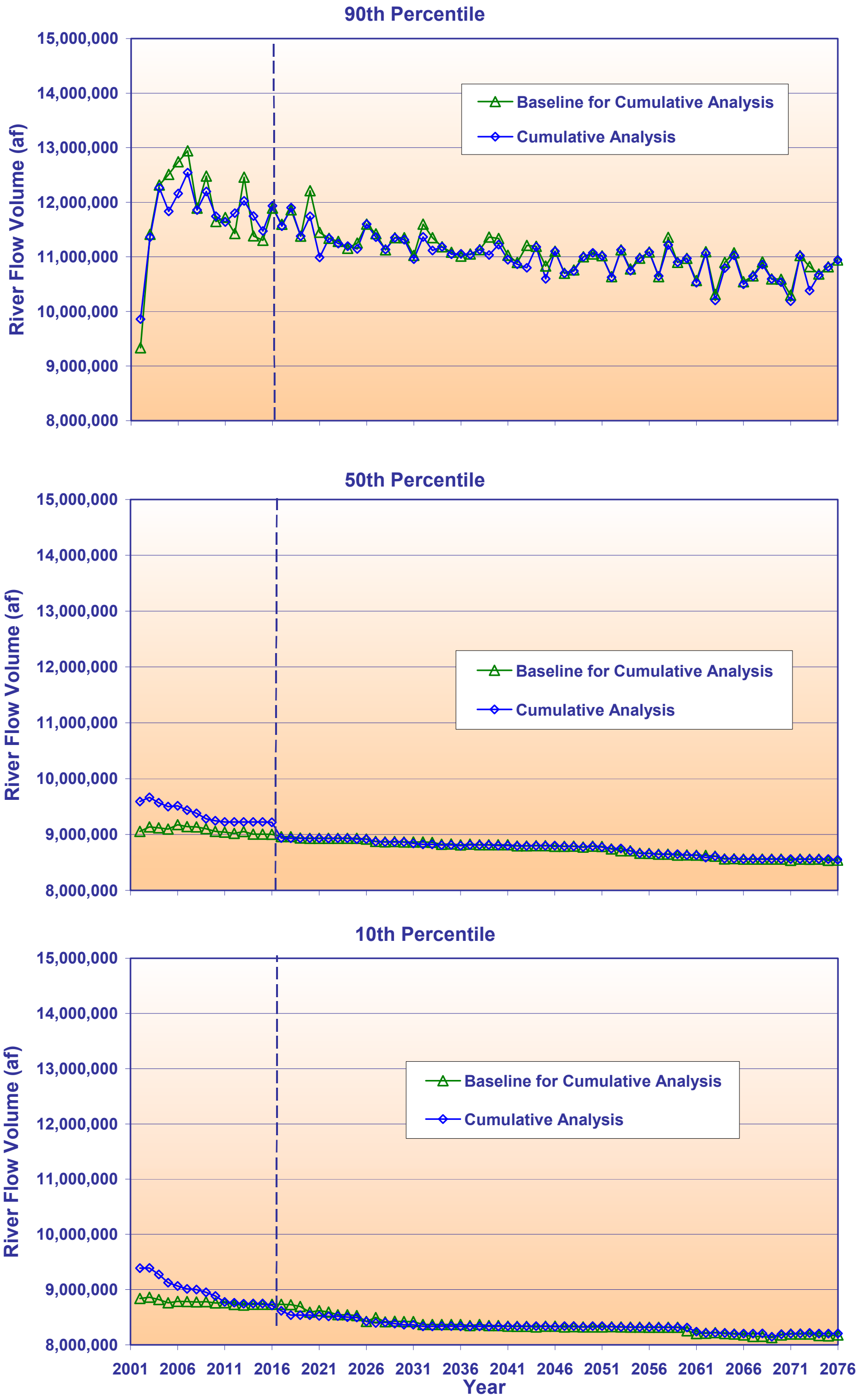


Figure 3.3-13
Colorado River Annual Flow Volume Downstream of Havasu NWR
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

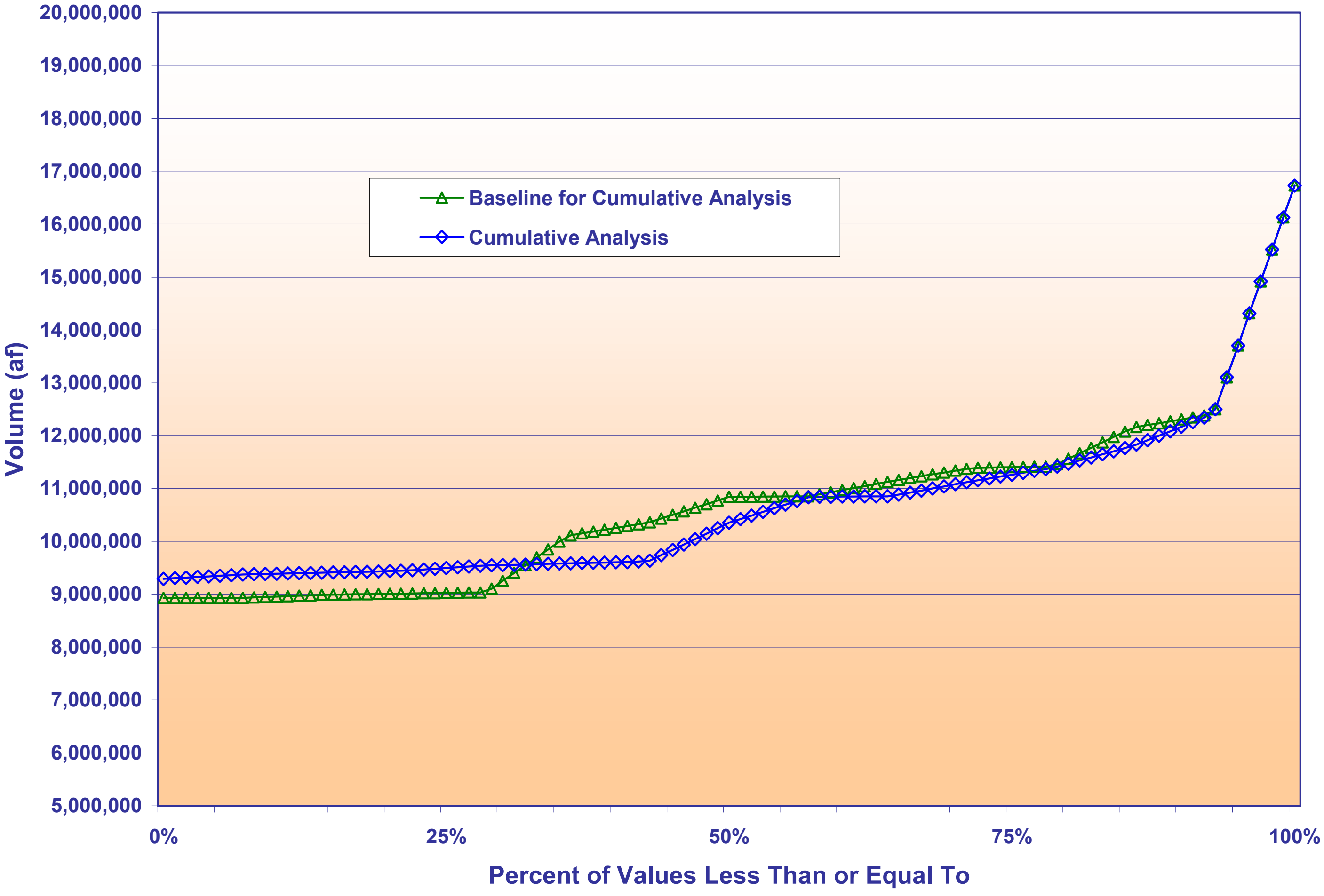


Figure 3.3-14a
Colorado River Seasonal Flows Downstream of Havasu NWR
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

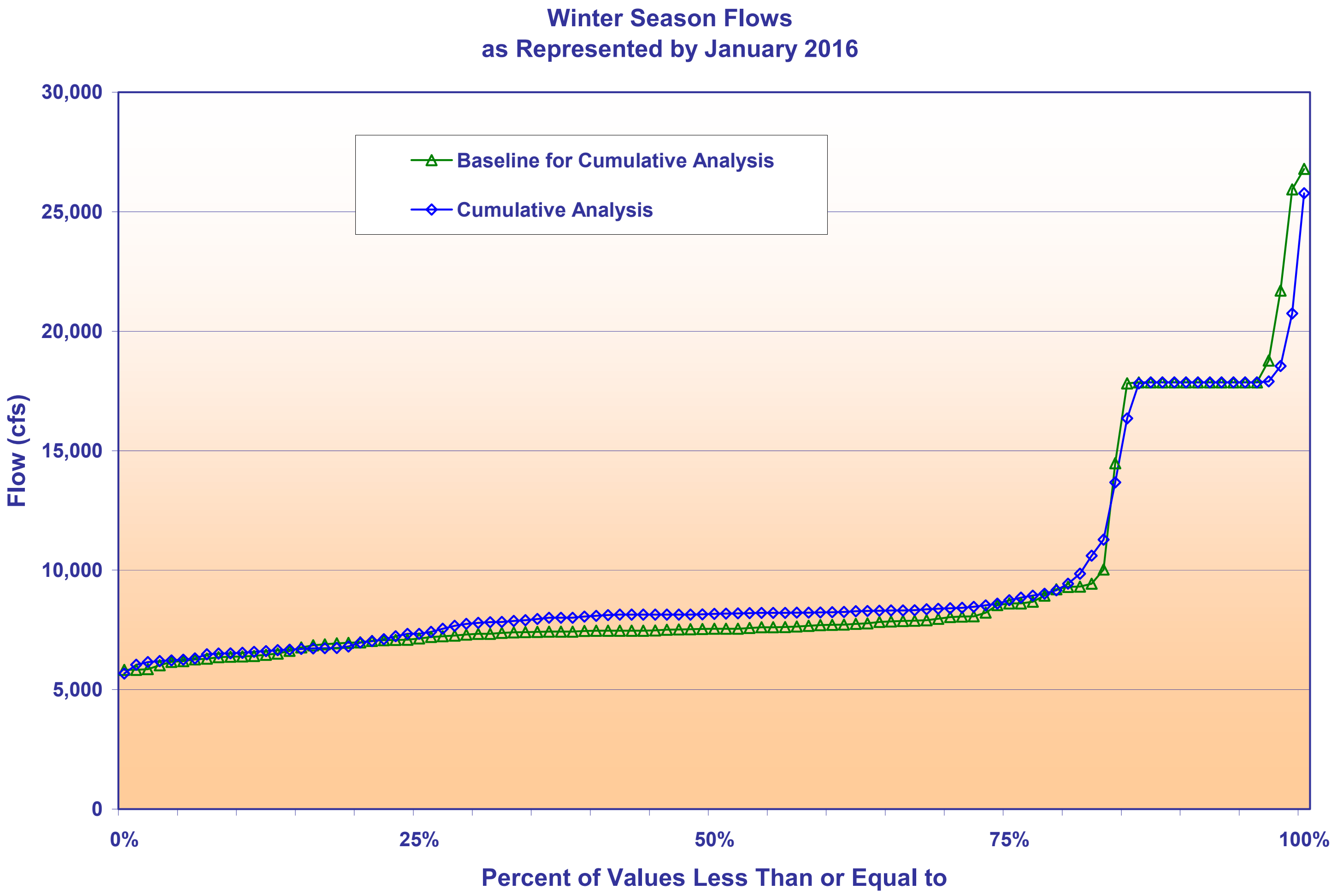


Figure 3.3-14b
Colorado River Seasonal Flows Downstream of Havasu NWR
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

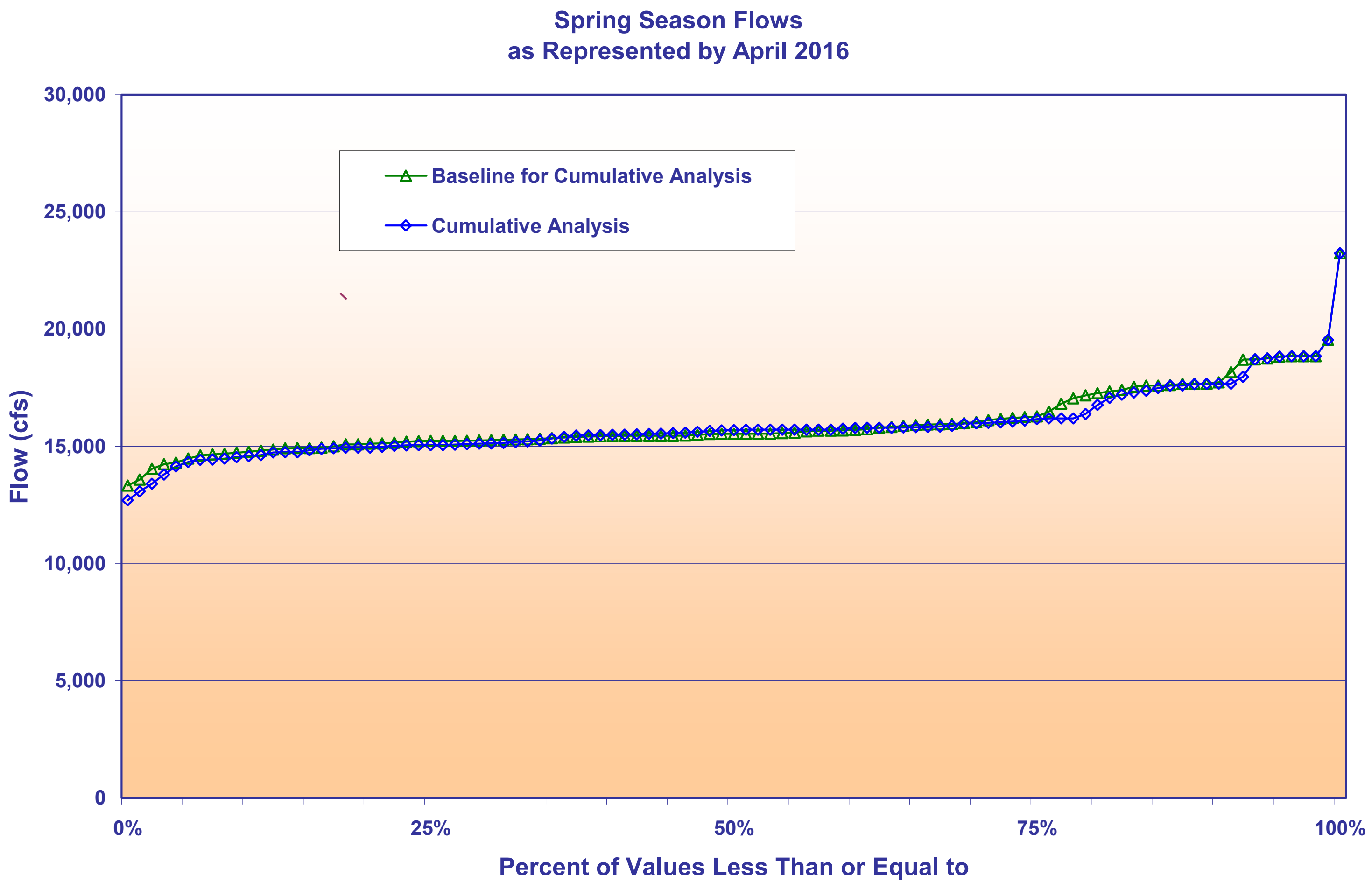


Figure 3.3-14c
Colorado River Seasonal Flows Downstream of Havasu NWR
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

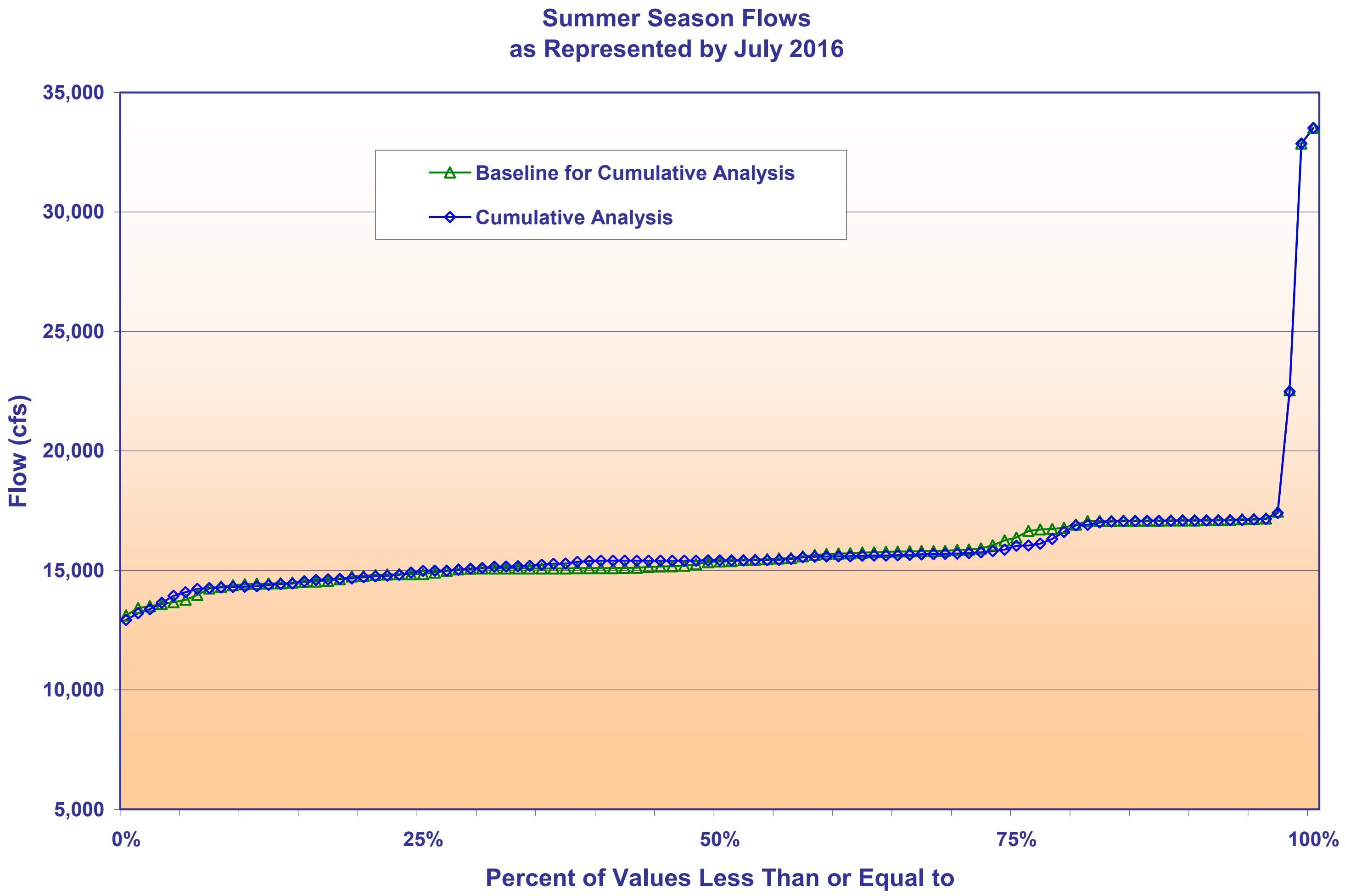
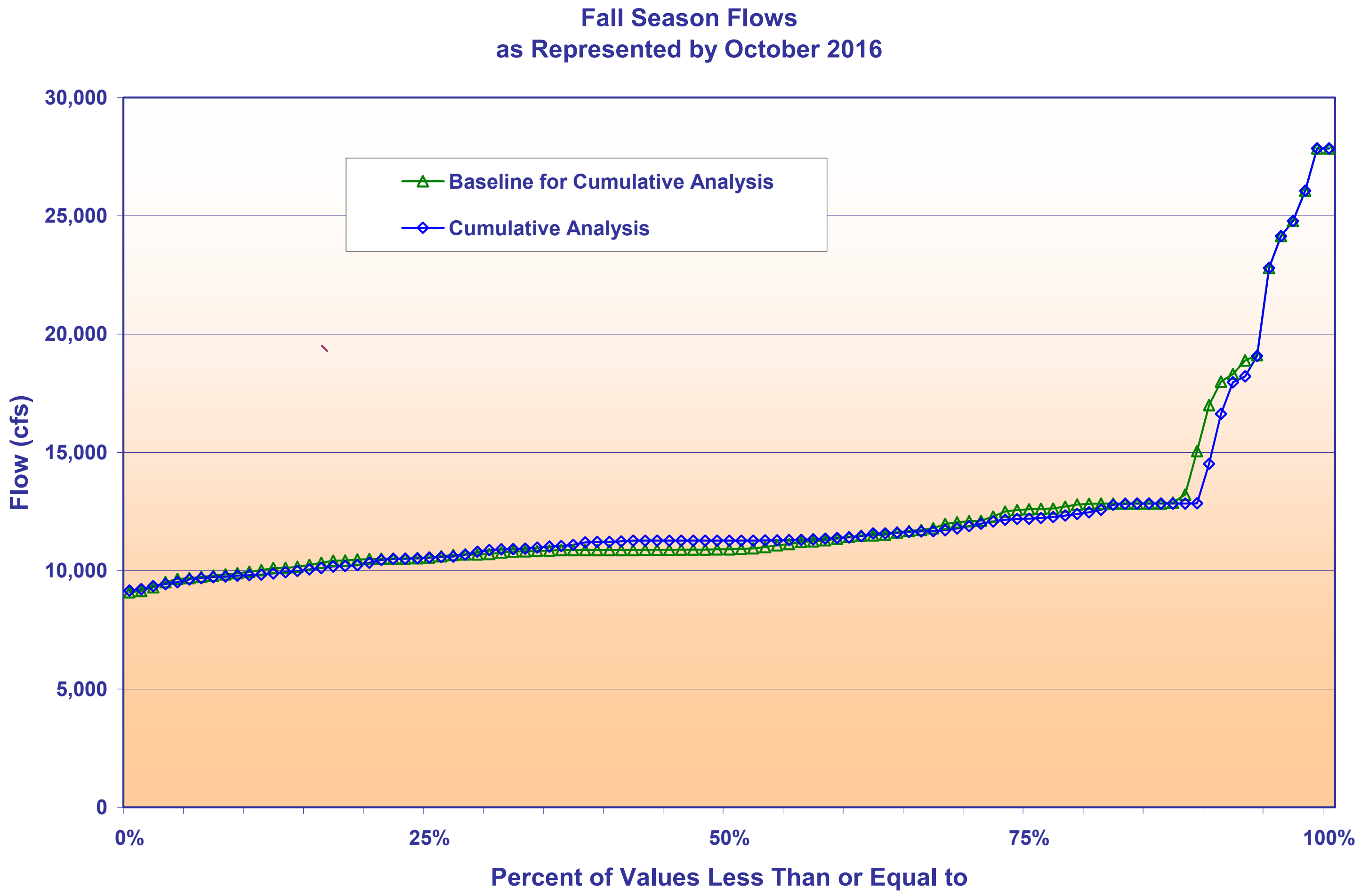


Figure 3.3-14d
Colorado River Seasonal Flows Downstream of Havasu NWR
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016



3.3.4.2 RIVER FLOWS BETWEEN PARKER DAM AND PALO VERDE DIVERSION DAM

The point on the Colorado used to evaluate the river flows in the reach of the river located between Parker Dam and the Palo Verde Diversion Dam is located immediately upstream of the Colorado River Indian Reservation (CRIR) diversion. 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 from Parker Dam (Lake Havasu).

Future flows in this reach would be affected by the Cumulative Analysis because the proposed water transfers and exchanges between the California agricultural water agencies and MWD would change the point of diversion from the river. For example, under a potential transfer between PVID and MWD, the water that would normally be diverted at Palo Verde Dam would now be diverted above Parker Dam.

The 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 3.3-15. As shown by the 50th percentile values, the modeled annual flow volumes in this reach under the Cumulative Analysis decline gradually between 2002 and 2016, as the water transfers take effect and certain amounts of California's water are diverted from Lake Havasu rather than at Imperial Dam. The difference results primarily from the proposed Implementation Agreement (See Section 3.2.4.2), augmented to a minor degree by the effect of the additional proposed water transfer in the cumulative analysis. The interim surplus guidelines do not affect this section of river significantly [Ref. ISC FEIS, Page 3.3-55]. After 2016 the volumes under Cumulative Analysis conditions continue to be less than for the Baseline.

At the 10th percentile level, the same comparative annual flow patterns occur. The 90th percentile flows under the Cumulative Analysis conditions vary higher or lower than the flows under the Baseline for Cumulative Analysis during the fall and winter seasons. However, the plots do not exhibit a significant difference between the Cumulative Analysis conditions and the Baseline for Cumulative Analysis conditions. At the 90th percentile level flows are dominated by surplus water deliveries and flood flows.

Figure 3.3-16, shows the cumulative distribution of annual flow volumes for year 2016.

Figures 3.3-17 (a-d) present comparisons of the representative seasonal flows under Baseline for Cumulative Analysis conditions and the Cumulative Analysis for 2016. As expected, the largest flows occur in the spring and summer seasons under the Baseline for Cumulative Analysis and Cumulative Analysis conditions due to downstream irrigation demands. The seasonal flows of the Cumulative Analysis conditions are slightly lower than those of the Baseline for Cumulative Analysis conditions. For flows that are due primarily to flood control releases from Lake Mead (flows in the 80th - 100th percentile range), the seasonal flows under the Cumulative Analysis conditions vary higher or lower than the flows under the Baseline for Cumulative Analysis during the fall and winter seasons. However, the range of the seasonal flows is not affected by the Cumulative Analysis.

A numerical comparison of the 70th percentile seasonal flow values is shown on Table 3.3-11. The values tabulated are the mean monthly flows in January, April, July and October.

Table 3.3-11
Comparison of Mean Monthly Flow Data – Baseline for Cumulative Analysis and Cumulative Analysis
Colorado River Upstream of CRIR Diversion (River Mile = 180.8)
70th Percentile Values for Year 2016

Season (Representative Month)	Mean Monthly Flows (cfs) for Year 2016 at the 70th Percentile	
	Baseline for Cumulative Analysis	Cumulative Analysis
Winter (January)	4,090	3,835
Spring (April)	12,009	11,455
Summer (July)	13,307	12,841
Fall (October)	8,119	7,825

Figure 3.3-15
Colorado River Upstream of CRIR Diversion Annual Flow Volume (af)
Comparison of Implementation Agreement to Baseline for Cumulative Analysis Conditions
90th, 50th and 10th Percentile Values

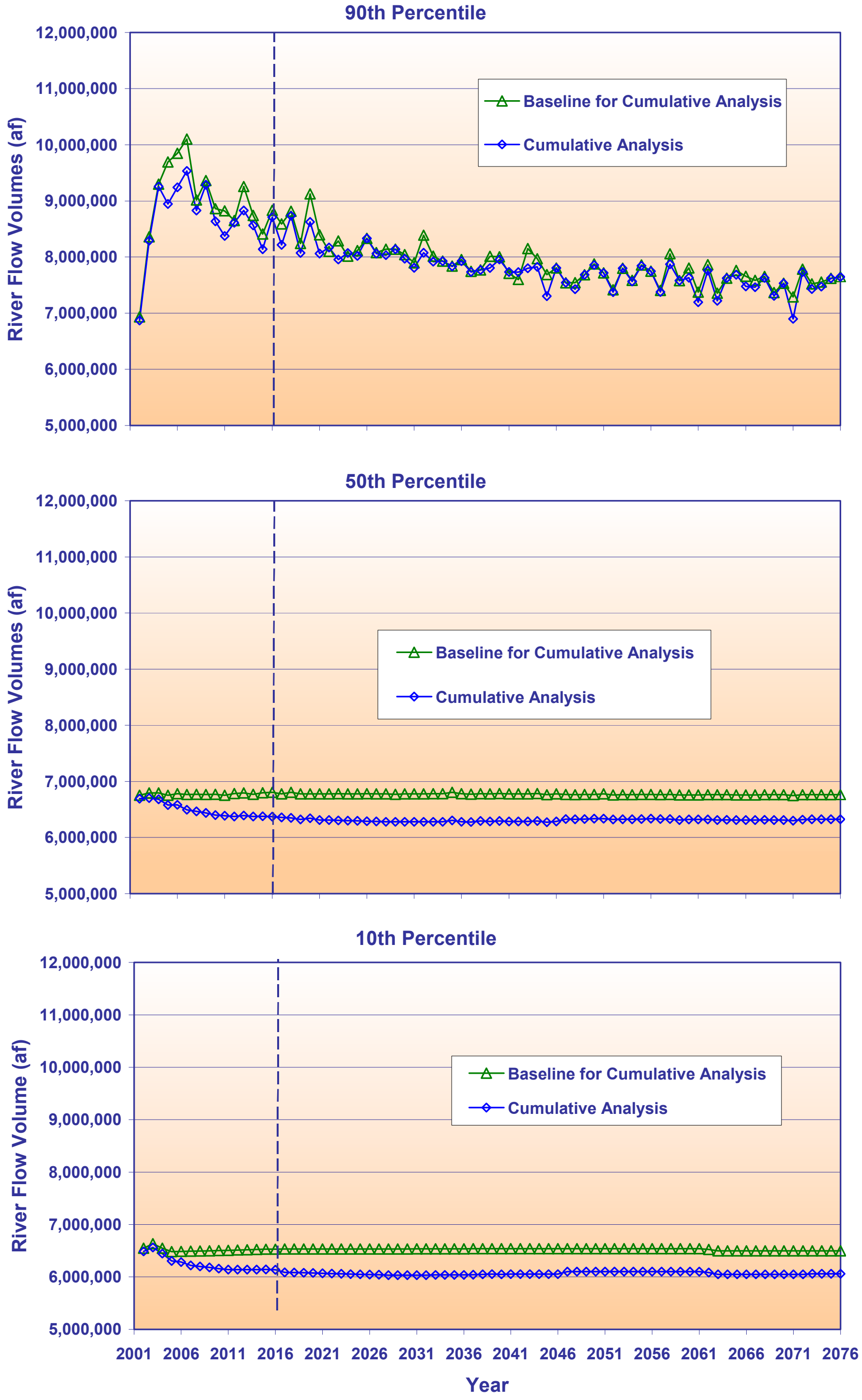


Figure 3.3-16
Colorado River Annual Flow Volumes Upstream of Colorado River Indian Reservation
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

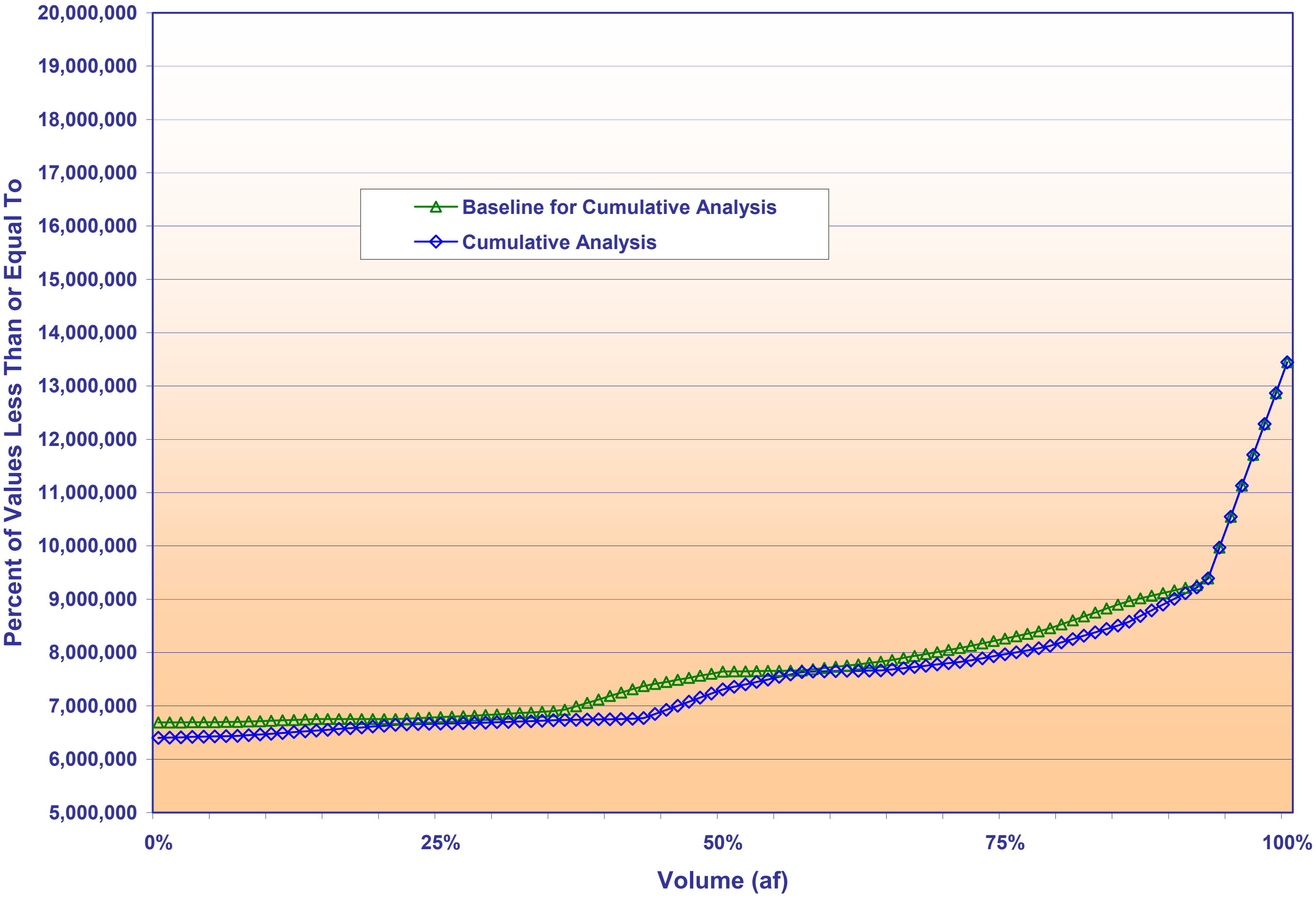


Figure 3.3-17a
Colorado River Seasonal Flows Upstream of Colorado River Indian Reservation
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

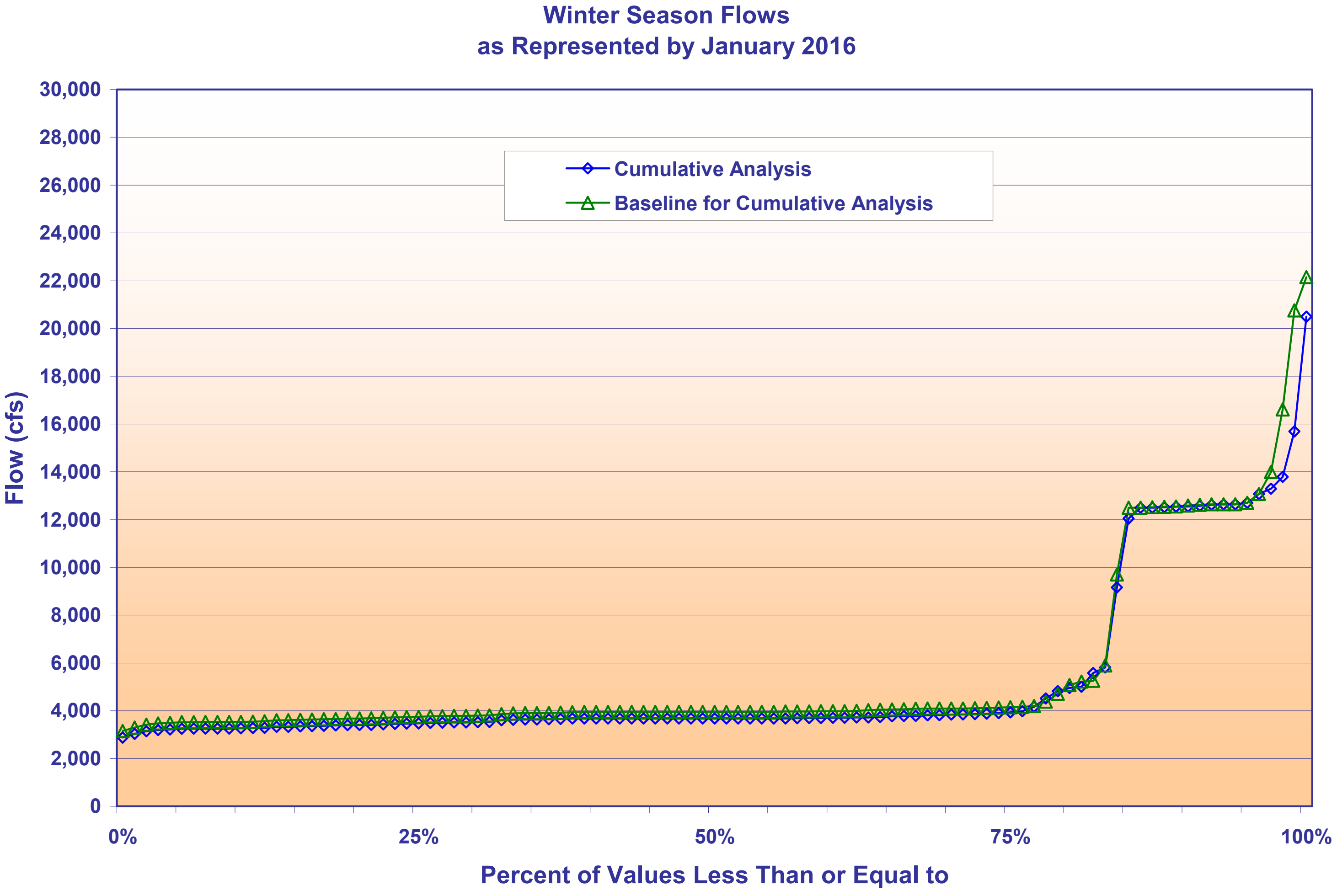


Figure 3.3-17b
Colorado River Seasonal Flows Upstream of Colorado River Indian Reservation
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

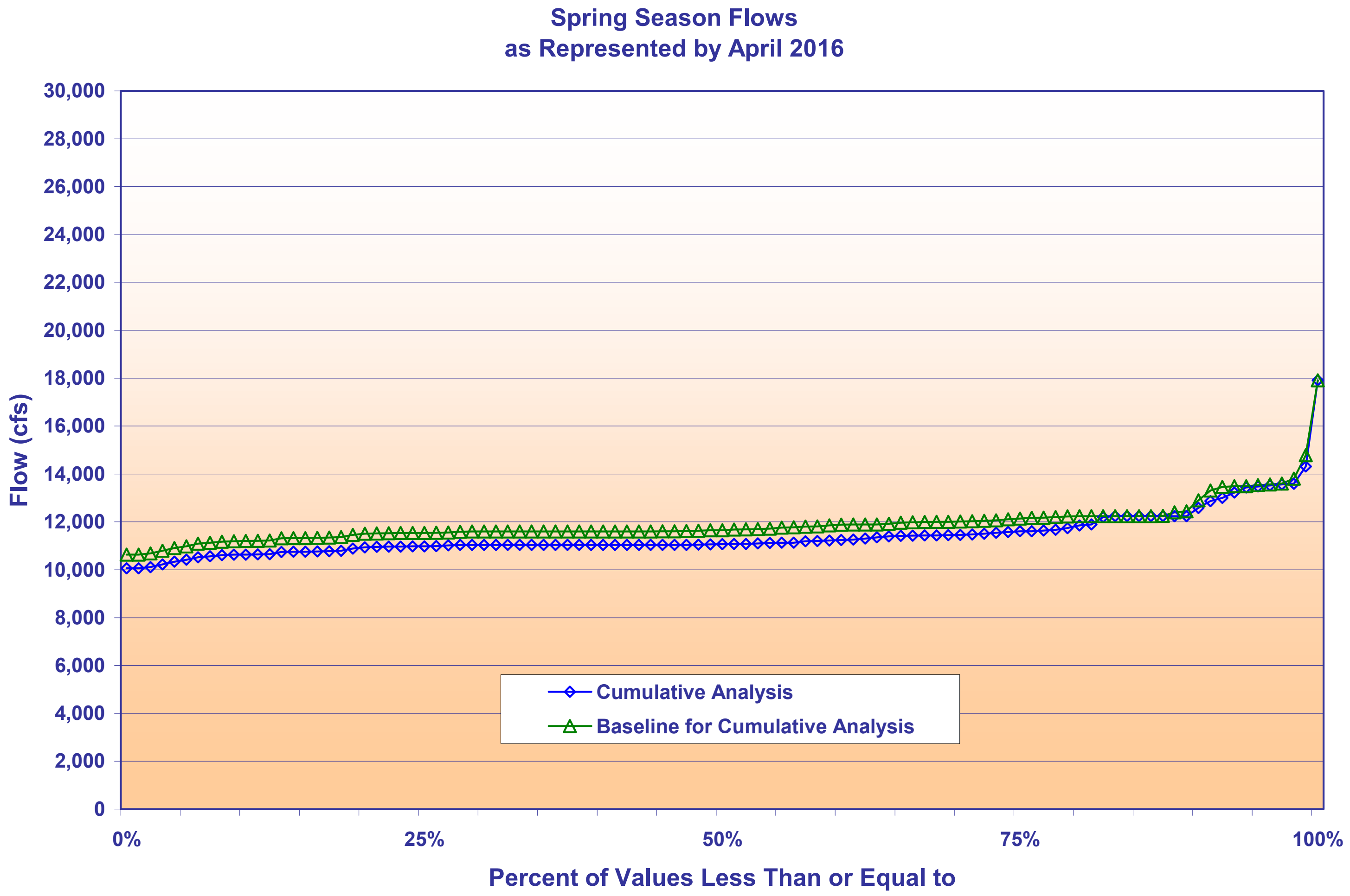


Figure 3.3-17c
Colorado River Seasonal Flows Upstream of Colorado River Indian Reservation
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

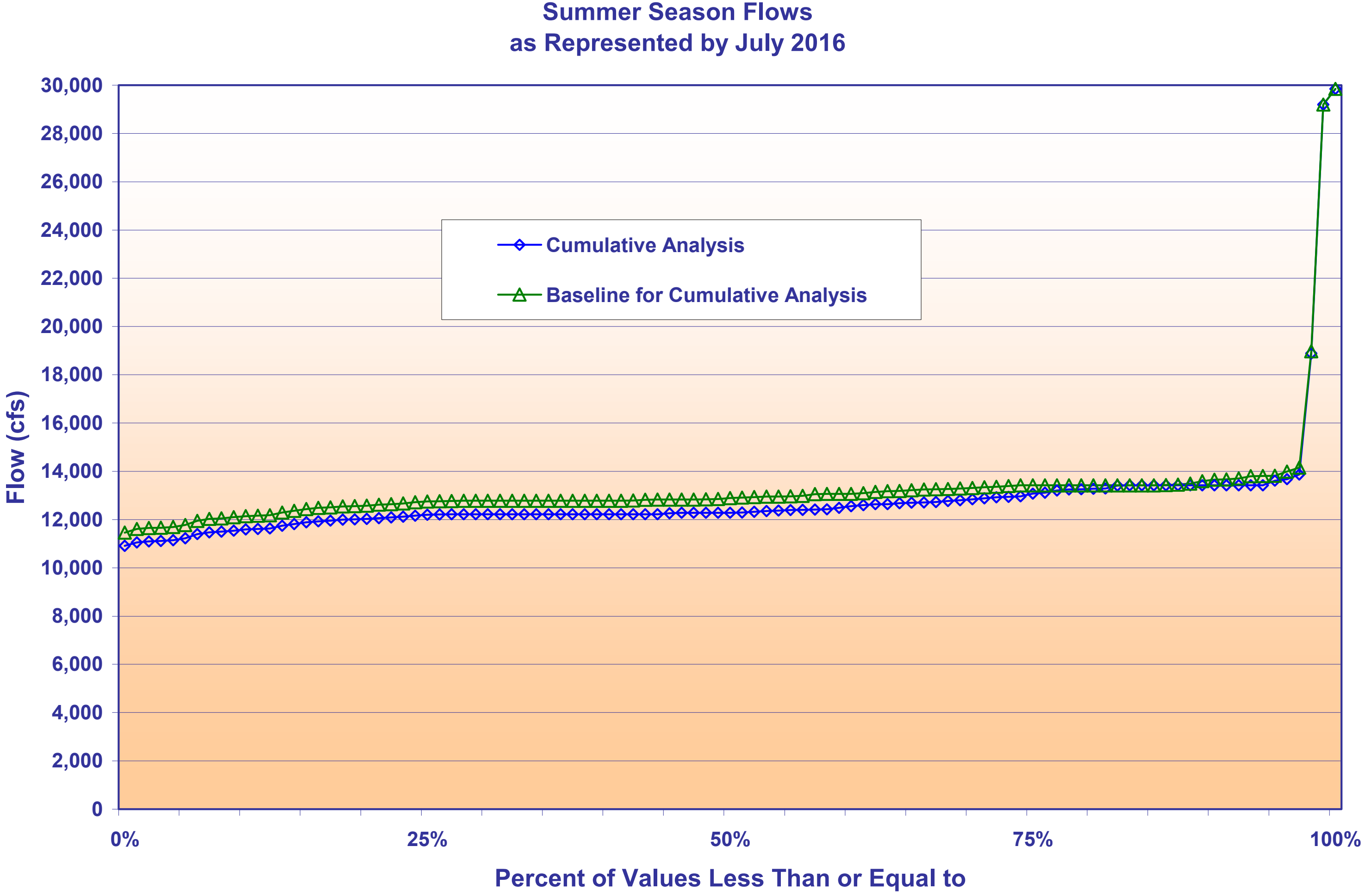
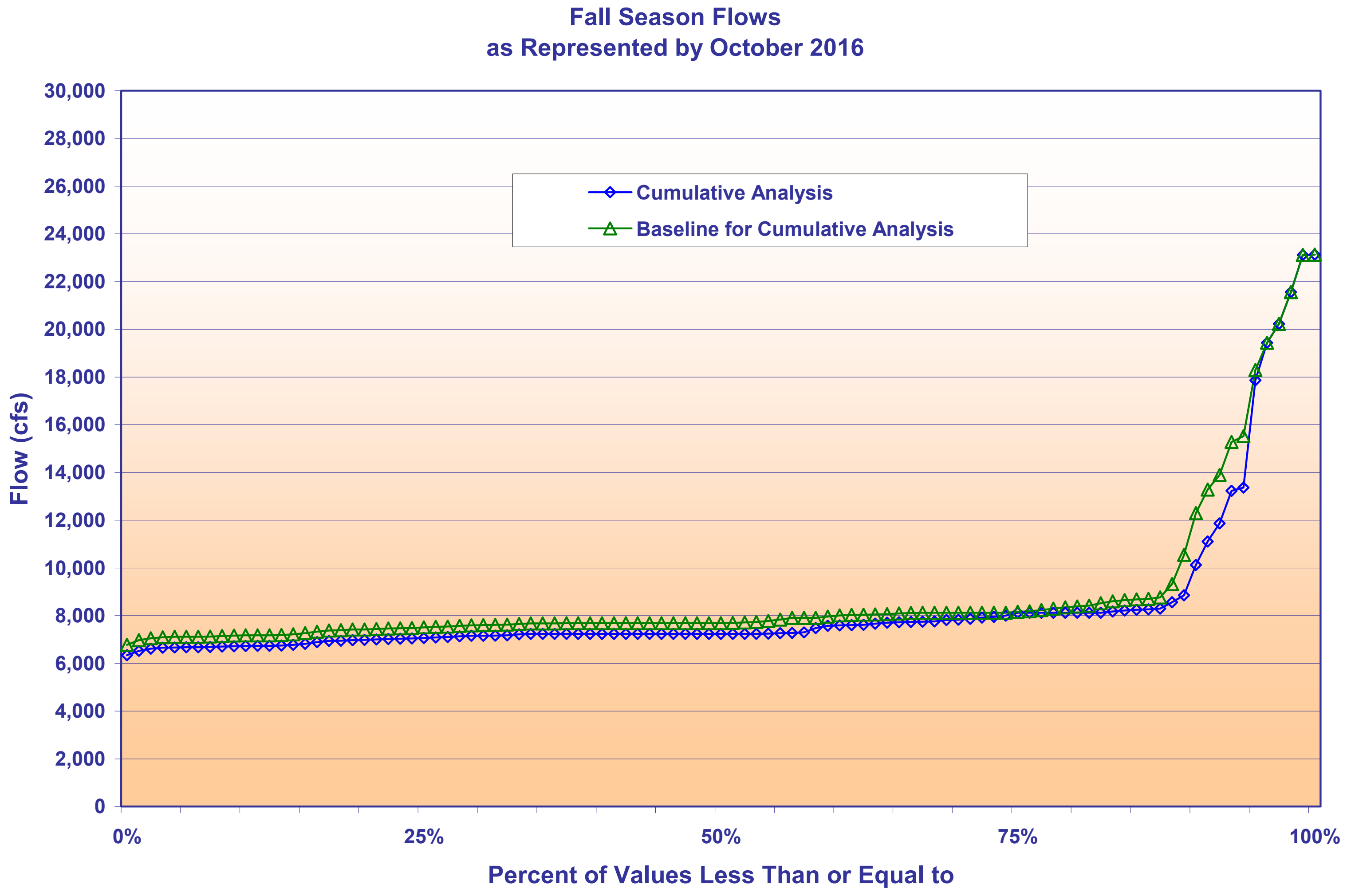


Figure 3.3-17d
Colorado River Seasonal Flows Upstream of Colorado River Indian Reservation
Comparison of Implementation Agreement to Baseline for Cumulative Analysis Conditions for Modeled Year 2016



3.3.4.3 RIVER FLOWS BETWEEN PALO VERDE DIVERSION DAM AND IMPERIAL DAM

The flow of the Colorado River between Palo Verde Diversion Dam and Imperial Dam is normally set at the amount needed to meet the United States diversion requirements downstream of the Palo Verde Diversion plus deliveries to Mexico. The river location that was modeled for this reach of the river is located immediately downstream of the Palo Verde Diversion Dam.

Future flows in this reach would be affected by the Cumulative Analysis because the proposed water transfers and exchanges between the California agricultural water agencies and MWD would change the point of diversion from the river. 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 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 3.3-18. As shown by the 50th percentile values, the modeled annual flow volumes in this reach under the Cumulative Analysis decline gradually between 2002 and 2016, as the water transfers take effect and certain amounts of California's water are diverted from Lake Havasu rather than at Imperial Dam. After 2016 the annual flow conditions would remain lower than under the baseline. The difference results primarily from the proposed Implementation Agreement (See Section 3.2.4.3), augmented to a minor degree by the effect of the additional proposed water transfer in the cumulative analysis. The interim surplus guidelines do not affect this section of river significantly

At the 10th percentile level, the same comparative annual flow patterns occur. The 90th percentile flows under the Cumulative Analysis conditions vary higher or lower than the flows under the Baseline for Cumulative Analysis during the fall and winter seasons. However, the plots do not exhibit a significant difference between the Cumulative Analysis conditions and the Baseline for Cumulative Analysis conditions. At the 90th percentile level, flows are dominated by surplus water deliveries and flood flows.

Figure 3.3-19, shows the cumulative distribution of annual flow volumes for year 2016.

Figures 3.3-20 (a-d) present comparisons of the representative seasonal flows under Baseline for Cumulative Analysis conditions and the Cumulative Analysis for 2016. As expected, the largest flows occur in the spring and summer seasons under the Baseline for Cumulative Analysis and Cumulative Analysis conditions due to downstream irrigation demands. The seasonal flows under the Cumulative Analysis are slightly lower than those under Baseline for Cumulative Analysis conditions. For flows that are due primarily to flood control releases from Lake Mead (flows in the 80th - 100th percentile range), the range of mean monthly flows is not affected by the Cumulative Analysis, since these magnitudes are dictated by the flood control regulations. In the lower percentiles, the seasonal flows with the Cumulative Analysis are slightly lower than the flows under Baseline for Cumulative Analysis conditions (from six to 11 percent lower in various seasons in 2016).

A numerical comparison of the 70th percentile seasonal flow values is shown on Table 3.3-12. The values tabulated are the mean monthly flows in January, April, July and October.

Table 3.3-12
Comparison of Mean Monthly Flow Data – Baseline for Cumulative Analysis and Cumulative Analysis
Colorado River Downstream of Palo Verde Diversion Dam (River Mile = 133.8)
70th Percentile Values for Year 2016

Season (Representative Month)	Mean Monthly Flows (cfs) for Year 2016 at the 70th Percentile	
	Baseline for Cumulative Analysis	Cumulative Analysis
Winter (January)	3,695	3,420
Spring (April)	10,202	9,633
Summer (July)	11,008	10,458
Fall (October)	7,444	7,003

Figure 3.3-18
Colorado River Downstream of Palo Verde Diversion Dam Annual Flow Volume (af)
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
90th, 50th and 10th Percentile Values

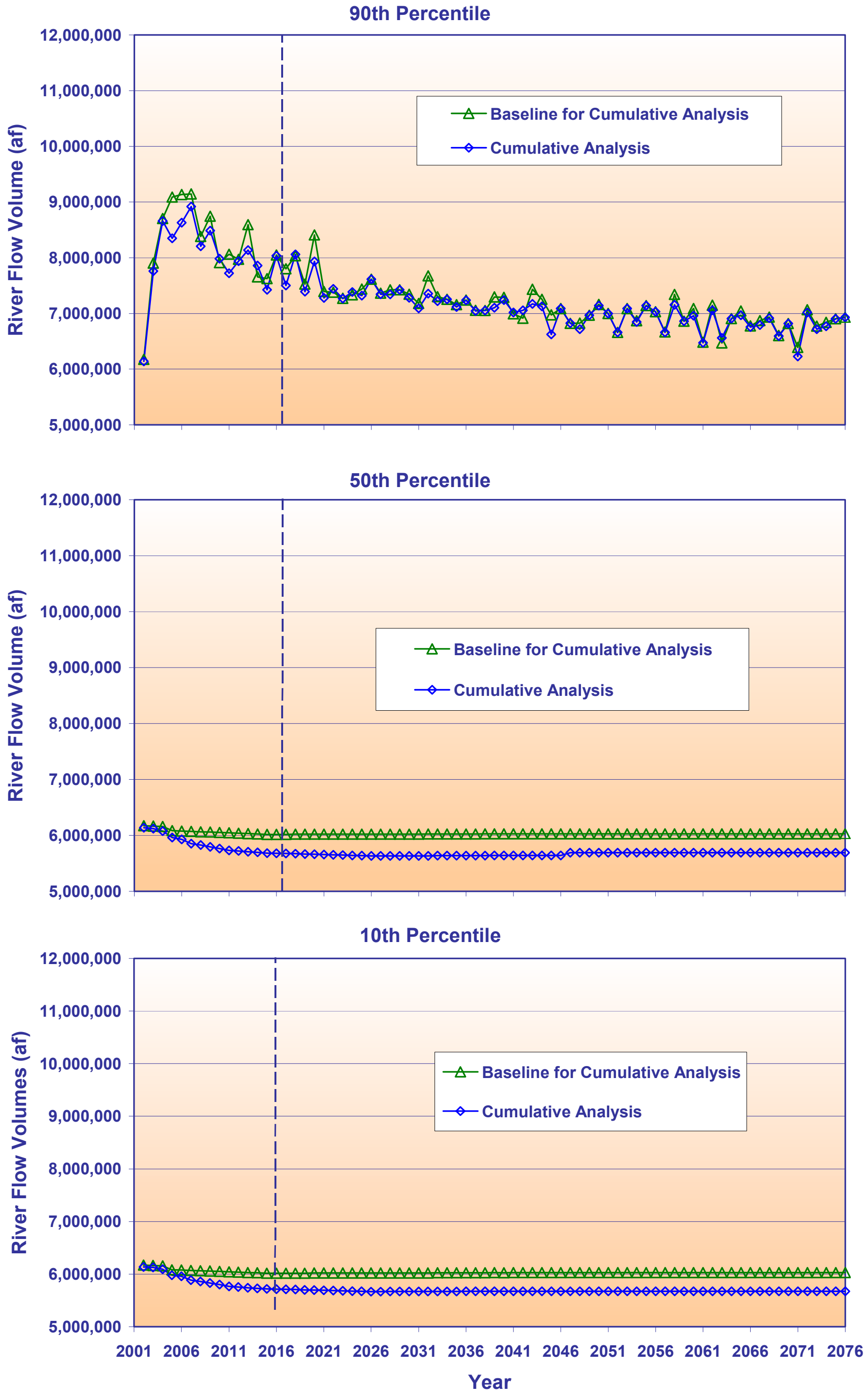


Figure 3.3-19
Colorado River Annual Flow Volumes Downstream of Palo Verde Irrigation Diversion
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

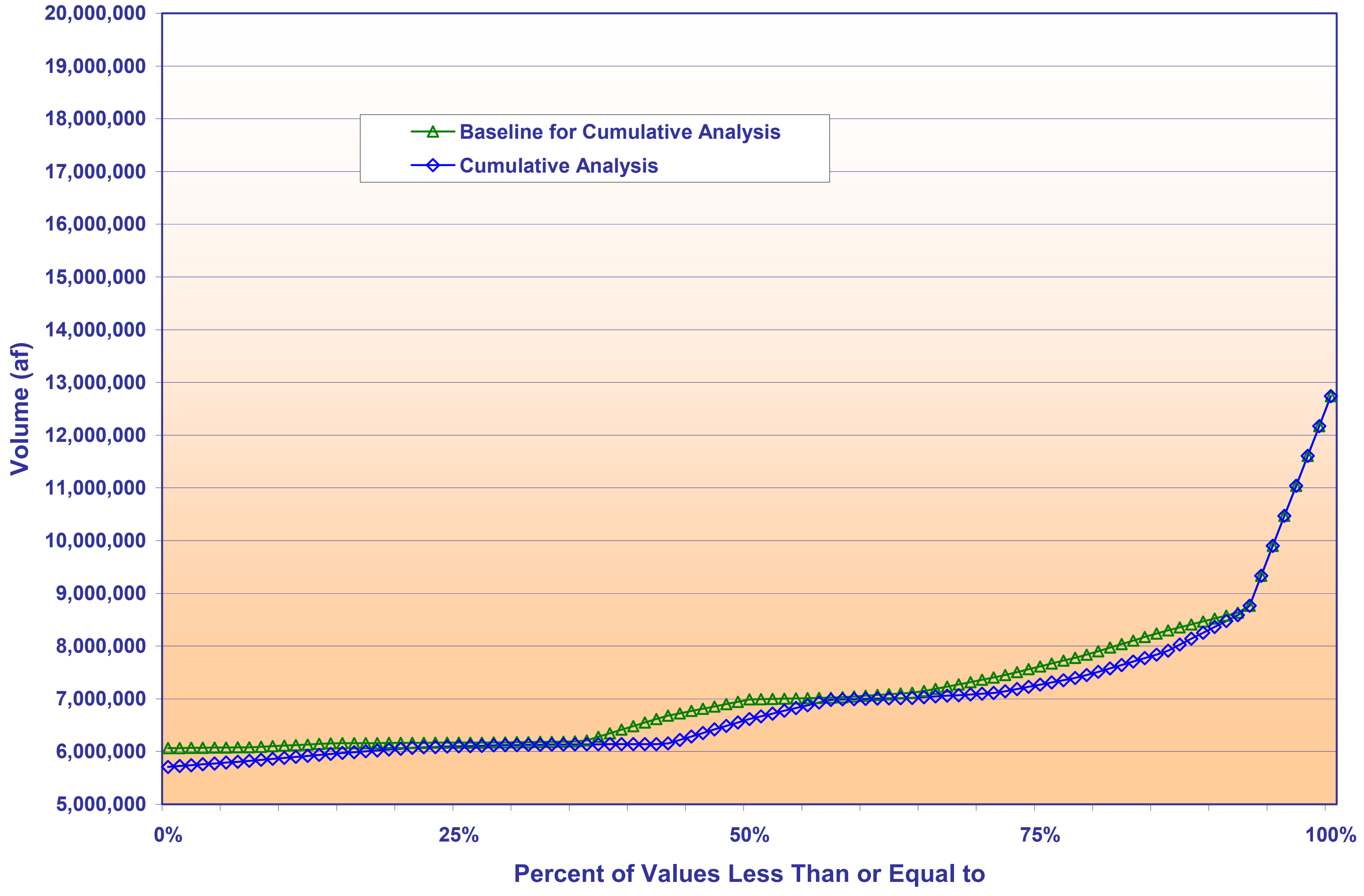


Figure 3.3-20a
Colorado River Seasonal Flows Downstream of Palo Verde Diversion Division
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

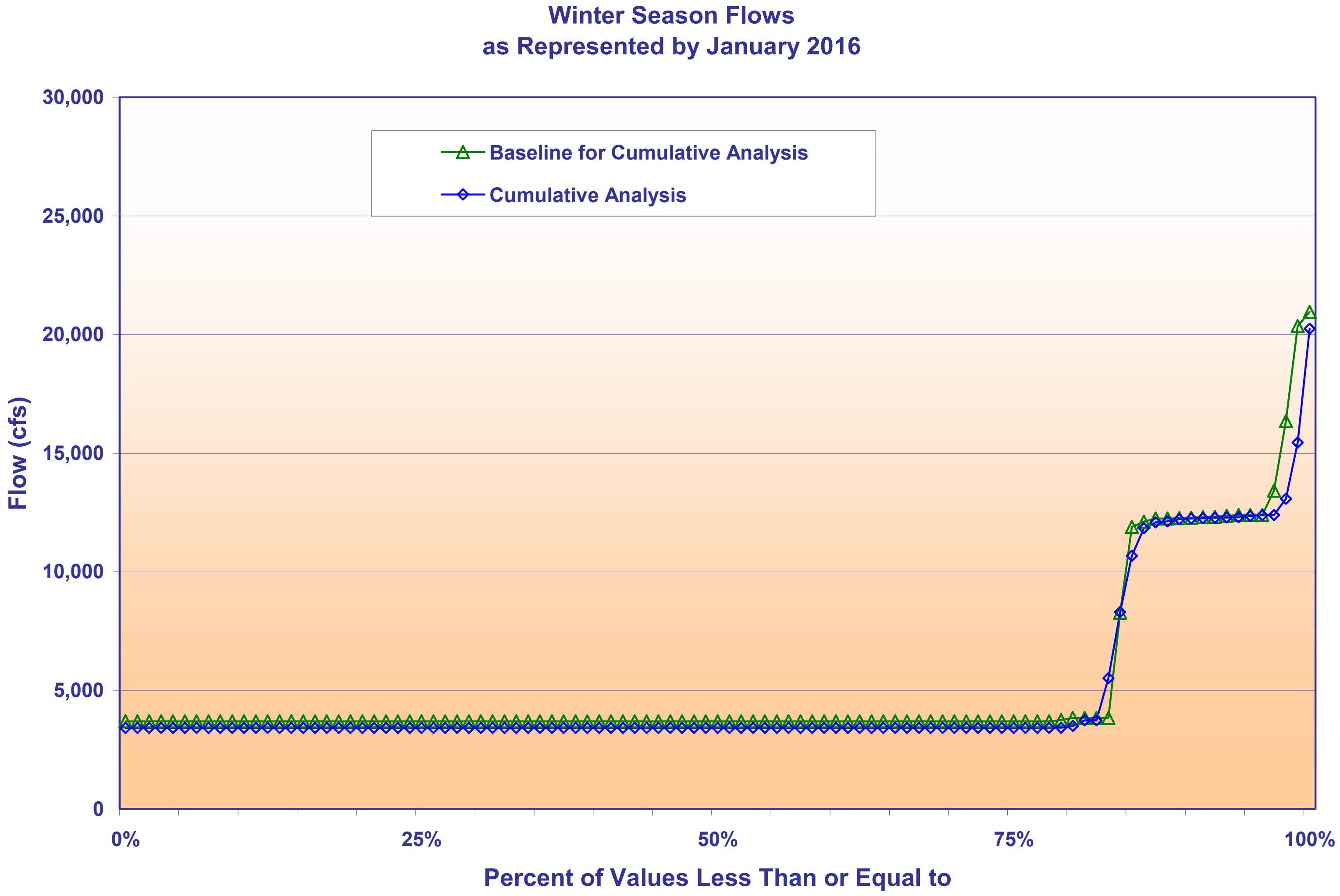


Figure 3.3-20b
Colorado River Seasonal Flows Downstream of Palo Verde Diversion Division
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

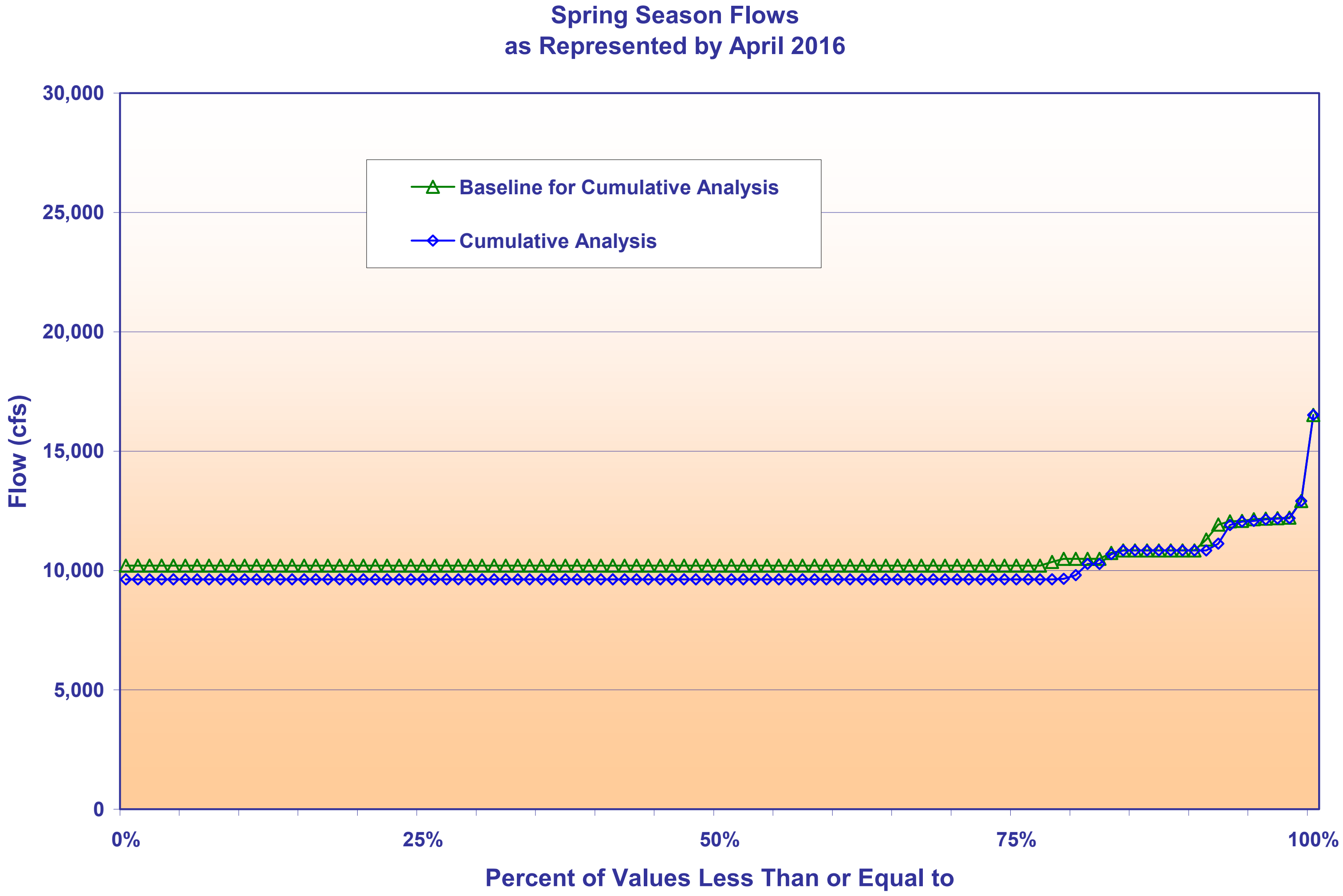


Figure 3.3-20c
Colorado River Seasonal Flows Downstream of Palo Verde Diversion Division
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

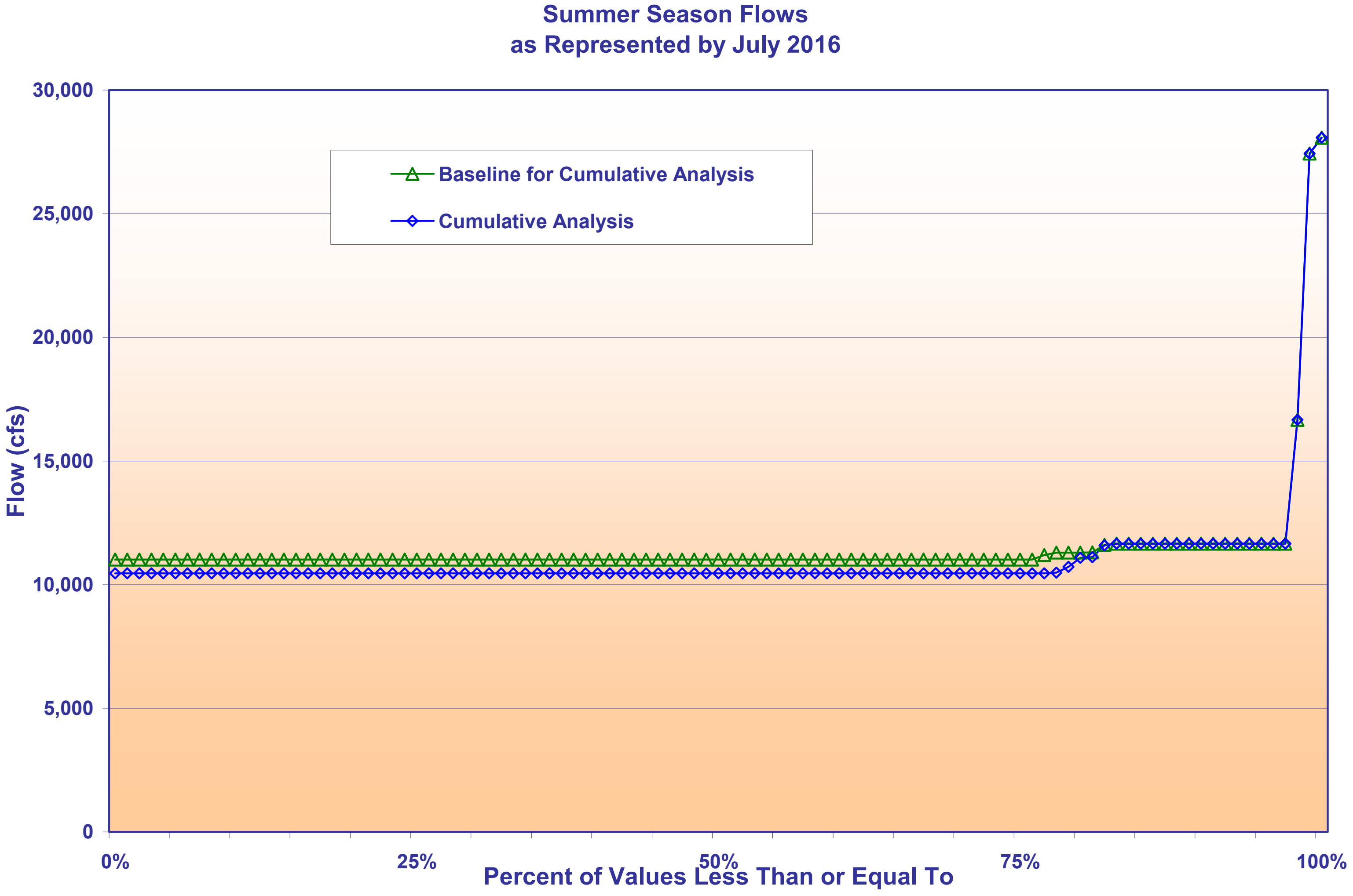
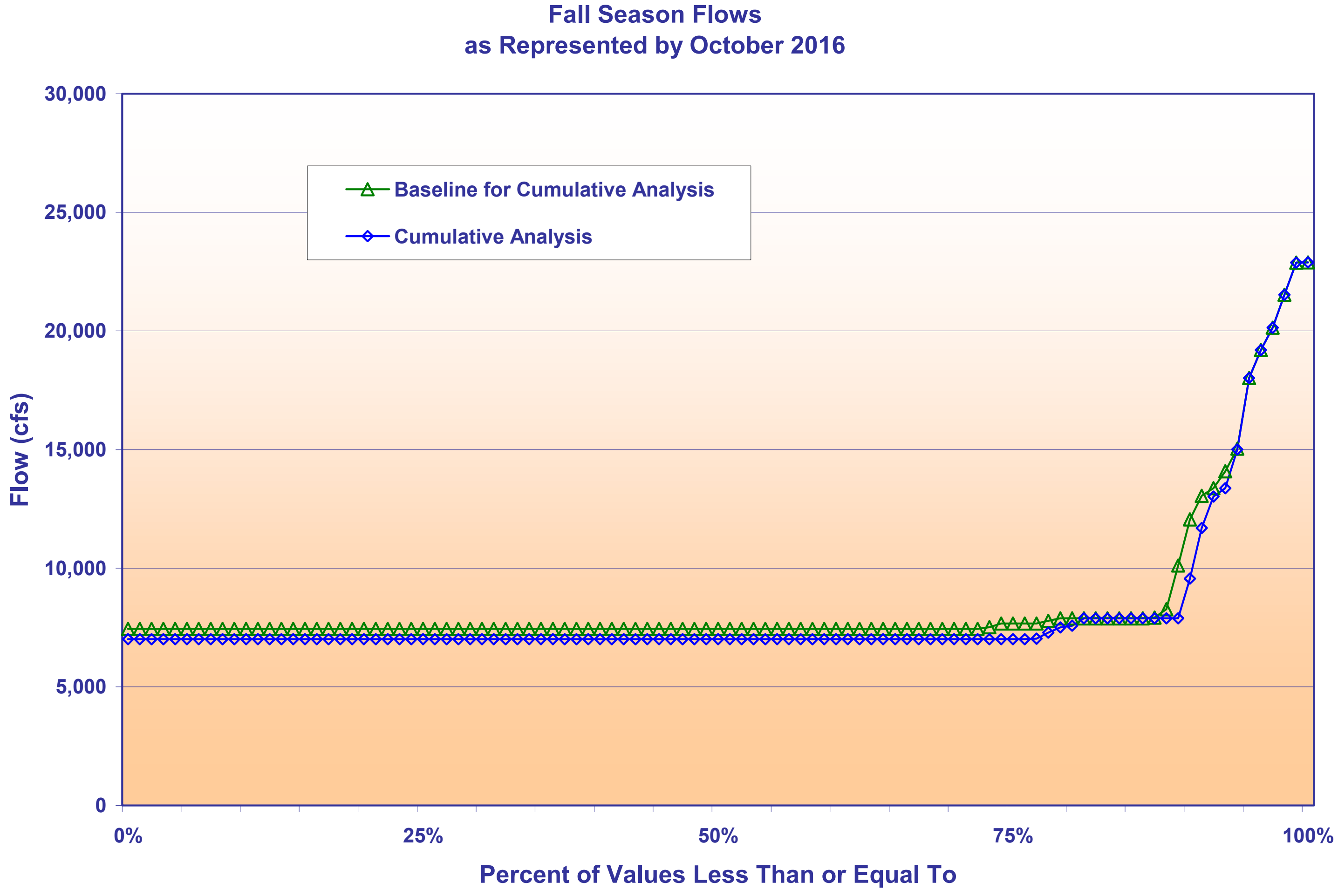


Figure 3.3-20d
Colorado River Seasonal Flows Downstream of Palo Verde Diversion Division
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016



3.3.4.4 RIVER FLOWS BETWEEN IMPERIAL DAM AND MORELOS DAM

As explained in Section 3.2.4.4, the flows in the Colorado River below Imperial Dam consist primarily of the water delivered to Mexico in accordance with the provisions of the US-Mexican Water Treaty of 1944. Mexico's principal diversion is at Morelos Dam, which is located approximately nine miles southwest of Yuma, Arizona.

