COCHITI - A KEY WATER RESOURCE DEVELOPMENT FOR NEW MEXICO

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My subject is Cochiti Lake, the dam and reservoir currently under construction by the Corps of Engineers on the Rio Grande, 50 miles north of Albuquerque, New Mexico. It is the largest project ever undertaken by the Corps of Engineers in New Mexico and is the last of four dams on the Rio Grande basin in New Mexico designed for flood control. When completed, it will not only ensure a high level of protection for the Middle Rio Grande Valley from flooding on the main stem, but will also provide a strategically located permanent lake for recreation.

In this presentation I plan to cover background leading to the project, significant design considerations, main structural features, current status, and recreational development.

History of Flooding on Rio Grande

Flood flows on the Rio Grande are erratic but can be very devastating. In the early days it was reported that entire vallages were washed away. In 1828, records left by a Catholic priest indicate a flow of about 100,000 cubic feet per second just below Albuquerque. High level water marks left by a mid Rio Grande Valley flood in 1874 indicate an estimated flow of 125,000 cfs. When compared with a normal spring runoff which can be expected to produce a little over 5,000 cubic feet per second at Albuquerque, this gives us a conception as to the order of magnitude of floods which have occurred and could occur on the middle Rio Grande without special flood control measures.

Survey Report and Authorization History

In 1956, the Committee on Public Works, United States Senate, by resolution, requested the Corps of Engineers to make a study. The resulting survey report, published in 1960, recommended construction of Cochiti Lake and Galisteo Dam. This was subsequently authorized in the same year as Public Law 86-645.

Initial authorization of the Cochiti Lake project in 1960 was prior to the San Juan-Chama Transmountain Diversion Project and did not provide for a permanent pool. Any pool for recreation would, of necessity, have to be provided by water obtained entirely outside the drainage basin of the Rio Grande. The San Juan-Chama Diversion provided this opportunity, and Public Law 88-293 in 1964 authorized the use of 50,000 acre feet of storage in Cochiti for "Conservation and Development of Fish and Wildlife Resources and for Recreation," provided that the water for the per-

1/ Corps of Army Engineers, Albuquerque, New Mexico

manent pool be made available from water diverted into the Rio Grande from the Colorado Basin via the San Juan-Chama Transmountain Diversion.

Site Location (Figure 1)

Site selection studies completed in 1961 fixed the Cochiti Dam, immediately upstream of Cochiti Pueblo, about 50 miles north of Albuquerque, New Mexico, and about 25 miles southwest of Santa Fe, New Mexico. Project structures and a large portion of the reservoir area are on Cochiti Pueblo lands. The embankment was aligned to intercept flows from the Santa Fe River and Canada de Cochiti as well as the Rio Grande.

Galisteo Dam, authorized concurrently with Cochiti, was designed to control flows on Galisteo Creek at a location about 12 miles upstream from its confluence with the Rio Grande. Galisteo was completed in September 1970.

Geology of the Site

From the Geologist's standpoint the selected site is an exciting one.

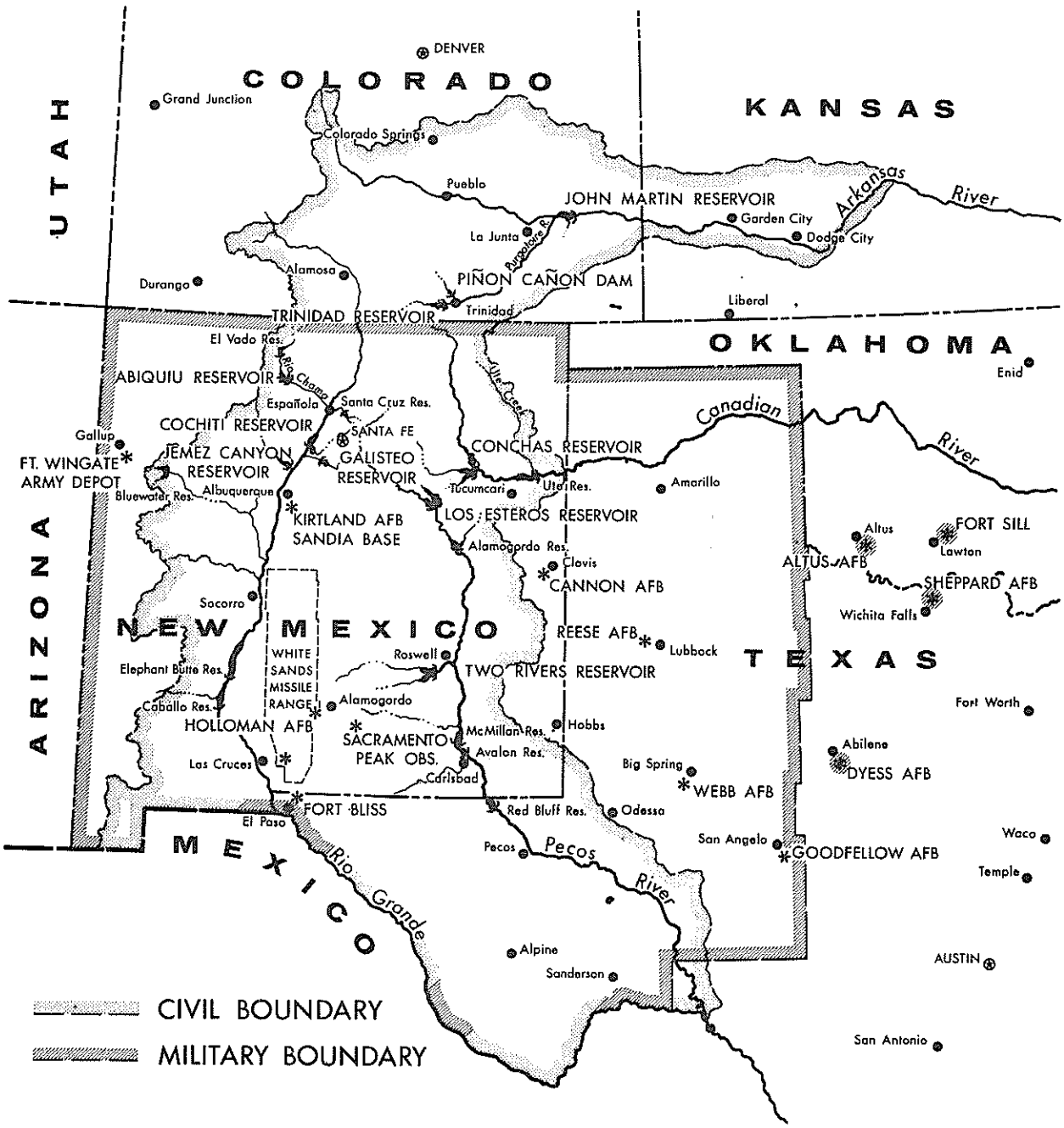
What today is called the Rio Grande valley was at one time in geologic history a series of isolated bowl shaped depressions called basins. These basins formed along a large fault zone extending from the San Luis valley in South Central Colorado to the vicinity of El Paso, Texas. Drainage in these basins was trapped and probably each one had its own ephemeral lake. As the basins filled with sediments, the drainage became integrated from one to another and formed a through flowing stream, the Rio Grande.

