Rio Grande and Tributaries, Remainder New Mexico

ABIQUIU RESERVOIR REVIEW SURVEY

US Army Corps of Engineers
Albuquerque District
DECEMBER 1987

SYLLABUS

The purpose of this study was to determine the advisability of recommending to Congress that additional conservation storage be made available in Abiquiu Reservoir, a Corps of Engineers project which was constructed in 1963 for the authorized purposes of flood and sediment control. At the beginning of the study, requests were received from several entities interested in storing water in Abiquiu.

As a result of these requests, Albuquerque District began studies to determine the costs and impacts of increased storage in Abiquiu. Under current Federal Law, the costs associated with storing water in a Federal facility are completely a non-Federal responsibility.

Analysis performed during the study showed that the costs of storing additional water in Abiquiu would range form $9,400,000 for 50,000 acre-feet to $95,300,000 for the maximum available storage of 467,000 acre-feet. Studies accomplished to date conclude that while it is technically possible to store additional water in Abiquiu, no local entity is willing to pay the cost of that storage.

This report recommends that no additional conservation storage

at Abiquiu Reservoir be authorized by Congress at this time. It also recommends the possibility of additional storage be reconsidered if and when conservation storage at Abiquiu becomes a viable, necessary and feasible alternative for beneficial use at some time in the future.

ABIQUIU RESERVOIR REVIEW SURVEY
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STUDY AUTHORITY

The authority for this water resources study is contained in a Senate Resolution dated December 5, 1975. Through this resolution Congress requested the Corps of Engineers to review the original report for the project, entitled "Rio Grande and Tributaries, New Mexico," in order to determine "whether any addition or modification should be made to the recommendations contained therein, with particular respect to the existing Abiquiu Dam in the interest of flood control, water supply, irrigation, recreation, fish and wildlife enhancement, [hydroelectric] power, and other related water and land resources needs." The study progressed until 1981 when Congress passed Public Law 97-140. This public law authorized the Corps of Engineers"... to enter into agreements with entities which have contracted with the Secretary of the Interior for water from the San Juan- Chama Project pursuant to Public Law 87-483 for storage of a total of 200,000 acre-feet of such water in Abiquiu Reservoir." This approximate volume of water is currently stored within the flood control pool and the unused portion of the sediment reserve. Because Public Law 97-140 satisfied storage needs at that time, the comprehensive study was suspended in 1982.

The suspended study was resumed in 1985 under the title "Abiquiu Reservoir Review Survey." Its objective is to evaluate potential additional conservation storage of both imported (Colorado River Basin water imported by the San Juan-Chama Diversion Project) and native (Rio Grande Basin water) waters in the unused portion of Abiquiu Reservoir. This action was requested by members of the Rio Grande Compact Commission and the city of Albuquerque. Additional entities that have expressed written interest for storage are the Elephant Butte Irrigation District, the U.S. Bureau of Reclamation and the Public Service Company of New Mexico. The concerns of these entities were largely prompted by the regional need for additional long-term storage of San Juan-Chama Diversion Project allocations which are surplus to immediate needs, and the desire to manage Rio Grande water above Fort Quitman, Texas, for maximum beneficial use.

Project Location: Abiquiu Dam and Reservoir are located on the Rio Chama about 32 river miles upstream from its confluence with the Rio Grande near the city of Espanola, New Mexico (Plate 1). It is located approximately seven miles northwest of the village of Abiquiu, 30 miles northwest of Espanola, 60 miles northwest of Santa Fe, and 110 miles north of Albuquerque. Abiquiu Dam and Reservoir are in Rio Arriba County and can be reached via U.S. Highway 84. New Mexico State Highway 96 leads to the project and crosses the dam.

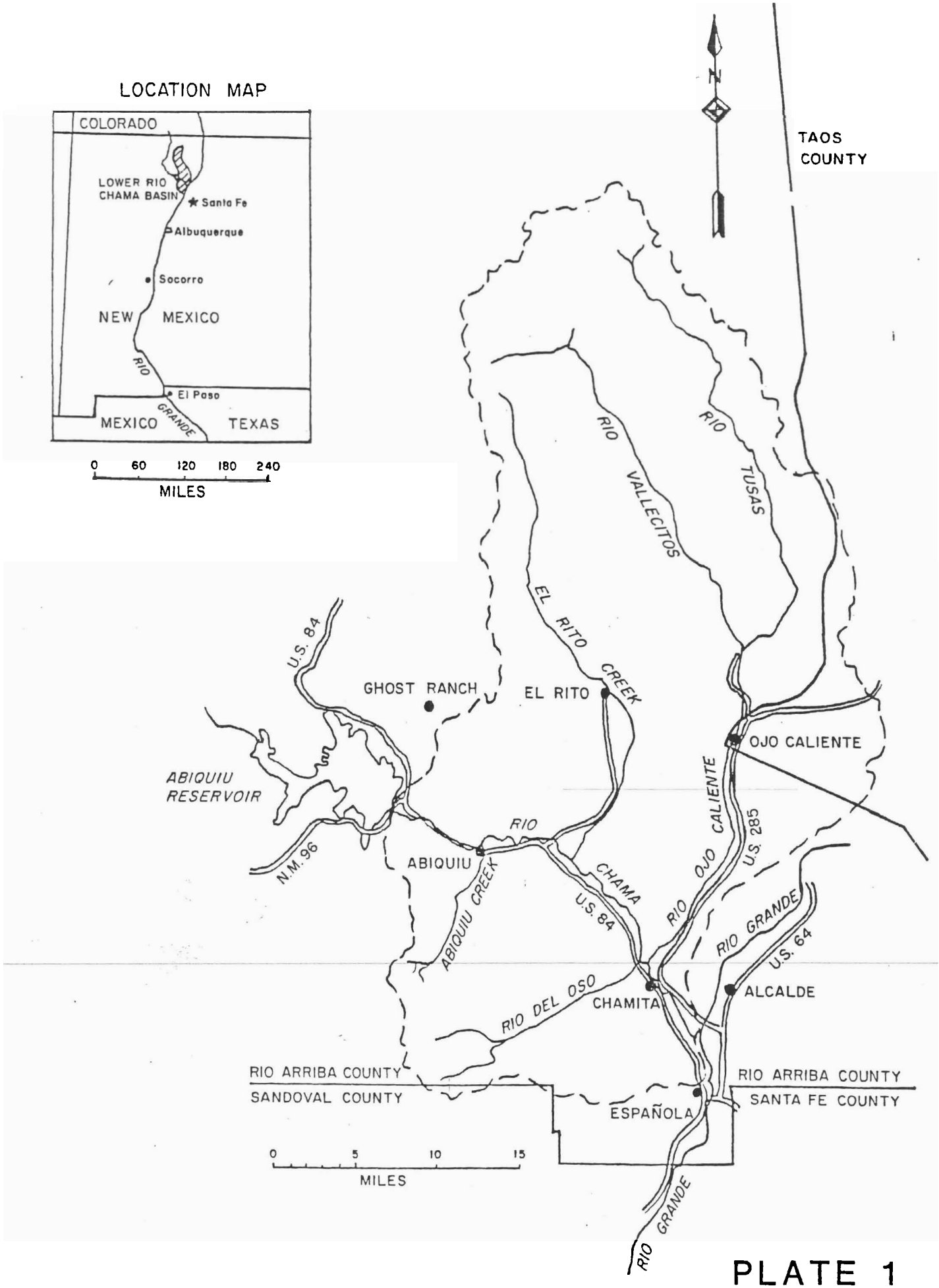

LOCATION MAP
COLORADO
LOWER RIO CHAMA BASIN
Santa Fe
Albuquerque
Socorro
NEW MEXICO
RIO GRANDE
El Paso
MEXICO
TEXAS
0 60 120 180 240
MILES
N
TAOS COUNTY
RIO VALLECITOS
RIO TUSAS
EL RITO CREEK
U.S. 84
GHOST RANCH
EL RITO
OJO CALIENTE
ABIQUIU RESERVOIR
RIO
N.M. 96
ABIQUIU
ABIQUIU CREEK
CHAMA
U.S. 84
RIO OJO CALIENTE
U.S. 285
RIO GRANDE
U.S. 64
ALCALDE
RIO DEL OSO
CHAMITA
RIO ARRIBA COUNTY
SANDOVAL COUNTY
ESPAÑOLA
RIO ARRIBA COUNTY
SANTA FE COUNTY
0 5 10 15
MILES
RIO GRANDE

PLATE 1

Project Features and Settings. Construction of Abiquiu Dam was initiated in 1956 and was completed and placed into operation in 1963 at a total cost of $21,275,000. The dam is a rolled, earthfill structure with a crest length of 1,540 feet, a crest width of 30 feet, and a bottom width of 2,000 feet. The top of the dam is at elevation 6381 (ft. NGVD) and approximately 338 feet above the streambed. The outlet works is located at the base of the dam and consists of a 12-foot diameter tunnel, intake structure, gate chamber and flip bucket. The outlet structure has a maximum release capacity of 8,000 c.f.s. at maximum pool level. The spillway is located abut 4,000 feet north of the dam's left (north) abutment and is uncontrolled. It is about 2,600 feet long, 68 feet wide, and has a maximum depth of about 42 feet. The spillway crest elevation is 6,350 feet. The reservoir is defined as that area below elevation 6353. The embankment's grout curtain was extended in 1966 to 1967 and 1978 to 1980 to reduce and control seepage along the embankment's abutments.