As discussed in Section 2.3, the model accounts for all deliveries to Mexico as diversions at the NIB (Morelos Dam). Flows that are modeled downstream of Morelos Dam represent mean monthly flows that are excess flows in the Colorado River due to Lake Mead flood control releases. These excess flows may reach the Colorado River Delta, although Mexico has the authority to divert them for other uses. Such decisions by Mexico are not modeled as they are not known. The excess flows are over and above Mexico's normal 1.5 mafy water entitlement plus the 200,000 afy of surplus delivery when available.

The 90th, 50th, and 10th percentile annual flow volumes for this reach are shown in Figure 3.3-21. Since these flows are dependent solely upon infrequent flood control releases, no flows are observed at either the 10th or 50th percentiles. At the 90th percentile level, the Implementation Agreement produces a pattern of annual flow volumes similar to that produced by No Action conditions, with the Implementation Agreement values occasionally being slightly higher or slightly lower than the No Action values.

Figure 3.3-22 shows the cumulative distribution of annual flow volumes for year 2016.

Figures 3.3-23 (a-d) present comparisons of the representative seasonal flows under Baseline for Cumulative Analysis conditions and the Cumulative Analysis for 2016. As expected, the only differences seen for flows are due to flood control releases from Lake Mead (flows in the 80th – 100th percentile range). As seen in the figures, where the Cumulative Analysis flows differ significantly from the Baseline for Cumulative Analysis flows, the Cumulative Analysis flows are lower than Baseline flows. This is primarily caused by the interim surplus guidelines in effect from 2002 to 2016.

A numerical comparison of the 90th percentile seasonal flow values is shown on Table 3.3-13. The values tabulated are the mean monthly flows in January, April, July and October.

Table 3.3-13
Comparison of Mean Monthly Flow Data – Baseline for Cumulative Analysis and Cumulative Analysis
Colorado River Downstream of Morelos Dam (River Mile = 23.1)
90th Percentile Values (cfs) for Year 2016

Season (Representative Month)	Mean Monthly Flows (cfs) for Year 2016 at the 90th Percentile	
	Baseline for Cumulative Analysis	Cumulative Analysis
Winter (January)	8,384	8,346
Spring (April)	0	0
Summer (July)	0	0
Fall (October)	4,176	1,679

Figure 3.3-21
Colorado River Below Mexico Diversion at Morelos Dam Annual Flow Volume (af)
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions
90th, 50th and 10th Percentile Values

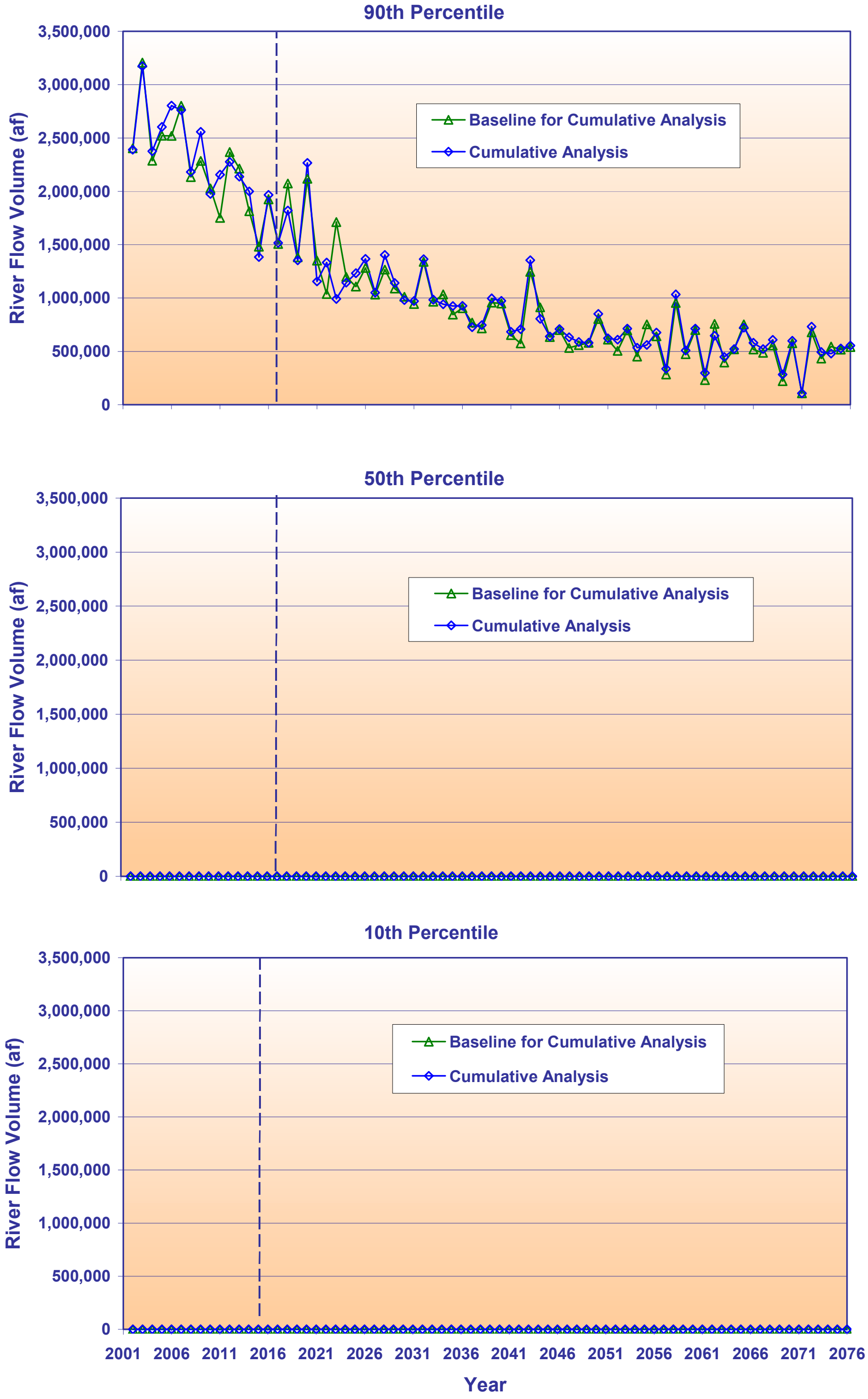


Figure 3.3-22
Colorado River Annual Flow Volumes Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

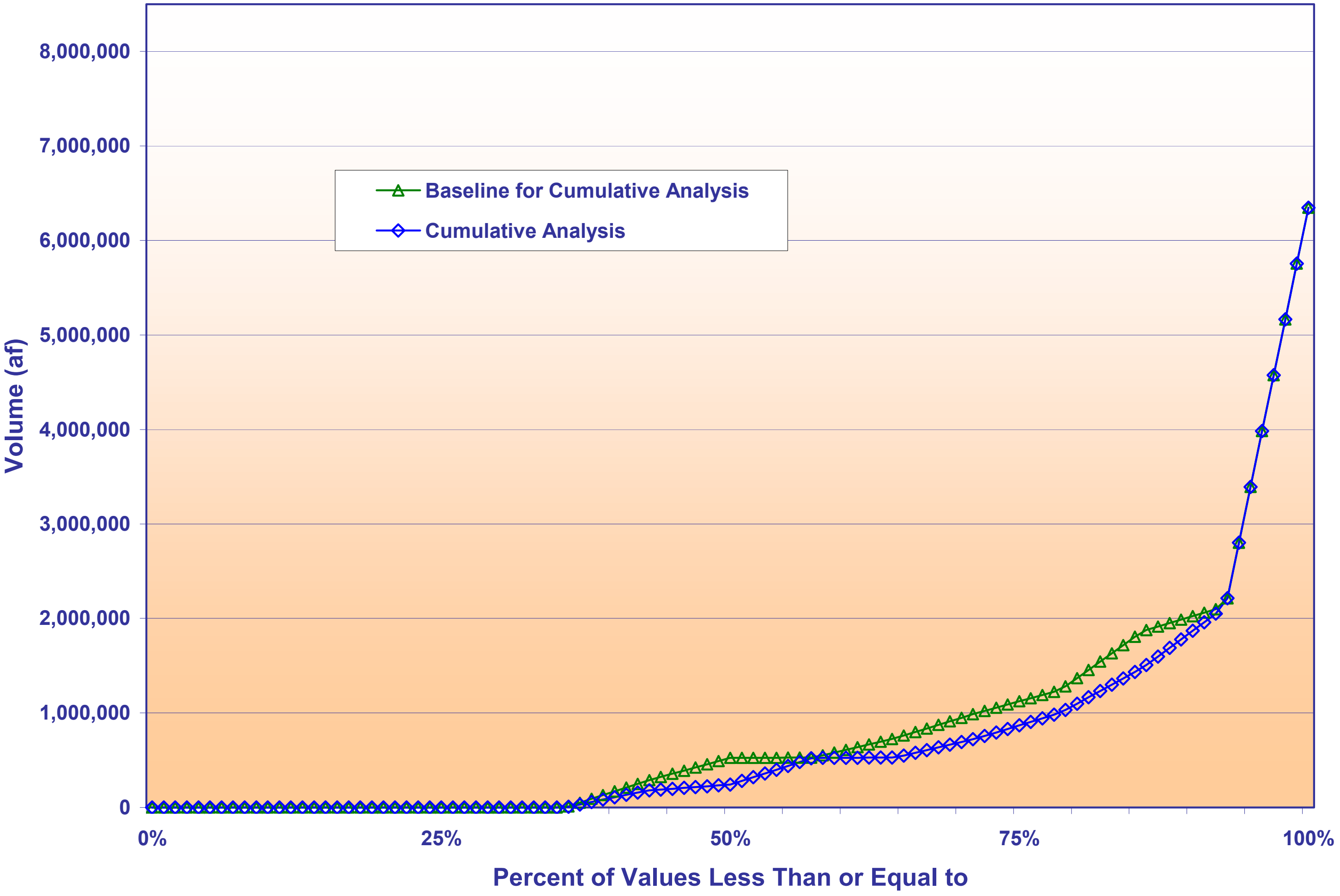


Figure 3.3-23a
Colorado River Seasonal Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

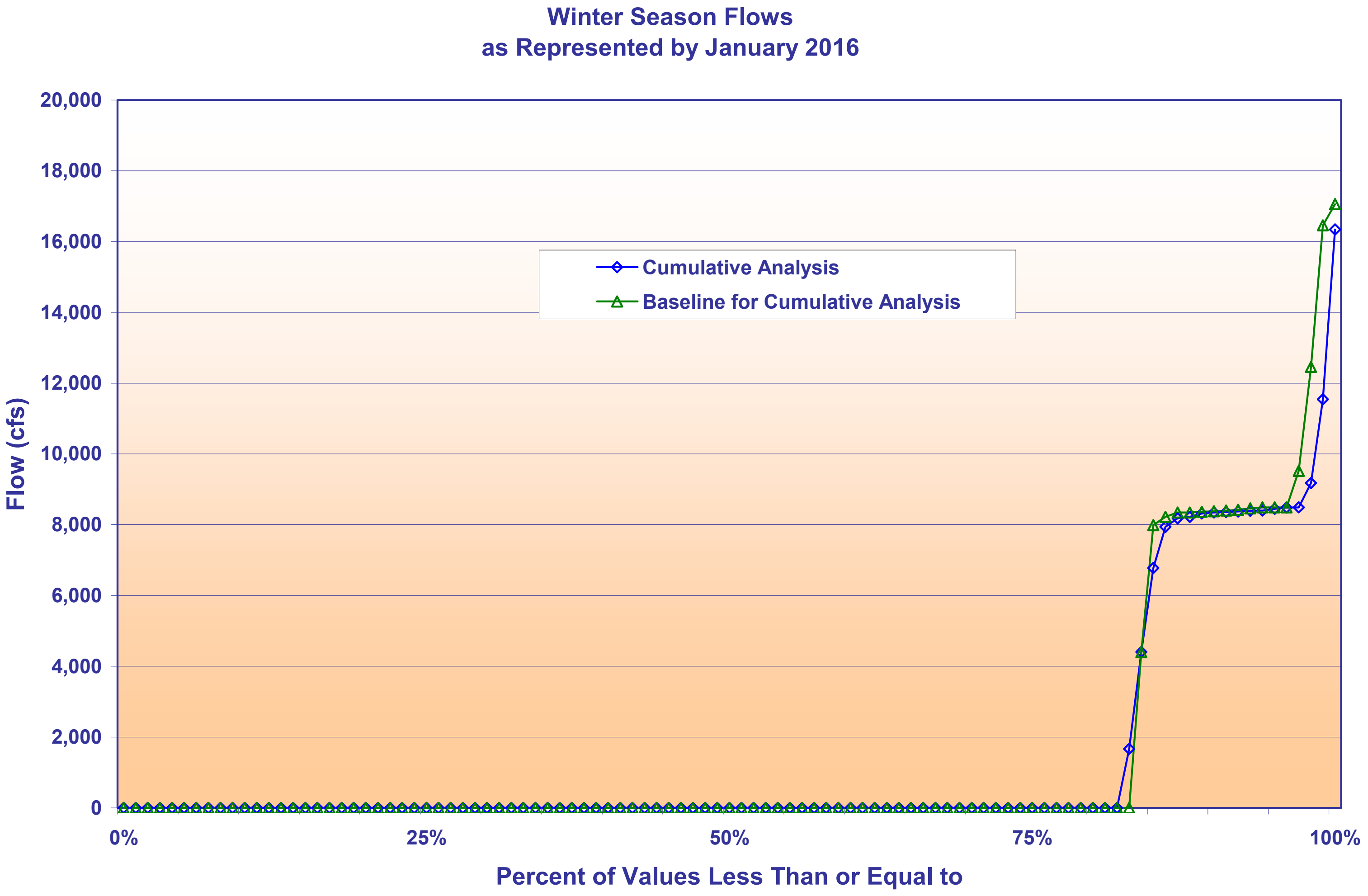


Figure 3.3-23b
Colorado River Seasonal Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

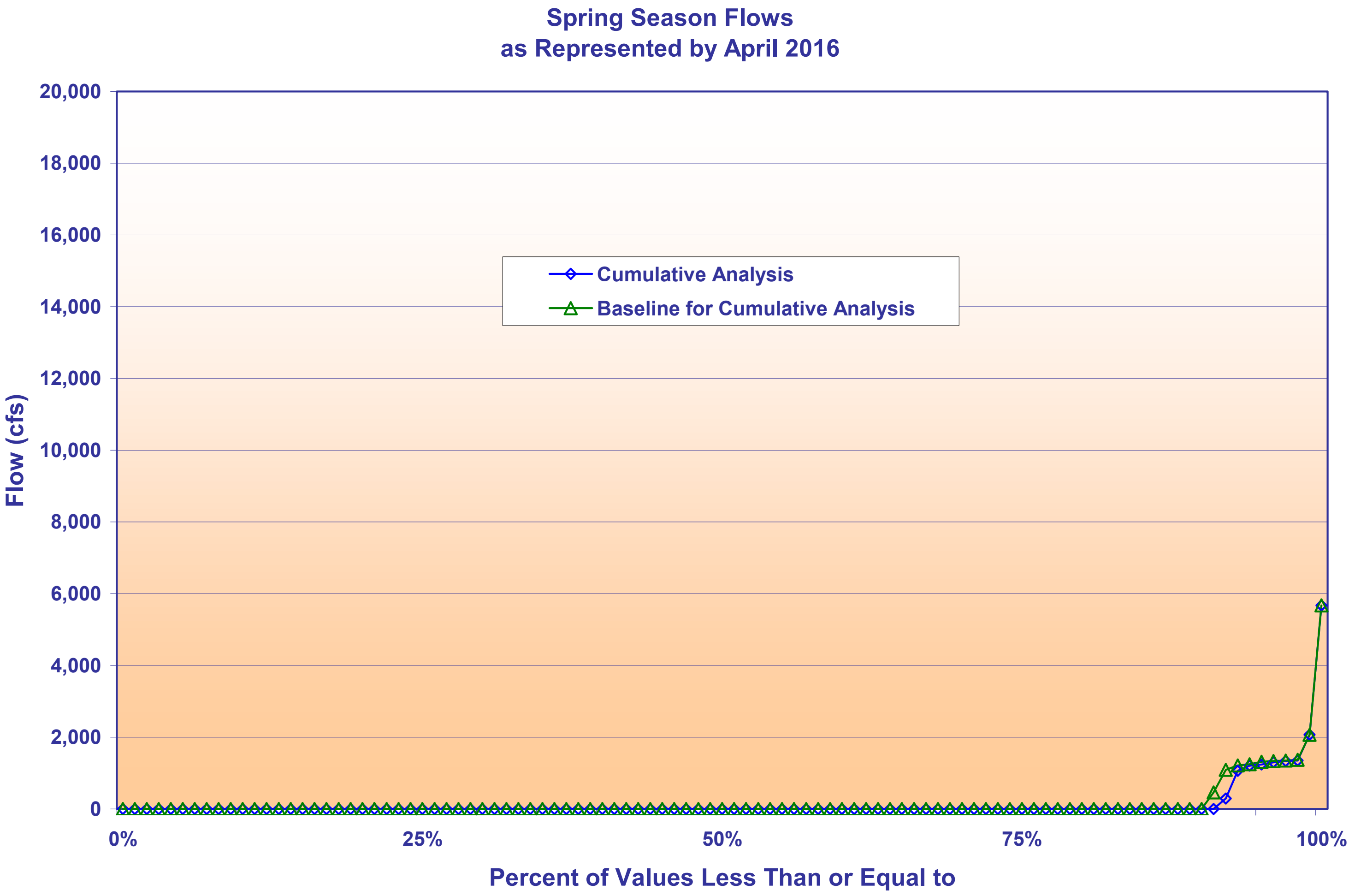


Figure 3.3-23c
Colorado River Seasonal Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016

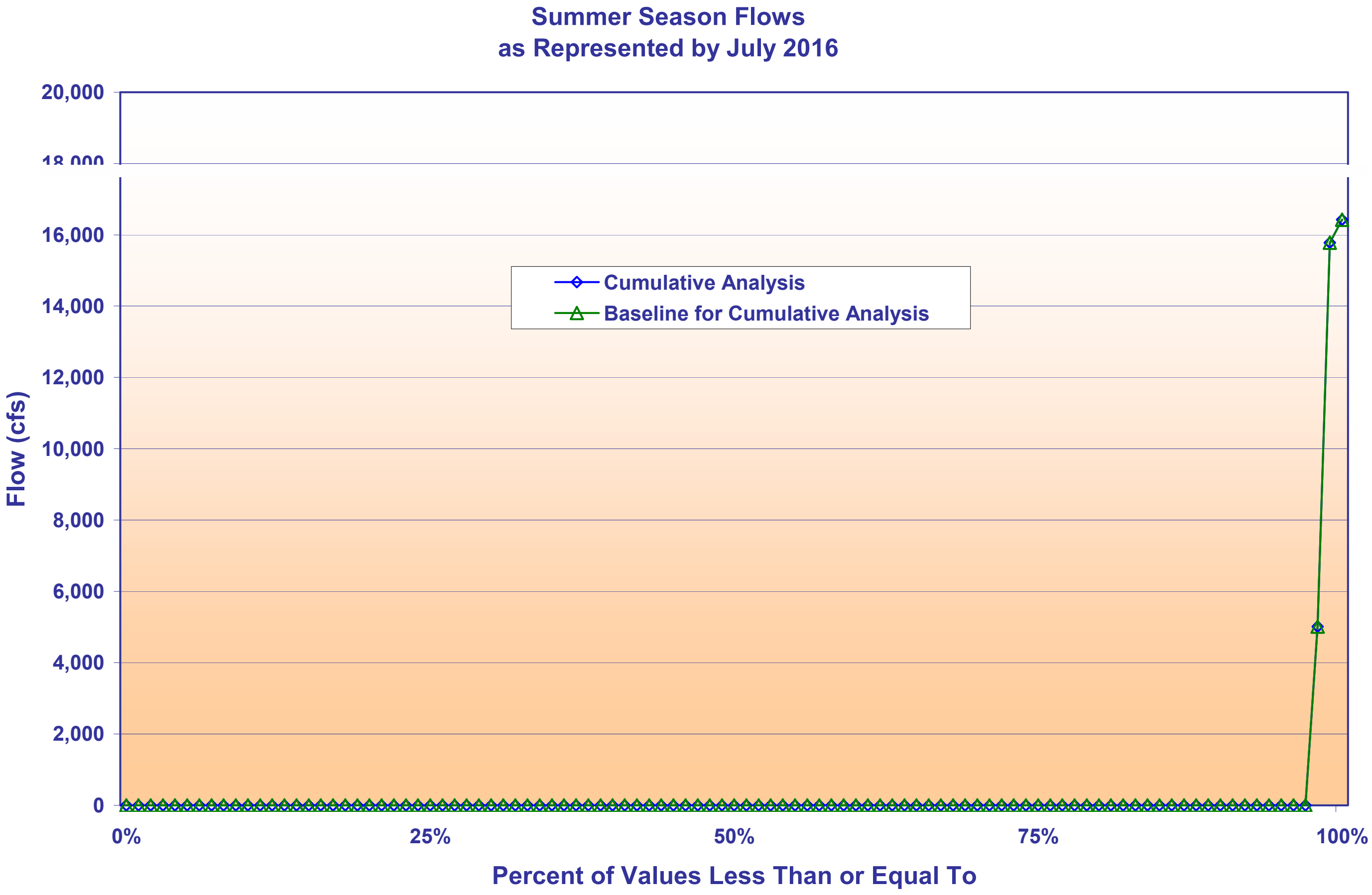
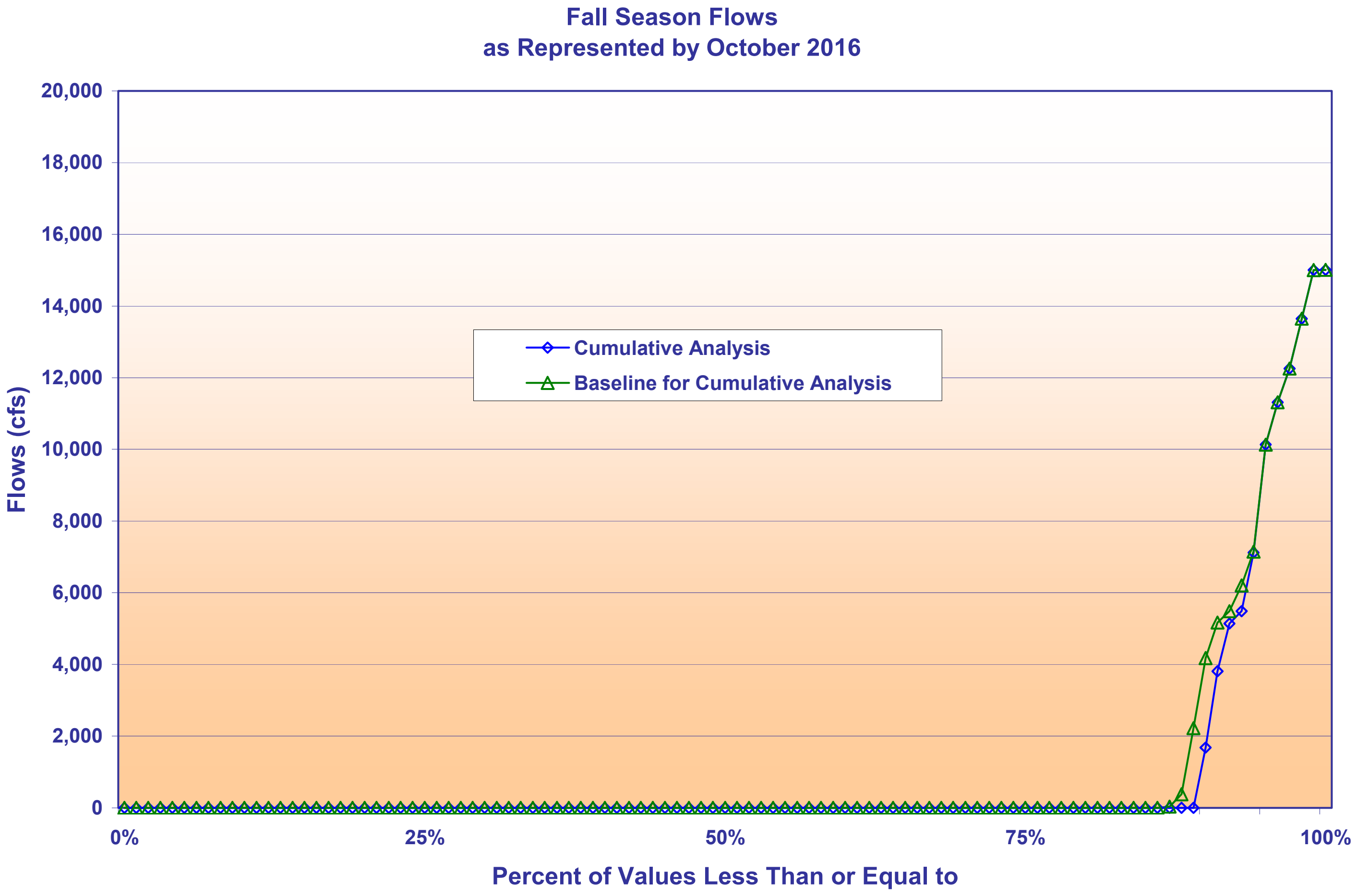


Figure 3.3-23d
Colorado River Seasonal Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline for Cumulative Analysis Conditions for Modeled Year 2016



4.0 WATER SUPPLY

4.1 INTRODUCTION

This section discusses the water supply available to the Lower Division states and Mexico under the four operational scenarios modeled. It provides an evaluation of the effectiveness of meeting the water delivery objectives previously articulated by the Lower Division states and notes the states' contingency plans in the event of shortages. Water supply deliveries are the deliveries of Colorado River water by Reclamation to entities in the seven Basin States and Mexico, consistent with the *Law of the River*, as discussed in Section 1.1.

As with the previous river operations analysis, the water supply is also presented in the form of two different analyses. Section 4.5 provides a summary of the analysis that evaluates the potential effects of water transfers on water supply. Section 4.6 provides a summary of the cumulative analysis that evaluates the potential effects of the various proposed water management programs on water supply.

4.2 METHODOLOGY

The model was used to produce estimates of future water supply deliveries for the Lower Division states and Mexico under the four modeled operational scenarios. The modeled water demands of the Lower Division states reflect demand projections provided by the water users. The demand schedules used to model the Lower Division States' normal depletions are included in Attachment A of this Technical Memorandum. The demand schedule used to model the Upper Division states' depletions is included in Attachment B of this Technical Memorandum.

The output from each model run included monthly and annual diversions, return flows and depletions for the Colorado River water users in acre-feet (af). The water supply data was analyzed using statistical methods as discussed in Section 2.6. The analysis of water transfers (Section 4.5) focused upon the comparison of the model results of the No Action to those of the Implementation Agreement conditions. The analysis of cumulative effects (Section 4.6) focused upon the comparison of the model results of the Baseline for Cumulative Analysis to those of the Cumulative Analsysis conditions. See Section 2.0 for a further explanation of the modeling process and assumptions.

The data evaluated consisted principally of data relating to the amount of water available for consumptive use in the Lower Division states under the four modeled scenarios during the 75-year period of analysis. Because differences between the modeled scenarios are at times small in relation to the quantities and time periods, it was necessary to compare the data in precise terms. However, it should be noted results described below represent approximations of probable future conditions that become increasingly uncertain over time.

The time period for the analysis is 2002 through 2076. The analysis is based on depletion schedules for those years provided by the states and Tribes.

Protection was provided for the water level of Lake Mead at elevation 1083 feet msl and elevation 1000 feet msl by imposing shortages. As discussed earlier in Section 2.4, the elevation of 1083 feet msl is assumed to be the lowest elevation at which the Hoover Powerplant can produce power efficiently and the elevation of 1000 feet msl is assumed to be the lowest that the secondary SNWA intake can operate.

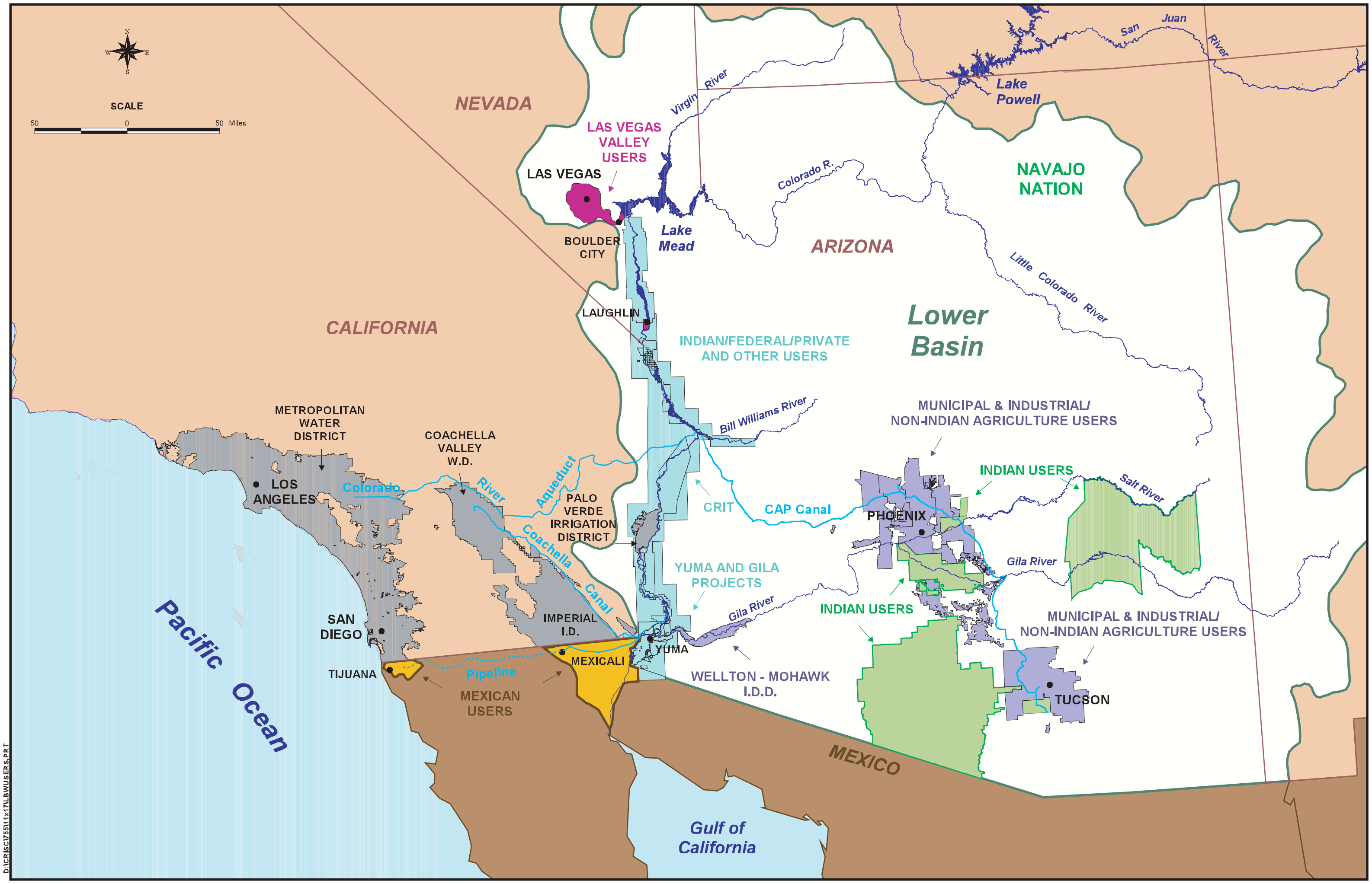
The results are portrayed graphically in two ways. As discussed in section 2.5, the modeling process involved making 85 separate runs (traces) which were then examined for the range of water supply available in a given year under each of the four modeled scenarios. One way that these results can be portrayed graphically is to plot the 90th percentile values (meaning that 90 percent of the values produced by the model were less than that value), the 50th percentile values (the median value) and the 10th percentile values (meaning that 10 percent of the values produced by the model were less than that value). Plots of the maximum and minimum depletion values produced by the model for any given year were added to this “90-50-10” array. Plots for the Lower Division states and Mexico under the four modeled scenarios are presented in this section.

A second way that the results are portrayed is derived by first ranking all the annual values for a desired period, e.g., the 15-year interim surplus guidelines period (2002 through 2016), the subsequent 60-year period (2017 through 2076) and the entire 75-year period of analysis (2002 through 2076). The annual depletion values can then be plotted versus the percent of values that are greater than or equal to. This type of plot provides a distribution of the respective state’s depletion and allows for a generalized comparison of the water supply available under each respective modeled scenario, for each period of time.

4.3 WATER SERVICE AREAS

Colorado River water diverted at or below Lake Mead is used in the states of Arizona, California, and Nevada, and in Mexico. Map 4.3-1 presents the water service areas in the Lower Basin.

Map 4.3-1
Colorado River Water Service Areas in the Lower Basin



4.4 WATER USE PROJECTION PROCESS

For the Upper Division States, estimates of future projected use to 2050 were taken from the ISC FEIS (USBR, 2000). Beyond 2050, the same value used for 2050 was used for years 2051 through 2076 (i.e., the Upper Division Water use was at "full development" by 2050). The schedules are presented in Attachment B.

For the Lower Division States, estimates of future projected use under normal conditions were also taken from the ISC FEIS. For the operational scenarios that include the QSA, these schedules were modified to reflect the assumed water transfers and extended appropriately. These schedules are detailed in Attachment A and reflect each state's annual water apportionment from the Colorado River.

Similarly, Lower Division States' surplus schedules for the Interim Surplus Guidelines (referred to as the "Basin States Plan" in the ISC FEIS) and the 70R strategy were taken from the ISC FEIS. These schedules are shown in Attachment C.

Finally, Lower Division Entities' Shortage amounts are computed within the model as described in Section 2.4.

The states' water delivery requests are distributed among the major diversion points along the river system (approximately 120 such points are modeled for all seven Basin States).

4.4.1 STATE OF ARIZONA

The portions of Arizona in the Lower Basin that depend on Colorado River mainstream water consist of the following areas:

- The lower Colorado River from Lake Mead to the SIB;
- The Gila River Valley upstream from Yuma, Arizona; and
- A large area in the central part of the state served by facilities of the CAP.

Under the Boulder Canyon Project Act of 1928 (BCPA) and the Supreme Court Decree, Arizona v. California, 1964 (Decree), Arizona receives on annual apportionment of 2.8 maf from the Lower Division states' total of 7.5 maf.

In addition, Arizona can also use up to 50,000 afy of water pumped from Lake Powell under the State's Upper Basin apportionment. Numerous districts and other entities that divert and distribute the water administer the contractual arrangements for the use of Colorado River water in Arizona. The Central Arizona Water Conservation District (CAWCD) administers the CAP water diversions. The Director of the Arizona Department of Water Resources has state statutory authority to represent the state in Colorado River water supply matters.

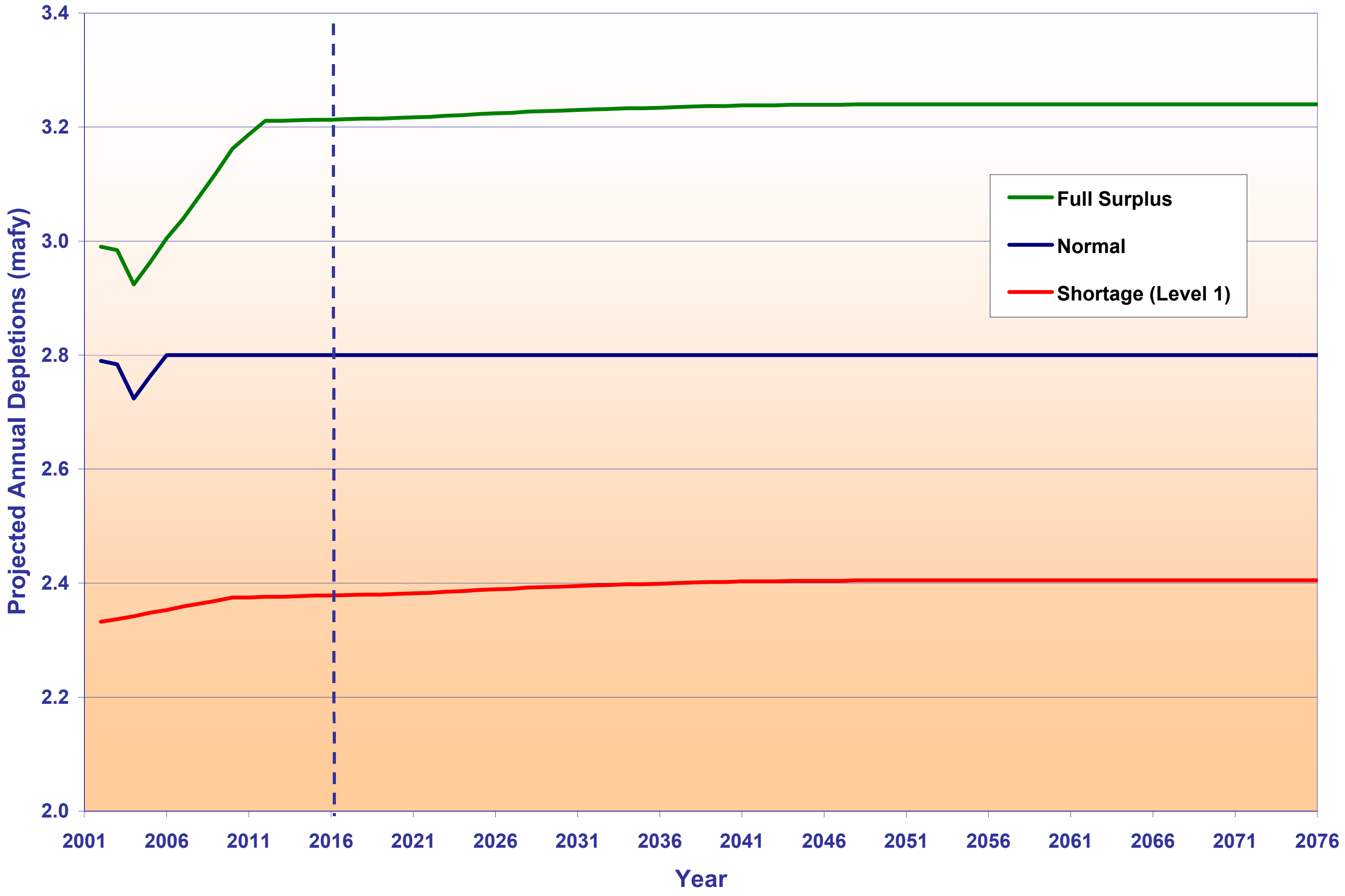
Arizona established the Arizona Water Banking Authority (AWBA) in 1996. The state legislation that authorized the AWBA states that it was created: 1) to increase Arizona's use of Colorado River water by delivering through the CAP system and storing water that otherwise would be unused by Arizona; 2) to ensure an adequate water supply to CAP municipal and industrial (M&I) users in times of shortages or disruptions of the CAP system; 3) to meet water management plan objectives of the Arizona state groundwater code; 4) to assist in settling Indian water rights claims; and 5) to provide an opportunity for authorized agencies in California and Nevada to store unused Colorado River water in Arizona for future use.

Arizona has numerous users of Colorado River water. The largest diversion of water is the CAP that delivers water to contractors in the central part of the state. CAP's diversion is located at Lake Havasu. The next three largest diversions are those of the Colorado River Indian Reservation at Headgate Rock Dam and the Gila and Yuma Projects, whose diversions are located at Imperial Dam. The remaining diversions serve irrigated areas and community development along the river corridor, including lands of the Fort Mojave Indian Reservation, water used by federal agencies in Arizona, the cities of Bullhead, Lake Havasu and Parker, Mojave Valley Irrigation District and Cibola Irrigation District. A portion of the water from the river corridor is also diverted by wells located along the river.

The CAP and other fourth priority Arizona users that contracted for Colorado River water after September 30, 1968, have the lowest priority. The exceptions are lower priority contractors that contracted for unused normal year entitlement and surplus year supplies when available. Included in the CAP category are Bullhead City, Lake Havasu City, Mojave Valley Irrigation District and others. For the most part, the non-CAP contracts total 164,652 afy. The non-CAP users include present perfected rights or other rights that predate the BCPA and users that contracted before September 30, 1968.

Under shortage conditions, initial shortages in the United States would be shared between Nevada and Arizona on a four and 96 percent basis, respectively. Within Arizona, if any use of water was occurring under contracts for unused entitlement, that use would be the first eliminated under shortage conditions. Any remaining reduction in Arizona would be shared pro rata between the CAP and the non-CAP holders of fourth priority entitlements. More severe shortages would result in holders of higher priority entitlements having to incur reduction in their water use. For this report, all Arizona shortages are assigned to the CAP. Furthermore, the analysis of Arizona's water supply has been limited to an analysis of the effects of water availability on total Arizona diversions. Figure 4.4-1 presents a graphical illustration of Arizona's normal, full surplus and first level shortage condition depletion schedules that were used as input for the model. These data are presented in tabular format in Attachment A.

Figure 4.4-1
Arizona Projected Colorado River Water Demand Schedules
(Full Surplus, Normal and Shortage Water Supply Conditions)



Arizona's consumptive use of Colorado River water, including that used for groundwater banking, reached its normal year entitlement of 2.8 maf in 1997. However, its consumptive use since then has been somewhat less than this amount.

As shown on Figure 4.4-1, Arizona's normal year depletion schedule is projected to reach 2.8 maf in 2006, and remains at that level thereafter. For modeling purposes, Arizona's unused apportionment in 2002 through 2005 was distributed to MWD (73 percent) and SNWA (27 percent). The CAP's projected normal year depletions are approximately 1.458 maf in 2002 and gradually decrease to 1.395 maf by 2048, which represent approximately one-half of the state's total normal demand. The demands of Arizona's non-CAP users meanwhile increase towards their full apportionment amount as time progresses, making up the balance of Arizona's normal 2.8 maf apportionment.

The state's projected full surplus depletions increase from 2.99 maf in 2002 to approximately 3.24 maf in 2037. The projected CAP surplus condition demand rises steadily from 1.658 maf in 2002 to approximately 1.835 maf in 2012. Thereafter, the CAP surplus condition depletion schedule remains flat at approximately 1.835 maf. First level shortage condition depletions for Arizona increases from 2.332 maf in 2002 to 2.405 maf by 2048 and remain at that level thereafter, reflecting the modeling assumption discussed in Section 2.4 of limiting CAP to 1.0 maf.

The modeled Colorado River water deliveries under the four modeled operational scenarios assumed that all Arizona shortages would be assigned to the CAP, as discussed in Section 2.4. Although it is recognized that under the current Arizona priority framework there would be some sharing of Arizona shortages between the CAP and users at the same priority, modeling at this level of detail was not necessary to analyze deliveries on a statewide basis.

Arizona's basic strategy for meeting short-term shortages in CAP M&I supply centers on reduced uses for recharge, reduced agricultural deliveries and an increased use of groundwater. In addition to naturally occurring groundwater, Arizona has established a groundwater bank and is currently actively storing CAP water that is in excess of its current needs for future withdrawal. As discussed above, the AWBA administers the groundwater bank. Groundwater banking is occurring with the intent of providing a source for withdrawal during periods when the amount of Colorado River water available for diversion under the CAP priority is curtailed by shortage conditions. Additionally, CAWCD has stored a substantial amount of CAP water in central Arizona.

It is projected that CAP water will be used for groundwater recharge until about 2040 under normal and surplus conditions. This use will be terminated first in case of shortage. For other interim and long term contract users, agriculture has the lowest priority. Therefore, irrigation users will be reduced before CAP M&I or Indian users in case of shortage conditions. Most irrigation users have rights to pump groundwater as a replacement supply. The increased use of the groundwater supplies and the management of the groundwater basins are expected to be consistent with the state's groundwater management goals.

When CAP diversions are limited to 1.0 maf during first-level shortage conditions, the impact before year 2020 would be to both groundwater recharge and agricultural users. After 2020, CAP M&I users would also be impacted by shortage conditions.

4.4.2 STATE OF CALIFORNIA

The Colorado River supplies about 14 percent of the water used in California by agriculture, industry, commercial businesses and residential customers. All of the Colorado River water used by California is used in the southern California region. Colorado River water is by far the most important source of water for southern California, accounting for over 60 percent of its water supply. During the last several years, the Colorado River has supplied up to 5.2 maf of the 8.4 maf of water used annually in southern California.

Under the BCPA and the Decree, 7.5 maf of Colorado River water is apportioned for consumptive use in the Lower Division states (California, Nevada and Arizona). In 1964, the Decree established California's normal apportionment of 4.4 maf from within the Lower Division states' 7.5 maf apportionment. The 1979 and 1984 Supplemental Decrees also awarded present perfected water rights to Indian reservations along the Colorado River. The 1964 Decree granted California, Arizona and Nevada respectively 50 percent, 46 percent, and four percent shares of any surplus water the Secretary determines to be available for use by the Lower Division states.

In California, a priority system for the principal parties that claimed rights to Colorado River water was established by the California Seven-Party Agreement of August 31, 1931, the provisions of which are included in water delivery contracts between the Secretary and California Parties. The priority system allows water apportioned but unused by a senior priority holder to cascade down to the next lower priority. The Seven-Party Agreement limits a priority holder's use of this water to beneficial use exclusively on lands within the priority holder's service area. Water transfers that are proposed in California's Draft Colorado River Water Use Plan (CRBC, 2000) will work within the framework of the Seven-Party Agreement and within the framework of the agreements that are executed to carry out those transfers.

Agriculture and present perfected rights have highest priority to about 90 percent of California's entitlement. The balance goes to the MWD, which provides wholesale water service to most of the communities within the southern California coastal plain. California's largest agricultural water agencies that rely on Colorado River water include the IID, Palo Verde Irrigation District (PVID) and the Coachella Valley Water District (CVWD).

Three major structures divert water from the Colorado River to California. Parker Dam forms Lake Havasu, which supplies water for MWD's Colorado River Aqueduct on the

California side of the state line and for the Central Arizona Project on the Arizona side of the state line. Palo Verde Diversion Dam supplies water to PVID's canal system. Imperial Dam diverts water to the All American Canal on the California side of the state line and to the Gila Gravity Main Canal on the Arizona side of the state line. The AAC is used to deliver water to the Yuma Project, IID and the CVWD.

California has relied on the Secretary's release of unused Nevada and Arizona Colorado River apportionments in accordance with Article II(B)(6) of the Decree for more than three decades. In recent years, Nevada and Arizona depletions have approached their apportionment amounts as a result of the completion of the CAP and rapid population growth in these states. Additionally, Arizona has started to bank its water (such as by groundwater storage) to protect against future shortages. As a result, there is currently not enough Nevada and Arizona unused apportionment to meet California's demand. Since 1996, California has received as much as 800,000 af above its annual 4.4 maf normal apportionment due to determinations by the Secretary of surplus conditions on the Colorado River through the AOP process.

The California Department of Water Resources (Department) projects that over the next several decades, California's overall demand for water will continue to increase. Urban demand is expected to outweigh projected declines in agricultural demand. For example, the Department's 1993 California Water Plan projected that urban water demand will increase by 60 percent from 1990 to 2020. However, California's ability to access Colorado River water beyond its normal apportionment may be limited for the following two reasons:

- Since Arizona and Nevada will be using their normal apportionments, California's access to any substantial amount of water above its normal apportionment will depend on surplus determinations by the Secretary on a year-by-year basis. Under pre-Interim Surplus Guidelines conditions Colorado River system management practices, such determinations were not certain, as they depended on conditions which change each year, namely snowpack runoff and reservoir storage.

- Even with a surplus determination, California's access is limited by the capacity of its delivery systems. Currently, the existing delivery system to urban users, the Colorado River Aqueduct, is operating at near capacity (approximately 1.3 maf per year).

If the amount of Colorado River water available for use in California was limited to the 4.4 maf normal apportionment, the immediate impact would fall mainly on the MWD because much of the allocation to California above normal apportionment now is used by urban users serviced by MWD. MWD (or its customers) would have to look to: 1) other California users of Colorado River water, namely the agriculture agencies, or 2) other sources, such as northern California water supplies, for about 700,000 af of the approximately 2 maf of MWD's normal annual water deliveries, which ranged between 1.5 maf and 2.6 maf during the 1990s.

California faces other issues that may impact the quantity or quality of the supply of Colorado River water to certain users. In particular, listing of additional endangered bird and fish species could reduce the amount of water available for non-environmental purposes. Also, Colorado River salinity control projects could impact the quantity and quality of future Colorado River water. Both the type of crops produced (high market value crops generally require water that is low in salinity) and the quality of southern California drinking water could change.

The Colorado River Board of California (Board) developed a plan for California to live within its normal apportionment of 4.4 maf. The Board's draft plan was previously referred to as the California 4.4 Plan (dated August 11, 1997) and addressed various water supply management issues that are focused on changes in the use, supply or transfer of Colorado River water. The draft plan was updated, renamed and re-released in May 2000 as the *California Colorado River Water Use Plan* (CA Plan). The CA Plan relies first on a variety of intrastate measures that either conserve water or increase water supplies. The plan also relies on measures that would make extra water available to California. (CRBC, 2000)

California's use of Colorado River water reached a high of 5.4 maf in 1974 and has varied from 4.5 to 5.2 maf per year over the past 10 years. Limiting California to 4.4 maf per year would reduce California's annual water supply by approximately 800,000 afy. All or most of this reduction would be borne by MWD unless arrangements with agricultural agencies are implemented. While the water supply analysis for this report is focused on the total California depletions, the assumption is made that the surplus deliveries that may become available would be managed and distributed by and between the California users in accordance with the proposed provisions of the CA Plan, the corresponding Quantification Settlement Agreement (QSA) and associated cooperative programs. Most of these cooperative programs are between MWD or one of its member agencies and the agricultural water agencies. Under these programs, MWD will be able to use its basic Colorado River water apportionment plus water made available from water conservation by other California agencies and from groundwater storage programs. These programs include the following:

- **Coachella Groundwater Storage Program** - Cooperative program with the Desert Water Agency and the CVWD that exchanges their State Water Project (SWP) entitlements for MWD's Colorado River water and provides storage of Colorado River water for future extraction by these two agencies.

- **Water Conservation Program with Imperial Irrigation District** - MWD and the IID entered into a water conservation agreement in December 1988. The agreement called for IID to implement various projects to conserve water including improving its water distribution system and on-farm management of water.

- **Demonstration Project on Underground Storage of Colorado River Water in Central Arizona** - Under a cooperative program with the CAP, MWD has placed 89,000 af and the SNWA has placed 50,000 af of unused Colorado River water in underground storage (groundwater banking) in central Arizona.

- **Agricultural-to-Urban Intrastate Water Transfers** – The SDCWA and IID have negotiated an agreement by which IID will transfer agricultural water conserved through various conservation and efficiency programs to SDCWA for urban use – where demand is growing. The agreement contemplates transfer of up to 200,000 afy. A number of bills have been introduced in the California Senate that attempt to address this and other similar intrastate water transfers, including SB 1011 (Costa), SB 1082 (Kelley), SB 1335 (Polanco) and AB 554 (Papan). To date, the legislature has enacted only SB 1082 which would facilitate a transfer of water between the IID and the SDCWA.

- **Palo Verde Irrigation District Land Management, Crop Rotation and Water Supply Program** – MWD and Palo Verde Irrigation District are developing a land management, crop rotation and water supply program in the Palo Verde Valley. The program's objective is to develop a flexible and reliable water supply for MWD of approximately 100,000 AFY for 35 years to assist in stabilizing the farm economy within the Palo Verde Valley through sign-up payments and annual payments for participating farmers and through implementation of specific community improvement programs. Participation in the program would be voluntary. Participating farmers would, at MWD's request and with specific notice periods, not irrigate a portion of their farmland. The same land would not be irrigated for a minimum one-year term and a maximum three-year term, at the farmer's option. A base load area of 6,000 acres would not be irrigated each year of the program's 35-year period. MWD would have the option to increase the non-irrigated area from 6,000 acres up to a maximum of 26,500 acres. However, a maximum of 24,000 acres in any 25-year period or 26,500 acres in any 10-year period during the 35-year program would be dedicated to the program. MWD would provide financial compensation to the participating farmers. Not irrigating a portion of the Palo Verde Valley's farmland would result in less Colorado River water being used by PVID. The amount of water conserved by the program would be determined on an annual basis by a verification committee composed of MWD, PVID and Reclamation and would be made available for diversion by MWD at Lake Havasu through its CRA facilities.

Table 4.4-1
Cooperative Water Conservation/Transfer and Exchange Projects

Cooperative Water Conservation/ Transfer Project	*Annual Yield (AF)*	*Estimated Start Date*
IID/MWD 1988 Agreement	100,000 – 110,000[1]	On-going
IID/SDCWA Water Conservation and Transfer Agreement	130,000 – 200,000[2]	2002
CVWD/MWD SWP Water Transfer/Colorado River Water Exchange	35,000	2002
Coachella Canal Lining – MWD/SLR[3]	26,000[3]	2005[4]
All American Canal Lining – MWD/SLR[3]	67,700[3]	2006[4]
CVWD/IID/MWD Water Conservation and Transfer (First 50 KAFY and Second 50 KAFY)[5]	100,000[5]	2007
TOTAL	**458,700 – 538,700**	—

***Notes*:**

(1) Yield to MWD, except for 20 KAFY to be made available to CVWD under the IA and QSA.

(2) Yield to SDCWA; will ramp up at 20 KAFY during project implementation.

(3) Yield to MWD of 21.5 and 56.2 KAFY from Coachella Canal and All American Canal lining projects, respectively; and to the San Luis Rey Indian Water Rights Settlement Parties of 4.5 and 11.5 KAFY from the Coachella Canal and All American Canal lining project, respectively.

(4) Date by which full conservation benefits will be achieved.

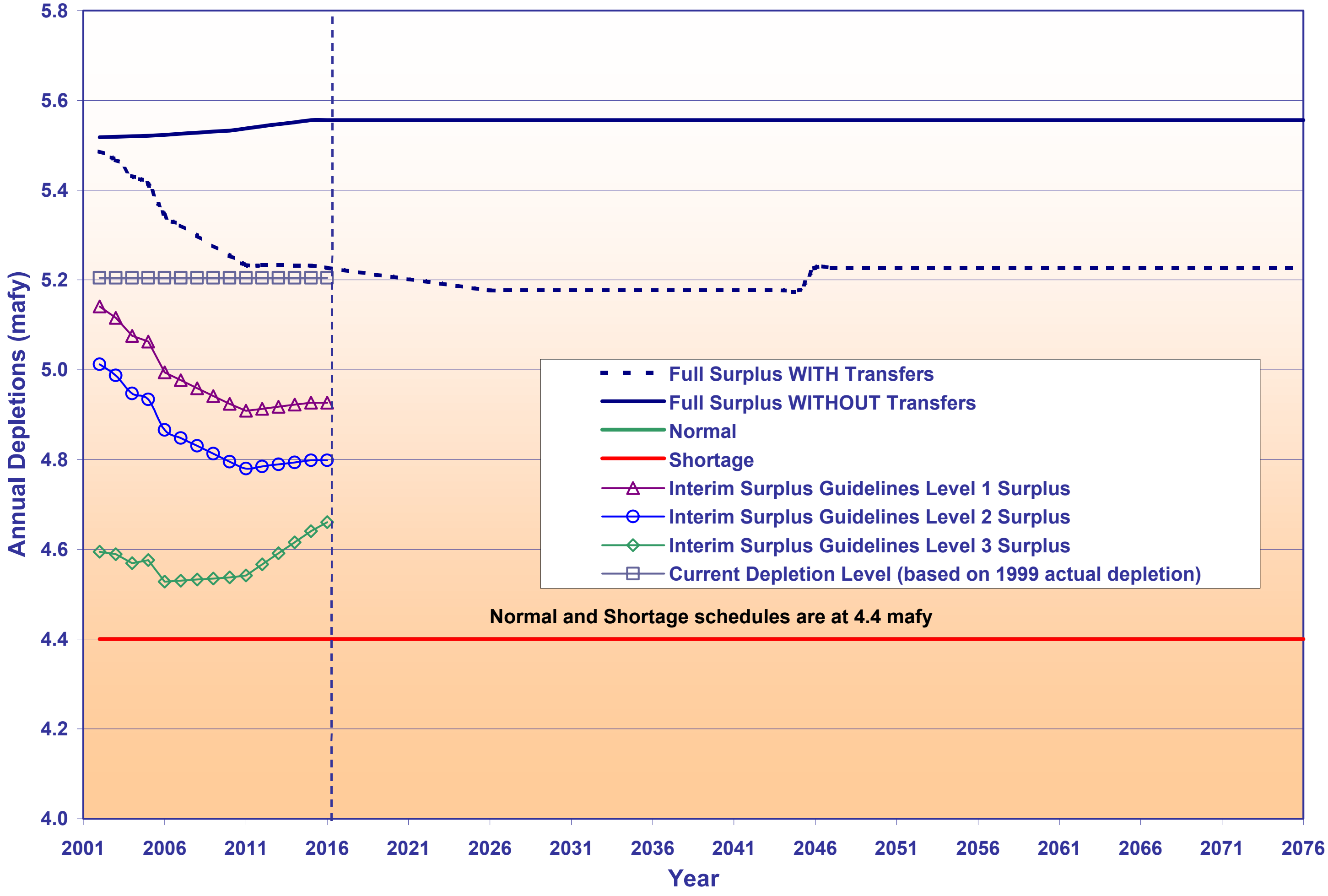
(5) Yield to CVWD; will ramp up at 5 KAFY during project implementation. MWD has option to utilize part or all water not utilized by CVWD.

Figure 4.4-2 presents a graphical illustration of California's full surplus, normal and first level shortage demand schedules that were used as input to the model. Two full surplus depletion schedules are shown (with and without transfers). These two surplus schedules consider the fact that California anticipates a 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 toward its normal apportionment of 4.4 mafy.

However, California’s full surplus schedule that considers the proposed intrastate water transfers is substantially less than the full surplus schedule without the transfers over time. This reflects the additional cooperative programs that would increase the amount of water transferred from agricultural agencies to MWD. Therefore, as a result of the Quantification Settlement Agreement (QSA), the cooperative programs, and the proposed increased intrastate transfers, the full surplus depletion schedules for California are reduced while at the same time allowing MWD to continue to meet its users’ needs.

As illustrated by the graph, the interim surplus guidelines provide an opportunity to manage the surplus deliveries coincident with the management of Lake Mead water levels while at the same time, providing a structure whereby total deliveries to California are reduced. These reductions are significant when compared to California’s current depletion level of 5.2 mafy, also shown on Figure 4.4-2. Both California’s normal and Level 1 shortage condition water depletion schedules are at 4.4 maf throughout the period of analysis.

Figure 4.4-2
California Projected Colorado River Water Demand Schedules
(Full Surplus, Normal and Shortage Water Supply Conditions)



4.4.3 STATE OF NEVADA

The portion of Nevada that depends on Colorado River water is limited to southern Nevada, primarily the Las Vegas Valley and the Laughlin area further south. The Colorado River Commission and SNWA manage Nevada's Colorado River water supply. The SNWA coordinates the distribution and use of the water by its member agencies whose systems provide retail distribution.

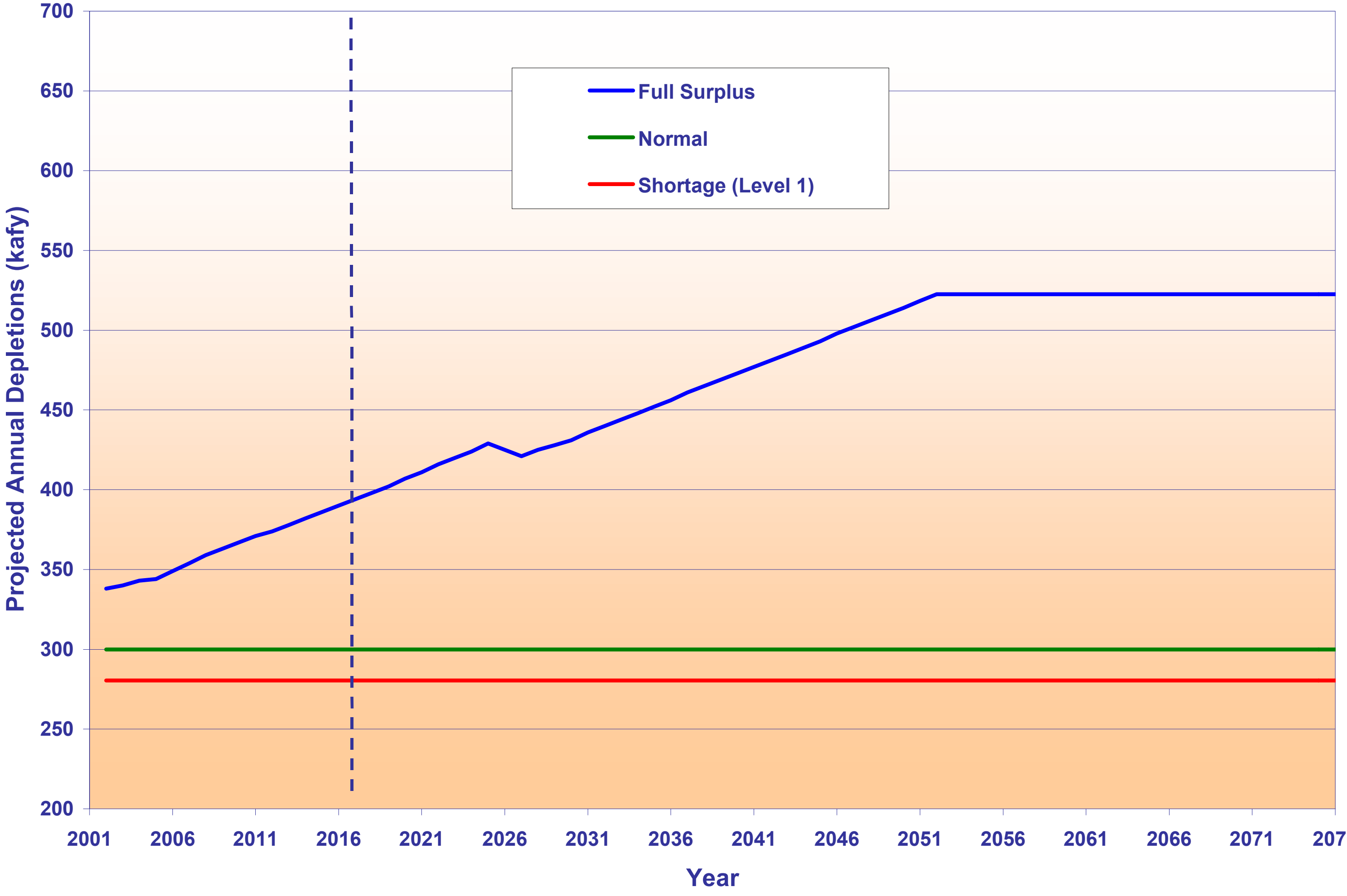
Nevada has five principal points of diversion for Colorado River water. The largest of these is the Las Vegas Valley that pumps water from Lake Mead at Saddle Island (on the west shore of the lake's Boulder Basin) through facilities of SNWA. The water is pumped at two adjacent pumping plants. The Lake Mead minimum water surface elevations for each intake are 1050 feet msl and 1000 feet msl, respectively. The pumped water is treated before being distributed to the Las Vegas Valley and to Boulder City water distribution systems. Three other diversion points are downstream of Davis Dam. They serve the community of Laughlin, Southern California Edison's coal fired Mohave Generating Station and uses on that portion of the Fort Mojave Indian Reservation lying in Nevada. The fifth diversion consists of water used by federal agencies in Nevada, primarily the National Park Service and its concessionaires at various points on lakes Mead and Mohave.

Nevada’s current Colorado River water demand is currently at or slightly above its Colorado River normal water apportionment under the BCPA and the Decree of 300,000 afy. SNWA depletions represent approximately 90 percent of this amount. Figure 4.4-3 presents a graphical illustration of the full surplus, normal and first level shortage demand schedules for Nevada that were used as input to the model.

Nevada's water demand projections for full surplus years rise steadily from a current value of approximately 338,000 af to approximately 514,000 af in approximately 50 years and remains at that level thereafter. Projected depletions under Level 1 Shortage Conditions are approximately 282,000 afy over the period of analysis, reflecting the fact that Nevada’s reduction in consumptive use of Colorado River water is four percent of the total shortage during shortage years.

SNWA's Integrated Resource Plan calls for optimizing both the use of Colorado River water and the use of the Las Vegas Valley shallow aquifer before developing water from additional sources, including the lower Virgin River and Muddy River. The SNWA has been supporting groundwater recharge in the Las Vegas Valley through facilities of member agencies. The artificial recharge of Colorado River water into the Las Vegas Valley groundwater basin is intended to help meet summer peak demands, provide an interim future water supply, and stabilize declining groundwater tables. Water agencies in the valley will be able to withdraw water to meet temporary shortfalls in supply. However, such withdrawals would be coupled with the opportunity for replenishment of the aquifer.

Figure 4.4-3
Nevada Projected Colorado River Water Demand Schedules
(Full Surplus, Normal and Shortage Water Supply Conditions)



Nevada also proposes to bank water in Arizona through arrangements with the AWBA using available groundwater storage capacity as described above in the discussion of alternate supplies for Arizona.

4.4.4 UPPER BASIN STATES

The depletions for the Upper Basin states were developed and submitted by the Upper Colorado River Commission (Commission) to Reclamation in December 1999. These depletions were then modified in coordination with the Commission to include updated Indian Tribe depletions provided by Keller-Bliessner Engineering, acting on behalf of the Indian Tribes with Colorado River water rights, during the preparation of the Interim Surplus Guidelines FEIS. Figure 4.4-4 shows that the Upper Basin depletions are approximately at 4.278 maf in 2002, increase gradually to approximately 5.429 maf by 2060 and for modeling purposes, are assumed to remain at that level thereafter. These depletions do not include the evaporation losses that occur within the Upper Basin and that are estimated to be approximately 574,000 afy. The Upper Division depletion schedule that includes the estimated evaporation losses are presented in tabular form in Attachment B. The modeled depletions as shown on Figure 4.4-4 and presented in Attachment B are consistent with the Upper Division states' apportionment of Colorado River water.

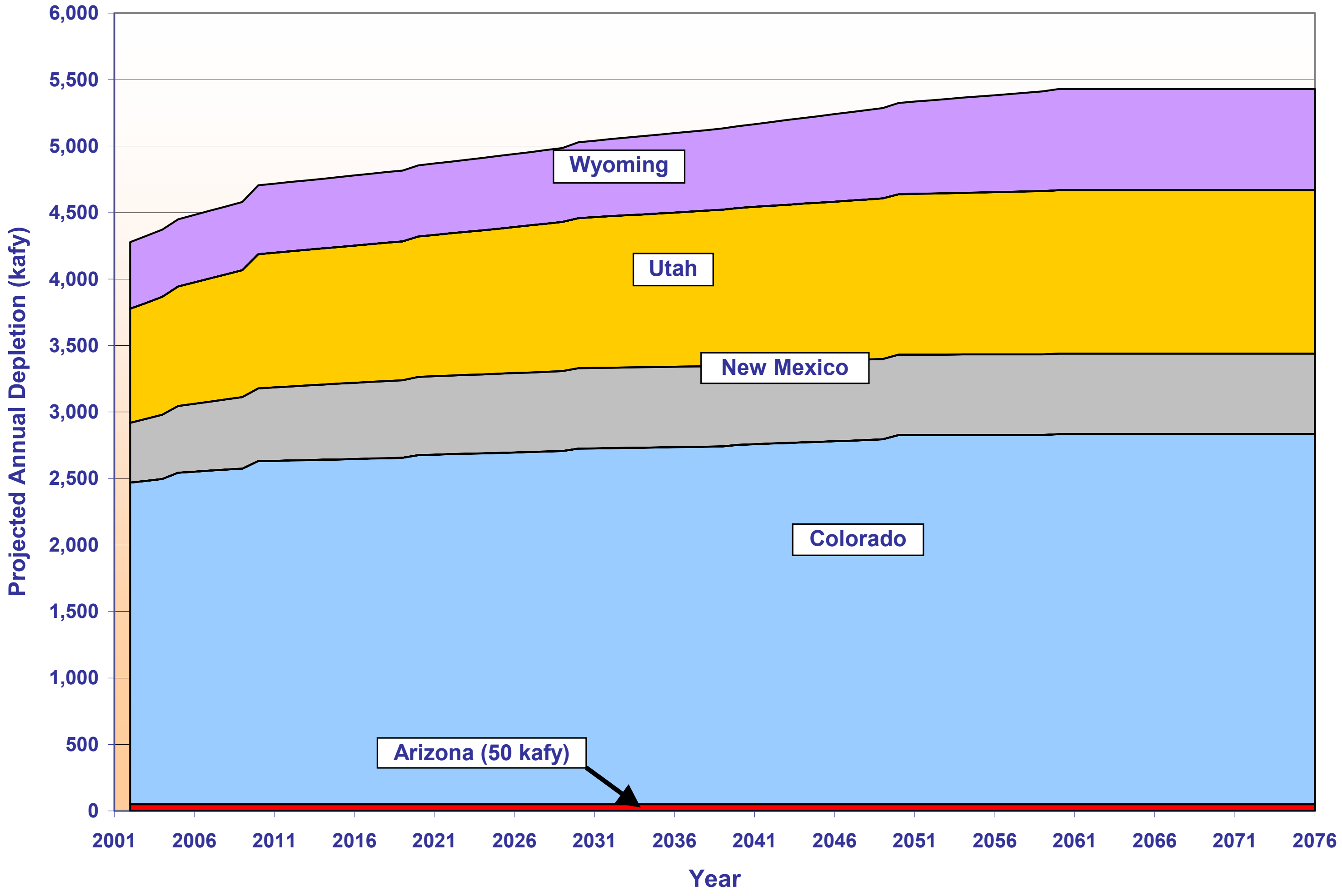
4.4.5 MEXICO

Mexico has a Treaty entitlement to Colorado River water. This entitlement is set forth in Article 10 of the 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 af (1,850,234,000 cubic meters) to be delivered in accordance with the provisions of Article 15 of this Treaty.

Figure 4.4-4
Upper Basin Depletion Projections
(Based on 1999 Depletion Schedule)



> (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 af (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 af (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 af (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 af (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 acre-feet (1,677,545,000 cubic meters) annually upstream of Morelos Dam and approximately 140,000 acre-feet (172,689,000 cubic meters) annually on the land boundary at San Luis and in the limitrophe section of the Colorado River downstream from Morelos Dam. It should be noted that while a portion of Mexico's 1.5 maf annual apportionment is actually delivered below Morelos Dam, the entire delivery to Mexico was modeled at Morelos 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 Conditions and Implementation Agreement Conditions.

4.5 ANALYSIS OF WATER TRANSFERS

The following discussion is based on the results of analysis of water supply data generated by the model. This section describes the results of the analysis that evaluated the effect of water transfers on the water deliveries to each of the Lower Basin states. The modeled operational scenarios that are used to evaluate the effects of water transfers in this section include the No Action and the Implementation Agreement conditions.

4.5.1 STATE OF ARIZONA

This section presents the simulated water deliveries to Arizona under the no action and implementation modeled scenarios. The analysis of Arizona's water supply concentrated on total Arizona water depletions.

4.5.1.1 MODELING RESULTS OF NO ACTION

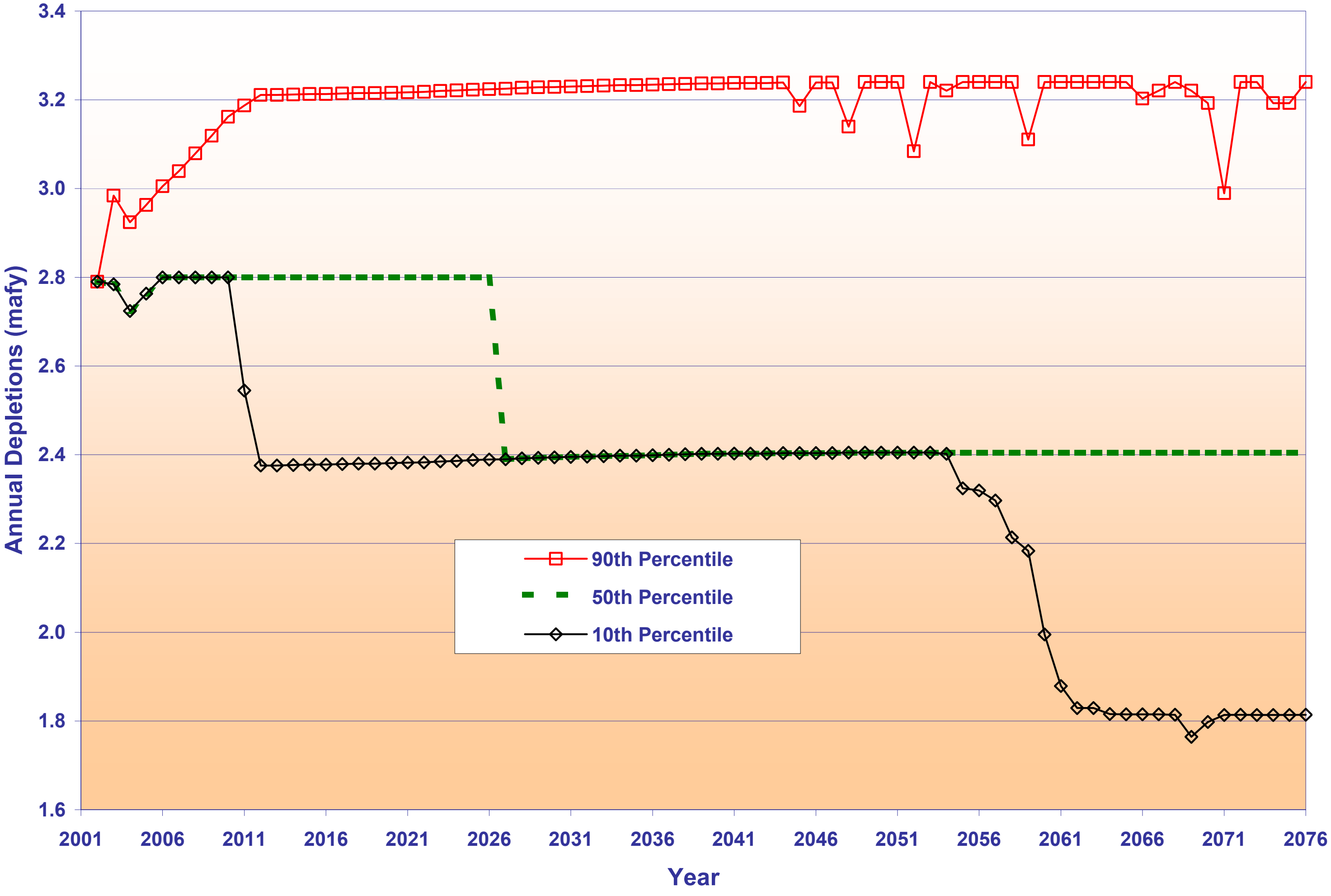
The water deliveries to Arizona are projected to fluctuate throughout the 75-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50th and 10th percentile ranking of modeled water deliveries to Arizona under the no action conditions are presented in Figure 4.5-1.

