# COCHITI RESERVOIR REREGULATION INTERAGENCY BIOLOGICAL REPORT

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Contributions by:

Chuck Mullins, U.S. Fish and Wildlife Service
Brian Hanson, U.S. Fish and Wildlife Service
John Pittenger, New Mexico Dept. of Game and Fish
Jerry Maracchini, New Mexico Dept. of Game and Fish
Terrell Johnson, Ecological Consultant
Richard Pecos, Pueblo de Cochiti
Floyd Pecos, Pueblo de Cochiti
José Herrera, Pueblo de Cochiti
Craig Allen, Bandelier National Monument
Lynette Giesen, U.S. Army Corps of Engineers
William Deragon, U.S. Army Corps of Engineers
Rob Leutheuser, Bureau of Reclamation
Lee Johnson, Santa Fe National Forest

Edited by:

Craig Allen, Brian Hanson, and Chuck Mullins

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## ACKNOWLEDGEMENTS

The interagency biological working group expresses its gratitude to Roberta Ball (U.S. Army Corps of Engineers) for processing and providing data on water fluxes and elevation levels at Cochiti Reservoir, Kay Beeley (Bandelier National Monument) for extensive work on the figures, and Steve Bracker (Bandelier National Monument) for writing software to analyze stream flow data and for graphics support. Dick Kreiner (U.S. Army Corps of Engineers), Garry Rowe (USDI Bureau of Reclamation), Mike Hamman (USDI Bureau of Reclamation), and Gary Daves (City of Albuquerque) contributed essential background information and feedback on ideas to the working group. The Pueblo de Cochiti graciously provided space in its recreation center for many of the working group's meetings, and allowed access through its land for field trips to portions of Cochiti Reservoir.

# EXECUTIVE SUMMARY

This report evaluates the biological effects of a proposal to use Cochiti Reservoir to reregulate irrigation water by occasionally and temporarily storing up to 5000 acre-feet of water during the summer irrigation season, from June through October of each year. Cochiti Reservoir is not presently authorized for storage of irrigation water - an authorization from Congress would be necessary to implement the reregulation proposal.

Reregulation may increase divertable water for the Middle Rio Grande Conservancy District (MRGCD) by capturing transit water from upstream storage not immediately needed for irrigation which currently must be passed through Cochiti Reservoir. From an ecological standpoint this passage of water is beneficial as it maintains the stability of the lake and provides water for plant and animal use in the riparian ecosystem downstream. Available information indicates a probable average savings to MRGCD of 440 acre-feet/year through this reregulation proposal, about 0.1% of the water diverted annually by MRGCD.

Data from the Otowi gage are analyzed to define the historic patterns of unregulated stream flow, especially flood events, in the Cochiti Reservoir reach of the Rio Grande. These data provide a template for defining an ecologically desirable pattern of management for Cochiti Reservoir. In particular, this analysis indicates that it is desirable to maintain stable pool levels during the summer. Historic flow data from the lower Rio Chama show that low flows on the Rio Chama are natural, and that winter low flows can be adequately supplemented without reregulation of Cochiti Reservoir by careful timing of water passages down the Rio Chama to replace evaporative losses in Cochiti's permanent pool.

An impressive delta and associated wetlands have developed in the headwaters of Cochiti Lake. Wetlands covered 199 acres in the delta area in 1991, with 47 acres of wetland inundated by the raising of the permanent pool in 1992. An additional 66 of the remaining 152 acres of wetland would be subject to flooding by the proposed reregulation storage. These lowest elevation wetlands are the most productive in the delta, as most organic sediments are deposited closest to the lake. The growing delta wetlands of Cochiti Lake are ecologically valuable due to the scarcity of such wetlands in the arid Southwest.

Even the relatively small amounts of water which would be held under the reregulation proposal would impose significant, negative impacts upon the vegetation and wildlife of the reservoir area, particularly in the headwaters delta region. The wetland vegetation of the delta would be directly impacted by reregulation water storage during the summer growing season. The fluctuating pool levels associated with reregulation storage

would also tend to physically destabilize the channel and bars in the delta area, leading to less stable environments for littoral vegetation development. In addition, the increases in water utilization by MRGCD on which the proposed reregulation focuses would further dewater biologically sensitive downstream reaches of the Rio Grande.

**Thus, the proposed reregulation is ecologically undesirable because of significant, direct and indirect, adverse biological impacts - it would move both Cochiti Reservoir and the downstream reaches of the Rio Grande farther away from the desired template of historic natural conditions and associated ecological integrity.** Avoidance of these impacts is impossible as the impacts are inherent in the core reregulation proposal to store irrigation water during the growing season. Measures to mitigate these impacts would still involve overall diminishment of ecosystem integrity and wildlife habitat and would therefore be ineffective.

Therefore: **The interagency biological working group recommends rejection of the reregulation proposal.**

Significant, unrealized opportunities exist within the current authorization to greatly enhance management for fish, wildlife, and recreation at Cochiti Reservoir and still meet the primary flood and sediment control purposes of the dam. The interagency biological working group envisions a "desired future condition" for Cochiti Reservoir as a diverse, productive ecosystem occupying a strategic location on the Rio Grande flyway. We believe that the Cochiti delta area can develop into one of the most ecologically significant wetlands in New Mexico, with great benefits for local wildlife, migratory waterfowl, several threatened or endangered species, fisheries, and human enjoyment of these values. **Thus, regardless of whether the reregulation proposal is pursued and implemented, the interagency biological working group recommends implementation of the following management measures for Cochiti Reservoir, all of which can be implemented within the current authorization:**

**1)** avoid carryover storage;
**2)** maintain adequate flow capacity on the Rio Grande below Cochiti Dam to avoid carryover storage at Cochiti Reservoir;
**3)** restore vegetation that has been impacted by prolonged water storage;
**4)** use the improved annual operation scenario outlined in Figure 15 as a guide for operating Cochiti Reservoir;
**5)** all petitions for extraordinary water holding operaions should be reviewed to insure consistency with the reservoir's authorization, including fish and wildlife; and
**6)** develop and maintain a single interagency biological team to enhance the ecological condition of Cochiti Lake and its delta.

## INTRODUCTION

This report evaluates the biological effects of a proposed plan to use Cochiti Reservoir to reregulate irrigation water by occasionally and temporarily storing up to 5000 acre-feet of water during the summer irrigation season, from June through October of each year. Cochiti Reservoir is not presently authorized for storage of irrigation water - an authorization from Congress would be necessary for this activity. Reregulation may increase divertable water for the Middle Rio Grande Conservancy District (MRGCD) which is downstream of Cochiti Dam (U.S. Army Corps of Engineers 1989); transit water from upstream storage not immediately needed for irrigation could be captured at Cochiti Reservoir and held until demanded by MRGCD. Under the present management of Cochiti Reservoir, once irrigation water is released from El Vado or Abiquiu Reservoirs it must be passed through Cochiti Reservoir. From a fish and wildlife standpoint this passage of water is beneficial, providing water for plant and animal use in the riparian ecosystem.

A biological assessment team was formed from a variety of agencies to investigate the biological effects of storing irrigation water in the reservoir. These agencies are the U.S. Fish and Wildlife Service, Bureau of Indian Affairs, Bureau of Reclamation, City of Albuquerque, Cochiti Pueblo, National Park Service, U.S. Army Corps of Engineers, U.S. Forest Service, New Mexico Department of Game and Fish, and a private ecological consultant. This interagency team met numerous times from 1991 to 1993, including several field trips to review conditions in the reservoir area.

During the analysis of the proposed project, the interagency biological team developed a mission statement to:

1. Analyze present water management and its relationship to fish and wildlife resources;
2. Evaluate the biological effects of the proposed reregulation of Cochiti Reservoir; and
3. Develop management recommendations to enhance fish and wildlife resources.

Individual members of the team prepared draft sections of this report, which were then collated and subjected to three rounds of editing and review to achieve the final report. The interagency team has tried to take a broad and inclusive, rather than parochial, view of the ecological, social, and water management issues surrounding this reregulation proposal. However, the team members share the perspective that a "balanced" view should not allow further degradation of the natural resources under consideration, which have already been greatly compromised by past and ongoing human activities.

## LEGISLATIVE AUTHORIZATION FOR OPERATION OF COCHITI RESERVOIR

Cochiti Dam is located on Cochiti Pueblo land on the southeast flank of the Jemez Mountains. The dam was completed in 1975 and is the only flood control reservoir for snow-melt runoff regulation on the mainstem of the Rio Grande. Thus Cochiti Reservoir is the key dam protecting the Middle Rio Grande Valley from severe flooding, in conjunction with the Rio Grande tributary reservoirs of Abiquiu, Galisteo, and Jemez Canyon. At the maximum flood control pool level of 5474.1 feet the reservoir would inundate 9060 surface acres and have a storage capacity of 736,000 acre-feet, including a sediment reserve of 110,000 acre-feet (U.S. Army Corps of Engineers 1974).

The original 1960 authorization for Cochiti Reservoir (P.L. 86-845, presented in Appendix A) was "solely for flood control and sediment control". This authorization further specifies that: "the outflow from Cochiti Reservoir during each spring flood and thereafter will be at the maximum rate of flow that can be carried at the time in the channel of Rio Grande through the middle valley without causing flooding of areas protected by levees or unreasonable damage to channel protective works...". Congressional intent was clearly to evacuate water from this reservoir as rapidly as possible and to avoid storing any water in Cochiti unless necessary for short-term flood control for the middle Rio Grande valley; storage of water for other reasons was not authorized. However, to protect downstream water rights, P.L. 86-645 does provide for carryover storage when excess water is in Cochiti Reservoir on July 1 and certain other conditions are met, although this legislation further states that Cochiti Reservoir "will be evacuated completely on or before March 31 of each year" in order to have the maximum capacity available to handle spring snow-melt runoff. Further, this law provides the Rio Grande Compact Commission with the authority to approve departures from the authorized operation schedule for authorized uses of the reservoir storage capacity. Neither current law nor the reservoir's easement from Cochiti Pueblo allow use of the reservoir to store excess water for water management or water conservation purposes.

In 1964, through P.L. 88-293 (see Appendix B), the original authorization was "supplemented to authorize, **for conservation and development of fish and wildlife resources** and for recreation, approximately 50,000 acre-feet of water for the initial filling of a permanent pool of 1200 surface acres in Cochiti Reservoir, and thereafter sufficient water annually to offset the evaporation from such area..." **One of the unique characteristics of Cochiti Reservoir is this specific secondary authorization for conservation and development of fish and wildlife resources.** Water conservation storage was not authorized. Overall, Cochiti Dam is operated to pass inflow and maintain the permanent pool year-round. Evaporation replacement water for the permanent, wildlife/recreation pool is delivered periodically by the Bureau of Reclamation from the San Juan-Chama Project. This permanent pool originally extended about 8 miles upstream from the dam and had about 24 miles of shoreline (U.S. Army Corps of Engineers 1974), but sedimentation of the upper end has reduced those numbers by about 20 percent to 6 and 19 miles, respectively.

A Memorandum of Agreement was signed March 25, 1977, between the National Park Service and the U.S. Army Corps of Engineers. This agreement permits inundation of 350 acres of Bandelier National Monument at the maximum flood-pool elevation of 5465.5 feet above sea level. It also provided a one-time partial payment for trail relocation in the Monument.

While several proposals for hydropower additions to Cochiti Dam have been made over the past fifteen years, the Pueblo de Cochiti has consistently opposed all such proposals. Current law (P.L. 101-644) expressly prohibits the licensing of any hydropower addition to the Cochiti Dam.

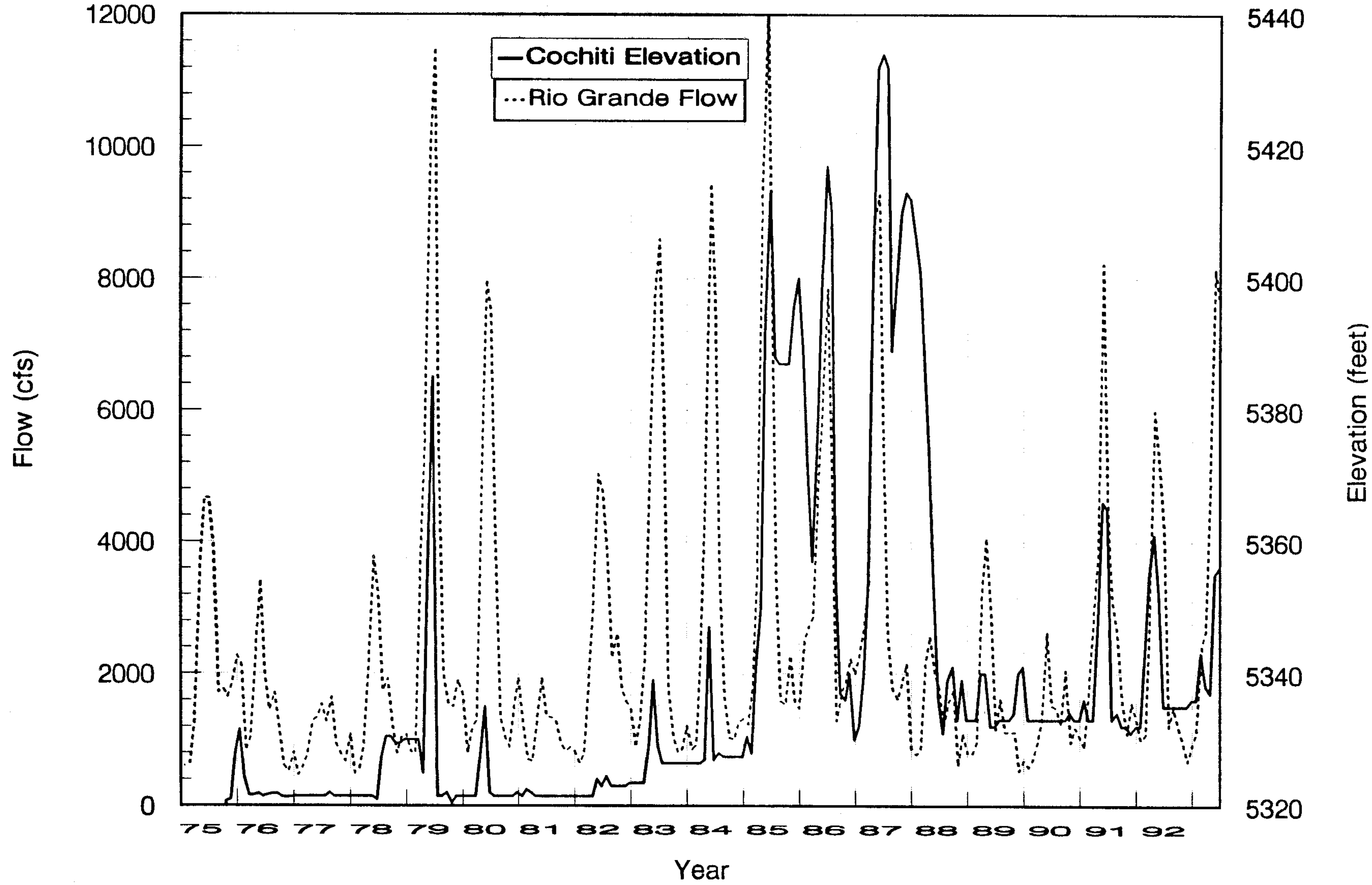
## REVIEW OF COCHITI RESERVOIR MANAGEMENT TO DATE

Figure 1 provides an overview of the water-holding history of Cochiti Reservoir to date. This graph shows the temporary storage of significant amounts of spring snow-melt runoff in 1979, 1980, 1983, 1984, 1989, 1991, and 1992 - this is the type of operation which was envisioned for this dam as outlined in its authorizing legislation (Appendices A and B) and Final Environmental Statement (U.S. Army Corps of Engineers 1974).

Larger amounts of snowmelt runoff were also retained after July 1 in 1985, 1986, and 1987, with water held through the winters of two of these years (Figure 1). These major retention events generally resulted from flow release restrictions imposed by human activities and channel conditions downstream, although in 1985-86 and 1987-88 excess water was also held during the winter months for other human reasons. Downstream channel capacity in the Rio Grande has varied from 3000 to 8000 cubic feet per second (cfs) in recent years, primarily due to sedimentation of the channel at the head of Elephant Butte Reservoir after this reservoir filled in 1985. Inflow peaks between 8000 cfs and 11,500 cfs occurred in 1979, 1980, 1983, and 1984 but resulted in only small, short-term storage events of the sort the dam was planned for, whereas similar inflow peaks and spring runoff volumes (Figures 1 and 2) in 1985, 1986, and 1987 led to long-term storage of large quantities of water at Cochiti.

Figure 1 also illustrates the increasing pressure since 1985 to store water in Cochiti Reservoir for reasons outside of its

Figure 1. Maximum Monthly Inflow (Rio Grande at Otowi) & Water Levels of Cochiti Reservior



current authorization. With the exception of the winter of 1978-79, during the period 1975-1984 only temporary, spring water storage occurred to control snow-melt runoff flooding; note how water storage mirrored the inflow to the reservoir during this period (Figure 1). However, since 1985 water has been held many times for a variety of reasons often unrelated to reservoir inflow, which is readily observable as discordance between inflow and storage and in the increased variability in reservoir elevation levels for non-spring runnoff seasons observed in recent years (Figure 1).

In general, the Rio Grande Compact Commission has approved exceptional storage operations for Cochiti Reservoir outside the dam's current authorization in order to conserve the maximum amount of total water in the Rio Grande system for human use, as well as to facilitate in-channel human activities downstream of Cochiti. Reasons for the major storage events which occurred during the high runoff period of 1985-1988 include: a) efforts to avoid losing the recreation pool at Elephant Butte (1985-1986) from a "spill" of the reservoir by tranferring this pool on paper to Cochiti Reservoir; b) an apparent generalized desire to store as much water as possible as far upstream as possible in case the runoff next year proved to be less generous, with a corollary recognition that water stored at Cochiti suffered less evaporative loss than water at Elephant Butte Reservoir; and c) in one or more years the extra water held through the winter at Cochiti helped generate enough volume to "spill" Elephant Butte in the subsequent spring, which canceled interstate water debts under the Rio Grande Compact. In 1989 conservation storage was planned (but never utilized) at Cochiti Reservoir to provide some flood control space in then-full Elephant Butte Reservoir while retaining the volume of water vacated from Elephant Butte in storage at Cochiti (see the resolution in the minutes of the 1989 Rio Grande Compact Commission meeting which outlines this plan). The smaller, irregular storage events observed since 1988 at Cochiti Reservoir have largely been due to restrictions in reservoir releases to provide reduced downstream flows to facilitate human activities, such as: outflow restricted to 100-300 cfs for water quality testing in the Albuquerque area (November-December 1989, February 1993); MRGCD repairs on the Isleta Diversion Dam (November 1990); outflow restricted to 300 cfs for foundation drilling exploration for the Alameda and I-40 bridges (February 1991); outflow restricted to 292 cfs for Bureau of Reclamation aerial survey of the Middle Rio Grande (February-March 1992); and outflow restricted to about 1100 cfs for construction work on the Alameda and I-40 bridges (February-March 1992, and January-March 1993). Note that the Corps of Engineers and Bureau of Reclamation worked hard in 1991, 1992, and 1993 to successfully evacuate the spring runoff from Cochiti Reservoir by July 1.

"Conservation and development of fish and wildlife resources" at Cochiti Reservoir has had a rather low profile. A "Fish and Wildlife Management Plan" was developed for Cochiti Lake (U.S. Army Corps of Engineers 1980), but this document has remained obscure and apparently not been implemented. "Proposals for a revised fish and wildlife management plan for Cochiti Lake" were subsequently developed (Johnson 1987), but have not been implemented. The National Park Service and U.S. Army Corps of Engineers have funded research on wintering bald eagles since the late 1970's (cf. Johnson 1979-1992). The main wildlife management activities undertaken to date have been the New Mexico Department of Game and Fish program to develop a recreational fishery through the planting of millions of non-native fish (see Table 8 in U.S. Army Corps of Engineers 1980). In addition the Corps did plant a one-acre "food plot" for several years in the Santa Fe Marsh area (see Table 9 in U.S. Army Corps of Engineers 1980).

