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The Delta's Perennial Drought: Instream Flows for an Over-Allocated River

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I. INTRODUCTION

The Colorado is a profoundly degraded river. Perhaps the area most affected by the development of the Colorado River is its delta-estuary ecosystem. Historically, the Colorado River Delta and the Upper Gulf of California sustained tremendous levels of biological productivity and diversity. As late as 1922, even after much of the delta had been cleared for agriculture and irrigators had begun to divert the river, Aldo Leopold described the region as a "milk and honey wilderness."[1]

For millions of years, the Colorado River flowed into its expanding delta. The first recorded diversion from the river occurred in 1870, where the river diverted into the Colorado River Indian Reservation in Arizona.[2] However, the Anasazi and others diverted Colorado River tributary waters nine hundred years earlier.[3] Large-scale depletion of the river began at the turn of the twentieth century, with diversions into the Imperial Valley. By 1929, more than twenty-two percent of the river's flow had been depleted by non-Indian anthropogenic diversions and consumptive uses.[4] These depletions, coupled with the construction of dams capable of storing four times the river's average annual flow, dramatically reduced the amount of water reaching the delta. Except for unusually high flood years, virtually the entire flow of the Colorado is now captured and used before reaching the river's mouth. Despite this, the remaining delta and upper gulf regions still comprise the largest and most critical desert wetland in North America, as well as one of the world's most diverse and productive marine ecosystems.[5]

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1. Mark Muro, *Colorado River Clams Provide Benchmark*, SCIENCE MAGAZINE, Dec. 15, 2000, at 2045, *available at* http://www.sciencemag.org/cgi/content/full/290/5499/2045a.

2. U.S. Department of the Interior, Bureau of Reclamation, Lower Colorado Region, http://www.usbr.gov/lc/region/g4000/hisdiv.html (last visited May 19, 2006).

3. Fred Plog, *Prehistory: Western Anasazi, in* Alfonso Ortiz, 9 HANDBOOK OF NORTH AMERICAN INDIANS: SOUTHWEST 111, 111-12 (Alfonso Ortiz ed., 1979).

4. Native American claims to Colorado River mainstem and tributary water continue to be adjudicated.

5. D.F. LUECKE ET AL., A DELTA ONCE MORE: RESTORING RIPARIAN AND WETLAND HABITAT IN THE COLORADO RIVER DELTA 1(1999), *available at* http://www.environmentaldefense.org/documents/425_Delta.pdf.

The Colorado River Delta once extended from Indio, California, in the northwest; to Yuma, Arizona, in the east; and to the Upper Gulf of California in the south; covering approximately 3325 square miles (8611 km^2).[6] Due to land conversion and upstream diversions, the extent of the delta has been reduced to approximately 230 square miles (60,000 ha) that is primarily comprised of the land between two flood-control levees and the Cienega de Santa Clara, a 20,000 ha wetland sustained by agricultural drainage from the United States.[7] In the late 1990s, flood releases from upstream dams prompted the re-emergence of ecologically valuable riparian habitat, and were strongly correlated with a rise in the shrimp catch in the upper gulf, both of which indicated the estuary's renewed viability.[8]

For restoration advocates, the challenge is to ensure that the delta's various habitat types receive sufficient flows of water at the frequency, magnitude, and quality needed to ensure their long-term survival.[9] Potential sources of this water could conceivably come from voluntary leasing agreements with irrigators in Mexico and the United States, supplemented by an agreement to coordinate management of periodic pulse flows.[10] Additionally, the source of water for the Cienega de Santa Clara will need protection to ensure that its quality and quantity is not diminished.[11]

Acquiring and dedicating this water to the delta will be difficult. The Colorado River is over-allocated: more water is apportioned to the Colorado River Basin states and to Mexico than actually flows in the river in most years. Further frustrating efforts to secure a dedicated supply of water for the delta is the recent drought in the Colorado River Basin, the most severe in the 100-year historical record. Since the drought began in 2000, total water storage on the system has decreased by almost fifty percent. The surface elevation of Lake Powell dropped more than 115 feet from the end of 1999 to the end of 2004, while Lake Mead dropped by more than 80 feet. This eliminated flood releases and spills from Lake Mead, decreasing dramatically the likelihood of flood waters reaching the river's delta. With the exception of one series of lower basin storm events that overwhelmed storage capacity on the lowest reaches of the

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6. G. Sykes, *The Colorado Delta*, *in* 19 AMERICAN GEOGRAPHICAL SOCIETY SPECIAL PUBLICATION 3 (1937).

7. E.P. Glenn et al., *Ciénega de Santa Clara: Endangered Wetland in the Colorado River Delta, Sonora, Mexico*, 32 NAT. RESOURCES J. 817 (1992).