The Rio Chama emanates in the San Juan Mountains of southwestern Colorado and flows generally southward for 130 miles to its confluence with the Rio Grande. Elevations range from about 12,000 feet in the mountains to 5,600 feet at the confluence. The drainage area above Abiquiu Dam is 2,146 square miles. The upper areas of the watershed have steep slopes with a dense coniferous tree cover while slopes are much more gradual at

lower elevations, and the vegetation transitions to pinon-juniper woodland, shrubs, and short grass prairie. Between El Vado Dam and the headwaters of Abiquiu Reservoir is an approximately 33 mile-long canyon, the Rio Chama Canyon, which is up to 1,500 feet deep. The area surrounding Abiquiu Dam and Reservoir has a wide range of topographic features. Much of the reservoir shoreline is steep and rocky with numerous small coves. To the west is a broad, flat grassland with gently sloping mesas. To the north and east is a hilly shrubland of pinon and juniper with numerous natural and man-made clearings. To the south of the dam and reservoir are steeply sloping wooded foothills. The Rio Chama is sharply constricted just above the dam by a deep and narrow canyon which extends about three miles below the dam. From this point the canyon opens into a wide, agriculturally dominated floodplain, which continues for about 29 miles to the confluence with the Rio Grande.

HISTORY OF PROJECT

The Flood Control Acts of 1948 and 1950 were the legislative starting point for the major flood control improvements along the Middle Rio Grande Valley. In these Acts, Congress approved most of the provisions and recommendations presented in House Document 243, 81st Congress, 1st session. The Jemez and Abiquiu Reservoirs are a direct result of this report. The House Document offered a comprehensive solution to the flooding problems in the Middle Rio

Grande Valley. It called for the construction of three dams: Chiflo on the Rio Grande, Chamita on the Rio Chama, and Jemez on the Jemez River. Due to opposition by Texas and Colorado the Chiflo project was dropped from the plan.

The original plan in the Flood Control Act of 1948 called for the construction of a high dam called Chamita on the Rio Chama. However, in the preliminary studies of the area it was determined that a more cost effective means of obtaining the desired amount of flood protection would be the construction of two dams, one at Abiquiu and a lower dam at the Chamita site. This would result in a savings in excess of $8,000,000. This plan was presented by the Corps of Engineers in hearings before a subcommittee of the Appropriations Committee during the 1st session of the 83rd Congress.

This alternative plan ran into problems due to opposition by Colorado and Texas. The reason for this opposition was that the alternative plan had more storage capacity between the two dams than the original one dam. Texas informed the Corps that its opposition would be withdrawn if the storage capacities were reduced: "The position of Texas has been and is that the plan as proposed by the Corps is not authorized by any act of the Congress, and that it violates the provisions of the Rio Grande Compact and is contrary to the Flood Control Act of 1948". Texas informed the Corps that no objection would be made to the revised

plans provided the Abiquiu Dam would be constructed with an uncontrolled outlet so as to limit storage to approximately 562,000 acre-feet.

The authorization was interpreted as meaning that only a limited storage capacity was allowed under the 1948 Act. The states were reading the statute very literally. Texas and, to a lesser extent, Colorado, did not want the reservoir to retain any water which would otherwise flow freely downstream. The controversy surrounding the construction of both the Abiquiu Dam and the low Chamita Dam continued on through the Senate Public Works subcommittee hearings for 1957 where the Corps of Engineers was requesting funds to begin construction of Abiquiu Dam. The schedule called for Abiquiu Dam to be constructed first, followed by the the low dam at the Chamita site. This was approved by the Senate Public Works Committee and $1,500,000 was appropriated to begin construction in FY 1957 on Abiquiu Dam.

While Abiquiu Dam was under construction, the Corps continued its studies on the Rio Grande above Elephant Butte. In December 1958, the Review Survey for Flood Control, Rio Grande and Tributaries was completed. The recommendations in this report further changed the situation with regard to Abiquiu Dam and the low Chamita Dam.

The Corps of Engineers found that with the deletion of Chiflo

Dam in 1948, essential storage for control of major floods on the main stem of the Rio Grande had been eliminated. Also, with the unanticipated growth in the flood plain, particularly at and in the vicinity of Albuquerque, it became apparent that a higher degree of protection was required than could be accomplished by the construction of Chiflo Dam.

The Corps went on to recommend that the most feasible means of providing for adequate flood control, sediment control, and major drainage through stream bed degradation would be the provision of two additional reservoirs to be operated in conjunction with the authorized projects: one on the Rio Grande at the Cochiti site at the upper end of the Middle Valley and the other near the mouth of Galisteo Creek, a major tributary which joins the Rio Grande about 5 miles below the Cochiti site. The Cochiti Dam would obviate the construction of the authorized low Chamita Dam but together with the Galisteo Dam still would provide the desired degree of protection to the most critical areas at the least cost.

As a result of these recommendations Cochiti and Galisteo Dams were authorized by the Flood Control Act of 1960 (Public Law 86-645, 86th Congress, 2nd session) in lieu of the authorized low Chamita Dam.

The Flood Control Act of 1960 (Public Law 86-645) further

expanded the potential use of the reservoir by stating the purpose of the project could be increased to include fish and wildlife propagation provided the water to establish and maintain such a pool was obtained from sources entirely outside the drainage basin of the Rio Grande. However, no additional water has been stored to date under this provision of P.L. 86-645.

Abiquiu Dam and Reservoir became operational in February 1963. The most economical design for Abiquiu Dam required building the dam much higher than needed to contain the sediment and flood control pools, in order to minimize the cost of excavating the spillway. About one half of the reservoir's capacity of 1.2 million acre-feet of storage is intended to contain the major part of the spillway design flood rather than have the water from such a flood pass through the spillway.

Abiquiu Dam and Reservoir is operated for flood and sediment control in accordance with conditions and limitations stipulated in the Flood Control Act of 1960. Reservoir regulation is coordinated with regulations at Jemez Canyon Dam, Cochiti Lake, Galisteo Dam, El Vado Dam of the Middle Rio Grande Conservancy District, the Bureau of Reclamation's San Juan-Chama project, and Platoro Reservoir on the Conejos River. Abiquiu Reservoir is operated in such a manner as to limit discharges on Rio Chama, insofar as possible, to the capacity of the Rio Chama above the mouth of the Rio Ojo Caliente. Storage and release of

floodwaters is contingent upon discharges in the Rio Grande and on the regulations shown in the Master Regulation Manual for the Rio Grande Basin.

When Abiquiu was completed the total capacity at the spillway crest was 1,215,000 acre-feet; including 502,000 acre-feet for flood control plus 77,000 acre-feet for sediment. The remaining 636,000 acre-feet were additional storage necessary to contain the spillway design flood.

On December 5, 1975, the Senate Committee on Public Works passed the following resolution:

> RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River$\frac{s}{}$ and Harbor$\frac{s}{}$ Act, approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers, on the Rio Grande and Tributaries, New Mexico, published in House Document numbered 243, Eighty-First Congress, First Session, with a view to determining whether any addition or modification should be made in the recommendations contained therein with particular respect to the existing Abiquiu Dam in the interest

of flood control, water supply, irrigation, recreation, fish and wildlife enhancement, power, and other related water and land resources needs.

As a result of this Resolution in 1976, the Corps of Engineers, Albuquerque District began to study the advisability of storing conservation water in Abiquiu Reservoir.

On 29 December 1981, Congress passed Public Law 97-140. This law authorizes the Secretary of the Army to enter into agreements with recipients of San Juan-Chama Project water to store a total of 200,000 acre-feet of such water in the reservoir of Abiquiu Dam. The law further specifies that this storage shall not interfere with the authorized purposes of Abiquiu Dam and each user of storage space shall pay any increased operation and maintenance costs attributable to their respective storage.

The U.S. Bureau of Reclamation under the authority of Public Law 87-483 has implemented the importation of water from the San Juan Basin of the Colorado River Drainage into the Rio Chama of the Rio Grande drainage. Specific municipal and irrigation water supply needs are provided for by the importation and storage of San Juan-Chama water in the Rio Grande Basin.

As a result of the passage of P.L. 97-140, the Corps of

Engineers suspended its study on additional conservation storage of Abiquiu Reservoir. The first increment of conservation storage under P.L. 97-140 began in December 1982 and reached its authorized limit of 200,000 acre-feet in 1985.

In 1984, the ongoing Corps of Engineers dam safety assurance program identified the Abiquiu Dam project as having an inadequate spillway for control of the revised Probable Maximum Flood. As a result of this determination, the project has been modified. As an indirect result of these dam safety modifications, a permanent pool of about 520,000 acre-feet, including sediment reserve, could be maintained in the reservoir without affecting operations for current project purposes or needs. This, therefore, represents excess capacity that could be allocated to other purposes, such as conservation storage for water supply.

In the Fall of 1985, the Abiquiu Reservoir Survey was resumed by the Corps of Engineers pursuant to requests by the Rio Grande Compact Commission and the City of Albuquerque.

The Water Resources Act of 1986, (P.L. 99-662) authorized the construction of a set of emergency gates at Abiquiu Dam unless unfavorably reviewed by the Secretary of the Army within three years.

EXISTING CONDITIONS

Available Reservoir Storage. The most economical design for Abiquiu Dam required that it be constructed much higher than needed to contain sediment and flood control pools, in order to minimize the costs of excavating the spillway. As originally built the total capacity of the reservoir at spillway crest was 1,215,000 ac. ft. This included 502,000 ac. ft. of authorized flood control storage (elev. 6283.5) and 77,000 ac. ft. for sediment (this sediment allocation has been depleted to about 52,600 ac. ft). About half (640,000 ac. ft.) of the reservoir's capacity was therefore "excess" storage intended to contain the major part of the spillway design flood. Abiquiu Dam was evaluated under the Corps of Engineers' Dam Safety Assurance Program for its ability to safely pass increased spillway design flows resulting from the updated probable maximum precipitation developed by the National Weather Service. This evaluation demonstrated that the existing combination of storage, outlet, and spillway capacity at Abiquiu Dam was insufficient to control flood flows indicated by the new criteria. Necessary corrective measures, completed in December 1985, consisted of widening the spillway by 28 feet and raising the dam by 13 feet. An indirect consequence of this action is that storage of about 467,000 ac. ft. (excluding the sediment reserve) could be made available for conservation purposes without affecting current project

operations for authorized flood control.