With the exception of the first year modeled (2002), the 90th percentile line coincides with Arizona's depletion schedule during full surplus water supply conditions through year 2045 (compare Figure 4.5-1 to Figure 4.4-1). As indicated by this 90th percentile line, the probability that the No Action Conditions would provide Arizona's full surplus depletion schedule is at least 10 percent during this period. After year 2045, the 90th percentile line occasionally falls below the full surplus schedule albeit still remains close to Arizona's depletion schedule during full surplus water supply conditions and generally well above 3.0 mafy.

The 50th percentile line represents the median annual depletion values. This 50th percentile line generally coincides with Arizona's projected depletion schedule under normal water supply conditions through year 2025 (see Figure 4.4-1). After 2025, the median values drop to approximately 2.4 maf and remain at approximately that level for the remainder of the 75-year period of analysis.

As noted in Section 4.4.1, under shortage conditions, Arizona would bear 96 percent of the reduction and Nevada would bear four percent. In Arizona, the reduction would be shared prorata among CAP and non-CAP holders of fourth priority entitlements. To simplify the modeling process, the model sets the CAP's shortage water supply condition deliveries at 1.0 maf when the Lake Mead water level is between elevation 1000 feet msl and the assumed shortage protection line as discussed in Section 2.4. This modeling assumption kept Arizona's annual deliveries above 2.4 maf until further cuts to the CAP were necessary to maintain the Lake Mead water level above the 1000 feet msl elevation (a Level 2 shortage condition). Under the No Action modeled scenario, Level 2 shortage condition deliveries to Arizona (below 2.3 mafy) were observed to occur only during years 2054 to 2075 and occurred less than eight percent of the time.

Figure 4.5-1
Arizona Modeled Annual Depletions Under No Action Conditions
90th, 50th and 10th Percentile Values



4.5.1.2 COMPARISON OF IMPLEMENTATION AGREEMENT TO NO ACTION

Figure 4.5-2 provides a comparison of the distribution of Arizona's depletions under the Implementation Agreement to those of the No Action conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016). This type of graph is used to represent the frequency that annual deliveries of different magnitudes occur in the respective period. The results presented in Figure 4.5-2 indicate a 70 percent probability that Arizona’s depletions would meet or exceed its normal depletion schedule during this period under No Action conditions. The probability that Arizona would receive surplus condition deliveries during this period was approximately 23 percent. The maximum surplus condition depletions under the No Action Conditions were 3.213 maf during this period. The probability that Arizona would receive shortage condition deliveries was 30 percent. The minimum shortage condition depletion was 2.375 maf during this 15-year period.

Figure 4.5-3 provides a comparison of the distribution of the water deliveries to Arizona under the Implementation Agreement to those of the No Action conditions for the 60-year period (years 2017 to 2076) that would follow the Interim Surplus Guidelines period. The results presented in Figure 4.5-3 indicate a 37 percent probability that water deliveries to Arizona would meet its normal depletion schedule during this period under the No Action conditions. The probability that Arizona would receive surplus condition deliveries during this same period under the No Action conditions was approximately 18 percent. The maximum surplus condition depletions under the No Action Conditions were 3.24 maf during this period. The probability that Arizona would receive deliveries less than its normal schedule (Level 1 or Level 2 shortage condition deliveries) was 63 percent. Second level shortage conditions occurred less than 11 percent of the time during this 60-year period. The minimum shortage condition depletion was 1.405 maf.

Figure 4.5-4 provides a comparison of the distribution of the water deliveries to Arizona under the Implementation Agreement conditions to those of the No Action conditions for the entire 75-year period of analysis (years 2002 to 2076). The results presented in Figure 4.5-4 indicate a 44 percent probability that water deliveries to Arizona would meet its normal depletion schedule during this period under the No Action conditions. The probability that Arizona would receive surplus condition deliveries during this same period under the No Action conditions was approximately 19 percent. The maximum surplus condition depletions under the No Action Conditions were 3.24 maf during this period. The probability that Arizona would receive deliveries less than its normal schedule (Level 1 or Level 2 shortage condition deliveries) was 56 percent. Second level shortage conditions occurred less than nine percent of the time during this 75-year period. The minimum shortage condition depletion under the No Action conditions was 1.405 maf.

Figure 4.5-2
Arizona Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2002 to 2016

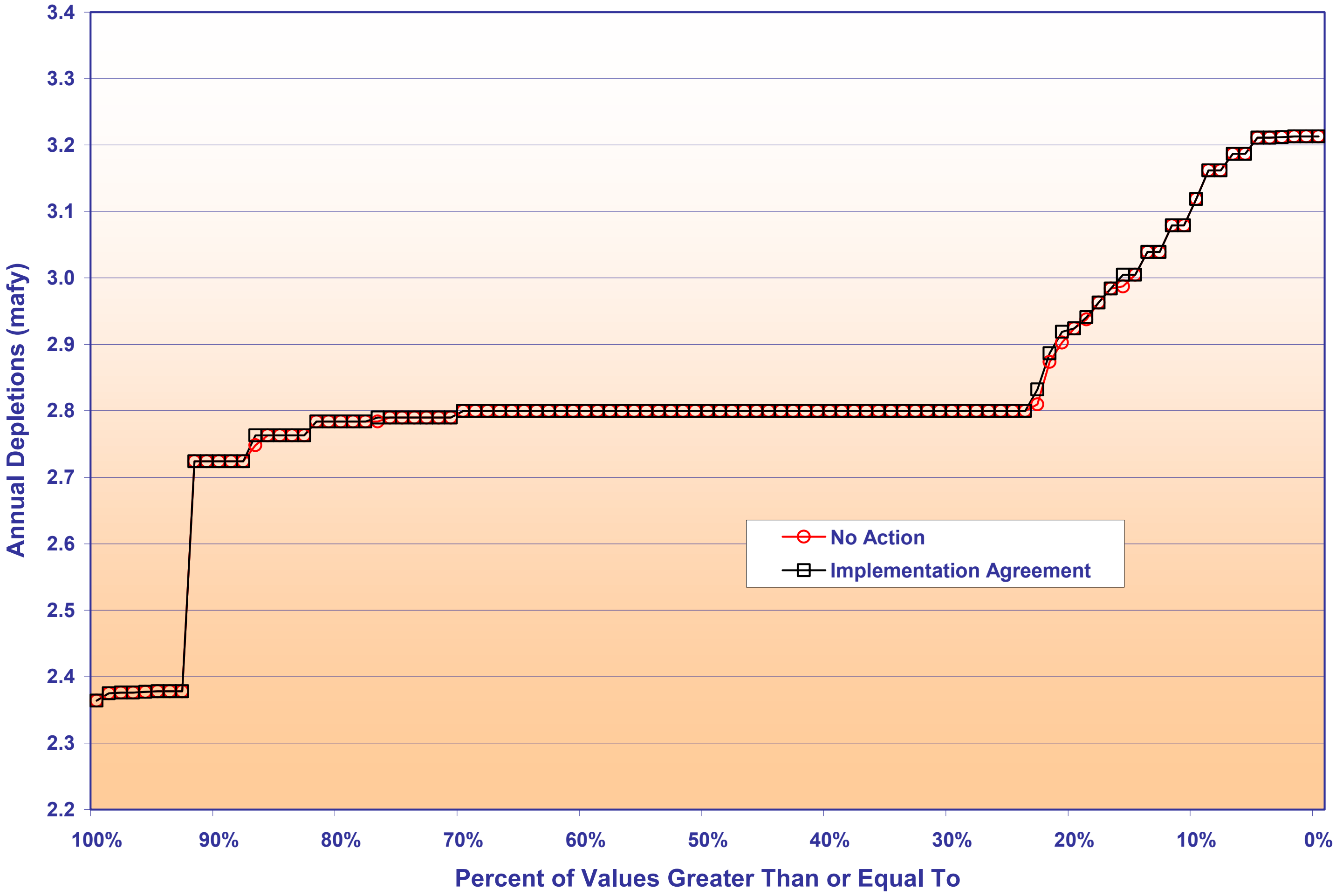


Figure 4.5-3
Arizona Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2017 to 2076

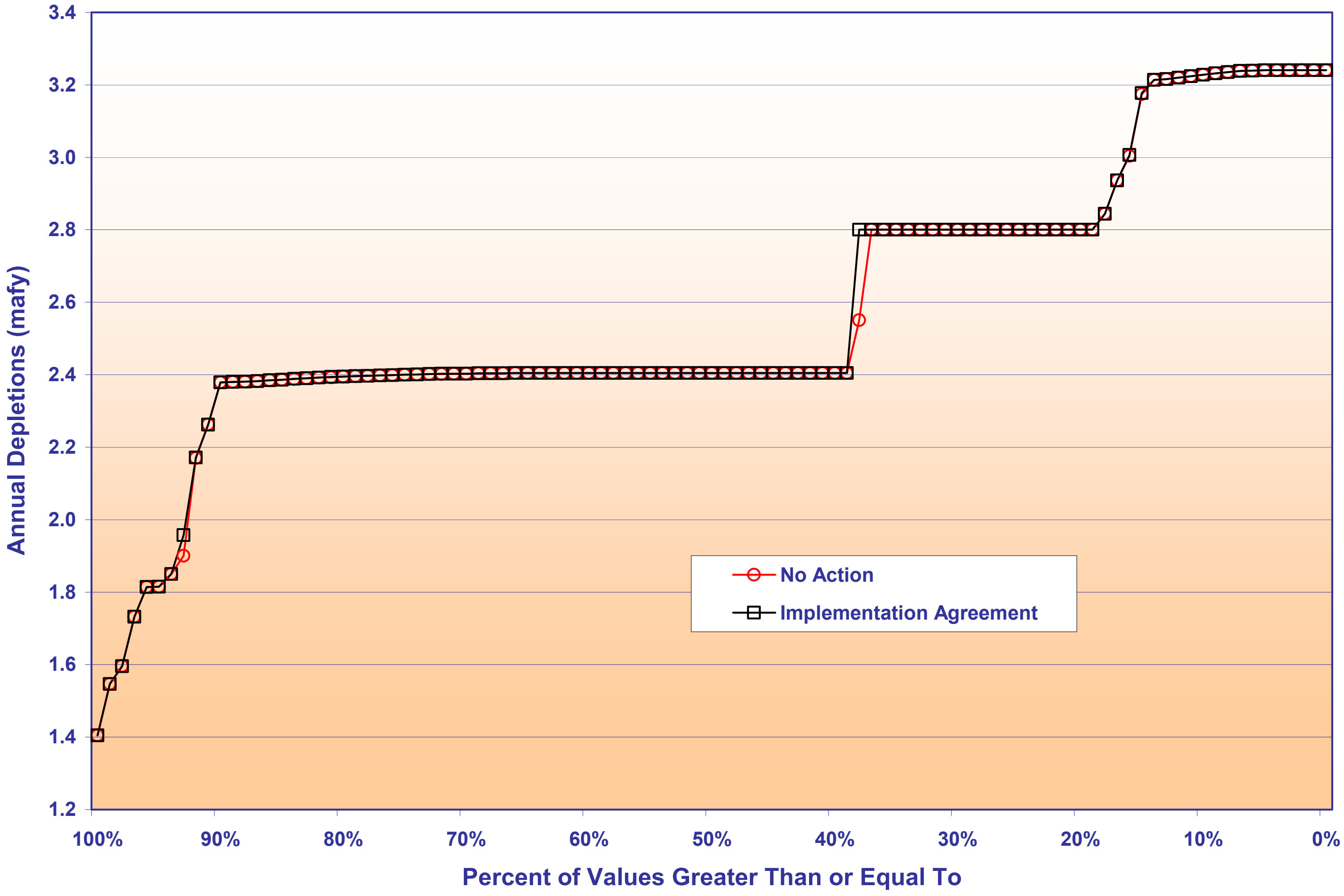


Figure 4.5-4
Arizona Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2002 to 2076

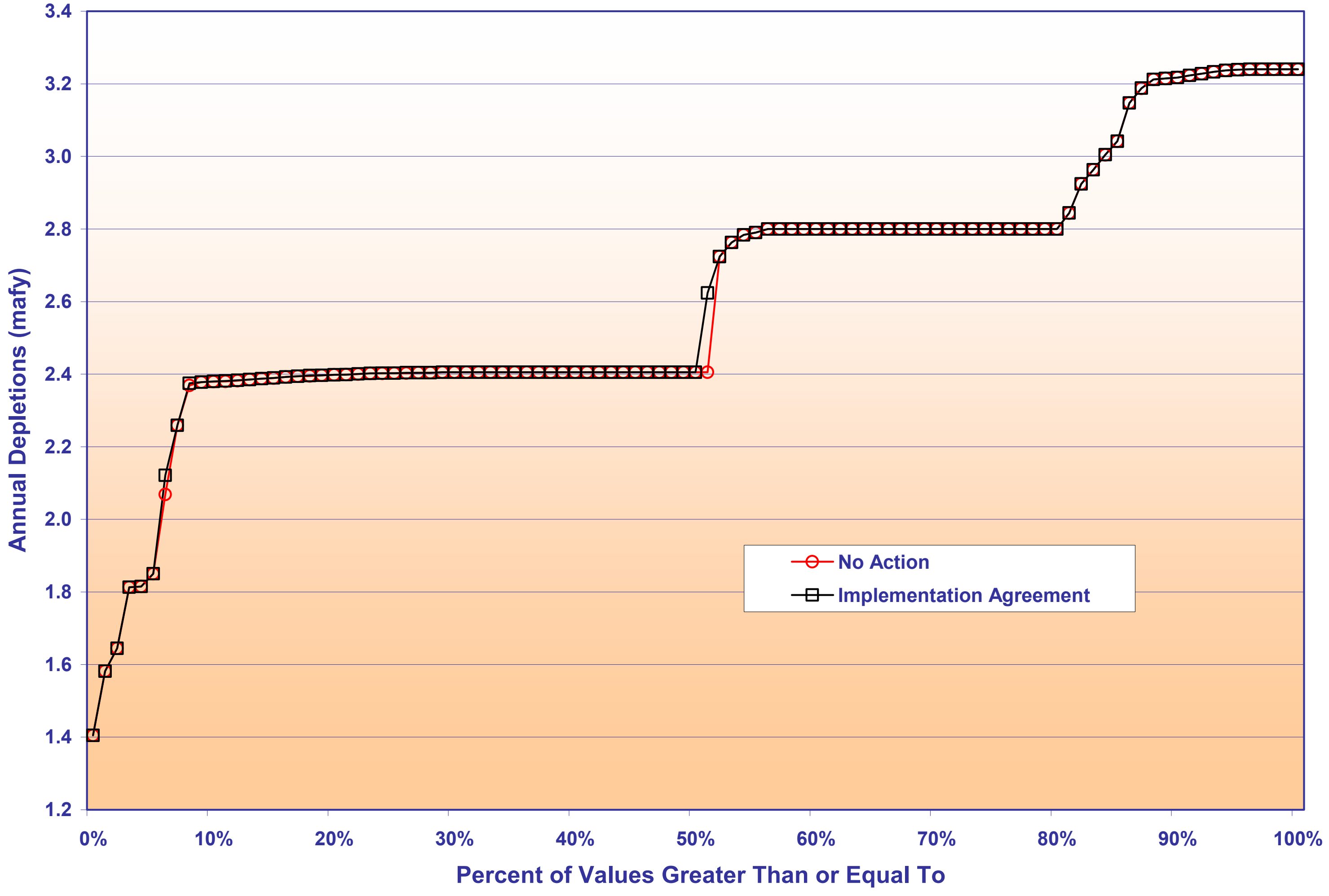


Figure 4.5-5 provides a comparison of the 90th, 50th and 10th percentile values for Arizona's modeled depletions under the No Action conditions to those of the Implementation Agreement conditions. As depicted in Figure 4.5-5, there is little difference in the 90th percentile lines resulting from the Implementation Agreement conditions as compared to those of the No Action conditions. The 90th percentile lines generally coincide with Arizona's full surplus depletion schedule.

The 50th percentile lines for the No Action and Implementation Agreement conditions are identical to each other through year 2024 and coincide with Arizona's surplus depletion schedule during this period. After year 2024, the 50th percentile values for the No Action conditions fall due to increasing probability of the Level 1 shortage condition deliveries. The 50th percentile line for the Implementation Agreement conditions continue to coincide with the normal depletion schedule through year 2026. After 2026, the 50th percentile lines for the Implementation Agreement conditions also falls due to increasing probability of the Level 1 shortages. The 50th percentile values for the No Action and Implementation Agreement conditions remain at approximately 2.4 mafy after year 2027.

The 10th percentile lines for the No Action and the Implementation Agreement conditions are essentially at or above Arizona's normal depletion schedule through year 2010. After 2010, the 10th percentile values of the No Action and the Implementation Agreement conditions begin to drop down to the Level 1 shortage condition delivery values (approximately 2.4 mafy) and remain at this level through 2053. After 2053, the 50th percentile lines for the No Action and the Implementation Agreement conditions decrease further due to increasing probability of the Level 2 shortage condition deliveries.

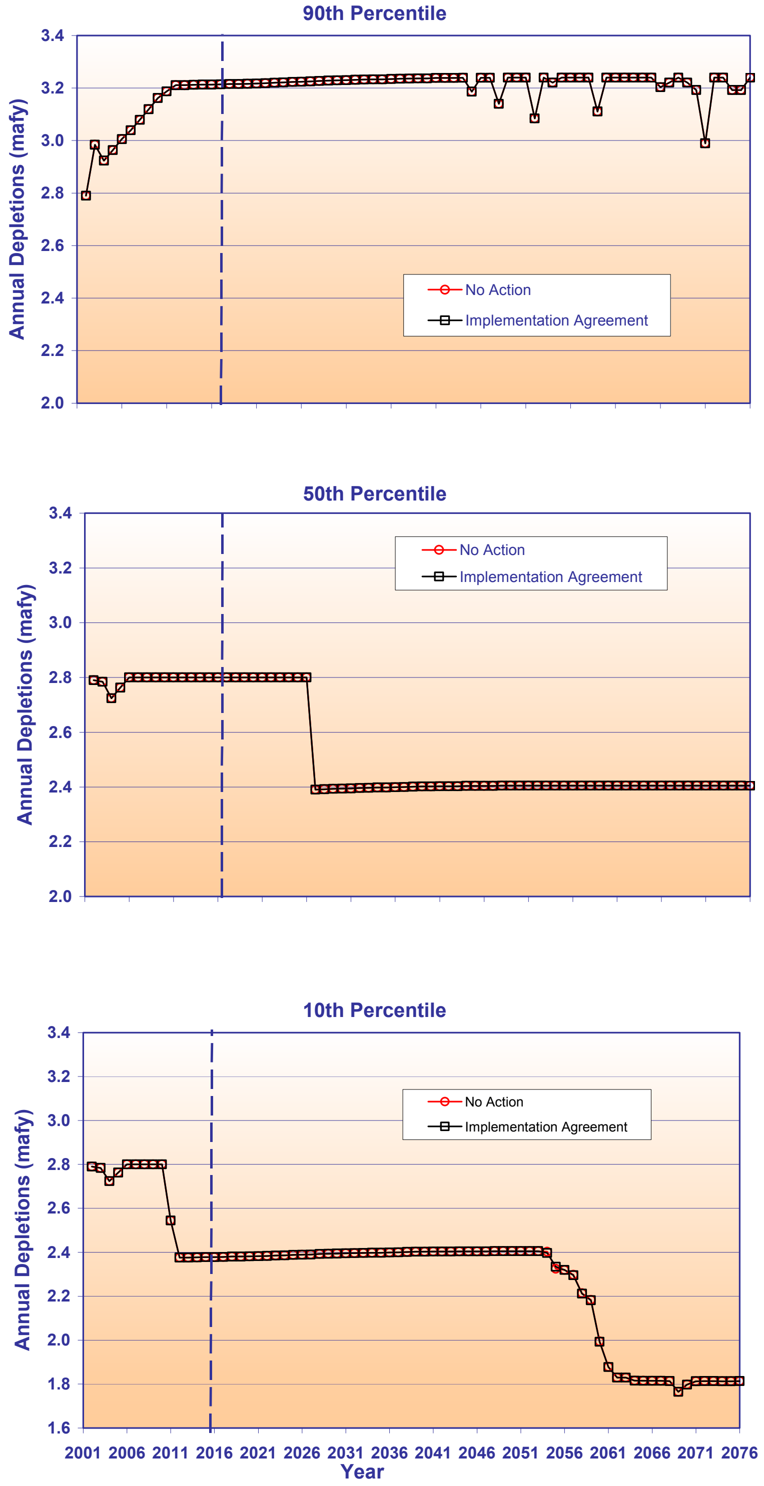
Figures 4.5-2, 4.5-3 and 4.5-4 presented comparisons of the distribution of Arizona's depletions under the No Action and the Implementation Agreement conditions during the15-year Interim Surplus Guidelines period (years 2002 to 2016), the 60-year period that follows the Interim Surplus Guidelines (years 2017 to 2076), and the entire period of analysis (years 2002 to 2076), respectively. These graphs best illustrate the frequency that different amounts of annual Arizona water deliveries occur over these time frames. Table 4.5-1 provides a summary of the comparison for these three time periods.

Table 4.5-1
Summary of Arizona Modeled Annual Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions

	Years 2002 to 2016			Years 2017 to 2076			Years 2002 to 2076		
Alternative/Conditions	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**
No Action	70%	23%	30%	37%	18%	63%	44%	19%	56%
Implementation Agreement	70%	23%	30%	38%	18%	62%	44%	19%	56%

*The values under normal represent the total percentage of time that depletions would be at or above the normal depletion conditions.

Figure 4.5-5
Arizona Modeled Annual Depletions
Comparison of No Action Conditions to Implementation Agreement Conditions
90th, 50th and 10th Percentile Values



The percentage values presented under the column heading labeled “Normal” in Table 4.5-1 represent the total percentage of time that depletions under the noted conditions would be at or above the normal depletion schedule amount. The values presented under the column labeled “Surplus” represent the total percentage of time that depletions under the noted conditions exceed the normal depletion schedule amount. The values presented under the column labeled “Shortage” represent the total percentage of time that depletions under the noted conditions would be below the normal depletion schedule amount.

4.5.2 STATE OF CALIFORNIA

This section presents the simulated water deliveries to California under the No Action and Implementation Agreement conditions. The analysis of California's water supply concentrated on total California water depletions.

4.5.2.1 MODELING RESULTS OF NO ACTION

The water deliveries to California are projected to fluctuate throughout the 75-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50th and 10th percentile rankings of modeled water deliveries to California under the No Action Conditions are presented in Figure 4.5-6. The actual reported (historical) depletions (for years 1990 to 2001) have been added to this graph to provide a benchmark for comparison of the projected future depletion trends.

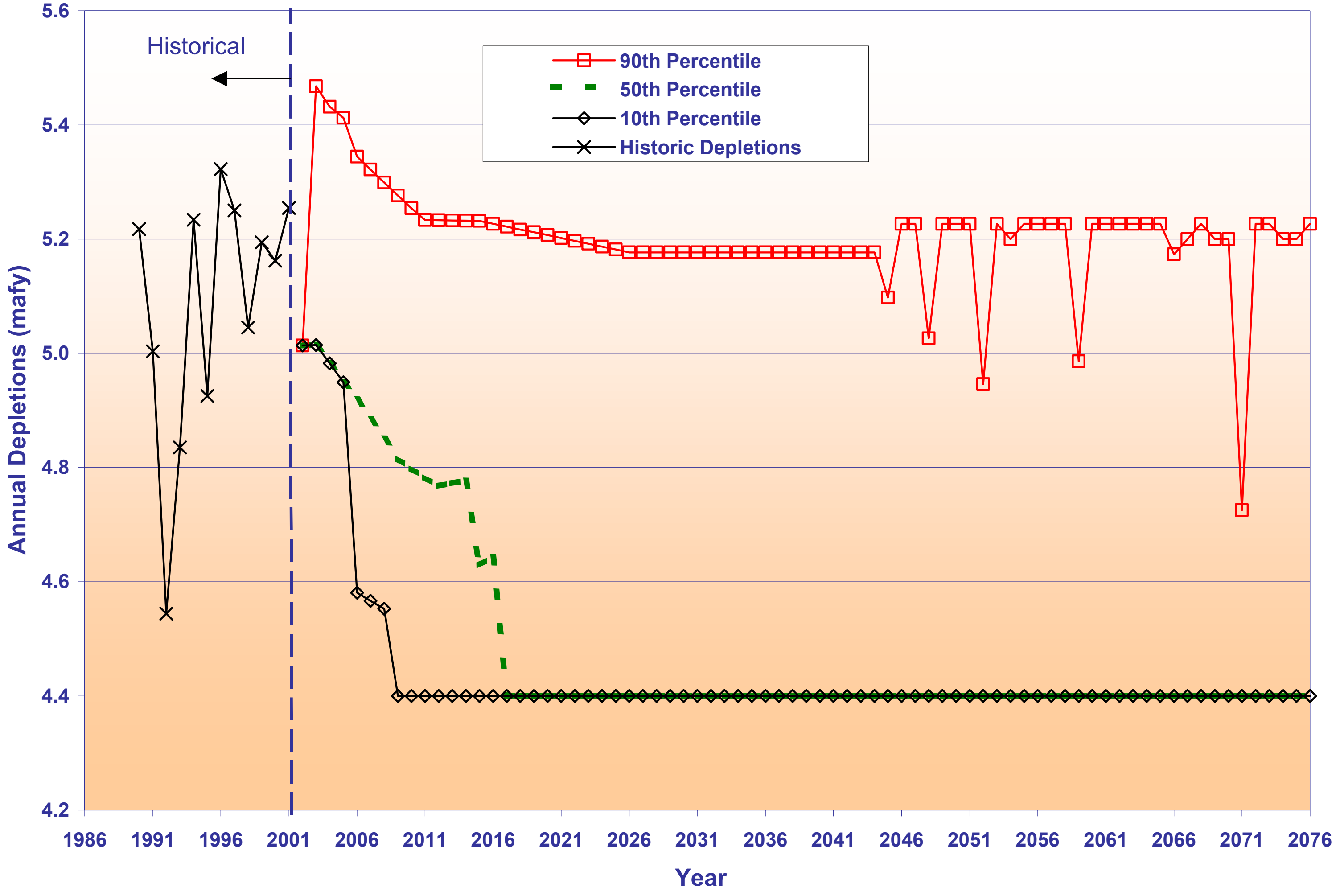
The 90th percentile values generally coincide with California's depletion schedule during full surplus water supply conditions through year 2044. The 90th percentile line represents the magnitude of surplus condition deliveries that would be available at least 10 percent of the time throughout the 75-year period of analysis. After year 2044, the 90th percentile line occasionally falls below the full surplus schedule, an indication of the occurrence of more frequent limited surplus conditions.

From 2002 through 2016, under No Action Conditions, the 50th percentile line for California is above the normal depletion schedule suggesting a better than average probability of surplus condition deliveries. After 2016, the 50th percentile line coincides with California's normal depletion schedule.

From 2002 through 2008, under No Action Conditions, the 10th percentile line for California is also above the normal depletion schedule suggesting at least a 90 percent probability of surplus condition deliveries during this period. After 2008, the 10th percentile line coincides with California's normal depletion schedule.

Annual water deliveries to California were observed to fall below California's normal apportionment of 4.4 maf (a Level 2 shortage condition) less than one percent of the time throughout the 75-year period of analysis. The minimum delivery observed under the No Action conditions was 3.847 maf.

Figure 4.5-6
California Modeled Annual Depletions Under No Action Conditions
90th, 50th and 10th Percentile Values



4.5.2.2 COMPARISON OF IMPLEMENTATION AGREEMENT TO NO ACTION

Figure 4.5-7 provides a comparison of the distribution of the observed California depletions under the Implementation Agreement Conditions to those of the No Action Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016). These graphs are best used to represent the frequency that different magnitude annual water deliveries to California occur in the respective period. The results presented in Figure 4.5-7 indicate a 100 percent probability that California's depletions would meet its normal depletion schedule during this period under the No Action Conditions. The probability that California would receive surplus condition deliveries (any amount greater than 4.4 mafy) during this period under No Action Conditions was approximately 85 percent. The maximum surplus condition depletions observed under the No Action Conditions were 5.468 maf during this 15-year period.

Figure 4.5-8 provides a comparison of the distribution of the water deliveries to California under the Implementation Agreement Conditions to those of the No Action Conditions for the 60-year period (years 2017 to 2076) that follows the Interim Surplus Guidelines period. The results presented in Figure 4.5-8 indicate an approximate 99 percent probability that water deliveries to California would meet its normal depletion schedule during this period under the No Action Conditions. Only one trace was observed to fall below the normal depletion schedule, an indication of a Level 2 shortage condition. The minimum delivery observed under this trace was 3.847 maf. The probability that California would receive surplus condition deliveries during this same period under the No Action Conditions was approximately 18 percent. The maximum surplus condition depletions under the No Action Conditions were 5.227 maf during this 60-year period.

Figure 4.5-9 provides a comparison of the distribution of the water deliveries to California under the Implementation Agreement Conditions to those of the No Action Conditions for the entire period of analysis (years 2002 to 2076). The results presented in Figure 4.5-9 also indicate an approximate 99 percent probability that water deliveries to California would meet its normal depletion schedule under the No Action Conditions. Again, only one trace was observed to fall below the normal depletion schedule, an indication of a Level 2 shortage condition. The minimum delivery observed under this trace was 3.847 maf. The probability that California would receive surplus condition deliveries during this same period under the No Action Conditions was approximately 32 percent. The maximum surplus condition depletions under the No Action Conditions were 5.468 maf during this 75-year period.

Figure 4.5-7
California Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2002 to 2016

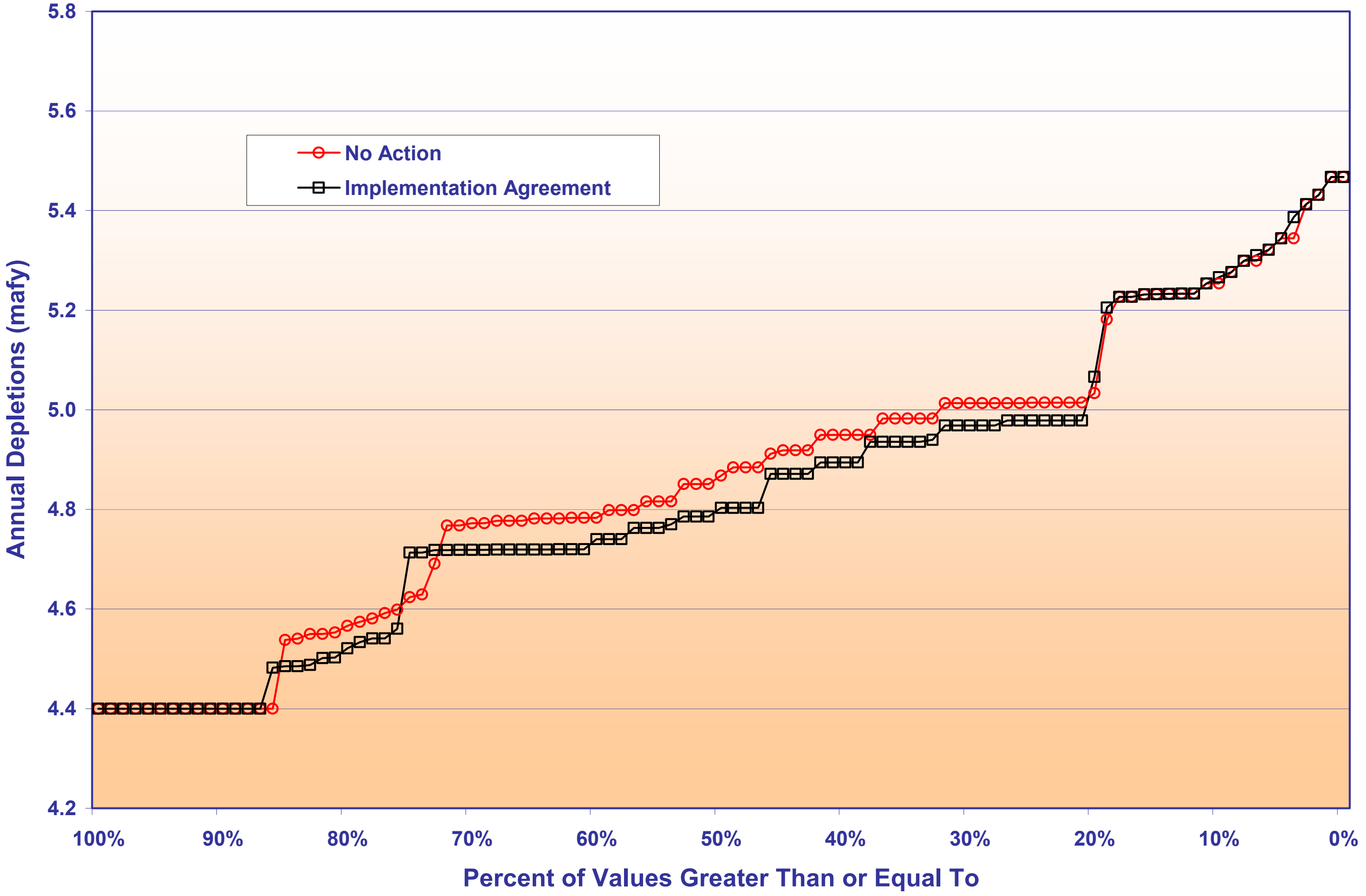


Figure 4.5-8
California Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2017 to 2076

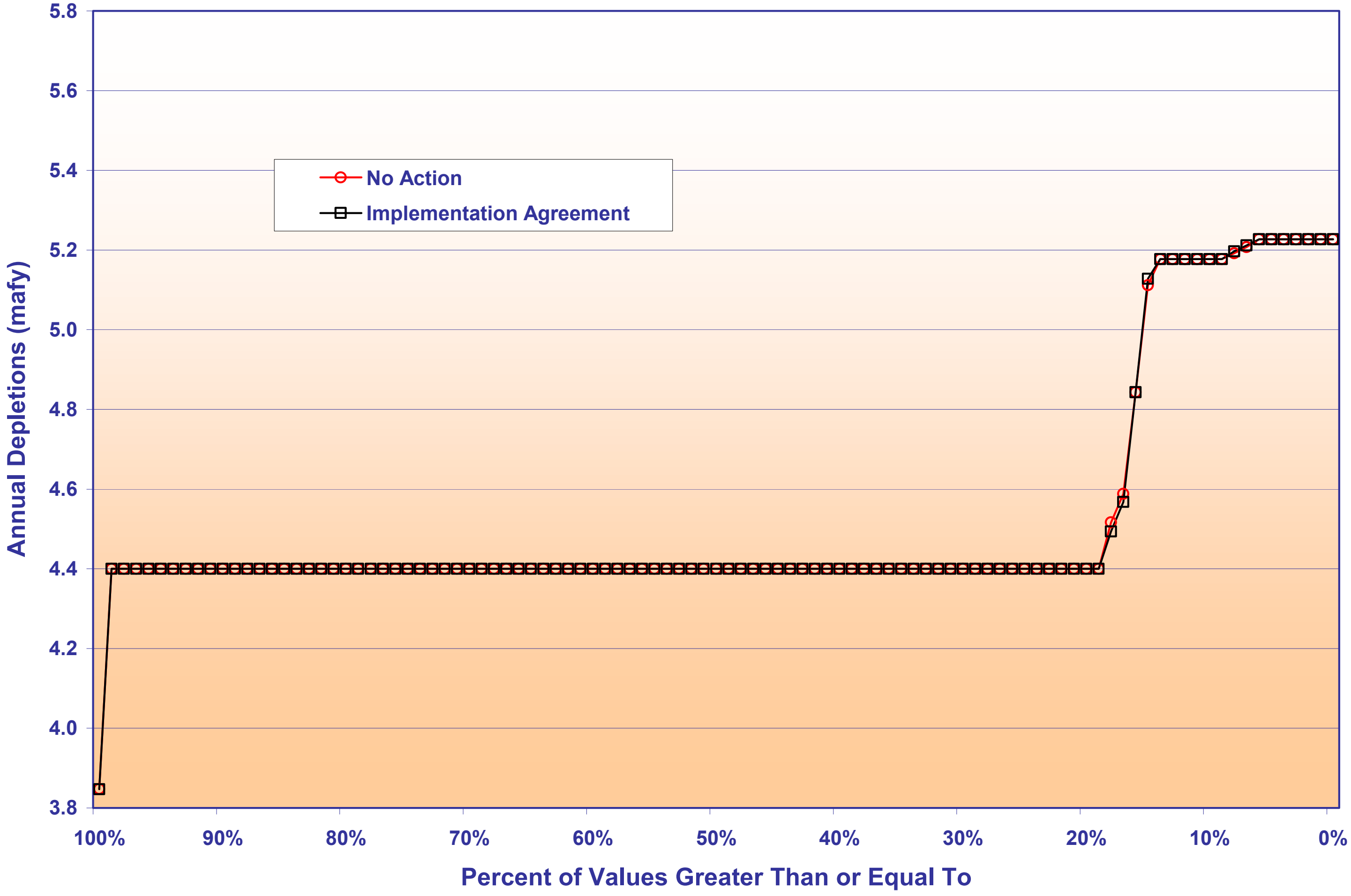


Figure 4.5-9
California Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2002 to 2076

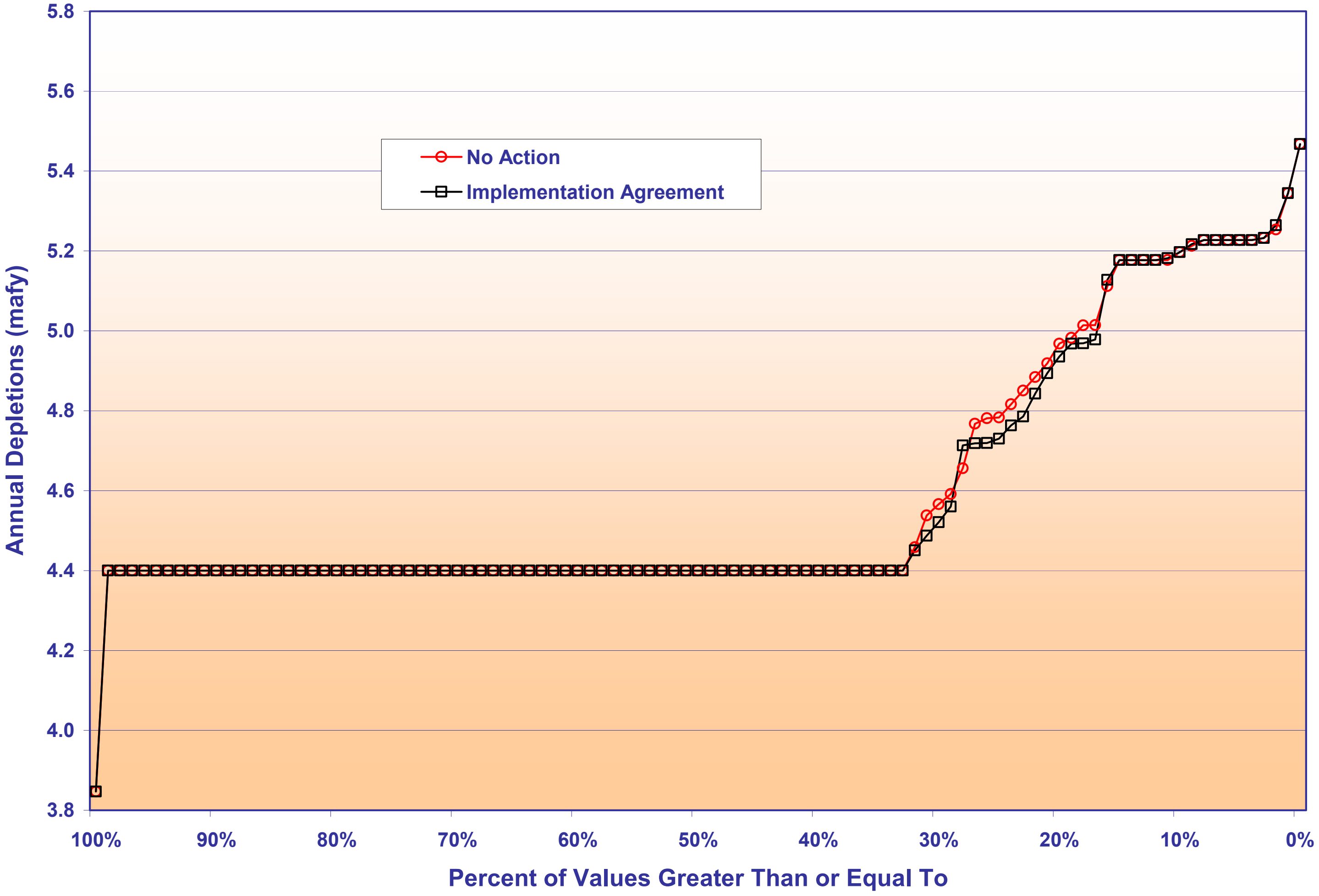


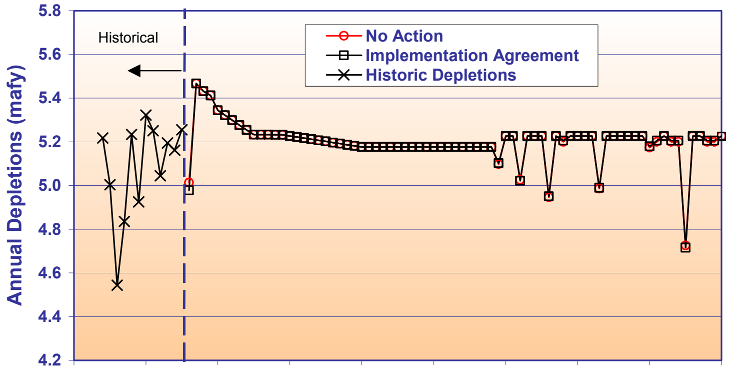
Figure 4.5-10 provides a comparison of the 90th, 50th and 10th percentile values for California's depletions under the Implementation Agreement Conditions to those of the No Action Conditions. The historical depletions (for years 1990 to 2001) have been added to this graph to provide a benchmark for comparison of the projected future depletion trends. As noted in Figure 4.5-10, there is little difference in the 90th percentile values resulting from the Implementation Agreement Conditions to those of the No Action Conditions. Both 90th percentile values generally coincide with California's depletion schedule during full surplus water supply conditions through year 2044. After year 2044, both 90th percentile lines occasionally fall below the full surplus schedule suggesting an increased probability of limited surplus conditions.

From 2002 through 2016, the 50th percentile lines for the Implementation Agreement and No Action conditions are above the normal depletion schedule suggesting a better than average probability of surplus condition deliveries. Comparing the two 50th percentile plots, it can be seen that with the Implementation Agreement California's depletions would reduce steadily during the initial years. In contrast, the depletions would remain higher under No Action conditions. After 2016, the 50th percentile lines for the Implementation Agreement and No Action conditions coincide with California's normal depletion schedule.

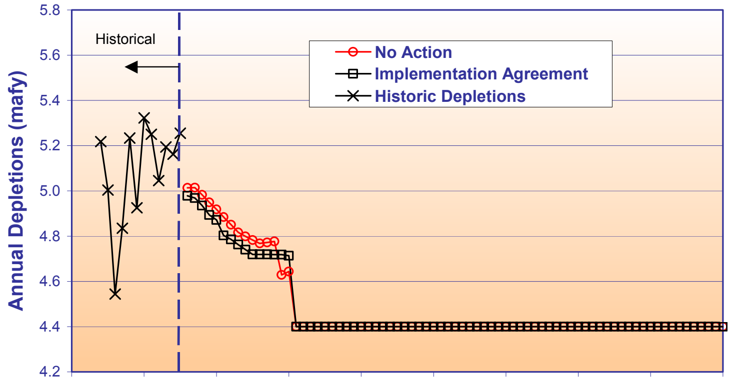
From 2002 through 2008, the 10th percentile lines for the Implementation Agreement and No Action conditions are generally above the normal depletion schedule, indicating a better than 90 percent frequency of surplus condition deliveries. The Implementation Agreement would result in a steady reduction in California's depletions in the initial years, in contrast to the No Action conditions. After 2008, the 10th percentile lines for the Implementation Agreement and No Action conditions coincide with California's normal depletion schedule.

Figure 4.5-10
California Modeled Annual Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
90th, 50th and 10th Percentile Values

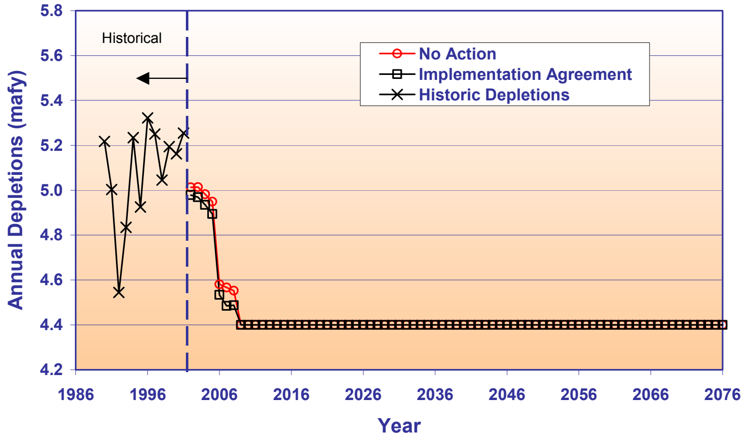
90th Percentile



50th Percentile



10th Percentile



Figures 4.5-7, 4.5-8 and 4.5-9 presented comparisons of the distribution of California's depletions under the Implementation Agreement Conditions to those of the No Action Conditions during the 15-year interim surplus guidelines period (years 2002 to 2016), the 60-year period that would follow the interim surplus guidelines (years 2017 to 2076) and the entire 75-year period of analysis (years 2002 to 2076), respectively. Table 4.5-2 provides a tabular summary and comparison for these three periods.

Table 4.5-2
Summary of California Modeled Annual Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions

Alternative/Conditions	Years 2002 to 2016			Years 2017 to 2076			Years 2002 to 2076		
	Normal*	Surplus	Shortage	Normal*	Surplus	Shortage	Normal*	Surplus	Shortage
No Action	100%	85%	0%	99%	18%	1%	99%	32%	<1%
Implementation Agreement	100%	86%	0%	99%	18%	1%	99%	32%	<1%

*The values under normal represent the total percentage of time that depletions would be at or above the normal depletion conditions.

The percentage values presented under the column heading labeled "Normal" in Table 4.5-2 represent the total percentage of time that depletions under the noted conditions would be at or above the normal depletion schedule amount. The values presented under the column labeled "Surplus" represent the total percentage of time that depletions under the noted conditions exceed the normal depletion schedule amount. The values presented under the column labeled "Shortage" represent the total percentage of time that depletions under the noted conditions would be below the normal depletion schedule amount.

4.5.3 STATE OF NEVADA

This section presents the simulated water deliveries to Nevada under the No Action Conditions and Implementation Agreement Conditions. The analysis of Nevada's water supply concentrated on total Nevada water depletions.

4.5.3.1 MODELING RESULTS OF NO ACTION

The water deliveries to Nevada are projected to fluctuate throughout the 75-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50th and 10th percentile ranking of modeled water deliveries to Nevada under the No Action Conditions is presented in Figure 4.5-11.

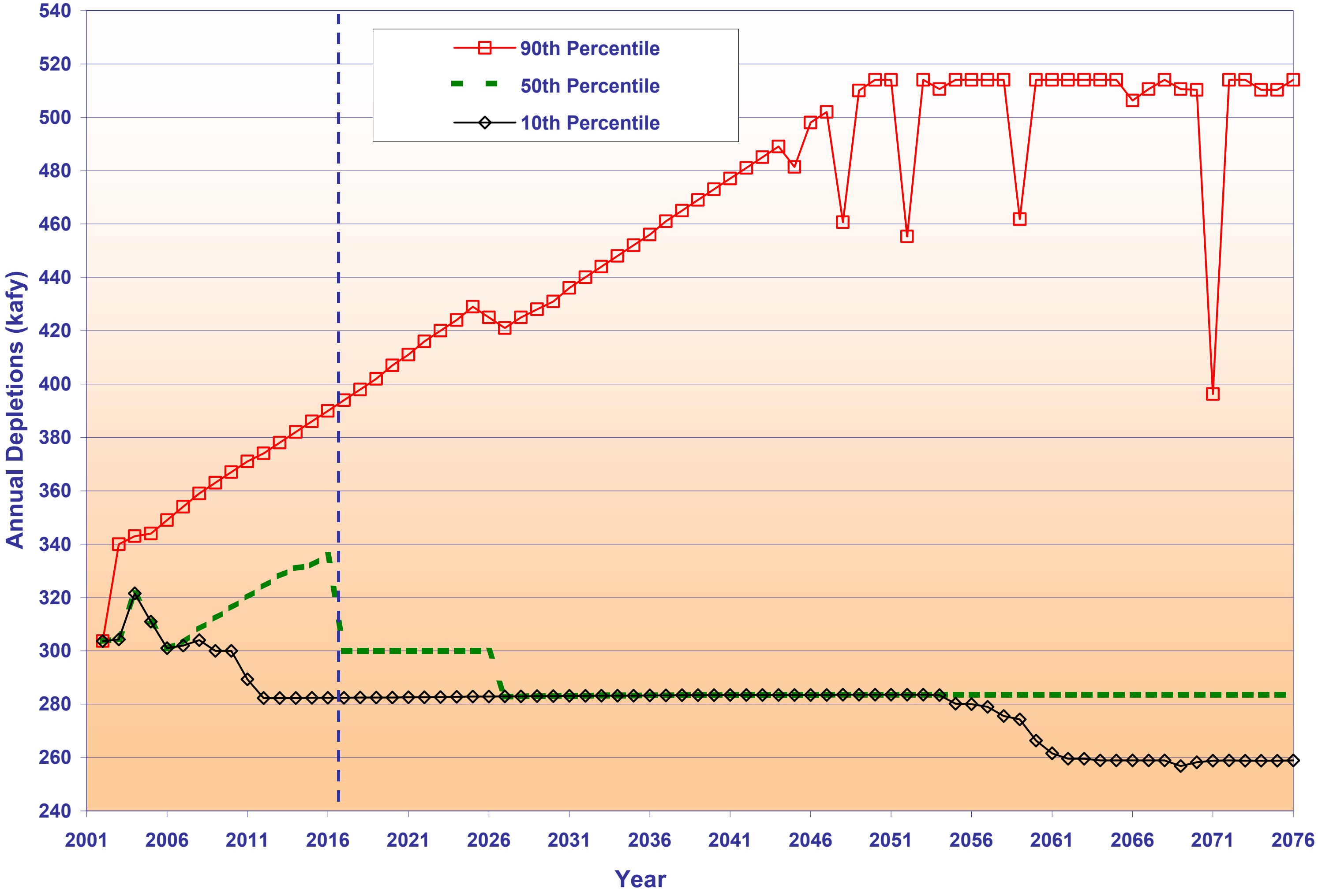
The 90th percentile values generally coincide with Nevada's normal depletion schedule under No Action Conditions through year 2045. After year 2045, the 90th percentile occasionally falls below the full surplus schedule, an indication of limited surplus conditions.

From 2002 through 2016, under No Action Conditions, the 50th percentile line for Nevada is at or above the normal depletion schedule suggesting a better than average probability of surplus condition deliveries. From 2017 through 2024, the 50th percentile line coincides with Nevada's normal depletion schedule. After 2024, the 50th percentile line coincides with Nevada's Level 1 shortage condition depletion schedule.

From 2002 through 2008, under No Action Conditions, the 10th percentile line for Nevada is also at or above the normal depletion schedule suggesting at least a 90 percent probability of surplus condition deliveries during this period. From 2009 through 2054, the 10th percentile line coincides with Nevada's Level 1 shortage condition depletion schedule. After 2054, under No Action Conditions, the 10th percentile begins to fall below 280 maf, an indication of frequent Level 2 shortage conditions.

As noted in Section 4.4.1, the SNWA and CAP essentially take all the reductions in water deliveries during shortage conditions (for modeling purposes). The model sets the SNWA's shortage condition delivery reductions to four percent of the total shortage condition delivery reduction amount when the Lake Mead water level is between elevation 1000 feet msl and the assumed shortage protection line as discussed in Section 2.3. This modeling assumption kept Nevada' annual delivery above 280 kaf until further cuts to the SNWA and CAP were necessary to maintain the Lake Mead water level above the 1000 feet msl elevation, a level 2 shortage condition. Under the No Action Conditions, deliveries to Nevada below 280 kaf occurred less than seven percent of the time during the 75-year period.

Figure 4.5-11
Nevada Modeled Annual Depletions Under No Action Conditions
90th, 50th and 10th Percentile Values



4.5.3.2 COMPARISON OF IMPLEMENTATION AGREEMENT TO NO ACTION

Figure 4.5-12 provides a comparison of the distribution of Nevada's depletions under the Implementation Agreement Conditions to those of the No Action Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016). This graph is best used to represent the frequency that different magnitude water deliveries to Nevada occurred during the 15-year Interim Surplus Guidelines period. The results presented in Figure 4.5-12 indicate an 92 percent probability that water deliveries to Nevada would meet or exceed its normal depletion schedule during this period under the No Action Conditions. The probability that Nevada would receive surplus condition deliveries under the No Action Conditions during this period was approximately 85 percent. The maximum surplus condition depletions under the No Action Conditions were 390 kaf during this 15-year period. The probability that Nevada would receive shortage condition deliveries under No Action Conditions was 8 percent. The minimum shortage condition depletion was 282.3 kaf.

Figure 4.5-13 provides a comparison of the distribution of the water deliveries to Nevada under the Implementation Agreement Conditions to those of the No Action Conditions for the 60-year period (years 2017 to 2076) that would follow the interim surplus guidelines period. The results presented in Figure 4.5-13 indicate a 37 percent probability that water deliveries to Nevada would meet or exceed its normal depletion schedule during this period under the No Action Conditions. The probability that Nevada would receive surplus condition deliveries during this same period under the No Action Conditions was approximately 18 percent. The maximum surplus condition depletions under the No Action Conditions were 514 kaf during this 60-year period. The probability that Nevada would receive shortage condition deliveries was less than 63 percent. The minimum shortage condition depletion during this period was 236.3 kaf.

Figure 4.5-14 provides a comparison of the distribution of the water deliveries to Nevada under the Implementation Agreement Conditions to those of the No Action Conditions for the entire 75-year period of analysis (years 2002 to 2076). The results presented in Figure 4.5-14 indicate a 48 percent probability that water deliveries to Nevada would meet or exceed its normal depletion schedule during this period under the No Action Conditions. The probability that Nevada would receive surplus condition deliveries during this same period under the No Action Conditions was approximately 31 percent. The maximum surplus condition depletions under the No Action Conditions were 514 kaf during this 75-year period. The probability that Nevada would receive shortage condition deliveries was less than 52 percent. The minimum shortage condition depletion during this period was 236.3 kaf.

Figure 4.5-12
Nevada Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2002 to 2016

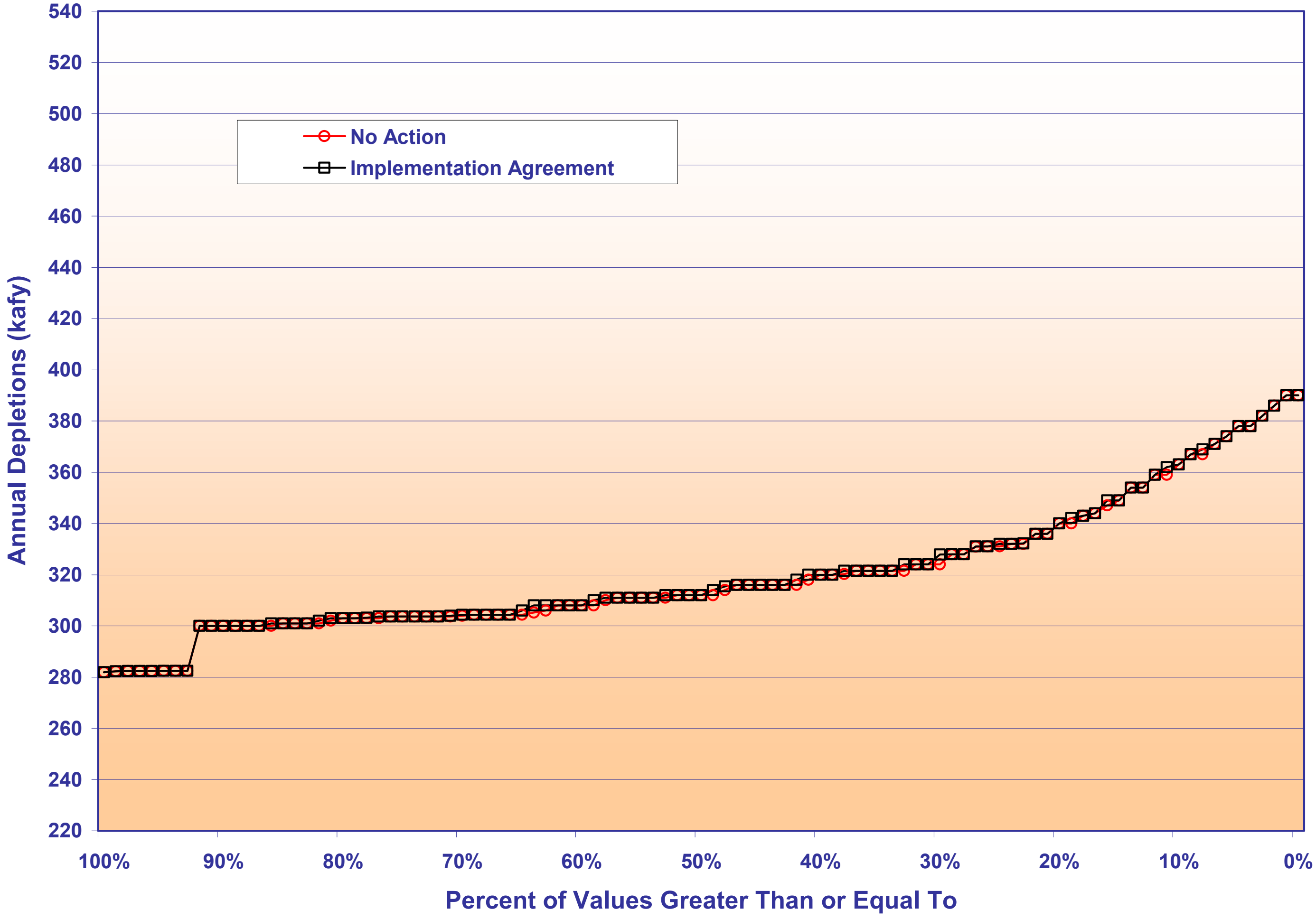


Figure 4.5-13
Nevada Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2017 to 2076

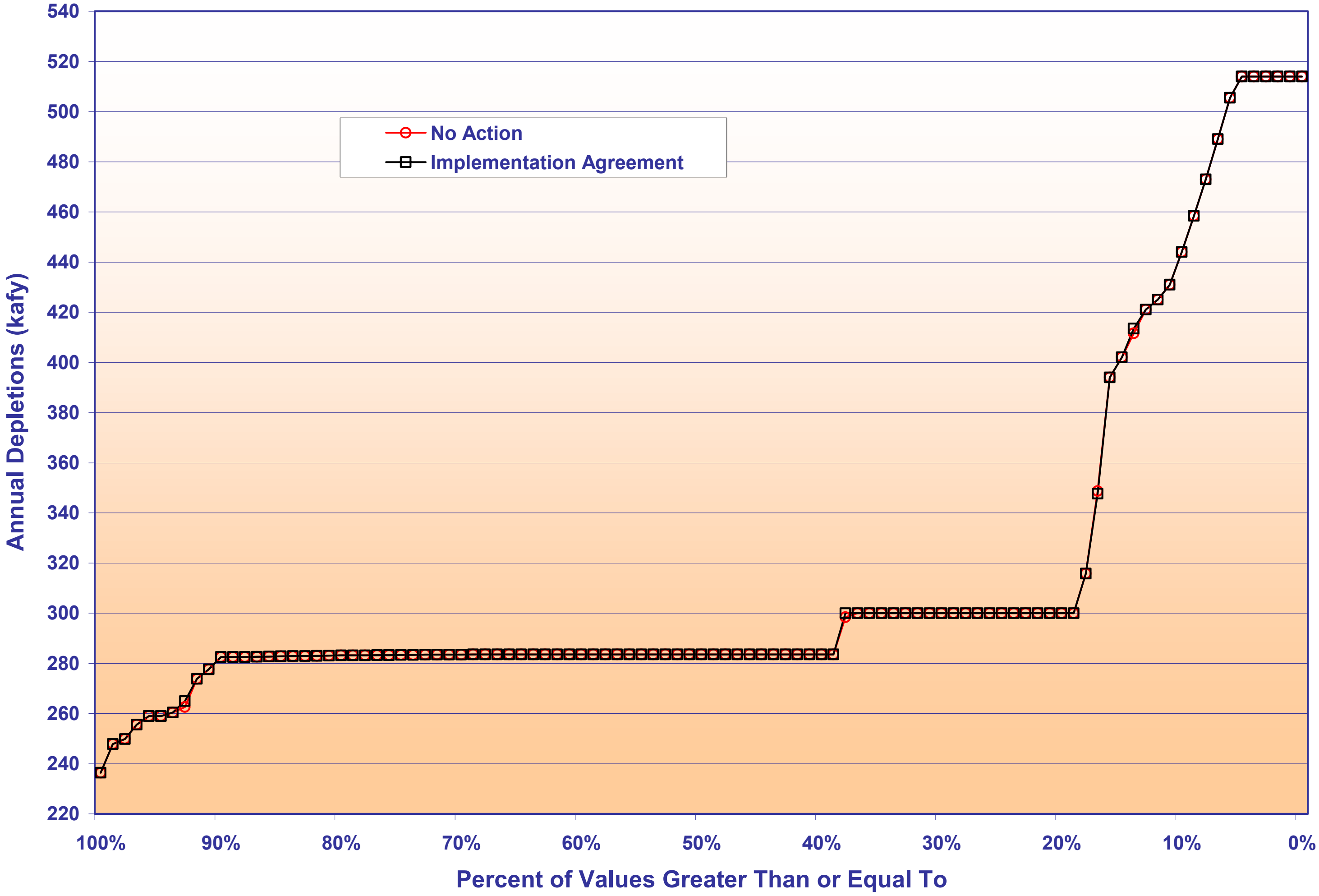


Figure 4.5-14
Nevada Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2002 to 2076

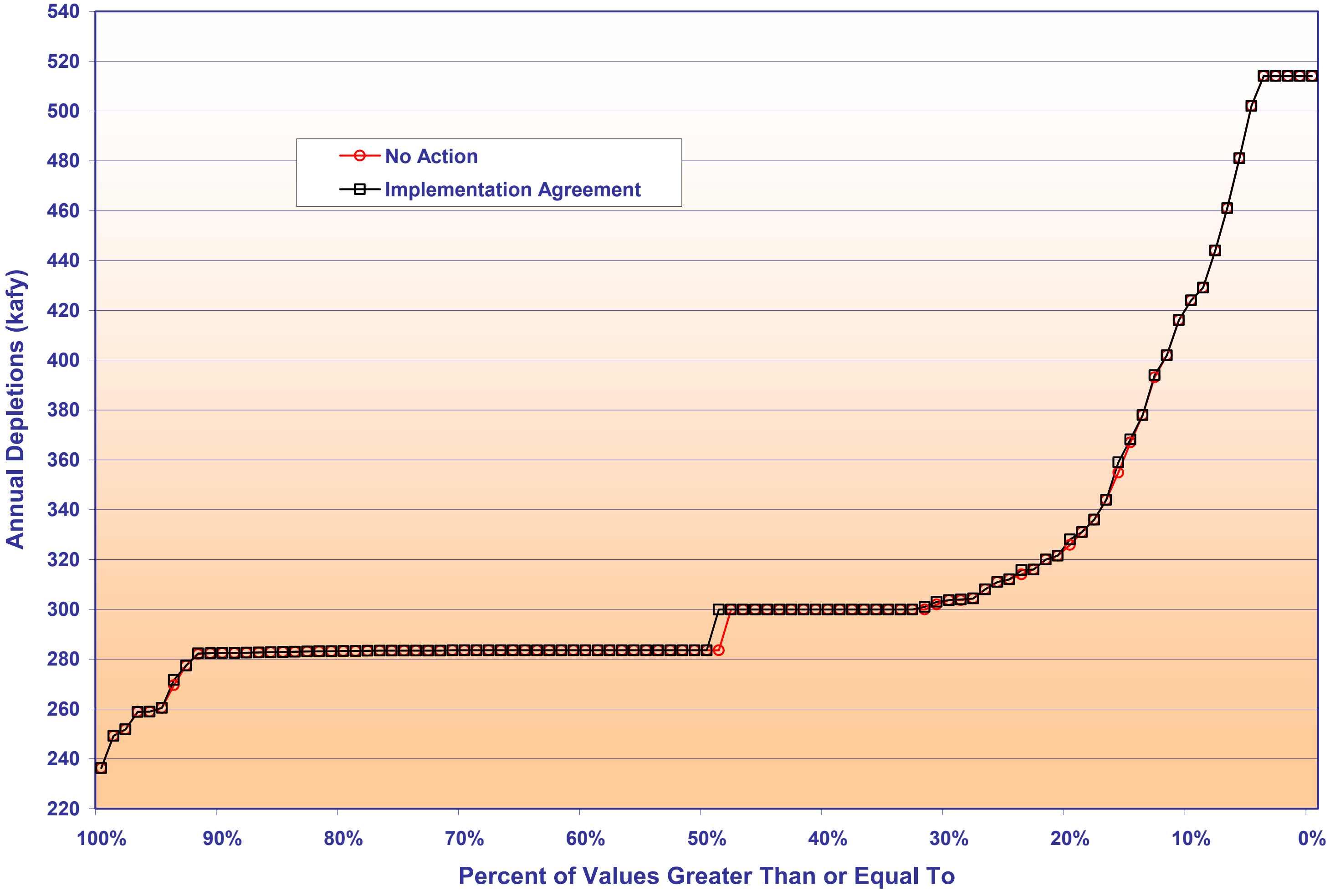
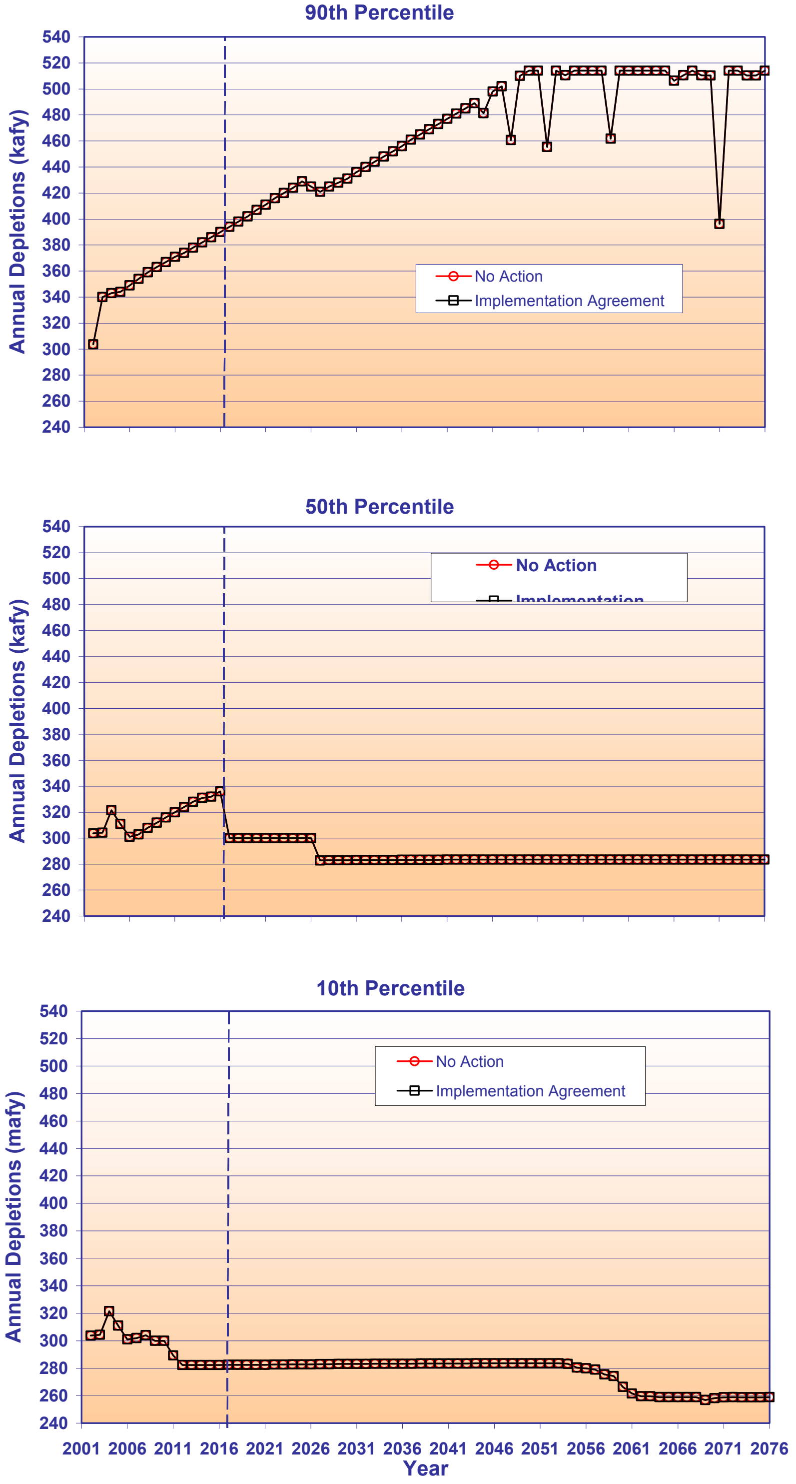


Figure 4.5-15 provides a comparison of the 90th, 50th and 10th percentile values for Nevada's depletions under the No Action Conditions to those of the Implementation Agreement Conditions. As noted in Figure 4.5-15, there is little difference between the 90th percentile values resulting from the Implementation Agreement Conditions and those of the No Action Conditions. Both 90th percentile lines generally coincide with Nevada's normal depletion schedule under No Action Conditions through year 2045. After year 2045, both 90th percentile lines occasionally fall below the full surplus schedule, an indication of limited surplus conditions.

From 2002 through 2016, the 50th percentile lines for both the No Action and Implementation conditions are at or above the normal depletion schedule, an indication of better than average probability of surplus condition deliveries. From 2017 through 2024, both 50th percentile lines coincide with Arizona's normal depletion schedule. After 2024, the 50th percentile line of the No Action Conditions falls to and thereafter coincides with Arizona's Level 1 shortage condition depletion schedule. The 50th percentile line under the Implementation Agreement Conditions continues to coincide with Arizona's normal depletion schedule until year 2026, two years longer than that of the No Action Conditions. After 2026, the 50th percentile line under the Implementation Agreement Conditions also falls to and thereafter coincides with Arizona's Level 1 shortage condition depletion schedule.

As noted in Figure 4.5-15, there is little difference between the 10th percentile values resulting from the Implementation Agreement Conditions and those of the No Action Conditions. Both 10th percentile lines are generally at or above Nevada's normal depletion schedule through year 2010. From 2011 through 2057, both 10th percentile lines generally coincide with Arizona's modeled Level 1 shortage condition depletion schedule. After 2057, the 10th percentile values resulting from the Implementation Agreement Conditions and No Action conditions fall and remain below the Level 1 shortage depletion schedule, an indication of the occurrence of more frequent Level 2 shortage condition deliveries.

Figure 4.5-15
Nevada Modeled Annual Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
90th, 50th and 10th Percentile Values



Figures 4.5-12, 4.5-13 and 4.5-14 presented comparisons of the distribution of Nevada's depletions under the Implementation Agreement Conditions to those of the No Action Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016), the 60-year period that would follow the Interim Surplus Guidelines (years 2017 to 2076), and the entire 75-year period of analysis (years 2002 to 2076), respectively. These graphs represent the frequency that different magnitude annual deliveries to Nevada occurred under each respective period. Table 4.5-3 provides a tabular summary of the comparison for these three periods.

Table 4.5-3
Summary of Nevada Modeled Annual Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions

	Years 2002 to 2016			Years 2017 to 2076			Years 2002 to 2076		
Alternative/Conditions	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**
No Action	92%	85%	8%	37%	18%	63%	48%	31%	52%
Implementation Agreement	92%	86%	8%	38%	18%	62%	49%	32%	51%

*The values under normal represent the total percentage of time that depletions would be at or above the normal depletion conditions.

The percentage values presented under the column heading labeled "Normal" in Table 4.5-3 represent the total percentage of time that depletions under the noted conditions would be at or above the normal depletion schedule amount. The values presented under the column labeled "Surplus" represent the total percentage of time that depletions under the noted conditions exceed the normal depletion schedule amount. The values presented under the column labeled "Shortage" represent the total percentage of time that depletions under the noted conditions would be below the normal depletion schedule amount.

4.5.4 UPPER BASIN STATES

There are no specific criteria in the *Law of the River* for surplus or shortage condition water deliveries to users within the Upper Basin states. The normal depletion schedule of the Upper Basin states would be met under both the No Action and Implementation Agreement conditions. The exceptions are potential reductions to certain Upper Basin users whose diversions are located upstream of Lake Powell. For these users, the potential reductions would be attributed to dry hydrologic conditions and inadequate regulating reservoir storage capacity upstream of their diversions.

The proposed water transfers were determined to have no effect on water deliveries to the Upper Basin states, including the Upper Basin Tribes. Therefore, detailed analyses were not necessary for the Upper Basin states' water supply.

4.5.5 MEXICO

This section presents the analyses of the simulated water deliveries to Mexico under the No Action and Implementation Agreement conditions. As discussed previously, Mexico's normal depletion schedule is modeled as 1.5 maf. An additional 15,000 af is included to account for typical scheduling errors and water that is ordered by the Lower Division users but that is not diverted. Therefore, the normal annual depletion schedule deliveries to Mexico were modeled as 1.515 maf. Surplus deliveries to Mexico of up to 200 kaf are delivered under both No Action and the Implementation Agreement conditions only when Lake Mead makes flood control releases. Shortage deliveries to Mexico would only occur if the CAP were cut to zero and further cuts to MWD and Mexico were necessary to keep the Lake Mead water surface elevation above 1000 feet msl, a Level 2 shortage water supply condition.