8. M.S. Galindo-Bect et al., *Penaeid Shrimp Landings in the Upper Gulf of California in Relation to Colorado River Freshwater Discharge*, 98 FISHERY BULLETIN 222, 222-25 (2000).

9. J. Pitt et al., *Two Nations, One River: Managing Ecosystem Conservation in the Colorado River Delta* 40 NAT. RESOURCES J. 819 (2000).

10. Robert Jerome Glennon & Peter W. Culp, *The Last Green Lagoon: How and Why the Bush Administration Should Save the Colorado River Delta*, 28 ECOLOGY L. Q. 903, 903-20 (2002); M. CLINTON ET AL., IMMEDIATE OPTIONS FOR AUGMENTING WATER FLOWS TO THE COLORADO RIVER DELTA IN MEXICO (May 2001), *available at* http://sonoran.org/pdf/Colorado_river.pdf.

11. Yuma Desalting Plant/Cienega de Santa Clara Workgroup, Balancing Water Needs on the Lower Colorado River (April 22, 2005), *available at* http://www.cap-az.com//images/newfinaldocument.pdf.

river in October and November 2004, virtually no water flowed into the remnant delta in 2003 or 2004.

On December 17, 2004, five years into the most severe recorded drought on the Colorado River, the Department of the Interior gave the Colorado River Basin states an April 2005 deadline to develop drought-management strategies. This deadline was subsequently extended[12] when the basin states[13] could not come to an agreement. On February 3, 2006, representatives of the basin states submitted a consensus proposal for managing shortage conditions, and for more generally managing Colorado River reservoirs.[14] While the basin states proposal offers innovative management opportunities and flexibility within the United States, it would exclude Mexico from these opportunities. The proposal would apportion shortages to Mexico simply based upon elevations at Lake Mead.[15] These drought-management strategies are important because further reduction in the volume of Colorado River water that flows to Mexico would increase the challenge of securing dedicated supplies of water for this threatened resource, thereby creating an additional threat to the remnant delta.

II. INSTITUTIONAL CONTEXT: BUREAU & RECLAMATION

In the United States, a complex set of treaties, laws, compacts, contracts, court decisions, and regulations known as the "Law of the River" controls the flows and uses of the Colorado River.[16] The Law of the River largely determines the quantity and timing of water entering the remnant delta. In contrast, Mexican regulation of the Colorado River use is centralized at the federal level.[17]

The flows of the Colorado River below Hoover Dam are controlled and regulated based on flood control requirements, downstream diversion orders, and demands for hydroelectric power.[18] The degree of institutional control over the Colorado River cannot be overstated: the 1983 flood was the only instance since

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12. Development of Management Strategies for Lake Powell and Lake Mead under Low Reservoir Conditions, 70 Fed. Reg. 34794 (June 15, 2005); Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead Under Low Reservoir Conditions, 70 Fed. Reg. 57322 (September 30, 2005); Development of Lower Basin Shortage Guidelines and Coordinated Management Strategies for Lake Powell and Lake Mead, Particularly Under Low Reservoir Conditions, 71 Fed. Reg. 16342 (March 31, 2006).

13. Colorado, New Mexico, Utah, and Wyoming comprise the upper basin states, while Arizona, California, and Nevada constitute the lower basin states.

14. Letter from the Seven Basin States to Secretary Norton (February 3, 2006), *available at* http://www.usbr.gov/lc/region/programs/strategies/documents.html.

15. Seven Basin States' Preliminary Proposal Regarding Colorado River Interim Operations [hereinafter Preliminary Proposal] 5 (February 3, 2006), *available at* http://www.usbr.gov/lc/region/programs/strategies/consultation/Feb06SevenBasinStatesPreliminaryProposal.pdf.

16. *See* D. Getches, *Competing Demands for the Colorado River*, 56 U. COLO. L. REV. 413 (1985). *See also* M.N. NATHANSON, UPDATING THE HOOVER DAM DOCUMENTS: 1978 (1980).

17. J.E Castro, *Decentralization and Modernization in Mexico: The Management of Water Services*, 35 NAT. RESOURCES J. 461 (1995).

18. *Cf.* NATHANSON, *supra* note 16.

the construction of Hoover Dam in 1935 when discharge from the dam and along the Lower Colorado River exceeded the 40,000 cfs Flood Control Release Guidelines established by the Army Corps of Engineers.[19] The concept of a major river whose flow can be turned on and off is difficult to comprehend, but it is the central characteristic of the Lower Colorado River. Except in extremely rare instances of unusually high inflows to Lake Mead and limited storage availability (triggering U.S. Army Corps of Engineers Flood Control Release Guidelines), the flows in the Lower Colorado River are released by the U.S. Bureau of Reclamation from Hoover Dam. The Bureau of Reclamation determines release rates based on a complex algorithm to meet the downstream beneficial consumptive use orders for agricultural, municipal, and industrial diversions. This algorithm integrates agricultural diversion orders, required deliveries to Mexico, storage requirements, flood control, and hydroelectric power generation contracts. The determination of releases takes into consideration the priorities of water use that is required by applicable federal law.[20] In-stream flows through the Colorado River Delta are mostly dependent on releases from upstream dams.