Real Estate Interests: The Corps of Engineers has acquired interest in real estate up to elevation 6293.5, which is 10 feet above the top of the flood control pool. This interest includes 3,368 acres of fee simple lands and 6,133 acres of flowage easement for periodic and temporary inundation. The majority of the fee lands are located at the site of the structures and within the sediment pool. The majority of the flood control pool is on the easement lands. The City of Albuquerque has acquired additional easement interests in the project lands which allows for permanent inundation up to elevation 6220.

Streamflow Characteristics: Heron, El Vado, and Abiquiu Reservoirs control flows on about 80 miles of the lower Rio Chama. Streamflow is significantly regulated for irrigation, flood control, transport of San Juan-Chama Project water, and for interstate streamflow requirements. Historical discharges have averaged about 419 c.f.s. Discharges fluctuate commonly with the extremes of about 7.5 c.f.s to 6,550 c.f.s.

Climate: The climate of the project area is semi-arid. Annual precipitation ranges from about 10-12 inches, the majority of which occurs in the form of summer thunderstorms. The mean annual precipitation at the project site is 9.65 inches for the 1958 to the 1987 period of record. On the average, half of the

precipitation falls in the months of July, August, and September. The mean annual temperature at Espanola is 51 degrees Fahrenheit. Mean annual pan evaporation is 79.48 inches at the project. The mean annual lake evaporation is estimated to be 55.64 inches. The net evaporation rate is 46 inches when rainfall in subtracted. During the winter months snowfall is heavy on the upper mountainous areas of the watershed and light on the lower portions. Snow usually remains in the mountains above elevation 8,000 feet from the beginning of December until early in April when the smowmelt runoff begins.

Geology: The Abiquiu Dam site is located in a canyon that is approximately 350 feet deep, varying in width from 300 feet at the streambed level to 1,500 feet at the top. The site is about one mile downstream from the head of the canyon. Upstream from the head of the canyon, the reservoir area is a wide valley eroded in soft shales and mudstone of Middle Triassic age. At the dam site, the abutment slopes range from near vertical sandstone ledges and cliffs, to talus or overburden slopes. The deep canyon is eroded through hard resistant Poleo sandstone of Lover Triassic and Abo sandstones and mudstones of Permian Age. No faulting occurs in the general area. In the streambed area, bedrock is covered by an average 20-foot thickness of streambed alluvium (silts and gravel). Overburden on the abutments consists of slope wash, slump material, and talus averaging about 50 feet in thickness. Bedrock in the upper slopes of the

abutments is massive sandstone; the lower slopes and steambed area are interbedded sandstone and mudstone. The outlet works in the left abutment are in the Abo mudstone; the access shaft penetrates the full abutment section. The unlined spillway is excavated in the Poleo sandstone. The abutment and streambed mudstones are dense, well consolidated, and relatively impervious. The sandstones, particularly near the canyon walls, are a source of potential leakage due to the open fractures, cracks, joints, and bedding planes.

Faults have been mapped in the immediate vicinity of the site. A Pre-Triassic fault was found during foundation excavation. Normal faulting is prevalent with most excavations having steep dips. Six earthquakes have been recorded by instrumentation since 1969 with epicenters 7 to 16 miles from the dam with Richter magnitudes of 2.5 to 4.4.

Surface Drainage: About 5,000 acres of land in the Rio Chama valley below Abiquiu Dam are subject to chronic high water table problems. A soil and drainage study done in 1977 (Folks) indicates that the situation could be caused by any of the following factors.

-Over-irrigation

-Underground seepage from irrigation canals

-Underground seepage from adjacent streams

-Storm runoff and flood water from channels

-Artesian flow from deep aquifers

-Basin-type free water table (In valley bottoms, such as the Rio Chama, the free ground water saturates the sediments down to the first impervious barrier. Eventually, the groundwater discharges at the ground surface in low areas and escapes through aquifers at the lower end of the valley or bench land).

The lands located directly below the dam which are affected by a high water table appear to be most affected by underground seepage from adjacent streams, storm runoff, and basin type free water. The situation is probably a historical one and there is no evidence to suggest that the existence of Abiquiu Dam and Reservoir has contributed to the high water table problem. The diversion of San Juan water into the Rio Chama has resulted in above-natural flows in the Rio Chama: however, there is no indication this has had any significant effect on the water table.

Dam Safety: The subject of dam safety, both under existing storage conditions and with any additional storage has been an issue throughout this study. The primary dam safety issues involved the geologic risk of possible dam failure associated with fractures in the rock abutments of the dam, faults near the embankment, and seismic (earthquake) activity that could be induced by additional water storage. Concerns about dam failure

due to an infrequent large magnitude earthquake have been expressed. These concerns are based on allegations that Abiquiu Dam and Reservoir are in a potentially dangerous site, that the dam w. constructed at a time when there was not a great concern for the geologic hazards of such public works, and that the technical ability to access such hazards did not exist. An independent analysis utilizing state of the art techniques and theory was requested to evaluate the geologic safety of current storage and as a decision basis for any additional storage. A brief non-technical discussion of these issues follows:

A. Seismic Analysis. A seismic analysis study for Abiquiu Dam and Reservoir was conducted in 1980 (COE, 1980). Based on this study, the maximum earthquake was determined to be of magnitude 5.5 to 6.0 and the operating basis earthquake was determined to be of magnitude 3.5 to 3.7. The 1980 Seismic Study was supplemented by a Seismic and Seepage Report, completed in June 1986 for the Corps of Engineers by Tierra Engineering Consultants, Inc. Three faults are located from 0.2 to 2.5 miles from the dam. Because of these faults proximity to the dam, this report assumed more severe seismic conditions than in the 1980 study, using a maximum earthquake magnitude of 7 rather than 5.5 to 6.0. This report concluded that the dam is considered to be safe under present conditions, and would be safe under any future conditions with additional permanent storage, provided that certain seepage control measures be installed.

B. Reservoir Induced Seismicity. The 1986 report states that

there is not enough information available to evaluate induced seismicity from water storage. However, the absence of observed seismic activity at the dam suggests that the problem would not occur at this particular site. There have been small earthquake "swarms" at nearby reservoirs, but these would not be expected to increase the magnitude of the maximum earthquake used in the seismic analysis.

Seepage: Some seepage of water occurs through the embankment foundations and abutments of Abiquiu Dam, as is normally expected with large dams. This seepage is monitored routinely. Seepage control measures were designed and installed for the dam embankment, foundation, and abutments when the dam was constructed. Since construction, the embankments grout curtain was extended to reduce and control seepage along the abutments. Seepage measurements to date have shown an increased amount, and a rise in the water level of the abutments as a result of increased flood control storage in recent years.

As a result of this, adits, which gather the seepage and pass it safely through the abutments will be constructed at Abiquiu in the near future. With any increase in water storage, the amount of seepage is also expected to increase. However, with the adits in place, any additional seepage will pass safely through the abutments. Seepage from the abutments is clear, is passing through stable abutment material, and is not enlarging or increasing significantly by erosion.

FORMULATION OF ALTERNATIVES

Alternatives Evaluated. In order to adequately evaluate the economic viability of additional storage at Abiquiu Reservoir, numerous alternatives were considered to satisfy regional water management problems. The alternatives considered include the following:

a. Maximum utilization of reservoir space available.

b. Use of other existing reservoirs.

c. Construction of an additional dam on the Rio Chama.

d. Construction of an additional dam on the Rio Grande at the Chiflo site.

e. Aquifer recharge (storage).

f. Improve irrigation diversions below Abiquiu Dam.

g. Initiate water conservation practices (water demand management), and

h. No action.

Alternatives Eliminated from Further Detailed Consideration

a. Use of Other Existing Reservoirs. Heron Reservoir, El Vado Reservoir, Cochiti Lake, and Jemez Canyon Reservoir are water resource facilities that would be considered for additional water storage; however, the available storage of these reservoirs is already fully allocated for purposes such as flood control,

irrigation storage, recreation, fish and wildlife, and municipal and industrial use.

b. Additional Dam on the Rio Chama. A potential site for the creation of an additional dam and reservoir on the Rio Chama is the site that was originally designated for a flood control structure on the Rio Chama, but later deleted in favor of the present Abiquiu Dam site. Its location is about five river miles upstream from the confluence of the Rio Chama with the Rio Grande. The cost of this alternative is estimated to be $267,000,000 (1986 prices) for a high dam and $106,000,000 for a low dam. These prices would not be economical for potential water storage entities and the low dam option would not satisfy present storage needs. Further detracting issues would be the anticipated significant social, cultural and environmental effects.

c. Additional Dam on the Rio Grande. Chiflo Dam was one of the three reservoirs recommended for construction in conjunction with levees, channel improvements, and other measures in the 1948 U.S. Army Corps of Engineers report on the Rio Grande Basin (House Document No. 243, 81stCongress, 1st Session). The Chiflo project was to consist of a concrete dam, located on the Rio Grande about eighteen miles downstream of the Colorado-New Mexico state line, serving the purposes of main stem flood control, recreation, and hydroelectric power. Chiflo Dam was excluded from the authorization, without prejudice, subsequent to reconsideration by Congress because of objections by the states of Colorado and Texas that the project might not be economically justified, and

could adversely affect allocation of waters under the Rio Grande Compact. Some local interests have suggested that planning for Chiflo Dam be reactivated to provide flood control along the Rio Grande between the dam site and Coc...i Reservoir, and to stimulate local economic development through recreational visitation. The cost of the project is currently estimated to be approximately $312,000,000, which seems unlikely to be justified by the economic benefits that might result. Also, the reservoir would be located in what is now part of the Federal Wild and Scenic River System, which would be a major obstacle to project implementation.