The Cochiti Dam is being constructed in one of these historical bowl shaped depressions known as the Santo Domingo Basin. The basin is bounded by volcanoes and has been partially filled with sand, gravel, silt, and clay deposits. This material can be found to depths in excess of 400 feet. Drilling in the Rio Grande valley downstream of the Santo Domingo basin has shown that unconsolidated sediments, fine and coarse grained sandstone and conglomerate also occur in this vicinity. In the past, lava or basalt flows have covered much of the area.

Geologic materials on or near the ground surface and within the area of construction for the dam and other structures consist of sandstone, sand, gravel, cobbles, boulders, silt, clay, and pumice deposited in step-like benches or terraces. Intermittent flows of lava or basalt have contributed to the accumulation of materials found at the site.

Coarse grained sandstone is the oldest rock exposed in the project area. This rock has been exposed by faulting in the area of the outlet works and in the Canada de Cochiti. This sandstone is the foundation rock for the outlet works and for portions of the earth dam. Lava flows up to 200 feet thick are present in the Santa Fe River portions of the dam and form the foundation rock for the dam and spillway structure in this area.

Foundation conditions along the 5.4 mile long earth dam are extremely varied and complex. Depth of overburden or alluvial material over sand-



ALBUQUERQUE DISTRICT

SCALE IN MILES

0 30 60 120 180 240

stone or basalt bedrock varies from zero on the left abutment of the Rio Grande and in the Santa Fe River Canyon to more than 200 feet in other areas of the dam foundation. Much of the dam will be founded on overburden or alluvial materials. In four foundation areas along the dam alignment, deposits of low strength fat clay were found above bedrock level, necessitating special design and construction procedures.

Project Features (Figure 2)

The project consists of a major earth dam; a conveyance channel to connect the Rio Grande, Canada de Cochiti, and Santa Fe River arms of the reservoir; an uncontrolled overflow type, mass concrete spillway structure; an outlet works equipped with hydraulically operated slide gates to control discharges from the lake; recreational development; and necessary operation facilities, roads, and utilities. The project also requires revision to the existing Sile Irrigation Canal on the west side of the river, and the Cochiti main irrigation canal on the east side of the river.

Land Acquisition

Land acquisition was somewhat unique in the case of the Cochiti project, because a large portion of this project is located on lands belonging to the Cochiti Indians. The Cochitis stated a willingness to agree to conveying the necessary land to the U. S. Government if recreational rights could be preserved to them. After a period of negotiation, an "Easement Grant and Agreement" was entered into in November 1965. A "Memorandum of Understanding" with the Pueblo governing the construction, operation, and maintenance of the public use facilities of the project was executed at the same time. Basically, the memorandum describes the responsibilities of the Corps of Engineers and the Cochiti Pueblo as they relate to constructing various public use facilities and concession facilities. It further defines responsibilities for and maintaining the facilities. The memorandum allows the Cochiti Pueblo to charge for admission to these facilities to the extent necessary to finance operating and maintenance costs.

Other lands and easements were acquired through agreements with the U. S. Forest Service, Atomic Energy Commission, National Park Service, and the University of New Mexico.

Design

1. Reservoir Storage Allocations:

Capacity of the reservoir at maximum pool elevation will be 736,000 acre feet. Capacity at maximum flood control pool will be 602,000 acre feet. Storage allocations are: Recreation (Permanent pool) - 50,000 acre feet; Sediment Reserve - 110,000 acre feet; and flood control - 442,000 acre feet. The permanent pool was authorized for conservation, development of fish and wildlife resources, and recreation.