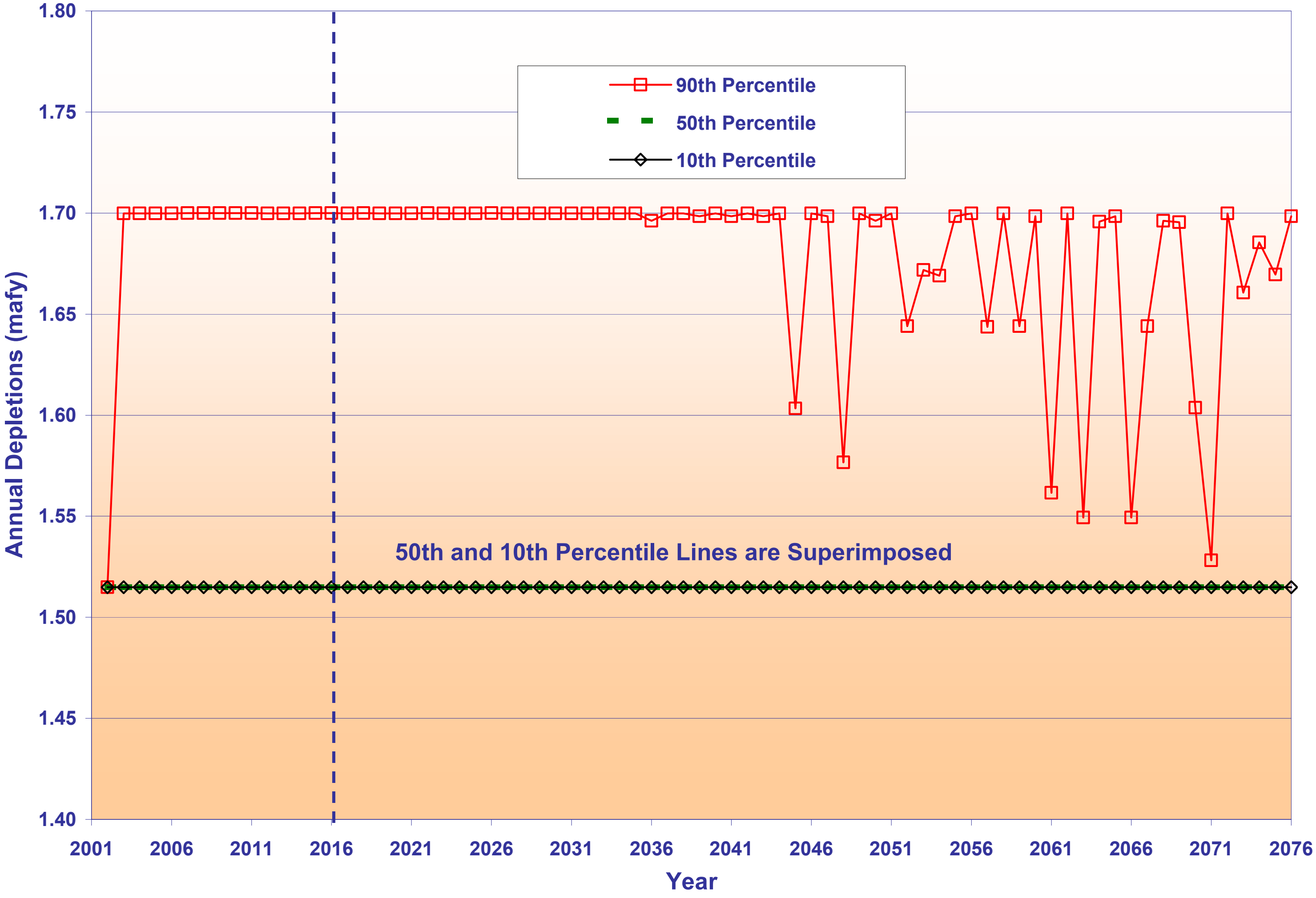
4.5.5.1 MODELING RESULTS OF NO ACTION

The water deliveries to Mexico are projected to be mostly at or above Mexico’s normal delivery schedule throughout the 75-year period of analysis. Under the No Action Conditions, annual deliveries to Mexico that were less than its normal depletion schedule were observed to occur in only 19 of the 85-modeled traces, an indication of Level 2 shortage water supply conditions. In these 19 traces, the frequency of occurrence of annual deliveries to Mexico that were less than its normal depletion schedule was only one year of the 75 modeled years, after 2057. The minimum observed delivery to Mexico was 962,019 af.

The 90th, 50th and 10th percentile ranking of modeled water deliveries to Mexico under the No Action Conditions are presented in Figure 4.5-16. The 90th percentile line generally coincides with Mexico’s full surplus condition schedule under No Action Conditions through year 2045. After year 2045, the 90th percentile occasionally falls below the full surplus schedule, an indication of limited surplus conditions. As indicated by this 90th percentile line, the probability that the No Action Conditions would provide Mexico some level of surplus condition deliveries is at least 10 percent throughout the 75-year period of analysis.

Under No Action Conditions, the 50th and 10th percentile lines coincide with Mexico’s normal depletion schedule. Again, it is noted that the depletion amount depicted by both the 50th and 10th percentile lines is equal to 1.515 maf. The 15,000 af above the 1.5 maf Mexico apportionment was added to the model to account for typical scheduling errors and water that is ordered by the Lower Division users but that is not diverted. Again, it should be noted that the modeled water deliveries to Mexico under No Action Conditions were observed to drop below Mexico’s normal depletion schedule in 19 of the 85-modeled traces.

Figure 4.5-16
Mexico Modeled Annual Depletions Under No Action Conditions
90th, 50th and 10th Percentile Values



4.5.5.2 COMPARISON OF IMPLEMENTATION AGREEMENT TO NO ACTION

Figure 4.5-17 provides a comparison of the distribution of Mexico's depletions under the Implementation Agreement Conditions to those of the No Action Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016). Again, this type of graph is used to represent the frequency that annual deliveries of different magnitudes occur in the respective period. The results presented in Figure 4.5-17 indicate a 100 percent probability that Mexico’s depletions would meet or exceed its normal depletion schedule during this period under the No Action Conditions. The probability that Mexico would receive surplus condition deliveries during this period was approximately 21 percent under No Action Conditions. The surplus condition depletion under the No Action Conditions was 1.7 maf during this 15-year period.

Figure 4.5-18 provides a comparison of the distribution of the water deliveries to Mexico under the Implementation Agreement Conditions to those of the No Action Conditions for the 60-year period (years 2017 to 2076) that would follow the Interim Surplus Guidelines period. The results presented in Figure 4.5-18 indicate an approximately 99 percent probability that water deliveries to Mexico would meet or exceed its normal depletion schedule during this period under the No Action Conditions. The probability that Mexico would receive surplus condition deliveries during this same period under the No Action Conditions was approximately 16 percent. The maximum surplus condition depletion under the No Action Conditions was also 1.7 maf during this 60-year period.

Figure 4.5-19 provides a comparison of the distribution of the water deliveries to Mexico under the Implementation Agreement Conditions to those of the No Action Conditions for the entire 75-year period of analysis (years 2002 to 2076) that would follow the Interim Surplus Guidelines period. The results presented in Figure 4.5-19 indicate an approximately 99 percent probability that water deliveries to Mexico would meet or exceed its normal depletion schedule during this period under the No Action Conditions. The probability that Mexico would receive surplus condition deliveries during this same period under the No Action Conditions was approximately 17 percent during this 75-year period. The surplus condition depletion under the No Action Conditions was also 1.7 maf during this 75-year period.

Figure 4.5-17
Mexico Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2002 to 2016

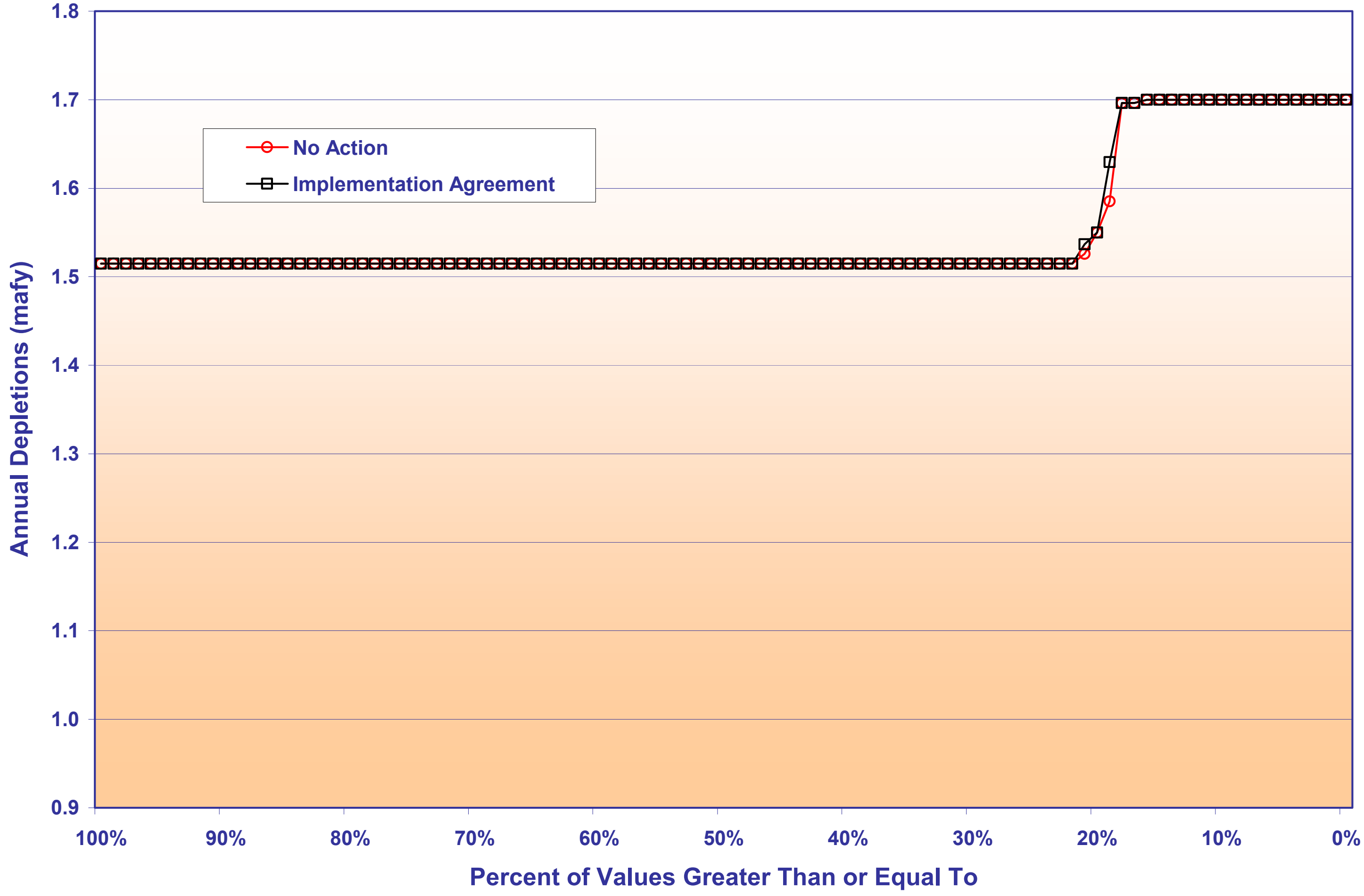


Figure 4.5-18
Mexico Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2017 to 2076

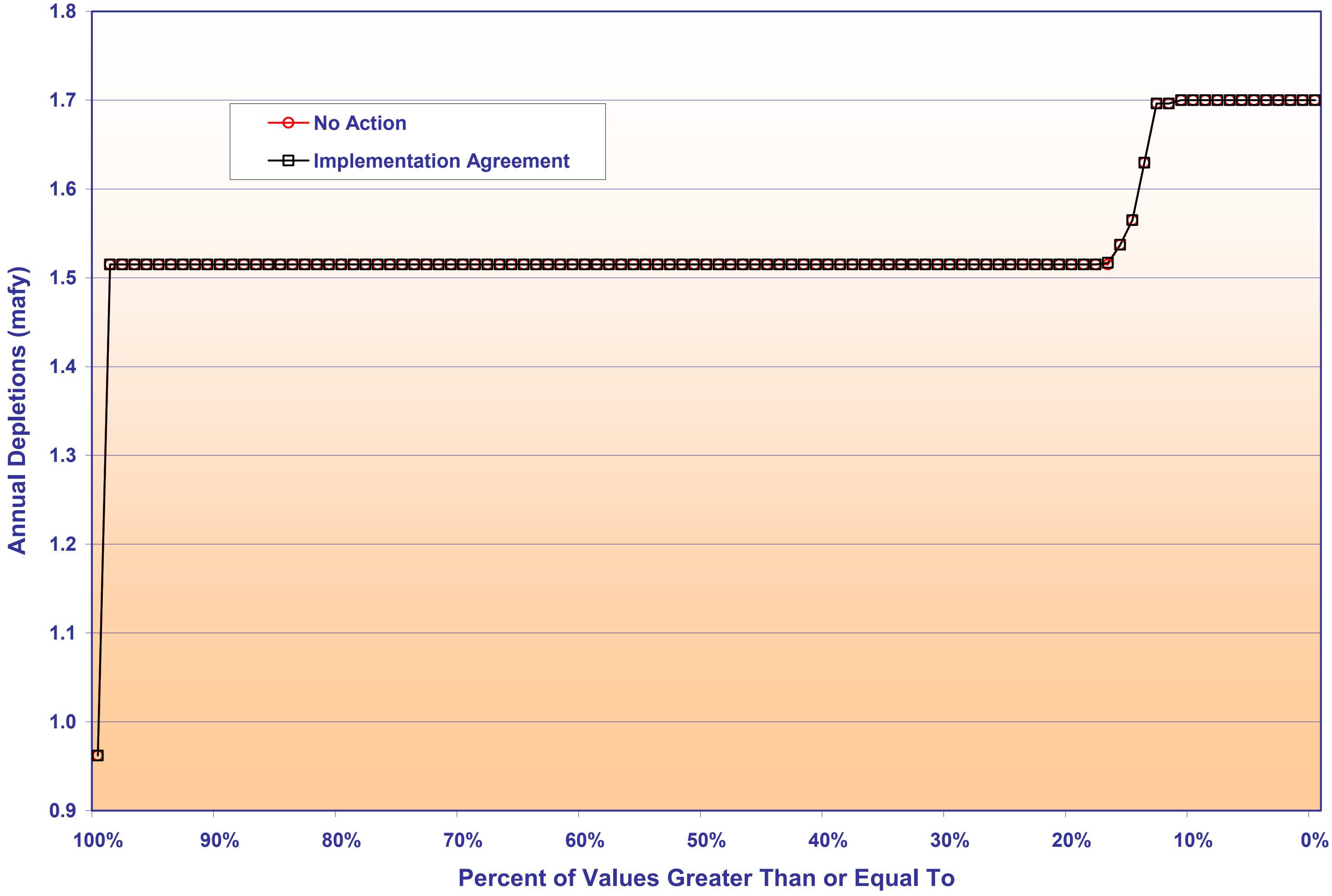


Figure 4.5-19
Mexico Modeled Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
Years 2002 to 2076

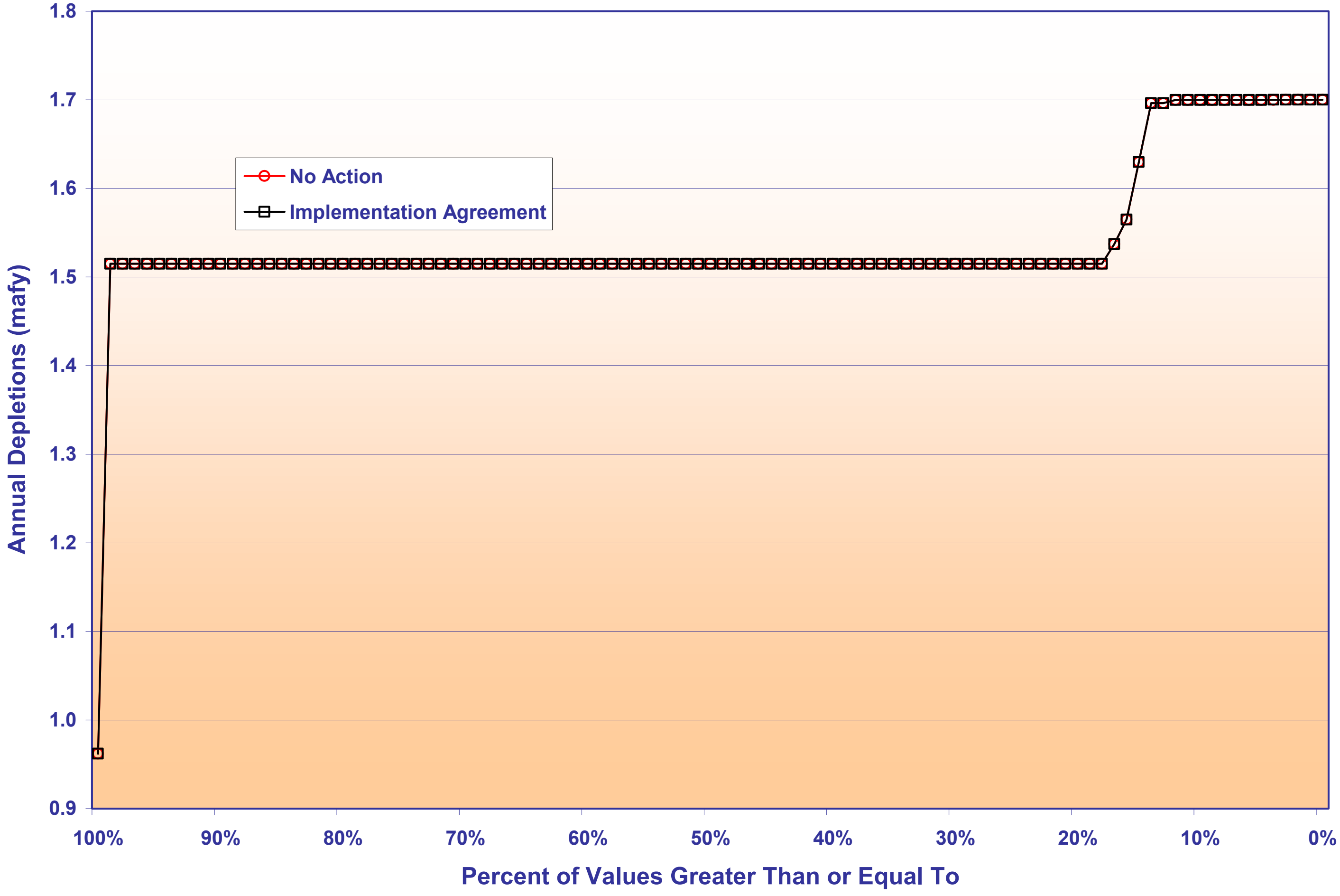


Figure 4.5-20 provides a comparison of the 90th, 50th and 10th percentile values for Mexico's depletions under the Implementation Agreement Conditions to those of the No Action Conditions. As noted in Figure 4.5-20, there is essentially no difference in the 90th percentile lines resulting from the Implementation Agreement Conditions when compared to those of the No Action Conditions. Both 90th percentile lines generally coincide with Mexico's full surplus depletion schedule through year 2045. After year 2045, both 90th percentile lines occasionally fall below the full surplus schedule, an indication of more limited surplus conditions.

The 50th and 10th percentile lines for the Implementation Agreement and the No Action conditions coincide with Mexico's normal depletion schedule, an indication of better than 90 percent probability that water deliveries to Mexico would meet or exceed its normal depletion schedule. Again, Level 2 shortage condition deliveries to Mexico were observed to occur in only 19 of the 85-modeled traces in both the No Action and Implementation Agreement conditions. In each of these 19 traces, deliveries of less than the normal depletion schedule amounts occurred in only one of the 75 years modeled.

Figures 4.5-17, 4.5-18 and 4.5-19 presented comparisons of the distribution of Mexico's depletions under the Implementation Agreement Conditions to those of the No Action Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016), the 60-year period that follows the Interim Surplus Guidelines (years 2017 to 2076) and the entire 75-year period of analysis (years 2002 to 2076), respectively. Table 4.5-4 provides a tabular summary of the comparison for these three periods.

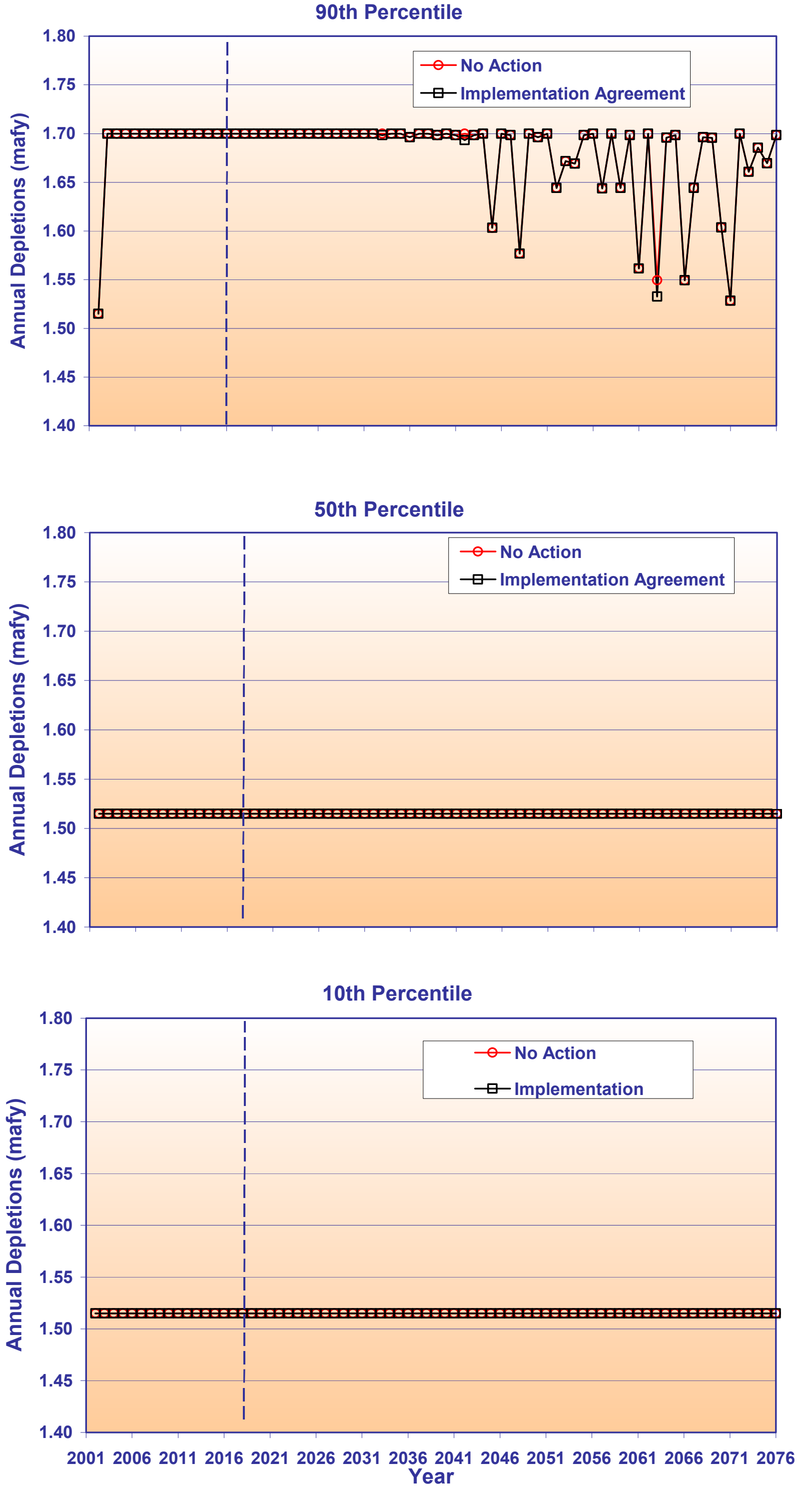
Table 4.5-4
Summary of Mexico Modeled Annual Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions

	Years 2002 to 2016			Years 2017 to 2076			Years 2002 to 2076		
Alternative/Conditions	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**
No Action	100%	21%	0%	99%	16%	1%	99%	17%	1%
Implementation Agreement	100%	21%	0%	99%	17%	1%	99%	17%	1%

*The values under normal represent the total percentage of time that depletions would be at or above the normal depletion conditions.

The percentage values presented under the column heading labeled "Normal" in Table 4.5-4 represent the total percentage of time that depletions under the noted conditions would be at or above the normal depletion schedule amount. The values presented under the column labeled "Surplus" represent the total percentage of time that depletions under the noted conditions exceed the normal depletion schedule amount. The values presented under the column labeled "Shortage" represent the total percentage of time that depletions under the noted conditions would be below the normal depletion schedule amount.

Figure 4.5-20
Mexico Modeled Annual Depletions
Comparison of Implementation Agreement Conditions to No Action Conditions
90th, 50th and 10th Percentile Values



4.6 ANALYSIS OF CUMULATIVE EFFECTS

This section describes the results of the analysis that evaluates the potential cumulative impacts to the water deliveries to each of the Lower Basin states and Mexico resulting from the proposed implementation of all the water management programs contemplated under this Technical Memorandum. The modeled operational scenarios that are used to evaluate the cumulative effects of the various water management programs in this section consist of the Baseline for the Cumulative Analysis (Baseline) and the Cumulative Analysis Conditions. These scenarios are defined in Section 2.2.

4.6.1 STATE OF ARIZONA

This section presents the simulated water deliveries to Arizona under the Baseline and Cumulative Analysis Conditions. The analysis of Arizona's water supply concentrated on total Arizona water depletions.

4.6.1.1 MODELING RESULTS OF BASELINE

The water deliveries to Arizona are projected to fluctuate throughout the 75-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50th and 10th percentile ranking of modeled water deliveries to Arizona under the Baseline conditions are presented in Figure 4.6-1.

With the exception of the first year modeled (2002), the 90th percentile line coincides with Arizona’s depletion schedule during full surplus water supply conditions through year 2044 (compare Figure 4.6-1 to Figure 4.4-1). As indicated by this 90th percentile line, the probability that the Baseline Conditions would provide Arizona’s full surplus depletion schedule is at least 10 percent during this period. After year 2044, the 90th percentile line occasionally falls below the full surplus schedule although it still remains close to Arizona’s depletion schedule during full surplus water supply conditions and generally at or above 3.0 mafy.

The 50th percentile line represents the median annual depletion values. This 50th percentile line generally coincides with Arizona’s projected depletion schedule under normal water supply conditions through year 2027 (see Figure 4.4-1). After 2027, the median values drop to approximately 2.4 mafy and remain at approximately that level for the remainder of the 75 year period of analysis.

Under the Baseline Conditions, the 10th percentile values generally coincide with Arizona’s normal depletion schedule through year 2013. After 2013, the median values drop to approximately 2.4 maf and remain at approximately that level until year 2054. After 2054, the 10th percentile line falls below 2.4 mafy and remains below this amount for the remainder of the 75 year period of analysis, an indication of an increased frequency of Level 2 Shortage conditions.

As noted in Section 4.4.1, under shortage conditions, Arizona would bear 96 percent of the reduction and Nevada would bear four percent. In Arizona, the reduction would be shared prorata among CAP and non-CAP holders of fourth priority entitlements. To simplify the modeling process, the model sets the CAP's shortage water supply condition deliveries at 1.0 maf when the Lake Mead water level is between elevation 1000 feet msl and the assumed shortage protection line as discussed in Section 2.4. This modeling assumption kept Arizona's annual deliveries above 2.4 maf until further cuts to the CAP were necessary to maintain the Lake Mead water level above the 1000 feet msl elevation (a Level 2 shortage condition). Under the Baseline scenario modeled, Level 2 shortage water supply condition deliveries to Arizona below 2.4 maf were observed to occur less than seven percent of the time during the 75-year period of analysis.

Figure 4.6-1
Arizona Modeled Annual Depletions Under Baseline Conditions
90th, 50th and 10th Percentile Values

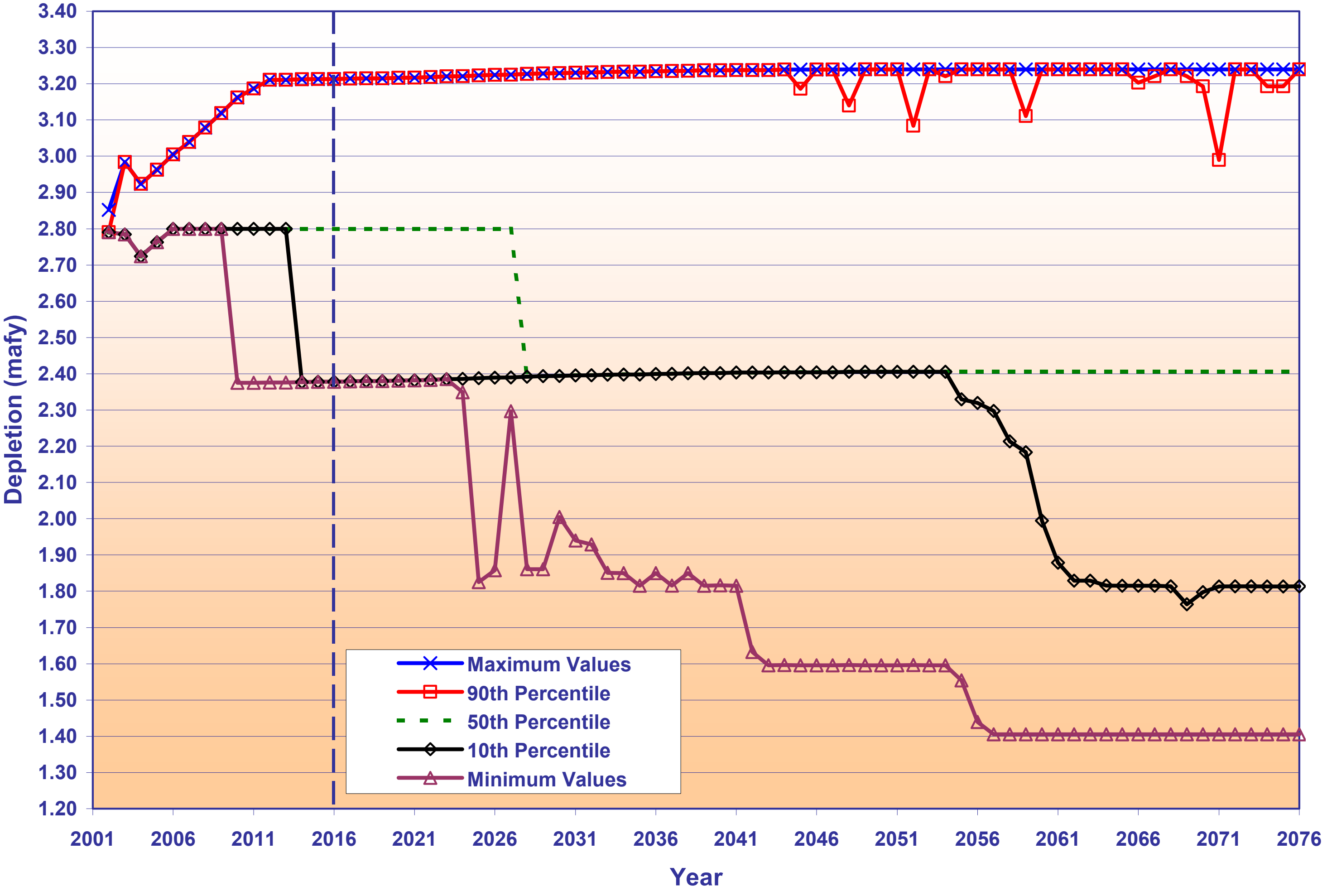


Figure 4.6-2 provides a comparison of the distribution of Arizona's depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016). This type of graph is used to represent the frequency that annual deliveries of different magnitudes occur in the respective period. The results presented in Figure 4.6-2 indicate a 74 percent probability that annual water deliveries to Arizona would meet or exceed its normal depletion schedule during this period under Baseline conditions. The probability that Arizona would receive surplus condition deliveries during this period was approximately 26 percent. The maximum surplus condition depletions under the Baseline Conditions were 3.213 maf during this period. The probability that Arizona would receive shortage condition deliveries was 26 percent. The minimum shortage condition depletion was 2.376 maf during this 15-year period.

Figure 4.6-3 provides a comparison of the distribution of the water deliveries to Arizona under the Cumulative Analysis Conditions to those of the Baseline Conditions for the 60-year period (years 2017 to 2076) that would follow the Interim Surplus Guidelines period. The results presented in Figure 4.6-3 indicate a 39 percent probability that water deliveries to Arizona would meet its normal depletion schedule during this period under the Baseline conditions. The probability that Arizona would receive surplus condition deliveries during this same period under the Baseline conditions was approximately 18 percent. The maximum surplus condition depletions under the Baseline Conditions were 3.24 maf during this period. The probability that Arizona would receive deliveries less than its normal schedule (Level 1 or Level 2 shortage condition deliveries) was approximately 61 percent. Second level shortage conditions occurred less than eight percent of the time during this period. The minimum shortage condition depletion was 1.405 maf.

Figure 4.6-4 provides a comparison of the distribution of the water deliveries to Arizona under the Cumulative Analysis Conditions to those of the Baseline Conditions for the entire 75-year period of analysis (years 2002 to 2076). The results presented in Figure 4.6-4 indicate a 46 percent probability that water deliveries to Arizona would meet or exceed its normal depletion schedule during this period under the Baseline Conditions. The probability that Arizona would receive surplus condition deliveries during this same period under the Baseline Conditions was approximately 20 percent. The maximum surplus condition depletions under the Baseline Conditions were 3.24 maf during this period. The probability that Arizona would receive deliveries less than its normal schedule (Level 1 or Level 2 shortage condition deliveries) was approximately 54 percent. Second level shortage conditions occurred less than seven percent of the time during this period. The minimum shortage condition depletion under the Baseline conditions was 1.405 maf.

Figure 4.6-2
Arizona Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2002 to 2016

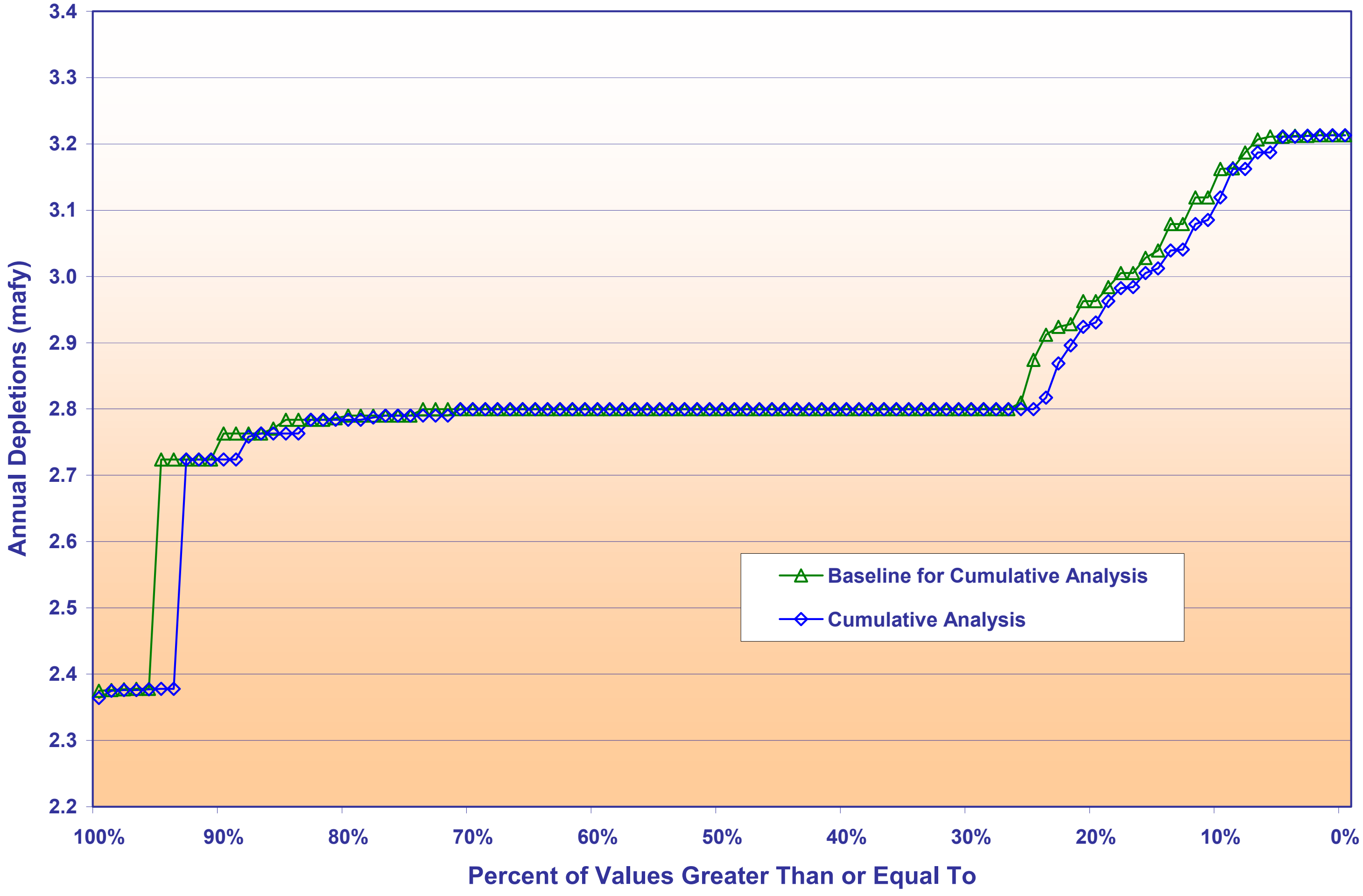


Figure 4.6-3
Arizona Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2017 to 2076

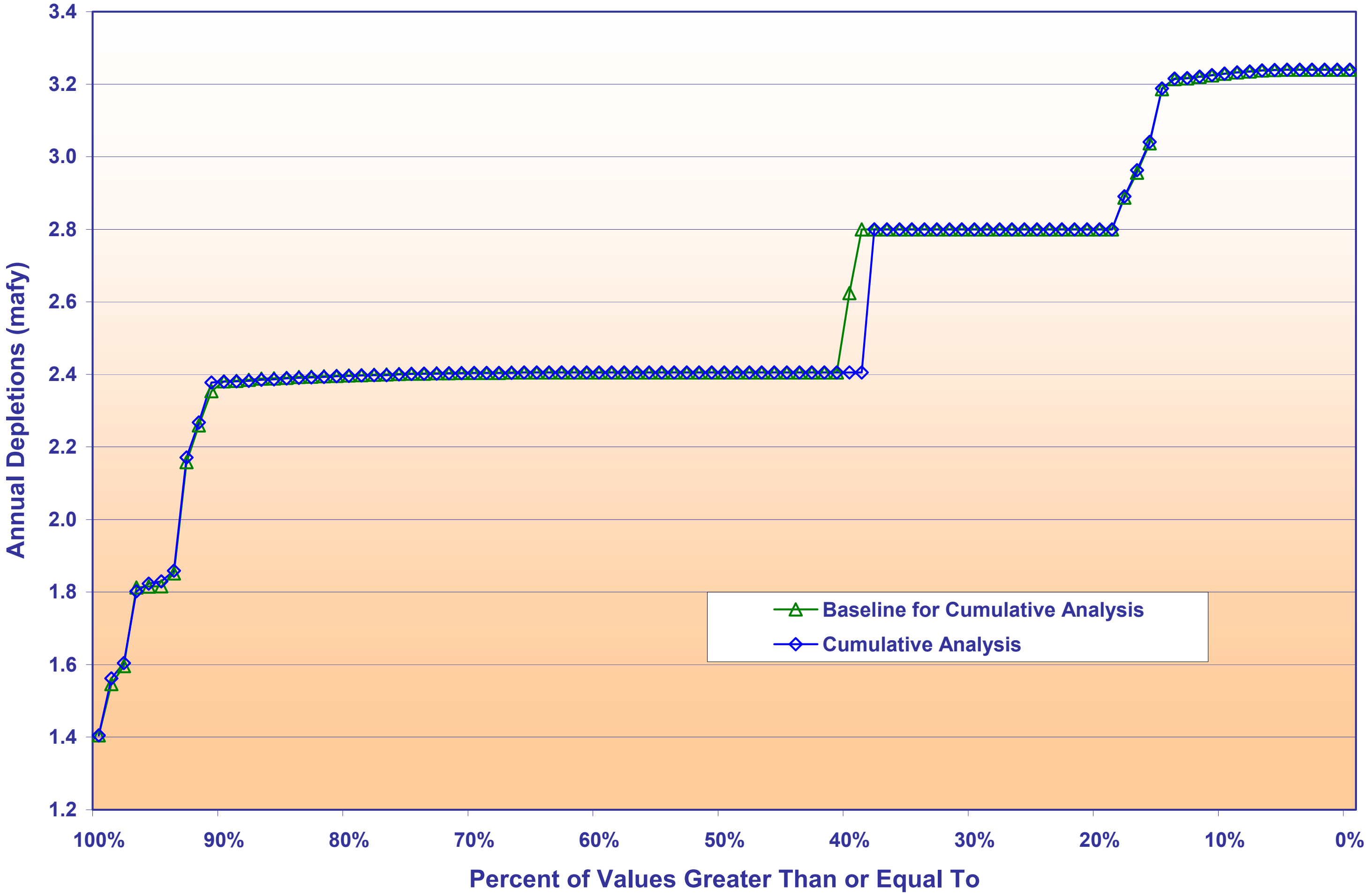
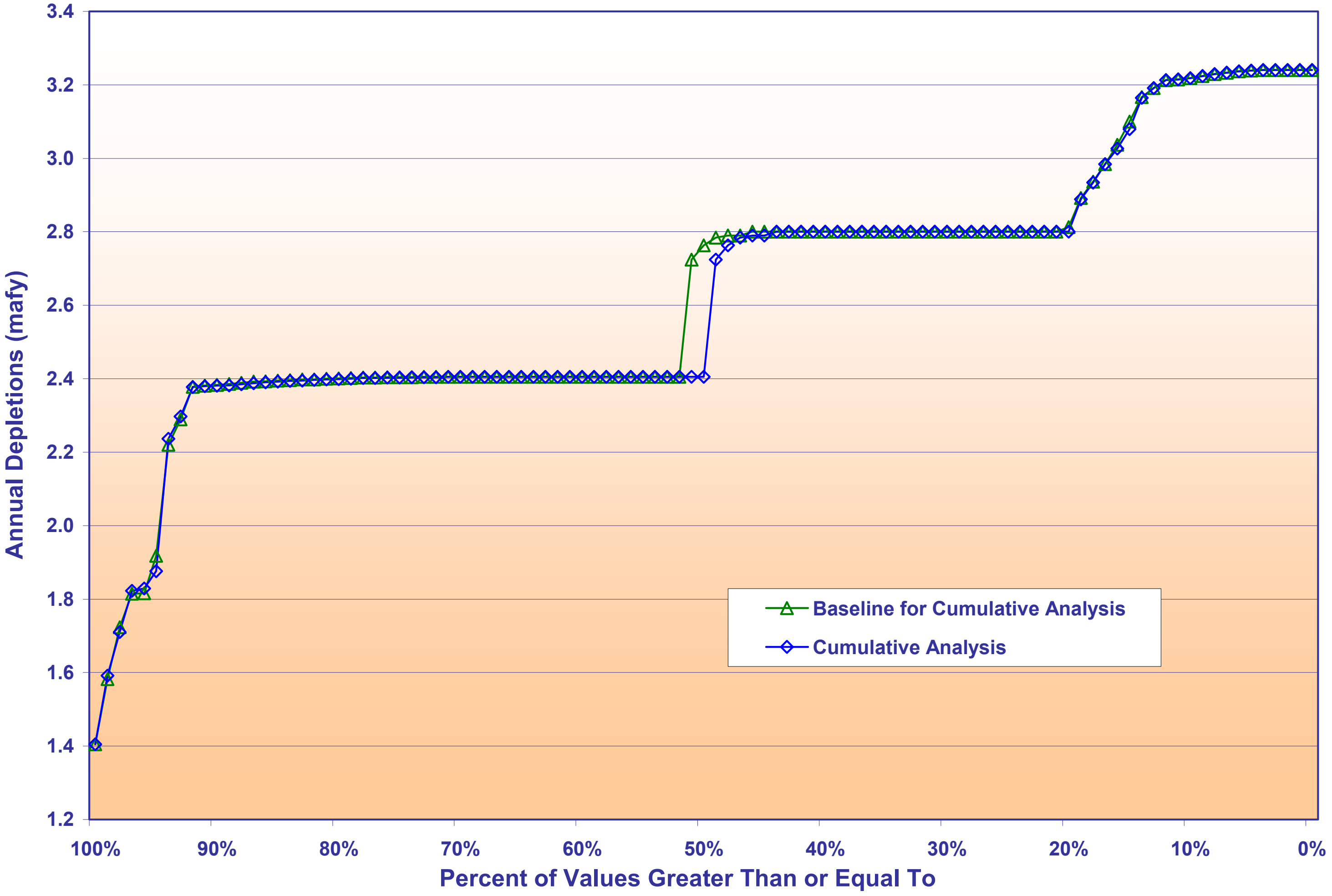


Figure 4.6-4
Arizona Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2002 to 2076



4.6.1.2 COMPARISON OF BASELINE TO CUMULATIVE ANALYSIS

Figure 4.6-5 provides a comparison of the 90th, 50th and 10th percentile values for Arizona's modeled depletions under the Baseline conditions to those of the Cumulative Analysis conditions. As depicted in Figure 4.6-5, there is little difference in the 90th percentile lines resulting from the Cumulative Analysis conditions as compared to those of the Baseline conditions. Both 90th percentile lines generally coincide with Arizona's full surplus depletion schedule through year 2044. After year 2044, both 90th percentile lines occasionally fall below the full surplus schedule. Nevertheless, both 90th percentile lines remain close to Arizona's depletion schedule during full surplus water supply conditions and generally at or above 3.0 mafy.

The 50th percentile lines for the Baseline and Cumulative Analysis conditions are identical to each other through year 2026 and coincide with Arizona's normal depletion schedule during this period. After year 2026, the 50th percentile values for the Cumulative Analysis Conditions fall due to the increasing probability of Level 1 shortage condition deliveries. The 50th percentile line for the Baseline Conditions continues to coincide with the normal depletion schedule through year 2027, one year more than under the Cumulative Analysis. After 2028, the 50th percentile lines for the Baseline Conditions also falls due to the increasing probability of the Level 1 shortages conditions, under this modeled scenario. The 50th percentile values for the Baseline and Cumulative Analysis conditions remain at approximately 2.4 mafy after year 2028.

The 10th percentile lines for the Baseline and the Cumulative Analysis conditions are essentially at or above Arizona's normal depletion schedule through year 2010. After 2010, the 10th percentile values of Cumulative Analysis Conditions fall below the normal depletion schedule to approximately 2.4 mafy, an indication of the occurrence of more frequent Level 1 shortage condition delivery. The 10th percentile values observed under the Baseline Conditions remain at or above Arizona's normal depletion schedule through year 2013. After 2010, the 10th percentile values of Cumulative Analysis Conditions fall below the normal depletion schedule to approximately 2.4 mafy, an indication of the occurrence of more frequent Level 1 shortage condition delivery. The 10th percentile lines for the Baseline and the Cumulative Analysis conditions at approximately 2.4 mafy until 2054 and 2056, respectively and then fall below 2.4 mafy, due to increasing frequency of Level 2 shortage condition deliveries.

Figures 4.6-2, 4.6-3 and 4.6-4 present comparisons of the cumulative distribution of Arizona's depletions under the Baseline and the Cumulative Analysis conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016), the 60-year period that follows the Interim Surplus Guidelines (years 2017 to 2076), and the entire 75-year period of analysis (years 2002 to 2076), respectively. These graphs best illustrate the frequency that different amounts of annual Arizona water deliveries occur over these time frames. Table 4.6-1 provides a summary of the comparison for these three time periods.

Figure 4.6-5
Arizona Modeled Annual Depletions
Comparison of Baseline Conditions to Cumulative Analysis Conditions
90th, 50th and 10th Percentile Values

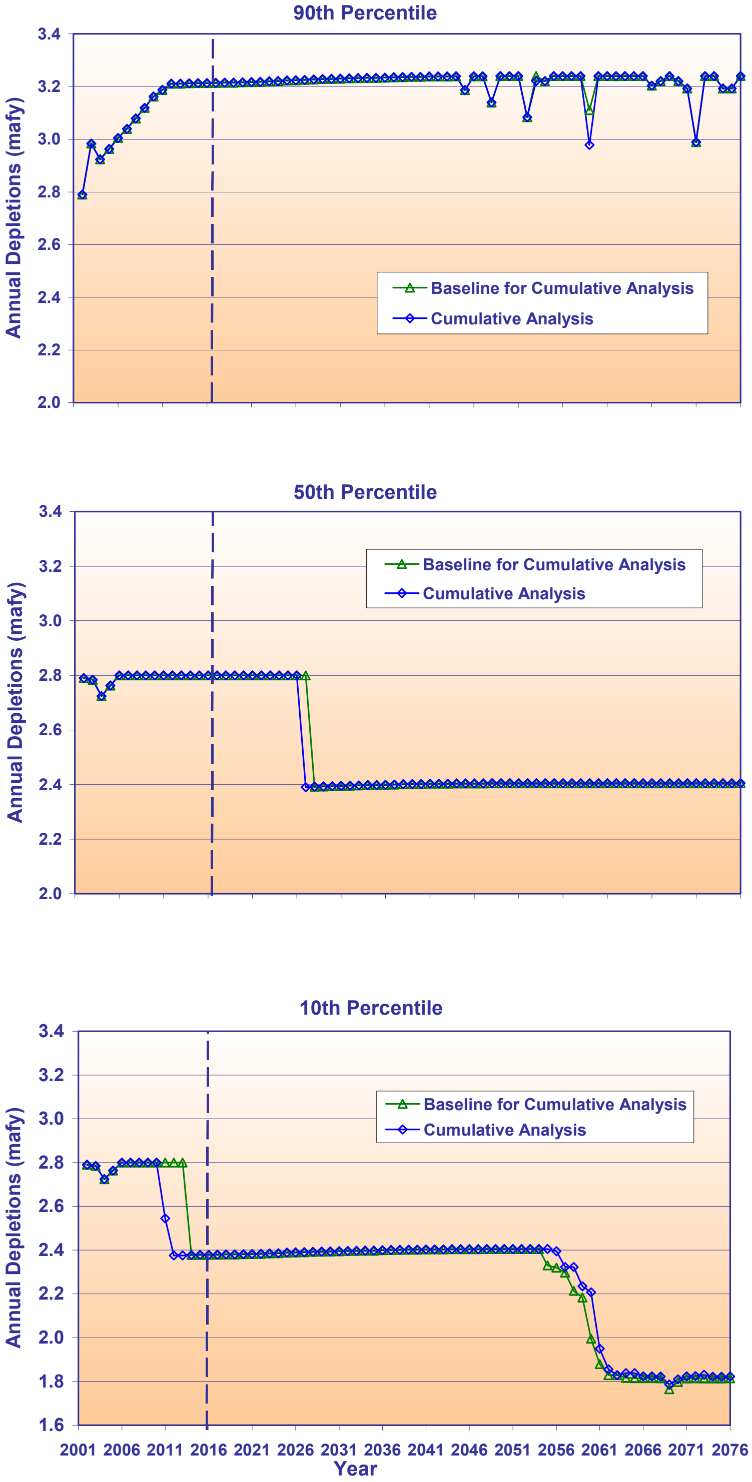


Table 4.6-1
Summary of Arizona Modeled Annual Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions

	Years 2002 to 2016			Years 2017 to 2076			Years 2002 to 2076		
Alternative/Conditions	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**
Baseline	74%	26%	26%	39%	18%	61%	46%	20%	54%
Cumulative Analysis	71%	24%	29%	38%	18%	62%	44%	19%	56%
*The values under normal represent the total percentage of time that depletions would be at or above the normal depletion conditions.									

The percentage values presented under the column heading labeled "Normal" in Table 4.6-1 represent the total percentage of time that depletions under the noted conditions would be at or above the normal depletion schedule amount. The values presented under the column labeled "Surplus" represent the total percentage of time that depletions under the noted conditions exceed the normal depletion schedule amount. The values presented under the column labeled "Shortage" represent the total percentage of time that depletions under the noted conditions would be below the normal depletion schedule amount.

4.6.2 STATE OF CALIFORNIA

This section presents the simulated water deliveries to California under the Baseline and Cumulative Analysis conditions. The analysis of California's water supply concentrated on total California water depletions.

4.6.2.1 MODELING RESULTS OF BASELINE

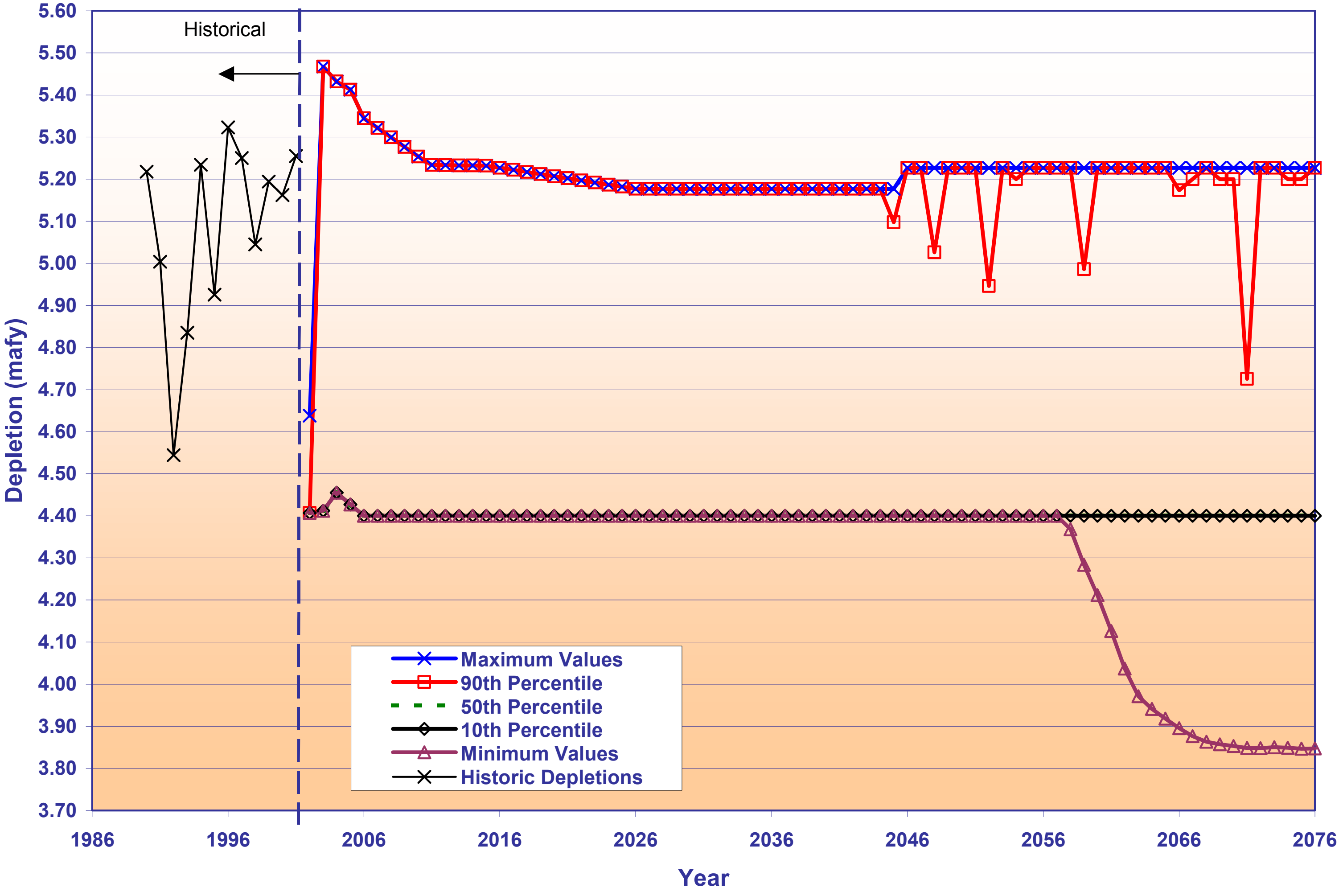
The water deliveries to California are projected to fluctuate throughout the 75-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50th and 10th percentile rankings of modeled water deliveries to California under the Baseline Conditions are presented in Figure 4.6-6. The actual reported (historical) depletions (for years 1990 to 2001) have been added to this graph to provide a benchmark for comparison of the projected future depletion trends.

The observed 90th percentile values under the Baseline Conditions generally coincide with California’s depletion schedule during full surplus water supply conditions through year 2044. The 90th percentile line represents the magnitude of surplus condition deliveries that would be available at least 10 percent of the time throughout the 75-year period of analysis. After year 2044, the 90th percentile line occasionally falls below the full surplus schedule, an indication of the occurrence of more frequent limited surplus conditions.

Under Baseline Conditions, the 50th and 10th percentile lines generally coincide with the normal depletion schedule throughout the 75-year period of analysis, and indication that water deliveries to California would meet or exceed its normal depletion schedule at least 90 percent of the time.

Annual water deliveries to California were observed to fall below California’s normal apportionment of 4.4 maf (a Level 2 shortage condition) less than one percent of the time. The minimum observed delivery to California under baseline Conditions was 3.847 mafy.

Figure 4.6-6
California Modeled Annual Depletions Under Baseline Conditions
90th, 50th and 10th Percentile Values



4.6.2.2 COMPARISON OF BASELINE TO CUMULATIVE ANALYSIS

Figure 4.6-7 provides a comparison of the cumulative distribution of the observed California depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016). These graphs are best used to represent the frequency that different magnitude annual water deliveries to California occur in the respective period. The results presented in Figure 4.6-7 indicate a 100 percent probability that California's depletions would meet its normal depletion schedule during this period under the Baseline Conditions. The probability that California would receive surplus condition deliveries (any amount greater than 4.4 mafy) during this period under Baseline Conditions was approximately 47 percent. The maximum surplus condition depletions observed under the Baseline Conditions were 5.468 maf during this period.

Figure 4.6-8 provides a comparison of the cumulative distribution of the water deliveries to California under the Cumulative Analysis Conditions to those of the Baseline Conditions for the 60-year period (years 2017 to 2076) that follows the Interim Surplus Guidelines period. The results presented in Figure 4.6-8 indicate an approximate 99 percent probability that water deliveries to California would meet its normal depletion schedule during this period under the Baseline Conditions. Only one trace was observed to fall below the normal depletion schedule, an indication of a Level 2 shortage condition. The minimum delivery observed under this trace was 3.847 maf. The probability that California would receive surplus condition deliveries during this same period under the Baseline Conditions was approximately 18 percent. The maximum surplus condition depletions under the Baseline Conditions were 5.227 maf during this period.

Figure 4.6-9 provides a comparison of the cumulative distribution of the water deliveries to California under the Cumulative Analysis Conditions to those of the Baseline Conditions for the entire 75-year period of analysis (years 2002 to 2076). The results presented in Figure 4.6-9 also indicate an approximate 99 percent probability that water deliveries to California would meet its normal depletion schedule under the Baseline Conditions. Again, only one trace was observed to fall below the normal depletion schedule, an indication of a Level 2 shortage condition. The minimum delivery observed under this trace was 3.847 maf. The probability that California would receive surplus condition deliveries during this same period under the Baseline Conditions was approximately 24 percent. The maximum surplus condition depletions under the Baseline Conditions were 5.468 maf during this period.

Figure 4.6-7
California Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2002 to 2016

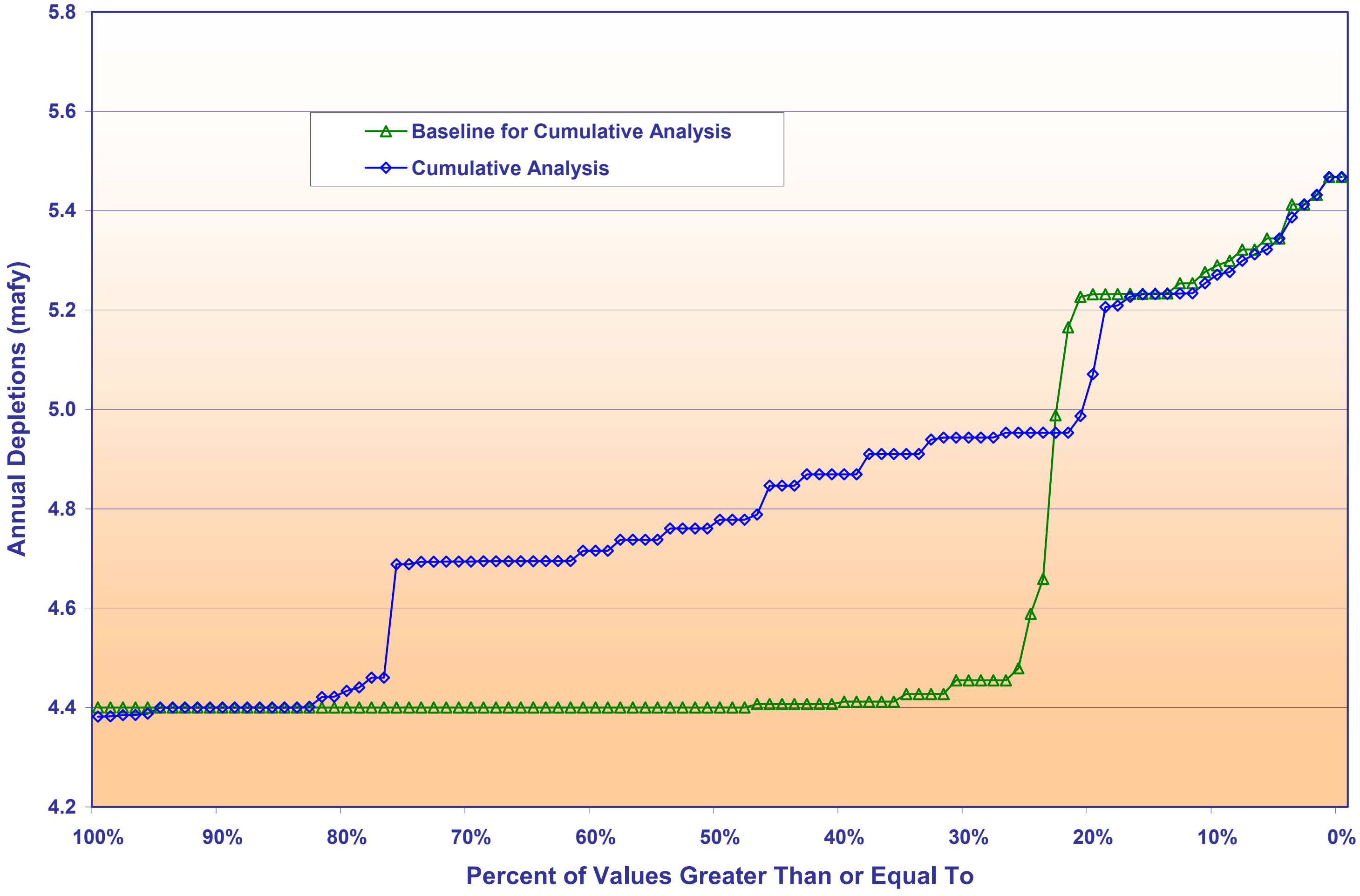


Figure 4.6-8
California Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2017 to 2076

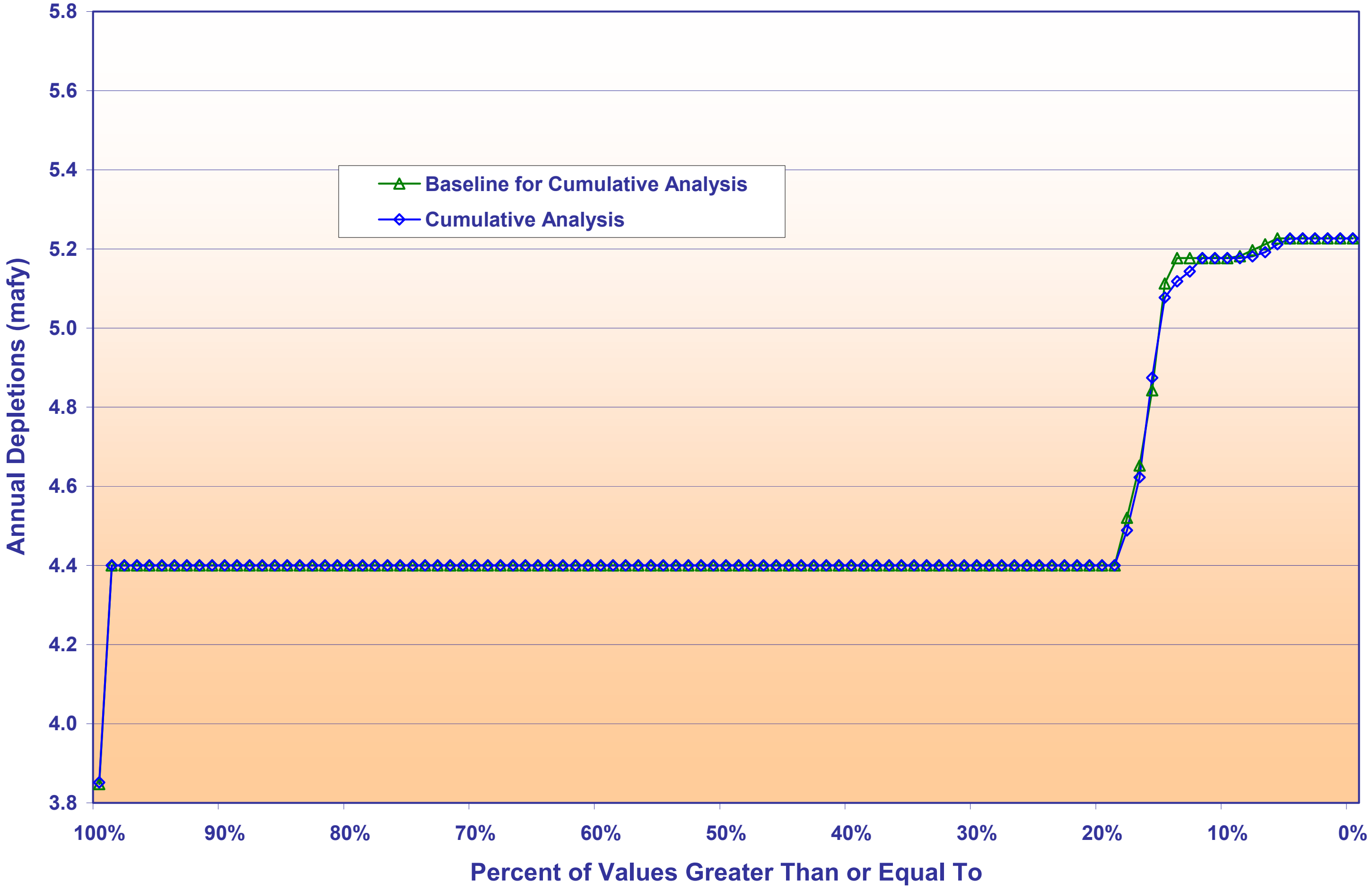


Figure 4.6-9
California Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2002 to 2076

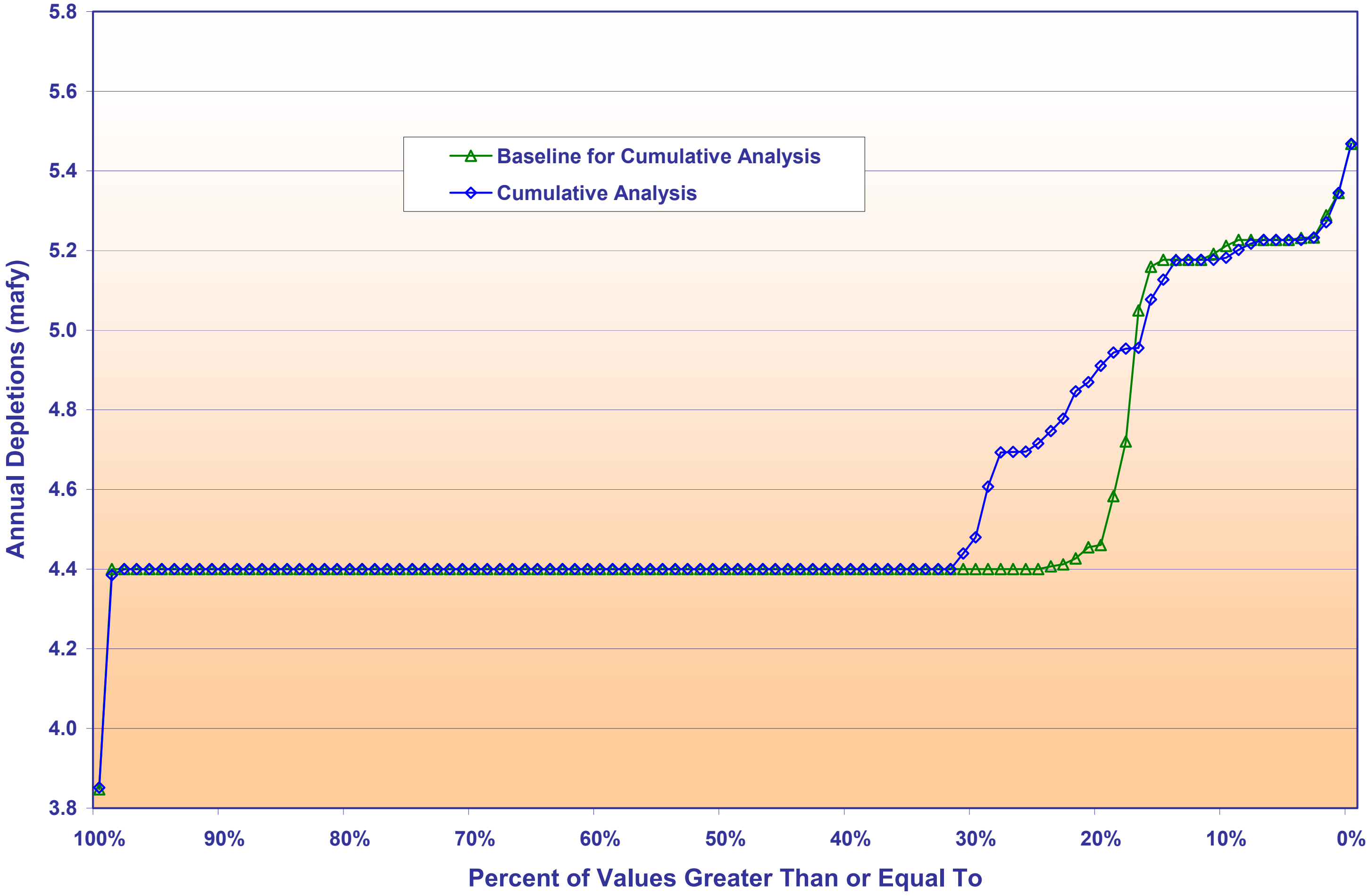
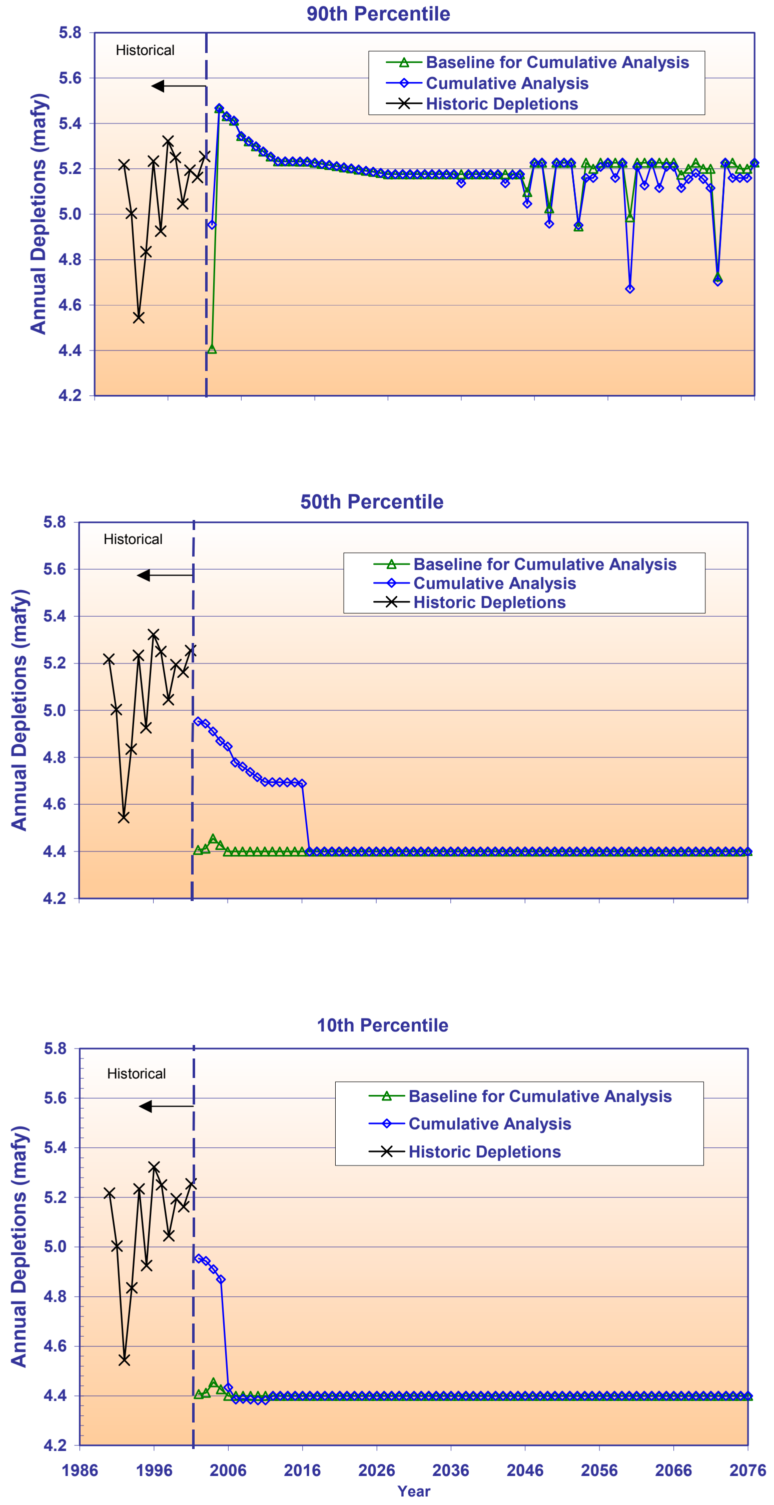


Figure 4.6-10 provides a comparison of the 90th, 50th and 10th percentile values for California's depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions. The historical depletions (for years 1990 to 2001) have been added to this graph to provide a benchmark for comparison of the projected future depletion trends. As depicted in Figure 4.6-10, there is little difference in the 90th percentile values resulting from the Cumulative Analysis Conditions to those of the Baseline Conditions. Both 90th percentile values generally coincide with California's depletion schedule during full surplus water supply conditions through year 2044. After year 2044, both 90th percentile lines occasionally fall below the full surplus schedule suggesting an increased probability of limited surplus conditions.