d. Aquifer Recharge. Based on available knowledge to date, aquifer storage is not considered to be a viable measure due to high injection costs consisting of investment in new wells and high energy costs for pumping. There would also be difficulty with finding an aquifer in an area of suitable characteristics to prevent high water table problems and lower water quality. Also, this alternative would not provide the year to year flexibility needed for management of native and imported water.

e. Improve Irrigation Structures Below Abiquiu Reservoir. The Water Resources Development Act of 1986 contains provisions to restore the irrigation ditch systems (acequia systems) of northern New Mexico. Federal funds of $40,000,000 are requested to restore these features of cultural, historic, and economic

value.

f. Institute Water Conservation Practices (Water Demand Management). Water demand management is the deliberate control of the level and timing of water used by manipulation of its price, voluntary action, or administrative restriction. The term "conservation" is usually used to refer to these demand management techniques. Water demand management measures occupy an unusual role in this study. For future municipal and industrial water supply, the problem is the antithesis of the scarcity which demand management is intended to address. In western water law, a right to use a certain quantity is achieved by physically diverting it, putting it to a legally recognized beneficial use, and maintaining the full level of that use. Failure to maintain beneficial use of the full water right invites a legal finding of abandonment or forfeiture.In this context, there is a strong incentive not to reduce water use. The resulting climate of jealous protection of full water rights through continued beneficial use is as easily observed in relations between states as in relations between individuals and lead to the distinctively western interpretation of "conservation" to mean maximum development and beneficial utilization of the resource rather than "using less." Several of the contractors for San Juan-Chama Project water presently find themselves with a water surplus, an excess supply over present and near future use, and wish to protect their rights to these

supplies until such time as they would be fully utilized. Conservation storage would provide an interim beneficial use for this surplus and extend the life of their present water supply sources by postponing the need to develop new ones. Water demand management measures alone, however, could worsen the contractor's problem by increasing the magnitude of the surplus to be stored. While such measures would be beneficial in the long term -- a larger surplus, if stored, would last longer, and demand management would reduce the level and cost of new supplies needed after the storage is gone -- the implementability of such measures by the cities during a period of surplus, unless protection for the full amount of their water rights is assured, would be difficult to rationalize. Therefore, while water demand management measures would play a role of varying nature in each of the previously discussed alternatives addressing future municipal and industrial water supply -- each of which, by the preceding argument, is probably considered a conservation measure to some degree -- water demand management is not in itself an alternative for this purpose. For irrigation water supply, demand management would be a legitimate alternative since the need is to extend the capabilities of water supplies that are not perceived to be in surplus, but that may, under adverse conditions, be inadequate. Storage of water at Elephant Butte Reservoir for irrigation purposes is subject to evaporation rates of about eight feet annually. Evaporation at Abiquiu is about four feet. Therefore, the storage of irrigation water at Abiquiu

Reservoir could be a significant conservation measure.

NO ACTION - WITHOUT CONDITION

The no action alternative represents those conditions that are expected to occur in the absence of additional storage at Abiquiu Reservoir. These conditions are those that presently exist with the reservoir's flood control function (Public Law 858), conservation storage of 200,000 acre-feet at San Juan-Chama Project water (Public Law 97-140), and management (operations) functions as directed by the Flood Control Act of 1960 (Public Law 86-645), and the Rio Grande Compact. Seven out of eight years of above-normal stream flow and the need for municipalities to make beneficial use of San Juan-Chama Project water that is surplus to immediate needs have created a regional awareness that additional storage volume is needed for public safety, maximum conservation of water, and more efficient water management. Possible alternatives for water users and managers, if additional storage in Abiquiu Reservoir is foregone, include the following:

a. Forfeit periodic delivery of contracted San Juan-Chama Project water and associated values -(contracting entities).

b. Take receipt of yearly allocation of surplus San Juan-Chama water and sell if a market exists -(contracting entities).

c. Modify contract agreements with the Secretary of Interior

to delay delivery of San Juan-Chama Project water -(contracting entities and Secretary of Interior).

d. Continue high evaporational losses by storing irrigation water in Elephant Butte Reservoir -(downstream farming interests).

e. Continued threat of flooding to communities below Elephant Butte Dam in water-rich years - (Corps of Engineers and Bureau of Reclamation).

f. Forego beneficial use of water surplus to immediate needs below Elephant Butte Dam because of insufficient storage - (farming interests in New Mexico).

ADDITIONAL STORAGE IN ABIQUIU RESERVOIR

With the elimination of the other alternatives for conservation measures and other storage measures, efforts during the study focused on the feasibility of storing additional water in Abiquiu. Issues which arose with the additional storage of water included: dam safety, loss of white water rafting areas on the Rio Chama, cost of additional storage, and the potential environmental impacts.

Storage Available: As an indirect result of the dam safety modifications performed in 1985, the maximum additional storage

available in Abiquiu Reservoir is about 520,000 acre-feet inclusive of the 52,000 acre-feet that remains of the original 77,000 acre-feet sediment reserve. In addition, 502,000 acre-feet of authorized flood control storage will remain as it is now, even with the addition of any additional storage. Allocation of excess storage in Abiquiu would also not alter the 200,000 acre-feet of San Juan-Chama water authorized by Public Law 97-140, and this water will continue to be stored in the unused portion of the flood control pool. However, if runoff forecasts indicate that the total flood control space was necessary to control snowmelt, all or a portion of the 200,000 acre-feet would be evacuated to provide the needed flood control space. Figure 1 depicts the existing division of storage within Abiquiu Reservoir. Figure 2 displays what the potential division of storage would be with the maximum available storage in place.

MAXIMUM WATER SURFACE EL. 6375
(1,555,000 A.F.)

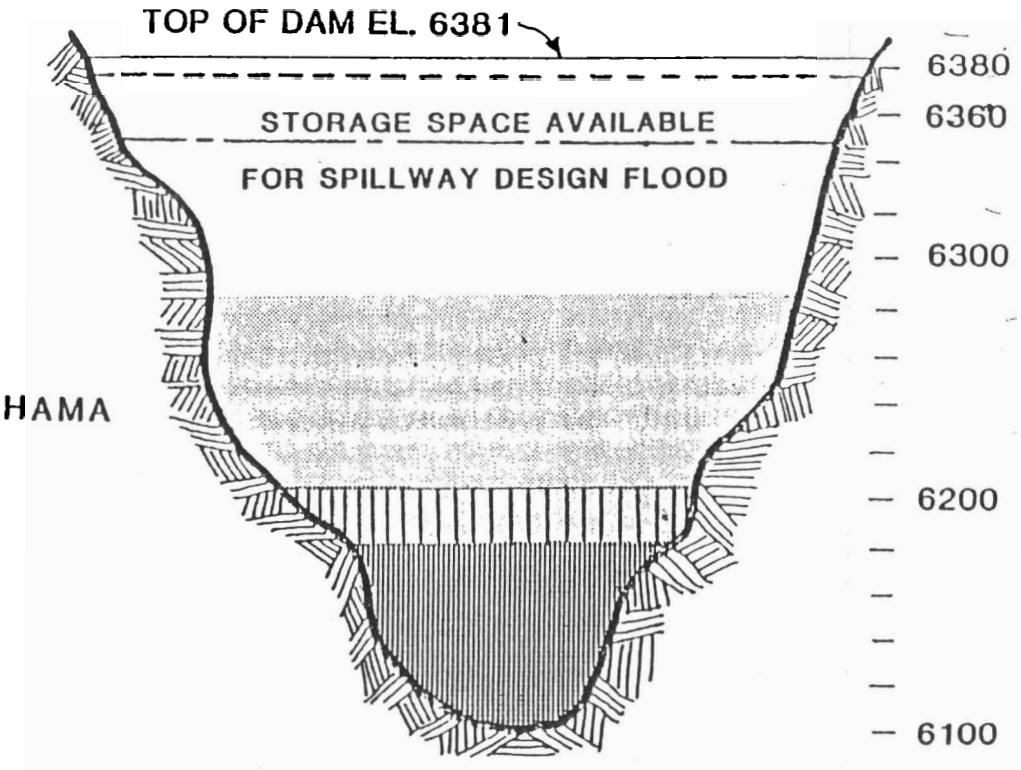
SPILLWAY CREST EL. 6350
(1,212,000 A.F.)

TOP OF FLOOD CONTROL POOL EL.6283.5
FLOOD CONTROL STORAGE 502,000 A.F.

STORAGE OF 200,000 A.F. OF SAN JUAN-CHAMA
PROJECT WATER EL. 6220

TOP OF SEDIMENT POOL EL. 6176
(52,600 A.F.)

ABIQUIU DAM



EXISTING CONDITIONS AT ABIQUIU RESERVOIR

FIGURE

MAXIMUM WATER SURFACE EL. 6375
(1,555,000A.F.)

SPILLWAY CREST EL. 6350
(1,212,000 A.F.)