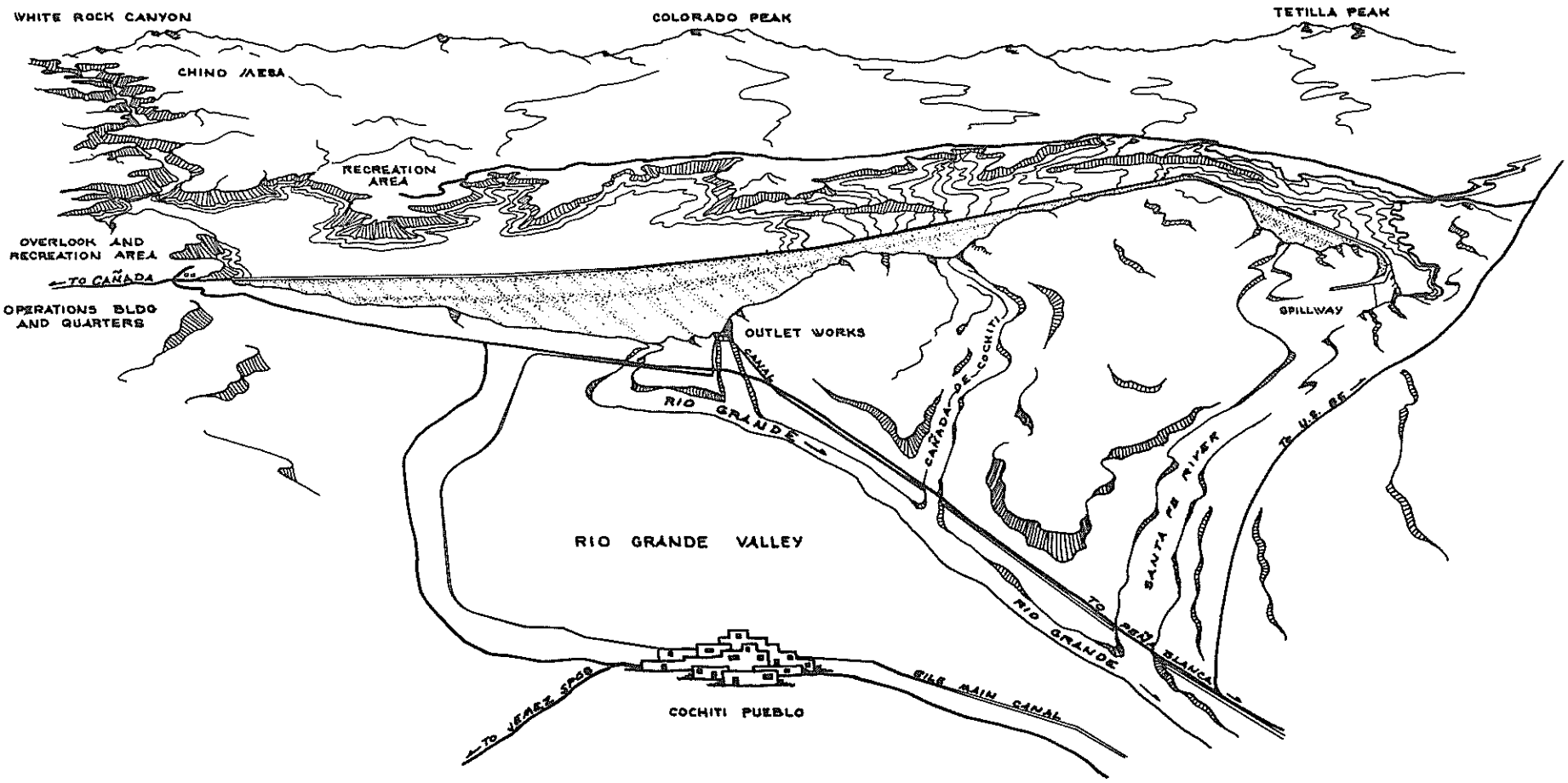


Figure 2. **COCHITI DAM & RESERVOIR**

2. Embankment: (Figure 3)

The design calls for a rolled earth fill dam, 5.4 miles long, maximum height 251 feet above Rio Grande streambed level. The earth dam, after crossing the Rio Grande, extends southward across Canada de Cochiti and the Santa Fe River, both left bank tributaries to the Rio Grande. A conveyance channel connects the Santa Fe River and Canada de Cochiti reservoir arms with the main Rio Grande reservoir area. The dam will be founded on material ranging from overburden to sandstone or basalt bedrock. The grout curtain, 125 feet into bedrock, will be provided to limit underseepage losses through bedrock. Zoned sections designed for the earth dam utilize the earth and rock materials locally available at the site. The zoned section will have a centrally located impervious fill core zone supported by upstream and downstream shells of higher strength granular fill. Internal drainage blankets of pervious fill and processed drain material, both having a high permeability or the ability to convey water, are provided downstream of the central core zone to collect, convey or otherwise care for any through seepage or underseepage waters or pressures.

3. Outlet Works:

The outlet works is located on the left abutment of the Rio Grande adjacent to the present river channel. The outlet works consists of an approach structure, gated intake structure, a triple conduit, and terminal stilling basin. The conduit is 1,286 feet long. Dimension of each rectangular conduit is 6.5 x 12 feet. The control tower is 261 feet in height. Pairs of service and emergency hydraulically operated slide gates are provided for each conduit opening. The control tower is a circular shaft, 25 feet inside diameter, containing an elevator, stairs, air vent pipes, and other installed equipment and utilities. A control house is provided at the top of the tower. Access to the control house will be by a bridge from the top of the earth fill dam to the intake structure. Total length of the bridge is 474 feet. A two-level stilling basin at the end of the conduit is required to dissipate the energy of the water discharged through the outlet works. The higher level is required for gravity deliveries of irrigation water to the downstream existing canal systems. The lower level is required for dissipation of energy of flows from the upper basin before returning releases to the river. Irrigation takeoffs are provided on both sides of the upper basin complete with control gates and sluices for delivery of irrigation water to the downstream Sile and Cochiti main canals.