The 50th percentile line for the Baseline Conditions generally coincide with California's normal depletion schedule throughout the 75-year period of analysis. However, the 50th percentile values for the Cumulative Analysis Conditions are above the normal depletion schedule (above 4.4 mafy) for the initial 15 years (2002 to 2016), an indication of the frequent availability of surplus flows. After 2016, the 50th percentile lines for the Cumulative Analysis Conditions coincide with California's normal depletion schedule.

The 10th percentile line for the Baseline Conditions also coincides with California's normal depletion schedule throughout the 75-year period of analysis. Similar to the median values, the 10th percentile values for the Cumulative Analysis Conditions are above the normal depletion schedule (above 4.4 mafy) for the initial 5 years (2002 to 2006), an indication of the frequent availability of surplus flows during these initial five years. After 2006, the 10th percentile lines for the Cumulative Analysis Conditions coincide with California's normal depletion schedule.

Figure 4.6-10
California Modeled Annual Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
90th, 50th and 10th Percentile Values



Figures 4.6-7, 4.6-8 and 4.6-9 presented comparisons of the cumulative distribution of California's depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions during the Interim Surplus Guidelines period (years 2002 to 2016), the 60-year period that would follow the Interim Surplus Guidelines (years 2017 to 2076) and the entire period of analysis (years 2002 to 2076), respectively. Table 4.6-2 provides a tabular summary and comparison for these three periods.

Table 4.6-2
Summary of California Modeled Annual Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions

	Years 2002 to 2016			**Years 2017 to 2076**			**Years 2002 to 2076**		
Alternative/Conditions	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**
Baseline	100%	47%	0%	99%	18%	1%	99%	24%	1%
Cumulative Analysis	95%	83%	5%	99%	18%	1%	98%	31%	2%

*The values under normal represent the total percentage of time that depletions would be at or above the normal depletion conditions.

The percentage values presented under the column heading labeled "Normal" in Table 4.6-2 represent the total percentage of time that depletions under the noted conditions would be at or above the normal depletion schedule amount. The values presented under the column labeled "Surplus" represent the total percentage of time that depletions under the noted conditions exceed the normal depletion schedule amount. The values presented under the column labeled "Shortage" represent the total percentage of time that depletions under the noted conditions would be below the normal depletion schedule amount.

4.6.3 STATE OF NEVADA

This section presents the simulated water deliveries to Nevada under the Baseline and Cumulative Analysis conditions. The analysis of Nevada's water supply concentrated on total Nevada water depletions.

4.6.3.1 MODELING RESULTS OF BASELINE

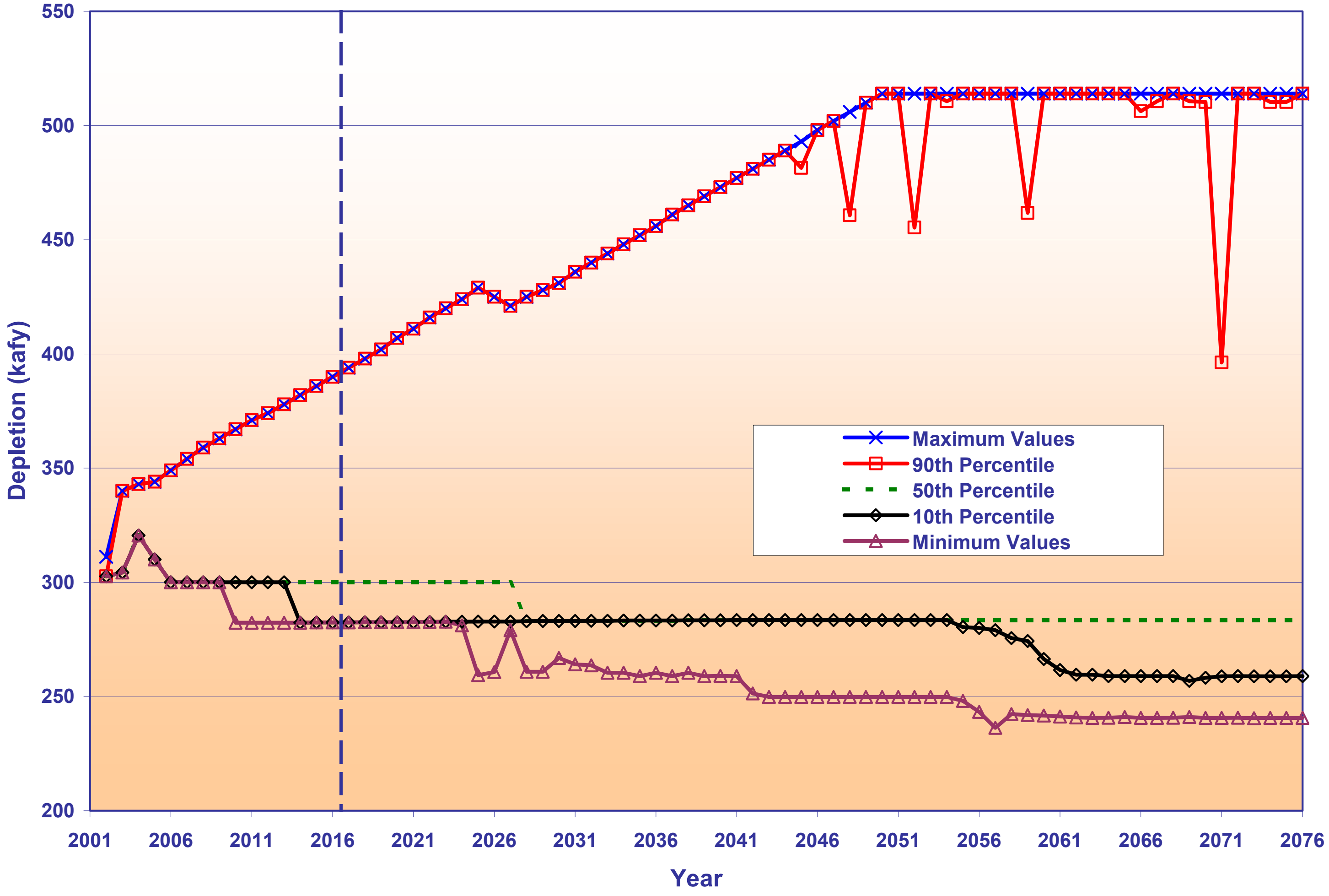
The water deliveries to Nevada are projected to fluctuate throughout the 75-year period of analysis reflecting variations in hydrologic conditions. The 90th, 50th and 10th percentile ranking of modeled water deliveries to Nevada under the Baseline Conditions is presented in Figure 4.6-11.

The 90th percentile values generally coincide with Nevada's normal depletion schedule under Baseline Conditions through year 2047. After year 2047, the 90th percentile values occasionally fall below the full surplus schedule, an indication of the occurrence of more frequent limited surplus conditions.

From 2002 through 2027, under Baseline Conditions, the 50th percentile line for Nevada coincides with the normal depletion schedule. After 2027, the 50th percentile line coincides with Nevada's Level 1 shortage condition depletion schedule (approximately 280 kafy).

From 2002 through 2013, under Nevada Baseline Conditions, the 10th percentile line for Nevada also coincides with the normal depletion schedule. From 2013 to 2054, the 10th percentile line coincides with Arizona's Level 1 shortage condition depletion schedule. After 2054, under Baseline Conditions, the 10th percentile begins to fall below 280 mafy, an indication of frequent Level 2 shortage conditions. Under Baseline Conditions, deliveries to Nevada below 280 kaf occurred less than seven percent of the time during the 75-year period.

Figure 4.6-11
Nevada Modeled Annual Depletions Under Baseline Conditions
90th, 50th and 10th Percentile Values



4.6.3.2 COMPARISON OF BASELINE TO CUMULATIVE ANALYSIS

Figure 4.6-12 provides a comparison of the cumulative distribution of Nevada's depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions during the Interim Surplus Guidelines period (years 2002 to 2016). This graph is best used to represent the frequency that different magnitude water deliveries to Nevada occurred during the 15-year Interim Surplus Guidelines period. The results presented in Figure 4.6-12 indicate a 95 percent probability that water deliveries to Nevada would meet or exceed its normal depletion schedule during this period under the Baseline Conditions. The probability that Nevada would receive surplus condition deliveries under the Baseline Conditions during this period was approximately 47 percent. The maximum surplus condition depletions under the Baseline Conditions were 390 kaf during this period. The probability that Nevada would receive shortage condition deliveries under Baseline Conditions was five percent. The minimum shortage condition depletion was 282.3 kaf.

Figure 4.6-13 provides a comparison of the cumulative distribution of the water deliveries to Nevada under the Cumulative Analysis Conditions to those of the Baseline Conditions for the 60-year period (years 2017 to 2076) that would follow the Interim Surplus Guidelines period. The results presented in Figure 4.6-13 indicate a 40 percent probability that water deliveries to Nevada would meet or exceed its normal depletion schedule during this period under the Baseline Conditions. The probability that Nevada would receive surplus condition deliveries during this same period under the Baseline Conditions was approximately 18 percent. The maximum surplus condition depletions under the Baseline Conditions were 514 kaf during this period. The probability that Nevada would receive shortage condition deliveries was approximately 60 percent. The minimum shortage condition depletion during this period was 236.3 kaf.

Figure 4.6-14 provides a comparison of the cumulative distribution of the water deliveries to Nevada under the Cumulative Analysis Conditions to those of the Baseline Conditions for the entire 75-year period of analysis (years 2002 to 2076). The results presented in Figure 4.6-14 indicate a 51 percent probability that water deliveries to Nevada would meet or exceed its normal depletion schedule during this period under the Baseline Conditions. The probability that Nevada would receive surplus condition deliveries during this same period under the Baseline Conditions was approximately 24 percent. The maximum surplus condition depletions under the Baseline Conditions were 514 kaf during this period. The probability that Nevada would receive shortage condition deliveries was approximately 49 percent. The minimum shortage condition depletion during this period was 236.3 kaf.

Figure 4.6-12
Nevada Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2002 to 2016

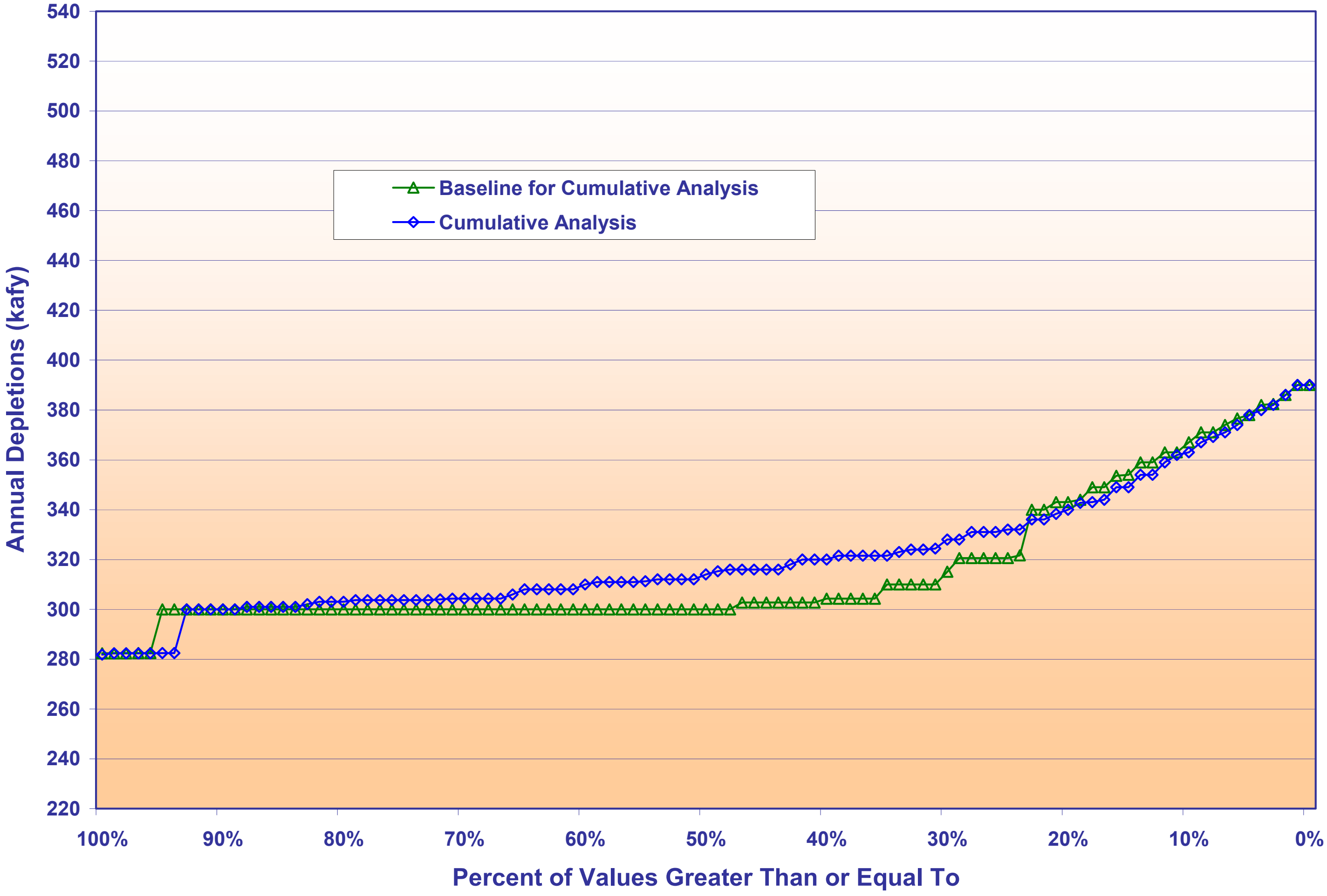


Figure 4.6-13
Nevada Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2017 to 2076

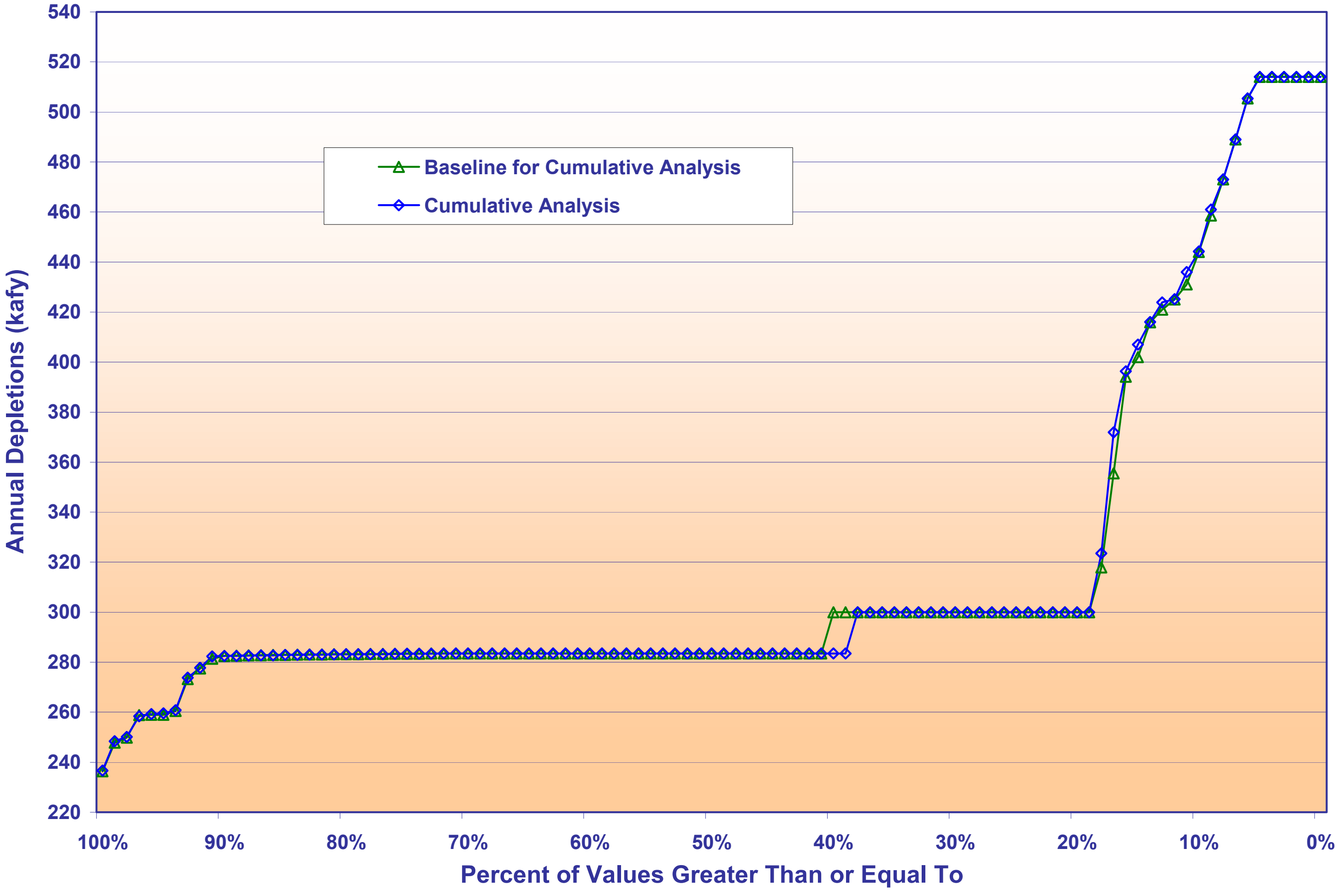


Figure 4.6-14
Nevada Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2002 to 2076

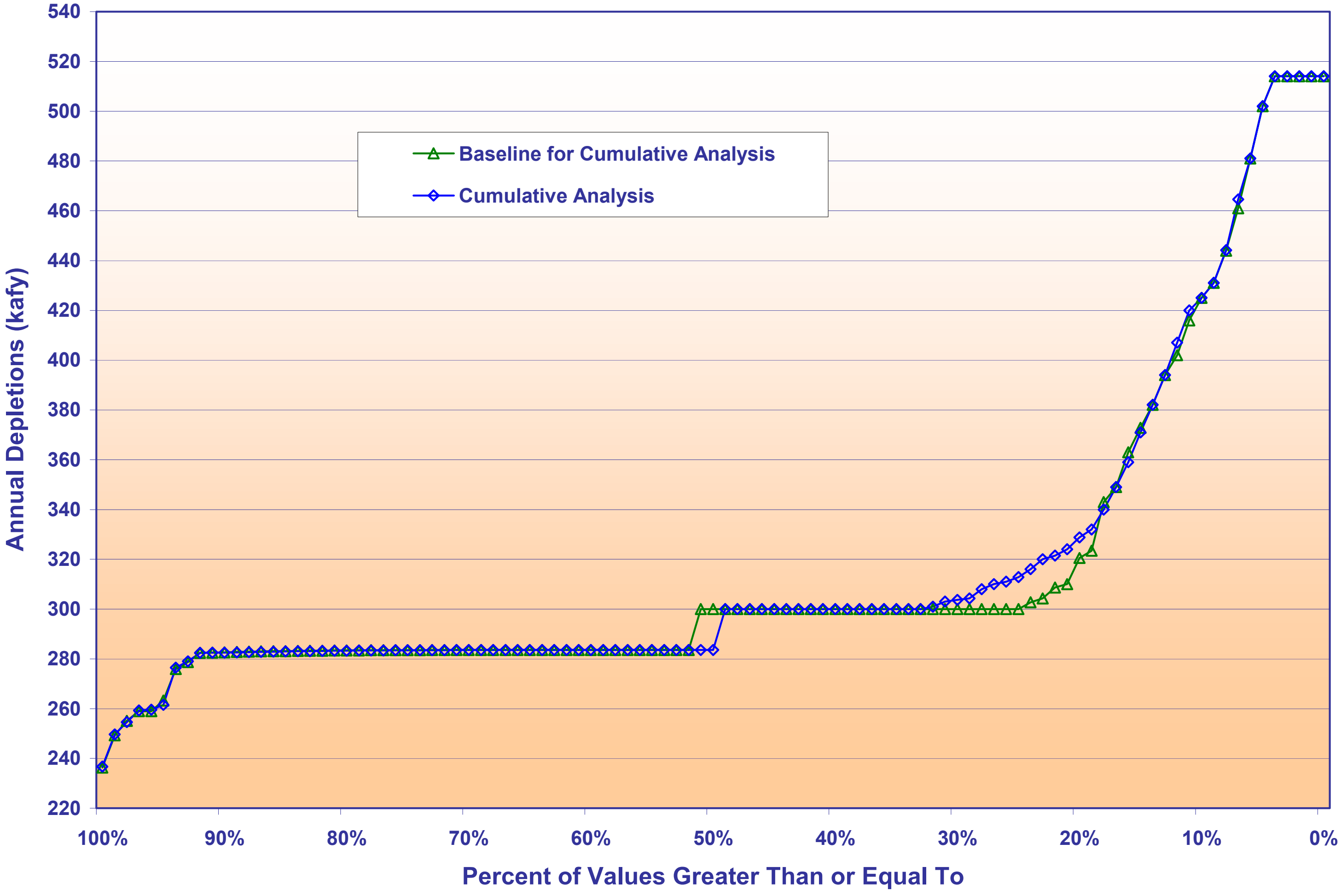


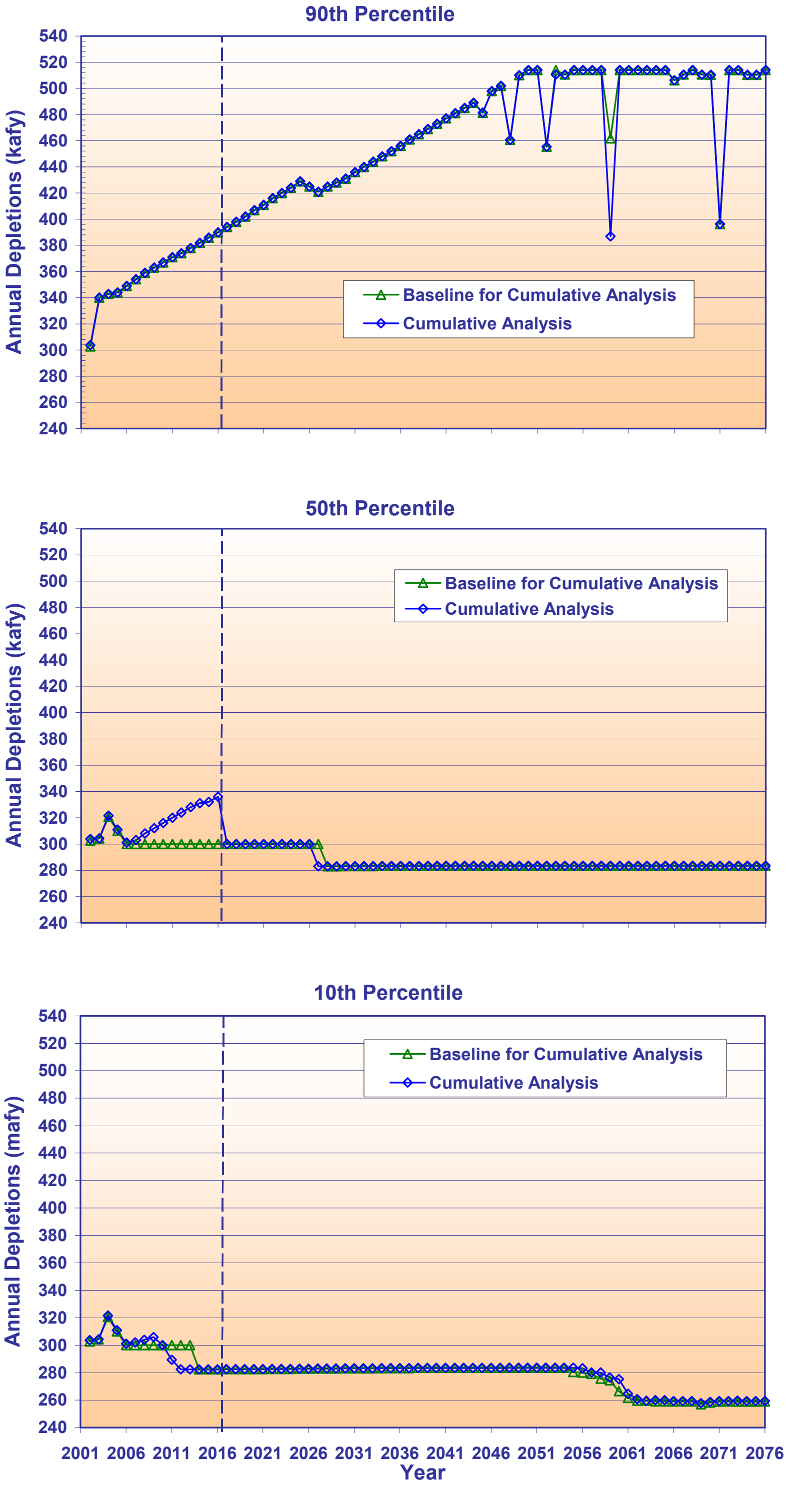
Figure 4.6-15 provides a comparison of the 90th, 50th and 10th percentile values for Nevada's depletions under the Baseline Conditions to those of the Cumulative Analysis Conditions. As noted in Figure 4.6-15, there is little difference between the 90th percentile values resulting from the Cumulative Analysis Conditions and those of the Baseline Conditions. Both 90th percentile lines generally coincide with Nevada's normal depletion schedule under Baseline Conditions through year 2047. After year 2047, both 90th percentile lines occasionally fall below the full surplus schedule, an indication of limited surplus conditions.

From 2002 through 2027, under Baseline Conditions, the 50th percentile line for Nevada coincides with the normal depletion schedule. After 2027, the 50th percentile line coincides with Nevada's Level 1 shortage condition depletion schedule (approximately 280 kafy). Under the Cumulative Analysis Conditions, the 50th percentile line is generally at or above Nevada's normal depletion schedule from year 2002 to 2016, an indication of better than average probability of the availability of limited surplus condition deliveries during this 15-year period. From 2016 to 2026, the 50th percentile values for Nevada under the Cumulative Analysis Conditions coincides with Nevada's normal depletion schedule. After 2026, the 50th percentile line under the Cumulative Analysis Conditions also falls to and thereafter coincides with Nevada's Level 1 shortage condition depletion schedule.

As noted in Figure 4.6-15, there is little difference between the 10th percentile values resulting from the Cumulative Analysis Conditions and those of the Baseline Conditions. From 2002 through 2013, under Baseline Conditions, the 10th percentile line for Nevada also coincides with the normal depletion schedule. From 2013 to 2054, the 10th percentile line of the Baseline Conditions coincides with Nevada's Level 1 shortage condition depletion schedule. After 2054, under Baseline Conditions, the 10th percentile begins to fall below 280 kafy. From 2002 through 2010, under Cumulative Analysis Conditions, the 10th percentile line for Nevada also coincides with the normal depletion schedule. However, this is approximately three years less than under the Baseline Conditions. From 2010 to 2059, the 10th percentile line coincides with Nevada's Level 1 shortage condition depletion schedule. After 2059, under Cumulative Analysis Conditions, the 10th percentile begins to fall below 280 kafy, an indication of the occurrence of more frequent Level 2 shortage condition deliveries.

Deliveries to Nevada below 280 kafy (Level 2 Shortage Condition deliveries) occurred less than seven percent of the time during the 75-year period of analysis under both the Baseline and Cumulative Analysis conditions.

Figure 4.6-15
Nevada Modeled Annual Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
90th, 50th and 10th Percentile Values



Figures 4.6-12, 4.6-13 and 4.6-14 presented comparisons of the cumulative distribution of Nevada's depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016), the 60-year period that would follow the Interim Surplus Guidelines (years 2017 to 2076), and the entire 75-year period of analysis (years 2002 to 2076), respectively. These graphs represent the frequency that different magnitude annual deliveries to Nevada occurred under each respective period. Table 4.6-3 provides a tabular summary of the comparison for these two periods.

Table 4.6-3
Summary of Nevada Modeled Annual Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions

	Years 2002 to 2016			Years 2017 to 2076			Years 2002 to 2076		
Alternative/Conditions	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**
Baseline	95%	47%	5%	40%	18%	60%	51%	24%	49%
Cumulative Analysis	93%	88%	7%	38%	18%	62%	49%	32%	51%

*The values under normal represent the total percentage of time that depletions would be at or above the normal depletion conditions.

The percentage values presented under the column heading labeled "Normal" in Table 4.6-3 represent the total percentage of time that depletions under the noted conditions would be at or above the normal depletion schedule amount. The values presented under the column labeled "Surplus" represent the total percentage of time that depletions under the noted conditions exceed the normal depletion schedule amount. The values presented under the column labeled "Shortage" represent the total percentage of time that depletions under the noted conditions would be below the normal depletion schedule amount.

4.6.4 UPPER BASIN STATES

There are no specific criteria in the *Law of the River* for surplus or shortage condition water deliveries to users within the Upper Basin states. The normal depletion schedule of the Upper Basin states would be met under both the Baseline and Cumulative Analysis conditions. The exceptions are potential reductions to certain Upper Basin users whose diversions are located upstream of Lake Powell. For these users, the potential reductions would be attributed to dry hydrologic conditions and inadequate regulating reservoir storage capacity upstream of their diversions.

The proposed water transfers were determined to have no effect on water deliveries to the Upper Basin states, including the Upper Basin Tribes. Therefore, detailed analyses were not necessary for the Upper Basin states' water supply.

4.6.5 MEXICO

This section presents the analyses of the simulated water deliveries to Mexico under the Baseline and Cumulative Analysis conditions. As discussed previously, Mexico's normal depletion schedule is modeled as 1.5 maf. An additional 15,000 af is included to account for typical scheduling errors and water that is ordered by the Lower Basin users but that is not diverted. Therefore, the normal annual depletion schedule deliveries to Mexico were modeled as 1.515 maf. Surplus deliveries to Mexico of up to 200 kaf are delivered under both Baseline and the Cumulative Analysis conditions only when Lake Mead makes flood control releases. Shortage deliveries to Mexico would only occur if the CAP diversions were reduced to zero and further reductions to MWD and Mexico were necessary to keep the Lake Mead water surface elevation above 1000 feet msl, a Level 2 shortage water supply condition. This condition was observed to occur less than one percent of the time during the 75-year period of analysis in both the Baseline and Cumulative Analysis conditions.

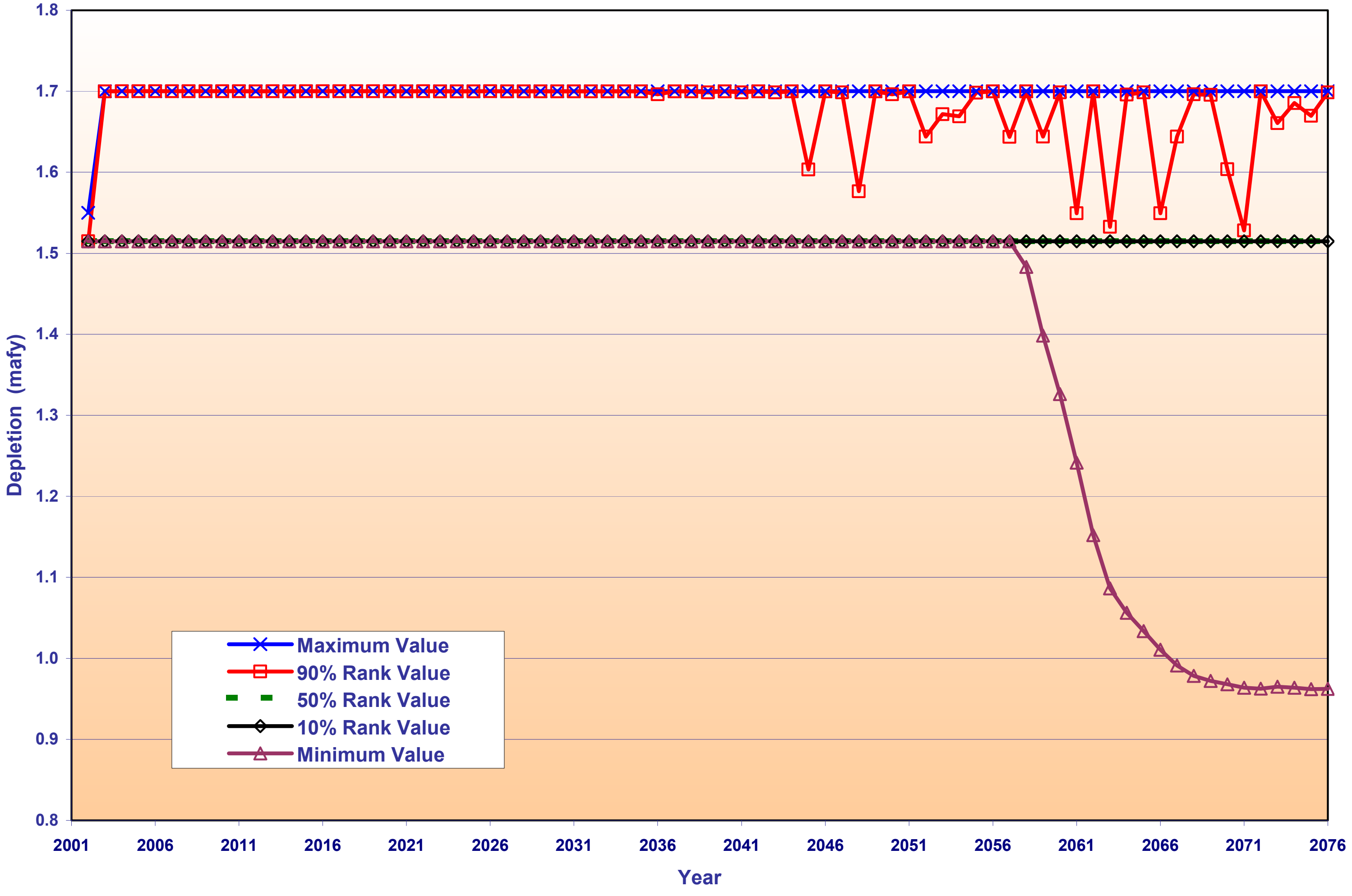
4.6.5.1 MODELING RESULTS OF BASELINE

The water deliveries to Mexico were observed to be mostly at or above Mexico’s normal delivery schedule throughout the 75-year period of analysis. Under the Baseline Conditions, annual deliveries to Mexico that were less than its normal depletion schedule were observed to occur in only 19 of the 85-modeled traces, an indication of Level 2 shortage water supply conditions. In these 19 traces, the frequency of occurrence of annual deliveries to Mexico that were less than its normal depletion schedule was only one year of the 75 modeled years. The minimum observed delivery to Mexico was 962,019 af.

The 90th, 50th and 10th percentile ranking of modeled water deliveries to Mexico under the Baseline Conditions are presented in Figure 4.6-16. The 90th percentile line generally coincides with Mexico’s full surplus condition schedule under Baseline Conditions through year 2044. After year 2044, the 90th percentile occasionally falls below the full surplus schedule, an indication of more frequent limited surplus conditions.

Under Baseline Conditions, the 50th and 10th percentile lines coincide with Mexico’s normal depletion schedule. It is noted that the depletion amount depicted by both the 50th and 10th percentile lines is equal to 1.515 maf. The 15,000 af above the 1.5 maf Mexico apportionment was added to the model to account for typical scheduling errors and water that is ordered by the Lower Division users but that is not diverted. Under Baseline Conditions, deliveries to Mexico that were less than its normal depletion schedule were observed to occur less than one percent of the time during the 75-year period of analysis.

Figure 4.6-16
Mexico Modeled Annual Depletions Under Baseline Conditions
90th, 50th and 10th Percentile Values



4.6.5.2 COMPARISON OF BASELINE TO CUMULATIVE ANALYSIS

Figure 4.6-17 provides a comparison of the cumulative distribution of Mexico's depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016). Again, this type of graph is used to represent the frequency that annual deliveries of different magnitudes occur in the respective period. The results presented in Figure 4.6-17 indicate a 100 percent probability that Mexico’s depletions would meet or exceed its normal depletion schedule during this period under the Baseline Conditions. The probability that Mexico would receive surplus condition deliveries during this period was approximately 23 percent under Baseline Conditions. The maximum surplus condition depletion under the Baseline Conditions was 1.7 maf during this period.

Figure 4.6-18 provides a comparison of the cumulative distribution of the water deliveries to Mexico under the Cumulative Analysis Conditions to those of the Baseline Conditions for the 60-year period (years 2017 to 2076) that would follow the Interim Surplus Guidelines period. The results presented in Figure 4.6-18 indicate an approximately 99 percent probability that water deliveries to Mexico would meet or exceed its normal depletion schedule during this period under the Baseline Conditions. The probability that Mexico would receive surplus condition deliveries during this same period under the Baseline Conditions was approximately 17 percent. The maximum surplus condition depletion under the Baseline Conditions was also 1.7 maf during this period.

Figure 4.6-19 provides a comparison of the cumulative distribution of the water deliveries to Mexico under the Cumulative Analysis Conditions to those of the Baseline Conditions for the entire 75-year period of analysis (years 2002 to 2076). The results presented in Figure 4.6-19 indicate an approximately 99 percent probability that water deliveries to Mexico would meet or exceed its normal depletion schedule during this period under the Baseline Conditions. The probability that Mexico would receive surplus condition deliveries during this same period under the Baseline Conditions was approximately 18 percent during this 75-year period. The maximum surplus condition depletion under the Baseline Conditions was also 1.7 maf during this period.

Figure 4.6-17
Mexico Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2002 to 2016

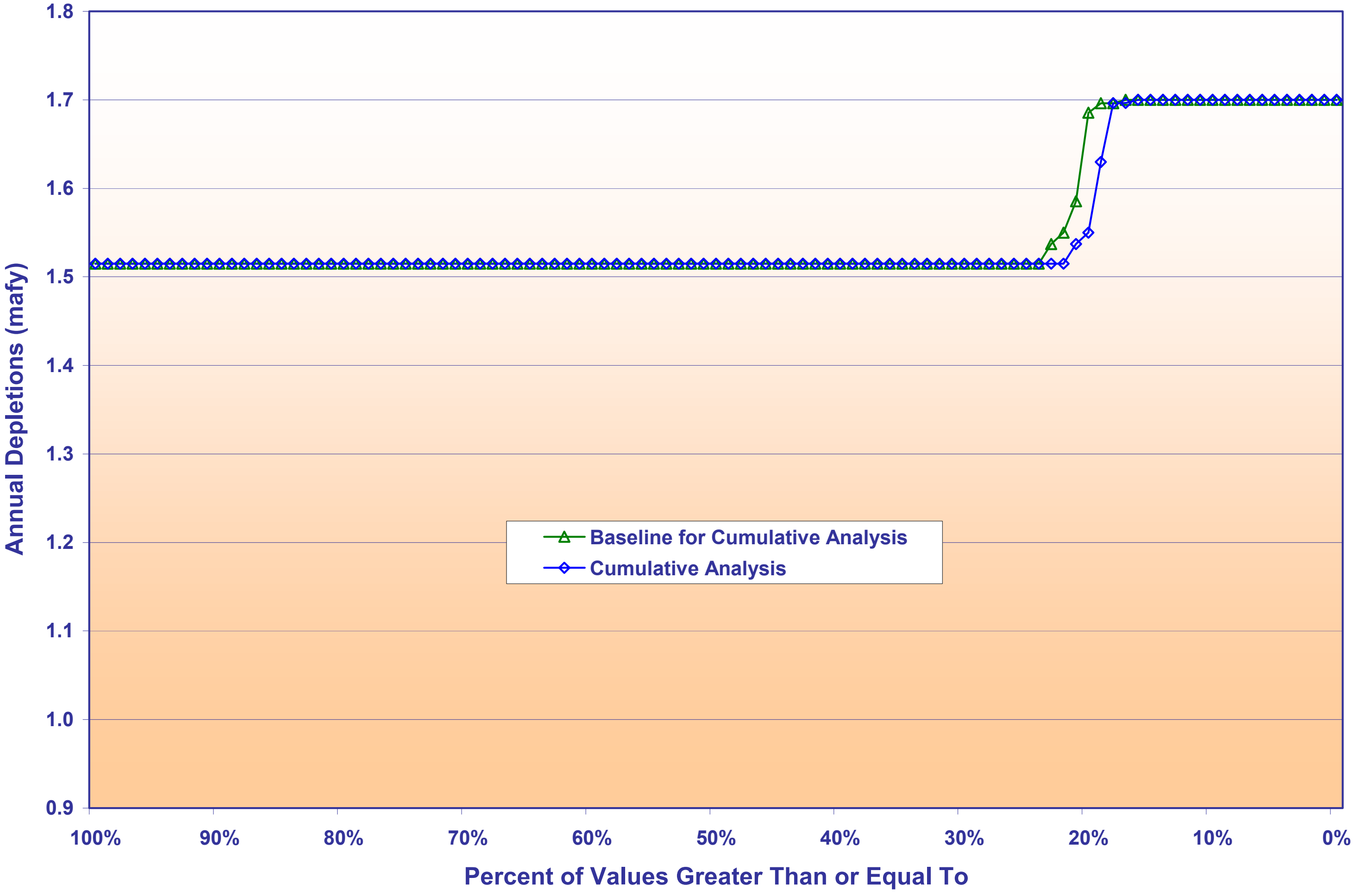


Figure 4.6-18
Mexico Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2017 to 2076

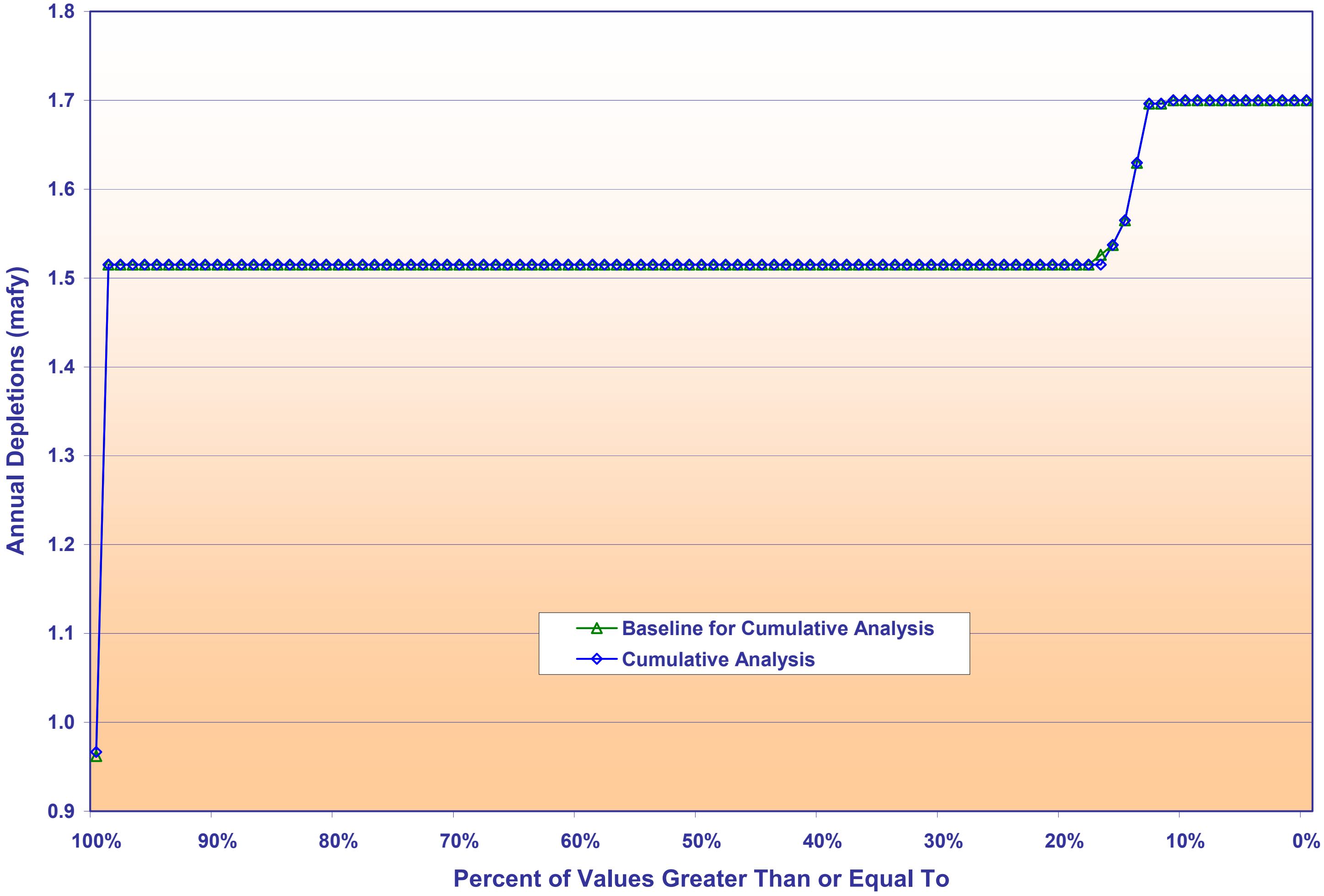


Figure 4.6-19
Mexico Modeled Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
Years 2002 to 2076

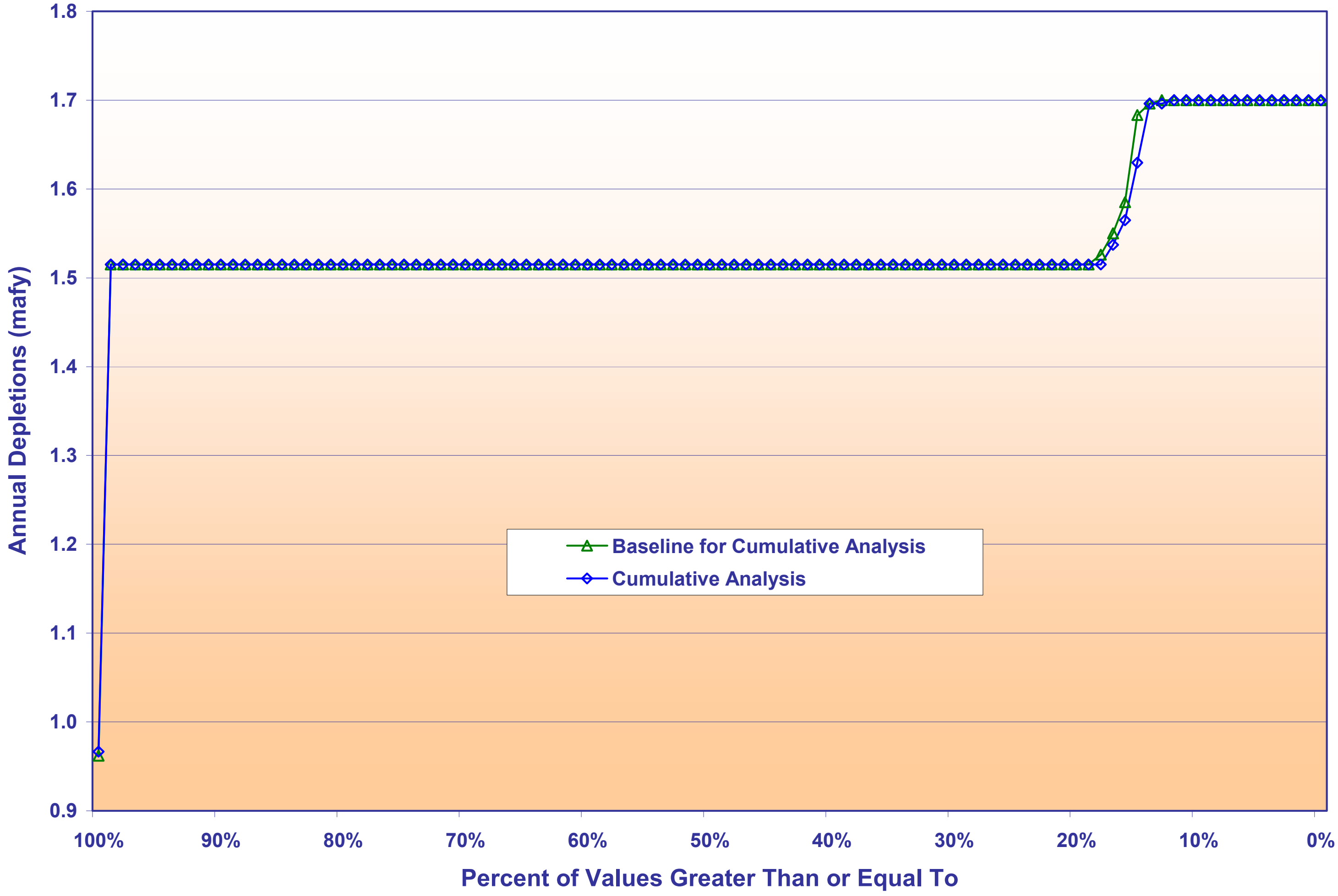


Figure 4.6-20 provides a comparison of the 90th, 50th and 10th percentile values for Mexico’s depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions. As noted in Figure 4.6-20, there is essentially no difference in the 90th percentile lines resulting from the Cumulative Analysis Conditions when compared to those of the Baseline Conditions. Both 90th percentile lines generally coincide with Nevada’s normal depletion schedule under Baseline Conditions through year 2044. After year 2044, both 90th percentile lines occasionally fall below the full surplus schedule, an indication of limited surplus conditions.

The 50th and 10th percentile lines for the Cumulative Analysis and the Baseline conditions coincide with Mexico’s normal depletion schedule, an indication of better than 90 percent probability that water deliveries to Mexico would meet or exceed its normal depletion schedule. Again, Level 2 shortage condition deliveries to Mexico were observed to occur in only 19 of the 85-modeled traces in both the Baseline and Cumulative Analysis conditions. In each of these 19 traces, deliveries of less than normal annual depletion conditions to Mexico were observed to occur in only one of the 75-year period modeled. Under Baseline and Cumulative Analysis conditions, deliveries to Mexico that were less than its normal depletion schedule were observed to occur less than one percent of the time during the 75-year period of analysis.

Figures 4.6-17, 4.6-18 and 4.6-19 presented comparisons of the guidelines cumulative distribution of Mexico's depletions under the Cumulative Analysis Conditions to those of the Baseline Conditions during the 15-year Interim Surplus Guidelines period (years 2002 to 2016), the 60-year period that follows the Interim Surplus Guidelines (years 2017 to 2076) and the entire 75-year period of analysis (years 2002 to 2076), respectively. Table 4.6-4 provides a tabular summary of the comparison for these two periods.

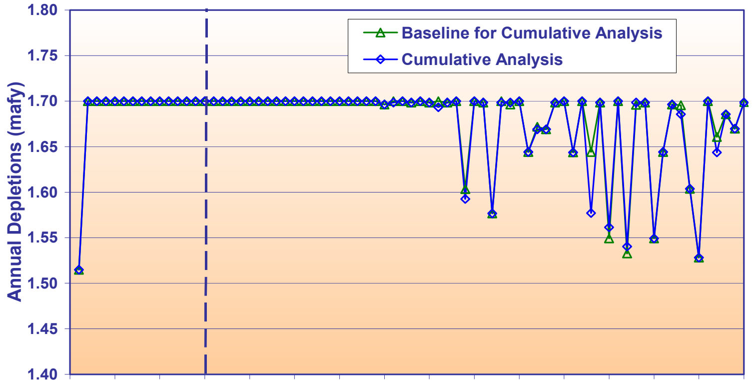
Table 4.6-4
Summary of Mexico Modeled Annual Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions

	Years 2002 to 2016			Years 2017 to 2076			Years 2002 to 2076		
Alternative/Conditions	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**	**Normal***	**Surplus**	**Shortage**
Baseline	100%	23%	0%	99%	17%	1%	99%	18%	1%
Cumulative Analysis	100%	21%	0%	99%	16%	1%	99%	17%	1%
*The values under normal represent the total percentage of time that depletions would be at or above the normal depletion conditions.									

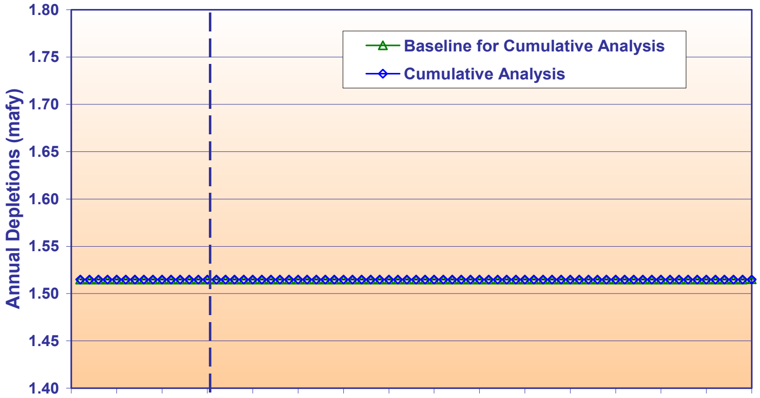
The percentage values presented under the column heading labeled “Normal” in Table 4.6-4 represent the total percentage of time that depletions under the noted conditions would be at or above the normal depletion schedule amount. The values presented under the column labeled “Surplus” represent the total percentage of time that depletions under the noted conditions exceed the normal depletion schedule amount. The values presented under the column labeled “Shortage” represent the total percentage of time that depletions under the noted conditions would be below the normal depletion schedule amount.

Figure 4.6-20
Mexico Modeled Annual Depletions
Comparison of Cumulative Analysis Conditions to Baseline Conditions
90th, 50th and 10th Percentile Values

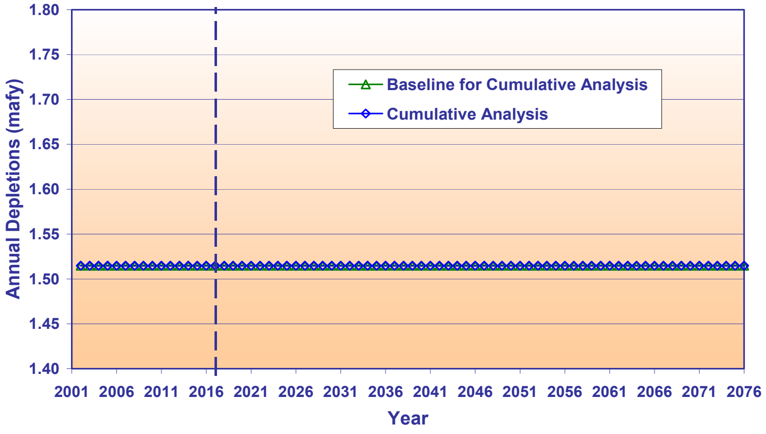
90th Percentile



50th Percentile



10th Percentile



5.0 EXCESS FLOWS TO MEXICO

This section addresses the probability of excess flows in the Colorado River downstream of Morelos Dam, which is the diversion point for most of the water delivered to Mexico under the US-Mexico Water Treaty of 1944. There is a potential for Colorado River water to flow past Morelos Dam under three conditions: (1) as a result of operational activities upstream (e.g., canceled water orders in the United States, maintenance activities, etc.); (2) during a Gila River flood event; and (3) during flood control releases along the mainstream Colorado River. Each of these conditions may cause flows to reach Mexico that are in excess of Mexico's monthly or yearly water orders. However, Mexico has complete autonomy as to how it chooses to manage excess flows that arrive at Morelos Dam, so excess flows do not necessarily flow past Morelos Dam.

Water released from Parker Dam, in response to water 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, this excess water is then diverted at Morelos Dam for use in Mexico; however, some of this water may flow past Morelos Dam. The volume of water passing by Morelos Dam is rarely enough to have much effect on species and habitat in Mexico below the NIB.

Gila River flood events are extremely rare. Only once has flow been recorded over 4,000 cfs at the Dome, Arizona, gaging station 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 (Glenn, 2000).

Excess flows to Mexico are mostly caused by flood control releases originating at Hoover Dam. As discussed in Section 1.1.2, these flood control releases are dictated by the flood control criteria established for Lake Mead and Hoover Dam and are dependent upon hydrologic conditions.

5.1 ANALYSIS OF WATER TRANSFERS

This section analyzes the effects of the proposed water transfers through a comparison of the Implementation Agreement and No Action modeling results. Section 5.2 analyzes the cumulative effects through a comparison of the Baseline to the Cumulative Analysis modeling results.

5.1.1 NO ACTION CONDITIONS

The potential range of water deliveries to Mexico under the No Action Conditions were discussed in Section 3.2.4.4. Flows below Morelos Dam at various seasons were also analyzed in Section 3.2.4.4. Both the frequency and magnitude of excess flows are important factors in restoring and maintaining riparian habitat below Morelos Dam and are analyzed in more detail in this section. It should be emphasized that Mexico's management decisions at and below Morelos Dam are not modeled. This is due to uncertainty of how Mexico may choose to use excess water. The assumption made for the hydrologic analyses is that annual flows in excess of Mexico's scheduled surplus deliveries (any amount greater than 1.7 mafy) would have the potential to flow past Morelos Dam.

Figure 5.1-1 presents a comparison of the frequency of occurrence of future delivery of excess flows to Mexico observed under the Implementation Agreement to those of No Action conditions.

The frequency of occurrence is compiled by counting the number of modeled traces for each year that have excess flows and dividing by the total number of traces (85 traces). As illustrated in Figure 5.1-1, the excess flows below Morelos Dam are generally similar under the Implementation Agreement and No Action conditions. The exception to this is the eight-year period between 2013 to 2020 where the excess flows observed under the Implementation Agreement are slightly higher than those observed under the No Action conditions. The average difference during this eight-year period is approximately 2.1 percent. The largest difference (4.7 percent) during this eight-year period occurs in year 2013.

The low frequency of occurrence of excess flows under the No Action conditions in the first year (2002) is attributable to the fact that the starting conditions used in the model include less-than-full reservoirs (for example, Lake Mead at approximately 35 feet below full content). Reservoir starting conditions are discussed in Section 2.3. The slightly higher excess flows observed in some traces under the Implementation Agreement can be attributed to the slightly higher Lake Mead water levels also observed under this condition. With higher reservoir levels, the frequency of flood control releases (which are the primary source of the excess flows) is increased.

The maximum frequency under No Action conditions is observed in 2007 (29.4 percent). Thereafter, a gradually declining tendency is observed to about 10.6 percent in 2071 and recovering back to about 16.5 percent by 2076. The gradual declining trend observed under both the No Action and Implementation Agreement conditions coincide with the Basin States' plans to use their water apportionments under the Colorado River Compact for agricultural, municipal and industrial purposes.

It has been estimated that periodic annual flows of 250,000 af or greater are necessary for maintaining the health of the Colorado River corridor in Mexico and the estuary at the upper end of the Sea of Cortez (Leucke *et al.,* 1999), and to help to restore floodplain habitat. Figure 5.1-2 presents the probability of occurrence of excess flows greater than 250,000 af and Figure 5.1-3 presents the probability of occurrence of excess flows greater than 1,000,000 af below the Mexico Diversion at Morelos Dam.

Figure 5.1-1
Probability of Occurrence of Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action

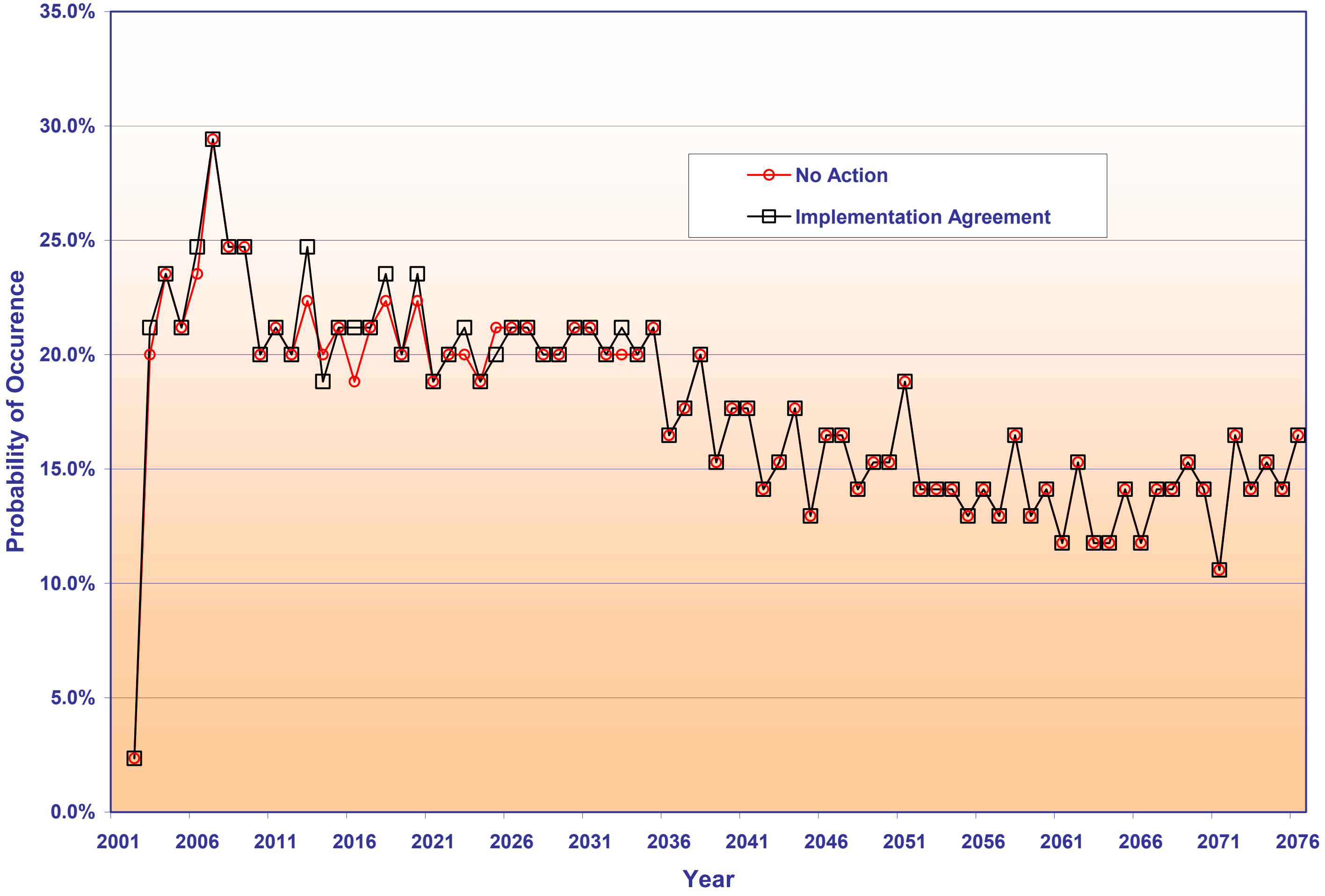


Figure 5.1-2
Probability of Occurrence of Excess Flows Greater than 250,000 Acre-Feet
Below Mexico Diversions at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions

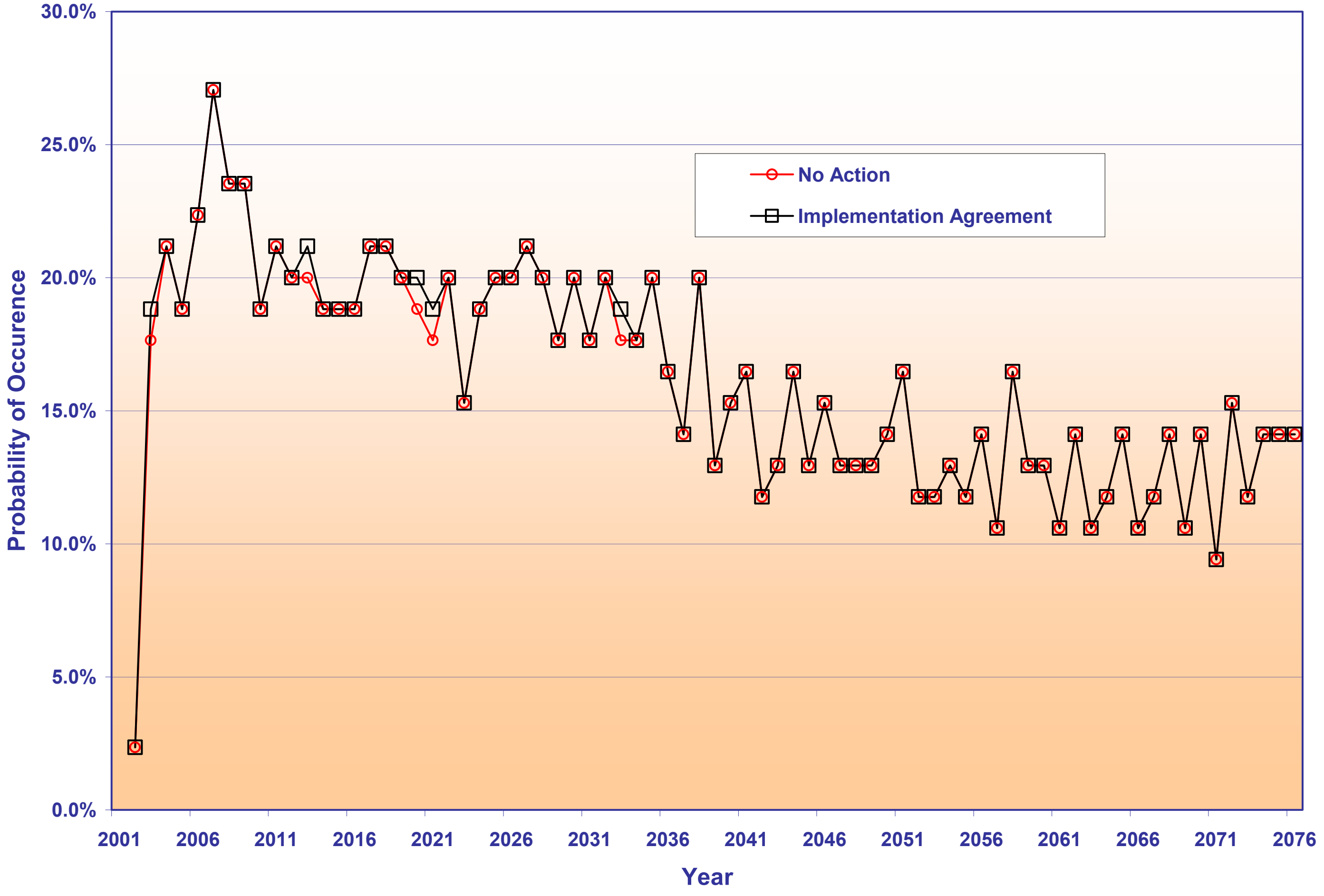
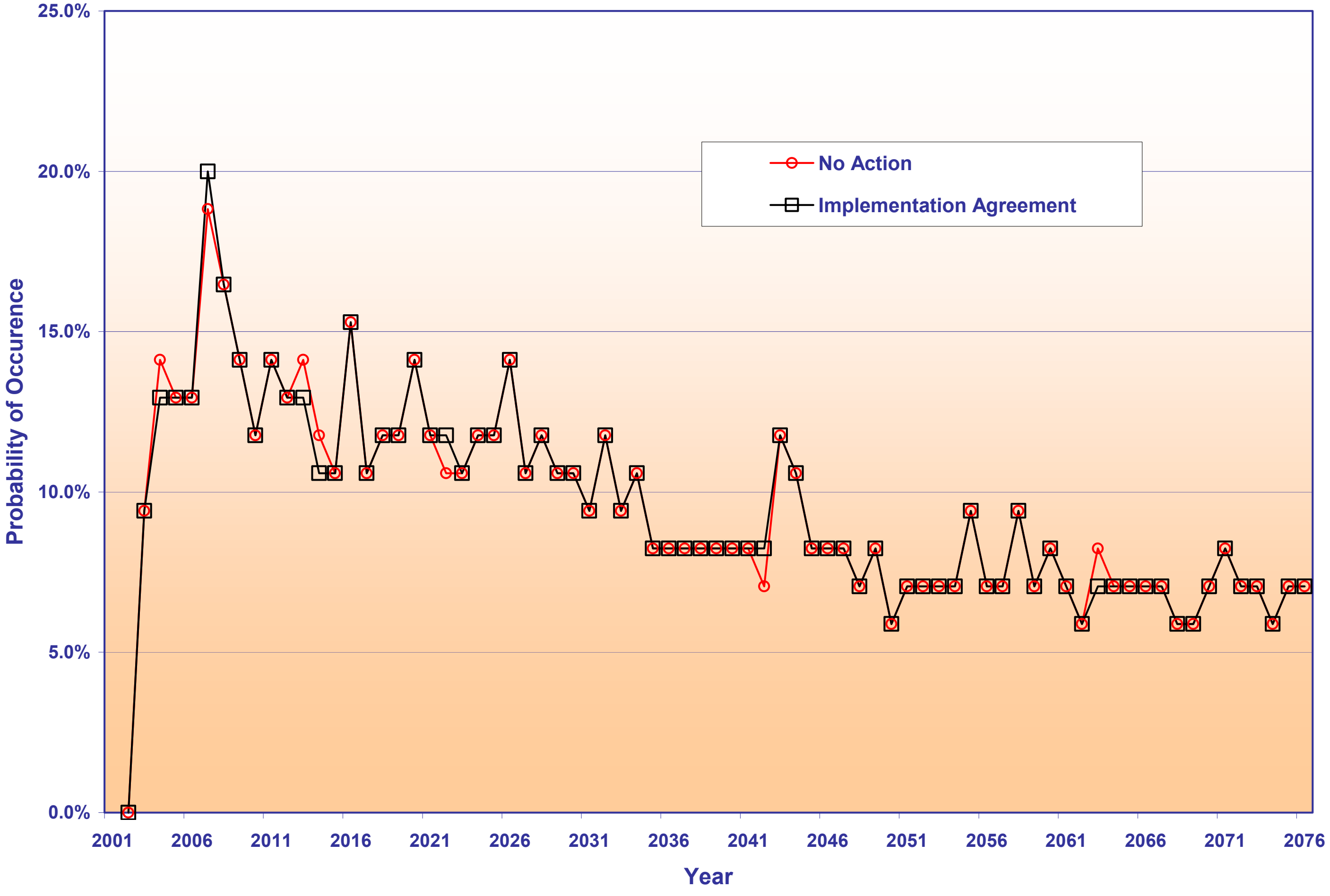


Figure 5.1-3
Probability of Occurrence of Excess Flows Greater Than 1,000,000 Acre-Feet
Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions



5.1.2 COMPARISON OF IMPLEMENTATION AGREEMENT TO NO ACTION CONDITIONS

Figure 5.1-1 presented a graphical comparison of the probability of delivery of future excess flows to Mexico under the Implementation Agreement to those under the No Action conditions. A similar comparison for selected years is presented in tabular format in Table 5.1-1. In general, the Implementation Agreement provides a slightly higher frequency of excess flows than the No Action conditions. Differences between the two conditions were noted in only 14 of the 75 years modeled. The average of frequency differences that were noted in these 14 years was 1.6 percent. The largest difference in frequency observed occurs in year 2013 and is about 4.7 percent (rounded to 5.0 percent in table). This difference is reduced to approximately one percent by 2037. After 2037, there were no differences in frequency between the Implementation Agreement and No Action conditions.

Table 5.1-1
Frequency Occurrence of Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions

Selected Year	No Action	Implementation Agreement	Difference
2002	2%	2%	0%
2003	20%	21%	1%
2004	24%	24%	0%
2005	21%	21%	0%
2006	24%	25%	1%
2007	29%	29%	0%
2008	25%	25%	0%
2009	25%	25%	0%
2010	20%	20%	0%
2011	20%	21%	1%
2012	20%	20%	0%
2013	20%	25%	5%
2014	19%	19%	0%
2015	20%	21%	1%
2016	19%	21%	2%
2020	21%	24%	3%
2025	21%	20%	1%
2030	21%	21%	0%
2035	21%	21%	0%
2040	18%	18%	0%
2045	13%	13%	0%
2050	15%	15%	0%
2055	13%	13%	0%
2060	14%	14%	0%
2065	14%	14%	0%
2070	14%	14%	0%
2075	14%	14%	0%

Figures 5.1-4 and 5.1-5 compare the cumulative distribution of annual volume of excess flows observed under the Implementation Agreement and No Action conditions for years 2016 and 2050, respectively. Although the frequency of occurrence of flows of a particular magnitude is increased, the range of excess flows is preserved under the Implementation Agreement when compared to No Action conditions. In the long-term, both frequency and magnitude between these two modeled conditions appear to be similar.

Alternatively, the potential magnitudes of excess flows for the 75th and 90th percentiles are shown in Figure 5.1-6. The 75th and 90th percentile values are also presented in tabular format for selected years between 2002 through 2026 in Table 5.1-2 and Table 5.1-3, respectively. The 75th percentile flow is defined as the flow that would not be exceeded 75 percent of the time (i.e., the minimum flow that would be expected to occur 25 percent of the time) and likewise, the 90th percentile flow would be expected to occur 10 percent of the time.

In summary, there are only minor differences in the potential magnitudes and potential frequencies of excess flows between No Action and the Implementation Agreement conditions. During the initial 15 years that were modeled (interim surplus guidelines period), the average frequency of occurrence of flows exceeding 250,000 af in any year is 18.9 percent for No Action conditions, which is slightly less than one year in five. This compares to a frequency of 19.7 percent for the Implementation Agreement (approximately one year in five). For the entire 75-year period of analysis, the average frequency of occurrence is approximately the same for the No Action and Implementation Agreement conditions (ranging between 15.9 percent and 16.2 percent or about one in every six years).

The above probabilities indicate conditions below Morelos Dam would be similar to those presumed to be beneficial. Leucke, et al, 1999 states it is not yet possible to quantify with certainty the volume and frequency of these high flows that would be beneficial.

The probable average frequency of approximately 15.9 percent under the No Action conditions would change to a probable average frequency of approximately 16.2 percent under the Implementation Agreement conditions, a slightly improved but still insignificant condition. As such, the potential change in benefits to species and habitat would likely be insignificant.

Mexico has complete discretion over the use of water entering that country. As stated previously, excess flows do not necessarily flow past Morelos Dam. The assumption made for the hydrologic analysis is that annual flows in excess of Mexico's scheduled surplus deliveries (any amount greater than 1.7 maf) would have the potential to flow past Morelos Dam.