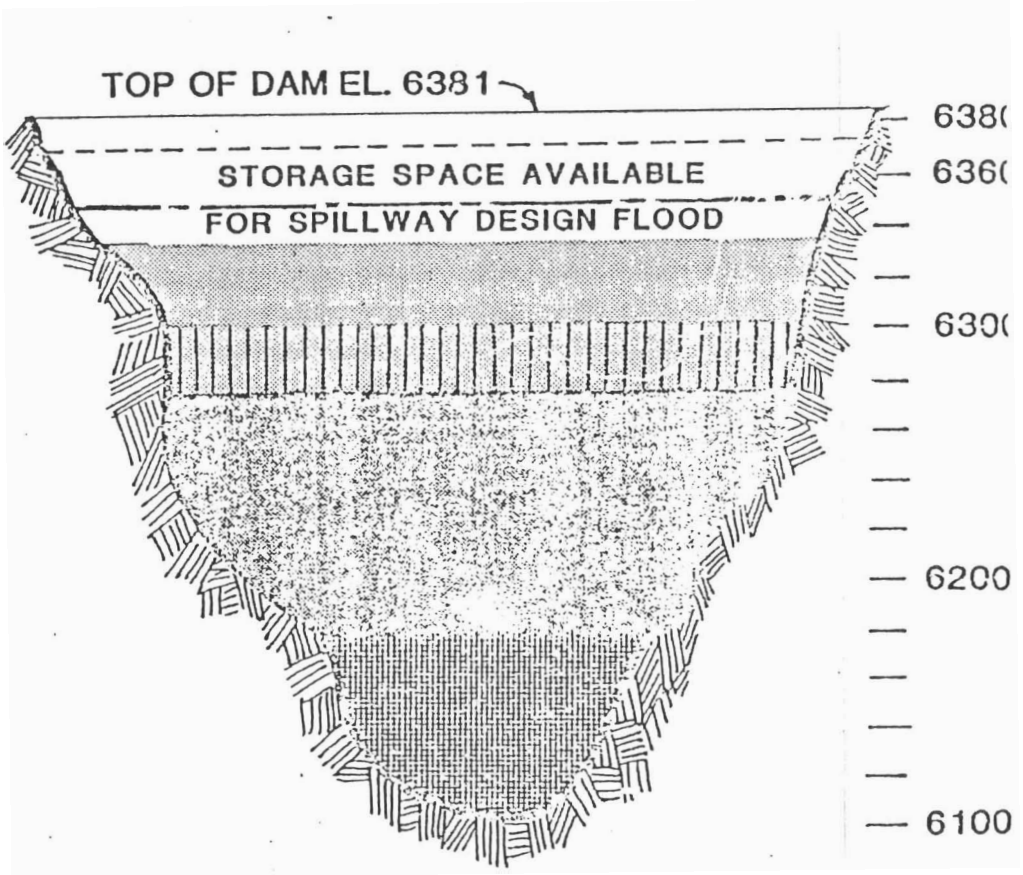
FLOOD CONTROL STORAGE EL. 6335
(502,000 A.F.)

STORAGE OF 200,000 A.F. OF SAN JUAN-CHAMA PROJECT WATER EL. 6304

SPACE AVAILABLE FOR CONSERVATION STORAGE EL. 6279 (467,000 A.F.)

TOP OF SEDIMENT POOL EL. 6176
(52,600A.F.)

ABIQUIU DAM



STORAGE POTENTIALLY AVAILABLE IN ABIQUIU RESERVOIR

FIGURE 2

EFFECTS OF ADDITIONAL STORAGE

In general, the effects of increased water storage at Abiquiu Reservoir are extensions or amplifications of current storage. The significance of resources affected, either beneficially or adversely, depend on the cumulative amount affected, the relative value or productivity of the resource, and its regional abundance/scarcity and importance. Of special attention are social, cultural, recreational, and economic values. Where areas of uncertainty exist as to the extent to which a particular resource or feature would be affected, a reasonable scenario for the storage of an additional 467,000 acre-feet is presented.

This section addresses those areas of concern conveyed during the scoping meetings, as well as resources identified in Federal, state, and local laws and regulations. Briefly, principal areas of concern were the need for increased storage capacity; dam safety and effects of increased seepage on downstream farmland; effects of livestock grazing and associated income; effects on terrestrial, riparian, and riverine habitat; effects on recreational uses, especially white water boating and associated economic effects; possible conflicts with special or proposed land and water use classifications; socioeconomic effects; and effects on transportation facilities. Table 1 presents the comparative pool sizes of the existing reservoir and the maximum available storage.

TABLE 1
COMPARATIVE POOL SIZES
ABIQUIU RESERVOIR

LAKE VOLUME	ELEVATION	MILES ABOVE DAM
	Existing Conditions	
Baseline Pool(200,000 af)	6,220	12.8
Flood Control Pool(502,000)	6,283.5	15.3
	Pool Sizes With Maximum Storage	
New Conservation Pool (467,000af)	6,279	15.1
Current Conservation Pool, Stored in Flood Control Pool(200,000af)	6,304	16.2
Remaining Flood Control Pool(302,000af)	6,335	17.3

Detailed discussions of these and other effects are as follows.

WATER MANAGEMENT NEEDS

STORAGE OF 467,000 ACRE-FEET. The availability of increased storage capacity at Abiquiu would contribute to the regional need to manage water which is temporary surplus to immediate needs, conserve water for irrigation uses, and provide a higher degree of flood protection to communities below Elephant Butte Dam.

Entities that would contract for San Juan-Chama Project water could take delivery of their yearly allocated quantity and reserve it for resale or conserve it on a long term basis until it is required. Under existing agreements, payment for the contracted quantity of water is required, whether or not the water is delivered. Consequently, this water would be conserved for future beneficial use rather than forfeited. However, while water is conserved for future use, it is subject to evaporational

depletions of about four feet per year, with depletions increasing as the surface area of the lake increases. Therefore, a portion (amount depending on storage) of annual water deliveries are essentially lost as the price of storing water.

The storage of water for irrigation purposes in the lower Rio Grande Valley of New Mexico has an effect of increasing the effective quantity of water available for irrigation use. This is because the evaporational rate at Elephant Butte Reservoir, where this water would be stored under existing conditions, is almost twice as great as at Abiquiu Reservoir. The provision of additional storage capacity plus the conservation of evaporational losses has financial benefits to the 6,800 landowners of the Mesilla Valley who, collectively, make up the largest and most productive farming area in New Mexico and West Texas. These benefits would be derived from the economy of using surface water rather than pumping groundwater, greater ability to sustain irrigable acreage in water-lean years, greater crop yield because surface water is of higher quality than pumped groundwater, and increased availability of higher quality water to leach soils to improve its plant growing ability.

A higher degree of flood protection to communities below Elephant Butte Dam could be achieved if a 100,000 acre-foot flood control reserve is provided for in Elephant Butte Reservoir. This flood control reserve can be achieved by making an

equivalent amount of conservation space available in Abiquiu Reservoir to offset the new flood pool at Elephant Butte. An awareness of the need for a flood control pool in Elephant Butte Reservoir became evident in 1985 when emergency storage of run-off water was required at Abiquiu Reservoir to prevent spillway releases at Elephant Butte and attendant flooding and loss of property.

NO ACTION. Without additional conservation storage municipalities contracting for San Juan-Chama Water will likely be limited to the following alternatives until this water is needed:

(1) Periodic forfeiture of paid annual allotments.

(2) Sell the water if the market exists.

(3) Attempt to modify their contract with the Department of Interior.

No additional capacity for the storage of irrigation water would forego the water conservation benefit of deceased evaporational losses and the financial benefits of "banked water", especially in water-short years. Since there is no flood control pool currently available in Elephant Butte Reservoir, communities downstream of the dam would remain subject to uncontrolled spillway releases from Elephant Butte Dam.

FLOOD CONTROL

STORAGE OF 467,000 ACRE-FEET. The flood control purpose and volume for which the project was authorized and constructed would not change. The preservation of this function was an inviolate factor in determining the excess reservoir capacity. In the extremely remote possibility of a Probable Maximum Flood, there would be less volume available to contain this flood and a corresponding increase in spillway discharges. The effects of this additional volume on downstream flooding reduction is not measurable compared with the magnitude of flooding that would occur with a Probable Maximum Flood.

NO ACTION. With this alternative, the authorized flood control function and capacities of the project would not change. As stated, the unavailability of a flood control pool in Elephant Butte Reservoir would continue to subject downstream communities to uncontrolled spillway releases that could occur during exceptionally wet years.

DAM SAFETY/STRUCTURAL INTEGRITY

STORAGE OF 467,000 ACRE-FEET. The recent analysis (Tierra Engineering Consultants, 1986) found that increased storage to elevation 6314 (802,000 acre-feet) would increase seepage along the abutment/embankment interface. This increased seepage could

increase the potential for erosion and emergence of seepage at unprotected areas downstream. Although seepage quantities are anticipated to be small, this situation must be considered as serious since seepage quantities are unpredictable and the points and time of emergence are difficult to predict. Remedial measures consisting of horizontal tunnels (adits) in each abutment would be required to insure that increased seepage would not adversely effect the integrity of the embankment and its abutments. With these measures, all of the analysis to date shows the project could store the maximum volume of water on a long-term basis with a high degree of safety.

NO ACTION. The referenced study of the structural integrity of Abiquiu Dam under worst-case conditions indicates that the current storage volumes can be impounded with a high degree of safety. As a result of record flood storage in Abiquiu Reservoir for the past two years, the amount of seepage through the embankments has increased and caused rock slides downstream of the dam. While these slides pose no hazard to the structural integrity of the dam, they are a hazard to people working or utilizing the Rio Chama in the area. For this reason the Corp of Engineers is planning to install the adits mentioned in the previous paragraph to control the seepage. The completion of the Feature Design Memorandum of these adits is scheduled for September 1988.

GROUNDWATER

STORAGE OF 467,000 ACRE-FEET. Maximum total seepage and percolation as a consequence of increased storage could be on the order of 1,000 acre-feet per year and would not contribute to the high water table downstream. This storage would be expected to be discharged into the alluvion downstream of the dam and controlled by the adits which are to be installed, and would not be significant enough to alter existing conditions. Upstream, the impoundment of additional water would increase base levels, with the increases attenuating with increasing distance from the reservoir. This latter effect would provide a beneficial reduction in pumping to existing wells.