4. Spillway:

The uncontrolled concrete gravity spillway structure is located at the south (left) end of the dam. Spillway flows discharge into the natural Santa Fe River channel. The structure is founded on multiple lava or basalt flows having a thickness in excess of 100 feet. Its total length is 650 feet. Principal features are an ogee overflow section, 460 feet wide, and non-overflow end sections for connection to the dam. Maximum height of the overflow sections above bedrock is about 84 feet.

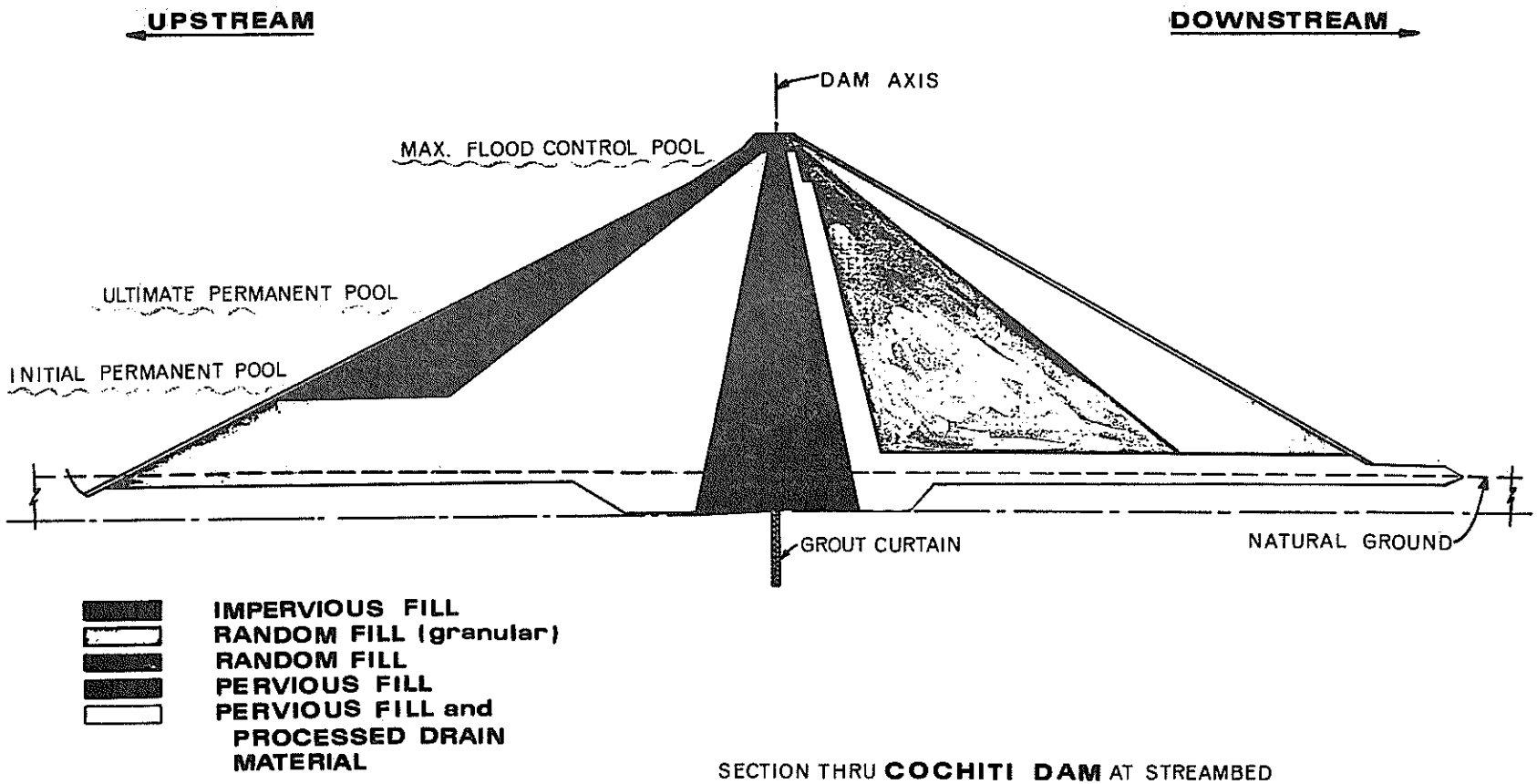

UPSTREAM
DOWNSTREAM
DAM AXIS
MAX. FLOOD CONTROL POOL
ULTIMATE PERMANENT POOL
INITIAL PERMANENT POOL
GROUT CURTAIN
NATURAL GROUND
IMPERVIOUS FILL
RANDOM FILL (granular)
RANDOM FILL
PERVIOUS FILL
PERVIOUS FILL and PROCESSED DRAIN MATERIAL
SECTION THRU COCHITI DAM AT STREAMBED

Figure 3.

Construction of the spillway structure was completed in August 1967.

Construction

Phases

The total project was broken down into parcels for purposes of construction in the following order:

1. Access Road and Operations Building. Constructed by Universal Constructors, Inc., in 1965 at a cost of $473,000.

2. Spillway. Constructed by Universal Constructors, Inc., from January 1966 to August 1967 at a cost of $2,500,000.

3. Outlet Works. Constructed by Nolan Brothers from 1967 to 1970 at a cost of $5,600,000.

4. Embankment. Bids for construction of the 63 million cubic yard Cochiti Dam were solicited on 6 March 1970 and opened on 13 May 1970. There were four bidders for the job. Two bidders based their estimates on a belt-conveyor operation and the other two based theirs on conventional hauling methods, which the successful bidder is using. The low bid of $61.7 million was submitted by Guy F. Atkinson Construction Company, South San Francisco, California. The contract was awarded on 1 June 1970.