Figure 5.1-4
Potential Magnitude of Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2016

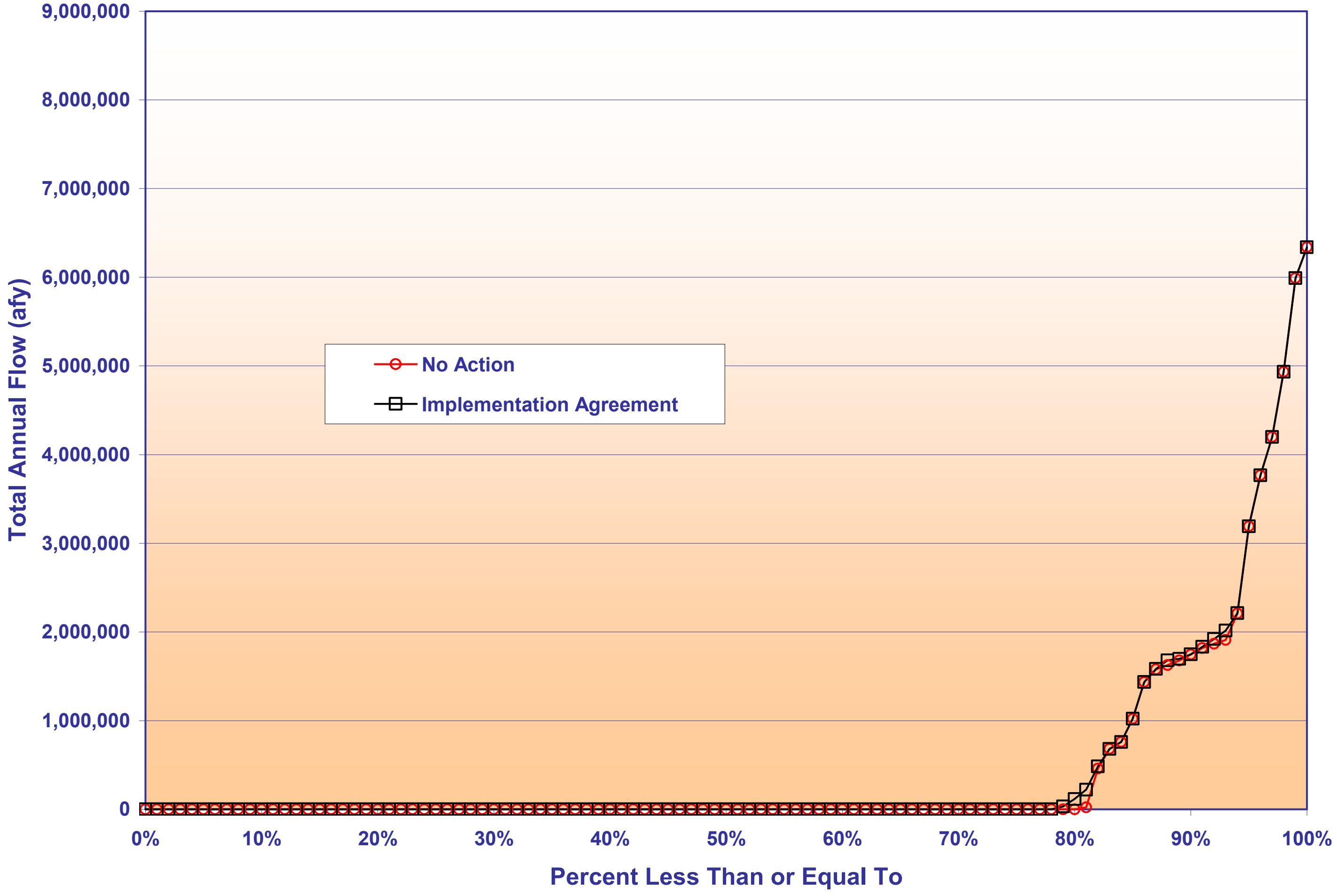


Figure 5.1-5
Potential Magnitude of Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions for Modeled Year 2050

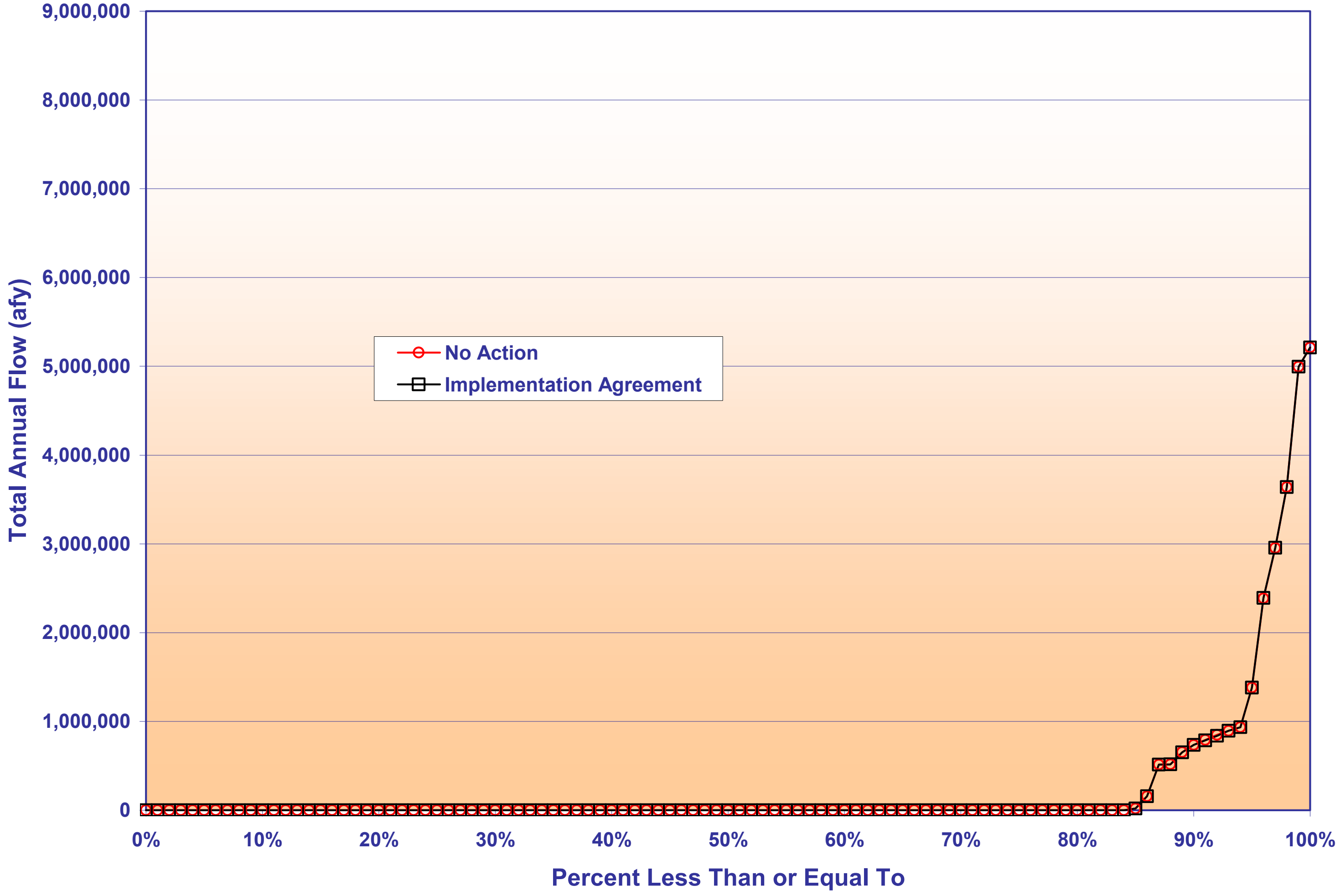


Figure 5.1- 6
Potential Magnitude of Excess Flows To Mexico
90th and 75th Percentile Values

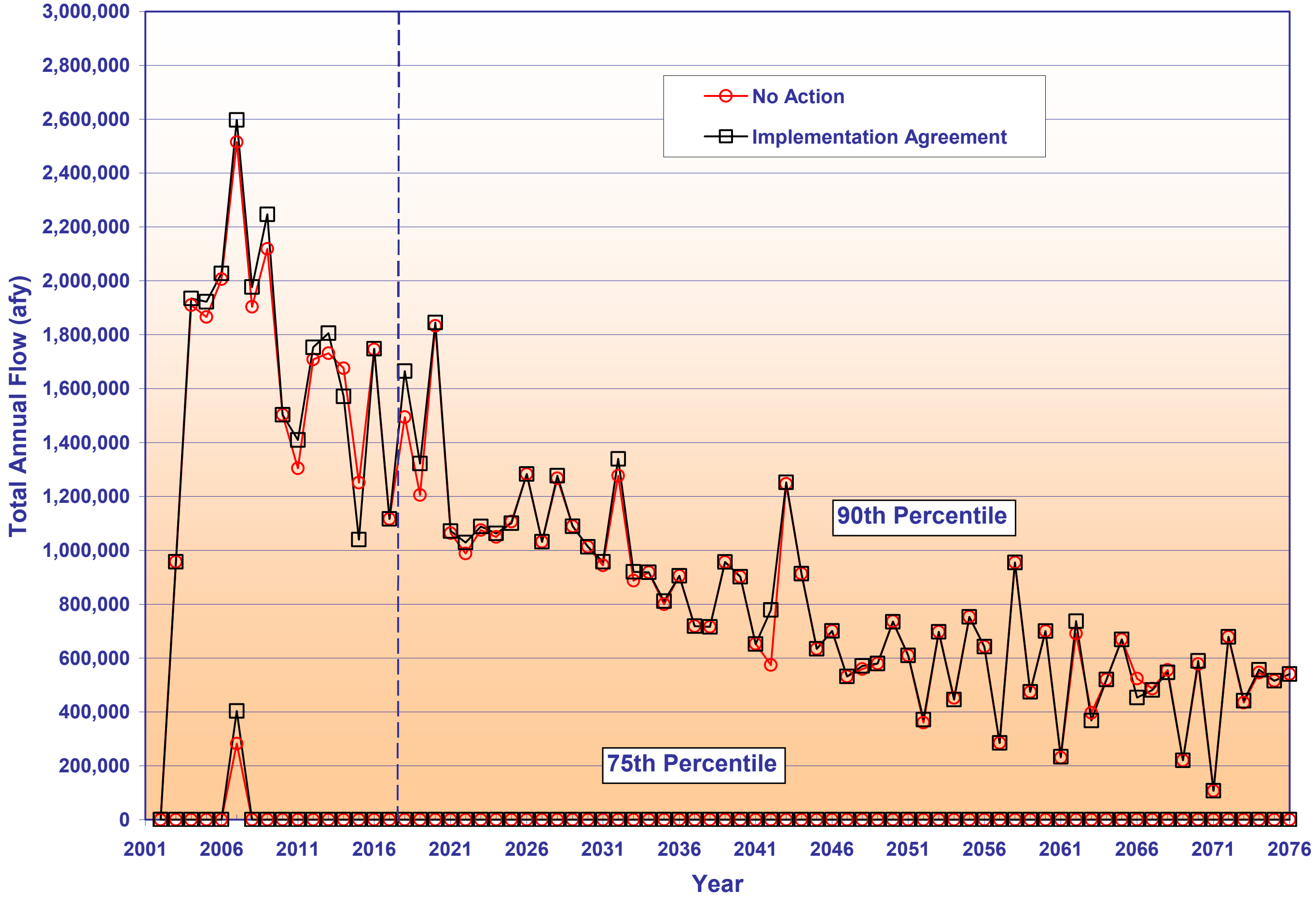


Table 5.1-2
Potential Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions
75th Percentile Values for Selected Years (kaf)

Selected Years	No Action	Implementation Agreement
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	283	404
2008	0	0
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2020	0	0
2025	0	0
2030	0	0
2035	0	0
2040	0	0
2045	0	0
2050	0	0
2055	0	0
2060	0	0
2065	0	0
2070	0	0
2075	0	0

Table 5.1-3
Potential Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Implementation Agreement to No Action Conditions
90th Percentile Values for Selected Years (kaf)

Selected Years	No Action	Implementation Agreement
2002	0	0
2003	957	957
2004	1,908	1,934
2005	1,836	1,922
2006	1,981	2,027
2007	2,445	2,597
2008	1,842	1,977
2009	2,015	2,247
2010	1,503	1,503
2011	1,214	1,409
2012	1,921	1,753
2013	1,580	1,806
2014	961	1,571
2015	900	1,039
2016	1,591	1,748
2020	1,833	1,846
2025	1,107	1,101
2030	1,013	1,013
2035	800	811
2040	902	902
2045	634	634
2050	734	734
2055	753	753
2060	700	700
2065	669	669
2070	577	589
2075	516	516

5.2 ANALYSIS OF CUMULATIVE EFFECTS

This section analyzes the cumulative effects through a comparison of the Cumulative Analysis and Baseline modeling results. The Baseline hereinafter refers to the Baseline for Cumulative Analysis Conditions as well as the No Action Condition for the Action Alternative.

5.2.1 BASELINE CONDITIONS

Figure 5.2-1 presents a comparison of the frequency of occurrence of future delivery of excess flows to Mexico observed under the Cumulative Analysis to those of Baseline conditions.

As previously noted, the frequency of occurrence is compiled by counting the number of modeled traces for each year that have excess flows and dividing by the total number of traces (85 traces). As illustrated in Figure 5.2-1, the excess flows below Morelos Dam are generally similar under the Cumulative Analysis and Baseline conditions. The exception to this is the eighteen-year period between 2002 to 2019 where the excess flows observed under the Cumulative Analysis are slightly lower than those observed under the Baseline conditions. The average difference during this eighteen-year period is approximately 1.9 percent. The largest difference (5.9 percent) during this eighteen-year period occurs in year 2012.

The low frequency of occurrence of excess flows under the Baseline conditions in the first year (2002) is attributable to the fact that the starting conditions used in the model include less-than-full reservoirs (for example, Lake Mead at approximately 35 feet below full content). The slightly higher excess flows observed in some traces under the Baseline conditions can be attributed to the slightly higher Lake Mead water levels also observed under this condition. With higher reservoir levels, the frequency of flood control events (which are the primary source of the excess flows) is increased.

The maximum frequency under Baseline conditions is observed in 2007 (29.4 percent). Thereafter, a gradual declining tendency is observed to about 10.6 percent in 2071 and recovering back to about 16.5 percent by 2076. The gradual declining trend observed under both the Baseline and Cumulative Analysis conditions coincide with the Basin States' plans to use their water apportionments under the Colorado River Compact for agricultural, municipal and industrial purposes.

Figure 5.2-2 presents the probability of occurrence of excess flows greater than 250,000 af. Figure 5.2-3 presents the probability of occurrence of excess flows greater than 1,000,000 af below the Mexico Diversion at Morelos Dam.

Figure 5.2-1
Probability of Occurrence of Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline

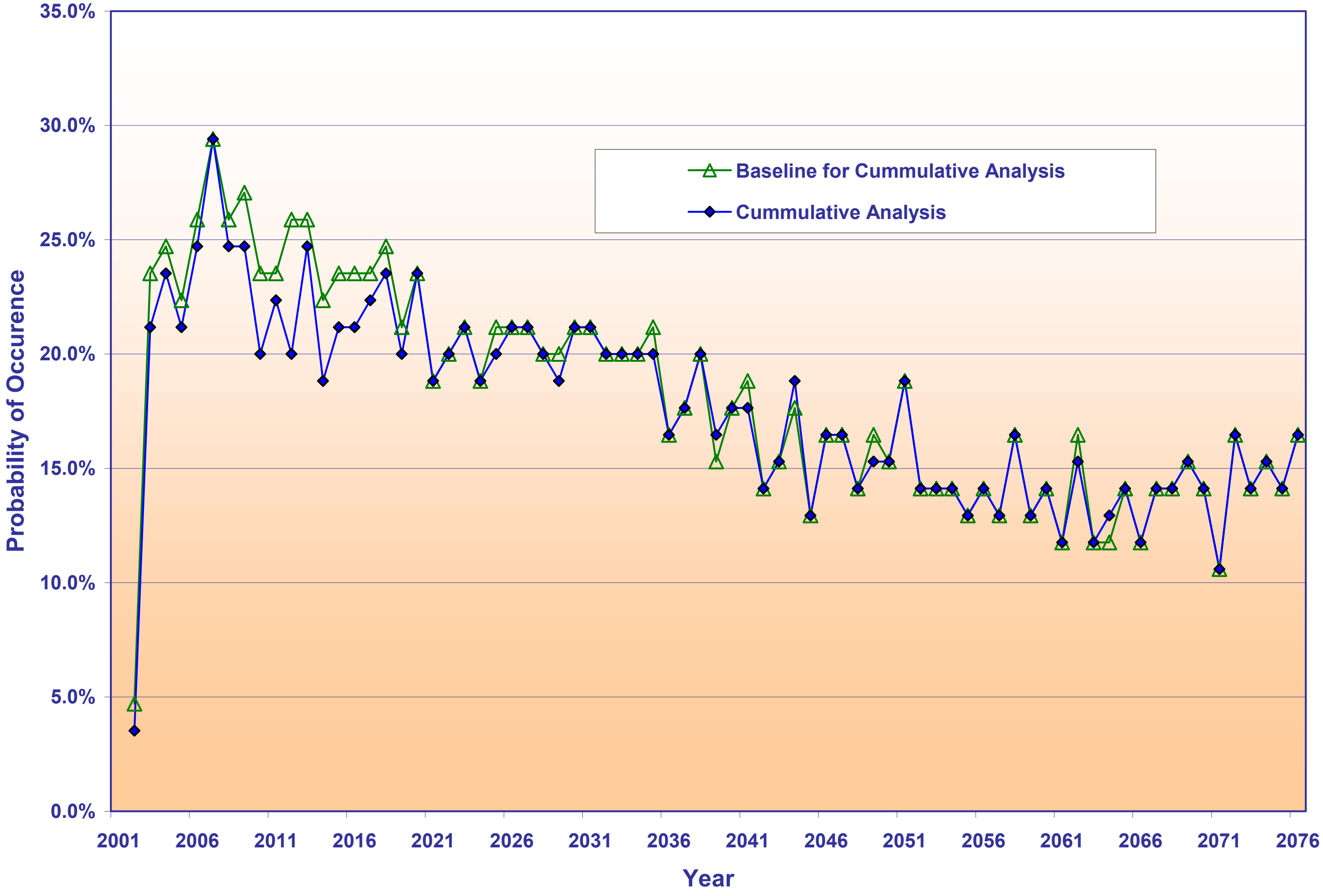


Figure 5.2-2
Probability of Occurrence of Excess Flows Greater than 250,000 Acre-Feet
Below Mexico Diversions at Morelos Dam
Comparison of Cumulative Analysis to Baseline Conditions

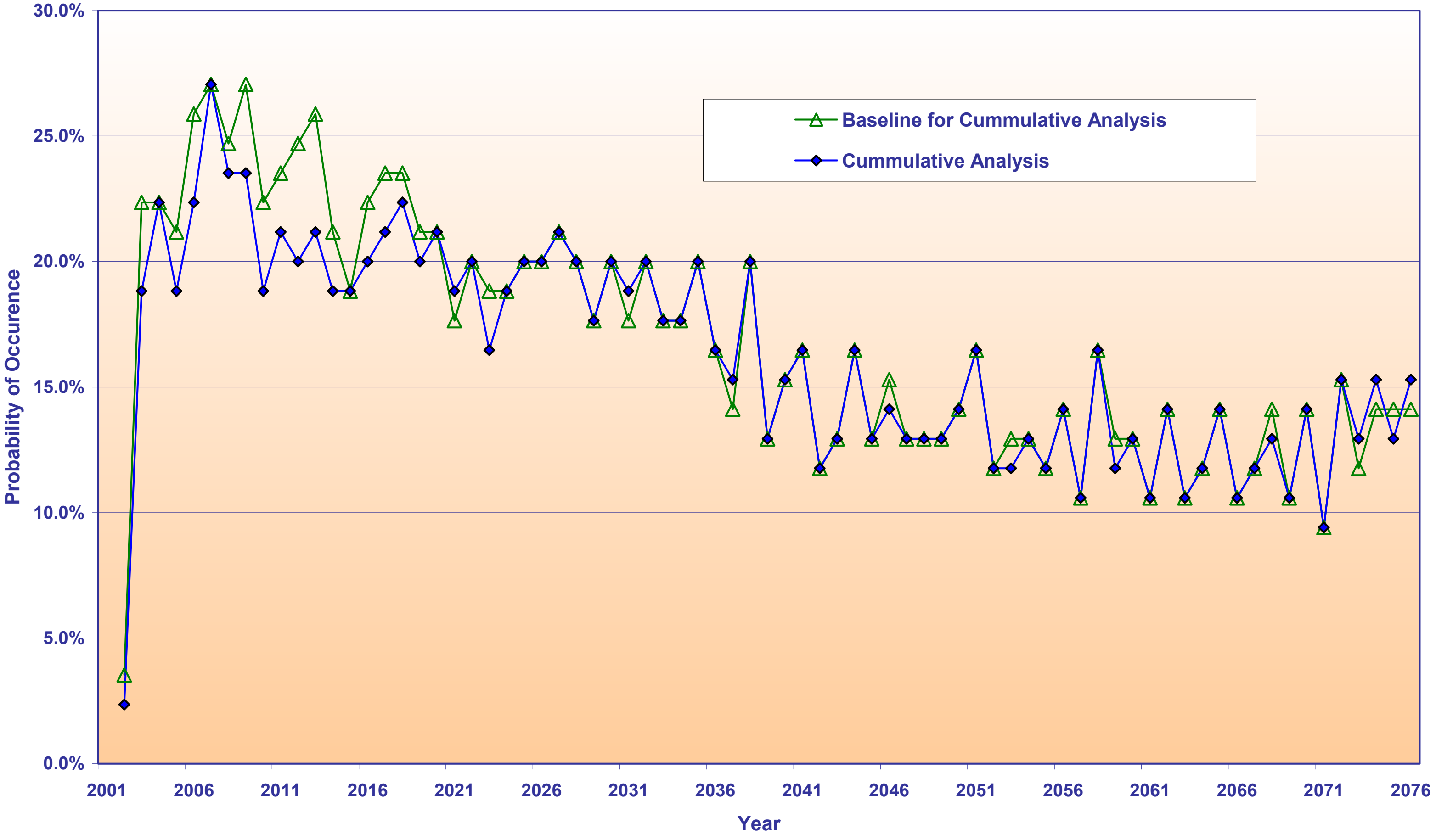
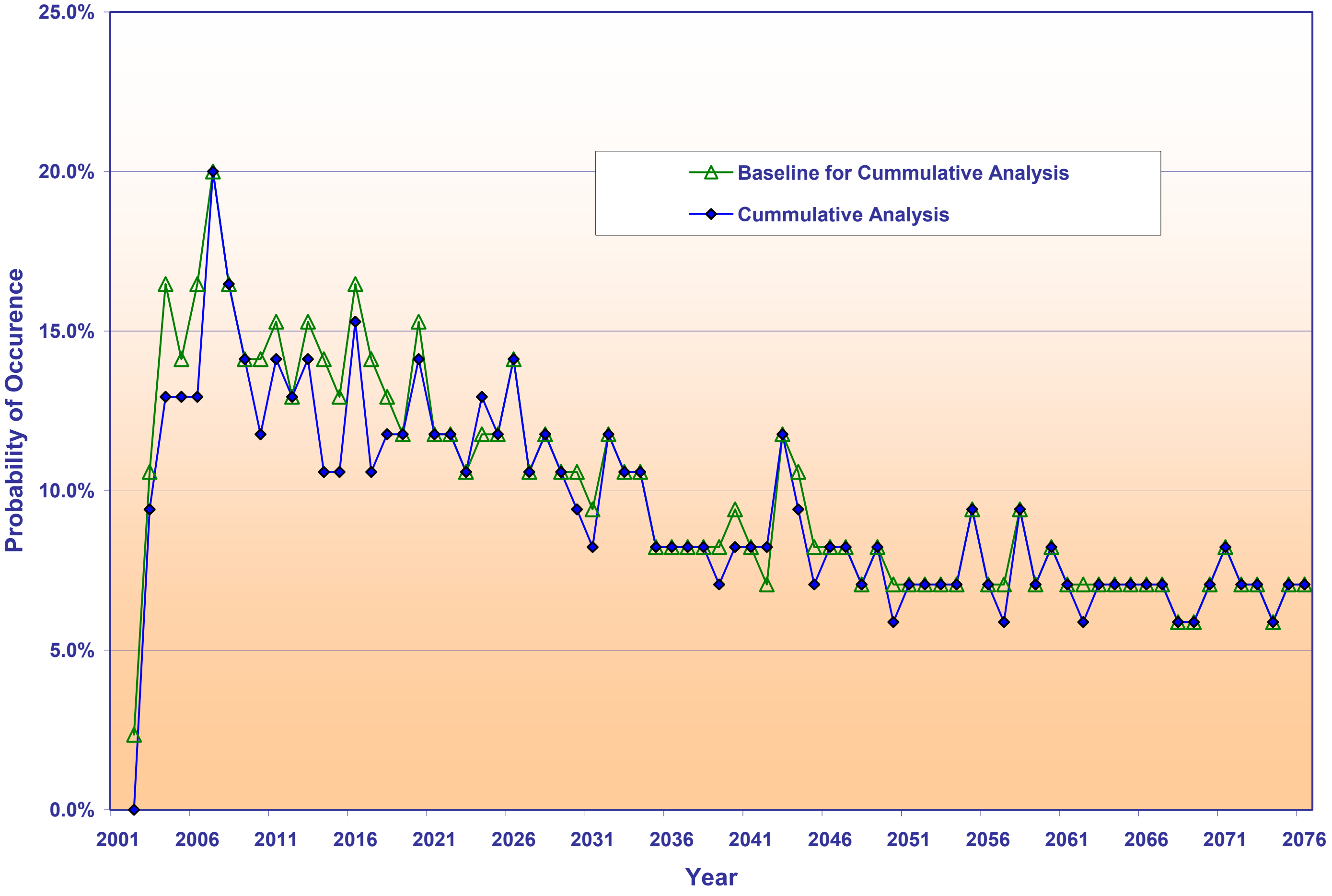


Figure 5.2-3

Probability of Occurrence of Excess Flows Greater Than 1,000,000 Acre-Feet

Below Mexico Diversion at Morelos Dam

Comparison of Cumulative Analysis to Baseline Conditions



5.2.2 COMPARISON OF CUMULATIVE ANALYSIS TO BASELINE CONDITIONS

Figure 5.2-1 presented a graphical comparison of the probability of delivery of future excess flows to Mexico under the Cumulative Analysis to those under the Baseline conditions. A similar comparison for selected years is presented in tabular format in Table 5.2-1. In general, the Cumulative Analysis conditions provide a slightly lower frequency than the Baseline. Differences between the two conditions were noted in approximately one third (26 years) of the 75 years modeled. The average of the observed differences in these 26 years was 1.4 percent. The largest difference in frequency occurs in year 2012 and is approximately 5.9 percent (rounded to 6.0 percent in table). Up to year 2035, the frequency of excess flows is slightly lower under the Cumulative Analysis conditions. However, after 2035, in the few years where differences occur, the conditions alternate in terms of higher frequency (+/- 1 to 2 percent). As such, after 2035, the observed differences can be considered negligible.

Table 5.2-1
Potential Frequency of Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline Conditions

Selected Year	Baseline	Cumulative Analysis	Difference
2002	5%	4%	-1%
2003	24%	21%	-3%
2004	25%	24%	-1%
2005	22%	21%	-1%
2006	26%	25%	-1%
2007	29%	29%	0%
2008	26%	25%	-1%
2009	27%	25%	-2%
2010	24%	20%	-4%
2011	24%	22%	-2%
2012	26%	20%	-6%
2013	26%	25%	-1%
2014	22%	19%	-3%
2015	24%	21%	-3%
2016	24%	21%	-3%
2020	24%	24%	0%
2025	21%	20%	-1%
2030	21%	21%	0%
2035	21%	20%	-1%
2040	18%	18%	0%
2045	13%	13%	0%
2050	15%	15%	0%
2055	13%	13%	0%
2060	14%	14%	0%
2065	14%	14%	0%
2070	14%	14%	0%
2075	14%	14%	0%

Figures 5.2-4 and 5.2-5 compare the cumulative distributions of annual volume of excess flows observed under the Cumulative Analysis and Baseline conditions for years 2016 and 2050, respectively. Although the frequency of occurrence of flows of a particular magnitude is decreased, the range of excess flows is preserved for the Cumulative Analysis conditions when compared to Baseline conditions.

Table 5.2-2
Potential Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline Conditions
75th Percentile Values for Selected Years (kaf)

Selected Years	Baseline	Cumulative Analysis
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	526	0
2007	404	404
2008	56	0
2009	341	0
2010	0	0
2011	0	0
2012	206	0
2013	252	0
2014	0	0
2015	0	0
2016	0	0
2020	0	0
2025	0	0
2030	0	0
2035	0	0
2040	0	0
2045	0	0
2050	0	0
2055	0	0
2060	0	0
2065	0	0
2070	0	0
2075	0	0

Table 5.2-3
Potential Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline Conditions
90th Percentile Values for Selected Years (kaf)

Selected Years	Baseline	Cumulative Analysis
2002	0	0
2003	1,100	957
2004	1,954	1,911
2005	2,520	1,933
2006	2,577	2,052
2007	2,772	2,518
2008	2,134	2,028
2009	2,285	2,088
2010	1,582	1,518
2011	1,751	1,433
2012	1,767	1,887
2013	2,214	1,748
2014	1,452	1,482
2015	1,366	1,039
2016	1,822	1,710
2020	2,118	1,831
2025	1,107	1,121
2030	1,013	949
2035	822	822
2040	949	902
2045	634	544
2050	779	766
2055	753	753
2060	700	700
2065	712	691
2070	577	597
2075	516	516

Figure 5.2-4
Potential Magnitude of Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline Conditions for Modeled Year 2016

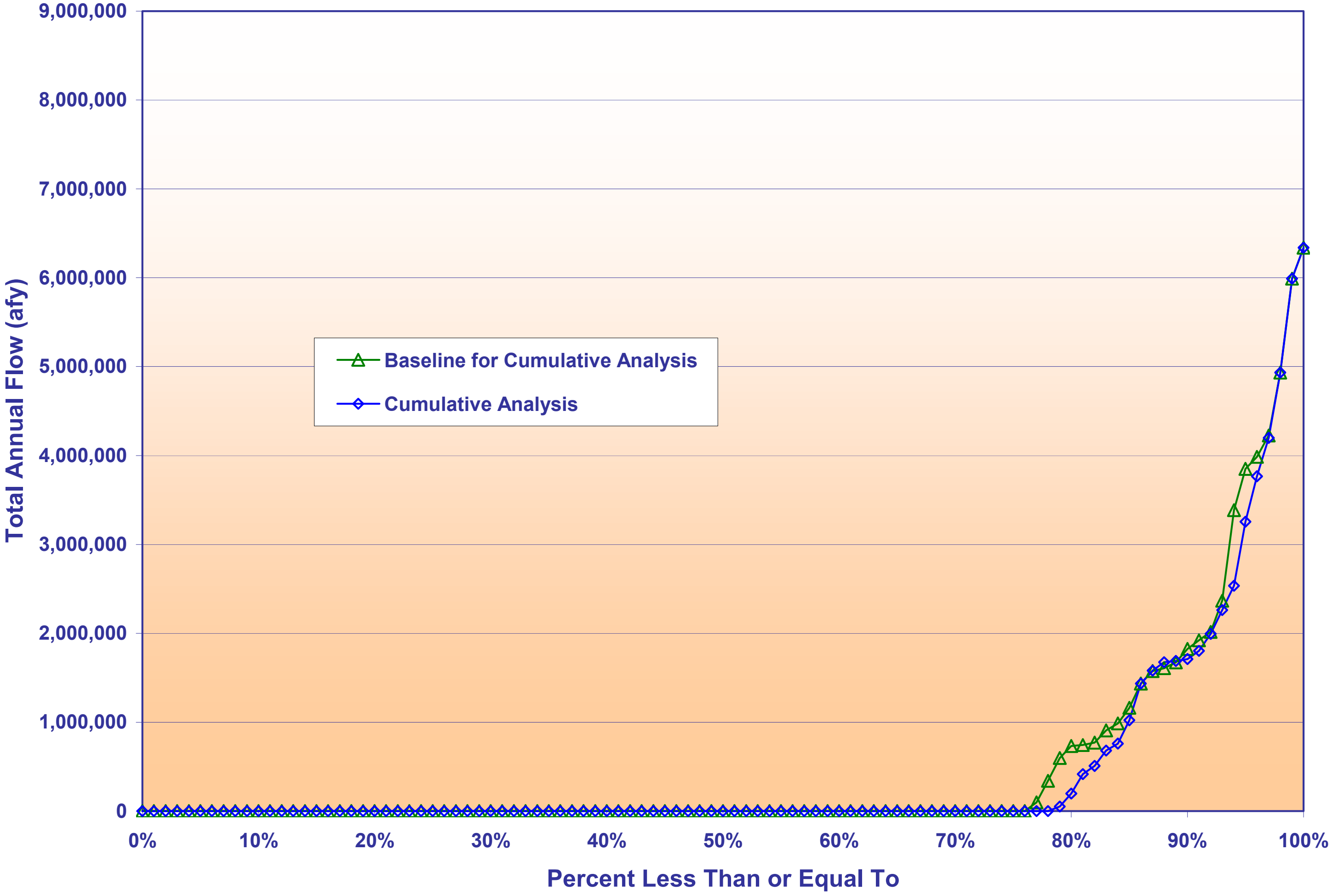
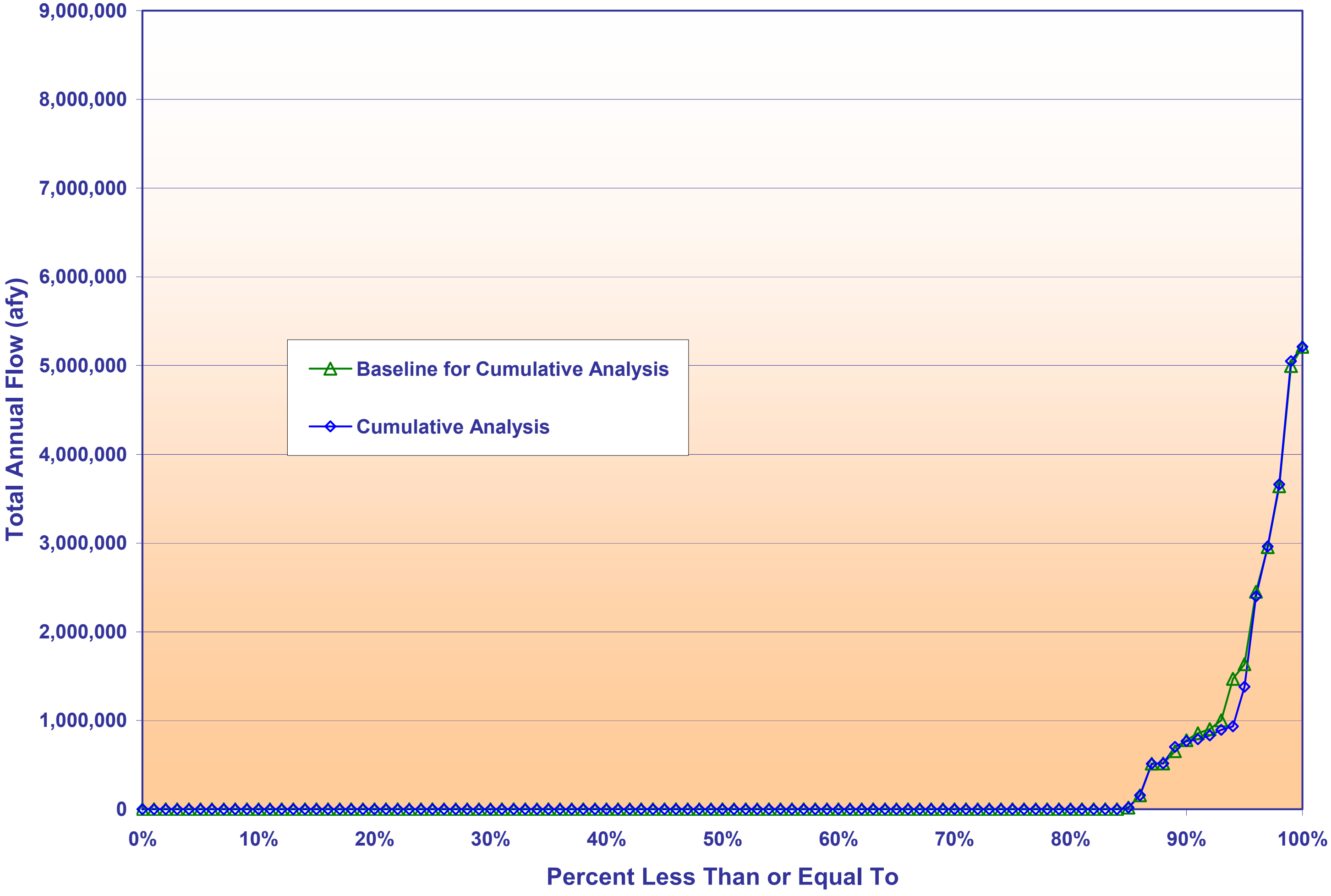


Figure 5.2-5
Potential Magnitude of Excess Flows Below Mexico Diversion at Morelos Dam
Comparison of Cumulative Analysis to Baseline Conditions for Modeled Year 2050



Alternatively, the potential magnitudes of excess flows for the 75th and 90th percentiles are shown in Figure 5.2-6. The 75th and 90th percentile values are also presented in tabular format for selected years between 2002 through 2076 in Table 5.2-2 and Table 5.2-3, respectively. The 75th percentile flow is defined as the flow that would not be exceeded 75 percent of the time (i.e., the minimum flow that would be expected to occur 25 percent of the time) and likewise, the 90th percentile flow would be expected to occur 10 percent of the time.

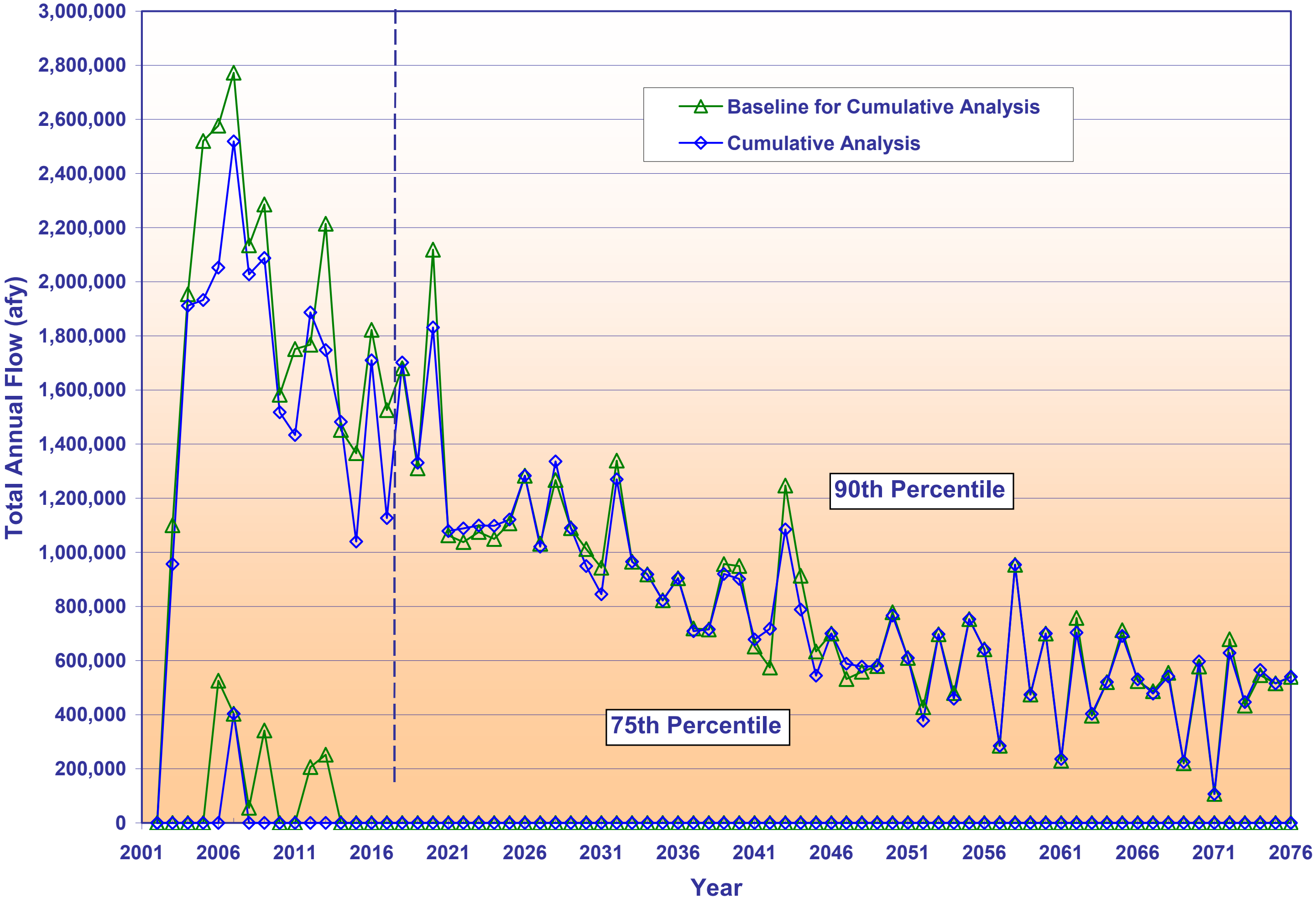
In summary, there are only minor differences in the potential magnitudes and potential frequencies of excess flows between Baseline and the Cumulative Analysis conditions. During the initial 15 years that were modeled (interim surplus guidelines period), the average frequency of occurrence of flows exceeding 250,000 af in any year is 22.2 percent for Baseline conditions, which is slightly better than one year in five. This compares to a frequency of 19.8 percent for the Cumulative Analysis (approximately one year in five). For the entire 75-year period of analysis, the average frequency of occurrence is approximately the same for the Baseline and Cumulative Analysis (ranging between 16.8 percent and 16.3 percent or about one in every six years).

The above probabilities indicate conditions below Morelos Dam would be similar to those presumed to be beneficial. Leucke, et al, 1999 states it is not yet possible to quantify with certainty the volume and frequency of these high flows that would be beneficial.

The probable average frequency of approximately 16.8 percent under the Baseline would change to a probable average frequency of approximately 16.3 percent under the Cumulative Analysis conditions, a slightly reduced yet insignificant condition. On this basis, the change in benefits to species and habitat would likely be insignificant.

Mexico has complete discretion over the use of water entering that country. As stated before, excess flows are generally diverted by Mexico when possible. Thus, the species and habitat can benefit only when the amount of water arriving at Mexico is in excess of that which can be diverted.

Figure 5.2-6
Potential Magnitude of Excess Flows To Mexico
90th and 75th Percentile Values



6.0 COLORADO RIVER SALINITY

This section addresses potential changes in salinity concentrations of Colorado River water from Lake Mead to Imperial Dam. The water transfers under the Secretarial Implementation Agreement could affect the salinity of Colorado River water, which affects municipal and industrial uses in the Lower Basin. “Salinity” refers to “total dissolved solids” (TDS), consisting of all of the soluble constituents dissolved in a river. The two terms are used interchangeably in this document.

6.1 BACKGROUND

The Colorado River increases in salinity from its headwaters to its mouth, carrying an average salt load of nine million tons annually past Hoover Dam. Approximately half (47 percent) of the salinity concentration is naturally caused and 53 percent of the concentration results from human activities including agricultural runoff, evaporation and municipal and industrial sources (Forum, 1999).

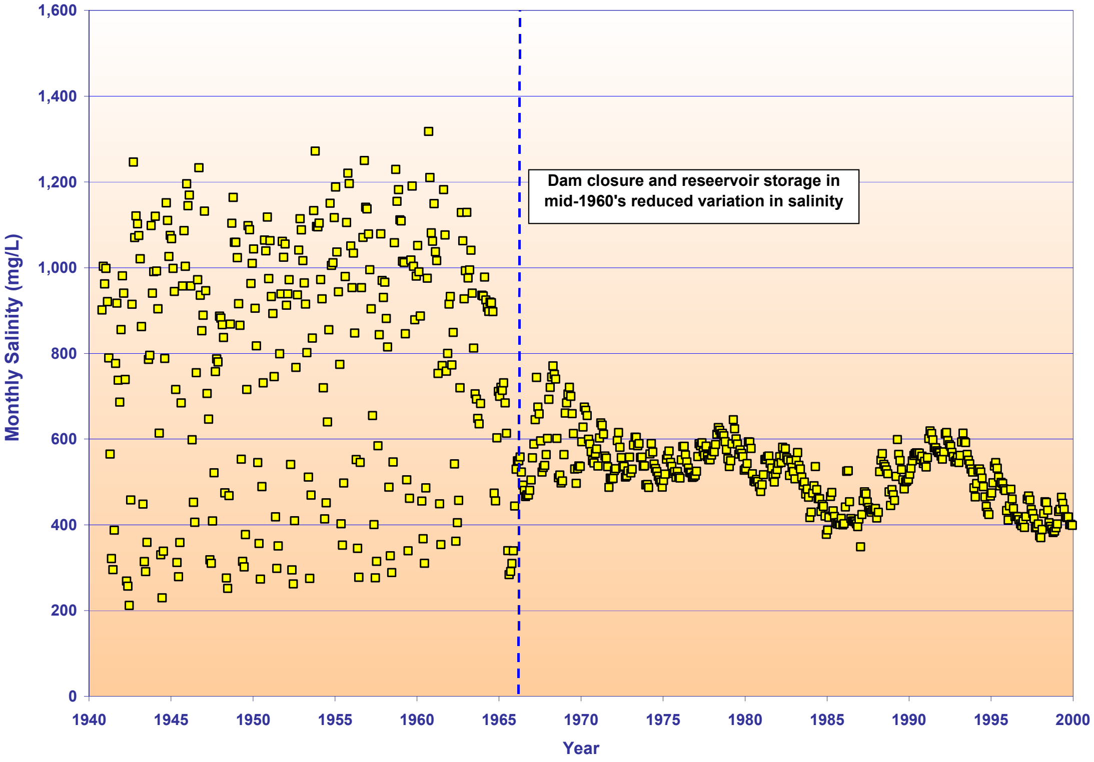
6.1.1 HISTORICAL SALINITY

Salinity of the river has fluctuated significantly over the period of record 1941 through 1997. Below Hoover Dam, annual salinity concentrations have ranged from 833 milligrams per liter (mg/l) in 1956 to 517 mg/l in 1986. However, the maximum monthly fluctuation in any year is approximately 50 mg/l. Salinity of the river is influenced by numerous factors including reservoir storage, water resource development (and associated return flows), salinity control, climatic conditions and natural runoff.

The impact of reservoir storage has almost eliminated seasonal fluctuations in salinity. As shown in Figure 6-1, the salinity of the river varied by as much as 1000 mg/l prior to the construction of Glen Canyon Dam in 1961 (Interior, 1999). By the 1980s, that variation was reduced to about 200 mg/l due to the mixing and dampening effect of the large volume of storage in Lake Powell.

Annual variations in salinity continue to occur, caused primarily by natural, climatic variations in precipitation and snowmelt runoff. The relationships between mainstream flows and salinity are described in the Interim Surplus Criteria Final EIS (USBR 2000, Pages 3.5-4 and 3.5-5).

Figure 6-1
Historical Monthly Salinity Concentrations Below Glen Canyon Dam (1940-1995)



6.1.2 REGULATORY REQUIREMENTS AND SALINITY CONTROL PROGRAM

In 1972, the EPA promulgated regulations requiring water quality standards for salinity, numeric criteria and a plan of implementation for salinity control. The Seven Colorado River Basin States, acting through the Forum, adopted numeric criteria for flow-weighted average annual salinity, at three points on the river as shown below:

Below Hoover Dam	723 mg/l
Below Parker Dam	747 mg/l
At Imperial Dam	879 mg/l

These criteria applied only to the lower portion of the Colorado River from Hoover Dam to Imperial Dam. Below Imperial Dam, salinity control is a federal responsibility to meet the terms of Minute 242 to the U.S.-Mexico Water Treaty of 1944. Minute 242 requires that salinity concentrations upstream of Mexico's diversion be no more than

115 mg/l ± 30 mg/l TDS higher than the average salinity of water arriving at Imperial Dam.

In 1974, the Colorado River Basin Salinity Control Act (P.L. 93-320) was enacted. The Act contains two Titles: 1) Title I provides the means for the United States to meet its commitment to Mexico; and 2) Title II creates a salinity control program within the Colorado River Basin in order that the numeric criteria will be met while the Basin States continue to develop their apportionment of Colorado River water.

It is estimated that 1,478,000 tons of salt will need to be removed or prevented from entering the Colorado River system to maintain the salinity concentration at or below the criteria through 2015. To date, over 720,000 tons have been controlled and an additional 756,000 tons will need to be controlled through 2015.

The federal/state salinity control program is designed to maintain the flow-weighted average annual salinity at or below the numeric criteria. The program is not intended to counteract short-term salinity variations resulting from short-term hydrologic conditions. Federal regulations provide for temporary increases above the criteria due to natural variations in flows.

The seven Basin States, acting through the Forum, review the numeric criteria and plan of implementation every three years and makes changes in the plan of implementation to accommodate changes salinity. The latest review was in 1999 (Forum, 1999). The review is currently undergoing adoption by the Basin States and approval by EPA.

At each triennial review, the current and future water uses are analyzed for their impact on the salinity of the Colorado River. If needed, additional salinity control projects are added to the plan to assure compliance with the standards.

The need for one or more additional salinity control projects is determined by monitoring the salinity of the river and making near-term projections of changes in diversions from and return flows to the river system. When an additional project is needed, it is selected from a list of potential projects that have undergone feasibility investigation. A proposal to implement the project is made through coordination with the Basin States. In selecting a project, considerable weight is given to the relative cost-effectiveness of the project. Cost-effectiveness is measured as the cost per ton of salt removed from the river system or prevented from entering the river system. Other factors are also considered, including environmental feasibility and institutional acceptability.

6.2 METHODOLOGY

Reclamation's model for salinity is used to create salinity reduction targets for the Colorado River Basin Salinity Control Program (SCP). To do this, the model simulates the effects of scheduled water development projects to predict future salinity levels. This data is then used to compute the amount of new salinity control projects required to reduce the river's salinity to meet the standards at some point in the future (2015). The model itself does not include future salinity controls because implementation schedules for future salinity control projects are not fixed and vary considerably. The salinity control standards are purposefully designed to be long-term (nondegradation) goals, rather than exceedance standards used for industry or drinking water.

By definition, the SCP is designed to be flexible enough to adjust for any changes caused by the water transfers and other operational changes addressed in this Technical Memorandum. Thus, it could be concluded that there would be no change in compliance with the standards from the implementation of the operational changes. However, if a change in river operation affects one of the factors influencing salinity (for example, if it changes the diluting effect of river flow on dissolved minerals) then that change in operation could increase or decrease the burden of the SCP to maintain the salinity standards on the river.

Such an increase or decrease can be inferred from the results of the salinity model operation in the following manner. For each future scenario (e.g., No Action Conditions or Implementation Agreement Conditions) the model produces different future TDS values, year by year, if the scenarios differ in their influence on river salinity. Thus the tendency of a future scenario to increase or decrease salinity relative to another scenario could be detected by comparing their modeled TDS values.

This approach was used to analyze the effect of the water transfers relative to no action, and of the cumulative conditions relative to the Baseline for Cumulative Analysis. Referring again to the assumption that the SCP would maintain the salinity control criteria listed above, the results are expressed in terms of the departures from the numeric criteria prior to any action by the Forum to address the changes.

6.3 ANALYSIS OF WATER TRANSFERS

The effect of the Implementation Agreement on the salinity of Colorado River water is expressed in terms of its differences from No Action Conditions. As discussed above under Methodology, the salinity under No Action Contusions is assumed to be at the numeric standards for the three locations along the lower Colorado River, and the effects of the water transfers are expressed as a departure from the numeric standards. The differences in salinity concentration between Implementation Agreement Conditions and No Action Conditions are presented in Table 6-1. The "Value" column for each measuring station and year cited shows 1) the TDS concentration assumed or the No Action Condition, and 2) the TDS concentration that would occur with the water transfers prior to any action by the Forum to address the changes. The "Effects" column shows the incremental change, with a negative entry indicating a reduction in TDS concentration.

As shown on Table 6-1 the Implementation Agreement would have no significant effect at Hoover Dam and Parker Dam. At Imperial Dam, the Implementation Agreement would tend to cause an increase in TDS concentration of several parts per million, in effect placing more of a burden on future salinity control projects. However, continued implementation of the CRB Salinity Control Program will ensure that the average salinity levels will be maintained at or below the numeric criteria levels.

Table 6-1
Estimated Effects on Colorado River Salinity

Condition Analyzed	Effect of Condition Analyzed					
	Hoover Dam		Parker Dam		Imperial Dam	
	Value	Effect	Value	Effect	Value	Effect
2016						
No Action	723	NA	747	NA	879	NA
Implementation Agreement	724	1	748	1	886	7
Baseline for Cumulative Analysis	723	NA	747	NA	879	NA
Cumulative analysis	721	-2	746	-1	879	-4
2050						
No Action	723	NA	747	NA	879	NA
Implementation Agreement	723	0	748	1	887	8
Baseline for Cumulative Analysis	723	NA	747	NA	879	NA
Cumulative analysis	723	0	746	-1	870	-9
2076						
No Action	723	NA	747	NA	879	NA
Implementation Agreement	723	0	748	1	887	8
Baseline for Cumulative Analysis	723	NA	747	NA	879	NA
Cumulative analysis	723	0	748	1	869	-10

6.4 ANALYSIS OF CUMULATIVE EFFECTS

The effect of the Cumulative Analysis Conditions on the salinity of Colorado River water is expressed in terms of its differences from Baseline for Cumulative Analysis. As discussed above under Methodology, the salinity under the Baseline for Cumulative Analysis is assumed to be at the numeric standards for the three locations along the lower Colorado River, and the effects of the Cumulative Analysis Conditions are expressed as a departure from the numeric standards.

The differences in salinity concentration between Cumulative Analysis Conditions and Baseline for Cumulative Analysis are also presented in Table 6-1. The "Value" column for each measuring station and year cited shows 1) the TDS concentration assumed for the Baseline for Cumulative Analysis, and 2) the TDS concentration that would occur under the Cumulative Analysis Conditions prior to any action by the Forum to address the changes. The "Effects" column shows the incremental change, with a negative entry indicating a reduction in TDS concentration.

As shown on Table 6-1 the Cumulative Analysis Conditions would have no significant effect at Hoover Dam and Parker Dam. However, at Imperial Dam, the Cumulative Analysis Conditions would tend to cause a reduction in salinity. In other words, the Cumulative Analysis scenario would reduce the burden on future salinity control projects. These results show that the tendency of the water transfers to increase salinity would be more than compensated for by other actions included in the Cumulative Analysis Conditions.

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REFERENCES

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Attachment A
Lower Basin Normal Depletion Schedules

Attachment A
Lower Basin Normal Depletion Schedules

As discussed in Section 2.0, four operational scenarios were modeled, labeled the No Action, Implementation Agreement, Baseline for Cumulative Analysis, and Cumulative Analysis scenarios. The primary areas of difference between the scenarios lie in the assumed schedules under normal conditions for certain California entities and the criteria used to determine surplus conditions. The differences in surplus determination are explained in Appendix C. This appendix focuses on the differences in the schedules under normal conditions (i.e., the "normal schedules").

Within each state, individual entities (or aggregations of individual entities) are represented in the model and normal schedules are provided as input. Since this DEIS is primarily concerned with the effect of the water transfers within California as defined by the Quantification Settlement Agreement (QSA), the schedules for the entities in Arizona and Nevada are consistent for all scenarios modeled. Similarly, since the QSA involves only the Metropolitan Water District (MWD), the Imperial Irrigation District (IID), and the Coachella Valley Water District (CVWD), all other California entities' schedules (with the exception of the Palo Verde Irrigation District (PVID)) are consistent for all of the scenarios. PVID's schedule varies only under the Cumulative Analysis scenario.

This leads to a logical presentation, which breaks out those entities in California (MWD, IID, CVWD and PVID) whose normal depletions may change between the operational scenarios. For this presentation, all California entities represented in the model except MWD, IID, CVWD, and PVID are termed "California Other Users".

Normal Schedules Consistent for All Operational Scenarios

As previously mentioned, the normal schedules for all entities within the states of Arizona and Nevada, as well as for the California Other Users, are assumed to be consistent for all operational scenarios.

The normal schedules used to model the normal depletions for the states of Arizona and Nevada are the same as those used in the Interim Surplus Criteria Final Environmental Impact Statement (Reclamation, 2000), extended to year 2076. These schedules are presented in Tables A-1 and A-2.

The normal schedules used for the California Other Users (as defined in this report) were the same as those used in the Interim Surplus Criteria Final Environmental Impact Statement (Reclamation, 2000), extended to year 2076. These schedules are presented in Table A-3.

Under the Law of the River, the Lower Division states' depletions total 7.5 maf under normal conditions. Of that total, California, Arizona, and Nevada are apportioned 4.4 maf, 2.8 maf, and 0.3 maf respectively; however, any apportionment unused by one state may be used by another state.

Arizona's unused apportionment in years 2002 - 2005 (as shown in Table A-1) has been allocated to MWD and the Southern Nevada Water Authority (SNWA) on a percentage basis (70% and 30% respectively) for all scenarios.

Although the individual schedules for MWD, IID, CVWD, and PVID may vary between scenarios, California's normal depletion schedule totals 4.4 maf in all years after 2005. Furthermore, Lower Division States Normal depletion schedules under all scenarios total 7.5 maf for all years, 2002-2076.

Normal Schedules for the No Action Scenario

Under the No Action scenario, no water transfers are assumed to take place (i.e., no QSA), other than the approximately 110 kaf transfer from the IID - MWD water conservation program under the IID/MWD 1988 Agreement and subsequent modifications in 1989 (the "1988/89 Agreements"). Table A-4 presents the normal depletion schedules for California under these assumptions.

Normal Schedules for the Implementation Agreement Scenario

Under the Implementation Agreement scenario, water transfers (in addition to the approximately 110 kaf transfer from the IID - MWD water conservation program under the 1988/89 Agreements) are assumed to take place consistent with the QSA. Table A-5 presents the normal depletion schedules for California under these assumptions.

Normal Schedules for the Baseline for Cumulative Analysis Scenario

Under the Baseline for Cumulative Analysis scenario, no water transfers are assumed to take place (i.e., no QSA), other than the 110 kaf transfer from IID to MWD under the 1988/89 Agreement. Consequently, the depletion schedules for all entities are identical to those used for the No Action scenario.

Normal Schedules for Cumulative Analysis Scenario

Under the Cumulative Analysis scenario, water transfers (in addition to the 110 kaf transfer from IID to MWD under the 1988/89 Agreement) are assumed to take place consistent with the QSA. Furthermore, an additional transfer from PVID to MWD under the Land Management, Crop Rotation, and Water Supply Program in the Palo Verde Irrigation District (PVID/MWD Program) is assumed to take place. The modeled transfer amount varies between 100 kaf and 111 kaf through the 75-year modeling period and was provided to Reclamation by MWD in April, 2001. Table A-6 presents the normal depletion schedules for California under these assumptions.

Transfers Considered In The Normal Schedules

A breakdown of the water transfers and conservation measures considered in the normal schedules under the Implementation Agreement and Cumulative Analysis scenarios is presented in Table A-7. The set of transfers and conservation measures was modeled to analyze the "worse case scenario", for the purpose of evaluating potential impacts with regards to reductions in river flow from Parker Dam to Imperial Dam. This table also provides the net subtotals for each affected entity (MWD, IID, CVWD & PVID). Information of the water transfers used to model the normal schedules under the previous Interim Surplus Guidelines EIS are also provided for comparison and reference purposes.

Table A-1
State of Arizona – Normal Depletion Schedules (kaf)

Year	CAP	Lake Mead NRA	Kingman	Fort Mohave Indian Res.	Mohave Valley I&DD	Mohave Valley M&I	Havasu NWR	Parker Ag.	Unused Depletion	Town of Parker et. al.	Imperial NWR	Cibola NWR	CRIR	CRIR Pumped	Gila Gravity Main Canal	Cocopah Ind. Res.	City of Yuma	Yuma Co. WUA	Arizona Pumpers	Total Arizona
2002	1,458	0	0	46	25	4	5	14	0	18	9	6	343	0	549	13	25	267	10	2,790
2003	1,447	0	0	50	25	4	5	13	0	19	9	6	351	0	543	13	25	264	10	2,784
2004	1,382	0	0	55	24	4	5	13	0	19	9	6	359	0	537	13	25	262	10	2,724
2005	1,415	0	0	60	24	4	5	13	0	20	9	7	367	0	531	13	25	259	10	2,763
2006	1,447	0	0	63	24	4	5	13	0	21	10	7	376	0	526	13	26	257	10	2,800
2007	1,441	0	0	65	24	4	5	13	0	22	10	7	386	0	521	13	26	255	10	2,800
2008	1,436	0	0	68	23	4	5	13	0	22	10	8	395	0	516	12	26	252	10	2,800
2009	1,431	0	0	70	23	4	5	13	0	23	10	8	405	0	510	12	26	250	10	2,800
2010	1,425	0	0	73	23	4	5	13	0	24	10	8	414	0	505	12	27	248	10	2,800
2011	1,425	0	0	73	22	4	5	12	0	24	10	8	424	0	499	12	27	245	10	2,800
2012	1,424	0	0	73	22	4	5	12	0	24	10	8	434	0	494	12	27	242	10	2,800
2013	1,424	0	0	73	21	4	5	12	0	24	10	8	443	0	487	12	27	239	10	2,800
2014	1,423	0	0	73	20	4	5	12	0	24	10	8	453	0	482	12	27	237	10	2,800
2015	1,422	0	0	73	20	5	5	12	0	24	9	8	463	0	477	12	27	234	10	2,800
2016	1,422	0	0	73	19	5	5	12	0	25	9	8	463	0	476	12	28	234	10	2,800
2017	1,421	0	0	73	19	5	5	12	0	25	9	8	463	0	477	12	28	234	10	2,800
2018	1,420	0	0	73	18	5	5	12	0	26	9	8	463	0	477	12	29	234	10	2,800
2019	1,420	0	0	73	18	5	5	12	0	26	9	8	463	0	476	12	29	234	10	2,800
2020	1,419	0	0	73	17	5	5	12	0	27	9	8	463	0	477	12	30	234	10	2,800
2021	1,418	0	0	73	17	5	5	12	0	27	9	9	463	0	477	12	30	233	10	2,800
2022	1,417	0	0	73	17	5	5	12	0	27	9	10	463	0	476	12	31	233	10	2,800
2023	1,415	0	0	73	17	5	5	12	0	28	10	10	463	0	477	12	32	233	10	2,800
2024	1,414	0	0	73	17	5	5	12	0	28	10	11	463	0	477	12	32	232	10	2,800
2025	1,412	0	0	73	17	5	5	12	0	28	10	12	463	0	477	12	33	232	10	2,800
2026	1,411	0	0	73	17	5	5	12	0	29	10	13	463	0	477	12	33	232	10	2,800
2027	1,410	0	0	73	17	5	5	12	0	29	10	14	463	0	476	12	34	231	10	2,800
2028	1,408	0	0	73	17	5	5	12	0	29	10	14	463	0	477	12	34	231	10	2,800
2029	1,407	0	0	73	17	6	5	12	0	30	10	15	463	0	477	12	35	230	10	2,800
2030	1,406	0	0	73	17	6	5	12	0	30	10	16	463	0	476	12	35	229	11	2,800
2031	1,405	0	0	73	17	6	5	12	0	30	10	16	463	0	476	12	36	229	11	2,800
2032	1,404	0	0	73	17	6	5	12	0	30	10	16	463	0	476	12	36	230	11	2,800
2033	1,403	0	0	73	17	6	5	12	0	30	10	16	463	0	476	12	37	230	11	2,800
2034	1,402	0	0	73	17	6	5	12	0	31	10	16	463	0	477	12	38	230	11	2,800
2035	1,402	0	0	73	17	6	5	12	0	31	10	16	463	0	476	12	38	229	11	2,800
2036	1,401	0	0	73	17	6	5	12	0	31	10	16	463	0	476	12	39	229	11	2,800
2037	1,400	0	0	73	17	6	5	12	0	31	10	16	463	0	476	12	39	230	11	2,800
2038	1,399	0	0	73	17	6	5	12	0	31	10	16	463	0	477	12	40	230	11	2,800
2039	1,398	0	0	73	17	6	5	12	0	32	10	16	463	0	477	12	40	230	11	2,800
2040	1,398	0	0	73	17	6	5	12	0	32	10	16	463	0	476	12	41	229	11	2,800
2041	1,397	0	0	73	17	6	5	12	0	32	10	16	463	0	477	12	41	230	11	2,800
2042	1,397	0	0	73	17	6	5	12	0	32	10	16	463	0	477	12	41	230	11	2,800
2043	1,397	0	0	73	17	6	5	12	0	32	10	16	463	0	476	12	41	230	11	2,800
2044	1,396	0	0	73	17	6	5	12	0	33	10	16	463	0	477	12	41	230	11	2,800
2045	1,396	0	0	73	17	6	5	12	0	33	10	16	463	0	477	12	41	230	11	2,800
2046	1,396	0	0	73	17	6	5	12	0	33	10	16	463	0	477	12	41	230	11	2,800
2047	1,396	0	0	73	17	6	5	12	0	33	10	16	463	0	476	12	41	230	11	2,800
2048	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	477	12	41	230	11	2,800
2049	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	477	12	41	230	11	2,800
2050	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2051	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2052	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2053	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2054	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2055	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2056	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2057	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2058	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2059	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2060	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2061	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2062	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2063	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2064	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2065	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2066	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2067	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2068	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2069	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2070	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2071	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2072	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2073	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2074	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2075	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800
2076	1,395	0	0	73	17	6	5	12	0	34	10	16	463	0	476	12	41	230	11	2,800

Table A-2
State of Nevada – Normal Depletion Schedules (kaf)

Date	Laughlin M&I	Mohave Steam Plant	Ft. Mohave Ind. Res.	Total Nevada	SNWA	Total NV
2002	4	16	6	26	277	303
2003	4	16	6	26	278	304
2004	4	16	7	27	294	321
2005	4	16	8	28	282	310
2006	4	16	8	28	272	300
2007	4	16	8	28	272	300
2008	4	16	9	29	271	300
2009	4	16	9	29	271	300
2010	4	16	9	29	271	300
2011	4	16	9	29	271	300
2012	4	16	9	29	271	300
2013	4	16	9	29	271	300
2014	4	16	9	29	271	300
2015	4	16	9	29	271	300
2016	4	16	9	29	271	300
2017	4	16	9	29	271	300
2018	4	16	9	29	271	300
2019	4	16	9	29	271	300
2020	4	16	9	29	271	300
2021	4	16	9	29	271	300
2022	4	16	9	29	271	300
2023	4	16	9	29	271	300
2024	4	16	9	29	271	300
2025	4	16	9	29	271	300
2026	4	8	9	21	279	300
2027	4	0	9	13	287	300
2028	4	0	9	13	287	300
2029	4	0	9	13	287	300
2030	4	0	9	13	287	300
2031	4	0	9	13	287	300
2032	4	0	9	13	287	300
2033	4	0	9	13	287	300
2034	4	0	9	13	287	300
2035	4	0	9	13	287	300
2036	4	0	9	13	287	300
2037	4	0	9	13	287	300
2038	4	0	9	13	287	300
2039	4	0	9	13	287	300
2040	4	0	9	13	287	300
2041	4	0	9	13	287	300
2042	4	0	9	13	287	300
2043	4	0	9	13	287	300
2044	4	0	9	13	287	300
2045	4	0	9	13	287	300
2046	4	0	9	13	287	300
2047	4	0	9	13	287	300
2048	4	0	9	13	287	300
2049	4	0	9	13	287	300
2050	4	0	9	13	287	300
2051	4	0	9	13	287	300
2052	4	0	9	13	287	300
2053	4	0	9	13	287	300
2054	4	0	9	13	287	300
2055	4	0	9	13	287	300
2056	4	0	9	13	287	300
2057	4	0	9	13	287	300
2058	4	0	9	13	287	300
2059	4	0	9	13	287	300
2060	4	0	9	13	287	300
2061	4	0	9	13	287	300
2062	4	0	9	13	287	300
2063	4	0	9	13	287	300
2064	4	0	9	13	287	300
2065	4	0	9	13	287	300
2066	4	0	9	13	287	300
2067	4	0	9	13	287	300
2068	4	0	9	13	287	300
2069	4	0	9	13	287	300
2070	4	0	9	13	287	300
2071	4	0	9	13	287	300
2072	4	0	9	13	287	300
2073	4	0	9	13	287	300
2074	4	0	9	13	287	300
2075	4	0	9	13	287	300
2076	4	0	9	13	287	300

Table A-3
State of California – Other Users – Normal Depletion Schedules (kaf)

Year	Ft. Mohave Ind. Res.	City of Needles	Havasu NWR	Chemehuevi Ind. Res.	Others & Misc. PPRs	Imperial NWR	CRIR Ind. Res.	Unused Depletion	AAC Yuma Project Bard Unit	AAC Yuma Project Unit Quechan	California Pumpers	Other Pumpers Below NIB	Total California Other
2002	14	1	0	2	2	0	5	0	18	19	0	0	61
2003	13	1	0	2	2	0	7	0	18	21	0	0	63
2004	13	1	0	3	2	0	8	0	18	22	0	0	65
2005	12	1	0	3	2	0	9	0	18	23	0	0	68
2006	12	1	0	3	2	0	11	0	18	24	0	0	71
2007	12	1	0	4	2	0	13	0	18	25	0	0	75
2008	12	1	0	4	2	0	15	0	18	27	0	0	78
2009	12	1	0	5	2	0	17	0	18	28	0	0	82
2010	12	1	0	5	2	0	19	0	18	29	0	0	86
2011	12	1	0	6	2	0	23	0	18	30	0	0	92
2012	12	1	0	6	2	0	27	0	18	32	0	0	98
2013	12	1	0	7	2	0	31	0	18	33	0	0	104
2014	12	1	0	7	2	0	35	0	18	35	0	0	110
2015	12	1	0	8	2	0	39	0	18	36	0	0	116
2016	12	1	0	8	2	0	39	0	18	36	0	0	116
2017	12	1	0	8	2	0	39	0	18	36	0	0	116
2018	12	1	0	8	2	0	39	0	18	36	0	0	116
2019	12	1	0	8	2	0	39	0	18	36	0	0	116
2020	12	1	0	8	2	0	39	0	18	36	0	0	116
2021	12	1	0	8	2	0	39	0	18	36	0	0	116
2022	12	1	0	8	2	0	39	0	18	36	0	0	116
2023	12	1	0	8	2	0	39	0	18	36	0	0	116
2024	12	1	0	8	2	0	39	0	18	36	0	0	116
2025	12	1	0	8	2	0	39	0	18	36	0	0	116
2026	12	1	0	8	2	0	39	0	18	36	0	0	116
2027	12	1	0	8	2	0	39	0	18	36	0	0	116
2028	12	1	0	8	2	0	39	0	18	36	0	0	116
2029	12	1	0	8	2	0	39	0	18	36	0	0	116
2030	12	1	0	8	2	0	39	0	18	36	0	0	116
2031	12	1	0	8	2	0	39	0	18	36	0	0	116
2032	12	1	0	8	2	0	39	0	18	36	0	0	116
2033	12	1	0	8	2	0	39	0	18	36	0	0	116
2034	12	1	0	8	2	0	39	0	18	36	0	0	116
2035	12	1	0	8	2	0	39	0	18	36	0	0	116
2036	12	1	0	8	2	0	39	0	18	36	0	0	116
2037	12	1	0	8	2	0	39	0	18	36	0	0	116
2038	12	1	0	8	2	0	39	0	18	36	0	0	116
2039	12	1	0	8	2	0	39	0	18	36	0	0	116
2040	12	1	0	8	2	0	39	0	18	36	0	0	116
2041	12	1	0	8	2	0	39	0	18	36	0	0	116
2042	12	1	0	8	2	0	39	0	18	36	0	0	116
2043	12	1	0	8	2	0	39	0	18	36	0	0	116
2044	12	1	0	8	2	0	39	0	18	36	0	0	116
2045	12	1	0	8	2	0	39	0	18	36	0	0	116
2046	12	1	0	8	2	0	39	0	18	36	0	0	116
2047	12	1	0	8	2	0	39	0	18	36	0	0	116
2048	12	1	0	8	2	0	39	0	18	36	0	0	116
2049	12	1	0	8	2	0	39	0	18	36	0	0	116
2050	12	1	0	8	2	0	39	0	18	36	0	0	116
2051	12	1	0	8	2	0	39	0	18	36	0	0	116
2052	12	1	0	8	2	0	39	0	18	36	0	0	116
2053	12	1	0	8	2	0	39	0	18	36	0	0	116
2054	12	1	0	8	2	0	39	0	18	36	0	0	116
2055	12	1	0	8	2	0	39	0	18	36	0	0	116
2056	12	1	0	8	2	0	39	0	18	36	0	0	116
2057	12	1	0	8	2	0	39	0	18	36	0	0	116
2058	12	1	0	8	2	0	39	0	18	36	0	0	116
2059	12	1	0	8	2	0	39	0	18	36	0	0	116
2060	12	1	0	8	2	0	39	0	18	36	0	0	116
2061	12	1	0	8	2	0	39	0	18	36	0	0	116
2062	12	1	0	8	2	0	39	0	18	36	0	0	116
2063	12	1	0	8	2	0	39	0	18	36	0	0	116
2064	12	1	0	8	2	0	39	0	18	36	0	0	116
2065	12	1	0	8	2	0	39	0	18	36	0	0	116
2066	12	1	0	8	2	0	39	0	18	36	0	0	116
2067	12	1	0	8	2	0	39	0	18	36	0	0	116
2068	12	1	0	8	2	0	39	0	18	36	0	0	116
2069	12	1	0	8	2	0	39	0	18	36	0	0	116
2070	12	1	0	8	2	0	39	0	18	36	0	0	116
2071	12	1	0	8	2	0	39	0	18	36	0	0	116
2072	12	1	0	8	2	0	39	0	18	36	0	0	116
2073	12	1	0	8	2	0	39	0	18	36	0	0	116
2074	12	1	0	8	2	0	39	0	18	36	0	0	116
2075	12	1	0	8	2	0	39	0	18	36	0	0	116
2076	12	1	0	8	2	0	39	0	18	36	0	0	116

Table A-4
State of California - Normal Depletion Schedules WITHOUT QSA (kaf)