The law of the river addresses U.S. obligations to Mexico through two main elements: the 1944 *Treaty on the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande*,[21] and Minute 242 of the International Boundary and Water Commission ("IBWC") issued in 1973.[22] The former guarantees delivery of 1.5 million acre-feet/year[23] (1850 MCM) to Mexico. Article 10(b) of the 1944 Treaty allocates an additional 200,000 acre-feet (200 KAF; 246.7 MCM) to Mexico when the U.S. section of the IBWC determines that there exists a surplus of Colorado River water above the amount needed to supply U.S. uses (these treaty surpluses were declared in 1997-2000). To date, sufficient water has been available in Lake Mead to meet treaty obligations to Mexico.

Article 10(b) of the 1944 Treaty also refers to conditions in which the United States may deliver less water to Mexico:

> 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

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19. M. B. Holburt, *The 1983 High Flows on the Colorado River and Their Aftermath*, 9 WATER INT'L 99 (1984).

20. *See* NATHANSON, *supra* note 16.

21. *See* N. HUNDLEY, DIVIDING THE WATERS: A CENTURY OF CONTROVERSY BETWEEN THE UNITED STATES AND MEXICO (U.C. Press 1966) (containing a comprehensive history of the 1944 Treaty with Mexico); *see also* Utilization of Waters of Colorado and Tijuana Rivers and of the Rio Grande, U.S.-Mex., February 3, 1944, [hereinafter Treaty] *available at* http://www.ibwc.state.gov/Files/1944Treaty.pdf.

22. International Water & Boundary Commission, Chronological Index of Minutes Numbers 180 through 311, Minute 242, http://www.ibwc.state.gov/html/body_minutes.HTM (last visited May 22, 2006).

23. By convention, large volumes of water in the western United States are measured and allocated in acre-feet. One acre-foot equals 1233 cubic meters; one cubic km equals 810,700 acre-feet.

> acre-feet (1,850,234,000 cubic meters) a year, the water allotted to Mexico under subparagraph (a) of this Article will be reduced in the same proportion as consumptive uses in the United States are reduced.[24]

"Extraordinary drought" has not been defined. Additionally, it is not clear whether "consumptive uses" refers to total consumptive use of Colorado River water in the United States, or solely to lower basin consumptive use (those permitted by deliveries, as opposed to run of the river diversions in the upper basin). Furthermore, the limited consumptive-use records hinder efforts to determine reductions.[25] The 1964 Supreme Court Decree requires the annual compilation of records of consumptive uses of Colorado River water in the lower basin, as well as records of annual deliveries to Mexico. Despite the decree, consumptive use reporting for the upper basin occurs only every five years.[26]

The Colorado River Basin Project Act of 1968 authorized development of the Long Range Operating Criteria for Colorado River Reservoirs ("LROC") and construction of the Central Arizona Project ("CAP"). In exchange for congressional authorization of the CAP, Arizona agreed that the CAP would bear future shortages before deliveries to California were reduced. Section III (3)(c) of the LROC recognizes the Secretary of the Interior's authority to determine the existence of a shortage condition, yet specific criteria for determining shortage conditions has not been developed. The five-year review of the LROC, which was finalized in March 2005,[27] does not define "shortage" for the Colorado River. The Secretary initiated the process of establishing criteria for determining shortage conditions in 2005, but to date there is no certainty as to what triggers a shortage declaration, or what a declaration would entail.[28]

In 1996, the Secretary of the Interior declared a limited U.S. surplus to permit the delivery of water to California in excess of the lower basin's Colorado River Compact apportionment,[29] no surplus waters were made available that year

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24. *See* Treaty, *supra* note 21.

25. The Upper Colorado River Commission claims that upper basin consumption use has been reduced by as much as 800,000 acre-feet in recent years.

26. The Colorado River Basin Project Act of 1968, Public Law 90-537, directs the Secretary of the Interior to "make reports as to the annual consumptive uses and losses of water from the Colorado River System after each successive five-year period, beginning with the five-year period starting on October 1, 1970. . . . Such reports shall be prepared in consultation with the States of the lower Basin individually and with the Upper Colorado River Commission and shall be transmitted to the President, the Congress, and to the Governors of each State signatory to the Colorado River Compact."

27. Review of Existing Coordinated Long-Range Operating Criteria for Colorado River Reservoirs, 70 Fed. Reg. 15873 (March 29, 2005).