The scheduled construction period of the earth dam is five years, assuming proper continuity of funding.

Quality Control System

In 1967, the Corps of Engineers adopted a quality control system for large projects requiring contractors to inspect their own work. This procedure greatly increases the contractor's responsibility to perform quality production. An earth fill dam such as Cochiti requires very close surveillance and much highly technical testing through all phases of construction. The contractor currently has a special organization for this purpose.

Interesting Construction Operations

Here again, the geology and water conditions play an important role in the contractor's scheduling sequence. During construction, it is necessary to consider and control the river water for three reasons. First, the water must be diverted so that the foundation can be cleaned, inspected, grouting performed, and prepared for earth fill. Second, adequate protection must be made to accomodate the river flow under both normal and flood conditions during the construction period. Third, irrigation water which flows in two canals adjacent to the river must not be interrupted.

During the first stages of work, the contractor constructed a cofferdam to protect his work area from the river, including needed de-watering operations to protect his work from underground water. One irrigation

canal has been relocated to flow on the side of the cofferdam; the other canal required no work. Next winter, when the irrigation water is not required, the contractor will remove the cofferdam and construct two dikes to contain the river within a new channel. The river will actually flow across a part of the completed work, but it will remain at its present elevation. During the closure operation, between the end of the irrigation season and the start of the spring floods (April), the contractor will complete the earth embankment across the Rio Grande and the Canada de Cochiti to a predetermined elevation. Normal flows and irrigation water will pass through the outlet works.

The following winter, when the chance of flood flow is at a minimum, the contractor will make closure of the Santa Fe River. He will also be completing the embankment to full height throughout its length.

Recreation

The recreational aspects of Cochiti Lake are most exciting from the public standpoint.

The project area is in an attractive foothill and valley region surrounded by scenic mountains possessing clear streams, extensive forests, fish, and game. The history and culture of this region are unique. Several ancient but still active indian pueblos are situated in the Rio Grande valley upstream and downstream from the lake. Cochiti, Santo Domingo, and San Ildefonso pueblos are in close proximity to the lake site. Nationally famous Taos Pueblo is located about 70 miles northeast of the dam. Bandelier National Monument lies about four miles north of the dam site. This monument contains many ancient indian ruins in a scenic mountainous area.

The public will have fully developed recreational areas on the lands adjacent to the lake. These will consist of picnic areas, overnight camping facilities, comfort stations, boat launching ramps, overlooks, access roads, water supply, and sanitation facilities. The Pueblo de Cochiti, through its agent 1/, will provide additional facilities.

A recreation area is also being planned for the White Rock Canyon area on Forest Service lands approximately 4.5 miles upstream from the embankment.

The lake, 1,200 surface acres at permanent pool level, will provide a well balanced water-oriented recreational program. The New Mexico Department of Game and Fish plans to assume responsibility for the development and management of a warm-water fishery. The fishery will include such species as largemouth bass, white crappie, bluegill, channel catfish, northern pike, and walleye. Sailboating, canoeing, swimming, and some water skiing will be available. Because of the small surface acreage that can safely sustain water skiing (approximately 320 of the 1,200 surface acres), area and time zoning restrictions will be required. Therefore, the Cochiti

1/ The Pueblo de Cochiti has contracted Great Western Cities, Inc., to provide and manage facilities that include a marina, swimming pool, restaurant-motel complex, riding stables, and concessions including a store and gas station.

Lake project will not only serve as a major recreational center in New Mexico, but will also complement other recreational activities such as wilderness outings, snow skiing, hunting, and fishing now available in the adjacent Carson and Santa Fe National Forests. It is strategically located within a 50-mile radius of forty percent of the New Mexico population.

Summary

The Cochiti Lake project is significant from three aspects.

First, it is particularly interesting from a technical engineering viewpoint; an outstanding example of a massive earth fill embankment and the largest structure of its kind to be built in New Mexico.

Secondly, it's the last and largest of the major flood control structures for protection of the Middle Rio Grande Valley. When completed, the valley will have a high degree of protection from flooding along the main stem of the Rio Grande.

And, finally, it will be a unique recreational asset in northern New Mexico, providing a variety of water-oriented activities in an area where this has not previously existed.

REFERENCES

1. French, James A., First Report of the State Engineer, State Engineer, December 1, 1914.

2. Bryan, Kirk, Geology and Ground Water Conditions of the Rio Grande Depression in Colorado and New Mexico, in Regional Planning, Part 6, The Rio Grande Joint Investigation in the Upper Rio Grande Basin in Colorado, New Mexico, and Texas, 1936-37 (U. S.) National Resources Committee, V. 1, Pt. 2, Sec. 1, pp. 197-225.

3. Public Act No. 96, May 31, 1939 (Covers Congressional Ratification of Rio Grande Compact between Colorado, New Mexico, and Texas as agreed 18 March 1938).

4. Resolution adopted June 28, 1956, the Committee on Public Works, United States Senate (Requested the Corps of Engineers to review House Document 243, 81st Congress).

5. Public Law 86-645, 14 July 1960 (authorized the construction of the Cochiti Lake Project).

6. Northrop, Stuart A., (Editor), Albuquerque Country, New Mexico Geological Society Guidebook, Twelfth Field Conference, October, 1961.

7. Public Law 87-483, June 13, 1962 (Authorized the construction of the San Juan-Chama Transmountain Diversion Project).

8. Cochiti Dam and Reservoir, Rio Grande, New Mexico, Design Memorandum on Geology, Soils and Construction Materials, Design Memorandum No. 4, August 1963.