## RIO GRANDE INFLOW TO COCHITI RESERVOIR: ANALYSIS OF RIVER FLOW DATA FROM THE OTOWI GAGE SITE

Since 1895 the USGS has maintained a flow gage just below the Otowi Bridge crossing of the Rio Grande. This gage is immediately upstream of Cochiti Reservoir and thus defines the water inputs to the reservoir. Daily mean flow data from this station, in cubic feet per second (cfs), were analyzed for the period 1895 to mid-1990 to ascertain the "natural" patterns of river flow - some of these analyses are presented below.

The USGS summary of data for the Otowi gage indicates that the Rio Grande has a watershed area of 14,300 $miles^2$ at this point. The mean flow value here is 1530 cfs, and the mean annual runoff volume is 1,108,000 acre-feet/year. The maximum recorded flow here was 24,400 cfs on May 23, 1920, and the minimum flow was 60 cfs on July 4, 1902.

Figure 2 shows the total annual flow for each year, revealing the tremendous variability in flow rates observed between years in Southwestern streams; for example, compare the years 1902-1905. Much of this annual variability is related to the El Niño-Southern Oscillation cycle which brings alternating wet and dry climatic conditions to this region (Molles and Dahm 1990). However, long-term trends are also visible in Figure 2, such as the period of reduced total annual flows in the 1930's, 1950's, 1960's, and 1970's.

Figure 3 presents the composite annual hydrograph for Otowi, displaying 10th, 50th (median), and 90th percentiles for daily flow rate, for each day of the year. Only the time period through 1962 was included in this analysis, as the closure of

Figure 2. Total Annual Flow, Rio Grande at Otowi Gage

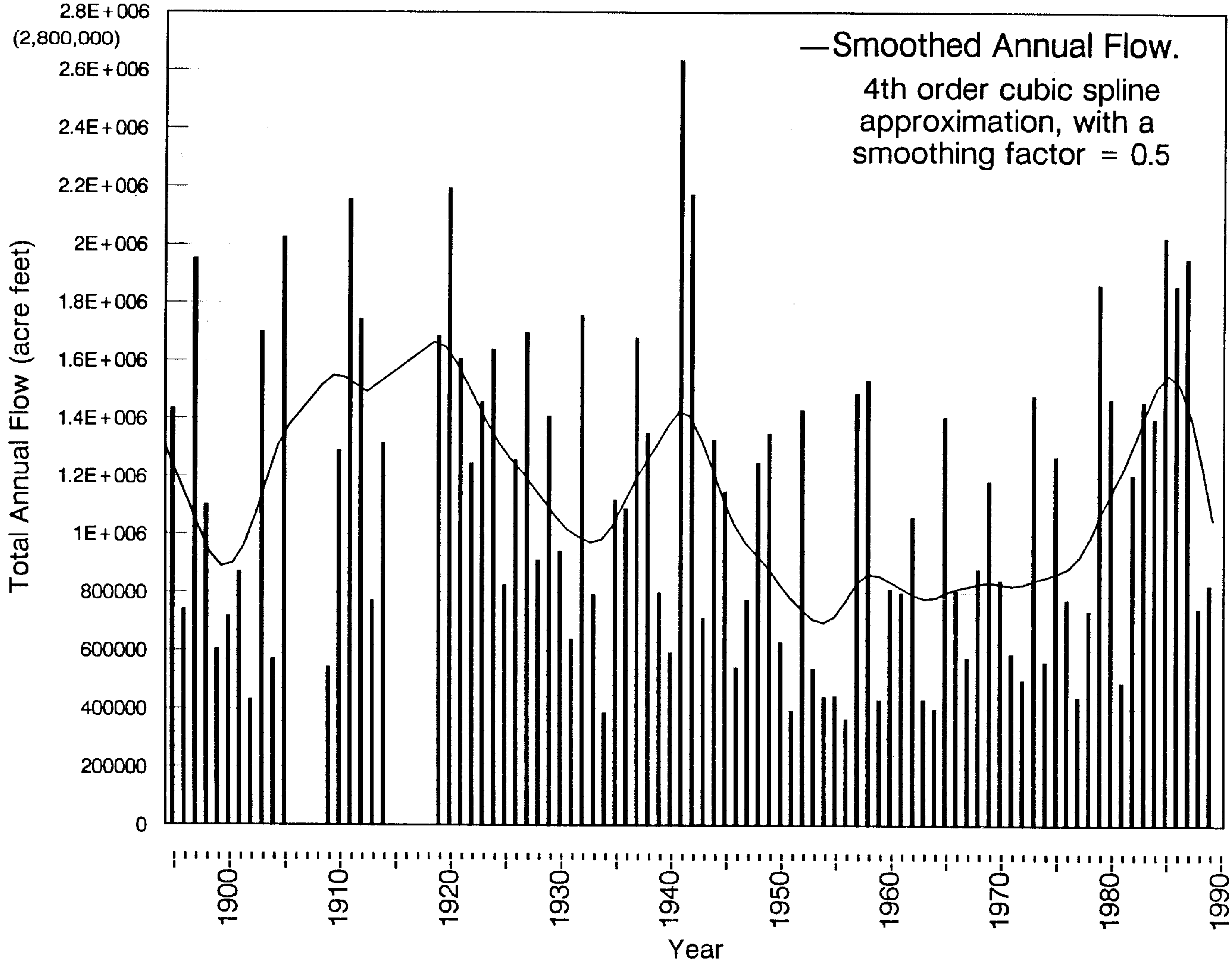
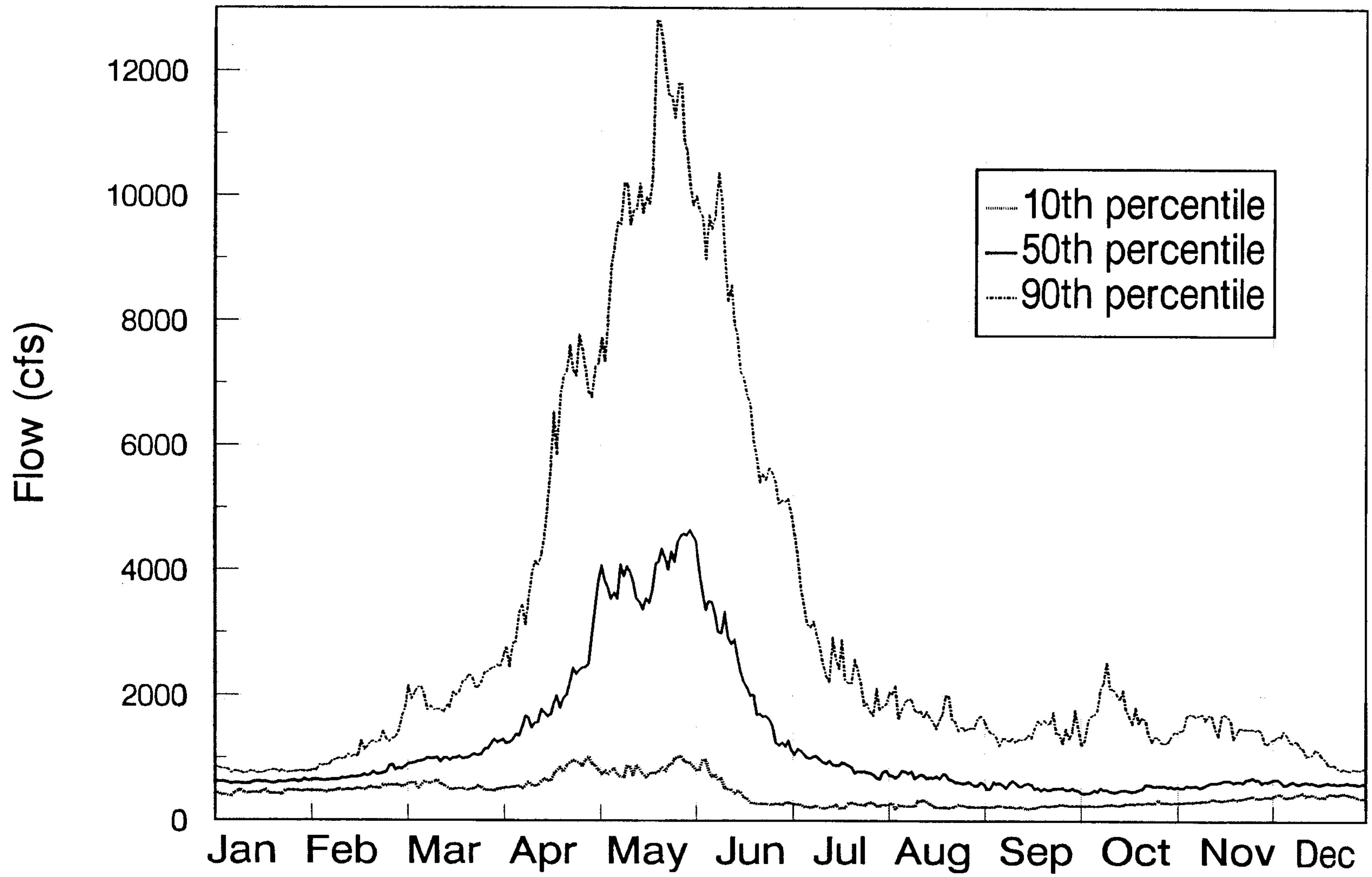


Figure 3. Rio Grande Daily Flow Rate at Otowi Gage, 1895-1962



Abiquiu Dam on the Rio Chama upstream in 1963 somewhat altered the natural flow regime. This composite hydrograph is dominated by the late-March to mid-July bulge from the spring snow-melt runoff, which typically peaks in mid to late May. Significant short-duration peak flows also occur on occasion in the summer and in the fall, caused by convectional thunderstorms in the summer and frontal precipitation in the fall; still, 90% of flows are almost entirely below 2000 cfs outside the spring runoff season. **The 90th percentile is the limiting template used by this committee to establish a desirable ecological pattern of management for Cochiti Reservoir**.

Figure 4 shows the annual, flow rate exceedence probabilites for several time periods at Otowi. The analysis of pre and post-1963 time periods was conducted to isolate effects from the regulation of the Rio Chama tributary by the closure of Abiquiu Dam in 1963. A 5% exceedance probability means a 5% chance of exceeding the plotted flow in any single year, which also indicates the 20-year flood, as 5% = 1/20. Reduced probabilities of moderate to high flows are observed after 1963, likely reflecting climatic variability as well as regulation of the Rio Chama. The increased probability of exceeding lower flows (<2500 cfs) after 1963 almost certainly reflects the the effects of regulated releases from Abiquiu Reservoir, as well as the transmountain influx of San Juan River water into the Rio Grande system after 1971.

Figure 5 displays overlapping circles for each day of the record which had out-of-bank flows, which were estimated as flows exceeding 5000 cfs. This estimate of 5000 cfs as the threshold of flood flows at Otowi is based upon Lagasse (1981), as well as use of Figure 4 which shows 5000 cfs as a 1.8-year return interval discharge, near the 1.5-year interval discharge which is considered to be a good estimator of bankfull discharge in many cases (Rosgen **et al** 1986). It is clear that out-of-bank flooding is largely confined to the season of snow-melt runoff, with occasional fall events in the period before 1930. Figure 6 displays these same data along with a measure of flood magnitude (total flow for each flood event) to emphasize that the greatest magnitude and longest duration out-of-bank flooding occurs during the spring runoff. Separate flood "events" were defined as the period bracketed by all days with flows over 5000 cfs which were separated by fewer than 10 days with flows below 5000 cfs, including the intervening lower flow days. Floods occur infrequently in fall, and are of short duration and moderately low magnitude, while floods are rare in summer and of very short duration and very low magnitude (Figures 5 and 6, and Table 1). Flows over 5000 cfs never occur in winter.

Figure 4. Rio Grande Flow Exceedence Probabilities, 1895-1990 at Otowi Gage

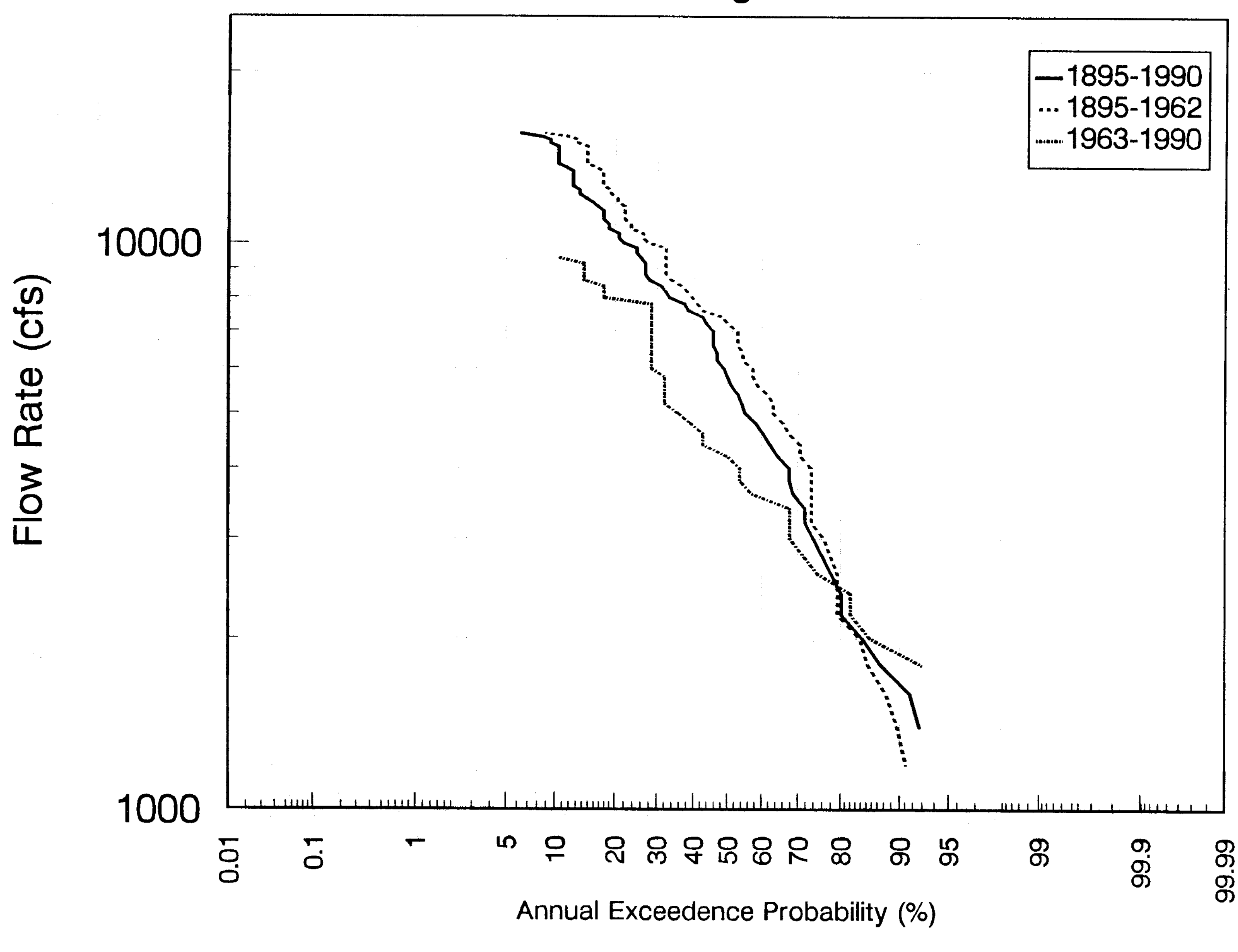


Figure 5. Dates of High Flows on the Rio Grande at Otowi Gage

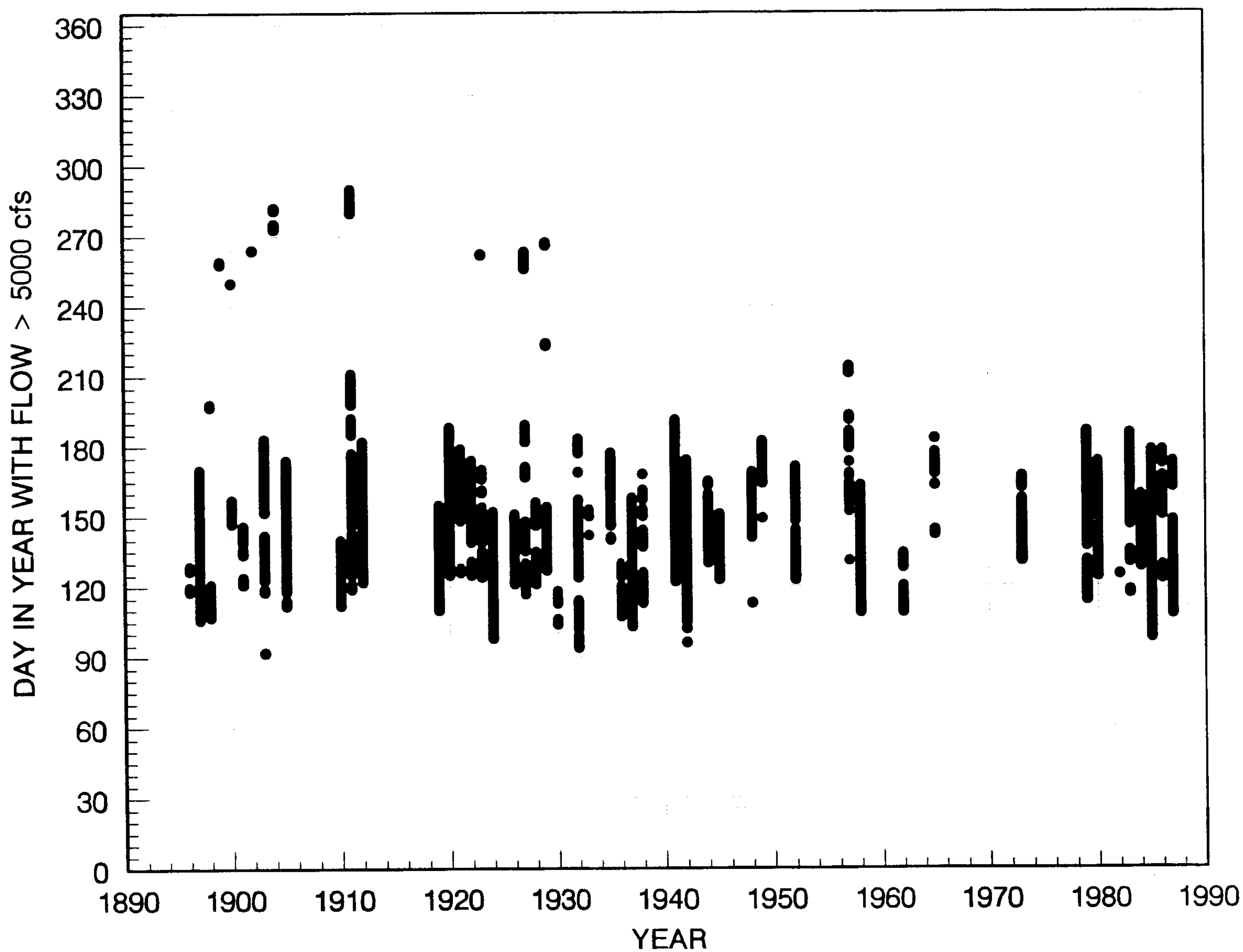


Figure 6. Date, Duration & Volume of High Flow Events, Rio Grande at Otowi Gage, 1895-1990. An event is defined as the period bracketed by all days with flows >5,000 cfs which were separated by fewer than 10 days with flows <5,000 cfs, including the intervening lower flow days.