NO ACTION. Based on studies by Folks (1977) and Tierra Engineering (1986) the high water table below the dam is a historical one and there is no evidence to suggest that the presence of the dam and reservoir have contributed to the high water table problem.

RESERVOIR REGULATION AND STREAM FLOW

STORAGE OF 467,000 ACRE-FEET. The expansion of multiple purpose uses of Abiquiu Reservoir would correspondingly modify the method in which the reservoir is operated. However, operation of the project for flood control purposes and current

water storage authorized by Public Law 97-140 would not change, nor would the normal transfer of water into the reservoir. Also, additional water supply storage would not result in any gains in total water supplies for the basin.

Reservoir regulation for additional storage would likely follow the plan being implemented for the current storage of 200,000 acre-feet of water supply. Generally, these waters would be stored until the early part of the next century. Then as releases of stored water exceeded their annual allocation of the imported water, releases of the stored water would begin. Releases would then be at a more or less continuous rate until the water was evacuated. The release period would likely be in excess of 20 years. However, some water storage entities could transfer water downstream. Since only a portion of total San Juan-Chama Project allotments would be stored at Abiquiu Reservoir, there would continue to be annual transfers of this water through Abiquiu Reservoir.

To store irrigation water, a portion of the normal stream flow destined for irrigation storage at Elephant Butte Reservoir would be stored at Abiquiu. Storage would normally be in the Spring when runoff is high. No storage would likely occur in those years when streamflows were low. Irrigation storage would reduce normal spring runoff, the extent of that reduction would be commensurate with the amount of water stored. Stored irrigation

water would likely be released during the winter months, augmenting regular transfers during that period.

NO ACTION. No change in the reservoir regulations would occur under the no action alternative.

WATER QUALITY

STORAGE OF 467,000 ACRE-FEET. Reservoir water quality tends, directly or indirectly, to be substantially dependent on thermal patterns (Smalley and Novak, 1978). The maximum water supply storage available would alter the hydraulic and physical characteristics of the existing 200,000 acre-foot pool by increasing its size and depth. The apparent weak to moderate thermal gradient or stratification that seasonally forms under existing conditions would likely continue. However, with increasing depths, stratification would be slower and the hypolimnion (the bottom layer of water characterized by colder, less oxygen abundant water) would be thicker. The increased depth of the lake would tend to lower the dissolved oxygen concentration in the bottom layer of the water. Because of the location of the intake of the outlet works at the base of the embankment, the withdrawal zone coincides with the bottom layer of the reservoir; therefore, water released through the reservoir outlet may be colder and lower in dissolved oxygen than is now

the case. However, rapid reaeration of oxygen deficient water occurs in the turbulence created by the flipbucket as water is discharged from the dam outlet. One of the more significant effects of the recent increase in water storage, and which would continue with additional storage, is the retention of waterborne soil which improves downstream water quality and streambed conditions. Also, the potential for occasional releases of turbid water due to the passage of density currents through the reservoir should continue to be reduced if the length and depth of the reservoir are increased. Reservoir water supply storage under conditions of no action or the maximum available storage is not expected to result in any deterioration of water quality or temperature phenomena which would affect its use. Concentration of heavy metals or other potential pollutants are below, and are expected to remain below, the standards and guidelines of the EPA for human use and aquatic fauna. Lakes in general tend to become more oligotrophic (lower in plant nutrients) with increased volume, and this tendency could further decrease the potential for nuisance algal blooms. An anticipated increase in recreational use would correspondingly increase the number of motorized boats utilizing the lake. This increase would result in an increase in the petroleum residues from boat motors. These emissions would be extremely small in relation to the total water surface and volume, and have not proven detrimental to water uses and aquatic or terrestrial life. Reservoir fluctuations would result in corresponding changes in water chemistry. In the long

term, withdrawal of San Juan-Chama Project water in the next century and periodic withdrawal for irrigation water will return the reservoir toward a more mesotrophic body of water and downstream water quality would also return to original conditions of periods of high turbidity.

NO ACTION. Conditions described in the affected environment section should generally continue until the present 200,000 acre-feet of water supply storage begins to be withdrawn in about the year 2005. As the lake becomes smaller, water quality would gradually return to prestorage conditions and a small sediment pool or no pool at all. Generally, water quality would decrease due to increased turbidity, temperatures, and nutrient relationships. Downstream water quality would also return to previous conditions of occasional periods of high turbidity. In the event of a severe drawdown or complete evacuation, considerable sediment would be flushed from the reservoir to the downstream Rio Chama and possibly the Rio Grande. Residential development may continue in available areas around the perimeter of the lower portion of the lake.

State regulations for the protection of the water quality should prevent any adverse effects that any development could have on the lake.

EVAPORATION, PERCOLATION, AND SEEPAGE

STORAGE OF 467,000 ACRE-FEET. Stored San Juan-Chama water would be subject to evaporational losses. However, an increase in storage results in a decrease in evaporational losses on each acre-foot stored. This is due to the fact that the surface area to volume ratio decreases with increased storage. The transfer of a portion of irrigation storage from Elephant Butte Reservoir to Abiquiu Reservoir results in an approximate 50 percent reduction of evaporational losses and an approximate resultant gain of four acre-feet per surface acre of water stored. Based on a 467,000 acre-foot pool with a surface area of 7,200 acres, the annual evaporational loss would increase by about 11,700 acre-feet. Storage of 667,000 acre-feet would have an additional annual evaporational loss of about 5,700 acre-feet. An increase in storage would likely result in infiltration and seepage amounts of a maximum of 1,000 acre-feet annually. This figure includes those unknown infiltration and seepage losses from the 200,000 acre-feet of existing storage. A portion of this amount would also likely return to the river below the dam with the balance going to groundwater.

NO ACTION. A portion of stored water is lost to evaporation each year. These amounts vary from year to year depending on storage, weather conditions, and water calls. Annual net lake evaporation is about 46 inches. Therefore, the water lost to

evaporation from the present pool with a surface area of 4,140 acres is about 16,000 acre-feet per year. Increased storage results in higher evaporation losses. These evaporational losses will continue until the pool begins to be withdrawn.

LANDS AND LAND USE

STORAGE OF 467,000 ACRE-FEET. In addition to the approximately 7,500 acres of land currently dedicated to flood control and water conservation purposes (elevation 6283.5), an additional 3,500 acres of predominantly low quality grazing land would be dedicated for these purposes by the implementation of this alternative. Of this acreage, 1,200 acres would be subject to long term inundation, and 2,300 acres subject to periodic flood control inundation. Temporarily inundated land would be available for grazing when not flooded, but productivity would be lower. The stated acreages represent maximum figures since not all acreage is suitable for grazing because of steep topography and some lands are dedicated to residential development.

An enlarged pool could act to accelerate residential and commercial development on those parcels of land adjacent to the reservoir that are planned or available for development, the extent of which is not known. The annual rate of growth could be 1.5 to 2 percent, but is dependent on a variety of factors. However, large scale development seems unlikely. Also, recently

enacted subdivision regulations could restrict potential residential development. There are numerous problems involving land titles in the area that may also discourage subdivisions and residential development.

As the lake levels decreased due to the gradual withdrawal of San-Juan Chama Water, use of inundated lands would gradually return to low quality livestock grazing.

NO ACTION. Since there is no land use plan for the project area or even for the designated socioeconomic study area, the foreseeable land use effects can only be compared with current trends. The predominant land use in the area is for flood control, sediment retention, conservation storage, recreation, and livestock grazing. Parcels of land adjacent to the reservoir are planned or are being developed for residential and commercial purposes. Approximately 4,100 acres have been converted to perennial water storage, another 1,900 acres have been temporarily inundated for flood control, and another 1,500 acres are dedicated to temporary inundation for flood control. However, their overall average annual productivity is lowered after inundation. These land uses are expected to continue.

BIOLOGICAL SYSTEMS

General. Of the four major vegetative cover types in the

general reservoir area - annual grasses, forbes, pinon-juniper-grassland, shrub-grassland, and canyon bottom/riparian forest and woodland, the pinon-juniper components are subject to the greatest and most lasting effects of inundation. The various levels of perennial and intermittent inundation would result in a strict loss of vegetation or conversion from one vegetated cover type to another. As the water level recedes in the early part of the next century, the previously inundated land would undergo some degree of vegetational redevelopment, but the cover type could be significantly different from what existed previously. These modifications of vegetative communities could be of long duration. In the upper portion of the reservoir, and generally where the slopes are gradual, previously inundated land would probably develop annual grasses-forbes immediately with eventual succession to riparian woodland, shrub-grassland, pinon-juniper-grassland, or all three depending on slope exposure, soil and other physical site characteristics. The pinon-juniper-grassland could take a relatively long time to become re-established because in a semi-arid climate, the development of the tree species to maturity would require at least 50 years. An increase in water storage would not effect any wetlands: therefore, both of the considered alternatives would be in compliance with Executive Order 11990, Protection of Wetlands.

STORAGE OF 467,000 ACRE-FEET. This alternative would inundate an additional 2,600 acres of vegetation and streams not

previously inundated (measured from elevation 6,256). Added to the area that is or has been inundated, a total of about 8,700 acres would be committed to water storage on a long term basis. Of this acreage, 132 acres is canyon bottom and riparian vegetation. The cottonwood dominated riparian community above the gaging station on the Rio Chama should not significantly be affected by this additional storage. The additional temporary storage of the maximum experienced flood volume would inundate an additional 1,500 acres. Of this about 60 acres is canyon bottom/riparian vegetation on about 1.6 miles of stream (about 0.7 miles on the Rio Chama). The cottonwood/juniper community above the gaging station would be affected by this temporary storage, the extent to which riparian species would be affected would be dependent upon storage duration, but because of likely periodic inundation, an early stage of cottonwood development would likely be the expected scenario. Its advancement to a mature cottonwood community would likely follow as the reservoir was eventually evacuated. The rare possibility of floodwater storage to the top of the flood control pool (elevation 6335) would inundate an additional 800 acres, of which about 54 acres is canyon bottom/riparian vegetation. The relocation of about four miles of Forest Road 151 would remove about 40 acres of sparse pinon-juniper woodland. About nine acres of pinon-juniper woodland would be removed from the relocation of State Road 96 and an associated bridge.