9. Public Law 88-293, approved 26 March 1964 (Authorized the storage of 50,000 acre feet of imported water).

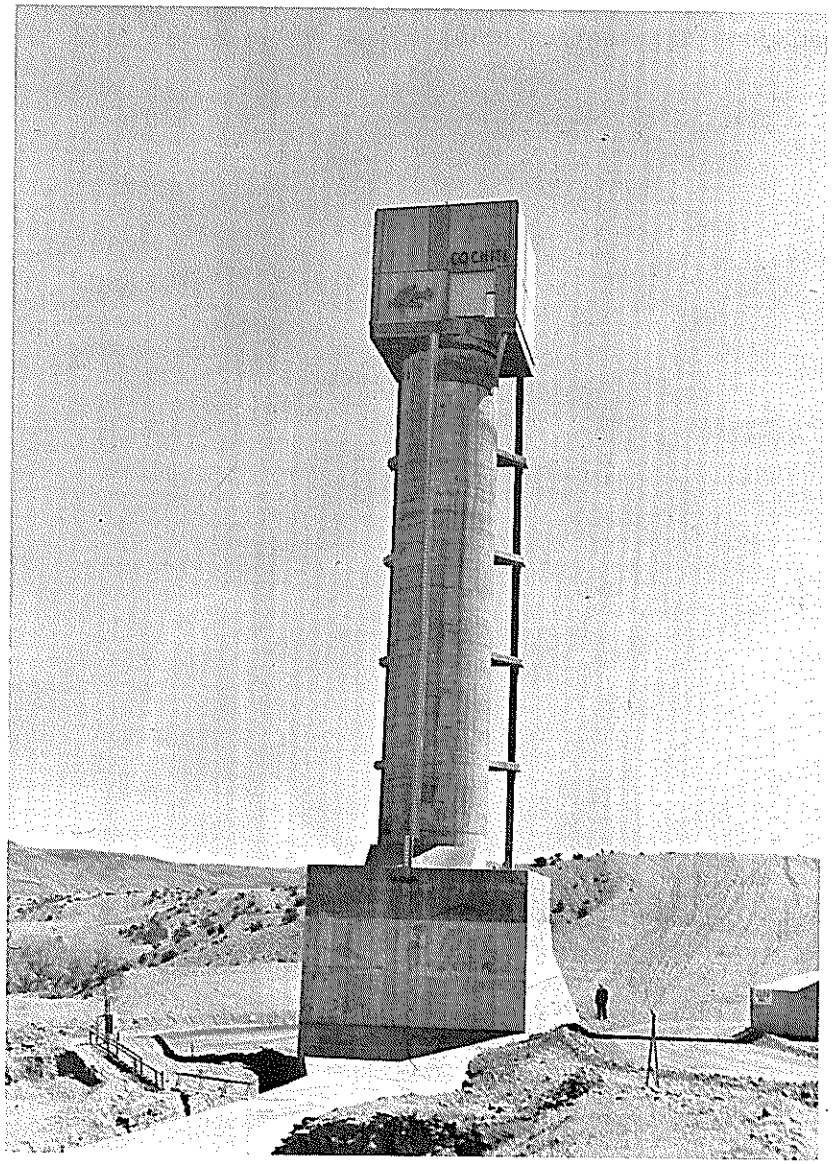
10. Cochiti Dam and Reservoir, General Design Memorandum, U. S. Army Engineer District, Albuquerque, Corps of Engineers, Albuquerque, New Mexico, approved 20 April 1964.

11. Easement Grant and Agreement, Cochiti Pueblo and Department of the Army, 16 November 1965 (99-year lease covering the project).