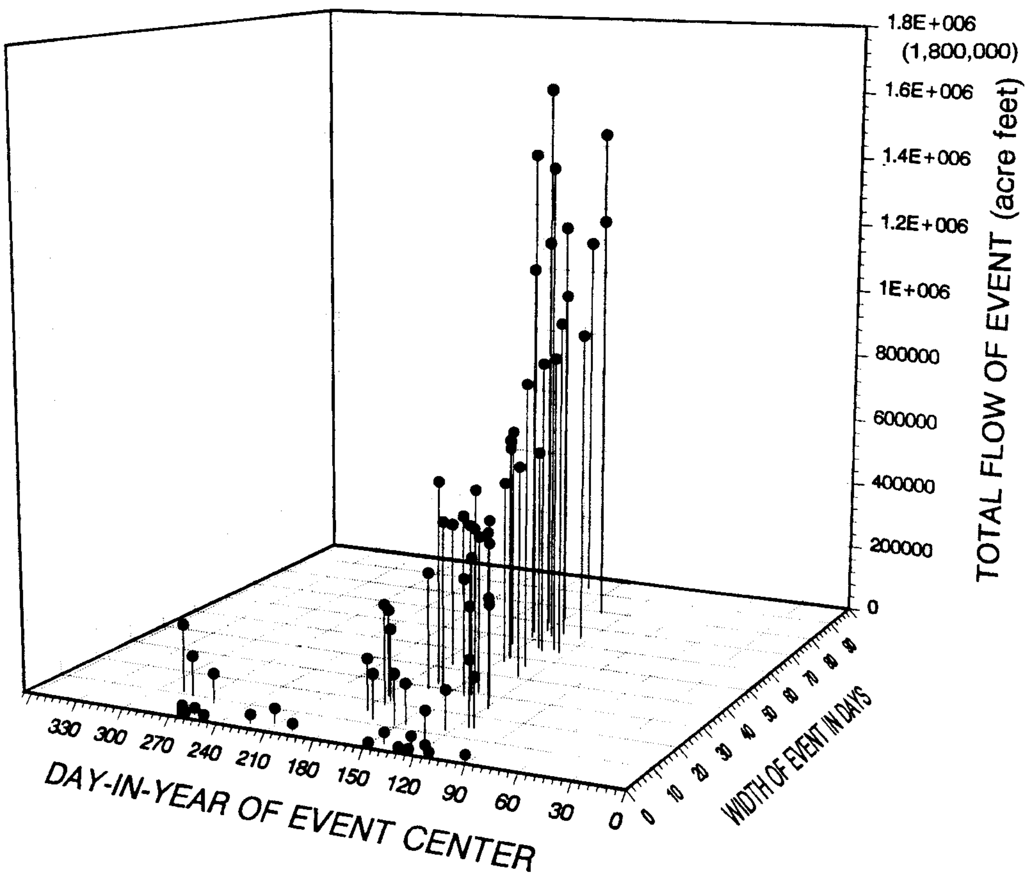


Table 1: Probability of flow greater than 5000 cfs on any day in the listed month at the Otowi gage on the Rio Grande, 1895-1990.

| Month | Probability | Month | Probability |
|---|---|---|---|
| January | 0 | July | 0.027 |
| February | 0 | August | 0.001 |
| March | 0 | September | 0.008 |
| April | 0.100 = 10.0% | October | 0.005 |
| May | 0.340 | November | 0 |
| June | 0.244 | December | 0 |

P = 0.059 for all days in all years.

**ANALYSIS OF RIO CHAMA FLOW DATA FROM THE CHAMITA GAGE SITE**

The USGS has maintained a flow gage on the Rio Chama at Chamita, just above the Chama's confluence with the Rio Grande, since 1912; this gage is the best measure of Rio Chama flows for the reach below Abiquiu Dam. Daily mean flow data from this station, in cubic feet per second (cfs), were analyzed for the period 1912 to mid-1990 to ascertain the "natural" patterns of river flow. Some of these analyses are presented here as it has been suggested that reregulation of Cochiti Reservoir could allow enhancement of Rio Chama low flows to provide ecological benefits for this reach of the Rio Chama.

The USGS summary of data for the Chamita gage indicates that the Rio Chama has a watershed area of 3144 miles$^2$ at this point. Prior to 1971, when trans-mountain water from the San Juan River began to be added to the Rio Chama, the mean flow value at Chamita was 541 cfs with a mean annual runoff volume is 392,000 acre-feet/year; after 1971 these values increased to 569 cfs and 412,200 acre-feet/year. The maximum recorded flow here was an estimate of 15,000 cfs on May 22, 1920, with ungaged floods on Sept. 29, 1904 and October 4-5, 1911 probably exceeding 15,000 cfs. Minimum flows of 0 cfs have occurred in many years.

Again, tremendous variability in total annual flow rates is observed on the Rio Chama (Figure 7), even though upstream storage at Abiquiu, El Vado, and Heron Reservoirs and the input of water diverted from the San Juan River have probably reduced the Rio Chama's inherent variability somewhat in recent decades.

Figure 8 presents the composite annual hydrograph for the Rio Chama, displaying the 10th, 50th (median), and 90th percentiles for daily flow rate, for each day of the year prior to the

Figure 7. Total Annual Flow, Rio Chama at Chamita Gage

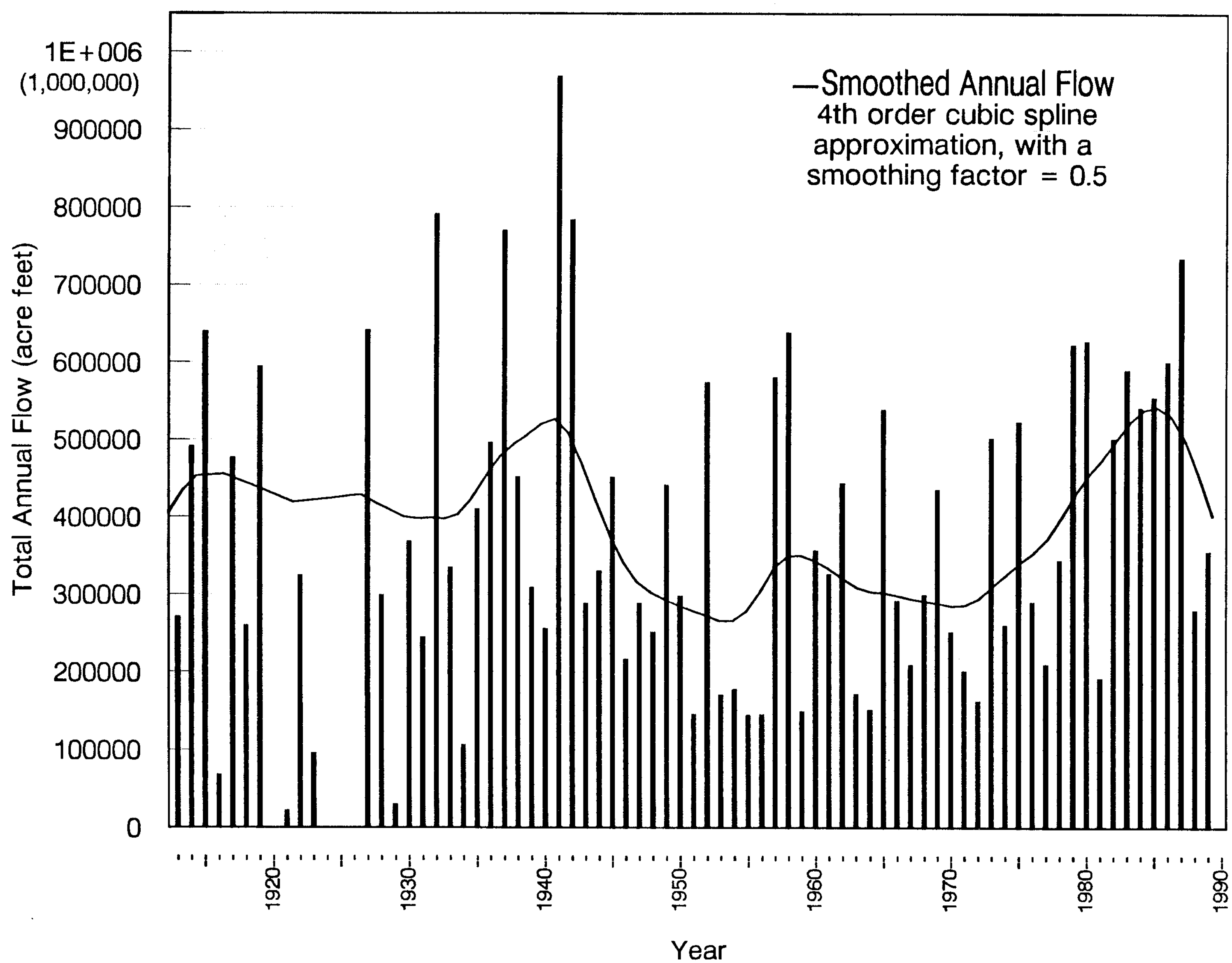
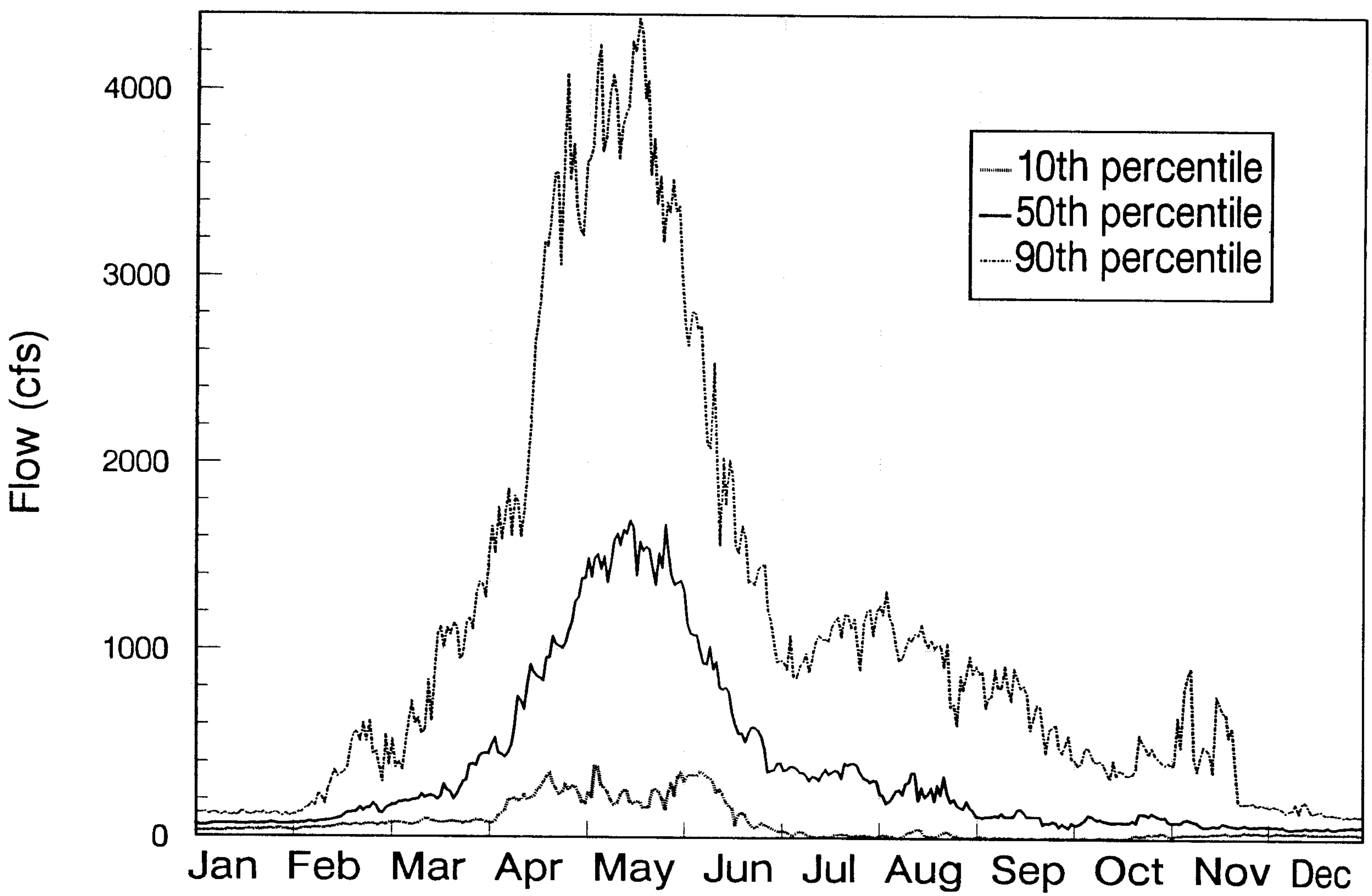


Figure 8. Rio Chama Daily Flow Rate at Chamita Gage, 1912-1962



closure of Abiquiu Dam in 1963. As with the Otowi site on the Rio Grande, the Chamita hydrograph is dominated by the spring snow-melt runoff from mid-March to late-June, which typically peaks in May. Again, smaller magnitude, shorter-duration events are observed due to convectional thunderstorms in the summer and frontal precipitation in the fall.

Figure 9 shows the annual, flow rate exceedence probabilites for the Chamita gage. A 5% exceedance probability means a 5% chance of exceeding the plotted flow in any single year - this also indicates the 20-year flood, as 5% = 1/20. This analysis shows markedly reduced probabilities of high peak flows after 1963, primarily due to the regulation of the Rio Chama by a number of upstream dams, especially Abiquiu Dam. Still, flows exceeding 3000 cfs have occurred as recently as 1987. For the period of record, a 2500 cfs event occurred about every other year (50% exceedance probability). The increased probability of exceeding lower flows (<1700 cfs) after 1963 almost certainly reflects the the effects of regulated releases from Abiquiu Reservoir, as well as the transmountain influx of San Juan River water into the Rio Chama after 1971.

Abiquiu Dam has altered human perceptions of flood hazards, leading to encroachment of human structures into the lower Rio Chama's flood plain, while the trapping of sediment loads behind the dam has increased the erosive power of the stream. As a result, flows of 1500 cfs are now claimed to be the threshold of damage to human property in this reach of the Rio Chama where historically flows of 1500 cfs or greater occurred in three out of every four years (Figure 9).

Analyses of historic patterns of low flow on the Rio Chama reveal that median flows below or near 100 cfs have been common throughout much of the year and are typically below 100 cfs in December and January (Figure 8). Even the 10th percentile often approaches flows of 0 cfs in late summer and early fall, likely reflecting the combination of typically low flows and irrigation demands during this season. However, extreme low flows in summer have become less frequent in recent decades due to the enhancement of the Rio Chama with San Juan River water which passes through on its way to the MRGCD and the City of Albuquerque. The U.S. Fish and Wildlife Service has recommended a minimum flow of 70 cfs, based upon fishery studies (Hanson 1992).

Figure 10 shows the sum (in acre-feet) of winter (November-February) water deficits below 50 and 75 cfs at the Chamita gage; i.e., the calculated value shows the total volume of water that would have been required to keep the Rio Chama flow from dropping below 50 (or 75) cfs each day that winter. (Note: a flow of 1 cfs = 1.98 acre-feet/day.) Over the period of record 1165 acre-feet of supplemental water is the maximum that would have been

Figure 9. Rio Chama Flow Exceedence Probabilities, 1912-1990, at Chamita Gage

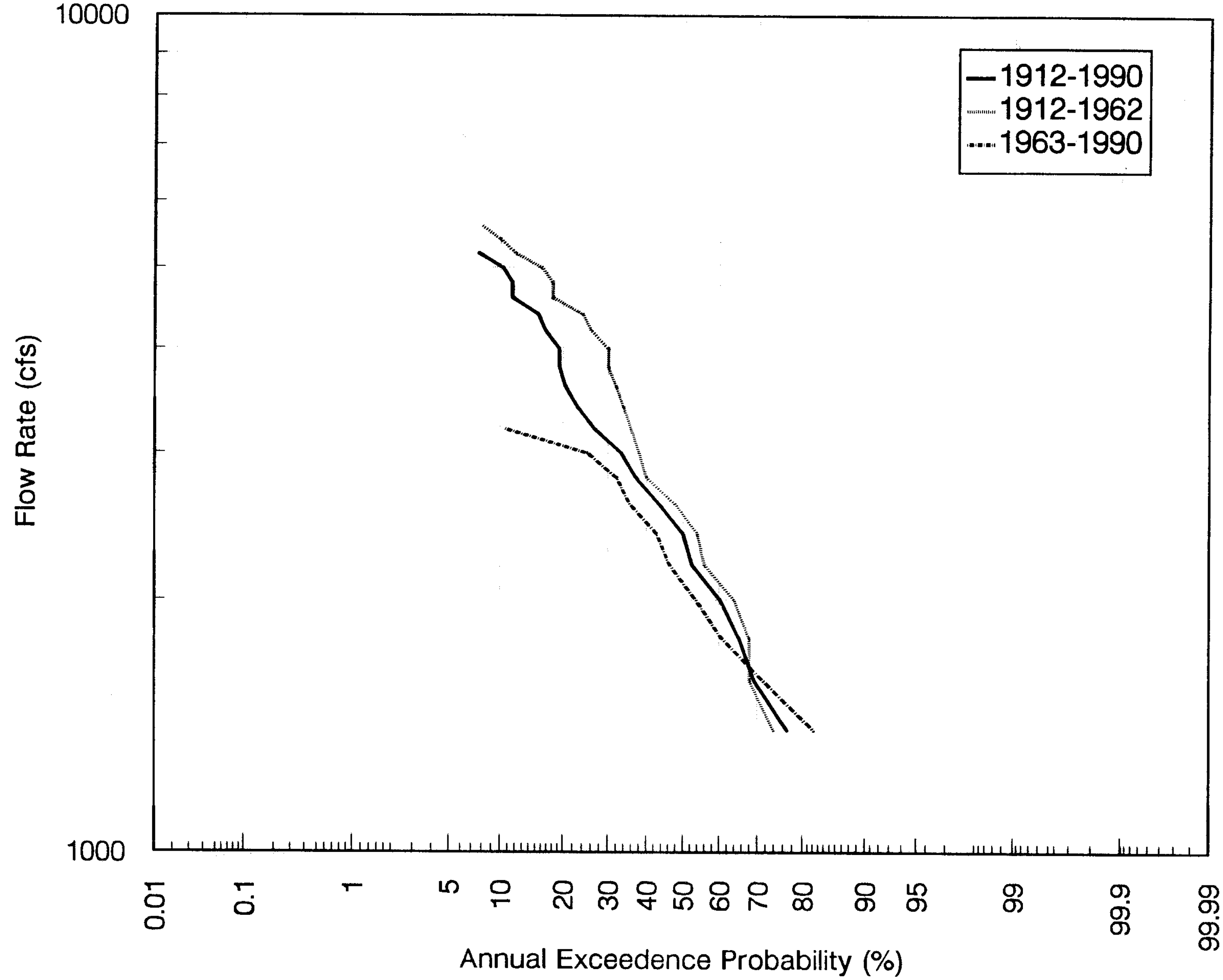
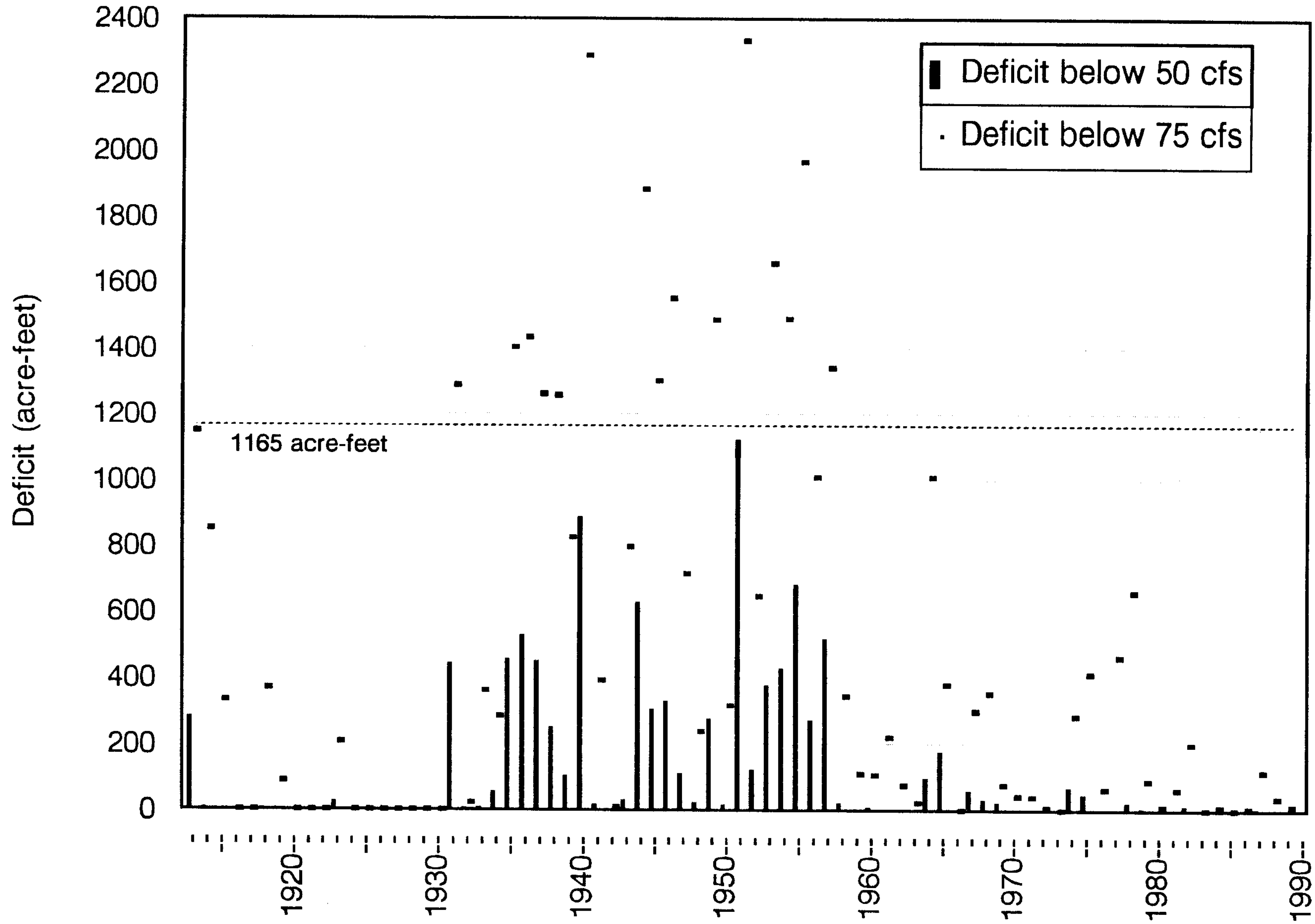


Figure 10. Cumulative Winter (Nov-Feb) Water Deficit, 1913-1989 at Lower Rio Chama



needed in any winter to keep the Rio Chama from dropping below 50 cfs, and since the late 1950's only 200 acre-feet would have sufficed. Since the mid-1960's no more than 660 acre-feet of supplemental water would have been needed in any winter to have prevented flows below 75 cfs.