NO ACTION. Approximately 4,100 acres of land, associated vegetation, and stream is perennially inundated from the present storage of 200,000 acre-feet. Based on the maximum experienced flood storage to date, an additional 2,000 acres was subject to inundation. An additional 1,400 acres within the flood control pool has not been inundated but is also subject to future inundation. A majority of vegetation inundated is pinon-juniper-grassland. Portions of the cottonwood dominated riparian communities in the upper canyon bottoms of Canones Creek, Arroyo Seco, and the Rio Puerco have been inundated as have the juniper dominated, intermittent riparian zones along the upper part of the reservoir. Inundated vegetation in this zone would be replaced with annual grasses or forbes following each inundation. During extended periods between inundation, plant succession would advance to more perennial grasses and the reestablishment of woody shrubs and deciduous trees. The cottonwood dominated community above the gaging station is not within the existing flood control pool.

Terrestrial Fauna

STORAGE OF 467,000 ACRE-FEET. The establishment of a large conservation pool would result in exchanging additional terrestrial and riverine habitat for aquatic habitat. Generally, water-dependent and associated species would continue to benefit and species associated with pinon-juniper-grassland would lose

some habitat. Of the plant associations affected, the one with the higher wildlife use is the riparian plant community. The extent of wildlife use of these communities and consequent habitat loss depends largely on the plant species and structure (vertical distribution of foliage). Those communities composed of surrounding xeric or mesic plant species with few riparian species have a lower wildlife use than a community type with dense large vegetation with foliage at multiple levels. The riparian cottonwood community on the Rio Chama at the horseshoe bend above the gaging station demonstrates a community/structure type that would probably have the highest wildlife use (especially birds) in the reservoir area. The extent to which these stands of cottonwood would be affected by intermittent flood control storage, and consequently, associated wildlife use, would be the more significant effect to terrestrial wildlife use. The beneficial, as well as adverse wildlife effects, are expected to be local in nature rather than regional. Increased motorboat access to the lower Rio Chama Canyon would add to existing and future increase in recreational use of this area. Additional wildlife disturbance, because of this increased use should be relatively minor. Relocation of Forest Road 151 and the New Mexico Highway 96 bridge would result in a relatively small loss of wildlife habitat but, collectively, would contribute to the overall reduction in terrestrial wildlife habitat. As the lake deceases in volume and surface area in the next century, terrestrial wildlife values would gradually increase as aquatic

habitat decreased.

NO ACTION. Wildlife habitat and utilization of the general reservoir area is likely to continue in the absence of additional water storage. The present increased size of the lake has benefitted waterfowl, shorebirds, wading birds, and some raptors. The planned establishment of food plots for waterfowl should contribute to a modest increase in use. The recent inundation of an additional 1,900 acres has reduced habitat for passerine (perching) birds, small mammals, reptiles and a small number of mule deer. This area will be the future zone of reservoir fluctuation and would have moderate beneficial effect for waterfowl, shore birds, and wading birds. The periodic reestablishment of annual grasses and forbes would partially compensate for lost habitat for passerine birds and reptiles. The most single effect on the wildlife has been the inundation of riverine and riparian habitat. Future factors that could contribute to wildlife disturbance and avoidance are increased recreational use of the lake and canyon areas and residential development. These effects would be local in nature and not regional. Following the elimination of the water supply pool and the regrowth of vegetation, wildlife use of this previously inundated area would resume. Wildlife species presence and use would depend on the type of vegetation community that would re-establish and the frequency of inundation. Reestablishment of grasses and riparian vegetation would be the most rapid, with

.onger to reestablish.

467,000 ACRE-FEET. Increased storage should :pand and improve the quality of lake habitat. The ze of fish should increase, and perhaps a modest use by waterfowl, shore birds, and raptors would ealization of the maximum fishery potential would on the extent of reservoir fluctuation during the rly summer. Based on probable operation procedures, variations of lake levels during this period will be ndent on flood control needs. An increase in surface consequence of a larger lake would decrease the extent r fluctuation. Approximately 3.4 miles of moderate- eam habitat (as measured from the top of the 200,000 ool) would be exchanged for lake habitat. Stream to an additional 0.7 miles would be subject to undation from flood storage. Stream habitat would lowered in this area of periodic inundation. Lake ld be reduced commensurate with the size of the lake an-Chama Project Water is withdrawn early in the next Additional water supply storage would give water users bility in managing flows and the potential for he downstream fishery on the Rio Chama and Rio Grande. procedures have not been developed in sufficient

detail to address the potential for improvement. However, based on current operational procedures, this opportunity may not be available until San Juan-Chama Project Water begins to be releas on a constant, long term basis. This would happen with the no action alternative but would not have as pronounced an effect as with this alternative.

NO ACTION. The quality and quantity of lake habitat has been significantly increased by the recent storage of 200,000 acre-feet of conservation water. Correspondingly, aquatic and semi-aquatic fauna have benefitted. Also, stream habitat in the lower Rio Chama has improved from the discharge of higher quality water, although the pronounced variation in flows still limit aquatic fauna. The stream fishery on the Rio Chama above Abiquiu Reservoir is being enhanced by the influence of the larger reservoir (primarily by warmwater species). These improved water conditions would continue until the evacuation of San Juan-Chama Water begins. Then lake habitat will diminish in quality and quantity. Long term, continuous releases of San Juan-Chama water would benefit aquatic fauna in the lower Rio Chama during the delivery period, although the effects of turbid water and sedimentation would gradually increase as the volume of the lake decreased. Also, aquatic habitat on the Rio Grande to Cochiti Lake could improve slightly from increased long term stream flow. Periodic storage of flood water would continue to lessen stream habitat on about 1.6 miles of the Rio Chama.

STORAGE OF 467,000 ACRE-FEET. A larger body of water has the potential to attract additional bald eagles through an increase in water associated prey. Increased storage would inundate some night roosts and perches currently being utilized. Inundation would require that other roosting and perching sites be used. Newer optional night roosts may require longer flights to and from the lake and lake use patterns could change. Any significant increase in recreational use of the lake during the winter months as a result of increased storage could disturb these birds, and recreational management could be required during peak use months. Effects of increased residential development should not be significantly different from the existing conditions. The gradual withdrawal of the San Juan-Chama Project water will result in a corresponding decline in eagle use and a regional redistribution of bald eagles. However, since irrigation water would be stored during certain years for a limited time, some bald eagle use could continue. Section 7 consultation under the 1973 Federal Endangered Species Act has been completed for the bald eagle. The results of this coordination conclude that this alternative would not likely jeopardize the continued existence of the bald eagle at Abiquiu. This alternative could possibly result in a small increase in prey availability for the peregrine falcon. Given the apparent light use of the area be peregrine falcons, increased water

storage would likely not effect this bird, either positively or adversely. Use of an enlarged lake by sensitive species of effects on these species, is not expected to vary significantly with this alternative.

NO ACTION. Enhanced bald eagle use of Abiquiu Reservoir would likely continue in the absence of increased water storage. Lake use patterns and populations would vary depending on flood storage needs, volumes and duration. Some night roosts and hunting and loafing perches have been inundated by periodic flood control storage, and these sites would continue to be subject to periodic inundation until conservation storage was evacuated. With time, roosting and perching trees could fall, requiring eagles to locate other suitable sites in the immediate lake area. Some potential roosting sites are near the lake. Increased recreational use and recreational home development may act to disturb these wintering eagles, and could require management of recreational use during the winter to avoid excessive disturbance. With gradual evacuation of the lake, there would be a corresponding decline in eagle use. At this time, there would be a regional redistribution of bald eagles. Based on available data, use of the lake area by peregrine falcons is light. There is no evidence available that would suggest peregrine falcons are being adversely affected by having an increased prey availability with a history of high pesticide levels.

RECREATION

General. The effects of additional water storage on recreational opportunities have been some of the most significant public concerns during the course of this study. In order to obtain the most accurate possible projections of recreation visitation, the Corps of Engineers implemented a contract study (Baxter, et al., 1982) with the Bureau of Business and Economic Research of the University of New Mexico. A visitation forecast made during this study was also used to project visitation related to the existing 200,000 acre-foot pool. Table 2 compares the visitation forecast for the present 200,000 acre-feet with that for the maximum storage alternative over the next 50 years. An intermediate level of facilities development is assumed for the proposed plan. The actual experienced visitation for the past four years was higher than the forecast and is likely a reflection of the unanticipated high and relatively long term storage levels for flood control.

STORAGE OF 467,000 ACRE-FEET. Additional conservation storage could begin in about 1989. The storage volume and duration of storage would be variable, dependent on storage needs, water availability and storage depletion. Storage volumes would be decreasing about the year 2006 when releases of San Juan-Chama Project water are greater than the amount stored. As irrigation storage forms a larger portion of the storage, pool levels would

fluctuate from minimal volumes to near 200,000 acre-feet. Visitation would increase as the surface area of the lake increased and would continue to rise during the pool duration. Participation in boating, fishing, sightseeing, swimming, picnicking, and camping can be expected to increase. The fishery would be expected to increase significantly with a commensurate increase in anglers.