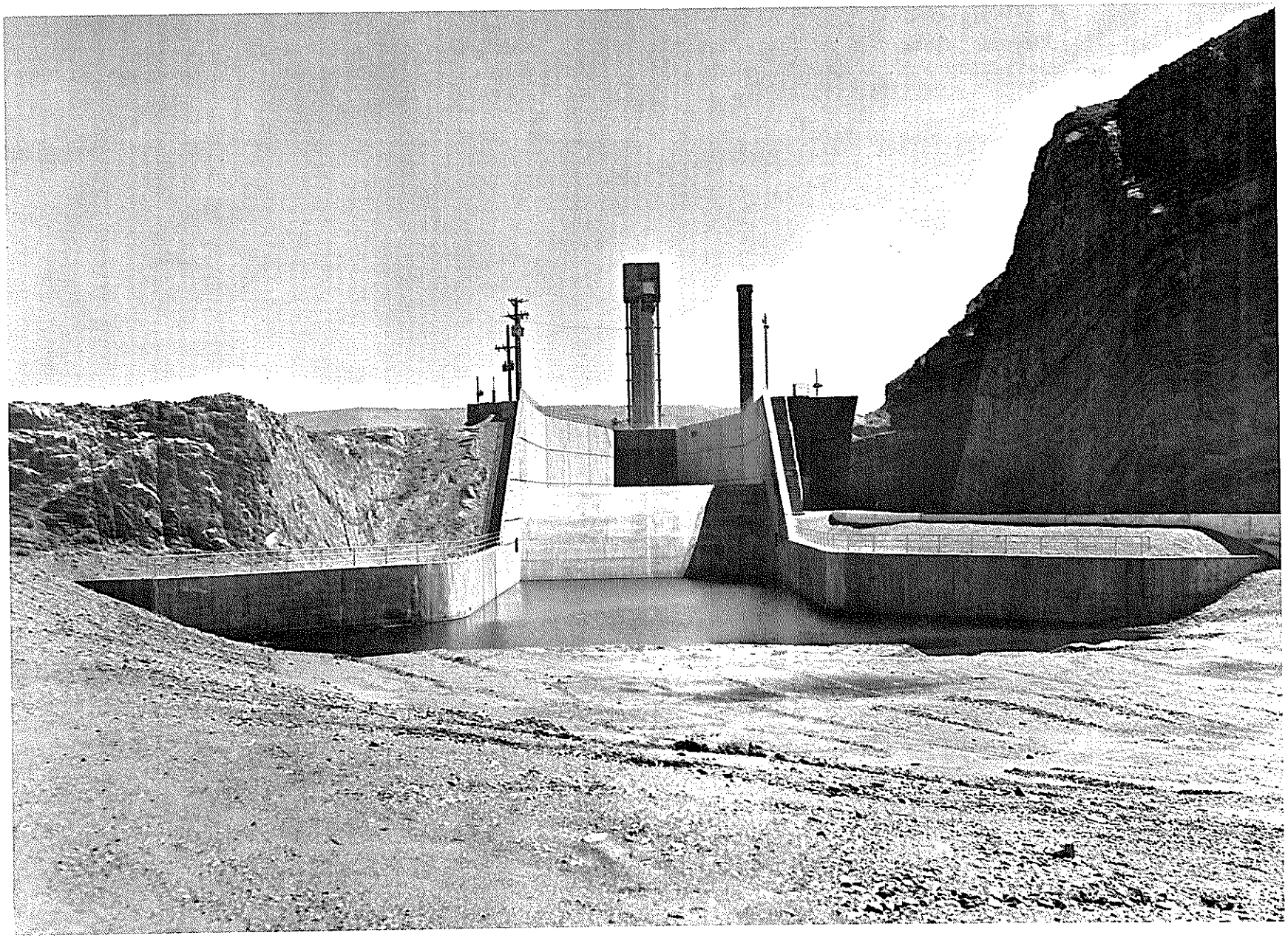
12. Memorandum of Understanding, Cochiti Pueblo and Department of the Army, 16 November 1965 (Agreement covering recreation facilities).

13. Lange, Charles H., Cochiti - A New Mexico Pueblo Past and Present, Southern Illinois University Press, Carbondale and Edwardsville, 1968.

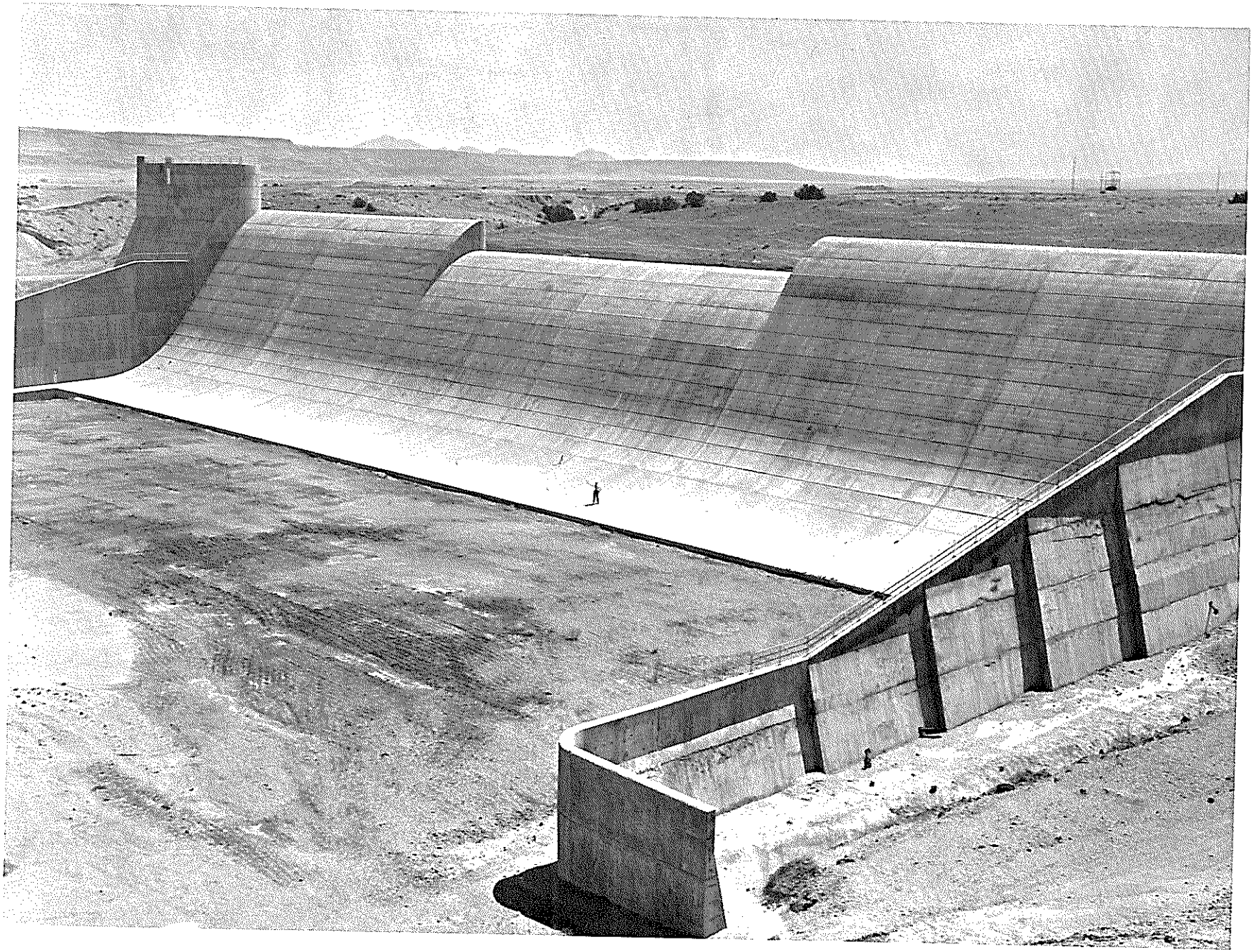
View of the intake structure of the outlet works. If you look very closely - you can see a man standing next to the trash rack on the concrete floor of the intake.