## ECOLOGICAL COMPONENTS OF COCHITI RESERVOIR

The ecological components of Cochiti Reservoir are treated in four sections: 1) emerging delta and other aquatic/wetland ecosystems; 2) vegetation; 3) wildlife; and 4) fish communities.

### EMERGING DELTA AND OTHER AQUATIC/WETLAND ECOSYSTEMS

Cochiti Reservoir is composed of three parts: the upper, shallow, delta wetland area; the deeper body of the lake; and the Santa Fe wetland. The upper delta area is formed by silt deposition from the Rio Grande caused by slow water at the head of the lake. The main body of the lake is very small relative to inflow and is characterized by deep, clear water except in spring. The Santa Fe wetland is created by an inflow from the Santa Fe River near the east side of Cochiti Dam, and is maintained as part of the 1200-acre permanent pool.

Aggradation of sediments in the river channel and adjacent floodplain was formerly a natural phenomenon along much of the Rio Grande, which combined with multiple, meandering stream channels and undiverted water flows to provide a variety of wetland environments in the riparian zone. Most of these native wetland habitats have been lost through such human activities as: diversion of water from the river channel for consumptive human uses; human alteration of the river channel, especially through the Bureau of Reclamation's "river maintenance program" (cf. chapters 6 and 7 **in** Graf 1991, USDI Bureau of Reclamation 1992); regulation of river flows and sediment loads with dams; and degradation of the channel downstream from reservoirs due to interruption of natural sediment loads. River deltas at the heads of the major reservoirs provide one of the few remaining opportunities to maintain such near-stream wetland habitats.

An impressive delta and associated wetlands (biologically defined) are developing in the headwaters of the lake in White Rock Canyon (see Figure 11 and Photo 1). The wetlands are forming on the sediments deposited by the Rio Grande during and after spring runoff, as well as on sediments from side tributaries such as Sanchez and Medio Canyons. Figure 12 shows the development of the delta as a wedge of sediments being deposited in the Bland Cañon to Frijoles Cañon reach. Figure 13 displays channel cross-section data collected by the Corps in 1972, 1981, and 1991 near the mouth of Medio Cañon (Range 8-1),

# Figure 11. Map of the Cochiti Lake Delta

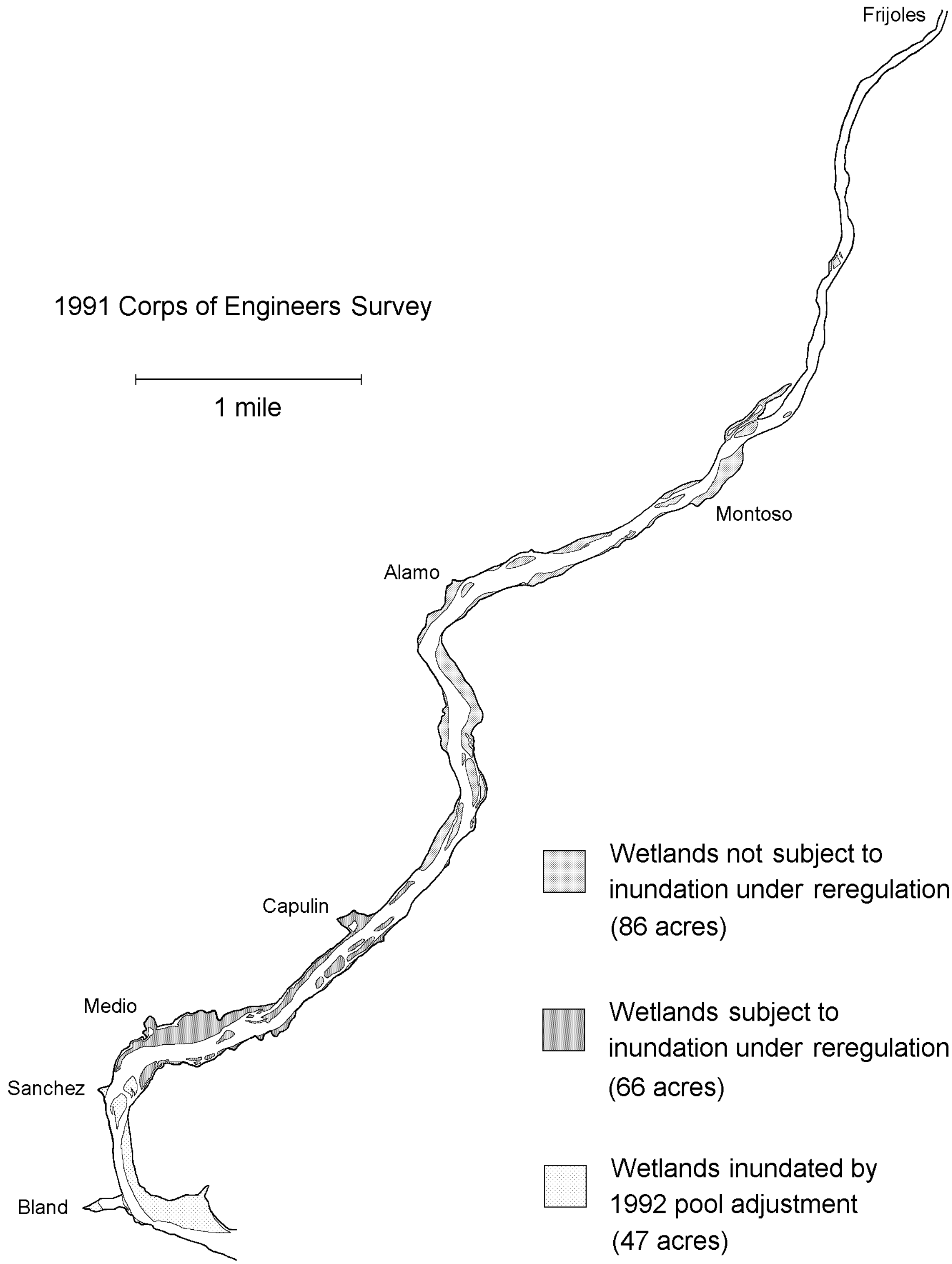


Photo 1.  Cochiti Lake Delta

Figure 12. Longitudinal Profile of Cochiti Lake Delta

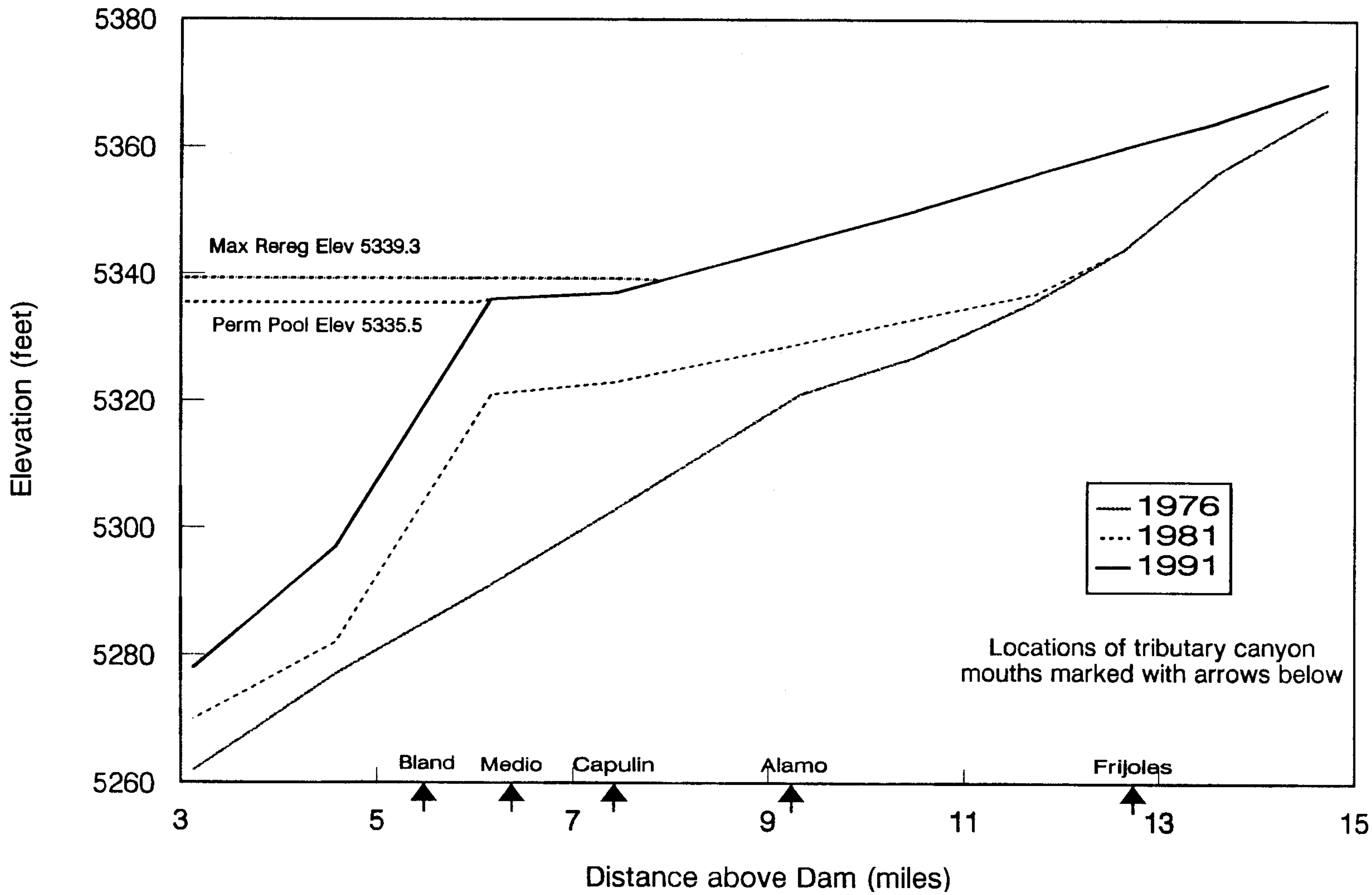
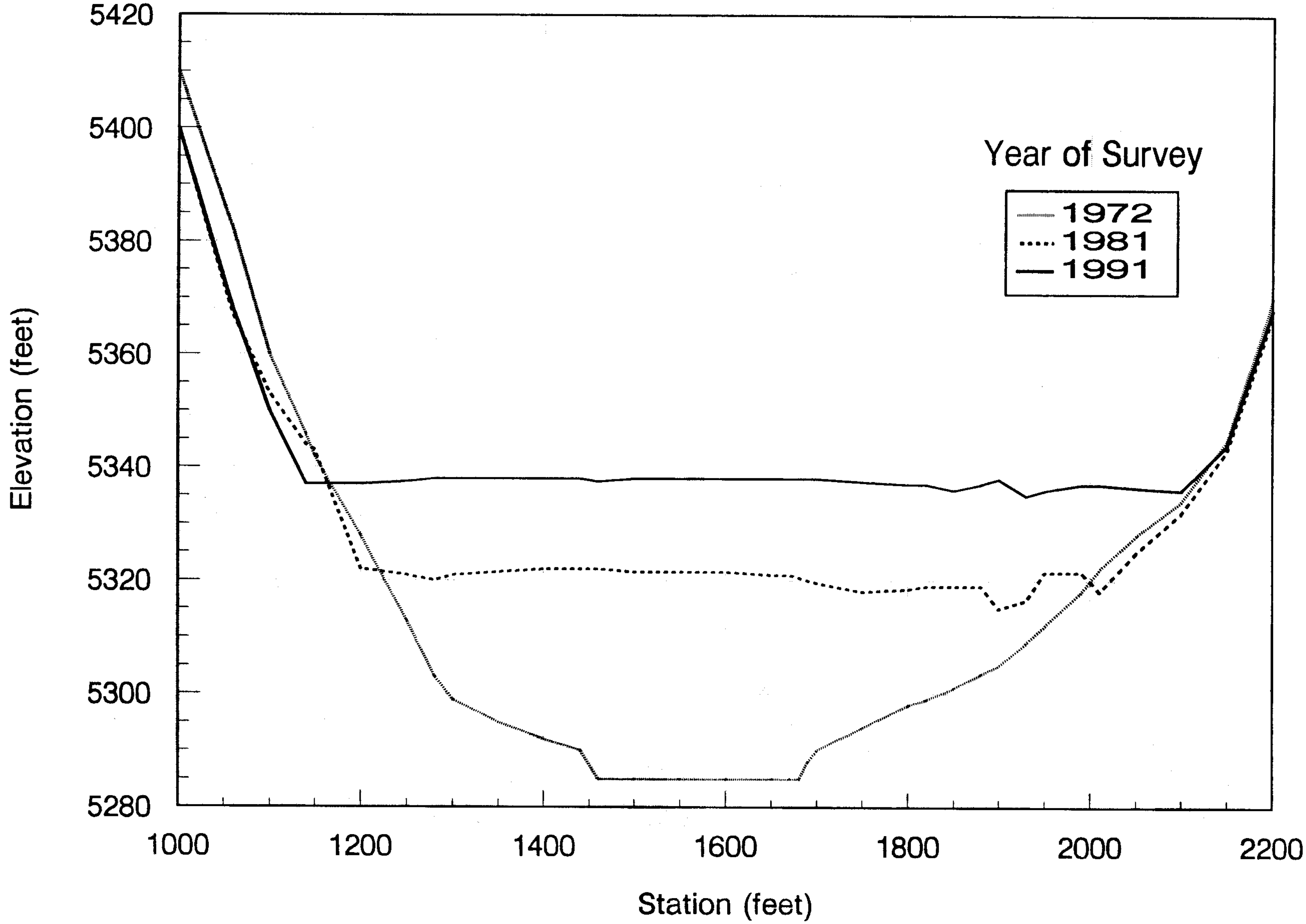


Figure 13. Survey Profile of Cochiti Lake Delta at Medio Canyon (Range 8-1)



showing up to 50 feet of sediment deposited by 1991. Figure 14 shows the delta as the flattened portion of the elevation **versus** area curve for Cochiti Reservoir.

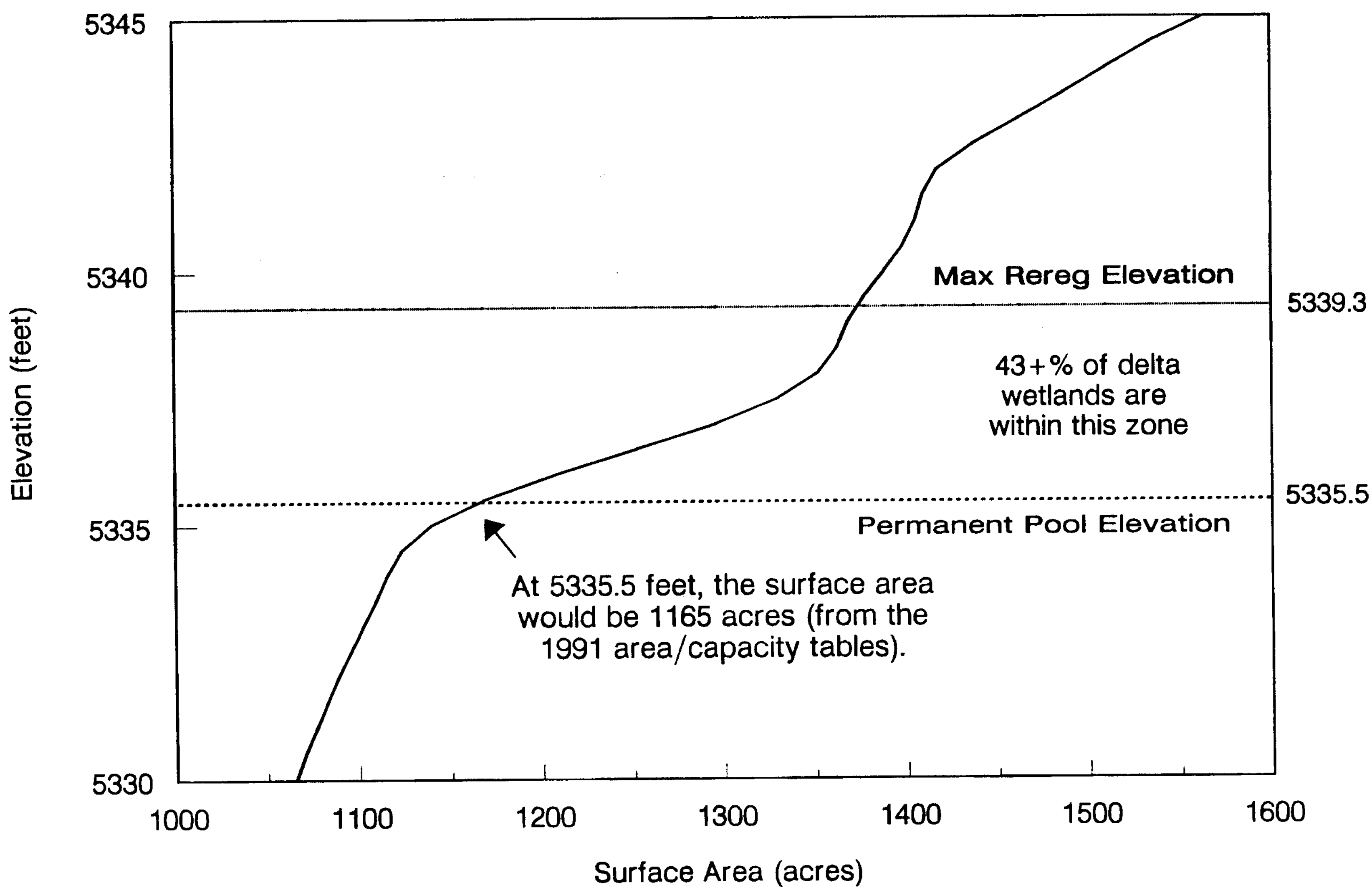
The delta area is characterized by a broad, generally shallow and often braided channel, with many mudbars and sloughs. Although confined by canyon walls, the river is free to wander between them. Thus the delta generally grows wider at the lower end, where sediments are deeper. This is also where finer sediments and more organic materials are deposited, and consequently where the richest growth of vegetation occurs. Figure 11 displays the 1991 spatial distribution within White Rock Cañon of the delta and its associated wetlands. Wetlands (here defined as **not** river channel, i.e., bars and sloughs) are estimated to have covered 199 acres in 1991, with 47 acres of wetland inundated by the raising of the permanent pool in 1992. Note that 66 of the 152 acres of non-inundated wetland are in the lower elevation portions of the delta closest to the lake, where they would be subject to flooding by the proposed reregulation storage.