28. See http://www.usbr.gov/lc/region/programs/strategies/documents.html for documentation on federal register notices.

29. Section II(B)(2) grants the Secretary of the Interior the authority to declare surplus conditions for the lower basin states "if sufficient mainstream water is available for release . . . to satisfy annual consumptive use in the [lower basin] states in excess of 7.5 million acre-feet." Ariz. v. Cal., 376 U.S. 340 (1964).

for Mexico. In January 2001, the Secretary of the Interior adopted the Colorado River Interim Surplus Guidelines,[30] which implemented a legal conceit for delivering additional water to lower basin contractors for a fifteen-year period. These Interim Surplus Guidelines are solely for U.S. lower basin contractors, and do not affect surplus for Mexico as defined by the 1944 Treaty. By decreasing storage at Lake Mead, these Interim Surplus Guidelines decrease the probability that Lake Mead will spill, thus decreasing the likelihood that water from the Colorado River will reach the delta. The Secretary of the Interior declared surplus conditions based on these guidelines for 2001-2004, but due to a variety of factors, including the drought, California did not order surplus water in either 2003 or 2004. The Secretary of the Interior permitted total lower basin consumptive use in 2001-2002 to exceed the lower basin's combined apportionment for those two years by more than one million acre-feet, thus decreasing the elevation of Lake Mead by more than ten feet. Since these U.S. surplus declarations may ultimately trigger shortage declarations a year earlier than would have otherwise occurred, it is unclear how the Mexican government will respond to efforts by the U.S. basin states to apportion shortages to Mexico.

After a long dispute between Mexico and the United States about the quality of water delivered to Mexico that was centered on the brackish discharge from Arizona's Wellton-Mohawk Irrigation and Drainage District in the early 1960s, the two countries adopted Minute 242 of the IBWC. Minute 242 states that 1.36 MAF (1678 MCM) of annual water deliveries to Mexico at the Northerly International Boundary ("NIB") would have an average salinity of no more than 115 ppm (±30 ppm) greater than the salinity of the river at Imperial Dam. The remaining 140 KAF (173 MCM) that is delivered at the international boundary with Mexico near San Luis would have "a salinity substantially the same as that of the waters customarily delivered there."[31] Congress then passed the Colorado River Basin Salinity Control Act of 1974, which authorizes measures to enable compliance with Minute 242, including the constructions of the $250 million Yuma Desalting Plant ("YDP"),[32] and the Main Outlet Drain Extension ("MODE") and its bypass extension, discharging agricultural drainage into Mexico's Cienega de Santa Clara.[33]

The Mexican Constitution establishes the legal framework for water management in Mexico and reserves the rights to national waters to the federal

30. The Secretary of the Interior, Colorado River Interim Surplus Guidelines Final Environmental Impact Statement (January 2001), *available at* http://www.usbr.gov/lc/region/g4000/surplus/surplus_rod_final.pdf.

31. Norris Hundley, Jr., *The West Against Itself: The Colorado River—An Institutional History*, *in* NEW COURSES FOR THE COLORADO RIVER: MAJOR ISSUES FOR THE NEXT CENTURY 9, 39 (Gary D. Weatherford & F. Lee Brown eds., 1986).

32. RICHARD W. WAHL, MARKETS FOR FEDERAL WATER: SUBSIDIES, PROPERTY RIGHTS, AND THE BUREAU OF RECLAMATION (1989).

33. Edward P. Glenn et al., *Cienega de Santa Clara: Endangered Wetland in the Colorado River Delta, Sonora, Mexico*, 32 NAT. RESOURCES J. 817 (1992).

government, including the Colorado River.[34] The Constitution also reserves ownership of groundwater to the national government.[35] In practice, Mexico's Comision Nacional de Aguas ("CNA") determines deliveries of Colorado River water, and regulates groundwater extraction within the delta region.[36] In recent years, however, efforts have begun to decentralize this authority and provide for greater autonomy at the local level.[37]

III. HYDROLOGY

Marked fluctuations in the volume of flow, both between and within years, characterized the flow of the Colorado River prior to the construction of dams and diversions. The maximum reconstructed flow during the 100-year period of record occurred in 1983, with an estimated virgin flow of 25 MAF (31,000 MCM); the minimum reconstructed virgin flow occurred in 1934, with an estimated flow of 6.2 MAF (7700 MCM). Researchers cite a range of estimates for the river's annual flow, from an estimated long-term mean of 13.5 MAF (16,700 MCM) based on tree-ring records,[38] to 15 MAF (18,600 MCM) for the period of record.[39]

The Colorado River is over-allocated: more water is legally apportioned from the river than actually flows in most years. This unfortunate situation arose from assumptions based on an incomplete and distorted record of river flows. The U.S. negotiators of the Colorado River Compact of 1922 based their allocations on a hydrologic anomaly. The fifteen years prior to the 1922 Compact were unusually wet: the annual flow of the river near Lee Ferry during that time was estimated at 18 MAF,[40] and in 1917, there was an extraordinarily high flow at Lee Ferry at 24 MAF.[41] The Colorado River was apportioned among the basin states based upon these limited records, allocating a total of 16 MAF to the states. The states deferred the determination of Mexico's share of the river by assuming that there would be sufficient unapportioned water to meet any international obligation that

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34. Jose Esteban Castro, *Decentralization and Modernization in Mexico: The Management of Water Services*, 35 NAT. RESOURCES J. 461, 466 (1992).