Year	CA Others	MWD	IID	CVWD	PVID	CA Total
2002	61	643	2,990	330	383	4,407
2003	63	647	2,990	330	381	4,412
2004	65	689	2,990	330	380	4,455
2005	68	660	2,990	330	379	4,427
2006	71	631	2,990	330	378	4,400
2007	75	629	2,990	330	377	4,400
2008	78	626	2,990	330	375	4,400
2009	82	624	2,990	330	374	4,400
2010	86	621	2,990	330	373	4,400
2011	92	617	2,990	330	372	4,400
2012	98	612	2,990	330	370	4,400
2013	104	608	2,990	330	369	4,400
2014	110	603	2,990	330	367	4,400
2015	116	598	2,990	330	366	4,400
2016	116	598	2,990	330	366	4,400
2017	116	598	2,990	330	366	4,400
2018	116	598	2,990	330	366	4,400
2019	116	598	2,990	330	366	4,400
2020	116	598	2,990	330	366	4,400
2021	116	598	2,990	330	366	4,400
2022	116	598	2,990	330	366	4,400
2023	116	598	2,990	330	366	4,400
2024	116	598	2,990	330	366	4,400
2025	116	598	2,990	330	366	4,400
2026	116	598	2,990	330	366	4,400
2027	116	598	2,990	330	366	4,400
2028	116	598	2,990	330	366	4,400
2029	116	598	2,990	330	366	4,400
2030	116	598	2,990	330	366	4,400
2031	116	598	2,990	330	366	4,400
2032	116	598	2,990	330	366	4,400
2033	116	598	2,990	330	366	4,400
2034	116	598	2,990	330	366	4,400
2035	116	598	2,990	330	366	4,400
2036	116	598	2,990	330	366	4,400
2037	116	598	2,990	330	366	4,400
2038	116	598	2,990	330	366	4,400
2039	116	598	2,990	330	366	4,400
2040	116	598	2,990	330	366	4,400
2041	116	598	2,990	330	366	4,400
2042	116	598	2,990	330	366	4,400
2043	116	598	2,990	330	366	4,400
2044	116	598	2,990	330	366	4,400
2045	116	598	2,990	330	366	4,400
2046	116	598	2,990	330	366	4,400
2047	116	598	2,990	330	366	4,400
2048	116	598	2,990	330	366	4,400
2049	116	598	2,990	330	366	4,400
2050	116	598	2,990	330	366	4,400
2051	116	598	2,990	330	366	4,400
2052	116	598	2,990	330	366	4,400
2053	116	598	2,990	330	366	4,400
2054	116	598	2,990	330	366	4,400
2055	116	598	2,990	330	366	4,400
2056	116	598	2,990	330	366	4,400
2057	116	598	2,990	330	366	4,400
2058	116	598	2,990	330	366	4,400
2059	116	598	2,990	330	366	4,400
2060	116	598	2,990	330	366	4,400
2061	116	598	2,990	330	366	4,400
2062	116	598	2,990	330	366	4,400
2063	116	598	2,990	330	366	4,400
2064	116	598	2,990	330	366	4,400
2065	116	598	2,990	330	366	4,400
2066	116	598	2,990	330	366	4,400
2067	116	598	2,990	330	366	4,400
2068	116	598	2,990	330	366	4,400
2069	116	598	2,990	330	366	4,400
2070	116	598	2,990	330	366	4,400
2071	116	598	2,990	330	366	4,400
2072	116	598	2,990	330	366	4,400
2073	116	598	2,990	330	366	4,400
2074	116	598	2,990	330	366	4,400
2075	116	598	2,990	330	366	4,400
2076	116	598	2,990	330	366	4,400

Table A-5
State of California - Normal Depletion Schedules WITH QSA (kaf)

Year	CA Others	MWD	IID	CVWD	PVID	CA Total
2002	61	679	2,959	326	383	4,407
2003	63	693	2,939	335	381	4,412
2004	65	770	2,919	321	380	4,455
2005	68	783	2,877	321	379	4,427
2006	71	778	2,852	321	378	4,400
2007	75	847	2,781	321	377	4,400
2008	78	864	2,761	321	375	4,400
2009	82	887	2,736	321	374	4,400
2010	86	910	2,711	321	373	4,400
2011	92	930	2,686	321	372	4,400
2012	98	930	2,681	321	370	4,400
2013	104	931	2,676	321	369	4,400
2014	110	931	2,671	321	367	4,400
2015	116	932	2,666	321	366	4,400
2016	116	937	2,661	321	366	4,400
2017	116	942	2,656	321	366	4,400
2018	116	947	2,651	321	366	4,400
2019	116	952	2,646	321	366	4,400
2020	116	957	2,641	321	366	4,400
2021	116	962	2,636	321	366	4,400
2022	116	967	2,631	321	366	4,400
2023	116	972	2,626	321	366	4,400
2024	116	977	2,621	321	366	4,400
2025	116	982	2,616	321	366	4,400
2026	116	987	2,611	321	366	4,400
2027	116	987	2,611	321	366	4,400
2028	116	987	2,611	321	366	4,400
2029	116	987	2,611	321	366	4,400
2030	116	987	2,611	321	366	4,400
2031	116	987	2,611	321	366	4,400
2032	116	987	2,611	321	366	4,400
2033	116	987	2,611	321	366	4,400
2034	116	987	2,611	321	366	4,400
2035	116	987	2,611	321	366	4,400
2036	116	987	2,611	321	366	4,400
2037	116	987	2,611	321	366	4,400
2038	116	987	2,611	321	366	4,400
2039	116	987	2,611	321	366	4,400
2040	116	987	2,611	321	366	4,400
2041	116	987	2,611	321	366	4,400
2042	116	987	2,611	321	366	4,400
2043	116	987	2,611	321	366	4,400
2044	116	987	2,611	321	366	4,400
2045	116	987	2,611	321	366	4,400
2046	116	987	2,611	321	366	4,400
2047	116	937	2,661	321	366	4,400
2048	116	937	2,661	321	366	4,400
2049	116	937	2,661	321	366	4,400
2050	116	937	2,661	321	366	4,400
2051	116	937	2,661	321	366	4,400
2052	116	937	2,661	321	366	4,400
2053	116	937	2,661	321	366	4,400
2054	116	937	2,661	321	366	4,400
2055	116	937	2,661	321	366	4,400
2056	116	937	2,661	321	366	4,400
2057	116	937	2,661	321	366	4,400
2058	116	937	2,661	321	366	4,400
2059	116	937	2,661	321	366	4,400
2060	116	937	2,661	321	366	4,400
2061	116	937	2,661	321	366	4,400
2062	116	937	2,661	321	366	4,400
2063	116	937	2,661	321	366	4,400
2064	116	937	2,661	321	366	4,400
2065	116	937	2,661	321	366	4,400
2066	116	937	2,661	321	366	4,400
2067	116	937	2,661	321	366	4,400
2068	116	937	2,661	321	366	4,400
2069	116	937	2,661	321	366	4,400
2070	116	937	2,661	321	366	4,400
2071	116	937	2,661	321	366	4,400
2072	116	937	2,661	321	366	4,400
2073	116	937	2,661	321	366	4,400
2074	116	937	2,661	321	366	4,400
2075	116	937	2,661	321	366	4,400
2076	116	937	2,661	321	366	4,400

Table A-6
State of California - Normal Depletion Schedules Used for Cumulative Analysis (With Additional Transfers from PVID to MWD, kaf)

Year	CA Others	MWD	IID	CVWD	PVID	CA Total
2002	61	711	2,959	326	351	4,407
2003	63	793	2,939	335	281	4,412
2004	65	870	2,919	321	280	4,455
2005	68	883	2,877	321	279	4,427
2006	71	878	2,852	321	278	4,400
2007	75	947	2,781	321	277	4,400
2008	78	964	2,761	321	275	4,400
2009	82	987	2,736	321	274	4,400
2010	86	1,010	2,711	321	273	4,400
2011	92	1,030	2,686	321	272	4,400
2012	98	1,030	2,681	321	270	4,400
2013	104	1,031	2,676	321	269	4,400
2014	110	1,031	2,671	321	267	4,400
2015	116	1,032	2,666	321	266	4,400
2016	116	1,037	2,661	321	266	4,400
2017	116	1,042	2,656	321	266	4,400
2018	116	1,047	2,651	321	266	4,400
2019	116	1,052	2,646	321	266	4,400
2020	116	1,057	2,641	321	266	4,400
2021	116	1,062	2,636	321	266	4,400
2022	116	1,067	2,631	321	266	4,400
2023	116	1,072	2,626	321	266	4,400
2024	116	1,077	2,621	321	266	4,400
2025	116	1,082	2,616	321	266	4,400
2026	116	1,087	2,611	321	266	4,400
2027	116	1,088	2,611	321	264	4,400
2028	116	1,098	2,611	321	255	4,400
2029	116	1,098	2,611	321	255	4,400
2030	116	1,098	2,611	321	255	4,400
2031	116	1,098	2,611	321	255	4,400
2032	116	1,098	2,611	321	255	4,400
2033	116	1,098	2,611	321	255	4,400
2034	116	1,098	2,611	321	255	4,400
2035	116	1,098	2,611	321	255	4,400
2036	116	1,098	2,611	321	255	4,400
2037	116	1,096	2,611	321	257	4,400
2038	116	1,087	2,611	321	266	4,400
2039	116	1,087	2,611	321	266	4,400
2040	116	1,087	2,611	321	266	4,400
2041	116	1,087	2,611	321	266	4,400
2042	116	1,087	2,611	321	266	4,400
2043	116	1,087	2,611	321	266	4,400
2044	116	1,087	2,611	321	266	4,400
2045	116	1,087	2,611	321	266	4,400
2046	116	1,087	2,611	321	266	4,400
2047	116	1,037	2,661	321	266	4,400
2048	116	1,037	2,661	321	266	4,400
2049	116	1,037	2,661	321	266	4,400
2050	116	1,037	2,661	321	266	4,400
2051	116	1,037	2,661	321	266	4,400
2052	116	1,037	2,661	321	266	4,400
2053	116	1,037	2,661	321	266	4,400
2054	116	1,037	2,661	321	266	4,400
2055	116	1,037	2,661	321	266	4,400
2056	116	1,037	2,661	321	266	4,400
2057	116	1,037	2,661	321	266	4,400
2058	116	1,037	2,661	321	266	4,400
2059	116	1,037	2,661	321	266	4,400
2060	116	1,037	2,661	321	266	4,400
2061	116	1,037	2,661	321	266	4,400
2062	116	1,038	2,661	321	264	4,400
2063	116	1,048	2,661	321	255	4,400
2064	116	1,048	2,661	321	255	4,400
2065	116	1,048	2,661	321	255	4,400
2066	116	1,048	2,661	321	255	4,400
2067	116	1,048	2,661	321	255	4,400
2068	116	1,048	2,661	321	255	4,400
2069	116	1,048	2,661	321	255	4,400
2070	116	1,048	2,661	321	255	4,400
2071	116	1,048	2,661	321	255	4,400
2072	116	1,046	2,661	321	257	4,400
2073	116	1,037	2,661	321	266	4,400
2074	116	1,037	2,661	321	266	4,400
2075	116	1,037	2,661	321	266	4,400
2076	116	1,037	2,661	321	266	4,400

Table A-7
Comparison of Modeled Transfers Between the
Interim Surplus Guidelines, Implementation Agreement and Cumulative Impacts Analysis Conditions

Modeled Transfer	Interim Surplus Guidelines Modeled Transfers (KAFY)	Implementation Agreement Modeled Transfers (KAFY)	Cumulative Analysis Modeled Transfers (KAFY)
MWD			
IID/SCWA Water Conservation and Transfer Agreement	200.0	200.0	200.0
First and Second 50 KAFY	0.0	100.0[2]	100.0
All American Canal Lining	67.7	67.7	67.7
Coachella Canal Lining	26.0	26.0	26.0
Miscellaneous and Federal PPRs	14.0	14.0	14.0
1988 IID/MWD Agreement, and Subsequent Agreements, as Modified by the QSA	(20.0)	(20.0)	(20.0)
MWD/CVWD SWP Exchange and Transfer	(35.0)	0.0	0.0
PVID/MWD Program [1]	0.0	0.0	110.0
Subtotal MWD	**253**	**388**[2]	**498**
CVWD			
First and Second 50 KAFY	100.0	0.0	0.0
1988 IID/MWD Agreement, and Subsequent Agreements, as Modified by the QSA	20.0	20.0	20.0
MWD/CVWD SWP Exchange and Transfer	35.0	0.0	0.0
Miscellaneous and Federal PPRs	(3.0)	(3.0)	(3.0)
Coachella Canal Lining	(26.0)	(26.0)	(26.0)
Subtotal CVWD	**126.0**	**(9.0)**	**(9.0)**
IID			
IID/SCWA Water Conservation and Transfer Agreement	(200.0)	(200.0)	(200.0)
First and Second 50 KAFY	(100.0)	(100.0)[2]	(100.0)
All American Canal Lining	(67.7)	(67.7)	(67.7)
Miscellaneous and Federal PPRs	(11.5)	(11.5)	(11.5)
Subtotal IID	**(379)**	**(379)**[2]	**(379)**
PVID			
PVID/MWD Program [1]	0.0	0.0	(110.0)
Subtotal PVID	**0**	**0**	**(110)**
Total CVWD+IID+PVID	**(253)**	**(388)**[2]	**(498)**

Notes:

1 The transfers between PVID and MWD that are associated with the PVID/MWD Program vary from 100 KAFY to 111 KAFY during the 75-year modeled period.

2 It is assumed that after year 45 (2046), the 2nd 50 is not available to MWD, reducing the total transfer to MWD to 338 KAF; similarly, the total transfer from IID is reduced to 329 KAF in year 2047.

Attachment B
Upper Division Depletion Schedule

Attachment B
Upper Division Depletion Schedule

This attachment consists of a table displaying the schedule of projected Colorado River system depletions, or consumptive use, by the Upper Division. These depletions were used to model the operation of the river system under No Action, Implementation Agreement, Baseline for Cumulative Analysis, and the Cumulative Analysis modeled conditions. Shown in the table are projected depletions of the Upper Division states 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. This is the depletion schedule that was used to model the various alternatives considered in the Interim Surplus Guideline EIS.

Table B-1
Upper Basin Depletion Schedules

Calendar Year	Colorado	Utah	Wyoming	New Mexico	Arizona	Total Upper Basin W/O Evap.	Reservoir Evaporation	Total Upper Basin
2002	2,419	859	501	449	45	4,273	574	4,847
2003	2,433	873	503	466	45	4,320	574	4,894
2004	2,447	886	505	484	45	4,367	574	4,941
2005	2,494	899	507	501	45	4,446	574	5,020
2006	2,501	913	508	510	45	4,477	574	5,051
2007	2,509	926	510	520	45	4,510	574	5,084
2008	2,517	940	512	529	45	4,543	574	5,117
2009	2,524	953	514	539	45	4,575	574	5,149
2010	2,580	1,009	517	548	50	4,704	574	5,278
2011	2,583	1,013	519	552	50	4,717	574	5,291
2012	2,586	1,017	520	557	50	4,730	574	5,304
2013	2,588	1,020	522	561	50	4,741	574	5,315
2014	2,591	1,024	524	565	50	4,754	574	5,328
2015	2,594	1,028	526	570	50	4,768	574	5,342
2016	2,597	1,032	527	573	50	4,779	574	5,353
2017	2,600	1,036	529	576	50	4,791	574	5,365
2018	2,603	1,041	531	579	50	4,804	574	5,378
2019	2,606	1,045	532	583	50	4,816	574	5,390
2020	2,626	1,055	535	589	50	4,855	574	5,429
2021	2,629	1,062	537	590	50	4,868	574	5,442
2022	2,633	1,069	540	591	50	4,883	574	5,457
2023	2,636	1,077	542	593	50	4,898	574	5,472
2024	2,639	1,084	544	594	50	4,911	574	5,485
2025	2,643	1,091	547	595	50	4,926	574	5,500
2026	2,646	1,099	549	597	50	4,941	574	5,515
2027	2,649	1,107	551	599	50	4,956	574	5,530
2028	2,652	1,114	553	600	50	4,969	574	5,543
2029	2,656	1,122	556	602	50	4,986	574	5,560
2030	2,675	1,129	571	604	50	5,029	574	5,603
2031	2,677	1,134	575	604	50	5,040	574	5,614
2032	2,679	1,139	580	604	50	5,052	574	5,626
2033	2,680	1,145	584	604	50	5,063	574	5,637
2034	2,682	1,150	588	604	50	5,074	574	5,648
2035	2,684	1,155	593	605	50	5,087	574	5,661
2036	2,686	1,160	597	605	50	5,098	574	5,672
2037	2,688	1,165	601	605	50	5,109	574	5,683
2038	2,689	1,171	605	605	50	5,120	574	5,694
2039	2,691	1,176	610	605	50	5,132	574	5,706
2040	2,703	1,177	615	605	50	5,150	574	5,724
2041	2,708	1,180	622	605	50	5,165	574	5,739
2042	2,712	1,184	629	605	50	5,180	574	5,754
2043	2,717	1,187	637	605	50	5,196	574	5,770
2044	2,721	1,190	644	605	50	5,210	574	5,784
2045	2,726	1,194	651	605	50	5,226	574	5,800
2046	2,731	1,197	658	605	50	5,241	574	5,815
2047	2,735	1,200	665	605	50	5,255	574	5,829
2048	2,740	1,203	673	605	50	5,271	574	5,845
2049	2,744	1,207	680	605	50	5,286	574	5,860
2050	2,776	1,207	687	605	50	5,325	574	5,899
2051	2,776	1,209	694	605	50	5,334	574	5,908
2052	2,777	1,212	701	605	50	5,345	574	5,919
2053	2,777	1,214	708	605	50	5,354	574	5,928
2054	2,777	1,216	715	605	50	5,363	574	5,937
2055	2,778	1,219	722	605	50	5,374	574	5,948
2056	2,778	1,221	729	605	50	5,383	574	5,957
2057	2,778	1,223	736	605	50	5,392	574	5,966
2058	2,778	1,225	743	605	50	5,401	574	5,975
2059	2,779	1,228	750	605	50	5,412	574	5,986
2060	2,784	1,230	760	605	50	5,429	574	6,003
2061	2,784	1,230	760	605	50	5,429	574	6,003
2062	2,784	1,230	760	605	50	5,429	574	6,003
2063	2,784	1,230	760	605	50	5,429	574	6,003
2064	2,784	1,230	760	605	50	5,429	574	6,003
2065	2,784	1,230	760	605	50	5,429	574	6,003
2066	2,784	1,230	760	605	50	5,429	574	6,003
2067	2,784	1,230	760	605	50	5,429	574	6,003
2068	2,784	1,230	760	605	50	5,429	574	6,003
2069	2,784	1,230	760	605	50	5,429	574	6,003
2070	2,784	1,230	760	605	50	5,429	574	6,003
2071	2,784	1,230	760	605	50	5,429	574	6,003
2072	2,784	1,230	760	605	50	5,429	574	6,003
2073	2,784	1,230	760	605	50	5,429	574	6,003
2074	2,784	1,230	760	605	50	5,429	574	6,003
2075	2,784	1,230	760	605	50	5,429	574	6,003
2076	2,784	1,230	760	605	50	5,429	574	6,003

Attachment C
Lower Basin Surplus Strategies and Depletion Schedules

Attachment C
Lower Basin Surplus Strategies and Depletion Schedules

As documented in Section 2.0, the following surplus strategies were used for each operational scenario:

- No Action Scenario:
  - Interim Surplus Guidelines, 2002-2016
  - 70R Strategy, 2017-2076
- Implementation Agreement Scenario:
  - Interim Surplus Guidelines, 2002-2016
  - 70R Strategy, 2017-2076
- Baseline for Cumulative Analysis Scenario:
  - 70R Strategy, 2002-2076
- Cumulative Analysis Scenario:
  - Interim Surplus Guidelines, 2002-2016
  - 70R Strategy, 2017-2076

This appendix presents a brief description of each strategy and documents the depletion schedules that were used to model each strategy for the four operational scenarios studied (No Action, Implementation Agreement, Baseline for Cumulative Analysis, and Cumulative Analysis).

INTERIM SURPLUS GUIDELINES

As stated in the Interim Surplus Guidelines Record of Decision (USBR, 2001) determination of Lake Mead surplus operation during the interim period (2002 - 2016) is as follows:

1. Partial Domestic Surplus (Lake Mead elevation between 1125 ft. and 1145 ft.)

   In years when Lake Mead storage is projected to be between elevation 1125 ft. and elevation 1145 ft. on January 1, the Secretary shall determine a Partial Domestic Surplus. The amount of such Surplus shall equal:

   a. For Direct Delivery Domestic Use by MWD, 1.212 maf reduced by:

      (1) the amount of basic apportionment available to MWD and

      (2) the amount of its domestic demand which MWD offsets in such year by offstream groundwater withdrawals or other options. The amount offset under (2) shall not be less than 400,000 af in 2002 and will be reduced by 20,000 af/yr over the Interim Period so as to equal 100,000 af in 2016.

   b. For use by SNWA, one half of the Direct Delivery Domestic Use within the SNWA service area in excess of the State of Nevada's basic apportionment.

   c. For Arizona, one half of the Direct Delivery Domestic Use in excess of the State of Arizona's basic apportionment.

2. Full Domestic Surplus (Lake Mead above Elevation 1145 ft. and below 70R Strategy)

   In years when Lake Mead content is projected to be above elevation 1145 ft., but less than the amount which would initiate a Surplus under B.3. 70R Strategy or B.4. Flood Control Surplus hereof on January 1, the Secretary shall determine a Full Domestic Surplus. The amount of such Surplus shall equal:

a. For Direct Delivery Domestic Use by MWD, 1.250 maf reduced by the amount of basic apportionment available to MWD.

b. For use by SNWA, the Direct Delivery Domestic Use within the SNWA service area in excess of the State of Nevada's basic apportionment.

c. For use in Arizona, the Direct Delivery Domestic Use in excess of Arizona's basic apportionment.

3. Quantified Surplus

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 a Quantified Surplus sequentially as follows:

a. Establish the volume of the Quantified Surplus.

b. Allocate and distribute the Quantified Surplus 50% to California, 46% to Arizona and 4% to Nevada, subject to c. through e. that follow.

c. Distribute California's share first to meet basic apportionment demands and MWD's Direct Delivery Domestic Use and Off-stream Banking demands, and then to California Priorities 6 and 7 and other surplus contracts. Distribute Nevada's share first to meet basic apportionment demands and then to the remaining Direct Delivery Domestic Use and Off-stream Banking 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.

d. Distribute any unused share of the Quantified Surplus in accordance with Section 1.0, Allocation of Unused Basic Apportionment Water Under Article II(B)(6).

e. Determine whether MWD, SNWA and Arizona have received the amount of water they would have received under Section 2.B.2., Full Domestic Surplus if a Quantified Surplus had not been declared. If they have not, then determine and meet all demands provided for in Section 2.B.2. Full Domestic Surplus (a), (b) and (c).

4. 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. In such years, releases will be made to satisfy all beneficial uses within the United States, including unlimited off-stream banking. Under current practice, surplus declarations under the Treaty for Mexico are declared when flood control releases are made. Modeling assumptions used in the FEIS are based on this practice. The proposed action is not intended to identify, or change in any manner, conditions when Mexico may schedule up to an additional 0.2 maf. Any issues relating to the implementation of the Treaty, including any potential changes in approach relating to surplus declarations under the Treaty, must be addressed in a bilateral fashion with the Republic of Mexico.

70R STRATEGY

Under the R surplus strategies, a surplus condition is based on the system space requirement at the beginning of each year. Based on an assumed runoff, Upper and Lower Basin depletion schedules, and Lake Powell and Lake Mead contents at the beginning of the year, the volume of water in excess of the system space requirement at the end of the year is estimated. If that volume is greater than zero, a surplus is declared and full surplus schedules are met for the year. It should be noted that variations of the R strategies include a “volume limited” surplus, where just the computed surplus volume is distributed to certain Lower Division States’ users (i.e., a full surplus is not assumed). This variation is used for the Quantified Surplus level in the Interim Surplus Guidelines.

The assumed runoff corresponds to a particular percentile historical runoff. For example, the 70R strategy assumes a runoff corresponding to the 70th percentile (70% of the historical values are less than that value, or approximately 17.4 maf of natural inflow into Lake Powell).

Based on the original CRSS implementation, the Surplus Volume (SurVol) is computed using the following equation:

$$\text{SurVol} = (\text{PowellStorage} + \text{MeadStorage} - \text{maxStorage}) \text{ X } (1.0 + \text{aveBankStorCoeff}) + \text{runoff} - \text{Ubdemand} - \text{Lbdemand}$$

Where:

PowellStorage = Lake Powell content at the beginning of the year

MeadStorage = Lake Mead content at the beginning of the year

maxStorage = Maximum combined storage at Lakes Powell and Mead that will meet the system space requirement at the beginning of the year, assuming 30% of that requirement will be met by the reservoirs upstream of Powell (live capacity of Lakes Powell and Mead - 0.7 x 5.35 maf = 47.96 maf)

aveBankStorageCoeff = Average of Lake Powell and Lake Mead bank storage coefficients

Runoff = assumed percentile runoff

Ubdemand = Upper Basin depletion scheduled for the year + the average evaporation loss in the Upper Basin (same as assumed in equalization, 560 kaf)

Lbdemand = sum of the depletions below Powell + the evaporation losses in the Lower Basin mainstream reservoirs (average loss of 900 kaf at Mead and computed for Lakes Mohave and Havasu, based on the target storage) – average gains between Powell and Mead (801 kaf) – average gains below Mead (427 kaf)

SURPLUS SCHEDULES COMMON TO ALL SCENARIOS

For all scenarios, a “flood control” surplus is declared when Lake Mead releases water in excess of normal downstream demand under the Army Corps of Engineers flood control procedures. All scenarios utilize this strategy for the entire length of the run. As previously noted, for time periods not utilizing the Interim Surplus Guidelines (i.e., the period 2017-2076 for the No Action, Implementation Agreement, and Cumulative Analysis scenarios, as well as the period 2002-2076 for the Baseline for Cumulative Analysis scenario) the 70R Strategy is used. It was assumed that the 70R Strategy would trigger a “full” surplus for these periods, allowing the same amount of water to be delivered as under Flood Control surplus. Table C-1 presents the surplus schedules utilized for Flood Control and Full surplus declarations. Schedules of other entities that do not receive surplus water have been included to yield the total Lower Basin depletion.

Table C-1
Flood Control Surplus and Full Surplus Schedules, (kaf)

Date	MWD	IID	CVWD	PVID	CA Other	CA Total	AZ Other	CAP	AZ Total	NV Other	SNWP	NV Total	Total L.B.
2002	1,250	3,208	585	383	61	5,487	1,332	1,658	2,990	26	312	338	8,815
2003	1,250	3,188	585	381	64	5,468	1,337	1,647	2,984	26	314	340	8,792
2004	1,250	3,152	585	380	66	5,433	1,342	1,582	2,924	27	316	343	8,700
2005	1,250	3,132	585	379	68	5,414	1,348	1,615	2,963	28	316	344	8,721
2006	1,250	3,061	585	378	71	5,345	1,353	1,652	3,005	28	321	349	8,699
2007	1,250	3,036	585	377	74	5,322	1,359	1,680	3,039	28	326	354	8,715
2008	1,250	3,011	585	375	79	5,300	1,364	1,715	3,079	29	330	359	8,738
2009	1,250	2,986	585	374	82	5,277	1,369	1,750	3,119	29	334	363	8,759
2010	1,250	2,961	585	373	86	5,255	1,375	1,787	3,162	29	338	367	8,784
2011	1,250	2,936	585	372	91	5,234	1,375	1,812	3,187	29	342	371	8,792
2012	1,250	2,931	585	370	98	5,234	1,376	1,835	3,211	29	345	374	8,819
2013	1,250	2,926	585	369	103	5,233	1,376	1,835	3,211	29	349	378	8,822
2014	1,250	2,921	585	367	110	5,233	1,377	1,835	3,212	29	353	382	8,827
2015	1,250	2,916	585	366	116	5,233	1,378	1,835	3,213	29	357	386	8,832
2016	1,250	2,911	585	366	116	5,228	1,378	1,835	3,213	29	361	390	8,831
2017	1,250	2,906	585	366	116	5,223	1,379	1,835	3,214	29	365	394	8,831
2018	1,250	2,901	585	366	116	5,218	1,380	1,835	3,215	29	369	398	8,831
2019	1,250	2,896	585	366	116	5,213	1,380	1,835	3,215	29	373	402	8,830
2020	1,250	2,891	585	366	116	5,208	1,381	1,835	3,216	29	378	407	8,831
2021	1,250	2,886	585	366	116	5,203	1,382	1,835	3,217	29	382	411	8,831
2022	1,250	2,881	585	366	116	5,198	1,383	1,835	3,218	29	387	416	8,832
2023	1,250	2,876	585	366	116	5,193	1,385	1,835	3,220	29	391	420	8,833
2024	1,250	2,871	585	366	116	5,188	1,386	1,835	3,221	29	395	424	8,833
2025	1,250	2,866	585	366	116	5,183	1,388	1,835	3,223	29	400	429	8,835
2026	1,250	2,861	585	366	116	5,178	1,389	1,835	3,224	21	404	425	8,827
2027	1,250	2,861	585	366	116	5,178	1,390	1,835	3,225	13	408	421	8,824
2028	1,250	2,861	585	366	116	5,178	1,392	1,835	3,227	13	412	425	8,830
2029	1,250	2,861	585	366	116	5,178	1,393	1,835	3,228	13	415	428	8,834
2030	1,250	2,861	585	366	116	5,178	1,394	1,835	3,229	13	418	431	8,838
2031	1,250	2,861	585	366	116	5,178	1,395	1,835	3,230	13	423	436	8,844
2032	1,250	2,861	585	366	116	5,178	1,396	1,835	3,231	13	427	440	8,849
2033	1,250	2,861	585	366	116	5,178	1,397	1,835	3,232	13	431	444	8,854
2034	1,250	2,861	585	366	116	5,178	1,398	1,835	3,233	13	435	448	8,859
2035	1,250	2,861	585	366	116	5,178	1,398	1,835	3,233	13	439	452	8,863
2036	1,250	2,861	585	366	116	5,178	1,399	1,835	3,234	13	443	456	8,868
2037	1,250	2,861	585	366	116	5,178	1,400	1,835	3,235	13	448	461	8,874
2038	1,250	2,861	585	366	116	5,178	1,401	1,835	3,236	13	452	465	8,879
2039	1,250	2,861	585	366	116	5,178	1,402	1,835	3,237	13	456	469	8,884
2040	1,250	2,861	585	366	116	5,178	1,402	1,835	3,237	13	460	473	8,888
2041	1,250	2,861	585	366	116	5,178	1,403	1,835	3,238	13	464	477	8,893
2042	1,250	2,861	585	366	116	5,178	1,403	1,835	3,238	13	468	481	8,897
2043	1,250	2,861	585	366	116	5,178	1,403	1,835	3,238	13	472	485	8,901
2044	1,250	2,861	585	366	116	5,178	1,404	1,835	3,239	13	476	489	8,906
2045	1,250	2,861	585	366	116	5,178	1,404	1,835	3,239	13	480	493	8,910
2046	1,250	2,911	585	366	116	5,228	1,404	1,835	3,239	13	485	498	8,965
2047	1,250	2,911	585	366	116	5,228	1,404	1,835	3,239	13	489	502	8,969
2048	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	493	506	8,974
2049	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	497	510	8,978
2050	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2051	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2052	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2053	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2054	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2055	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2056	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2057	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2058	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2059	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2060	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2061	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2062	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2063	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2064	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2065	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2066	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2067	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2068	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2069	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2070	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2071	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2072	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2073	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2074	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2075	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982
2076	1,250	2,911	585	366	116	5,228	1,405	1,835	3,240	13	501	514	8,982

For scenarios utilizing the Interim Surplus Guidelines (i.e., the No Action, Implementation Agreement, and Cumulative Analysis scenarios), a common schedule was used for the Quantified Surplus level. This schedule is presented in Table C-2.

Table C-2
Quantified Surplus Schedules, (kaf)

Date	MWD	IID	CVWD	PVID	CA Other	CA Total	AZ Other	CAP	AZ Total	NV Other	SNWP	NV Total	Total L.B.
2002	1,250	3,130	489	383	61	5,313	1,332	1,658	2,990	26	312	338	8,641
2003	1,250	3,110	483	381	63	5,287	1,337	1,647	2,984	26	314	340	8,611
2004	1,250	3,073	478	380	65	5,246	1,342	1,582	2,924	27	316	343	8,513
2005	1,250	3,053	485	379	68	5,235	1,348	1,615	2,963	28	316	344	8,542
2006	1,250	2,982	485	378	71	5,166	1,353	1,652	3,005	28	321	349	8,520
2007	1,250	2,957	490	377	75	5,149	1,359	1,680	3,039	28	326	354	8,542
2008	1,250	2,932	495	375	78	5,130	1,364	1,715	3,079	29	330	359	8,568
2009	1,250	2,907	500	374	82	5,113	1,369	1,750	3,119	29	334	363	8,595
2010	1,250	2,882	505	373	86	5,096	1,375	1,787	3,162	29	338	367	8,625
2011	1,250	2,857	510	372	92	5,081	1,375	1,812	3,187	29	342	371	8,639
2012	1,250	2,852	515	370	98	5,085	1,376	1,835	3,211	29	345	374	8,670
2013	1,250	2,847	520	369	104	5,090	1,376	1,835	3,211	29	349	378	8,679
2014	1,250	2,842	525	367	110	5,094	1,377	1,835	3,212	29	353	382	8,688
2015	1,250	2,837	530	366	116	5,099	1,378	1,835	3,213	29	357	386	8,698
2016	1,250	2,832	535	366	116	5,099	1,378	1,835	3,213	29	361	390	8,702

PARTIAL AND FULL DOMESTIC SURPLUS SCHEDULES FOR NO ACTION

For the No Action scenario, the Interim Surplus Guidelines were in effect from 2002 through 2016 and no water transfers were assumed among the California entities. Tables C-3 and C-4 present the Partial Domestic and Full Domestic surplus schedules respectively for the No Action Scenario. Schedules of other entities that do not receive surplus water have been included to yield the total Lower Basin depletion for each surplus declaration.

Table C-3
Partial Domestic Surplus Schedules Under No Action, (kaf)

Date	MWD	IID	CVWD	PVID	CA Other	CA Total	AZ Other	CAP	AZ Total	NV Other	SNWP	NV Total	Total L.B.
2002	832	2,990	330	383	61	4,596	1,332	1,458	2,790	26	278	304	7,690
2003	852	2,990	330	381	63	4,616	1,337	1,447	2,784	26	278	304	7,704
2004	839	2,990	330	380	65	4,604	1,342	1,382	2,724	27	295	322	7,650
2005	825	2,990	330	379	68	4,592	1,348	1,415	2,763	28	283	311	7,666
2006	812	2,990	330	378	71	4,581	1,353	1,447	2,800	28	273	301	7,682
2007	795	2,990	330	377	75	4,567	1,359	1,441	2,800	28	274	302	7,669
2008	779	2,990	330	375	78	4,552	1,364	1,436	2,800	29	275	304	7,656
2009	762	2,990	330	374	82	4,538	1,369	1,431	2,800	29	277	306	7,644
2010	762	2,990	330	373	86	4,541	1,375	1,425	2,800	29	279	308	7,649
2011	762	2,990	330	372	92	4,546	1,375	1,425	2,800	29	281	310	7,656
2012	762	2,990	330	370	98	4,550	1,376	1,424	2,800	29	283	312	7,662
2013	782	2,990	330	369	104	4,575	1,376	1,424	2,800	29	285	314	7,689
2014	802	2,990	330	367	110	4,599	1,377	1,423	2,800	29	287	316	7,715
2015	822	2,990	330	366	116	4,624	1,378	1,422	2,800	29	287	316	7,740
2016	842	2,990	330	366	116	4,644	1,378	1,422	2,800	29	289	318	7,762

Table C-4
Full Domestic Surplus Schedules Under No Action, (kaf)

Date	MWD	IID	CVWD	PVID	CA Other	CA Total	AZ Other	CAP	AZ Total	NV Other	SNWP	NV Total	Total L.B.
2002	1,250	2,990	330	383	61	5,014	1,332	1,458	2,790	26	278	304	8,108
2003	1,250	2,990	330	381	63	5,014	1,337	1,447	2,784	26	278	304	8,102
2004	1,217	2,990	330	380	65	4,982	1,342	1,382	2,724	27	295	322	8,028
2005	1,183	2,990	330	379	68	4,950	1,348	1,415	2,763	28	283	311	8,024
2006	1,150	2,990	330	378	71	4,919	1,353	1,447	2,800	28	273	301	8,020
2007	1,113	2,990	330	377	75	4,885	1,359	1,441	2,800	28	275	303	7,988
2008	1,077	2,990	330	375	78	4,850	1,364	1,436	2,800	29	279	308	7,958
2009	1,040	2,990	330	374	82	4,816	1,369	1,431	2,800	29	283	312	7,928
2010	1,020	2,990	330	373	86	4,799	1,375	1,425	2,800	29	287	316	7,915
2011	1,000	2,990	330	372	92	4,784	1,375	1,425	2,800	29	291	320	7,904
2012	980	2,990	330	370	98	4,768	1,376	1,424	2,800	29	295	324	7,892
2013	980	2,990	330	369	104	4,773	1,376	1,424	2,800	29	299	328	7,901
2014	980	2,990	330	367	110	4,777	1,377	1,423	2,800	29	302	331	7,908
2015	980	2,990	330	366	116	4,782	1,378	1,422	2,800	29	303	332	7,914
2016	980	2,990	330	366	116	4,782	1,378	1,422	2,800	29	307	336	7,918

A further explanation of the Partial and Full Domestic schedules for MWD under the No Action scenario is warranted. In the Interim Surplus Guidelines Record of Decision, benchmark quantities for agricultural use of Colorado River water in California were specified as shown in Table C-5.

Table C-5
Interim Surplus Guidelines Benchmarks for
Quantity of California Agricultural Use of Colorado River Water, (kaf)

Year	Benchmark Quantity	Required Reduction (from 3,850)
2003	3,740	110
2006	3,640	210
2009	3,530	320
2012	3,470	380

Since these benchmarks would not be met through water transfers under the No Action scenario, it was assumed that MWD would reduce its use to permit the benchmarks to be met and therefore keep the Interim Surplus Guidelines in effect. The first benchmark (110 kaf in 2003) was assumed to be met by the 1988/89 Agreements among IID, MWD, and CVWD. Further reductions necessary to meet the benchmarks were imposed linearly over time. It was also assumed that no reductions were necessary for the higher levels of surplus (Quantified and Flood Control). Table C-6 presents a comparison of the affected surplus schedules for MWD.

Table C-6
Comparison of MWD Surplus Schedules
With and Without Benchmark Reductions (kaf)

Year	Partial Domestic Surplus		Full Domestic Surplus	
	With	Without	With	Without
2002	832	832	1,250	1,250
2003	852	852	1,250	1,250
2004	839	872	1,217	1,250
2005	825	892	1,183	1,250
2006	812	912	1,150	1,250
2007	795	932	1,113	1,250
2008	779	952	1,077	1,250
2009	762	972	1,040	1,250
2010	762	992	1,020	1,250
2011	762	1,012	1,000	1,250
2012	762	1,032	980	1,250
2013	782	1,052	980	1,250
2014	802	1,072	980	1,250
2015	822	1,092	980	1,250
2016	842	1,112	980	1,250

PARTIAL AND FULL DOMESTIC SURPLUS SCHEDULES FOR IMPLEMENTATION AGREEMENT

For the Implementation Agreement scenario, the Interim Surplus Guidelines were in effect from 2002 through 2016 and water transfers as detailed in Attachment A were assumed among the California entities. Tables C-7 and C-8 present the Partial Domestic and Full Domestic surplus schedules respectively for the Implementation Agreement scenario. Schedules of other entities that do not receive surplus water have been included to yield the total Lower Basin depletion for each surplus declaration. A column has been added to show the difference (due to the water transfers) between the Implementation Agreement and No Action scenarios. This difference is the basis for the slight increases in lake elevations observed under the Implementation Agreement as noted in Section 3.1.

Table C-7
Partial Domestic Surplus Schedules for Implementation Agreement, (kaf)

Date	MWD	IID	CVWD	PVID	CA Other	CA Total	AZ Other	CAP	AZ Total	NV Other	SNWP	NV Total	Total LB	Difference from Baseline [1]
2002	832	2,959	326	383	61	4,561	1,332	1,458	2,790	26	278	304	7,655	-35
2003	852	2,939	335	381	63	4,570	1,337	1,447	2,784	26	278	304	7,658	-46
2004	872	2,919	321	380	65	4,557	1,342	1,382	2,724	27	295	322	7,603	-47
2005	892	2,877	321	379	68	4,537	1,348	1,415	2,763	28	283	311	7,611	-55
2006	912	2,852	321	378	71	4,534	1,353	1,447	2,800	28	273	301	7,635	-47
2007	932	2,781	321	377	75	4,486	1,359	1,441	2,800	28	274	302	7,588	-81
2008	952	2,761	321	375	78	4,487	1,364	1,436	2,800	29	275	304	7,591	-65
2009	972	2,736	321	374	82	4,485	1,369	1,431	2,800	29	277	306	7,591	-53
2010	992	2,711	321	373	86	4,483	1,375	1,425	2,800	29	279	308	7,591	-58
2011	1,012	2,686	321	372	92	4,483	1,375	1,425	2,800	29	281	310	7,593	-63
2012	1,032	2,681	321	370	98	4,502	1,376	1,424	2,800	29	283	312	7,614	-48
2013	1,052	2,676	321	369	104	4,522	1,376	1,424	2,800	29	285	314	7,636	-53
2014	1,072	2,671	321	367	110	4,541	1,377	1,423	2,800	29	287	316	7,657	-58
2015	1,092	2,666	321	366	116	4,561	1,378	1,422	2,800	29	287	316	7,677	-63
2016	1,112	2,661	321	366	116	4,576	1,378	1,422	2,800	29	289	318	7,694	-68

Notes:

1. The numbers shown in the column entitled “Difference from Baseline” reflect the differences in Total Lower Basin Depletions between the schedules used in the No Action alternative (Table C-3) and this schedule (Implementation Agreement) for each respective year.

Table C-8
Full Domestic Surplus Schedules for Implementation Agreement, (kaf)

Date	MWD	IID	CVWD	PVID	CA Other	CA Total	AZ Other	CAP	AZ Total	NV Other	SNWP	NV Total	Total L.B.	Difference from Baseline [1]
2002	1,250	2,959	326	383	61	4,979	1,332	1,458	2,790	26	278	304	8,073	-35
2003	1,250	2,939	335	381	63	4,968	1,337	1,447	2,784	26	278	304	8,056	-46
2004	1,250	2,919	321	380	65	4,935	1,342	1,382	2,724	27	295	322	7,981	-47
2005	1,250	2,877	321	379	68	4,895	1,348	1,415	2,763	28	283	311	7,969	-55
2006	1,250	2,852	321	378	71	4,872	1,353	1,447	2,800	28	273	301	7,973	-47
2007	1,250	2,781	321	377	75	4,804	1,359	1,441	2,800	28	275	303	7,907	-81
2008	1,250	2,761	321	375	78	4,785	1,364	1,436	2,800	29	279	308	7,893	-65
2009	1,250	2,736	321	374	82	4,763	1,369	1,431	2,800	29	283	312	7,875	-53
2010	1,250	2,711	321	373	86	4,741	1,375	1,425	2,800	29	287	316	7,857	-58
2011	1,250	2,686	321	372	92	4,721	1,375	1,425	2,800	29	291	320	7,841	-63
2012	1,250	2,681	321	370	98	4,720	1,376	1,424	2,800	29	295	324	7,844	-48
2013	1,250	2,676	321	369	104	4,720	1,376	1,424	2,800	29	299	328	7,848	-53
2014	1,250	2,671	321	367	110	4,719	1,377	1,423	2,800	29	302	331	7,850	-58
2015	1,250	2,666	321	366	116	4,719	1,378	1,422	2,800	29	303	332	7,851	-63
2016	1,250	2,661	321	366	116	4,714	1,378	1,422	2,800	29	307	336	7,850	-68

Notes:

1. The numbers shown in the column entitled “Difference from Baseline” reflect the differences in Total Lower Basin Depletions between the schedules used in the No Action alternative (Table C-4) and this schedule (Implementation Agreement) for each respective year.

PARTIAL AND FULL DOMESTIC SURPLUS SCHEDULES FOR CUMULATIVE ANALYSIS

For the Cumulative Analysis scenario, the Interim Surplus Guidelines were in effect from 2002 through 2016 and water transfers as detailed in Attachment A were assumed among the California entities. Tables C-9 and C-10 present the Partial Domestic and Full Domestic surplus schedules respectively for the Cumulative Analysis scenario. Schedules of other entities that do not receive surplus water have been included to yield the total Lower Basin depletion for each surplus declaration.

Table C-9
Partial Domestic Surplus Schedules for Cumulative Analysis, (kaf)

Date	MWD	IID	CVWD	PVID	CA Other	CA Total	AZ Other	CAP	AZ Total	NV Other	SNWP	NV Total	Total L.B.
2002	832	2,959	326	351	61	4,529	1,332	1,458	2,790	26	278	304	7,623
2003	852	2,939	335	281	63	4,470	1,337	1,447	2,784	26	278	304	7,558
2004	872	2,919	321	280	65	4,457	1,342	1,382	2,724	27	295	322	7,503
2005	892	2,877	321	279	68	4,437	1,348	1,415	2,763	28	283	311	7,511
2006	912	2,852	321	278	71	4,434	1,353	1,447	2,800	28	273	301	7,535
2007	932	2,781	321	277	75	4,386	1,359	1,441	2,800	28	274	302	7,488
2008	952	2,761	321	275	78	4,387	1,364	1,436	2,800	29	275	304	7,491
2009	972	2,736	321	274	82	4,385	1,369	1,431	2,800	29	277	306	7,491
2010	992	2,711	321	273	86	4,383	1,375	1,425	2,800	29	279	308	7,491
2011	1,012	2,686	321	272	92	4,383	1,375	1,425	2,800	29	281	310	7,493
2012	1,032	2,681	321	270	98	4,402	1,376	1,424	2,800	29	283	312	7,514
2013	1,052	2,676	321	269	104	4,422	1,376	1,424	2,800	29	285	314	7,536
2014	1,072	2,671	321	267	110	4,441	1,377	1,423	2,800	29	287	316	7,557
2015	1,092	2,666	321	266	116	4,461	1,378	1,422	2,800	29	287	316	7,577
2016	1,112	2,661	321	266	116	4,476	1,378	1,422	2,800	29	289	318	7,594

Table C-10
Full Domestic Surplus Schedules for Cumulative Analysis, (kaf)

Date	MWD	IID	CVWD	PVID	CA Other	CA Total	AZ Other	CAP	AZ Total	NV Other	SNWP	NV Total	Total L.B.
2002	1,250	2,959	326	358	61	4,954	1,332	1,458	2,790	26	278	304	8,048
2003	1,250	2,939	335	356	63	4,943	1,337	1,447	2,784	26	278	304	8,031
2004	1,250	2,919	321	355	65	4,910	1,342	1,382	2,724	27	295	322	7,956
2005	1,250	2,877	321	354	68	4,870	1,348	1,415	2,763	28	283	311	7,944
2006	1,250	2,852	321	353	71	4,847	1,353	1,447	2,800	28	273	301	7,948
2007	1,250	2,781	321	352	75	4,779	1,359	1,441	2,800	28	275	303	7,882
2008	1,250	2,761	321	350	78	4,760	1,364	1,436	2,800	29	279	308	7,868
2009	1,250	2,736	321	349	82	4,738	1,369	1,431	2,800	29	283	312	7,850
2010	1,250	2,711	321	348	86	4,716	1,375	1,425	2,800	29	287	316	7,832
2011	1,250	2,686	321	347	92	4,696	1,375	1,425	2,800	29	291	320	7,816
2012	1,250	2,681	321	345	98	4,695	1,376	1,424	2,800	29	295	324	7,819
2013	1,250	2,676	321	344	104	4,695	1,376	1,424	2,800	29	299	328	7,823
2014	1,250	2,671	321	342	110	4,694	1,377	1,423	2,800	29	302	331	7,825
2015	1,250	2,666	321	341	116	4,694	1,378	1,422	2,800	29	303	332	7,826
2016	1,250	2,661	321	341	116	4,689	1,378	1,422	2,800	29	307	336	7,825

Attachment D
Sensitivity Analysis of Shortage Protection Assumptions

Attachment D
Sensitivity Analysis of Shortage Protection Assumptions

Overview

This attachment to the Technical Memorandum presents the results of a sensitivity analysis conducted to assess the effects of using different Lake Mead shortage protection criteria in the modeling of the Implementation Agreement and the Cumulative Assessment Conditions. As discussed in Section 2.4 of the Technical Memorandum, it was assumed that the Lake Mead water surface elevation of 1083 feet msl would be protected with a certain degree of confidence (approximately 80 percent of the time). Also, separate modeling studies were used to determine a "protection line" or trigger such that if Lake Mead's water surface elevation falls below the specified protection line, a Level 1 shortage is declared. A representation of the modeled 1083 feet msl protection line is shown on Figure D-1. It should be noted that while an 80 percent level of confidence was desired, with respect to the protection of this Lake Mead water surface elevation, the actual assurance achieved was less than this amount. The actual assurance achieved is approximately 100 percent during the initial nine years. Thereafter, the assurance level decreases over time with the minimum assurance achieved being approximately 57 percent. As shown on Figure 3.2-9 of this Technical Memorandum, the assurance level drops below 80% in 2021.

The lower level of confidence achieved after 2021 can be attributed to the independently produced shortage protection line values and their integration with the index sequential method used in the RiverWare model simulation of the Colorado River system operation. However, while a lower level of confidence was achieved, the validity of the comparisons between the modeled operation scenarios is not compromised since all of the modeled conditions use the same shortage protection assumptions.

For the sensitivity analysis, the modeling assumptions included a lower protection line than was used for the analysis in the Technical Memorandum (one that was intended to protect Lake Mead water surface elevation of 1050 feet msl approximately 80% of the time). The lower protection line (i.e., the shortage protection triggers) used for this purpose is also presented graphically in Figure D-1. The actual assurance levels achieved with respect to the protection of the Lake Mead water level of 1050 foot msl were similar to those observed under the 1083 foot msl water level protection criteria. The actual assurance achieved under the 1050 foot msl water level protection criteria is approximately 100 percent during the initial nine years. Thereafter, the assurance level decreases over time with the minimum assurance achieved being approximately 55 percent.

The sensitivity analysis evaluates the effect that a change in shortage protection assumptions would have on the modeling results for the Implementation Agreement Conditions and the Cumulative Assessment Conditions. The effect is expressed as differences in Lake Powell and Lake Mead water surface levels observed under the two different modeled Lake Mead shortage protection criteria (1050 feet msl and 1083 feet msl Lake Mead protection lines). In general, the 1050 foot msl Lake Mead water level protection criteria resulted in lower Lake Mead water levels under the Implementation Agreement Conditions and the

Cumulative Assessment Conditions. At Lake Powell, the use of the 1050-foot msl protection line for Lake Mead produced little to no difference in water levels compared to the use of the 1083-foot protection line.

Lake Mead Water Surface Elevations

Comparisons of Lake Mead water surface elevations were made for the Implementation Agreement Conditions and for the Cumulative Analysis Conditions. The results of these two comparisons are presented on Figures D-2 and D-3, respectively.

Figure D-2 compares the Lake Mead water surface elevations observed under the modeled Implementation Agreement Condition that uses the1050-feet msl protection line to those under Implementation Agreement Condition that uses the1083-feet msl protection line. Specifically, the 90th, 50th and 10th percentile values of the observed Lake Mead water surface elevations from these two-modeled conditions are compared to each other. This figure may be compared to Figure 3.2-7 in the Technical Memorandum, which also presents Lake Mead water surface elevations under Implementation Agreement Conditions based on the 1083-foot protection level.

Figure D-2 shows that the 90th percentile values are essentially the same under the 1050-foot and 1083-foot modeled shortage protection conditions. The observed 50th percentile values (median values) under the 1050-foot protection conditions are also essentially the same as those observed under the 1083-foot protection conditions until 2016. Thereafter, the median elevations under the 1050-foot protection conditions fall below and remain at a lower level than those observed under the 1083-foot shortage protection conditions. The maximum departure between the two sets of median elevations is approximately 14.33 feet. The 10th percentile values observed under the 1050-foot protection conditions are the same as those observed under the 1083-foot protection conditions until 2009. Thereafter, the 10th percentile values observed under the 1050-foot protection conditions fall below and remain at a lower level than those observed under the 1083-foot shortage protection conditions. Table D-1 lists the observed maximum, minimum and average departures of the observed 90th, 50th and 10th percentile values of the 1050-foot shortage protection modeling results from those of the 1083-foot shortage protection conditions.

Table D-1
Lake Mead Water Surface Elevations
90th, 50th and 10th Percentile Values for Implementation Agreement Conditions
Departure of 1050-foot from 1083-foot Shortage Protection Modeled Conditions

	Departures (75-year Period)		
	90th Percentile Values	**50th Percentile Values**	**10th Percentile Values**
Maximum Departure	3.24	14.33	14.47
Minimum Departure	-3.65	0.00	0.00
Average Departure	0.32	5.39	4.15

Figure D-3 compares the Lake Mead water surface elevations observed under modeled Cumulative Analysis Condition that uses the1050-feet msl protection line to those under Cumulative Analysis Condition that uses the1083-feet msl protection line. Specifically, the 90th, 50th and 10th percentile values of the observed Lake Mead water surface elevations from these two-modeled conditions are compared to each other. This figure may be compared to Figure 3.3-7 in the Technical

Memorandum, which also presents Lake Mead water surface elevations under Cumulative Analysis Conditions based on the 1083-foot protection level.

Figure D-3 shows that the 90th percentile values are essentially the same under the 1050-foot and 1083-foot modeled shortage protection condition. The observed median values under the 1050-foot protection conditions are essentially the same as those observed under the 1083-foot protection condition until 2016. Thereafter, the median elevations under the 1050-foot protection condition fall and remain at a lower level than those observed under the 1083-foot shortage protection condition. The maximum departure between the two sets of median elevations is approximately 15.49 feet. The 10th percentile values observed under the 1050-foot protection conditions are also essentially the same as those observed under the 1083-foot protection condition until 2011. Thereafter, the 10th percentile elevations under the 1050-foot protection condition fall and remain at a lower level than those observed under the 1083-foot shortage protection condition. Table D-2 lists the observed maximum, minimum and average departures of the observed 90th, 50th and 10th percentile values of the 1050-foot shortage protection modeling results from those of the 1083-foot shortage protection conditions.

Table D-2
Lake Mead Water Surface Elevations
90th, 50th and 10th Percentile Values for Cumulative Analysis Conditions
Departure of 1050-foot from 1083-foot Shortage Protection Modeled Conditions

	Departures (75-year Period)		
	90th Percentile Values	50th Percentile Values	10th Percentile Values
Maximum Departure	2.95	15.49	14.01
Minimum Departure	-3.91	0.00	0.00
Average Departure	0.30	5.40	4.24

The lower Lake Mead levels observed under the 1050-foot protection condition can be attributed to a more liberal availability of surplus water, allowing Lake Mead to be drawn down lower before the shortage triggers takes effect and further water delivery reductions begin.

Lake Powell Water Surface Elevations

Comparisons of Lake Powell water surface elevations were made for the Implementation Agreement Conditions and for the Cumulative Analysis Conditions. The results of these two comparisons are presented on Figures D-4 and D-5, respectively.

Figure D-4 compares the Lake Powell water surface elevations observed under the modeled Implementation Agreement Condition that uses the 1050-foot msl protection line to those under Implementation Agreement Condition that uses the 1083-foot msl protection line. Specifically, the 90th, 50th and 10th percentile values of the observed Lake Powell water surface elevations from these two-modeled conditions are compared to each other. It should be noted that the shortage protection criteria (triggers) are applied to the Lake Mead operations in the model. As such, any effect that this criterion would have on Lake Powell water levels would result from equalization.

Figure D-4 shows that the 90th, 50th and 10th percentile values are essentially the same under the 1050-foot and 1083-foot modeled shortage protection conditions. Table D-3 lists the observed maximum, minimum and average departures of the observed 90th, 50th and 10th percentile values of

1050-foot shortage protection modeling results from those of the 1083-foot shortage protection conditions.

Table D3
Lake Powell Water Surface Elevations
90th, 50th and 10th Percentile Values for Implementation Agreement Conditions
Departure of 1050-foot from 1083-foot Shortage Protection Modeled Conditions

	Departures (75-year Period)		
	90th Percentile Values	**50th Percentile Values**	**10th Percentile Values**
Maximum Departure	0.56	0.85	0.00
Minimum Departure	0.00	0.00	0.00
Average Departure	0.01	0.01	0.00

Figure D-5 compares the Lake Powell water surface elevations observed under the modeled Cumulative Analysis Condition that uses the 1050-foot msl protection line to those under the Cumulative Analysis that uses the 1083-foot msl protection line. Figure D-5 shows that the 90th, 50th and 10th percentile values are essentially the same under the 1050-foot and 1083-foot modeled shortage protection conditions. Table D-4 lists the observed maximum, minimum and average departures of the observed 90th, 50th and 10th percentile values of 1050-foot shortage protection modeling results from those of the 1083-foot shortage protection conditions.

Table D-4
Lake Powell Water Surface Elevations
90th, 50th and 10th Percentile Values for Cumulative Analysis Conditions
Departure of 1050-foot from 1083-foot Shortage Protection Modeled Conditions

	Departures (75-year Period)		
	90th Percentile Values	**50th Percentile Values**	**10th Percentile Values**
Maximum Departure	0.38	0.69	0.00
Minimum Departure	0.00	0.00	0.00
Average Departure	0.01	0.01	0.00

Table D-5 lists the figures that were referenced above and that that are enclosed in the back of this attachment.

Table D-5
List of Figures

Figure D-1
Lake Mead Level 1 Shortage Triggers

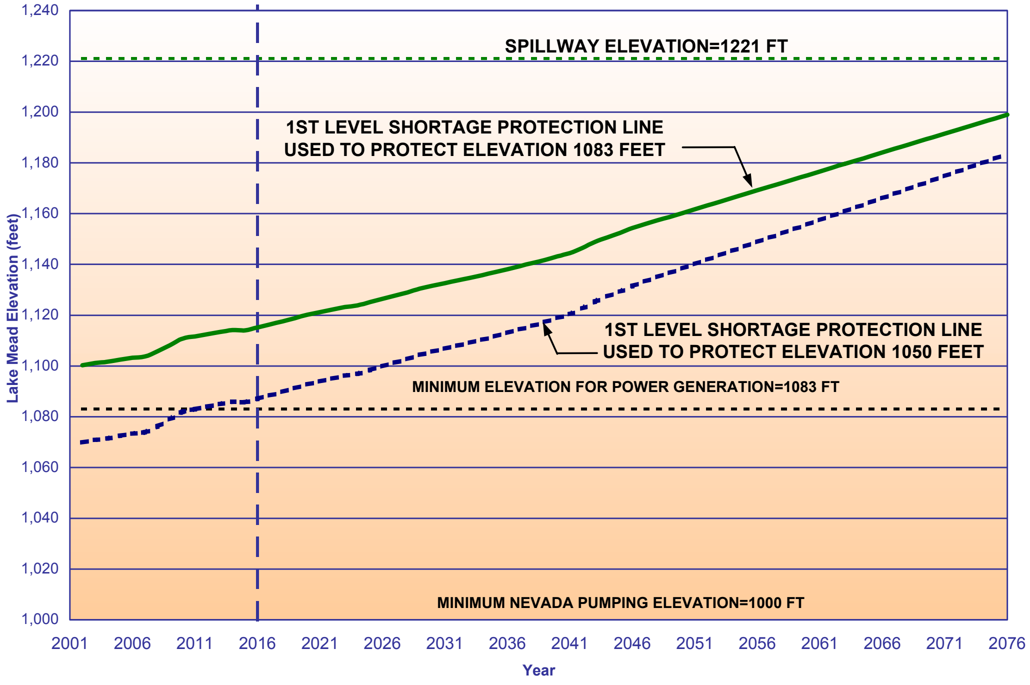


Figure D-2
Lake Mead End-of-December Water Elevations
Comparison of Shortage Assumptions for Implementation Agreement Conditions
90th, 50th, and 10th Percentile

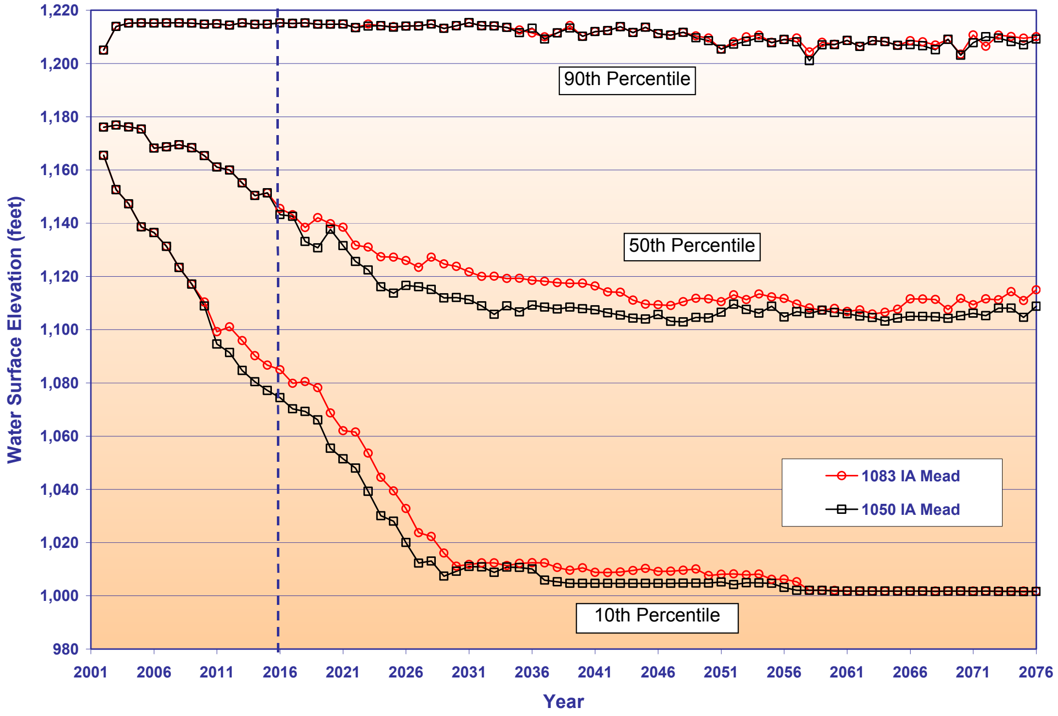


Figure D-3
Lake Mead End-of-December Water Elevations
Comparison of Shortage Assumptions for Cumulative Assessment Conditions
90th, 50th, and 10th Percentile Values

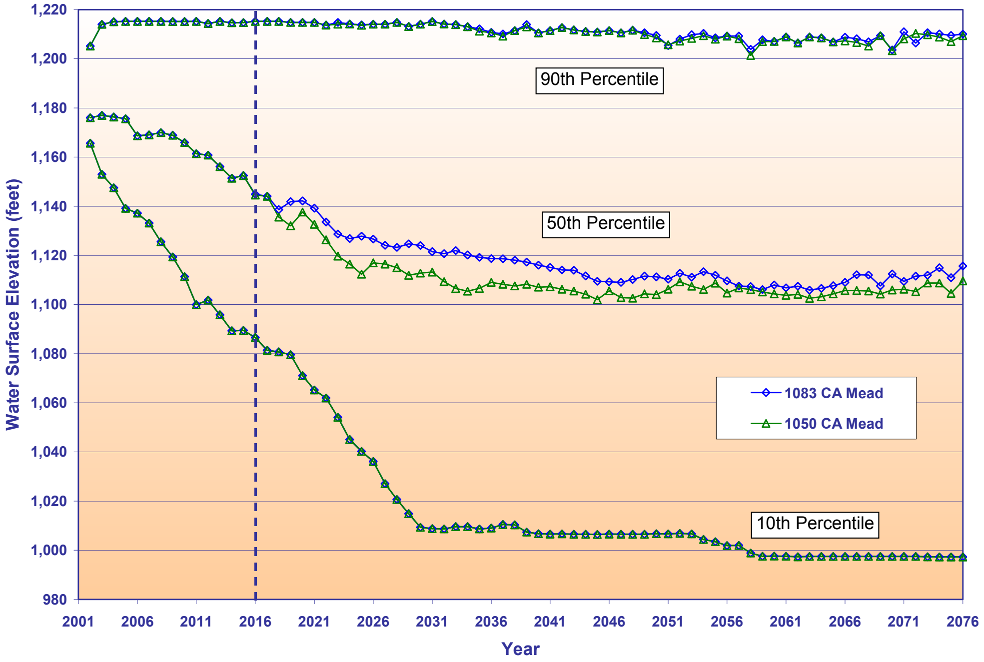


Figure D-4
Lake Powell End-of-July Water Elevations
Comparison of Shortage Assumptions for Implementation Agreement Conditions
90th, 50th, and 10th Percentile Values

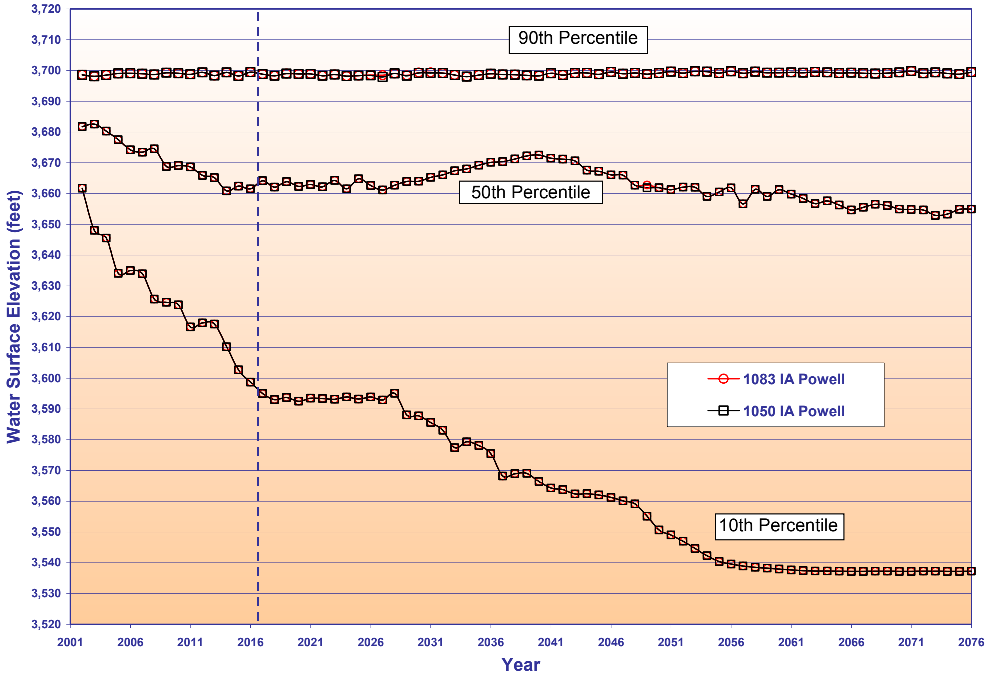
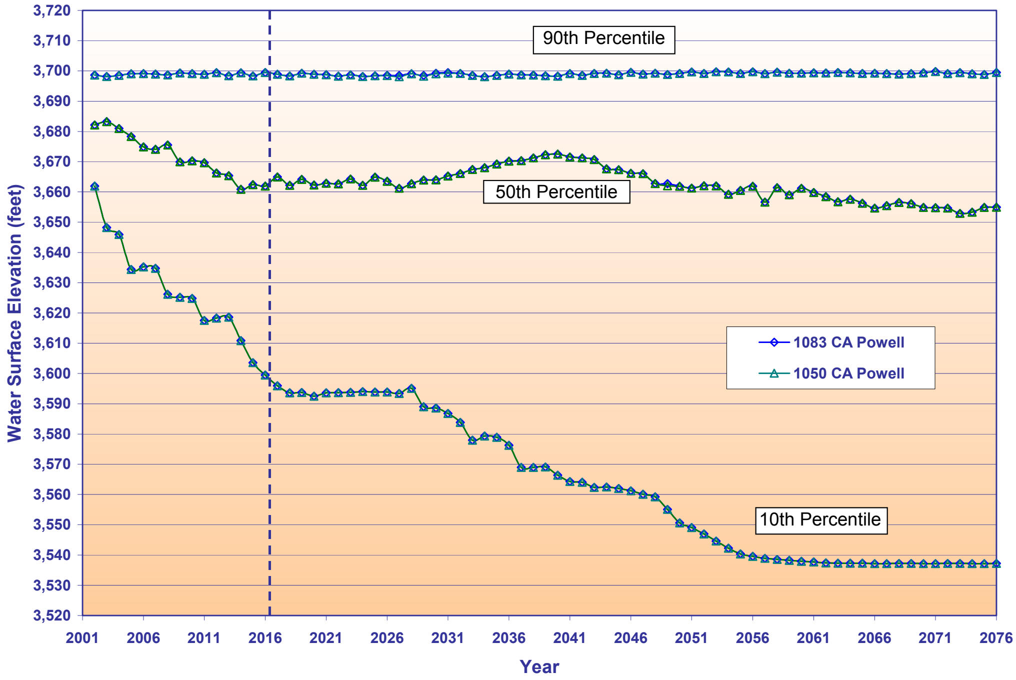


Figure D-5
Lake Powell End-of-July Water Elevations
Comparison of Shortage Assumptions for Cumulative Assessment Conditions
90th, 50th, and 10th Percentile Values



Attachment E
Volume-Elevation Relationships for Lakes Mead and Powell

Attachment E

Volume-Elevation Relationships for Lakes Mead and Powell

OVERVIEW

This attachment provides the relationship of water surface elevation to reservoir volume (or content) for Lake Mead and Lake Powell, in both tabular and graphical format. Figure E-1 provides a curve that represents the Lake Mead volume to elevation relationship and Figure E-2 provides the same for Lake Powell. The tabular data for lakes Mead and Powell are provided in Tables E-1 and E-2, respectively. The data can be used to determine the elevation effect of a given change in volume. The relationship for Lake Powell has been derived from data collected in a 1986 lake survey (Ferrari, 1988); the relationship for Lake Mead was derived from data collected in a 1964 lake survey (Lara and Sanders, 1970). Both derivations used Reclamation's Area-Capacity Program (ACAP). Additional information concerning ACAP can be found at www.usbr.gov/rsmg/xxx.