TABLE 2
PROJECTED ANNUAL RECREATIONAL VISITATION
ABIQUIU RESERVOIR

YEAR	NO ACTION	ADDITIONAL STORAGE
1990	333,000	490,000
1995	371,000	591,000
2000	412,000	704,000
2005	425,000	750,000
2010	439,000	801,000
2015	330,000	816,000
2020	156,000	831,000
2025	160,000	802,000
2030	164,000	680,000
2035	202,000	353,000
2040	240,000	248,000

Source: Baxter et al., 1982

Approximately 25 percent of recreation visitation would be anglers. Predictions of standing crop and harvest of fish in Abiquiu Reservoir were provided by the National Reservoir Research Program (USFWS, 1983). These predictions indicate the total harvest, standing crop, and angler use would all increase with a larger reservoir. An exception is the rainbow trout harvest projections which indicate a peak at about 200,000 acre-feet. A moderate increase in sport fishing would be expected in the two mile reach of the Rio Chama below the dam. Recreational

use would decline as San Juan-Chama water was withdrawn from the reservoir. The variability of storage prevents an accurate presentation of evacuation rates and time periods. Storage of irrigation water would become the dominant reservoir use when San Juan-Chama water was evacuated. Reservoir fluctuation and indefiniteness of a significant pool would limit recreation to about the 200,000 to 300,000 units visitation range. The anticipated level of recreational facilities reconstruction would still be insufficient for the potential recreational demand. Management measures, such as use limitations, could become necessary to prevent any degradation of recreational and environmental quality. The expanded recreationists opportunities at Abiquiu Reservoir would assist in filling the need for water recreation resources in New Mexico. Visitors would be recruited from other lakes in the region, as well as the state. The increased choice of lakes and dispersal of recreationalists made possible by expanding Abiquiu Reservoir could further assist in improving the overall recreational quality of water-associated recreation in the state.

Whitewater Boating. Conservation storage of an additional 467,000 acre-feet (667,000 total) could reduce the 29.2 mile length of the Rio Chama used for whitewater boating by about 2.7 miles. Of this 2.7 miles, about 1.6 miles would be subject to permanent inundation by the conservation pool, and 1.1 miles would be subject to intermittent inundation from waters held in

the authorized flood control pool. Within this reach are three rapids, two of which have not been inundated to date. The top of the 502,000 acre-foot flood control pool would be at elevation 6,335. The elevation is about 0.4 miles above the concrete bridge on the Rio Chama and there is one additional rapid in this stretch of the river, located next to the concrete bridge. This rapid would not likely be affected because of the relatively short storage period and low potential for flood water storage at this elevation. Conservation storage would probably not affect existing or future participation in the two day river float trips. It would shorten this trip by 1.5 to 2.0 hours if flows were below 2,000 cfs, thus allowing the boats clearance to go under the concrete bridge. Also, when the flow rate would permit passage under the bridge, the recreational experience could be diminished since three of the ten major rapids on the 31 mile reach from El Vado Dam are located below the concrete bridge. Participation in the one day float trips would be significantly reduced. The maximum length currently available for the one day trip is about nine miles (of this, 1.1 miles and three rapids are within the flood control pool) with the concrete bridge being about 5 miles below the Monastery of Christ in the Desert put-in/take-out point. There are two major rapids above the concrete bridge, one at the bridge, and three below the bridge. The use of the concrete bridge rapid is dependent upon the discharge ir the river. While boating use below the concrete bridge would be eventually reduced as a consequence of the flood control functior

of the dam, increased conservation storage would hasten the inundation and sedimentation of the last three rapids, thereby reducing the length of river and number of rapids used by the rafters. The current estimate for annual user days attributable to whitewater boating on the Rio Chama is 3,675. The addition of the maximum amount of conservation storage would reduce the number of user days for whitewater boating to about 1,840, with most of the reduction being in one day trips. This alternative would not affect the agreement between the City of Albuquerque and the State of New Mexico to supply recreational water for whitewater boating during summer weekends. The limited number of whitewater streams in the Southwest and the limited opportunities to participate in this sport increases the significance of reduced whitewater boating on the Rio Chama.

NO ACTION. With the no action alternative and no further development of recreation facilities at the lake, visitation will continue with the present trend of gradual increases until the lake level begins to drop. Continued abnormally high storage levels due to the retention of flood waters will increase the projected visitation slightly. About the year 2015, it is anticipated that visitation would rapidly decrease as a result of the reduced pool and lower aesthetic qualities at the reservoir. Visitation would then gradually increase during the following twenty years as recreation is adjusted and reinvasion of plants improves the visual quality of the surrounding lands. Management

measures, such as use limitations, may be necessary to prevent any degradation of recreational environmental quality.

Under existing conditions, the storage of flood water reduces the length of the Rio Chama which is available for whitewater boating. The Adobe Ruins Rapid and associated take-out points have been periodically inundated and will continue to be so. Presently, the Adobe Ruins Rapid and use of the inundated section of stream is restored following the evacuation of flood waters. However, with each succeeding inundation, increasing amounts of sediment are deposited. While the mechanics of sediment deposition and transport are complex, the assumption can be made that sediment deposition would alter stream channel characteristics and whitewater use of this area could be diminished. Also, that section of the Rio Chama below elevation 6283.5 (about two river miles above Adobe Ruins) is within the currently authorized flood control pool. There are two additional rapids in this area, which are subject to inundation and sedimentation with potential attentive reductions in whitewater boating activities. A quantitative prediction of stream and riparian conditions and the affects on whitewater boating use following the evacuation of the 200,000 acre-foot existing pool is not possible.

PALEONTOLOGICAL RESOURCES

STORAGE OF 467,000 ACRE-FEET. There are approximately 2,200 acres of the Chinle formation exposed at elevation 6304, and more at higher elevations. Prior to the addition of any more storage water, a survey would be required to determine the possible presence of fossilized remains. Approximately 75 percent of the formation would be surveyable since vertical slopes and talus would be difficult if not impossible to survey. No excavation of any identified Ceolophysis fossils would be anticipated. Any fossils inundated could be covered with sediment, the extent of which is not known. Sedimentation would increase the difficulty of excavation when the reservoir was evacuated.

NO ACTION. There are an estimated 1,000 acres of Chinle formation exposed at elevation 6240. This elevation is within the present zone of intermittent inundation. The presence of fossilized remains of Ceolophysis within the 200,000 acre-foot existing pool or the zone of intermittent inundation is not known. Sediment deposition will protect any resources present but conversely,could impair their detection as well as future accessibility.

COST OF ADDITIONAL STORAGE

The costs associated with the storage of additional

conservation water at Abiquiu can be categorized in two groups. The first group are those sunk costs associated with the construction of the project. In using the "Use of Facilities ..hod" in determining cost allocations, the percentage of the cost of dam (updated to current price levels), which would be attributable to increased conservation storage, must be paid by the local entity which will be using that storage. Abiquiu Dam and Reservoir was constructed at a cost of $21,275,000. When this cost is updated to October 1987 price levels, the cost to construct Abiquiu Reservoir today would be $139,300,000 (This includes $2,000,000 for the adits which are being installed and $2,700,000 for the emergency gates which were authorized by the Water Resources Development Act of 1986). The "Use of Facilities Method" of cost allocation basically states that, for example, if 1/2 of the capacity of the reservoir is going to be used for conservation storage by a local entity, then that entity must pay for 1/2 of the construction cost of the reservoir.

The second group of costs are the specific costs associated with the actual increase in the size of the permanent reservoir. At Abiquiu, these costs have been categorized into the following groups:

1. Land Acquisition (fee and easement)
2. Relocation of Recreational Facilities and Residential Structures.
3. Relocation of Raising Roads and Bridges

4. Fish and Wildlife Mitigation

5. Cultural Resources Mitigation

6. Administrative Costs

Table 3 presents a comparison of costs for several different levels of additional storage at Abiquiu. All costs are at October 1987 price levels.

These costs were presented to all of the entities which had expressed an interest in storing water in Abiquiu. All of these entities felt that the cost associated with storage were too high and said they would not be interested in storing water at the costs which were presented.

ABIQUIU RESERVOIR REVIEW SURVEY

TABLE 3
COST OF ADDITIONAL STORAGE INCLUDING SUNK COSTS OF DAM

TOTAL ADDITIONAL STORAGE	SUNK COSTS OF DAM	SPECIFIC COSTS OF ADDITIONAL STORAGE	TOTAL COST	AVERAGE ANNUAL COST (11.07%)	AVERAGE ANNUAL COST/A.F.
50,000 A.F.	$ 6,700,000	$ 2,700,000	$ 9,400,000	$ 1,046,000	$20.92
100,000 A.F.	13,400,000	4,700,000	18,100,000	2,014,000	20.14
200,000 A.F.	26,600,000	9,200,000	35,800,000	3,984,000	19.91
300,000 A.F.	39,900,000	16,600,000	56,500,000	6,287,000	20.96
350,000 A.F.	46,600,000	21,600,000	68,200,000	7,589,000	21.68
467,000 A.F,	62,200,000	33,100,000	95,300,000	10,605,000	22.70

RECOMMENDATIONS

As a result of the analyses accomplished to date on the feasibility of recommending additional conservation storage in Abiquiu Reservoir, studies on the Abiquiu Reservoir Review Survey, an interim of the Rio Grande and Tributaries authority, has been terminated. As a result of costs estimates which range from $9,400,000 to $95,300,000 for additional conservation storage in Abiquiu, and the fact that 100 percent of these costs must be paid by the local sponsor, no entities expressed any interest in storage at these costs. Therefore, I recommend that no additional conservation storage at Abiquiu Reservoir be authorized by Congress at this time. I also recommend that because of the physical feasibility of storing additional water in Abiquiu that the possibility of storing additional water be reconsidered, if and when conservation storage at Abiquiu becomes a viable, necessary, and feasible alternative for beneficial use of the reservoir in the future.

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