35. Jose Ramon Cossio Díaz, *Constitutional Framework for Water Regulation in Mexico*, 35 NAT. RESOURCES J. 489, 495 (1995).

36. MICHAEL CLINTON ET AL., IMMEDIATE OPTIONS FOR AUGMENTING WATER FLOWS TO THE COLORADO RIVER DELTA IN MEXICO 15-17 (2001).

37. David Meko et al., *The Tree-Ring Record of Severe Sustained Drought*, 31 WATER RESOURCES BULL. 789 (1995).

38. *Id.*

39. SANDRA J. OWEN-JOYCE & LEE H. RAYMOND, AN ACCOUNTING SYSTEM FOR WATER AND CONSUMPTIVE USE ALONG THE COLORADO RIVER, HOOVER DAM TO MEXICO, U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2407 (1996).

40. JASON I. MORRISON, ET AL., THE SUSTAINABLE USE OF WATER IN THE LOWER COLORADO RIVER BASIN, 22 (Nov. 1996), *available at* http://www.pacinst.org/reports/sustainable_co_river/sustainable_co_river_es.pdf.

41. Holburt, *supra* note 19, at 99.

might be negotiated in the future. Until the start of the current drought, this over-allocation of the river was tempered by an unusually wet period and by the fact that the upper basin states have yet to fully develop their allocations, which enabled the lower basin states (particularly California) to use more than their entitlement.

Intra-annual fluctuation characterized the flow of the pre-impounded Colorado River as much as the variation between years. The flow of the river is largely dependent on both the size of the snowpack in the headwaters and how quickly the snowpack melts. Peak flows typically occur in May-June, with the lowest flows in mid-winter.[42] Peak season flows of 80,000 cfs (2300 m^3/sec) were common at Lee Ferry, dropping to less than 3000 cfs (85 m^3/sec) from late summer through winter.[43] For several days in 1934, no measurable discharge was recorded for the river near Yuma, Arizona.[44]

Irrigators began diverting water from the Colorado River in the late nineteenth century, but the flood and drought cycles challenged development efforts and often washed out irrigation headgates, inundating fields and towns. Laguna Dam, the first major dam on the river, was completed in 1909, but there was not a structure on the river capable of regulating river flows until the completion of Hoover Dam in 1935. One of the major effects of the river's impoundment has been the near cessation of the river's transport of sediment that fundamentally changed the character of the river from warm, turbulent, and sediment-filled, to cold, regulated, and clear. Within a year of its construction, the Colorado River filled the reservoir behind Laguna Dam with silt. Imperial Reservoir, completed in 1938 and ten kilometers upstream from Laguna Dam, had an initial storage capacity of 83,000 acre-feet (100 MCM), but now has no useful storage due to silting by the river.[45] Measurements of suspended sediment collected at Lee Ferry prior to the closure of upstream dams indicated sediment concentrations in excess of 10,000 ppm; the concentrations of samples collected since the closure of upstream dams are generally below 200 ppm.[46] Upstream dams, especially Hoover and Glen Canyon, have been effective at trapping sediment that the sediment levels at Imperial Dam now average only 870

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42. ROBERT D. OHMART, ET AL., THE ECOLOGY OF THE LOWER COLORADO RIVER FROM DAVIS DAM TO THE MEXICO-UNITED STATES INTERNATIONAL BOUNDARY: A COMMUNITY PROFILE, U.S. FISH AND WILDLIFE SERVICE, BIOLOGICAL REP. NO. 85, § 7.19 (1988).

43. U.S. GENERAL ACCOUNTING OFFICE, BUREAU OF RECLAMATION, AN ASSESSMENT OF THE ENVIRONMENTAL IMPACT STATEMENT ON THE OPERATIONS OF THE GLEN CANYON DAM [hereinafter GAO] 3 (October 1996).

44. INTERNATIONAL BOUNDARY AND WATER COMMISSION (IBWC), WESTERN WATER BULLETIN: FLOW OF THE COLORADO AND OTHER WESTERN BOUNDARY STREAMS AND RELATED DATA 16 (2003).