Due to ongoing sediment deposition, this delta and its wetlands will continue to expand even as the level of the permanent pool is raised to maintain a constant surface area. The area of the delta is already 1/3 the size of the permanent pool, and has been growing by an average of 25 acres per year. The delta has displayed an average growth of about 1400 acre-ft/year to reach its 1991 volume of approximately 23,000 acre-ft, which is 21% of the 110,000 acre-ft sediment reserve of the reservoir. However, if the rate of annual pool adjustment falls behind the rate of delta advancement then relatively large areas of delta are inundated in post-survey adjustments, as occurred in 1992 (see Figure 11).

The Rio Grande brings water, nutrients, and sediment into the lake through the headwaters delta, which retains sediment and traps and releases nutrients. The mudbars, submerged at high flows, trap sediment, especially if vegetated. The presence of vegetation increases the level of nutrients on the bars, and amplifies the entire process of sediment deposition. The headwater delta thus buffers the flow of nutrients into the reservoir. This ability increases with its size and vegetative cover. The biological productivity of the delta wetland depends on the hydrologic stability of the channel and the reservoir, and the amount of vegetation on the bars. Vegetation is in itself biologically productive while also providing food and habitat for other wetland and aquatic organisms. Overall, the low water retention time of this flood control reservoir significantly limits the biotic productivity of Cochiti Lake.

The Santa Fe wetland, where the Santa Fe River becomes impounded behind Cochiti Dam, is characterized by a braided channel, mudbars, sloughs, shallow ponds, and a gentle shoreline; some

Figure 14. Cochiti Reservoir Elevation vs Area (1991 survey)



wind shelter is provided by Cochiti Dam. This area is a miniature of the headwaters delta and Cochiti Reservoir, differing primarily in scale. Thirty-five acres of the 1200-acre permanent pool are allocated for evaporative water loss in the Santa Fe wetland. This area is hydrologically cut off from the reservoir at current permanent pool levels, but it is occasionally inundated by high water stored in the reservoir. Sediment brought in by the Santa Fe River will gradually fill the ponds in this area, but it will remain a wetland for many years. Nutrient levels in the ponds are high due to sewage effluent from the Santa Fe area in the Santa Fe River.

**VEGETATION**

The National Park Service and U.S. Army Corps of Engineers sponsored research on the "Plant Ecology of (the) Shoreline Zone of Rio Grande-Cochiti Lake" (Potter 1981). Potter mapped the vegetation of the upper reaches of the reservoir from 1:14,400 air photos taken 8/7/80, field checked the mapping, and then field reviewed the effects of the 1979 water storage and the overall vegetation ecology of this area. Potter mapped and tabulated seven "shoreline types" in this area, namely bars and bare areas, sparse juniper-shrub, medium density juniper-shrub, dense juniper shrub, shrub-grass, juniper-cottonwood, and juniper-cottonwood-(ponderosa) pine. Potter provides detailed species lists of the graminoids, forbs, shrubs, and vines found in each of these shoreline types above and below the 1979 flood level. For example, in the "bars and bare areas" type Potter lists 41 forbs, 18 graminoids (including Carex spp., Distichlis stricta, Echinochloa crusgalli, Juncus interior, Phragmites communis, and Typha latifolia), 1 vine, and 10 tree or shrub species (including Salix spp., Populus angustifolia, and Tamarix pentandra).

To categorize the value and usage of the headwater's habitat for waterfowl, plants from the headwaters wetland area were collected during the biological team field trip of September 20, 1991, and identified (Table 2). Dominant plant types were classified based on their food value to waterfowl, and by the type of habitat indicator they may be according to the National Range of Indicators (NRI). The NRI is an index used to assess plant community types (Reed 1988); it estimates probabilities of a species occurring in wetland versus nonwetland habitats across the entire distribution of that species.

The wetlands at the head of Cochiti Lake provide a variety of valuable plants and habitat types for many species of wildlife. For example, ducks and other waterfowl will utilize a number of different plant species that may be typical of wet or moist areas for food such as barnyard grasses (Echinocloa spp.), but will also use some plants that may occur in upland areas for cover and nesting such as amaranthus (Amaranthus spp.). While some wetland plant species can occupy a wide range of habitats, other species are limited to more mesic environments and are rarely found in areas without readily available water.

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Table 2. Plants collected in the wetland at the headwaters of Cochiti Lake, September 20, 1991.

Dominant Plant Types

| Scientific Name | Common Name | Indicator | Food Value |
|---|---|---|---|
| Echinocloa colona | Jungle rice | FACW[1] | Excellent |
| Echinocloa crusgalli | Barnyard grass | FACW | Excellent |
| Cyperus aristatus | Awned flatsedge | OBL[2] | Good to excellent |
| Bidens cernua | Nodding beggar-ticks | OBL | Slight |
| Bidens frondosa | Devil's beggar-ticks | FACW | Slight |
| Eleocharis spp. | Spikerush | Mostly FACW | Fair to good |
| Amaranthus palmeri | Palmer's amaranthus | FACU[3] | Fair to good |

[1] National Range of Indicators (Reed 1988).
FACW - Facultative Wetland. This plant species occurs in wetlands at an estimated probability of 67-99%, but is occasionally found in nonwetlands.

[2] OBL - Obligate Wetland. This plant species occurs under natural conditions in wetlands at an estimated probability of >99%.

[3] FACU -Facultative Upland. This plant species usually occurs in nonwetlands at an estimated probability of 67-99%, but is occasionally found in wetlands at an estimated probability of 1-33%.

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The types, abundances, and diversity of plants found in the Cochiti Lake delta area provide essential habitat for many wildlife species. This vegetation is particularly valuable to overwintering waterfowl through its direct provision of energy-rich food in the form of seeds, protective cover for resting, and escape cover from predators (cf. Ringleman 1991). One of the most locally important waterfowl foods is barnyard grass (Echinocloa spp., see Martin and Uhler 1939), which is abundant within the headwaters delta. Except when disrupted by untimely flooding, the existing vegetation also supports significant invertebrate populations. These vegetation-dependent arthropods form another important trophic level in local food webs, providing an energy-rich food source for many vertebrate wildlife species, including waterfowl.

**WILDLIFE**

The delta wetland and the adjacent side canyons are a favorite loafing area for wintering waterfowl - between 500 and 1000 have been observed near Medio Cañon each of the past several winters (Photo 2). The delta is also a significant habitat within the migration corridor found along the Rio Grande, providing valuable shallow water loafing areas, an abundant food supply, and vegetative cover. Annual aerial surveys of waterfowl on "Cochiti Lake" since the mid-1980's by the New Mexico Dept. of Game and Fish (personal communication - Greg Schmidt) have counted up to 4714 waterfowl in October, 15,530 in November (mostly using Cochiti as a stopover point on their southerly migration), 11,312 in December, and 2785 in January (overwintering birds). These birds and other wildlife are particularly attracted to the delta when there is an ample supply of vegetation-associated food and cover, as well as water.

With respect to threatened and endangered species, the development of the permanent pool at Cochiti Reservoir has been beneficial for overwintering bald eagles, by providing improved food supplies in the form of fish (especially) and waterfowl (Johnson 1988-a). Observations indicate that peregrine falcons also forage for avian prey species in both the Santa Fe Marsh and the headwaters delta in White Rock Cañon. The delta area and Santa Fe wetland may also be used by whooping cranes during their spring and fall migrations through the Cochiti Lake area; certainly the more numerous sandhill cranes have been observed in both places.

The Santa Fe wetland similarly provides significant habitat for waterfowl and other wildlife. This area belongs to Cochiti Pueblo, and provides one of the best opportunities to view wildlife in the area.

**FISH**

Water level management in Cochiti Reservoir influences fish communities in three relatively distinct areas: the Rio Chama and Rio Grande from Abiquiu Dam to Cochiti Reservoir, Cochiti Reservoir pool, and the Rio Grande below Cochiti Reservoir. The following discussion is organized into two parts: 1) an overview of the fish communities in the Rio Grande above and below Cochiti Reservoir, with emphasis on the native ichthyofauna; and 2) the recreational fishery at Cochiti Reservoir, emphasizing non-native game fish.

**Overview of Rio Grande Fish Communities**

Historically, about 26 species comprised the native fish community of the Rio Grande between Velarde and Elephant Butte (Sublette et al. 1990, Bestgen and Platania 1989, Platania 1991). The native fish species of the Rio Grande evolved under flow conditions that have been disrupted by the impoundment of river water and regulation of flows, irrigation diversions, physical disruption of the channel and floodplain through practices such

Photo 2.  Waterfowl at Cochiti Lake Delta

as dredging and channelization, alteration of watershed conditions (e.g., through landscape-wide livestock grazing), and other factors. The dynamic changes in instream habitat and the resulting habitat diversity created by the variability of the historic hydrograph (which included recorded flows up to 24,400 cfs at the Otowi gage) have also been interrupted by regulation of the river.

The Rio Chama and Rio Grande from Abiquiu Dam to Cochiti Reservoir were historically inhabited by 13 species, six of which have been extirpated. Of these six extirpated species, three are listed or under listing review (Tables 3 and 4).

Historically, an assemblage of four native, mainstream cyprinids occurred in the Rio Grande: the Rio Grande bluntnose shiner, Rio Grande shiner, phantom shiner, and Rio Grande silvery minnow. These four species occupied only the mainstem of the Rio Grande and large tributary habitats, such as the Rio Chama (Bestgen and Platania 1987). All four species are in various states of biological endangerment. Three of the species have likely been extirpated from the Rio Grande drainage.

The Rio Grande shiner, phantom shiner, and the Rio Grande bluntnose shiner are thought to be extirpated from the Rio Grande of New Mexico (Bestgen and Platania 1990). While the Rio Grande shiner maintains erratic but enduring populations in the Pecos River drainage, the Rio Grande bluntnose shiner may be extinct. Because the reach of the Rio Grande above Cochiti Reservoir has remained relatively unaltered since the late 1800's, it is suspected as a possible site for bluntnose shiner to occur (Bestgen and Platania 1987). However, recent sampling of this reach has failed to locate any individuals of this species (Platania 1992).

Historically, the phantom shiner occurred sporadically throughout the Rio Grande in New Mexico from Isleta southward to the state line. The probable date of extirpation of the species is between 1939 and 1949 (Bestgen and Platania 1987).

The U.S. Fish and Wildlife Service propose to list the Rio Grande silvery minnow as an endangered species, effective March 1, 1993 (Proposed Rule, Federal Register, vol. 58, no. 38, pages 11821-11828). This fish species historically occurred in the Rio Grande below Velarde and the Rio Chama below Abiquiu. It now occupies approximately five percent of its known historic range, occurring only in the Rio Grande from Cochiti Dam downstream to the headwaters of Elephant Butte Reservoir, New Mexico (Bestgen and Platania 1991, Sublette **et al** 1990). Threats to the species include loss of stream habitat due to dewatering, channelization and regulation of river flow to provide water for irrigation; diminished water quality caused by municipal, industrial, and

Table 3. Fish species presently and historically occurring in the Rio Chama and Rio Grande from Abiquiu Dam to Cochiti Reservoir (from Sublette **et al** 1990, Bestgen and Platania 1987, Platania 1991).

| Family and Common Name | Scientific Name | Status |
|---|---|---|
| Acipenseridae | | |
| shovelnose sturgeon | Scaphirhynchus platorhynchus | Ex |
| Anguillidae | | |
| American eel | Anguilla rostrata | Ex |
| Salmonidae | | |
| brown trout | Salmo trutta | I |
| Cyprinidae | | |
| red shiner | Cyprinella lutrensis | N |
| common carp | Cyprinus carpio | I |
| speckled chub | Macrhybopsis aestivalis | Ex |
| Rio Grande chub | Gila pandora | N |
| Rio Grande silvery minnow | Hybognathus amarus | En |
| Rio Grande shiner | Notropis jemezanus | Ex, Nr |
| Rio Grande bluntnose shiner | Notropis simus simus | Ex, En |
| fathead minnow | Pimephales promelas | N |
| flathead chub | Platygobio gracilis | N |
| longnose dace | Rhinichthys cataractae | N |
| Catostomidae | | |
| river carpsucker | Carpiodes carpio | N |
| white sucker | Catostomus commersoni | I |
| Rio Grande sucker | Catostomus plebius | N |
| Ictaluridae | | |
| channel catfish | Ictalurus punctatus | I |
| Poeciliidae | | |
| mosquitofish | Gambusia affinis | I |
| Centrarchidae | | |
| green sunfish | Lepomis cyanellus | I |
| largemouth bass | Micropterus salmoides | I |

Key to Status:

- I Introduced
- N Native
- Ex Extirpated, Native
- En State Endangered, Native
- Nr Federal Notice-of-Review, Native

Table 4. Fish species presently and historically occurring in the Rio Grande between Cochiti Dam and Elephant Butte.

| Family and Common Name | Scientific Name | Status |
|---|---|---|
| Acipenseridae | | |
| shovelnose sturgeon | Scaphirhynchus platorhynchus | Ex |
| Anguillidae | | |
| American eel | Anguilla rostrata | Ex |
| Salmonidae | | |
| brown trout | Salmo trutta | I |
| Cyprinidae | | |
| red shiner | Cyprinella lutrensis | N |
| carp | Cyprinus carpio | I |
| speckled chub | Macrhybopsis aestivalis | Ex |
| Rio Grande chub | Gila pandora | N |
| Rio Grande silvery minnow | Hybognathus amarus | En |
| Rio Grande shiner | Notropis jemezanus | Ex, Nr |
| phantom shiner | Notropis orca | Ex, En |
| Rio Grande bluntnose shiner | Notropis simus simus | Ex, En |
| fathead minnow | Pimephales promelas | N |
| flathead chub | Platygobio gracilis | N |
| longnose dace | Rhinichthys cataractae | N |
| Catostomidae | | |
| river carpsucker | Carpiodes carpio | N |
| white sucker | Catostomus commersoni | I |
| Rio Grande sucker | Catostomus plebius | N |
| Ictaluridae | | |
| black bullhead | Ameiurus melas | I |
| channel catfish | Ictalurus punctatus | I |
| Poeciliidae | | |
| mosquitofish | Gambusia affinis | I |
| Centrarchidae | | |
| green sunfish | Lepomis cyanellus | I |
| bluegill | Lepomis macrochirus | N |
| largemouth bass | Micropterus salmoides | I |

Key to Status:
- I Introduced
- N Native
- Ex Extirpated, Native
- En State Endangered, Native
- Nr Federal Notice-of-Review, Native

agricultural discharge; and competition of predation by nonnative introduced fish species.

The success of MRGCD in seasonally capturing all or most of the available river flow for use on irrigated fields is detrimental to many species of plants and animals (see USDI Fish and Wildlife Service 1988, pp. 1-5, for a discussion of the biological effects of dewatering the Texas portions of the Rio Grande). In general, inefficiencies in the management of water **in** the river are better for the silvery minnow, as well as for many other floral and faunal resources below Cochiti Reservoir. Thus the present situation of occasionally having to pass water past water diversion structures during rainfall events is beneficial to riverine resources.

**Recreational Fishery of Cochiti Reservoir**

The fish community in Cochiti Reservoir consists primarily of introduced game fishes (Table 5) - millions of fish were stocked in the late 1970's (see Table 8 in U.S. Army Corps of Engineers 1980). Of the game fish species (rainbow trout, northern pike, black bullhead, channel catfish, white bass, green sunfish, bluegill, largemouth bass, smallmouth bass, white crappie, black crappie and bluegill), only rainbow trout do not reproduce in the reservoir. Spawning season and habitat for each of the species found in Cochiti Reservoir are described below, as excerpted from Sublette **et al** (1990). However, note that the cold, snowmelt runoff waters found in Cochiti Reservoir in late spring and early summer may delay spawning from the indicated dates for some of the listed species.

Sub-catchable rainbow trout (mean total length approximately seven inches) are stocked in the winter months to provide a seasonal trout fishery at Cochiti Reservoir. This species does not reproduce in the reservoir. Rainbow trout prey primarily upon benthic invertebrates and zooplankton. Larger individuals also consume fish.

Northern pike spawn during a three to nine week period in the early to mid-spring months. Spawning habitat for this species typically consists of beds of sedges and other aquatic plants. Reproductive success is closely related to high spring and early summer water levels which bring about flooding of terrestrial or wetland vegetation. Hatching larvae are closely associated with submerged aquatic vegetation. Zooplankton, insects and larval fish comprise the diet of young pike. Older individuals (50 millimeters and larger) prey on fish.

Carp spawn during the summer months. Females of the species produce an abundance of eggs, which are adhesive and attach to plants or debris. Carp are omnivorous and consume a variety of

Table 5. Occurrence, spawning season and status of fish species inhabiting Cochiti Reservoir.

| Family and Common Name | Scientific Name | Spawning Season | Status |
|---|---|---|---|
| Salmonidae | | | |
| rainbow trout | *Oncorhynchus mykiss* | NA | I |
| Esocidae | | | |
| northern pike | *Esox lucius* | ESP | I |
| Cyprinidae | | | |
| common carp | *Cyprinus carpio* | SU | I |
| Catostomidae | | | |
| river carpsucker | *Carpiodes carpio* | SU | N |
| white sucker | *Catostomus commersoni* | LS/ES | I |
| Ictaluridae | | | |
| black bullhead | *Ameirus melas* | SU | I |
| channel catfish | *Ictalurus punctatus* | SU | I |
| Poeciliidae | | | |
| mosquitofish | *Gambusia affinis* | SU | I |
| Percicthyidae | | | |
| white bass | *Morone chrysops* | LS/ES | I |
| Centrarchidae | | | |
| green sunfish | *Lepomis cyanellus* | SU | I |
| bluegill | *Lepomis macrochirus* | SU | N |
| largemouth bass | *Micropterus salmoides* | LS/ES | I |
| smallmouth bass | *Micropterus dolomieu* | LS/ES | I |
| white crappie | *Pomoxis annularis* | LS/ES | I |
| black crappie | *Pomoxis nigromaculatus* | LS/ES | I |
| Percidae | | | |
| walleye | *Stizostedion vitreum* | ESP | I |

**Status:**
I Introduced
N Native

**Key to Spawning Season:**
ESP Early Spring
SP Spring
LS/ES Late Spring, Early Summer
SU Summer
NA Not Applicable - Stocked

foods, including plankton, invertebrates, fish eggs, plants and organic detritus.

Sand and gravel shoals subject to wave action are preferred spawning sites for white sucker. Spawning takes place in the late spring and early summer. This species is primarily insectivorous, but also consumes plant material and organic detritus while foraging on the bottom. River carpsucker broadcast eggs over silt or sand substrates from early spring through mid-summer. River carpsuckers feed on detritus obtained from the bottom.

Black bullhead spawn during the summer in shallow water, where the female constructs a shallow nest in a secluded area. Adult black bullhead are bottom-feeders and prey on invertebrates, crustaceans, fish and filamentous algae. The channel catfish also spawns in the summer. Nests are located in protected areas (e.g., under logs, in crevices). Feeding habits are similar to those of the black bullhead.

Mosquitofish reproduce by internal fertilization. Young are born live during the summer months. The species occurs in dense populations in areas of thick aquatic vegetation. Mosquitofish are carnivorous and feed upon insect larvae, crustaceans, and larval fish.