REFERENCES

Ferrari, R.L., 1970, "1986 Lake Powell Survey", U.S. Bureau of Reclamation, Surface Water Branch, Denver, CO

Lara, J.M., and Sanders, J.I., "The 1963-64 Lake Mead Survey", Office of Chief Engineer, U.S. Bureau of Reclamation, Denver, CO (Reference number REC-OCE-70-21)

Figure E-1
Lake Mead Volume-Elevation Relationship

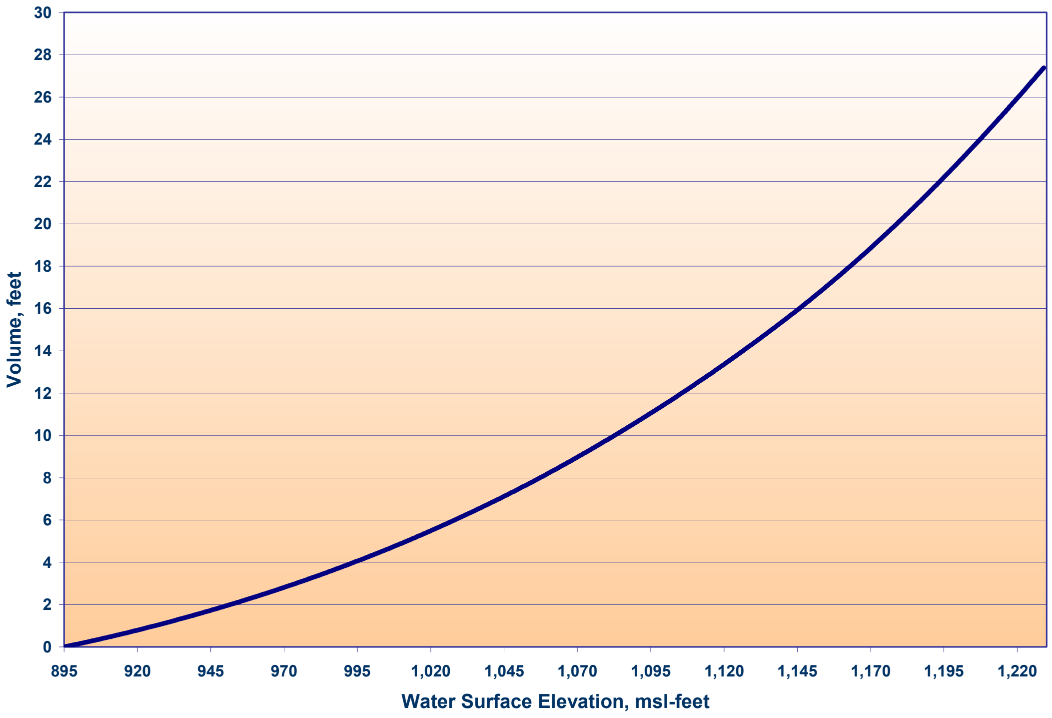


Figure E-2
Lake Powell Volume-Elevation Relationship

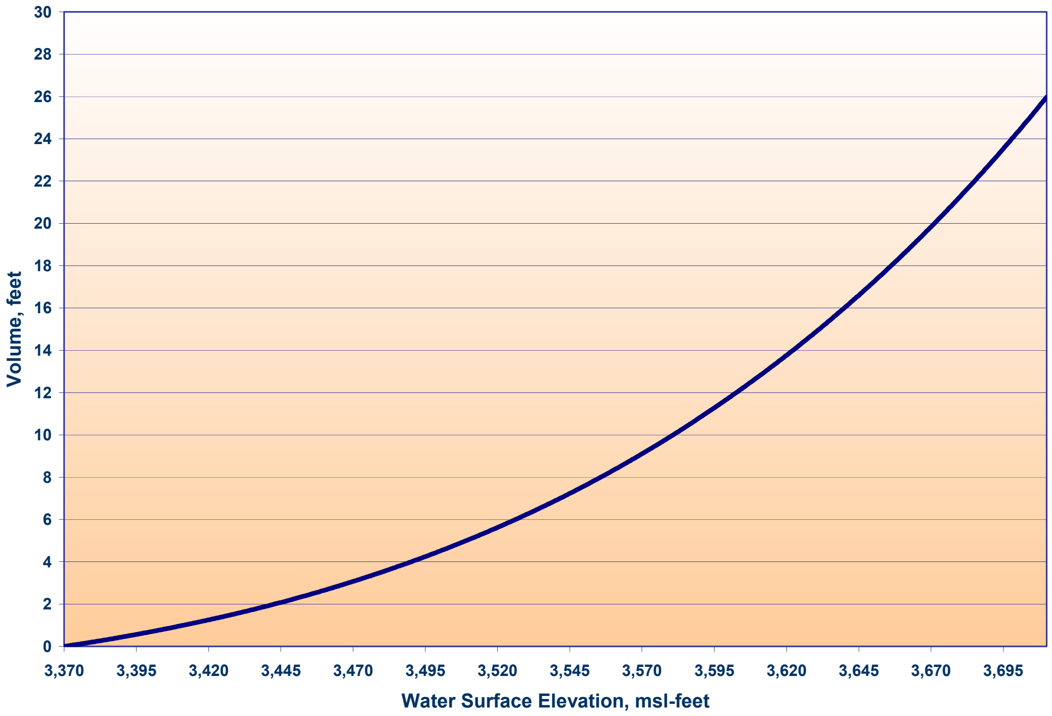


Table E-1
Lake Mead Water Surface Elevation to Storage Content Relationship (Table 1 of 2)

Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)
895.00	0	926.00	1,004,527	957.00	2,228,830	988.00	3,695,177	1,019.00	5,430,319	1,050.00	7,470,864
895.50	14,478	926.50	1,022,540	957.50	2,250,476	988.50	3,720,870	1,019.50	5,460,778	1,050.50	7,506,554
896.00	29,011	927.00	1,040,609	958.00	2,272,188	989.00	3,746,628	1,020.00	5,491,315	1,051.00	7,542,340
896.50	43,597	927.50	1,058,735	958.50	2,293,967	989.50	3,772,451	1,020.50	5,521,932	1,051.50	7,578,223
897.00	58,234	928.00	1,076,918	959.00	2,315,812	990.00	3,798,338	1,021.00	5,552,628	1,052.00	7,614,201
897.50	72,924	928.50	1,095,157	959.50	2,337,723	990.50	3,824,294	1,021.50	5,583,402	1,052.50	7,650,276
898.00	87,665	929.00	1,113,452	960.00	2,359,701	991.00	3,850,325	1,022.00	5,614,254	1,053.00	7,686,447
898.50	102,458	929.50	1,131,804	960.50	2,381,745	991.50	3,876,431	1,022.50	5,645,185	1,053.50	7,722,713
899.00	117,303	930.00	1,150,212	961.00	2,403,855	992.00	3,902,611	1,023.00	5,676,195	1,054.00	7,759,077
899.50	132,200	930.50	1,168,677	961.50	2,426,032	992.50	3,928,865	1,023.50	5,707,283	1,054.50	7,795,536
900.00	147,153	931.00	1,187,199	962.00	2,448,275	993.00	3,955,194	1,024.00	5,738,449	1,055.00	7,832,091
900.50	162,157	931.50	1,205,777	962.50	2,470,585	993.50	3,981,597	1,024.50	5,769,694	1,055.50	7,868,743
901.00	177,220	932.00	1,224,411	963.00	2,492,960	994.00	4,008,074	1,025.00	5,801,018	1,056.00	7,905,490
901.50	192,340	932.50	1,243,102	963.50	2,515,403	994.50	4,034,626	1,025.50	5,832,420	1,056.50	7,942,334
902.00	207,519	933.00	1,261,850	964.00	2,537,911	995.00	4,061,252	1,026.00	5,863,901	1,057.00	7,979,274
902.50	222,757	933.50	1,280,654	964.50	2,560,486	995.50	4,087,953	1,026.50	5,895,460	1,057.50	8,016,310
903.00	238,052	934.00	1,299,515	965.00	2,583,127	996.00	4,114,728	1,027.00	5,927,098	1,058.00	8,053,442
903.50	253,406	934.50	1,318,432	965.50	2,605,835	996.50	4,141,578	1,027.50	5,958,815	1,058.50	8,090,670
904.00	268,818	935.00	1,337,405	966.00	2,628,609	997.00	4,168,502	1,028.00	5,990,610	1,059.00	8,127,995
904.50	284,288	935.50	1,356,435	966.50	2,651,449	997.50	4,195,500	1,028.50	6,022,483	1,059.50	8,165,415
905.00	299,817	936.00	1,375,522	967.00	2,674,356	998.00	4,222,573	1,029.00	6,054,435	1,060.00	8,202,932
905.50	315,404	936.50	1,394,665	967.50	2,697,329	998.50	4,249,721	1,029.50	6,086,466	1,060.50	8,240,541
906.00	331,049	937.00	1,413,865	968.00	2,720,369	999.00	4,276,942	1,030.00	6,118,575	1,061.00	8,278,239
906.50	346,753	937.50	1,433,121	968.50	2,743,474	999.50	4,304,238	1,030.50	6,150,763	1,061.50	8,316,026
907.00	362,515	938.00	1,452,433	969.00	2,766,646	1,000.00	4,331,609	1,031.00	6,183,029	1,062.00	8,353,902
907.50	378,335	938.50	1,471,803	969.50	2,789,885	1,000.50	4,359,056	1,031.50	6,215,374	1,062.50	8,391,867
908.00	394,213	939.00	1,491,228	970.00	2,813,190	1,001.00	4,386,583	1,032.00	6,247,797	1,063.00	8,429,920
908.50	410,150	939.50	1,510,711	970.50	2,836,560	1,001.50	4,414,189	1,032.50	6,280,299	1,063.50	8,468,062
909.00	426,145	940.00	1,530,249	971.00	2,859,995	1,002.00	4,441,874	1,033.00	6,312,879	1,064.00	8,506,293
909.50	442,198	940.50	1,549,844	971.50	2,883,494	1,002.50	4,469,638	1,033.50	6,345,538	1,064.50	8,544,613
910.00	458,310	941.00	1,569,495	972.00	2,907,058	1,003.00	4,497,482	1,034.00	6,378,275	1,065.00	8,583,022
910.50	474,480	941.50	1,589,201	972.50	2,930,687	1,003.50	4,525,405	1,034.50	6,411,091	1,065.50	8,621,520
911.00	490,708	942.00	1,608,964	973.00	2,954,380	1,004.00	4,553,407	1,035.00	6,443,986	1,066.00	8,660,106
911.50	506,994	942.50	1,628,782	973.50	2,978,137	1,004.50	4,581,488	1,035.50	6,476,959	1,066.50	8,698,781
912.00	523,339	943.00	1,648,656	974.00	3,001,959	1,005.00	4,609,649	1,036.00	6,510,011	1,067.00	8,737,546
912.50	539,742	943.50	1,668,586	974.50	3,025,846	1,005.50	4,637,889	1,036.50	6,543,141	1,067.50	8,776,399
913.00	556,203	944.00	1,688,572	975.00	3,049,797	1,006.00	4,666,208	1,037.00	6,576,350	1,068.00	8,815,340
913.50	572,723	944.50	1,708,613	975.50	3,073,813	1,006.50	4,694,606	1,037.50	6,609,637	1,068.50	8,854,371
914.00	589,300	945.00	1,728,711	976.00	3,097,893	1,007.00	4,723,084	1,038.00	6,643,003	1,069.00	8,893,490
914.50	605,937	945.50	1,748,864	976.50	3,122,038	1,007.50	4,751,641	1,038.50	6,676,447	1,069.50	8,932,699
915.00	622,631	946.00	1,769,073	977.00	3,146,247	1,008.00	4,780,277	1,039.00	6,709,970	1,070.00	8,971,996
915.50	639,384	946.50	1,789,338	977.50	3,170,521	1,008.50	4,808,992	1,039.50	6,743,571	1,070.50	9,011,382
916.00	656,195	947.00	1,809,659	978.00	3,194,859	1,009.00	4,837,787	1,040.00	6,777,251	1,071.00	9,050,857
916.50	673,064	947.50	1,830,035	978.50	3,219,262	1,009.50	4,866,660	1,040.50	6,811,019	1,071.50	9,090,420
917.00	689,992	948.00	1,850,468	979.00	3,243,729	1,010.00	4,895,613	1,041.00	6,844,882	1,072.00	9,130,073
917.50	706,977	948.50	1,870,956	979.50	3,268,261	1,010.50	4,924,646	1,041.50	6,878,842	1,072.50	9,169,814
918.00	724,022	949.00	1,891,500	980.00	3,292,857	1,011.00	4,953,757	1,042.00	6,912,897	1,073.00	9,209,644
918.50	741,124	949.50	1,912,100	980.50	3,317,518	1,011.50	4,982,948	1,042.50	6,947,049	1,073.50	9,249,563
919.00	758,285	950.00	1,932,756	981.00	3,342,244	1,012.00	5,012,218	1,043.00	6,981,297	1,074.00	9,289,571
919.50	775,504	950.50	1,953,472	981.50	3,367,034	1,012.50	5,041,567	1,043.50	7,015,641	1,074.50	9,329,668
920.00	792,781	951.00	1,974,256	982.00	3,391,888	1,013.00	5,070,996	1,044.00	7,050,082	1,075.00	9,369,853
920.50	810,116	951.50	1,995,105	982.50	3,416,808	1,013.50	5,100,503	1,044.50	7,084,618	1,075.50	9,410,128
921.00	827,507	952.00	2,016,021	983.00	3,441,791	1,014.00	5,130,090	1,045.00	7,119,251	1,076.00	9,450,491
921.50	844,955	952.50	2,037,003	983.50	3,466,839	1,014.50	5,159,757	1,045.50	7,153,979	1,076.50	9,490,943
922.00	862,459	953.00	2,058,052	984.00	3,491,952	1,015.00	5,189,502	1,046.00	7,188,804	1,077.00	9,531,484
922.50	880,020	953.50	2,079,167	984.50	3,517,129	1,015.50	5,219,327	1,046.50	7,223,725	1,077.50	9,572,114
923.00	897,637	954.00	2,100,348	985.00	3,542,371	1,016.00	5,249,231	1,047.00	7,258,742	1,078.00	9,612,832
923.50	915,311	954.50	2,121,596	985.50	3,567,677	1,016.50	5,279,214	1,047.50	7,293,856	1,078.50	9,653,640
924.00	933,041	955.00	2,142,910	986.00	3,593,048	1,017.00	5,309,277	1,048.00	7,329,065	1,079.00	9,694,536
924.50	950,828	955.50	2,164,291	986.50	3,618,483	1,017.50	5,339,418	1,048.50	7,364,370	1,079.50	9,735,521
925.00	968,671	956.00	2,185,737	987.00	3,643,983	1,018.00	5,369,639	1,049.00	7,399,772	1,080.00	9,776,595
925.50	986,571	956.50	2,207,251	987.50	3,669,548	1,018.50	5,399,939	1,049.50	7,435,270	1,080.50	9,817,756

Table E-1 (Continued)
Lake Mead Water Surface Elevation to Storage Content Relationship (Table 2 of 2)

Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)
1,081.00	9,859,002	1,112.00	12,593,397	1,143.00	15,711,770	1,174.00	19,366,247	1,205.00	23,654,596
1,081.50	9,900,334	1,112.50	12,640,524	1,143.50	15,765,770	1,174.50	19,430,437	1,205.50	23,728,704
1,082.00	9,941,751	1,113.00	12,687,749	1,144.00	15,819,930	1,175.00	19,494,796	1,206.00	23,802,971
1,082.50	9,983,253	1,113.50	12,735,072	1,144.50	15,874,250	1,175.50	19,559,324	1,206.50	23,877,395
1,083.00	10,024,841	1,114.00	12,782,492	1,145.00	15,928,731	1,176.00	19,624,022	1,207.00	23,951,978
1,083.50	10,066,514	1,114.50	12,830,010	1,145.50	15,983,371	1,176.50	19,688,889	1,207.50	24,026,720
1,084.00	10,108,272	1,115.00	12,877,626	1,146.00	16,038,172	1,177.00	19,753,925	1,208.00	24,101,619
1,084.50	10,150,116	1,115.50	12,925,339	1,146.50	16,093,133	1,177.50	19,819,130	1,208.50	24,176,677
1,085.00	10,192,045	1,116.00	12,973,149	1,147.00	16,148,255	1,178.00	19,884,505	1,209.00	24,251,893
1,085.50	10,234,059	1,116.50	13,021,058	1,147.50	16,203,536	1,178.50	19,950,049	1,209.50	24,327,267
1,086.00	10,276,159	1,117.00	13,069,064	1,148.00	16,258,978	1,179.00	20,015,762	1,210.00	24,402,800
1,086.50	10,318,344	1,117.50	13,117,167	1,148.50	16,314,580	1,179.50	20,081,644	1,210.50	24,478,485
1,087.00	10,360,614	1,118.00	13,165,369	1,149.00	16,370,342	1,180.00	20,147,696	1,211.00	24,554,316
1,087.50	10,402,970	1,118.50	13,213,668	1,149.50	16,426,264	1,180.50	20,213,915	1,211.50	24,630,293
1,088.00	10,445,411	1,119.00	13,262,064	1,150.00	16,482,347	1,181.00	20,280,298	1,212.00	24,706,417
1,088.50	10,487,937	1,119.50	13,310,558	1,150.50	16,538,589	1,181.50	20,346,847	1,212.50	24,782,687
1,089.00	10,530,549	1,120.00	13,359,150	1,151.00	16,594,992	1,182.00	20,413,560	1,213.00	24,859,103
1,089.50	10,573,246	1,120.50	13,407,845	1,151.50	16,651,555	1,182.50	20,480,439	1,213.50	24,935,665
1,090.00	10,616,028	1,121.00	13,456,647	1,152.00	16,708,279	1,183.00	20,547,482	1,214.00	25,012,373
1,090.50	10,658,901	1,121.50	13,505,558	1,152.50	16,765,162	1,183.50	20,614,690	1,214.50	25,089,228
1,091.00	10,701,869	1,122.00	13,554,576	1,153.00	16,822,206	1,184.00	20,682,064	1,215.00	25,166,229
1,091.50	10,744,933	1,122.50	13,603,703	1,153.50	16,879,410	1,184.50	20,749,602	1,215.50	25,243,376
1,092.00	10,788,092	1,123.00	13,652,937	1,152.00	16,936,774	1,185.00	20,817,305	1,216.00	25,320,669
1,092.50	10,831,347	1,123.50	13,702,279	1,154.50	16,994,298	1,185.50	20,885,173	1,216.50	25,398,109
1,093.00	10,874,698	1,124.00	13,751,730	1,155.00	17,051,983	1,186.00	20,953,206	1,217.00	25,475,695
1,093.50	10,918,143	1,124.50	13,801,288	1,155.50	17,109,828	1,186.50	21,021,404	1,217.50	25,553,427
1,094.00	10,961,685	1,125.00	13,850,954	1,156.00	17,167,833	1,187.00	21,089,767	1,218.00	25,631,305
1,094.50	11,005,322	1,125.50	13,900,728	1,156.50	17,225,998	1,187.50	21,158,295	1,218.50	25,709,330
1,095.00	11,049,054	1,126.00	13,950,610	1,157.00	17,284,323	1,188.00	21,226,987	1,219.00	25,787,500
1,095.50	11,092,882	1,126.50	14,000,600	1,157.50	17,342,809	1,188.50	21,295,845	1,219.50	25,865,817
1,096.00	11,136,805	1,127.00	14,050,698	1,158.00	17,401,454	1,189.00	21,364,868	1,220.00	25,944,281
1,096.50	11,180,824	1,127.50	14,100,904	1,158.50	17,460,260	1,189.50	21,434,055	1,220.50	26,022,895
1,097.00	11,224,939	1,128.00	14,151,218	1,159.00	17,519,226	1,190.00	21,503,408	1,221.00	26,101,666
1,097.50	11,269,149	1,128.50	14,201,640	1,159.50	17,578,353	1,190.50	21,572,918	1,221.50	26,180,592
1,098.00	11,313,454	1,129.00	14,252,169	1,160.00	17,637,639	1,191.00	21,642,579	1,222.00	26,259,675
1,098.50	11,357,855	1,129.50	14,302,807	1,160.50	17,697,090	1,191.50	21,712,390	1,222.50	26,338,914
1,099.00	11,402,352	1,130.00	14,353,553	1,161.00	17,756,711	1,192.00	21,782,352	1,223.00	26,418,310
1,099.50	11,446,944	1,130.50	14,404,406	1,161.50	17,816,501	1,192.50	21,852,464	1,223.50	26,497,861
1,100.00	11,491,631	1,131.00	14,455,368	1,162.00	17,876,460	1,193.00	21,922,727	1,224.00	26,577,569
1,100.50	11,536,415	1,131.50	14,506,437	1,162.50	17,936,588	1,193.50	21,993,141	1,224.50	26,657,433
1,101.00	11,581,297	1,132.00	14,557,615	1,163.00	17,996,885	1,194.00	22,063,705	1,225.00	26,737,453
1,101.50	11,626,277	1,132.50	14,608,900	1,163.50	18,057,352	1,194.50	22,134,420	1,225.50	26,817,629
1,102.00	11,671,354	1,133.00	14,660,293	1,164.00	18,117,988	1,195.00	22,205,285	1,226.00	26,897,962
1,102.50	11,716,528	1,133.50	14,711,795	1,164.50	18,178,793	1,195.50	22,276,301	1,226.50	26,978,451
1,103.00	11,761,801	1,134.00	14,763,404	1,165.00	18,239,767	1,196.00	22,347,468	1,227.00	27,059,095
1,103.50	11,807,171	1,134.50	14,815,121	1,165.50	18,300,911	1,196.50	22,418,785	1,227.50	27,139,896
1,104.00	11,852,638	1,135.00	14,866,946	1,166.00	18,362,224	1,197.00	22,490,252	1,228.00	27,220,854
1,104.50	11,898,203	1,135.50	14,918,879	1,166.50	18,423,706	1,197.50	22,561,870	1,228.50	27,301,967
1,105.00	11,943,866	1,136.00	14,970,920	1,167.00	18,485,357	1,198.00	22,633,639	1,229.00	27,383,237
1,105.50	11,989,627	1,136.50	15,023,069	1,167.50	18,547,178	1,198.50	22,705,558		
1,106.00	12,035,485	1,137.00	15,075,326	1,168.00	18,609,168	1,199.00	22,777,628		
1,106.50	12,081,440	1,137.50	15,127,691	1,168.50	18,671,327	1,199.50	22,849,849		
1,107.00	12,127,494	1,138.00	15,180,164	1,169.00	18,733,655	1,200.00	22,922,220		
1,107.50	12,173,645	1,138.50	15,232,745	1,169.50	18,796,153	1,200.50	22,994,745		
1,108.00	12,219,893	1,139.00	15,285,433	1,170.00	18,858,820	1,201.00	23,067,429		
1,108.50	12,266,240	1,139.50	15,338,230	1,170.50	18,921,656	1,201.50	23,140,271		
1,109.00	12,312,683	1,140.00	15,391,135	1,171.00	18,984,661	1,202.00	23,213,271		
1,109.50	12,359,225	1,140.50	15,444,173	1,171.50	19,047,836	1,202.50	23,286,429		
1,110.00	12,405,864	1,141.00	15,497,372	1,172.00	19,111,179	1,203.00	23,359,746		
1,110.50	12,452,601	1,141.50	15,550,731	1,172.50	19,174,692	1,203.50	23,433,221		
1,111.00	12,499,435	1,142.00	15,604,251	1,173.00	19,238,375	1,204.00	23,506,855		
1,111.50	12,546,367	1,142.50	15,657,930	1,173.50	19,302,226	1,204.50	23,580,646		

Table E-2
Lake Powell Water Surface Elevation to Storage Content Relationship (Table 1 of 2)

Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)
3,370.00	0	3,401.00	719,827	3,432.00	1,632,024	3,463.00	2,775,184	3,494.00	4,196,921	3,525.00	5,926,566
3,370.50	10,174	3,401.50	732,982	3,432.50	1,648,472	3,463.50	2,795,845	3,494.50	4,222,235	3,525.50	5,957,319
3,371.00	20,393	3,402.00	746,187	3,433.00	1,664,978	3,464.00	2,816,580	3,495.00	4,247,626	3,526.00	5,988,168
3,371.50	30,657	3,402.50	759,442	3,433.50	1,681,542	3,464.50	2,837,388	3,495.50	4,273,093	3,526.50	6,019,114
3,372.00	40,966	3,403.00	772,747	3,434.00	1,698,165	3,465.00	2,858,271	3,496.00	4,298,636	3,527.00	6,050,156
3,372.50	51,320	3,403.50	786,101	3,434.50	1,714,845	3,465.50	2,879,228	3,496.50	4,324,256	3,527.50	6,081,295
3,373.00	61,719	3,404.00	799,506	3,435.00	1,731,584	3,466.00	2,900,259	3,497.00	4,349,953	3,528.00	6,112,531
3,373.50	72,162	3,404.50	812,960	3,435.50	1,748,381	3,466.50	2,921,363	3,497.50	4,375,725	3,528.50	6,143,863
3,374.00	82,651	3,405.00	826,463	3,436.00	1,765,236	3,467.00	2,942,542	3,498.00	4,401,575	3,529.00	6,175,292
3,374.50	93,185	3,405.50	840,017	3,436.50	1,782,149	3,467.50	2,963,794	3,498.50	4,427,500	3,529.50	6,206,818
3,375.00	103,764	3,406.00	853,620	3,437.00	1,799,120	3,468.00	2,985,120	3,499.00	4,453,502	3,530.00	6,238,440
3,375.50	114,387	3,406.50	867,274	3,437.50	1,816,150	3,468.50	3,006,521	3,499.50	4,479,580	3,530.50	6,270,159
3,376.00	125,056	3,407.00	880,977	3,438.00	1,833,237	3,469.00	3,027,995	3,500.00	4,505,735	3,531.00	6,301,974
3,376.50	135,770	3,407.50	894,729	3,438.50	1,850,383	3,469.50	3,049,543	3,500.50	4,531,972	3,531.50	6,333,886
3,377.00	146,529	3,408.00	908,532	3,439.00	1,867,587	3,470.00	3,071,165	3,501.00	4,558,298	3,532.00	6,365,895
3,377.50	157,332	3,408.50	922,384	3,439.50	1,884,850	3,470.50	3,092,861	3,501.50	4,584,713	3,532.50	6,398,000
3,378.00	168,181	3,409.00	936,286	3,440.00	1,902,170	3,471.00	3,114,631	3,502.00	4,611,216	3,533.00	6,430,202
3,378.50	179,074	3,409.50	950,238	3,440.50	1,919,555	3,471.50	3,136,475	3,502.50	4,637,808	3,533.50	6,462,501
3,379.00	190,013	3,410.00	964,240	3,441.00	1,937,011	3,472.00	3,158,392	3,503.00	4,664,488	3,534.00	6,494,896
3,379.50	200,996	3,410.50	978,291	3,441.50	1,954,537	3,472.50	3,180,384	3,503.50	4,691,257	3,534.50	6,527,388
3,380.00	212,025	3,411.00	992,393	3,442.00	1,972,134	3,473.00	3,202,450	3,504.00	4,718,115	3,535.00	6,559,976
3,380.50	223,101	3,411.50	1,006,544	3,442.50	1,989,802	3,473.50	3,224,589	3,504.50	4,745,061	3,535.50	6,592,661
3,381.00	234,226	3,412.00	1,020,745	3,443.00	2,007,541	3,474.00	3,246,803	3,505.00	4,772,096	3,536.00	6,625,443
3,381.50	245,401	3,412.50	1,034,995	3,443.50	2,025,350	3,474.50	3,269,090	3,505.50	4,799,220	3,536.50	6,658,321
3,382.00	256,625	3,413.00	1,049,296	3,444.00	2,043,231	3,475.00	3,291,451	3,506.00	4,826,432	3,537.00	6,691,296
3,382.50	267,899	3,413.50	1,063,646	3,444.50	2,061,182	3,475.50	3,313,886	3,506.50	4,853,733	3,537.50	6,724,368
3,383.00	279,222	3,414.00	1,078,046	3,445.00	2,079,204	3,476.00	3,336,396	3,507.00	4,881,122	3,538.00	6,757,536
3,383.50	290,595	3,414.50	1,092,496	3,445.50	2,097,296	3,476.50	3,358,979	3,507.50	4,908,600	3,538.50	6,790,801
3,384.00	302,017	3,415.00	1,106,995	3,446.00	2,115,460	3,477.00	3,381,636	3,508.00	4,936,167	3,539.00	6,824,162
3,384.50	313,489	3,415.50	1,121,545	3,446.50	2,133,694	3,477.50	3,404,367	3,508.50	4,963,822	3,539.50	6,857,620
3,385.00	325,010	3,416.00	1,136,144	3,447.00	2,151,999	3,478.00	3,427,171	3,509.00	4,991,566	3,540.00	6,891,175
3,385.50	336,581	3,416.50	1,150,793	3,447.50	2,170,375	3,478.50	3,450,050	3,509.50	5,019,399	3,540.50	6,924,832
3,386.00	348,201	3,417.00	1,165,492	3,448.00	2,188,821	3,479.00	3,473,003	3,510.00	5,047,320	3,541.00	6,958,600
3,386.50	359,871	3,417.50	1,180,240	3,448.50	2,207,338	3,479.50	3,496,029	3,510.50	5,075,330	3,541.50	6,992,477
3,387.00	371,590	3,418.00	1,195,038	3,449.00	2,225,927	3,480.00	3,519,130	3,511.00	5,103,428	3,542.00	7,026,464
3,387.50	383,359	3,418.50	1,209,886	3,449.50	2,244,585	3,480.50	3,542,307	3,511.50	5,131,615	3,542.50	7,060,561
3,388.00	395,177	3,419.00	1,224,784	3,450.00	2,263,315	3,481.00	3,565,558	3,512.00	5,159,891	3,543.00	7,094,767
3,388.50	407,045	3,419.50	1,239,732	3,450.50	2,282,115	3,481.50	3,588,887	3,512.50	5,188,255	3,543.50	7,129,083
3,389.00	418,962	3,420.00	1,254,729	3,451.00	2,300,987	3,482.00	3,612,291	3,513.00	5,216,708	3,544.00	7,163,509
3,389.50	430,929	3,420.50	1,269,782	3,451.50	2,319,928	3,482.50	3,635,773	3,513.50	5,245,250	3,544.50	7,198,045
3,390.00	442,945	3,421.00	1,284,891	3,452.00	2,338,941	3,483.00	3,659,330	3,514.00	5,273,880	3,545.00	7,232,690
3,390.50	455,011	3,421.50	1,300,059	3,452.50	2,358,025	3,483.50	3,682,964	3,514.50	5,302,599	3,545.50	7,267,445
3,391.00	467,126	3,422.00	1,315,285	3,453.00	2,377,179	3,484.00	3,706,674	3,515.00	5,331,406	3,546.00	7,302,309
3,391.50	479,291	3,422.50	1,330,570	3,453.50	2,396,404	3,484.50	3,730,461	3,515.50	5,360,302	3,546.50	7,337,284
3,392.00	491,505	3,423.00	1,345,912	3,454.00	2,415,700	3,485.00	3,754,324	3,516.00	5,389,287	3,547.00	7,372,368
3,392.50	503,769	3,423.50	1,361,313	3,454.50	2,435,066	3,485.50	3,778,263	3,516.50	5,418,360	3,547.50	7,407,561
3,393.00	516,082	3,424.00	1,376,772	3,455.00	2,454,504	3,486.00	3,802,279	3,517.00	5,447,522	3,548.00	7,442,864
3,393.50	528,445	3,424.50	1,392,289	3,455.50	2,474,012	3,486.50	3,826,371	3,517.50	5,476,773	3,548.50	7,478,277
3,394.00	540,857	3,425.00	1,407,864	3,456.00	2,493,591	3,487.00	3,850,540	3,518.00	5,506,112	3,549.00	7,513,800
3,394.50	553,319	3,425.50	1,423,497	3,456.50	2,513,240	3,487.50	3,874,785	3,518.50	5,535,540	3,549.50	7,549,433
3,395.00	565,830	3,426.00	1,439,189	3,457.00	2,532,961	3,488.00	3,899,106	3,519.00	5,565,056	3,550.00	7,585,175
3,395.50	578,391	3,426.50	1,454,938	3,457.50	2,552,752	3,488.50	3,923,504	3,519.50	5,594,661	3,550.50	7,621,026
3,396.00	591,001	3,427.00	1,470,746	3,458.00	2,572,614	3,489.00	3,947,978	3,520.00	5,624,355	3,551.00	7,656,988
3,396.50	603,661	3,427.50	1,486,612	3,458.50	2,592,547	3,489.50	3,972,528	3,520.50	5,654,141	3,551.50	7,693,059
3,397.00	616,370	3,428.00	1,502,536	3,459.00	2,612,551	3,490.00	3,997,155	3,521.00	5,684,024	3,552.00	7,729,240
3,397.50	629,129	3,428.50	1,518,519	3,459.50	2,632,625	3,490.50	4,021,859	3,521.50	5,714,004	3,552.50	7,765,530
3,398.00	641,937	3,429.00	1,534,559	3,460.00	2,652,770	3,491.00	4,046,638	3,522.00	5,744,080	3,553.00	7,801,930
3,398.50	654,795	3,429.50	1,550,658	3,460.50	2,672,987	3,491.50	4,071,494	3,522.50	5,774,253	3,553.50	7,838,440
3,399.00	667,702	3,430.00	1,566,815	3,461.00	2,693,279	3,492.00	4,096,427	3,523.00	5,804,522	3,554.00	7,875,060
3,399.50	680,659	3,430.50	1,583,030	3,461.50	2,713,644	3,492.50	4,121,436	3,523.50	5,834,888	3,554.50	7,911,789
3,400.00	693,665	3,431.00	1,599,303	3,462.00	2,734,083	3,493.00	4,146,521	3,524.00	5,865,351	3,555.00	7,948,628
3,400.50	706,721	3,431.50	1,615,635	3,462.50	2,754,597	3,493.50	4,171,683	3,524.50	5,895,910	3,555.50	7,985,577

Table E-2 (Continued)
Lake Powell Water Surface Elevation to Storage Content Relationship (Table 2 of 2)

Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)	Elevation (msl-feet)	Volume (acre-feet)
3,556.00	8,022,635	3,587.00	10,551,106	3,618.00	13,552,426	3,649.00	17,091,550	3,680.00	21,258,040
3,556.50	8,059,803	3,587.50	10,595,701	3,618.50	13,604,929	3,649.50	17,153,548	3,680.50	21,330,959
3,557.00	8,097,081	3,588.00	10,640,418	3,619.00	13,657,565	3,650.00	17,215,706	3,681.00	21,404,066
3,557.50	8,134,468	3,588.50	10,685,256	3,619.50	13,710,331	3,650.50	17,278,024	3,681.50	21,477,363
3,558.00	8,171,965	3,589.00	10,730,216	3,620.00	13,763,230	3,651.00	17,340,503	3,682.00	21,550,848
3,558.50	8,209,572	3,589.50	10,775,297	3,620.50	13,816,271	3,651.50	17,403,142	3,682.50	21,624,523
3,559.00	8,247,288	3,590.00	10,820,500	3,621.00	13,869,463	3,652.00	17,465,942	3,683.00	21,698,387
3,559.50	8,285,114	3,590.50	10,865,824	3,621.50	13,922,806	3,652.50	17,528,903	3,683.50	21,772,440
3,560.00	8,323,050	3,591.00	10,911,270	3,622.00	13,976,301	3,653.00	17,592,024	3,684.00	21,846,683
3,560.50	8,361,101	3,591.50	10,956,837	3,622.50	14,029,947	3,653.50	17,655,306	3,684.50	21,921,114
3,561.00	8,399,273	3,592.00	11,002,526	3,623.00	14,083,745	3,654.00	17,718,748	3,685.00	21,995,735
3,561.50	8,437,566	3,592.50	11,048,336	3,623.50	14,137,695	3,654.50	17,782,351	3,685.50	22,070,545
3,562.00	8,475,981	3,593.00	11,094,268	3,624.00	14,191,796	3,655.00	17,846,115	3,686.00	22,145,544
3,562.50	8,514,516	3,593.50	11,140,321	3,624.50	14,246,048	3,655.50	17,910,039	3,686.50	22,220,733
3,563.00	8,553,172	3,594.00	11,186,496	3,625.00	14,300,453	3,656.00	17,974,123	3,687.00	22,296,111
3,563.50	8,591,950	3,594.50	11,232,792	3,625.50	14,355,008	3,656.50	18,038,368	3,687.50	22,371,678
3,564.00	8,630,848	3,595.00	11,279,210	3,626.00	14,409,716	3,657.00	18,102,774	3,688.00	22,447,434
3,564.50	8,669,868	3,595.50	11,325,749	3,626.50	14,464,575	3,657.50	18,167,340	3,688.50	22,523,379
3,565.00	8,709,009	3,596.00	11,372,410	3,627.00	14,519,585	3,658.00	18,232,067	3,689.00	22,599,514
3,565.50	8,748,271	3,596.50	11,419,192	3,627.50	14,574,747	3,658.50	18,296,954	3,689.50	22,675,838
3,566.00	8,787,653	3,597.00	11,466,096	3,628.00	14,630,061	3,659.00	18,362,002	3,690.00	22,752,350
3,566.50	8,827,157	3,597.50	11,513,121	3,628.50	14,685,526	3,659.50	18,427,211	3,690.50	22,829,053
3,567.00	8,866,782	3,598.00	11,560,268	3,629.00	14,741,142	3,660.00	18,492,580	3,691.00	22,905,944
3,567.50	8,906,528	3,598.50	11,607,536	3,629.50	14,796,911	3,660.50	18,558,122	3,691.50	22,983,025
3,568.00	8,946,396	3,599.00	11,654,926	3,630.00	14,852,830	3,661.00	18,623,848	3,692.00	23,060,295
3,568.50	8,986,384	3,599.50	11,702,437	3,630.50	14,908,902	3,661.50	18,689,758	3,692.50	23,137,754
3,569.00	9,026,493	3,600.00	11,750,070	3,631.00	14,965,125	3,662.00	18,755,853	3,693.00	23,215,402
3,569.50	9,066,724	3,600.50	11,797,829	3,631.50	15,021,499	3,662.50	18,822,132	3,693.50	23,293,239
3,570.00	9,107,075	3,601.00	11,845,721	3,632.00	15,078,025	3,663.00	18,888,595	3,694.00	23,371,266
3,570.50	9,147,548	3,601.50	11,893,743	3,632.50	15,134,703	3,663.50	18,955,243	3,694.50	23,449,482
3,571.00	9,188,141	3,602.00	11,941,898	3,633.00	15,191,532	3,664.00	19,022,075	3,695.00	23,527,887
3,571.50	9,228,856	3,602.50	11,990,185	3,633.50	15,248,513	3,664.50	19,089,092	3,695.50	23,606,481
3,572.00	9,269,692	3,603.00	12,038,603	3,634.00	15,305,645	3,665.00	19,156,292	3,696.00	23,685,265
3,572.50	9,310,648	3,603.50	12,087,153	3,634.50	15,362,929	3,665.50	19,223,678	3,696.50	23,764,238
3,573.00	9,351,726	3,604.00	12,135,835	3,635.00	15,420,365	3,666.00	19,291,247	3,697.00	23,843,400
3,573.50	9,392,925	3,604.50	12,184,648	3,635.50	15,477,952	3,666.50	19,359,001	3,697.50	23,922,751
3,574.00	9,434,245	3,605.00	12,233,594	3,636.00	15,535,690	3,667.00	19,426,939	3,698.00	24,002,291
3,574.50	9,475,687	3,605.50	12,282,671	3,636.50	15,593,580	3,667.50	19,495,062	3,698.50	24,082,021
3,575.00	9,517,249	3,606.00	12,331,880	3,637.00	15,651,622	3,668.00	19,563,369	3,699.00	24,161,940
3,575.50	9,558,932	3,606.50	12,381,220	3,637.50	15,709,815	3,668.50	19,631,860	3,699.50	24,242,048
3,576.00	9,600,736	3,607.00	12,430,693	3,638.00	15,768,160	3,669.00	19,700,536	3,700.00	24,322,345
3,576.50	9,642,662	3,607.50	12,480,297	3,638.50	15,826,656	3,669.50	19,769,396	3,700.50	24,402,840
3,577.00	9,684,708	3,608.00	12,530,033	3,639.00	15,885,304	3,670.00	19,838,440	3,701.00	24,483,541
3,577.50	9,726,876	3,608.50	12,579,901	3,639.50	15,944,104	3,670.50	19,907,669	3,701.50	24,564,448
3,578.00	9,769,165	3,609.00	12,629,901	3,640.00	16,003,055	3,671.00	19,977,082	3,702.00	24,645,562
3,578.50	9,811,574	3,609.50	12,680,032	3,640.50	16,062,163	3,671.50	20,046,679	3,702.50	24,726,881
3,579.00	9,854,105	3,610.00	12,730,295	3,641.00	16,121,431	3,672.00	20,116,461	3,703.00	24,808,406
3,579.50	9,896,757	3,610.50	12,780,690	3,641.50	16,180,859	3,672.50	20,186,427	3,703.50	24,890,138
3,580.00	9,939,530	3,611.00	12,831,217	3,642.00	16,240,448	3,673.00	20,256,577	3,704.00	24,972,075
3,580.50	9,982,424	3,611.50	12,881,875	3,642.50	16,300,197	3,673.50	20,326,912	3,704.50	25,054,219
3,581.00	10,025,440	3,612.00	12,932,665	3,643.00	16,360,107	3,674.00	20,397,431	3,705.00	25,136,569
3,581.50	10,068,577	3,612.50	12,983,587	3,643.50	16,420,178	3,674.50	20,468,135	3,705.50	25,219,125
3,582.00	10,111,836	3,613.00	13,034,641	3,644.00	16,480,409	3,675.00	20,539,022	3,706.00	25,301,886
3,582.50	10,155,216	3,613.50	13,085,826	3,644.50	16,540,800	3,675.50	20,610,095	3,706.50	25,384,854
3,583.00	10,198,718	3,614.00	13,137,144	3,645.00	16,601,353	3,676.00	20,681,351	3,707.00	25,468,028
3,583.50	10,242,341	3,614.50	13,188,593	3,645.50	16,662,065	3,676.50	20,752,792	3,707.50	25,551,408
3,584.00	10,286,086	3,615.00	13,240,174	3,646.00	16,722,939	3,677.00	20,824,417	3,708.00	25,634,995
3,584.50	10,329,952	3,615.50	13,291,886	3,646.50	16,783,973	3,677.50	20,896,227	3,708.50	25,718,787
3,585.00	10,373,940	3,616.00	13,343,731	3,647.00	16,845,167	3,678.00	20,968,221	3,709.00	25,802,785
3,585.50	10,418,049	3,616.50	13,395,707	3,647.50	16,906,522	3,678.50	21,040,399	3,709.50	25,886,990
3,586.00	10,462,280	3,617.00	13,447,815	3,648.00	16,968,038	3,679.00	21,112,762	3,710.00	25,971,400
3,586.50	10,506,632	3,617.50	13,500,055	3,648.50	17,029,714	3,679.50	21,185,309		

Appendix H

Implementation Agreement Among the U.S., the La Jolla, Pala, Pauma, Rincon and San Pasqual Bands of Mission Indians, the San Luis Rey Indian Water Authority, the City of Escondido, and the Vista Irrigation District

IMPLEMENTATION AGREEMENT AMONG
THE NITED STATES OF AMERICA,
THE LA JOLLA, PALA, PAUMA, RINCON AND SAN PASQUAL BANDS
OF MISSION INDIANS,
THE SAN LUIS REY INDIAN WATER AUTHORITY,
THE CITY OF ESCONDIDO, AND
THE VISTA IRRIGATION DISTRICT

THIS IMPLEMENTATION AGREEMENT ("Implementation Agreement") is entered into as of this 18th day of January, 2001, among the United States of America ("United States"), acting by and through its Secretary of the Interior ("Secretary"); the San Luis Rey River Indian Water Authority, a permanent intertribal entity recognized and approved by Public Law 100-675 ("Indian Water Authority"); the La Jolla, Pala, Pauma, Rincon, and San Pasqual Bands of Mission Indians, acting through the governing bodies of each respective Band as duly recognized by the Secretary ("Indian Bands"); the City of Escondido, a general law city organized and existing under the laws of the State of California, acting on its on behalf and as successor to the Escondido Mutual Water Company ("Escondido"); and the Vista Irrigation District, a public agency of the State of California organized and existing under the Irrigation District Act of the State of California ("Vista"); and each of which is at times referred to individually as "Party" and which are at times collectively referred to as "Parties." This Implementation Agreement is entered into pursuant to the Act of Congress approved June 17, 1902 (32 Stat. 388), and acts amendatory thereof or supplementary thereto, all of which acts are commonly known and referred to as Federal Reclamation Law, including the Act of Congress approved December 21, 1928 (45 Stat. 1057), referred to as the "Boulder Canyon Project Act," and the Act of Congress approved November 17, 1988 (Public Law 100-675), and acts amendatory thereof or supplementary thereto, hereinafter referred to as "Public Law 100-675."

EXPLANATORY RECITALS

A. WHEREAS, the United States has constructed the All-American Canal and its Coachella Branch ("Coachella Canal") in accordance with the Boulder Canyon Project Act; and

B. WHEREAS, the Secretary, pursuant to Title II of Public Law 100-675 ("Title II"), is authorized to construct a new lined canal or to line the previously unlined portions of the All-American Canal, from the vicinity of Pilot Knob to Drop 4, or to construct seepage recovery facilities in the vicinity of Pilot Knob to Drop 4 ("All-American Canal Lining Project"), and to construct a new lined canal or to line the previously unlined portions of the Coachella Canal from Siphon 7 to Siphon 32 ("Coachella Canal Lining Project"), including measures to protect public safety; and

C. WHEREAS, appropriate environmental review and compliance for the All-American Canal Lining Project and the Coachella Canal Lining Project have been or are being completed in accordance with state and federal law; and

D. WHEREAS, the Congress has found the inadequacy of the San Luis Rey River, located in San Diego County, California, to supply the needs of both the Indian Bands, and Escondido, and Vista has given rise to litigation; and

E. WHEREAS, litigation is pending in the United States District Court for the Southern District of California to determine the rights of the Indian Bands and Escondido and Vista to the water in the San Luis Rey River, related proceedings are pending before the Federal Energy Regulatory Commission, and on November 17, 1988, the President of the United States approved Title I of Public Law 100-675 ("Title I"), to provide for the settlement of this litigation; and

F. WHEREAS, Title I authorized and directed the Secretary to: (1) arrange for the development of not more than a total of 16,000 acre-feet per year of supplemental water from public lands within the State of California outside the service area of the Central Valley Project; or (2) arrange to obtain not more than a total of 16,000 acre-feet per year either from water conserved by the works authorized in Title II, or through contract with the Metropolitan Water District of Southern California ("MWD"); and

G. WHEREAS, Title I was amended on October 27, 2000, to require that in order to fulfill the trust responsibility to the Bands, the Secretary, acting through the Commissioner of Reclamation, shall permanently furnish annually 16,000 acre-feet of the water conserved by the works authorized in Title II, for the benefit of the Indian Bands and Escondido and Vista (together with the Indian Water Authority, the "San Luis Rey Settlement Parties") in accordance with the settlement agreement referred to in Title I ("Settlement Agreement"), along with power capacity and energy in amounts sufficient to convey said water from Lake Havasu through the Colorado River Aqueduct and to the places of use on the Bands' reservations or in the service areas of Vista and Escondido (the "Local Entities"); and

H. WHEREAS, MWD, San Diego County Water Authority, the San Luis Rey Settlement Parties, and the United States are involved in the negotiation of the terms and conditions of an agreement which will provide the means to convey, exchange, or otherwise utilize the water conserved for the benefit of the San Luis Rey Settlement Parties; and

I. WHEREAS, appropriate environmental review and compliance for this Implementation Agreement is being conducted in accordance with federal law.

NOW THEREFORE, THE PARTIES AGREE AS FOLLOWS:

1. In order to fulfill the trust responsibility to the Indian Bands, and in accordance with his authority under the Boulder Canyon Project Act, the 1964 Decree in *Arizona v. California*, and Title I of Public Law 100-675, as amended, the Secretary, acting through the Commissioner of Reclamation, shall permanently furnish annually 16,000 acre-feet of the water conserved by the works authorized by Title II of Public Law 100-675 to the Indian Water Authority (for the benefit of the Indian Bands), Escondido, and Vista.

2. Until completion of the construction of the works authorized by Title II, the Secretary shall furnish annually 17% of any water conserved by said works up to a maximum of 16,000 acre-feet per year. After completion of construction, the Secretary shall permanently furnish annually 16,000 acre-feet of the water conserved by said works.

3. The water delivery obligations of the Secretary under paragraphs 1 and 2 above shall exist only when the following conditions are met:

3.1 The United States, Escondido, Vista, and the Indian Bands have entered into a settlement agreement providing for the complete resolution of all claims, controversies, and issues involved in all of the pending proceedings among the parties in the United States District Court for the Southern District of California and the Federal Energy Regulatory Commission, and stipulated judgments or other appropriate final dispositions have been entered in said proceedings.

3.2 The Indian Water Authority, Indian Bands, Escondido, and Vista have entered into an agreement or agreements with appropriate parties which provide the means to convey, exchange, or otherwise utilize said 16,000 acre feet per year of water for the benefit of the Indian Bands, Escondido, and Vista.

3.3 The Indian Water Authority and the Local Entities shall pay their proportionate share of such costs as are provided by section 203(b) of Title II or are agreed to by them.

4. This Implementation Agreement is subject to and conditioned upon the completion of the pending environmental analysis and review as required by federal law of the effects of the conservation and delivery of water as provided herein. Information obtained from such review may, in the discretion of the Secretary, serve as the basis to modify the terms of this Implementation Agreement. If any of the other Parties to this Implementation Agreement do not agree to such modifications, this Implementation Agreement will be terminated and all Parties will be permitted to proceed as if this Implementation Agreement had never been executed.

IN WITNESS WHEREOF, the Parties have executed this Implementation Agreement as of the day and year first above written.

UNITED STATES OF AMERICA

By:____________________
Bruce Babbitt
Secretary of the Interior

SAN LUIS REY RIVER INDIAN WATER AUTHORITY

By: Benjamin Magante Sr
Benjamin A. Magante, Sr.
President

APPROVED AS TO FORM:

By: ______________________
Robert S. Pelcyger, Special Counsel

LA JOLLA BAND OF MISSION INDIANS

By: ______________________
Jack W. Musick
Chairman

PALA BAND OF MISSION INDIANS

By: ______________________
Robert H. Smith
Chairman

PAUMA BAND OF MISSION INDIANS

By: Christobal C Devers
Chirstobal C. Devers
Chairman

RINCON SAN LUISENO BAND OF MISSION INDIANS

By: ______________________
John D. Currier
Chairman

SAN PASQUAL BAND OF MISSION INDIANS

By: ______________________
Allen E. Lawson
Chairman

CITY OF ESCONDIDO

By: ______________________
Lori Holt-Pfeiler
Mayor

By: Tony L Russell 1/17/01
Tony Russell
Acting City Clerk

APPROVED AS TO FORM:
OFFICE OF THE CITY ATTORNEY

By: ______________________
Jeffrey R. Epp, City Attorney

VISTA IRRIGATION DISTRICT

By:
Linden R. Burzell
President, Board of Directors

By:
John A. Amodeo
General Manager and Chief Engineer

APPROVED AS TO FORM:

By:
Kent H. Foster, General Counsel

Appendix I

Inadvertent Overrun and Payback Policy

APPENDIX I
INADVERTENT OVERRUN AND PAYBACK POLICY

SUMMARY

The Bureau of Reclamation (Reclamation) proposes a policy that will identify inadvertent overruns, will establish procedures that account for inadvertent overruns and will define subsequent payback requirements to the Lower Division States users of Colorado River mainstream, and invites comments on its draft proposal.

SUPPLEMENTARY INFORMATION

In its June 3, 1963 opinion in the case of Arizona v. California (373 U.S. 546), the Supreme Court of the United States held that the Congress has directed the Secretary of the Interior (Secretary) to administer a network of useful projects constructed by the Federal Government on the lower Colorado River, and it has entrusted the Secretary with sufficient power to direct, manage, and coordinate their operation. The Court held that this power must be construed to permit the Secretary to allocate and distribute the waters of the mainstream of the Colorado River within the boundaries set down by the Boulder Canyon Project Act (45 Stat. 1057, 43 U.S.C. 617) (BCPA). The Secretary has entered into contracts for the delivery of Colorado River water with entities in Arizona, California, and Nevada in accordance with section 5 of the BCPA. The Secretary has the responsibility of operating Federal facilities on the Colorado River and delivering mainstream Colorado River water to users in Arizona, California, and Nevada that hold entitlements, including present perfected rights, to such water.

Article V of the Decree of the Supreme Court of the United States in Arizona v. California dated March 9, 1964 (376 U.S. 340) requires the Secretary to compile and maintain records of diversions of water from the mainstream, of return flow of such water to the mainstream as is available for consumptive use in the United States or in satisfaction of the Mexican Treaty obligation, and of consumptive use of such water. Reclamation reports this data each year in the Decree Accounting Record.

Pursuant to the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs developed as a result of the Colorado River Basin Project Act of September 30, 1968, the Secretary annually consults with representatives of the governors of the Colorado River Basin States, general public and others and issues an Annual Operating Plan (AOP) for the coordinated operation of the Colorado River reservoirs. Reclamation also requires each Colorado River water user in the Lower Basin to schedule water deliveries in advance for the following calendar year (calendar year is the annual basis for decree accounting of consumptive use in the lower Colorado basin) and to later report its actual water diversions and returns to the mainstream.

Pursuant to 43 CFR part 417, prior to the beginning of each calendar year, Reclamation consults with entities holding BCPA section 5 contracts (Contractor) for the delivery of water. Under these consultations, Reclamation makes recommendations relating to water conservation measures and operating practices in the diversion, delivery, distribution, and use of Colorado River water. Reclamation also makes a determination of the Contractor's estimated water requirements for the ensuing calendar year to the end that deliveries of Colorado River water to each Contractor will not exceed those reasonably required for beneficial use under the respective BCPA contract or other authorization for use of Colorado River water. Reclamation then monitors the actual water orders, receives reports of measured diversions and return flows from major Contractors and federal establishments, estimates unmeasured diversions and return flows, calculates consumptive use from preliminary diversions and measured and unmeasured return flows, and reports these records on an individual and aggregate monthly basis. Later, when final records are available, Reclamation prepares and publishes the final Decree Accounting Record on a calendar year basis.

For various reasons, a user may inadvertently consumptively use Colorado River water in an amount that exceeds the amount available under its entitlement (inadvertent overrun). Further, the final Decree Accounting Record may show that an entitlement holder inadvertently diverted water in excess of the quantity of the entitlement that may not have been evident from the preliminary records. Reclamation is therefore considering an administrative policy that defines inadvertent overruns, establishes procedures that account for the inadvertent overruns and defines the subsequent requirements for pay back to the Colorado River mainstream.

Any effects of the proposed administrative policy decision on the environment will be addressed pursuant to the National Environmental Policy Act.

INADVERTENT OVERRUNS

Reclamation is proposing for the Lower Colorado River Basin an inadvertent overrun policy that would include the following features:

a. Inadvertent overruns are those which the Secretary deems to be beyond the control of the water user; for example, overruns due to the discrepancy between preliminary and final stream flow and diversion records, or overruns due to an unanticipated but lawful use by a higher-priority water user.

b. An inadvertent overrun is Colorado River water diverted, pumped or received by an entitlement holder of the Lower Division States that is in excess of the water user's entitlement for that year. The inadvertent overrun policy provides a structure to pay back the amount of water diverted, pumped or received in excess of entitlement. The inadvertent overrun policy does not create any right or entitlement to this water, nor does it expand the underlying entitlement in any way. An entitlement holder has no right to order, divert, pump or receive an inadvertent overrun. If, however, water is diverted, pumped or received inadvertently in excess of entitlement, and the Contractor's State's apportionment of Colorado River water for that year is exceeded, the inadvertent overrun policy will govern the payback. The IOP Policy cannot be applied to diversion or acreage based entitlements without appropriate methodology, nor does this policy apply in any manner to the deliveries made under the United States Mexico Water Treaty of 1944.

c. Payback will be required to commence in the calendar year that immediately follows the release date of a Decree Accounting Record that reports uses that are in excess of an individual's entitlement.

d. Payback must be made only from measures that are above and beyond the normal consumptive use of water (extraordinary conservation measures). Extraordinary conservation measures mean actions taken to conserve water that otherwise would not return to the mainstream of the Colorado River and be available for beneficial consumptive use in the United States or to satisfy the Mexican treaty obligation. Any entitlement holder with a payback obligation must submit to Reclamation, along with its water order, a plan which will show how it will intentionally forbear use of Colorado River water by extraordinary conservation and/or fallowing measures sufficient to meet its payback obligation and which demonstrates that the measures being proposed are in addition to those being implemented to meet an existing transfer or conservation agreement, and are in addition to the measures found in its Reclamation approved conservation plan. Plans for payback could also include supplementing Colorado River system water supplies with non-system water supplies through exchange or forbearance or other acceptable arrangements, provided that non-system water is not physically introduced into the system. Water banked off-stream or groundwater from areas not hydrologically connected to the Colorado River or its tributaries are examples of such supplemental supplies. Water ordered but subsequently not diverted is not included in this policy in any manner. If such water is not charged against a user's entitlement, it will not be counted in any other manner with respect to decree accounting.

e. Maximum cumulative inadvertent overrun accounts will be specified for individual entitlement holders as 10 percent of an entitlement holder’s normal year consumptive use entitlement. With regard to a conservation transfer, the specific terms of the transfer would address whether or not the proportionate overrun account is also transferred. (Normal year means a year for which the Secretary has determined that sufficient mainstream Colorado River water is available for release to satisfy 7.5 maf of annual consumptive use in the States of California, Arizona and Nevada.)

f. The number of years within which an overrun, calculated from consumptive uses reported in final Decree Accounting Records, must be paid back, and the minimum payback required for each year shall be as follows:

    1. In a year in which the Secretary makes a flood control release or a space building release, any accumulated amount in the overrun account will be forgiven.

    2. If the Secretary has declared a 70 R surplus in the AOP, any payback obligation will be deferred at the entitlement holder’s option.

    3. In a year when Lake Mead elevation is between the elevation for a 70R surplus declaration and elevation 1125 feet above mean sea level on January 1, the payback obligation incurred in that year must be paid back in full within 3 years of the reporting of the obligation, with a minimum payback each that year being of the greater of 20 percent of the individual entitlement holder’s maximum allowable cumulative overrun account amount or 33.3 percent of the total account balance.

    4. In a year when Lake Mead elevation is at or below elevation 1,125 feet above mean sea level on January 1, the total account balance will be paid back in full in that calendar year.

5. For any year in which the Secretary declares a shortage under the Decree, the total account will be paid back in full that calendar year, and further accumulation of inadvertent overruns will be suspended as long as shortage conditions prevail.

g. A separate inadvertent overrun account may be established in those limited cases in which a lower priority user is, or has agreed to be, responsible for consumptive uses by one or more un-quantified senior water entitlement or right holders having finite service area acreage. The separate inadvertent overrun account will be limited to a maximum cumulative amount of 10 percent of the senior right holders average consumptive use. Such inadvertent overrun accounts will be the assigned responsibility of the lower priority user in addition to their own entitlement based inadvertent overrun account. If, however, such senior entitlement or right holders' approved aggregate calendar year water orders are in excess of the specified amount above which the lower priority user will be responsible, such excess will not be deemed inadvertent and the lower priority user's water order for that year will be reduced accordingly by Reclamation.

h. Each month, Reclamation will monitor the actual water orders, receive reports of measured diversions and return flows from Contractors and federal establishments, estimate unmeasured diversions and return flows, and project individual and aggregate consumptive uses for the year. Should preliminary determinations indicate that monthly consumptive uses by individual users, or aggregate uses, when added to the approved schedule of uses for the remainder of that year, exceed contract entitlements but are not exceeding the maximum inadvertent overrun account amount, Reclamation will notify in writing the appropriate entities that the preliminary determinations are forecasting annual uses in excess of their entitlements.

i. During years in which an entitlement holder is forbearing use to meet its payback obligation, Reclamation would monitor the implementation of the extra-ordinary conservation measures, and require that the districts consumptive use be at or below their adjusted entitlement. Should the district actual monthly deliveries for about the first 5 months of the year exceed their forecasted orders, and projections indicate the district's end of year use is likely to be 5 percent above their adjusted entitlement, Reclamation will notify the district in writing. At the end of about 7 months if it continues to appear that the district is likely to be above their adjusted entitlement Reclamation will notify the district that they are at risk of exceeding their adjusted entitlement, and having their next years orders placed under enforcement proceedings. Reclamation will monitor the implementation of the extraordinary conservation measures and monitor the forbearance of consumptive use of Colorado River water. Should preliminary determinations of the implementation of extraordinary conservation or of monthly Colorado River consumptive uses indicate that sufficient extraordinary conservation or sufficient forbearance of Colorado River consumptive use is not projected to occur, Reclamation will notify the appropriate entitlement holders in writing that the preliminary determinations are forecasting that their annual payback obligations are not on target or being met. If this condition occurs for two consecutive years, in the second year Reclamation would enter enforcement proceedings, will advise the entitlement holder in writing by July 31, will consult with the entitlement holder on a modified release schedule and will limit releases to the entitlement holder for the remainder of the year such that by the end of the year the individual entitlement holder has met their payback obligation.

j. Under enforcement proceedings, during the year, Reclamation would again monitor the implementation of the extra-ordinary conservation measures, and require that the districts consumptive use be at or below their re-adjusted entitlement. Should the district actual monthly deliveries for about the first 5 months exceed their forecasted orders, and projections indicate the district's end of year use is likely to be 5 percent above their re-adjusted entitlement, Reclamation will notify the district in writing that they are at risk of being subjected to enforcement proceedings. Should the district actual monthly deliveries for the first 7 months exceed their forecasted orders, and projections indicate the district's end of year use is likely to be above their adjusted entitlement Reclamation would advise the entitlement holder in writing by July 31, consult with the entitlement holder on a modified diversion schedule and then limit diversions to the entitlement holder for the remainder of the year such that by the end of the year the individual entitlement holder has met their payback obligation. Should preliminary determinations indicate that monthly consumptive uses by individual users, or aggregate uses, when added to the approved schedule of uses for the remainder of that year, exceed the individual entitlement holder's maximum cumulative overrun account amount, Reclamation will advise the entitlement holder in writing by July 31, will consult with the entitlement holder on a modified release schedule and will limit releases to the entitlement holder for the remainder of the year such that by the end of the year the individual entitlement holder's maximum cumulative overrun account amount has not been exceeded.

k. Procedures will be established for accounting for inadvertent overruns on an annual basis and for supplementing the final Decree Accounting Record. The procedures and measures for administering the IOP will be reviewed every 5 years.

For further information, contact Mr. John Redlinger, (702) 293–8592.

Appendix J

Further Explanation of the Relationship of River Flow and Stage for the Parker Dam to Imperial Dam Reach of the Colorado River

Appendix J
Further Explanation of the Relationship of River Flow and Stage for the Parker Dam to Imperial Dam Reach of the Colorado River

INTRODUCTION

This appendix provides further explanation of the modeling methodology used to determine the relationship of river flow and stage in the Parker to Imperial reach. This information was previously presented in Reclamation's Biological Assessment (BA) for Proposed Interim Surplus Criteria, Secretarial Implementation Agreements for California Water Plan Components, and Conservation Measures (USBR, 2000), included in this EIS as Appendix D. Some additional analyses have been conducted and a summary of the results of these analyses is also presented herein.

MODELING APPROACH USED IN THE BIOLOGICAL ASSESSMENT (BA)

To assess the impacts to open water, marsh habitat, and riparian habitat as a result of potential future changes in flow in the Parker Dam to Imperial Dam reach, a range of possible reductions to the annual flow releases from Parker Dam were analyzed. This flow reduction range (200 KAF to 1.574 MAF) was chosen to capture the most likely, as well as the maximum changes in annual releases from Parker Dam that might occur as the result of a variety of possible future actions, including the Implementation Agreement. The observed annual release volume from Parker Dam for 1996 (approximately 7.3 MAF) was used as the reference point, from which to apply the range of possible future reductions. This particular year was deemed representative at the time of the preparation of the BA as it was a year of above normal deliveries from Parker Dam, reflecting the increased possibility of surplus releases during the Interim Surplus Guideline period. The year was also chosen since the increased deliveries were not due to flood control releases from Hoover Dam. Eight possible future Parker Dam flow release reductions were analyzed within the range as shown in Table J-1.

Table J-1
Reductions from 1996 Annual Parker Dam Flow Release Modeled for River Stage Effects

Reduction (KAF)	0	200	300	400	500	675	948	1,553	1,574
Annual Volume (KAF)	7,300	7,100	7,000	6,900	6,800	6,630	6,350	5,750	5,730

Once the annual volumes were determined, the analysis was conducted in a multi-step process. In summary, the annual Parker release volumes are first disaggregated to monthly, daily, and hourly time steps. The hourly releases are then routed to four (4) sites downstream (Waterwheel gage at River Mile 152.0, Taylor Ferry gage at 106.6, Cibola gage at River Mile 87.3, and Imperial Dam at River Mile 49.2). The assumption was made that the routed flow at one location would remain the same until it reached the halfway point to the next downstream routing location. The resulting hourly flows are then aggregated to daily flows and the daily flows are then converted to river stage at each site, using a rating formula for each site derived from the output of a HEC-RAS water surface profile model (USBR, 1999). Both an "annual average analysis" and a "monthly min/max analysis" were performed, with the differences in the two analyses lying in the methodologies applied for the disaggregation/aggregation steps. Table J-2 presents the details of each analysis.

Table J-2
Steps in River Flow and Stage Modeling

Step in the Process	Annual Average Analysis	Monthly Min/Max Analysis
Disaggregate to monthly	Divide by 12	Use historical monthly data (1996 Parker monthly release and 1996 IID diversion pattern)
Disaggregate to daily	Divide by number of days in the month and convert to cfs	Same
Disaggregate to hourly	Use typical Parker hourly release pattern, depending upon the mean daily release (8 patterns used)	Same
Route downstream	Use the Muskingum technique	Same
Aggregate to daily	Sum hourly values and divide by 24 to get mean daily flow	Choose either the minimum or maximum hourly flow for the day
Convert to stage	Use flow-stage relationship for each site, determined from HEC-RAS water surface profile model	Same

Given the estimated change in stage at the various sites, subsequent analysis was performed to estimate the corresponding effects on backwater areas and groundwater levels. This technical appendix, however, is focused on the flow and stage analysis.

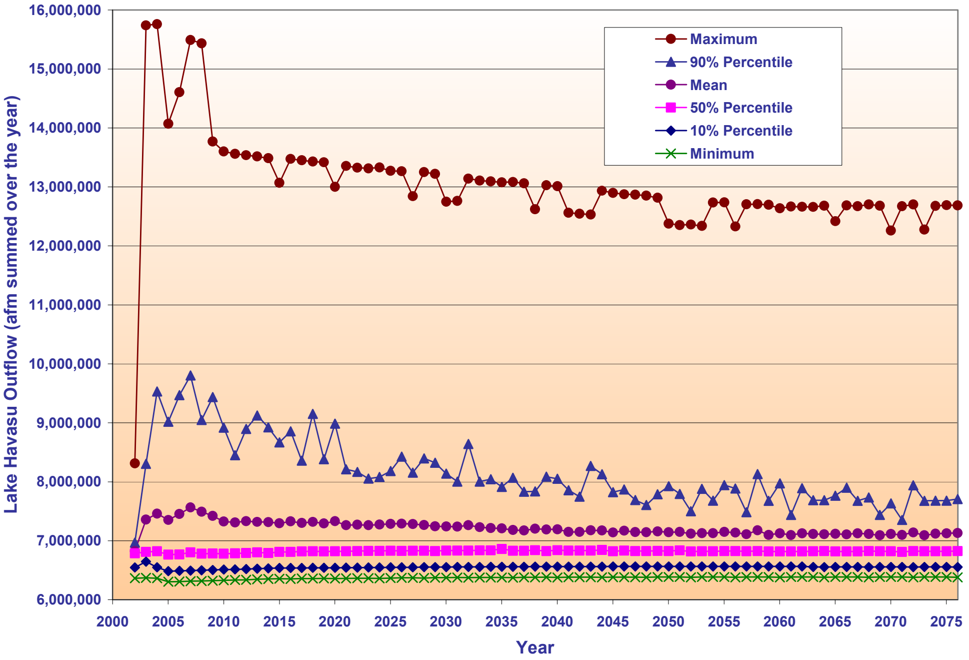
MODELED PARKER DAM RELEASES

Future Parker Dam releases were modeled for several operational scenarios (No Action, Implementation Agreement, Baseline for Cumulative Analysis, and Cumulative Analysis), as described in Appendix C in the EIS. Figure J-1 presents a graphical summary of the annual Parker Dam outflows observed under the modeled No Action conditions. The modeled flows for the No Action scenario assume no future water transfers due to the Implementation Agreement and can therefore be used to compare to the 1996 data chosen for the river analysis. As shown in Figure J-1, the observed annual Parker Dam outflows under this scenario ranged from a minimum of 6.3 maf to a maximum of 15.8 maf over the 75-year period of analysis. The observed trend of decreasing flows over time is due to increased use by the Upper Basin states and subsequently reduced surplus and flood control releases. Certainly, the upper limit of the flows analyzed in the BA (7.3 maf) falls within this range of modeled flows. More specifically, Table J-3 presents the data from Figure J-1 in tabular format for four selected years. As shown, the mean of annual Parker Dam outflows observed under the modeled No Action conditions in years 2016 and 2026 are approximately 7.3 maf. Further analysis showed that 7.3 maf was approximately the lower bound for the 85th percentile values over the entire 75-year period.

Table J-3
Summary of Observed Parker Dam Outflows for Selected Years
Under Modeled No Action Conditions (KAF)

	Minimum	10% Percentile	50% Percentile	Mean	90% Percentile	Maximum
2006	6,308	6,488	6,766	7,454	9,467	14,606
2016	6,353	6,536	6,807	7,328	8,856	13,475
2026	6,369	6,549	6,828	7,288	8,426	13,266
2050	6,384	6,564	6,825	7,142	7,925	12,377

Figure J-1
Range of Observed Parker Dam Outflows Under No Action Modeled Conditions



ADDITIONAL RIVER FLOW AND STAGE ANALYSIS

Table J-4 summarizes the effect (using the "annual average analysis" method) on water surface elevation for a 400 KAF reduction using 7.3 MAF as the mean annual flow from Parker Dam. The maximum observed river stage difference resulting from modeled reductions in Parker Dam release was approximately 0.4 feet and this occurred at river mile 116.5. The results of this analysis are also presented in graphical form in Figure J-2. River Mile 135.8 shows the backwater effects from Palo Verde Dam that tends to dampen out the effects on water surface elevation due to the flow reductions. It should be noted that this is the exact same data that was previously published in the BA (USBR, 2000).

Reclamation performed an additional analysis for 6.3 MAF as the mean annual flow from Parker Dam. Using this flow as the reference point, a subsequent reduction of 400 KAF was applied to yield an annual flow of 5.9 MAF. Table J-5 summarizes the modeling results (again using the "annual average analysis" method) on water surface elevation for this analysis. The maximum observed difference of approximately 0.4 feet once again occurred at river mile 116.5. These results are illustrated graphically in Figure J-3.

Table J-4
Potential Impacts to River Stage Based on Parker Dam Annual Outflow Reduction from 7.3 maf to 6.9 maf

River Mile	River Stage Elevation Coinciding With Parker Dam Outflow of 7.3 maf [1]	River Stage Elevation Coinciding With Parker Dam Outflow of 6.9 maf [1]	River Stage Elevation Difference (feet)	River Stage Elevation Difference (inches)
171.3	334.12	333.84	-0.28	-3.4
167.6	327.66	327.36	-0.30	-3.6
160.9	316.12	315.83	-0.29	-3.5
149.5	298.96	298.67	-0.29	-3.5
146.9	295.52	295.29	-0.23	-2.8
135.8	283.83	283.8	-0.03	-0.4
119.7	248.26	247.98	-0.28	-3.4
116.5	241.93	241.56	-0.37	-4.4
114.6	239.5	239.15	-0.35	-4.2
109.1	230.96	230.62	-0.34	-4.1
103.1	224.5	224.21	-0.29	-3.5
96.7	215.98	215.63	-0.35	-4.2
86.1	207.15	206.87	-0.28	-3.4
80.4	202.15	201.92	-0.23	-2.8
72.2	194.28	194.03	-0.25	-3.0
70.3	193.24	192.99	-0.25	-3.0
66.1	189.2	188.95	-0.25	-3.0

1. River Stage elevation based on NGVD29.

Table J-5
Potential Impacts to River Stage Based on Parker Dam Annual Outflow Reduction from 6.3 maf to 5.9 maf

River Mile	River Stage Elevation Coinciding With Parker Dam Outflow of 6.3 maf [1]	River Stage Elevation Coinciding With Parker Dam Outflow of 5.9 maf [1]	River Stage Elevation Difference (feet)	River Stage Elevation Difference (inches)
171.3	333.41	333.11	-0.30	-3.6
167.6	326.90	326.58	-0.32	-3.8
160.9	315.38	315.06	-0.32	-3.8
149.5	298.21	297.88	-0.33	-4.0
146.9	294.94	294.69	-0.25	-3.0
135.8	283.74	283.71	-0.03	-0.4
119.7	247.54	247.23	-0.31	-3.7
116.5	240.97	240.56	-0.41	-4.9
114.6	238.61	238.22	-0.39	-4.7
109.1	230.08	229.70	-0.38	-4.6
103.1	223.74	223.42	-0.32	-3.8
96.7	215.09	214.71	-0.38	-4.6
86.1	206.44	206.13	-0.31	-3.7
80.4	201.55	201.30	-0.25	-3.0
72.2	193.65	193.38	-0.27	-3.2
70.3	192.60	192.32	-0.28	-3.4
66.1	188.55	188.29	-0.26	-3.1

1. River Stage elevation based on NGVD29.

Figure J-2
Potential Impacts to River Stage Based on Parker Dam Annual Outflow Reduction from 7.3 maf to 6.9 maf

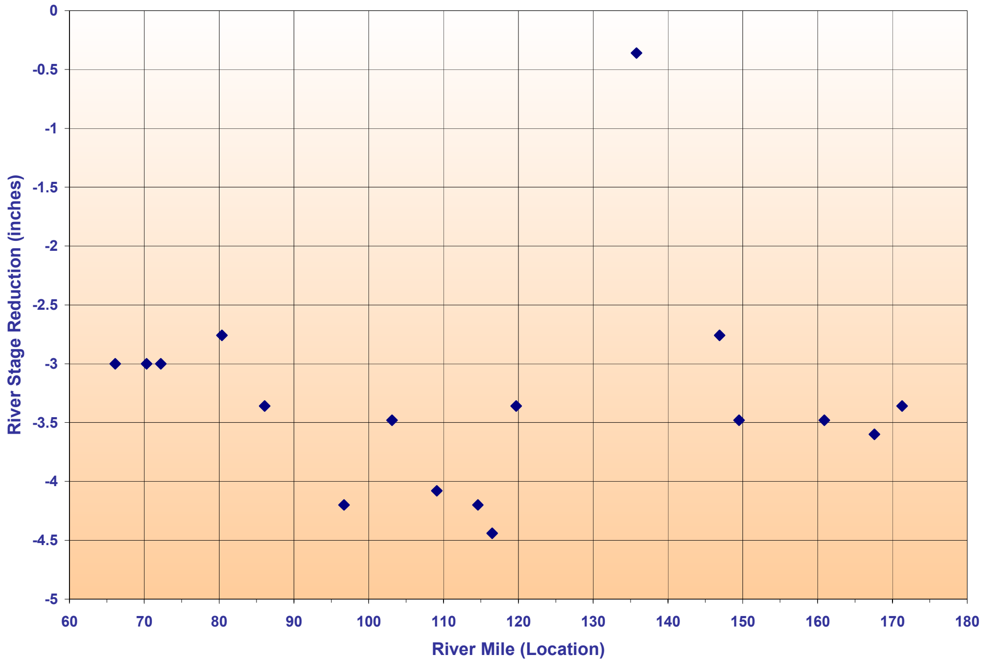
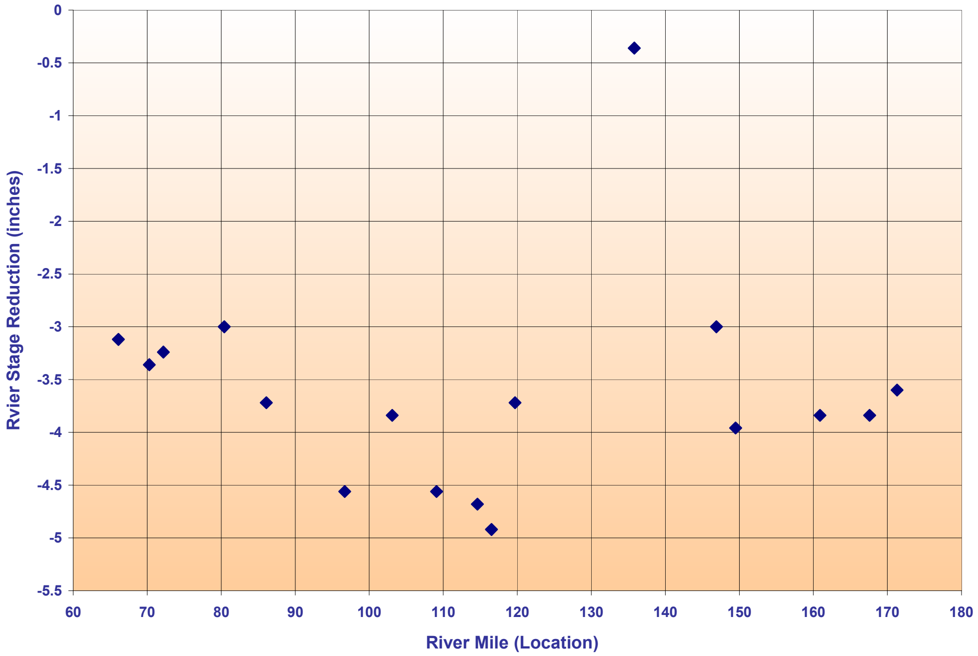


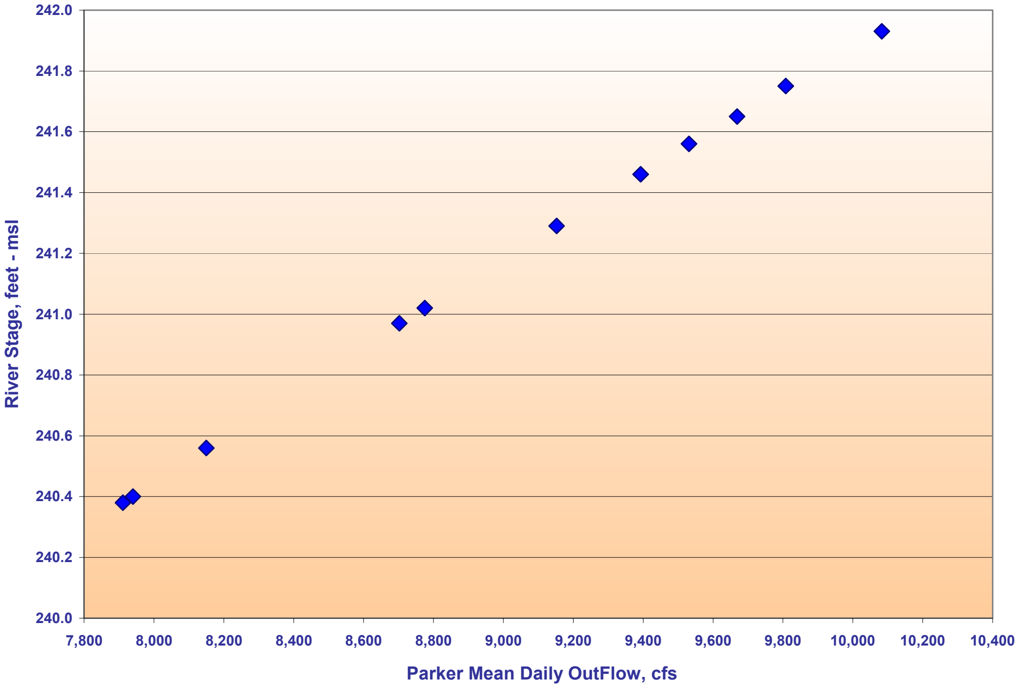
Figure J-3
Potential Impacts to River Stage Based on Parker Dam Annual Outflow Reduction from 6.3 maf to 5.9 maf



CONCLUSIONS

From these results, it can be seen that using 6.3 MAF as the reference point from which a 400 KAF reduction is applied yields essentially the same effect as seen previously when using 7.3 MAF as the reference point. Figure J-4 graphically presents the relationship between Parker Dam outflow and river stage at River Mile 116.5. It should be noted that the data that was used to produce this Figure J-3 consists of the Parker dam outflow and river stage data that was presented in Tables J-4 and J-5.

Figure J-3
Relationship Of Parker Dam Outflow and River Stage At River Mile 116.5



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