45. U.S. BUREAU OF RECLAMATION, GROUNDWATER STATUS REPORT FOR YUMA AREA AND CALIFORNIA IN 1994 (1996).

46. JOHN SCHMIDT & JULIA B. GRAF, AGGRADATION AND DEGRADATION OF ALLUVIAL SAND DEPOSITS, 1965 TO 1986, COLORADO RIVER, GRAND CANYON NATIONAL PARK, ARIZONA, U.S. GEOLOGICAL SURV., NO. 1493, 2 (1990).

tons/day,[47] which is well below the virgin river's load of 50,000 tons/day.[48] This loss of sediment input caused the river's delta to reverse the normal process of accumulation, as tidal action now removes more material from the delta than the river replaces.[49]

The construction of dams and diversionary structures created a storage capacity on the Colorado River system equal to four years of river flow. This storage capacity has, with few exceptions, enabled river managers to flatten the river's pre-impoundment hydrograph, largely eliminating the overbank flooding that previously characterized the system and sustained the Colorado River Delta. The pre-impoundment hydrograph was replaced by a predictable set of releases that are timed to meet the needs of irrigators and urban areas. These releases are further modified to maximize peaking power generation, so that river levels below dams rise and fall as much as four feet on a daily basis.[50]

Mexico's Morelos Dam lies 1.1 km downstream of the NIB, dividing Baja California from Arizona. Morelos Dam is a run-of-the-river diversion structure with no effective storage capacity. Mexico diverts deliveries of Colorado River water at Morelos Dam into its Alamo Canal[51] to meet agricultural and urban water orders. U.S. deliveries to Mexico at Morelos Dam that are in excess of these orders and in excess of Mexico's canal flushing needs and groundwater recharge capacity[52] are released through the dam into the remnant delta. Some of the water Mexico diverts at Morelos is returned to the mainstem via the KM 27 and KM 38 wasteways, downstream of the Southerly International Boundary ("SIB").[53]

IBWC's Minute 242 and the Colorado River Basin Salinity Control Act of 1974 require diversion of the brackish water that drains from the Wellton Mohawk Irrigation and Drainage District into a bypass canal, rather than discharging this water into the Colorado River above the NIB, and degrading the river's water quality. Each year, the United States discharges an average of 109 KAF of brackish (approximately 2900 ppm) water into Mexico via this bypass

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47. GAO, *supra* note 43.

48. *Id.*

49. Michal Kowalewski et al., *Dead Delta's Former Productivity: Two Trillion Shells at the Mouth of the Colorado River*, 28 GEOLOGY 1059 (December 2000).

50. U.S. Department of the Interior, Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Daily Report (hourly data), http://www.usbr.gov/lc/region/g4000/hourly/yester.html (last visited May 22, 2006).

51. Total diversion capacity is 226 m^3/sec (8000 cfs).

52. Mexico supplements its apportionment of Colorado surface water by extracting an estimated 700 KAF of groundwater annually; this groundwater has been recharged primarily by infiltration of periodic flood flows. MICHAEL J. COHEN & CHRISTINE HENGES-JECK, MISSING WATER: THE USES AND FLOWS OF WATER IN THE COLORADO RIVER DELTA REGION [hereinafter MISSING WATER] (Sept. 2001).

53. The SIB is the southern most point of the limitrophe dividing Baja California from Arizona. In flood years, 194 KAF returns to the river at the KM 27 wasteway and 10 KAF at the KM 38 wasteway on average. In non-flood years, this decreases to 17 KAF and 1 KAF, respectively. Michael Cohen et al., *A Preliminary Water Balance for the Colorado River Delta, 1992-1998*, 49 J. ARID ENV'TS. 35, 43, 45 (2001).

canal. This water is not accounted for as part of the U.S. treaty delivery to Mexico. In effect, this bypass water decreases storage at Lake Mead by roughly one foot each year. The YDP was constructed to treat this bypass water and return roughly two-thirds of the water to the Colorado River.[54] The remaining brine stream would be discharged via the Main Outlet Drain Bypass Extension, a fifty-six km concrete canal, into the Cienega de Santa Clara. Discharging this low quality water into the Cienega de Santa Clara would quickly eliminate the 4200-ha cattail wetland that currently thrives on the bypass water, destroying habitat for several endangered species, which includes the Yuma clapper rail.[55]

During the twentieth century, main stem flows into the delta were reduced nearly seventy-five percent. In twenty-four of the past forty-five years, less than two percent of the Colorado River's estimated undepleted flow reached the delta. The Colorado River discharges to the delta when either or both of the following sets of conditions are satisfied: the elevation of Lake Mead on the Colorado River or Painted Rock Reservoir on the Gila River and projected run-off into that reservoir are both sufficiently high to trigger flood-control releases, and the timing and magnitude of these releases exceed the demands and diversion capacity of downstream diverters.[56] In eleven years within the most recent thirty year period of record (1974-2003), annual discharge at the SIB has exceeded 500,000 acre-feet. The gauge at the SIB (the southernmost point of the limitrophe dividing Baja California from Arizona) records discharge to the upstream extent of the delta.