The fishes in the family Centrarchidae and Percicthyidae spawn in shallow water and spawning is initiated when water temperatures reach 58-60$^{o}$F. White bass spawn during the late spring and early summer, when they migrate to specific spawning areas. Spawning occurs in shallow water, typically along wave-swept shorelines. This species occurs in schools segregated by age-classes. Adults feed primarily upon fish and zooplankton, especially <u>Cladocera</u> species. Smallmouth bass spawn in the late spring and early summer over nests excavated in shallow water, typically on gravel or sand substrate. Smallmouth bass are carnivorous and feed primarily upon insects, crayfish and other fishes. Largemouth bass also spawn in late spring and early summer, similar to smallmouth bass. Feeding habits are also similar to smallmouth bass. Characteristics and timing of white and black crappie spawning are similar to the largemouth and smallmouth basses. The species is a midwater carnivore, feeding mainly on insects, invertebrates, and small fish. Green sunfish spawn in late summer over nests excavated in shallow water. Prey of adults consists mainly of insect, with small fish being taken occasionally. Bluegill spawn in similar habitats in the summer. Prey of adult bluegill consists primarily of insects and zooplankton.

Walleye spawn in the early spring over a shallow rubble or gravel substrate on windswept shoals. Eggs are broadcast and may drift great distances before adhering to a substrate. Survival of eggs is higher on gravel, sand and rock substrates than on mud or silt substrates. Adult walleye are principally piscivorous.

The tailwaters area, below the dam, is characterized by colder, more constant temperatures than the river above the lake. Scouring of the channel by clear water emerging from the lake maintains roughness in the river bed, which provides a substrate for aquatic invertebrates, adding to the food base for fish. The nutrient levels in the tailwaters are generally dependent on the levels in the lake, although transport phenomenon in the lake may affect the outflow. The channel of the tailwaters is also characterized by some bars, sloughs, and divisions, providing diverse fish habitats. Bald eagles commonly fish in this area.

## COCHITI REREGULATION PROPOSAL

The proposed authorization of a 5,000 acre-feet conservation pool at Cochiti Reservoir would allow for the temporary storage and reregulation of irrigation water that had been released from upstream reservoir storage, but is no longer required by downstream users because of sporadic declines in irrigation demand due to rainfall events. The greatest opportunities to conserve the irrigation water in Cochiti Reservoir would be July through mid-October in the irrigation season. The storage of the additional water would raise the water surface elevation up to 3.8 feet above the existing 1165 acre (approximately 50,000 acre-feet) conservation pool (Figures 12 and 14), inundating about 208 acres. Although the reregulated water captured in Cochiti Reservoir would be the first water released from storage in subsequent water calls, the duration of reregulation water storage would depend upon the frequency and intensity of downstream rainfall events. Without guidelines each water storage episode could last for several days to several weeks.

Another potential use of a reregulation pool in Cochiti Reservoir is to enhance winter low flow conditions on the lower Rio Chama. When winter flows drop below 50 cfs the water in the river can freeze solid, which has detrimental effects on aquatic organisms, notably the introduced brown trout which provide a recreational fishery and food source for wintering bald eagles.

Note that a variety of other water management agencies have expressed desires for a reregulation pool in Cochiti Reservoir on general grounds of "increasing management flexibility" for the overall Rio Grande system. These clearly expressed desires, along with the existing history of Cochiti Reservoir management, foreshadow a high probability that any authorized reregulation pool would be utilized for many currently unforseen purposes.

There are legal, institutional constraints on the Cochiti Reservoir reregulation concept which are not being considered for change in this initiative, namely:

1. No instantaneous native (natural Rio Grande) flows would be reregulated (i.e., additional management opportunities would only involve water released from upstream storage for downstream water users).

2. There would be no changes in overall flood or sediment control operations.

It has been verbally stated by water management agencies that this proposal, if implemented, could result in an annual savings of 3000-5000 acre-feet of water. However, the quantitative information presented to the biological working group to date fail to support this claim and do **not** indicate a significant need for this type of irrigation reregulation in Cochiti Reservoir. A preliminary review of Bureau of Reclamation's daily water accounting summaries from 1977 through August 1991 (Leutheuser 1991) found only about 9900 acre-feet of potential total reregulation water savings over the 15 years of record (Table 6), for an average potential savings of 660 acre-feet/year.

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TABLE 6. Potential Savings of Water at Cochiti Reservoir under the Reregulation Proposal, 1977-1991.

| Year | Month | Dates | Approx. # days of impact | Rereg at Cochiti Res. (rough # AF) |
|---|---|---|---|---|
| 1977 | 8 | 10-12 | 3 | 2000 |
| 1980 | 7 | 17-19 | 3 | 700 |
| 1981 | 6 | 23-25 | 3 | 600 |
| 1981 | 7 | 28-31 | 4 | 2500 |
| 1989 | 7 | 22-24 | 3 | 1000 |
| 1989 | 8 | 17-19 | 3 | 1200 |
| 1989 | 9 | 3-6 | 4 | 1200 |
| 1990 | 9 | 10-11 | 2 | 700 |
| | | | | ----- |
| | | | | Total = 9900 |

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Further, the preliminary review indicated that "(I)n reality, 1/3 [of the above-identified opportunities] probably would have been missed..." (Leutheuser 1991), indicating probable average savings of only 440 acre-feet year.

Thus the magnitude of potential reregulation water savings to the MRGCD is extraordinarily small relative to their total consumption of water. For example, in 1990, MRGCD diverted 506,730 acre-feet, with 162,430 acre-feet delivered to farms (USDI Bureau of Reclamation 1991). Given the larger magnitude of water losses from other sources (including inefficient water **use** by MRGCD), a probable average annual savings through reregulation of less than 0.1% of water diverted, or less than 0.3% of annual MRGCD consumption, appears to be a weak justification for changing the Congressional authorization of Cochiti Reservoir.

## BIOLOGICAL EFFECTS OF WATER STORAGE, INCLUDING PROPOSED REREGULATION STORAGE

### Effects on Vegetation and Wildlife

Inundation impacts upon vegetation and wildlife are closely intertwined, since vegetation conditions are a primary determinant of habitat quality for all wildlife species. Inundation impacts are determined by interactions among such variables as the duration, frequency, seasonal timing, and magnitude (depth) of flooding. As a general principle, management of water levels at Cochiti Reservoir should simulate the natural (historic) pattern of riverine inundations to promote diverse, productive communities of plants and animals, as the native biota have adapted to this particular flooding regime on the Rio Grande over millenia. While quantitative data on the effects of these inundation variables upon plant and animal species in Cochiti Reservoir are basically lacking, some observations and generalizations can be stated.

The **duration** of inundation is a primary variable determining the impact of flooding upon vegetation. Short duration inundation generally has less impact than longer duration flooding. Some riparian zone plants need short duration springtime inundations in order to germinate. In addition, short duration inundations during the growing season could be beneficial to some growing plants and seedlings, especially in a dry year with little precipitation. However, when growing seedlings and established plants are deprived of oxygen and sunlight for extended periods by water or sediment, they can no longer photosynthesize, and senescence or other chemical breakdown processes will commence, leading to the death of the plants. In addition, under anaerobic flooded conditions many fine roots die, and thus woody plants can actually be killed by an inability to uptake sufficient water to meet growing season transpirational needs during or immediately after flooding.

Potter (1981) documented the impacts of the 1979 flooding in Cochiti Reservoir upon the vegetation of the flood pool; note that snowmelt runoff was held less than two months (Figure 1).

He found that Sporobolus cryptandrus had survived up to 36 days of flooding while Aristida longiseta and Bouteloua hirsuta had survived up to 22 days of inundation, but "resistance to flooding was not observed in other species of grasses". Potter (1981) observed a variety of forbs growing vigorously in the flooded zone by May 1980 (listed on p. 38). Vitis arizonica (canyon grape) resprouted after up to 60 days of flooding. Forestiera neomexicana (New Mexico olive) resprouted after inundation for up to several weeks where not blanketed by thick silt deposits. Surprisingly, ponderosa pine trees survived up to 54 days of inundation in 1979, reflecting decreased impacts from cold, oxygenated, snowmelt runoff and perhaps ecotypic selection in this riparian environment for flood resistance.

Observations made in late July 1991, after the spring snowmelt storage was evacuated, revealed that many cottonwood saplings and most willows survived the spring snowmelt storage; some willows survived as much as 80 straight days (April - June) of inundation (Stuart 1991, Stuart and Clark 1991). Although all cattails were apparently killed as far up as the mouth of Frijoles Canyon (26 days of inundation), some bullrushes survived and many herbaceous plants were already beginning to recolonize sand bars and mud flats throughout the flooded area. These observations indicate that if spring snowmelt floodwaters can be evacuated by July 1 (avoiding carryover into November), the inundated areas can retain some of the biological "capital" that builds up through the time between water retention events, rather than being set back to ground zero each time there is a water holding event. However, prolonged inundation kills all vegetation and devastates the shoreline, where the loss of vegetation eliminates plants as food or cover resources for all wildlife, ranging from arthropods to waterfowl. Extended inundation may kill many of the seeds and other propagules which are stored in soils, thereby slowing post-flood recovery of vegetation. Prolonged storage may also deprive aquatic plants in the littoral zone of necessary sunlight. Even superficial recovery from such a severe loss of vegetation takes many years (e.g., the multi-year impact of the 1987-88 water holding), and successional changes would likely continue for decades or centuries if all flooding ceased.

The shoreline of the lake and of the headwaters delta are close to the reservoir's permanent pool level. Storage of even 5000 acre-ft, the maximum proposed reregulation storage, would raise the lake 3.8 feet and drown about 208 acres (Figures 12 and 14). Maximum reregulation storage would also inundate 43% to 57% of the delta wetlands (Figures 11 and 14), depending upon how much of the wetland area (sloughs and bars) submerged by the 1992 pool adjustment has re-emerged due to subsequent aggradation. Reregulation storage would also likely reduce the shoreline perimeters of numerous bars by flooding them. Thus the low-lying Cochiti Lake delta is particularly subject to all types of inundation impacts.

Although some of the vegetation which grows in wet portions of the delta is adapted to temporary inundation, much of the vegetation growing in the delta area is composed of annuals growing on relatively dry bars which are not tolerant of flooding - **inundation longer than one day would likely have significant impacts upon this vegetation.** Flooding of any duration kills all arthropods and other animals caught in the flood zone. **Further, even brief inundations by still lake waters will tend to coat vegetation with sediments, reducing its viability and utility for wildlife.** The deposition of sediment buries existing vegetation and creates conditions which can inhibit the establishment and growth of new vegetation. In contrast, natural river flood events are characterized by fast-moving water and do not uniformly coat vegetation with adverse sediment loads.

Waterfowl depend on the existing vegetation to provide food and cover. The value of vegetation to waterfowl depends upon the energetic resources (especially seeds) the plants can provide, their ability to foster invertebrate populations, and the type and quality of cover (resting and hiding) the plants may provide (Ringleman 1991). Ducks and geese will not utilize an area that is devoid of vegetation and may abandon areas where available plants are limited in quantity and variety (Haukos et al. 1991). If long duration flooding occurs during the winter months waterfowl will abandon the area in search of necessary food and cover sources. Water level management also directly influences waterfowl's selection of habitat to use since they have varying preferences for certain combinations of vegetation and water depth.

The **seasonality** of inundation also modulates the ecological effects of inundation. As noted above, some plants can tolerate relatively long periods of inundation by cold, oxygen-rich water in the spring (Stuart 1991, Stuart and Clark 1991). Evacuation of water down to the permanent pool level by June 30 also allows much of the current year's growing season for annuals and overall plant establishment to occur, thus leading to a rapid recovery of at least some form of vegetation in the flooded zone.

In contrast, carryover of excess water throughout the growing season causes more severe and longer-lasting impacts. Figures 4 and 5 show that natural flood events during the growing season are infrequent and of very short duration (one to several days) in this reach of the Rio Grande. Unnatural inundations caused by storage events during the growing season may damage growing vegetation. When these events occur during the early growing season, they can damage young plants (Fischer 1984). When flooding events occur during the late growing season, the effects can be even greater because vegetation will lack a chance to recover because of deposition of sediment layers or frost damage (Fredrickson 1991). Such a "late" event would have a greater effect on waterfowl loafing areas utilized during the ensuing winter months due to the consequent lack of vegetative food and cover sources.

Water storage in the fall and winter effects the suitability of the Cochiti Reservoir area for wildlife. Raising water levels at these times of year will flood or float away many seeds, making them unavailable to local fauna, while terrestrial arthropods and other animals are directly killed. Flooded vegetation is not available for wildlife cover either. Even if flooded vegetation is re-exposed by dropping water levels, the vegetation is flattened and coated with sediment, rendering it much less useful for most wildlife species. Waterfowl may be substantially affected because they depend upon seeds and grains for energetic food sources needed to sustain them during the winter season. Waterfowl may leave the area in search of better loafing areas, and this may have an effect on the diet of the bald eagle. However, water storage during the fall that only **slightly** raises the permanent water level (<2 feet) may result in an increase in invertebrate biomass which would benefit birds that feed on them, enhancing waterfowl usage of the delta area.

Even brief winter inundations can break or abrade the stems of woody plants around the lake margins through movements of the ice which forms on parts of the lake. For example, the four foot rise in reservoir level conducted in January 1991 (from 5332' to 5336') moved the icepack which broke off most of the cottonwood and willow regeneration at the mouth of Medio Canyon. Winter inundations also leave an ice pack on the bars that may take weeks to melt.

The interagency biological team took field trips to the delta area in July 1991, September 1991, July 1992, and September 1992. As recorded by Giesen (1992), by the last trip we observed that the large bar at the Sanchez/Medio Cañon area was:

> ...covered with a large array of annual plants as well as some existing woody species and new saplings. High water (spring 1992) had apparently facilitated the distribuiton and germination of various annual plants and the growth of existing perennials. The participants that attended the trip on the 16th of September 1992 observed that the sandbars had expanded and the diversity of plants on these sandbars had become very robust. Some plants observed in various stages of growth and fruition on the sandbar and in the water were: cattails (<u>Typhae</u>), bullrush (<u>Scirpus</u>), smartweed (<u>Polygonum</u>), barnyard grass (<u>Echinochloa crusgalli</u>), annuals from the family Asteraceae, willows (<u>Salix</u> spp.), and some seedling cottonwoods (<u>Populus wislizenii</u>). Most of these plants were also observed on the previous year's trip; however, the diversity and size of plants were much larger this year.

Avoidance of extended duration inundation and growing season flooding the past several years is permitting native vegetation succession to increase the diversity and productivity of the Cochiti Lake delta.

Little documentation exists of flood **magnitude** (depth) impacts upon Cochiti Reservoir. Magnitude impacts may be less important than duration impacts, and these two variables are typically confounded. However, Potter (1981) reported mortality of ponderosa pine trees as a function of duration and depth of inundation in 1979, finding that trees flooded to more than about 60% of their height died regardless of length of inundation.

The depth of water storage strongly affects the spatial distribution of sediment deposition, with heavy sediment loads deposited wherever the river first runs into slack water. Sedimentation kills plants and directly alters particular sites through burial, with significant and long-lasting effects on plant re-establishment through changes in such local soil properties as texture and nutrient status (Potter 1981). Sedimentation adds to cumulative strain on plants, too, as they must recolonize, or sprout or grow through annual sediments. This is most severe upstream at runoff peak flows, and therefore vegetation is richer at the lowest levels of the delta, where reregulation would have effects.

Careful consideration of the Cochiti Reservoir situation dispels any initial impressions that the proposed reregulation storage of irrigation water is too small in magnitude to have significant biological effects. The proposal to allow up to 5000 acre-ft of storage translates into a 3.8 foot rise in the reservoir level, which would inundate over 200 acres of the delta, including at least 43% of its wetlands (Figures 11 and 14). While the specific biological effects of reregulation would also depend upon the duration, seasonality, and frequency of water storage, significant impacts upon low-lying vegetation and dependent wildlife would occur.

Permanent pool surface elevations already fluctuate up to approximately one foot on a daily basis simply from the difficulties inherent in trying to precisely match reservoir inflow and outflow, as inflow is always varying to a greater or lesser degree. This unavoidable operational fluctuation in reservoir levels adds to to the cumulative effects of proposed reregulation storage by increasing the total range of variability in water levels which would occur. Thus the calculated value of 43% certainly underestimates the percentage of the lake's delta and its wetlands which could be directly affected by reregulation.

Higher water levels would also result in increased disturbance of wildlife species by humans due to easier boat access to areas that receive little human visitation when the reservoir is at permanent pool levels. Wildlife which could be negatively affected by increased human disturbance in the upper reaches of Cochiti Reservoir include waterfowl, shorebirds, and a variety of raptors. Bald eagles (Haliaeetus leucocephalus) would be particularly susceptible to elevated levels of human intrusion into their wintering habitat. Increased human disturbance could also reduce the potential of Cochiti Lake as a nesting area for southern bald eagles.

Data are lacking to separate the ecological effects of **frequency** of inundation from the duration, seasonality, and magnitude variables for Cochiti Reservoir. In general, more frequent flooding will have greater cumulative impacts than less frequent flooding once the frequency of flooding exceeds the ecological tolerances of the system's biota. We know that spring flood flows exceeding 5000 cfs occurred in this reach of the Rio Grande on average every two years (Figure 6), but that flood flows were infrequent after the snowmelt runoff (Figures 4 and 5). Thus, unless reregulation storage during the growing season occurred at extremely low frequencies (less than once/decade) such storage would be outside the range of conditions which are native to this locality, and would likely have negative impacts on the Cochiti Lake ecosystem.

The effects of reregulation on the bald eagle are of particular interest, as it is a federally listed endangered species. The Endangered Species Act of 1973, as amended, Section 4(b)(1)(A) requires federal agencies to maintain their facilities ". . . to protect such species [Federally protected Endangered or Threatened], whether by . . . protection of habitat and food supply, or other conservation practices, within any area under its jurisdiction". Furthermore, the Bald Eagle Protection Act of 1940 prohibits the molestation or disturbance of any bald or golden eagle by any person of any jurisdiction.

Degraded headwater delta wetland habitat, resulting from increased water level fluctuations, would have an indirect adverse effect on bald eagles. Bald eagles utilize the area for winter habitat and have been observed feeding on waterfowl that tend to congregate in the wetlands. As stated previously, they do not feed exclusively on waterfowl (Johnson 1990). However, the eagles have been observed consuming waterfowl when fish quantities and qualities are lacking (Johnson 1988-a). If the vegetative cover is drastically disturbed, waterfowl may not be attracted to the area, thus depriving the bald eagles of a potential food source. Under the Endangered Species Act and the Bald Eagle Protection Act, this action would constitute a threat to its habitat and food supply, thus creating a disturbance to the species. However, if the reservoir wetlands are properly managed the diversity and productivity of plants and animals can be maintained and likely enhanced.

Reregulation would also degrade the foraging habitat for peregrine falcons, since degrading the vegetation would reduce the prey base (other birds). Peregrine falcons are generally known to like to forage in wetlands, and they have been observed foraging in the Cochiti Reservoir area.

The southwestern willow flycatcher (Empidomax traillii extimus), a Category 1 candidate species, may be found in riparian areas downstream of the dam and along the Rio Grande upstream from Cochiti Lake and in wetland areas. Habitat for this species includes willows an d tees adjacent to water sources. Category 1 candidates are those species for which the U.S. Fish and Wildlife Service has substantial information to support their listing as endangered or threatened. Development and publication of proposed rules for these species is anticipated. On August 14, 1992, the petition to add the southwestern willow flycatcher to the list of Endangered and Threatened Wildlife and Plants was found to present substantial information indicating the requested action may be warranted. Fluctuating water levels in the lake caused by the reregulation proposal would prevent establishment of vegetation required by the southwestern willow flycatcher.

The New Mexican jumping mouse (Zapus hudsonius luteus), a Category 2 candidate species, may occur in mesic environments along the Rio Grande and along the shoreline of the lake. Category 2 candidates are those species for which the U.S. Fish and Wildlife Service has information indicating that proposing to list is possibly appropriate, but for which substantial data on biological vulnerability or threats are not currently known to support proposed rules. The vegetation in wet areas that is required for the jumping mouse could not develop at the upper end of Cochiti Lake with fluctuating water levels caused by the reregulation proposal.