IV. COLORADO RIVER DELTA FLOWS

In recent years, a number of reports and articles have been written describing various strategies for protecting and restoring the remnant Colorado River Delta.[57] Most of these writings recognize the importance of dedicating water to various delta habitats, though they differ in the sources and methods of acquisition of this water. Initial estimates of the volume required for preservation of the main stem below Morelos Dam are flood pulses of approximately 200 KAF every four to five years, with a minimum annual base flow of about 50 KAF to wet the streambed and provide habitat for the insects that are food

54. Reclamation recently estimated the YDP's annual operational costs at approximately $26 million, with an additional $26.2 million over four years in start-up costs, excluding environmental costs. Letter to Pete Domenici from Lynn Scarlett, Oct. 26, 2005 (on file with the *Pacific McGeorge Global Business & Development Law Journal*).

55. O. Hinojosa-Huerta et al., *Waterbird Communities and Associated Wetlands of the Colorado River Delta, México*, 27 STUDIES IN AVIAN BIOLOGY 52-60 (2004).

56. MISSING WATER, *supra* note 52.

57. *See e.g.* FRANCISCO ZAMORA-ARROYO, ET AL, CONSERVATION PRIORITIES IN THE COLORADO RIVER DELTA, MEXICO AND THE UNITED STATES (2005), *available at* http://www.sonoran.org/programs/sonoran_desert/si_ sdep_delta_priorities.html.

sources for many migrating birds.[58] The maintenance of the Cienega de Santa Clara will at least require the current quantity and quality of water that flows there. In early 1993, records of a disruption in flows to the Cienega de Santa Clara showed a rapid reduction in the size of the vegetated portion of the wetland.[59]

This water from the Colorado River could come from a variety of sources. Perhaps the most palatable sources would be to identify willing sellers or lessors of water rights in the United States and Mexico, and dedicate acquired waters for environmental purposes. Voluntary, market-based transactions involving willing participants are less likely to generate takings claims, and would offer the tangible benefit of providing capital infusions to the existing holder of the water right. Acquiring water within the United States for use in the limitrophe reach downstream of Morelos Dam would afford the opportunity to deliver water to one of the most valuable riparian areas of the river, though this would require cooperation from Mexico to ensure that this water is delivered through Morelos Dam. Acquiring water in Mexico, for use in Mexico, would offer the fewest institutional challenges, though this action could raise questions of equity because almost ninety percent of the river's depletions occur within the United States.

Other sources of water could include an assessment on water reallocations that dedicate a portion of the water transferred to the delta. The assessment could be combined with conservation improvements that enable agricultural and municipal users to improve their efficiency, and then transfer the resultant saved water. This water would require legal protections to ensure that it reached its intended destination. If the water was reallocated in the United States and the assessment dedicated for use in the limitrophe, any legal protection would likely require a treaty amendment to ensure that Mexico delivered the water through Morelos Dam.

V. THE CURRENT DROUGHT

After an unusually wet period in the late 1990s, during which Lake Mead filled and flood releases from Hoover Dam flowed past Morelos Dam through the limitrophe into the remnant delta, precipitation in the Colorado River Basin decreased dramatically, ushering in the lowest five-year period of run-off in the 100-year historical record. Since the drought began in 2000, total water storage on the system decreased by almost fifty percent, a loss of almost 30 MAF of water from the system. The surface elevation of Lake Mead dropped nearly eighty-three feet from December 1999 to December 2004.

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58. Jennifer Pitt et al., *Two Countries, One River: Managing for Nature in the Colorado River Delta*, 40 NAT. RESOURCES J. 819, 829-30 (2000).

59. S. Zengel, *Cienega de Santa Clara, A Remnant Wetland in the Rio Colorado Delta (Mexico): Vegetation Distribution and the Effects of Water Flow Reduction*, 4 ECOLOGICAL ENGINEERING 19, 36 (1996).

This rapid decrease in system storage raised the threat that lower basin users, especially the CAP, could face shortages in the near future. The basin states began discussions on the drought in early 2004. These discussions were contentious, driven by different interpretations of upper basin delivery obligations and acrimony due from the CAP because of the junior status of its water rights and its subsequent increased risk of shortage.

The states' discussions initially focused on federal and international drought management strategies, such as coordinated management of Lake Powell and Lake Mead, and sharing shortage with Mexico. Most of these drought management strategies would have a direct negative impact on efforts to acquire and dedicate water to the delta. The most immediate of these threats was an effort by Arizona water officials to force the operation of the YDP. This effort led to the insertion of language directing the Bureau of Reclamation to ready the plant for operation and report back to Congress on their efforts.[60] Congress has not appropriated sufficient funding to correct various design deficiencies at the plant. Full operation of the plant would decrease the volume of water flowing to the Cienega by two-thirds, and would triple the salinity of that water well beyond the tolerance of the vegetation that currently comprises the wetland.[61]

The basin states have also pressured the Bureau of Reclamation to reduce the volume of administrative spills and operational over-deliveries that reach the NIB. As in much of the arid West, these inefficiencies sustain the emergent wetlands and riparian forests that still exist. These spills and over-deliveries occur due to the absence of re-regulating reservoirs and limited storage capacity downstream of Parker Dam. When downstream users cancel water orders due to unexpected precipitation or other causes, the Bureau of Reclamation often has little recourse but to let this water flow to Mexico. Although Mexico often diverts this water at Morelos Dam, the dam lacks storage capacity, and this water either returns to the main stem through downstream wasteways or passes through the dam itself. In recent years, the Bureau of Reclamation has over-delivered about 70 KAF annually at the NIB. Reducing these over-deliveries would require capital-intensive construction projects, and would further decrease the volume of water reaching the delta.

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60. The House Report on the Energy and Water Development Appropriations Act includes: "the Committee believes the ability to operate the plant is critical and, therefore, directs the Bureau of Reclamation to expedite its modifications of the plant to accomplish state of the art operation, and accelerate the permitting and environmental compliance activities needed for operation of the plant. The Bureau of Reclamation is directed to report to the Committee on the status of those activities by December 31, 2003." H.R. REP. NO. 108-212, at 99 (2003).

61. Fortunately, the general manager of the Central Arizona Water Conservation District took the risk of convening a working group that included representatives of Arizona water users, federal regulators, and environmental interests toward developing a solution that met the needs of all of these interests. After months of work, this group developed a white paper that recommended a set of solutions to protect both Arizona's water interests and the Cienega de Santa Clara. This white paper (see supra note 11), was attached to the Secretary of the Interior's report to Congress on the status of the YDP. Preliminary Proposal, *supra* note 15.

The basin states also proposed apportioning shortage to Mexico.[62] Shortage for Mexico could be based on a proportion of the shortage borne by lower basin users. For example, assuming that consumptive use in the lower basin were reduced by 500 KAF, Mexico would be apportioned a shortage of 100 KAF.[63] It is unclear how Mexico would react to such a calculation, given that a surplus was declared in 2002 and lower basin users consumed some 900 KAF more than their basic apportionment that year, at the same time that upper basin users faced the greatest reductions in their consumptive use.

VI. CONCLUSION

The delta of the Colorado River boasts the largest remaining stands of native cottonwood-willow riparian forest on the river below Hoover Dam, as well as several large emergent wetlands fed by agricultural drainage. Though much reduced from their former extent, these habitats offer tremendous value to large numbers of migratory birds. The delta has attracted the interest of U.S. and Mexican environmental organizations and restoration practitioners, partly due to the rapid ecological response the riparian corridor demonstrated when flood waters flowed through the delta in the late 1990s. The simple return of water to the system prompted natural regeneration, which offered hope that dedicated instream flows could permanently protect this important ecological resource.

Several options exist for dedicating flows to the riparian corridor and emergent wetlands. Leasing water via voluntary, market-based transactions likely offers the least challenging option. Another option is to invest in efficiency-based improvements, either on-farm or more generally to water delivery systems, and dedicating a portion of the conserved water for environmental purposes. Finally, an assessment on other water transfers could be made that would return a portion of the conserved water to the stream. Each of these options faces various institutional obstacles, most notably a mechanism to ensure delivery of this water.

Rising demands in both Mexico and the United States challenge efforts to acquire this water. The recent and possibly on-going drought in the Colorado River Basin further challenges these efforts. Any reduction of surface water deliveries to the NIB will restrict the availability of Colorado River water in Mexico, challenging efforts to buy or lease water from irrigators to dedicate for ecological purposes. Increasing the demand for low-cost irrigation water will drive up its price, decreasing the volume of water that could be secured for these purposes. It is unclear that dedicated instream flows, assuming they could be leased, would be secure in times of shortage. Political pressure from urban and/or agricultural users could threaten instream flows that may have already been

62. *Id.*

63. 1500 KAF Mexican apportionment/9000 KAF (lower basin plus the Mexican apportionment) times a hypothetical declared shortage of 600 KAF.

secured if Mexico faces a reduction in surface water deliveries. These groups would call for the satisfaction of human demands before any ecological requirements, even if the instream flows have already been legally dedicated. Finally, a decrease in surface water deliveries to Mexico would lead to increased groundwater extraction, decreasing the elevation of the alluvial aquifer and drawing more water away from both the main stem and existing backwaters. If the aquifer is depleted, even surface water that has been secured and discharged to the main stem could rapidly disappear into the Colorado River's dry streambed.

The remnant Colorado River Delta offers one of the most promising locations for ecological restoration in the lower basin. All it needs is water.