**In summary, reregulation storage of irrigation waters in Cochiti Reservoir will certainly have negative impacts on low-lying wetland vegetation, and thus degrade the habitat quality for waterfowl and most other wildlife species, including the bald eagle, peregrine falcon, southwestern willow flycatcher, and New Mexican jumping mouse.**

Effects on Fish, and the Rio Grande Downstream

In the past, the predominant effect of water level fluctuation on the recreational fishery at Cochiti Reservoir has been to diminish the reproductive success of walleye and centrarchids (largemouth bass, smallmouth bass, white crappie, black crappie and sunfish). The surface elevation of the pool has ususally fluctuated during the spawning and post-spawning period for these species (March through June, see Figure 1) - this resulted in dewatering of spawning habitat and desiccation of eggs.

Another factor affecting the reproduction and recruitment of game fishes in Cochiti Lake in general and the delta area in particular is a diminishment of littoral vegetation and cover caused by the instability of the reservoir level. The delta provides good physical habitat for fish, especially where underwater and emergent vegetation exist to provide feeding areas and essential refuge areas where larval and juvenile fish can escape predators. Reregulation would directly alter these littoral environments, as water temperature and physical habitat characteristics change with water depth. Any diminishment of the vegetation caused by reregulation would have lasting effects on the quality of fish habitat and the stability of bars. Further, the raising and lowering of the pool level associated with reregulation storage would tend to physically destabilize the channel and bars in the delta area, leading to less stable environments for vegetation development. However, storage of water in the reservoir does introduce nutrients into the reservoir by inundating terrestrial areas, where aerobic decomposition generally is able to proceed faster than under water. High water levels also temporarily increase the amount of aquatic habitat in the reservoir, resulting in temporary increases in fish production.

Historically, the natural hydrograph of the Rio Grande consisted of elevated discharges associated with snowmelt in the higher elevations during the spring and early summer (see Figure 3). A period of low flows followed in the mid to late summer, persisting until the next year's snowmelt runoff. Summer thunderstorms and fall storms can cause short-duration increases in discharge. Fishes likely survived low flow conditions by congregating in refuge areas where depth or groundwater maintained suitable habitat.

Modification of flows in the Rio Grande have been cited as a major factor in the decimation of the native fish community of the Rio Grande. For example, a plausible description of the process of endangerment and extirpation of the four mainstream cyprinids was given by Bestgen and Platania (1987). The proposed process involved the contraction of species distributions by the 1940's through habitat modification resulting from water development. Ensuing dam construction, resulting inundation and habitat modification and range fragmentation, and subsequent modifications of flows then depleted or eliminated the populations occurring within the confined ranges. Channel morphology has been altered significantly. The broad floodplain and meandering pattern of the Rio Grande have been converted to agricultural fields and a confined, relatively homogenous channel. Ongoing activities such as sediment removal and channel maintenance continue to reduce instream habitat diversity (cf. USDI Bureau of Reclamation 1992).

Generally, the present management of MRGCD water below Cochiti Reservoir is detrimental to riverine fish and wildlife resources. The always-present potential of dewatering the river with irrigation diversions and the return to the river of lower quality water from agricultural fields (New Mexico Water Quality Control Commission 1992) creates serious natural resource impacts. Circumstances which prevent MRGCD from diverting every drop of water are usually viewed in positive terms by fish and wildlife managers because keeping water in the Rio Grande clearly benefits wildlife and vegetation.

The reregulation proposal was largely aimed to address MRGCD's concerns over those occasions when San Juan/Chama water which they request from El Vado Reservoir is not needed for agricultural purposes by the time it arrives because of subsequent rainfall events. When these situations arise, the requested water is passed through the middle valley and may eventually arrive undiverted by irrigators at Elephant Butte Reservoir. From an ecological standpoint, these passages of unused irrigation water are beneficial. This water supplements Rio Grande channel flows (which at times drop to zero during the irrigation season) and can be especially important during periods of general drought. The temporary rise in riverine water levels increases habitat diversity in the river channel. Shorebirds and waterfowl may utilize the increased wetted areas. Birds such as great blue herons that prey upon fish and other aquatic organisms may find their prey more vulnerable to capture. Mammals such as raccoons and skunks may also forage along the river when water is available. The extra water may also support small ponds and patches of aquatic vegetation in areas above the water level of unaugmented flows - such temporary catchments can be extremely valuable for amphibians and reptiles, especially for reproductive purposes. This supplementary MRGCD water may be vital to the continued existence of several fish species, especially the Rio Grande silvery minnow which currently persists only in limited channel reaches in which summer water flows are no longer secure because of human diversions (Bestgen and Platania 1991). The increased water flows could increase the diversity of habitat in the Rio Grande that various fish species could utilize. Occasional flows below the San Acacia diversion also water the growth of annual vegetation in and near the channel, which is important for concentrations of wintering waterfowl (personal communication, Don McCarter, New Mexico Game and Fish). Since the effect of the proposed reregulation would be to further reduce the already greatly depleted downstream water flows, this action would almost certainly have an adverse impact on the overall riverine and bosque ecosystem in the middle valley.

Other Environmental Impacts of Water Storage

Extended storage of carryover and other waters above the permanent pool level between 1985 and 1988 had numerous additional environmental impacts upon the upstream lands of **Bandelier National Monument** and the **Santa Fe National Forest**. Drift litter (including much human garbage) was deposited along miles of shoreline. Waves eroded the shoreline, leaving the terracettes typical of many reservoirs. A combination of erosion and water saturation triggered large scale slumping on canyon walls. Large quantities of fine-textured sediment were deposited in the upper reaches of the elevated reservoir, leaving a wasteland after the water level dropped which plants have had difficulty colonizing - even five years after the last carryover flood event the area around the mouth of Frijoles Creek remains quite barren. Many alien plant species became established in this disturbed area, which may be serving as a source for invasion of adjacent parklands. Re-established hiking trails were damaged and totally unavailable for human use during inundation periods, and most of these trail segments have now been abandoned. Inundation by Cochiti Reservoir damaged boundary and drift fences, fostering persistent problems with trespass and feral cattle. High water levels allowed increased levels of human access by boat into the heart of the Bandelier Wilderness. This easy, rapid, unregulated access of more people led to a variety of impacts on park resources, including harassment of wildlife, noise impacts to wilderness users, and theft and vandalism of cultural resources. Archeological resources were subjected to additional impacts from wave action, inundation, and sedimentation. Sediment burial of the floristically diverse spring at the mouth of Frijoles Canyon apparently caused the direct extirpation of six plant species from the park (Allen 1989), namely the western cardinal flower (Lobelia cardinalis), helleborine orchid (Epipactis gigantea), water smartweed (Polygonum amphicum), silverweed (Potentilla anserina), yerba-mansa (Anemopsis californica), and mountain water-parsnip (Cymopterus montanus). There was significant flood damage to riparian (especially) as well as upland vegetation along the Rio Grande and its tributary canyon streams (Frijoles, Lummis, Alamo, Capulin, Medio, Sanchez, and Bland); all of the woody vegetation in this area (including old-growth ponderosa pine) was killed, with some of the highest levels of damage found in the heart of the main bald eagle roost areas. Wetlands and sandbars normally used by migratory and overwintering waterfowl and shorebirds along the Rio Grande and in Cochiti Lake were drowned by water. The temporary storage of the small amounts of water called for in the reregulation proposal would have **none** of these impacts.

Extended storage of carryover water from 1985-1988 also affected Cochiti Pueblo agricultural lands below the dam, as seepage from the reservoir raised water tables enough to impact about 500 hundred acres of tillable land and about 300 acres of other Pueblo lands. Expensive mitigation measures are now being implemented to address this set of problems. Again, the proposed reregulation storage would **not** cause similar seepage impacts.

## RECOMMENDATION: COCHITI RESERVOIR REREGULATION PROPOSAL

Any modification to the present authorizing legislation should permit water conservation storage only when it does not hinder the conservation and development of fish and wildlife resources. It is important to remember that the legislation authorizing Cochiti Reservoir prioritized flood and sediment control as its main feature with fish and wildlife as the next priority. Any subsequent legislation affecting the reservoir should in no way diminish the relative priority of fish and wildlife resources.

**Recommendation: The interagency biological working group recommends rejection of the reregulation proposal.**

It is clear that even the relatively small amounts of water which would be held under the reregulation proposal would impose significant, negative impacts upon the vegetation and wildlife of the reservoir area, particularly in the headwaters delta region. In addition, the increases in water utilization by MRGCD on which the proposed reregulation focuses would further dewater biologically sensitive downstream reaches of the Rio Grande. **Thus, the proposed reregulation is ecologically undesirable because of significant, direct and indirect, adverse biological impacts - it would move both Cochiti Lake and the downstream reaches of the Rio Grande farther away from the desired template of historic natural conditions and associated ecological integrity.** Avoidance of these impacts is impossible as the impacts are inherent in the core reregulation proposal to store irrigation water during the growing season. Measures to mitigate these impacts would still involve overall diminishment of ecosystem integrity and wildlife habitat and would therefore be ineffective.

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If the reregulation proposal for Cochiti Reservoir continues to be pursued in spite of this biological recommendation to reject reregulation, the interagency biological working group considers implementation of the following measures, at a minimum, to be essential. These measures reduce or partially compensate for impacts, but do not eliminate them.

**No carryover storage should be permitted in Cochiti Reservoir.** This is the only mitigating change from the current situation which could significantly compensate for the direct impacts of the proposed reregulation on the reservoir ecosystem.

Several potential means to avoid carryover storage without compromising the Rio Grande Compact are discussed below.

The original objective of the carryover provision was to prevent the middle valley irrigators (essentially MRGCD) from using more than their historic share of the spring runoff. This objective could be achieved without carryover storage by: **a)** metering and limiting MRGCD diversions to the native flow of the Rio Grande after July 1, allowing releases of floodwaters stored in Cochiti to pass downstream to Elephant Butte; or **b)** requiring compensatory release of MRGCD San Juan/Chama water after July 1 when carryover would otherwise occur so that the sum of the native Rio Grande flow (not counting stored floodwater releases) and the San Juan/Chama water equaled the maximum use capacity of MRGCD; and/or **c)** releasing potential carryover waters in large "slugs" which would allow most of the water to pass undiverted down to Elephant Butte Reservoir. The timing and volume of the "slugs" would need to be researched and specified to determine their ecological effects.

Since legislative change of Cochiti Reservoir's authorizing legislation would be necessary to implement the reregulation proposal, the carryover provision should be deleted from the authorization at the same time.

**Reregulation storage would need to be closely restricted in magnitude, frequency, duration, and seasonality in order to limit the negative impacts to Cochiti Reservoir resources, since any reregulation storage would have adverse impacts.** Appropriate guidelines to limit reregulation storage do not currently exist and would need to be developed through research conducted **before** any reregulation proposal was implemented. Our current interagency group has been able to provide only limited review of the important ecological, social, and water management issues associated with this particular reregulation proposal. A detailed analysis, including sufficient time and funding to conduct needed research, would be required to adequately evaluate the ecological effects of, and mitigation guidelines for, water management operations at Cochiti Reservoir under any proposed change in authorization.

**A meaningful mitigation for dewatering downstream reaches of the Rio Grande caused by reregulation would be to find other ways to maintain water <u>in the channel</u>.** The most obvious way to maintain water in the Rio Grande channel would be for New Mexico to formally recognize "instream flow" as a beneficial use, and for the State Engineer to allow for the transfer of water rights to maintain instream flow.

**As a corollary to the maintenance of instream flows downstream, the beneficiaries of the reregulation proposal, specifically MRGCD, would need to examine their patterns of water consumption and the efficiency of their operations to determine means to save water which could be sold or otherwise transferred to other entities for the provision of instream flow for fish, wildlife, and vegetation support.**

Improved measurement and oversight of MRGCD water diversions (as proposed above to avoid carryover storage at Cochiti Reservoir) complements and supports this recommendation. It is no longer appropriate to try to squeeze more water for human use out of the Rio Grande system at the expense of the much-degraded, natural, riverine environment until patterns of human consumption are reviewed in detail and social and environmental tradeoffs are made explicit.

**Regardless of whether the reregulation proposal is pursued and implemented, the interagency biological working group recommends implementation of the following management measures for Cochiti Reservoir:**

**1)** avoid carryover storage;
**2)** maintain adequate flow capacity on the Rio Grande below Cochiti Dam to avoid carryover storage at Cochiti Reservoir;
**3)** develop and implement a revegetation plan to enhance the restoration of vegetation (and thus wildlife/fish habitat) whenever prolonged storage has destroyed or seriously reduced the vegetation;
**4)** use the improved annual operation scenario outlined in Figure 15 as a guide for operating Cochiti Reservoir;
**5)** all petitions for extraordinary water holding operations should be reviewed to insure consistency with the reservoir's authorization, including fish and wildlife; and
**6)** develop and maintain a single interagency biological team to enhance the ecological condition of Cochiti Lake and its delta, which would:
   a) assist in developing a new Fish and Wildlife Management Plan for Cochiti Reservoir;
   b) further evaluate the ecological effects of ongoing and potential water management and structural modifications at Cochiti Reservoir;
   c) develop a revegetation plan (see Recommendation 3); and
   d) review petitions for extraordinary water holding operations (see Recommendation 5)

These recommendations are developed in greater detail in the following section ("Recommendations: Ongoing Management of Cochiti Reservoir Under the Existing Authorization", pp. 51-58).

**For emphasis, we repeat: the interagency biological working group recommends rejection of the reregulation proposal.**

## RECOMMENDATIONS: ONGOING MANAGEMENT OF COCHITI RESERVOIR UNDER EXISTING AUTHORIZATION

The legislation authorizing Cochiti Reservoir places "conservation and development of fish and wildlife resources and... recreation" after flood and sediment control as management priorities. Various provisions of the authorization specify evacuation of floodwaters as rapidly as possible, and water conservation storage is not authorized. Thus the existing authorization for Cochiti Reservoir is basically well-designed from an ecological perspective, with the significant exception of the provision for holding carryover water from July through October.

However, through consideration of the Cochiti reregulation proposal, the interagency biological working group has come to recognize that significant, unrealized opportunities exist within the current authorization to greatly enhance management for fish, wildlife, and recreation at Cochiti Reservoir and still meet the primary flood and sediment control purposes of the dam. We envision a "desired future condition" for Cochiti Reservoir as a diverse, productive ecosystem occupying a strategic location on the Rio Grande flyway. We believe that the Cochiti delta area can develop into one of the most ecologically significant wetlands in New Mexico, with great benefits for local wildlife, migratory waterfowl, several threatened or endangered species, fisheries, and human enjoyment of these values. Cochiti Reservoir can become an ecological asset which would complement the missions of the primary land managers, rather than existing as an environmentally detrimental intrusion. Outlined below are specific recommendations which can be implemented within the current authorization to improve the management of Cochiti Reservoir from an ecological perspective.

**Recommendation 1: Carryover storage should be avoided in Cochiti Reservoir**, as extended storage events cause severe ecological damage to the reservoir ecosystem. **Elimination of these extreme carryover impacts is the key to improving the management of this reservoir from a biological standpoint.** Several potential means to avoid carryover storage without compromising the Rio Grande Compact are discussed above (p. 49).

Legislative change to delete the carryover provision from the authorizing legislation for Cochiti Reservoir, while desirable, is not strictly necessary to avoid carryover events if the Rio Grande Compact Commission became committed to this goal, as the Compact Commission is authorized to give its consent to early releases of carryover water. Indeed, in several years (1979, 1986, and 1987) the Compact Commission has allowed the release of carryover water from Cochiti Reservoir between July 1 and November 1. Also, if activities in the Rio Grande channel, such as bridgework and other construction activities, were planned to avoid the spring runoff period of April through June the "need" for carryover storage at Cochiti would be reduced.

**Recommendation 2: Adequate flow capacity needs to be provided through the middle Rio Grande valley below Cochiti Dam to avoid carryover storage at Cochiti Reservoir.**

Carryover storage events in Cochiti Reservoir can largely be avoided if adequate releases/downstream flows (about 10,000 cfs, as envisioned in the original authorizing legislation for Cochiti) can be allowed. Maintaining flow capacity in the middle Rio Grande reach from Cochiti to Elephant Butte is particularly critical, as Elephant Butte usually has storage capacity that can buffer the system downstream of Caballo Reservoir where channel capacities are significantly restricted. **While the flows in the middle Rio Grande need to be restricted to the floodway between the levees, the flows do not need to be held within a specific, human-designed, stabilized channel.** Indeed, permitting out-of-bank flows within the floodway could have numerous ecological, economic, and social benefits throughout this reach of the river which will be examined in 1993 through Senator Domenici's Bosque Initiative. Adequate flow capacity through the middle valley could be insured by periodically releasing large flows (> 10,000 cfs) from Cochiti Dam. Further channelizing the river and excavating and clearing the floodplain of vegetation would be extremely detrimental to fish and wildlife and therefore is not recommended. **It is imperative that no further human structural intrusions be permitted within this floodway, or the ecological, social, and water management problems now found on the lower Rio Chama will be replicated, and carryover events will recur often in Cochiti Reservoir.**

**Recommendation 3: The redevelopment of vegetation (and associated wildlife/fish habitat) within the flood pool should be enhanced by the planting of vegetation whenever prolonged storage has destroyed or seriously reduced the vegetation**. However, we emphasize that **avoidance** of flood damage to vegetation is far preferable to any post-inundation treatment.

The U.S. Army Corps of Engineers and the three primary land managers, namely the Santa Fe National Forest, Bandelier National Monument, and Cochiti Pueblo, **should develop a revegetation plan** detailing the materials and methods to mitigate flooding impacts to the reservoir ecosystem. By planting selected species the development of vegetation can be speeded up as well as directed toward species which provide the best food and cover for fish and wildlife, and toward species which are better able to withstand the temporary inundation by spring floodwaters to which they will be subjected. The headwaters delta and the Santa Fe Wetland are areas that should be planted. Some of the lake shore belonging to Cochiti Pueblo that is not suitable for growing human crops might also be revegetated. Potter (1981, pp. 69-71) provided a number of revegetation recommendations, reproduced in Appendix C, which remain relevant and should serve as the starting point for the development of a revegetation plan. **The revegetation plan should be implemented with funding provided by the beneficiaries of extended water storage, which would insure that water storage**

**only occurs when it is worth at least the cost of treating its impacts.**

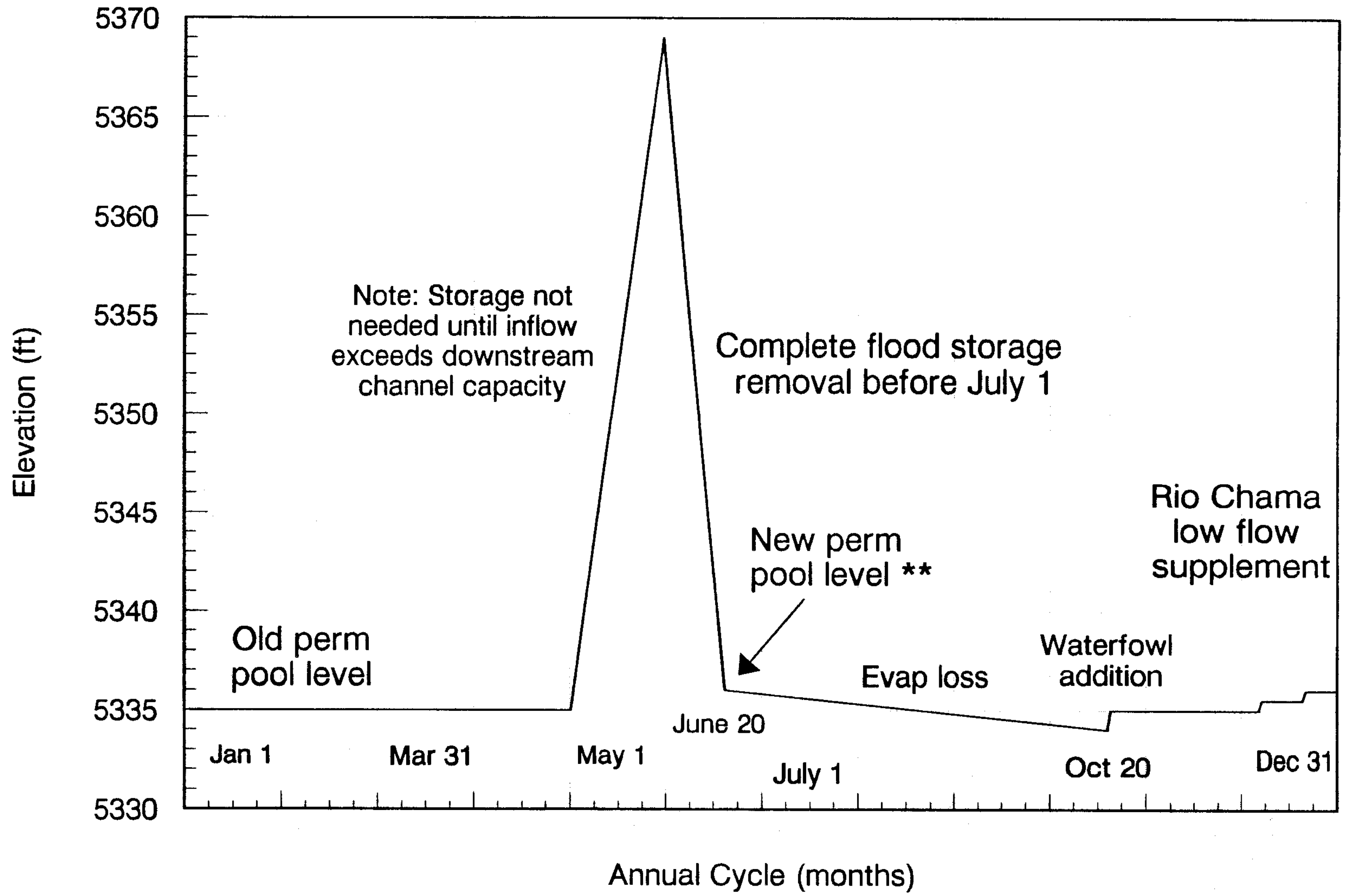
**The interagency working group suggests that the following components be included in the revegetation plan:** Component #1: Aerially seed the entire flooded area with a variety of **native** grasses and forbs to enhance rapid succession to a desirable vegetation condition, and to prevent alien agricultural weeds and tamarisk from establishing control over the area; Component #2: Hand plant cottonwood, willow, and ponderosa pine trees where such trees were, or now would be, the natural dominants (see Potter 1981), again to guide succession and prevent the dominance of tamarisk and Russian olive - use the pole planting methods developed recently by the SCS Plant Materials Center; Component #3: Hand plant native shrubs and plants like bullrush and wild grape over about 100 acres nearest the shoreline (note that volunteers spent about 56 person-hours to plant 1500 bullrush rootstocks in the fall of 1989 - some of these plants have apparently survived to the present); and Component #4: Hand control tamarisk on about 200 acres nearest the river to prevent it from dominating the vegetation of the reservoir ecosystem. (Note: tamarisk has not yet taken over the Cochiti Reservoir riparian zone as it has along so many other reaches of the Rio Grande and other Southwestern streams, but the potential for tamarisk establishment after each flood is great [see Potter 1981]; tamarisk control measures are reviewed by Kerpex and Smith 1987.)

**Recommendation 4: An improved annual operation scenario for Cochiti Reservoir outlined in Figure 15 should become the standard for operating this reservoir until a revised Fish and Wildlife Management Plan is developed. Implementation should be monitored and additional information collected to support refinement of these guidelines.**

This proposed operations plan is based upon the following premises: 1) management attention should focus on **native** biota, especially threatened and endangered species, which is consistent with the management policies of the primary land managers (USFS, NPS, Cochiti Pueblo); 2) water management should largely emulate the natural (historic) patterns of riparian inundation (i.e., season, frequency, duration, and magnitude of flooding) as the optimal template for restoration and maintenance of **native** vegetation and wildlife (see Figure 3).

Several features of the idealized annual operation plan outlined in Figure 15 merit elaboration here. **Storage of spring snowmelt runoff is kept to a minimum by closely following the dam's authorization** which specifies that: "the outflow from Cochiti Reservoir during each spring flood and thereafter will be at the maximum rate of flow that can be carried at the time in the channel of (sic) Rio Grande through the middle valley without causing flooding of areas protected by levees or unreasonable damage to channel protective works". Although snowmelt runoff storage can begin after March 31, no storage actually occurs

Figure 15. Proposed Annual Operation of Cochiti Reservoir




** About 1 ft annual rise in perm pool, reflecting variable, annual sediment increment.

until inflow into Cochiti exceeds the safe downstream release capacity, which is currently about 7000 cfs and can be increased further. In our idealized example storage begins on May 1. Note that 6000+ cfs inflows only occur about every other year, 8000+ cfs inflows about one year in three, and 10,000+ cfs inflows less than one year out of four (Figure 6) - **thus in most years no spring storage should be required at Cochiti Reservoir.** In our example storage peaks on May 31, and the reservoir is evacuated as rapidly as possible to the new permanent pool level by June 20. Achieving the stable permanent pool level as soon as possible is important to: a) enhance the spawning success of fish in the reservoir; b) provide the maximimum growing season for shoreline and wetlands vegetation, with associated benefits to terrestrial and aquatic wildlife; and c) minimize the period of inundation, and thus the survival, of perennial vegetation like willows and cottonwoods. **It is vital that every effort be made to completely remove all spring flood storage from the reservoir before July 1 to avoid carryover storage.**

After the snowmelt runoff has been evacuated the reservoir is brought to its new permanent pool level, reflecting adjustments for the influx of sediment over the preceding year and replacement of springtime evaporation. This **annual** adjustment for sedimentation will result in about a one foot rise in the permanent pool level each year, although the actual adjustment will likely vary somewhat, reflecting the calculated, actual, sediment influx for the preceding year. Annual adjustment of the permanent pool level for sedimentation will avoid the large, multi-foot jumps in pool level (and associated drowning of wetland vegetation) which occur when sediment adjustments happen less frequently. Post-runoff adjustment for sediment is preferable to increasing the pool levels in winter prior to the runoff, as earlier inundation would likely stress some plants (e.g., bullrushes) that would otherwise survive the temporary snowmelt storage and sedimentation.

The lake level should be allowed to gradually decline **no more than two feet** during the summer by deferring replacement of evaporative losses until fall, where two feet is about the amount of evaporative loss which typically occurs during this period. The declining pool level will facilitate the development of better-defined channels in the braided stream/delta region, fostering improved stability of the bars and their vegetation through time. A declining pool level will also allow sediment from summer thundershowers to be carried past the vegetated bars instead of being deposited on them. This small, gradual drop in pool level is not expected to impact fish spawning.

One-half of this evaporative loss (up to one vertical foot) could be replaced in late October to improve waterfowl habitat by inundating some dormant shoreline vegetation for the winter, while leaving other areas exposed. The details of this waterfowl enhancement guideline are the least certain part of Recommendation 4.

The rest of the evaporative loss (about one vertical foot, or 1200 acre-feet) is available to allow supplementation of winter low flow conditions on the lower Rio Chama. Note that these Rio Chama supplements could occur at any time throughout the winter and would probably occur gradually, although for simplicity of presentation the idealized operation schedule in Figure 15 shows two low-flow supplementation events in December to bring the permanent pool back up to its full level. As described in in the Rio Chama flow analysis above and in Figure 10, **the 1200 acre-feet available in Cochiti Reservoir under this scenario should be more than adequate to supplement Rio Chama low flows in most years**. For example, 1200 acre-feet would allow supplementation of lower Rio Chama flows from 25 cfs to 50 cfs for 24 days. If additional supplementation is needed it should be possible to pass some evaporation replacement water for the Elephant Butte recreation pool through the Rio Chama, as about 4000 acre-feet of evaporation loss must be replenished annually at Elephant Butte. Also, flows in the lower Rio Chama may receive some supplementation from the City of Albuquerque's efforts to maintain at least 250 cfs at the Central Bridge, although our Otowi gauge analyses indicate that little enhancement of native flows will be needed to maintain winter Rio Grande flows of 250 cfs.

Finally, note that relatively constant permanent pool levels are maintained throughout the winter, until spring runoff storage begins. Cochiti Reservoir is currently being managed as a put-grow-take winter and spring rainbow trout fishery with emphasis on the shoreline angler; stable winter reservoir levels significantly improve the winter trout fishery. Minimum reservoir surface acreage also increases the angler opportunity and return to creel of rainbow trout. Additionally, maintaining a stable pool elevation through the walleye spawn in late February and March improves the reproductive success and recruitment of young fish into the walleye population.

**Recommendation 5: All petitions for extraordinary water holding operations should be reviewed by an interagency committee to insure consistency with the reservoir's authorization, including the "conservation and development of fish and wildlife resources" of Cochiti Reservoir.**

Various circumstances have occasionally (but increasingly) led to operation of Cochiti Reservoir outside of its legislated authorization, which is "solely for flood control and sediment control" (Appendix A) and "for conservation and development of fish and wildlife resources and for recreation" (Appendix B). Water storage at Cochiti should occur only for authorized purposes, not simply for the convenience of a downstream party. Petitions for variances from authorized water holding operations need to undergo a more formal review process which includes the perspectives of the parties directly affected by water storage to demonstrate that the proposed action is consistent with the authorized purposes of the reservoir. Thus we recommend that an interagency committee should review all such petitions for consistency with the reservoir's authorization, including the "conservation and development of fish and wildlife resources". This committee should include representatives of the entities which have provided easements for Cochiti Reservoir, including Cochiti Pueblo, Bandelier National Monument, and the Santa Fe National Forest.

If extraordinary water holding situations recur, every effort should be made to protect the reservoir's ecosystems from unnecessary damage. Once again, reservoir operations should follow the proposed annual operation plan (Figure 15). Petitioners should be required to plan ahead to mesh their desired activities with the natural rhythms of the river system - e.g., in-channel activities in the Rio Grande below Cochiti should be planned for seasons when flows are typically low (see Figure 3). Inundations should be particularly avoided during the growing season when vegetation would be most damaged. If vegetation damage occurs, the revegetation plan (see recommendation #3 above) should be followed. Inundation should also be avoided during early and mid winter, when waterfowl depend on the vegetation for food.

If water must be held for some downstream project activity, several mitigation measures can be taken to reduce impacts to the reservoir ecosystem.

**a) Pre-evacuate the permanent pool** when water release restrictions are anticipated to eliminate or minimize any net rise in the pool above its authorized permanent level, thereby avoiding inundation damage to plant and animal communities. This measure was successfully employed in November 1990.

**b) Segment the water holding actions to reduce the length of time of continuous inundation.** For example, if it is necessary to hold water for two weeks to accomplish some levee work below Cochiti Dam, conduct the work in two, one-week segments, allowing a week or two in between when the water level can be dropped back to the permanent pool level to allow inundated vegetation to recover.

**c) Any restrictions in outflow from Cochiti Dam should be carefully coordinated to coincide only with periods when downstream project work actually occurs.** For example, excess storage could be evacuated from the reservoir at night and on weekends if water is being held for a weekday project.

**Recommendation 6: A single interagency biological team should be developed and maintained to: a) assist in developing a new Fish and Wildlife Management Plan for Cochiti Reservoir; b) further evaluate the ecological effects of ongoing and potential water management and structural modifications at Cochiti Reservoir; c) develop a revegetation plan (see Recommendation 3); and d) review petitions for extraordinary water holding operations (see Recommendation 5).**

An interagency biological team should be assembled to assist the Corps of Engineers in developing a new Fish and Wildlife

Management Plan for Cochiti Reservoir which would help institutionalize the recommendations of the biological team. This Fish and Wildlife Management Plan should outline a specific role for each agency, including the Corps, the Santa Fe National Forest, Bandelier National Monument, Cochiti Pueblo, New Mexico Game and Fish Department, and the U.S. Fish and Wildlife Service. The operations at Cochiti Reservoir should be linked to the North American Waterfowl Management Plan (USDI Fish and Wildlife Service 1992), the Fish and Wildlife Coordination Act, and the developing interagency watchable wildlife programs. The interagency team should explore possibilities for the reintroduction of extirpated native species, including river otter, mink, and bighorn sheep. Reintroduction of the Rio Grande silvery minnow into its historic range in White Rock Canyon (Platania 1991) should also be explored, as parts of the lake delta and upstream river reaches may provide suitable habitat (see habitat descriptions in Bestgen and Platania 1991) and could perhaps become a refuge for this endangered species.

It is clear that careful manipulation of Cochiti Reservoir's water levels is the key to nurturing wetland and shoreline vegetation, promoting productive fisheries, attracting and supporting waterfowl, promoting recovery of endangered species, and maintaining a generally productive ecosystem. The interagency biological team should meet at least annually to review recent observations and to further refine operations to support "conservation and development of wildlife and fish resources". Additional meetings, including field trips, would be called as necessary.

This same interagency team should also be used to develop the revegetation plan for Cochiti Reservoir (Recommendation 3) as well as review petitions for extraordinary water holding operations (Recommendation 5).

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## **APPENDIX A:** PUBLIC LAW 86-645 JULY 14, 1960 [74 Stat. 493]

TITLE II--FLOOD CONTROL Sec. 201.

RIO GRANDE BASIN

The project for improvement of the Rio Grande Basin is hereby authorized substantially as recommended by the Chief of Engineers in Senate Document Numbered 94, Eighty-sixth Congress, at an estimated cost of $58,300,000.

The approval granted above shall be subject to the following conditions and limitations:

Cochiti Reservoir, Galisteo Reservoir, and all other reservoirs constructed by the Corps of Engineers as a part of the Middle Rio Grande project will be operated solely for flood control and sediment control, as described below:

(a) **the outflow from Cochiti Reservoir during each spring flood and thereafter will be at the maximum rate of flow that can be carried at the time in the channel of Rio Grande through the middle valley without causing flooding of areas protected by levees or unreasonable damage to channel protective works**: *Provided*, That whenever during the months of July, August, September, and October, there is more than two hundred twelve thousand acre-feet of storage available for regulation of summer floods and the inflow to Cochiti Reservoir (exclusive of that portion of the inflow derived from upstream flood-control storage) is less than one thousand five hundred cubic feet per second, no water will be withdrawn from storage in Cochiti Reservoir and the inflow derived from upstream flood-control storage will be retained in Cochiti Reservoir.

(b) Releases of water from Galisteo Reservoir and Jemez Canyon Reservoir during the months of July, August, September, and October, will be limited to the amounts necessary to provide adequate capacity for control of subsequent summer floods; and such releases when made in these months, or thereafter, will be at the maximum rate practicable under the conditions at the time.

(c) Subject to the foregoing, the storage of water in and the release of water from all reservoirs constructed by the Corps of Engineers as part of the Middle Rio Grande project will be done as the interests of flood and sediment control may dictate: *Provided*, That the Corps of Engineers will endeavor to avoid encroachment on the upper two hundred and twelve thousand acre-feet of capacity in Cochiti Reservoir, and **all reservoirs will be evacuated completely on or before March 31 of each year**: *And provided further*, That when estimates of anticipated stream flow made by appropriate agencies of the Federal Government indicate that the operation of reservoirs constructed as a part of the Middle Rio Grande project may affect the benefits accruing to New Mexico or Colorado, under the provisions of the eighth unnumbered paragraph of article VI of the Rio Grande compact, **releases from such reservoirs shall be regulated to produce a flow of ten thousand cubic feet per second at Albuquerque**, or such greater or lesser rate as may be determined by the Chief of Engineers at the time to be the maximum safe flow, whenever such operation shall be requested by the Rio Grande compact commissioner for New Mexico or the commissioner for Colorado, or both, in writing prior to commencement of such operation.

(d) All reservoirs of the Middle Rio Grande project will be operated at all in the manner described above in conformity with the Rio Grande compact, and **no departure from the foregoing operation schedule will be made except with the advice and consent of the Rio Grande Compact Commission**: *Provided*, That whenever the Corps of Engineers determines that an emergency exists affecting the safety of major structures or endangering life and shall so advise the Rio Grande Compact Commission in writing these rules of operation may be suspended during the period of and to the extent required by such emergency.

(e) The foregoing regulations shall not apply to storage capacity which may be allocated to permanent pools for recreation and fish and wildlife propagation: *Provided*, That the water required to fill and maintain such pools is obtained from sources entirely outside the drainage basin of the Rio Grande.

(BOLDED EMPHASES ADDED)

## **APPENDIX B:** PUBLIC LAW 88-293 MARCH 26, 1964

AN ACT

To authorize the Secretary of the Interior to make water available for a permanent pool for fish and wildlife and recreation purposes at Cochiti Reservoir from the San Juan-Chama unit of the Colorado River storage project.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That the proviso to subdivision (e) of the conditions applicable to the project for improvement of the Rio Grande Basin authorized by section 203 of the Flood Control Act of 1960 (Public Law 86-645; 74 Stat. 493), is hereby supplemented to authorize, **for conservation and development of fish and wildlife resources and for recreation**, approximately fifty thousand acre-feet of water for the initial filling of a permanent pool of one thousand two hundred surface acres in Cochiti Reservoir, and thereafter sufficient water annually to offset the evaporation from such area, to be made available by the Secretary of the Interior for water diverted into the Rio Grande Basin by the works authorized by section 8 of the Act of June 13, 1962 (Public Law 87-483, 76 Stat. 97), subject to the conditions specified in sections 8, 12, 13, 14, and 16 of said Act. An appropriate share of the costs of said works shall be reallocated to recreation and fish and wildlife, and said allocation, which shall not exceed $3,000,000, shall be nonreimbursable and nonreturnable.

Sec. 2. Nothing contained in this Act shall be construed to increase the amount heretofore authorized to be appropriated for construction of the Colorado River storage project or any of its units.

Approved March 26, 1964.

(BOLDED EMPHASES ADDED)

## **APPENDIX C:** REVEGETATION RECOMMENDATIONS FROM POTTER (1981).

Extended quote from pp. 69-71 in Potter (1981):

After a major flood which covers the lower river terraces, mouths of the principal canyons, and the extensive delta deposits, it is recommended that an aerial seeding program be put into practice. It is recommended that the above areas be seeded by air within a few weeks after the lowering of the water level. The species should be those native, or at least presently common, to the area. A seed mixture should be used to be appropriate to both sandy areas and those covered by a layer of silt.

Species recommended would include: Echinochloa crusgalli (barnyard grass or wild millet) for its large seeds produced and general value for waterfowl and shorebirds; Distichlis stricta (saltgrass) because it was at one time a dominant of the lower terraces, produces a soil binding rhizome system, is salt tolerant, and provides a dense sod cover; Agropyron smithii (western wheatgrass) because it has proven itself capable of germinating and growing on the silt deposits, has a large seed and is a vigorous plant, has a rhizomatous growth form, and is a good forage producer; Sporobulus cryptandrus (sand dropseed) and Oryzopsis hymenoides (Indian ricegrass) because they readily become established on sandy soils and produce a large supply of seed; and one of the species of Polygonum, e.g., P. persicaria (ladysthumb), P. pennsylvanicum (bigseed smartweed), or P. punctatum (dotted smartweed) because of their high priority as feed for ducks and songbirds and their growth on exposed mud flats from which water levels have recently receded (Martin, Zim, and Nelson 1951).

Several benefits to be derived from the above seeding would be to reduce surface erosion; to provide for a food supply for a variety of waterfowl and shorebirds; to produce an increase in the forage of this normally high-producing area; to produce a ground cover which in some way may be competitive to the increased vigor and growth of tamarisk; and to provide a quick, green cover of the barren, gray silty areas which would overcome some of the negative aesthetic reaction to the effects of the flooding. The improvement of the area to supply more food and habitat for waterfowl and shorebirds may be considered in regard to the welfare of the bald eagles which have been wintering in the area of Alamo Canyon.

It has been observed in New Mexico and along the Colorado River that the growth of cottonwood into mature form is competitive against the thicket development of tamarisk. Anything to encourage the growth of cottonwood would therefore be advantageous.