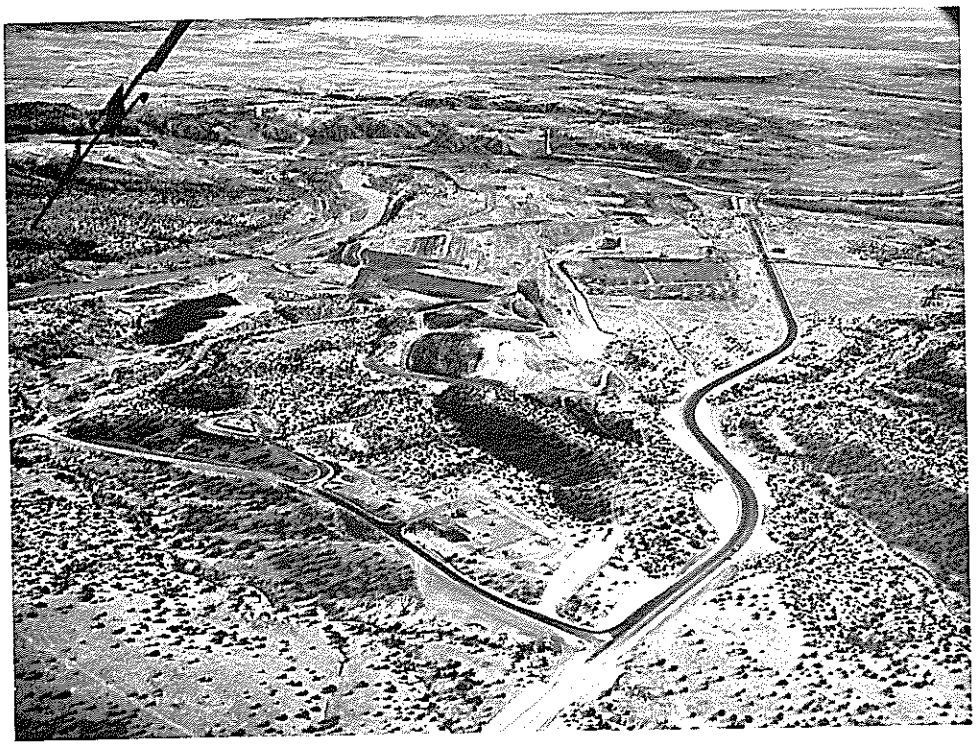
This is a view of the downstream side of the intake tower of the outlet works.



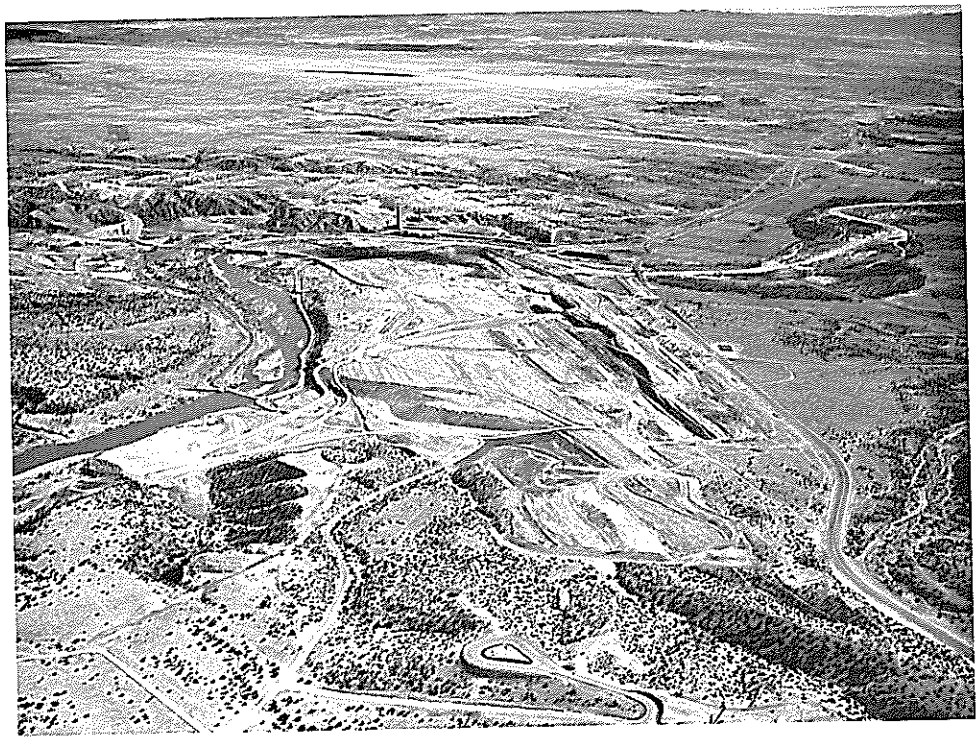
A graphic view of the downstream end of the outlet works. This photo shows the unique double weir designed into the outlet works.



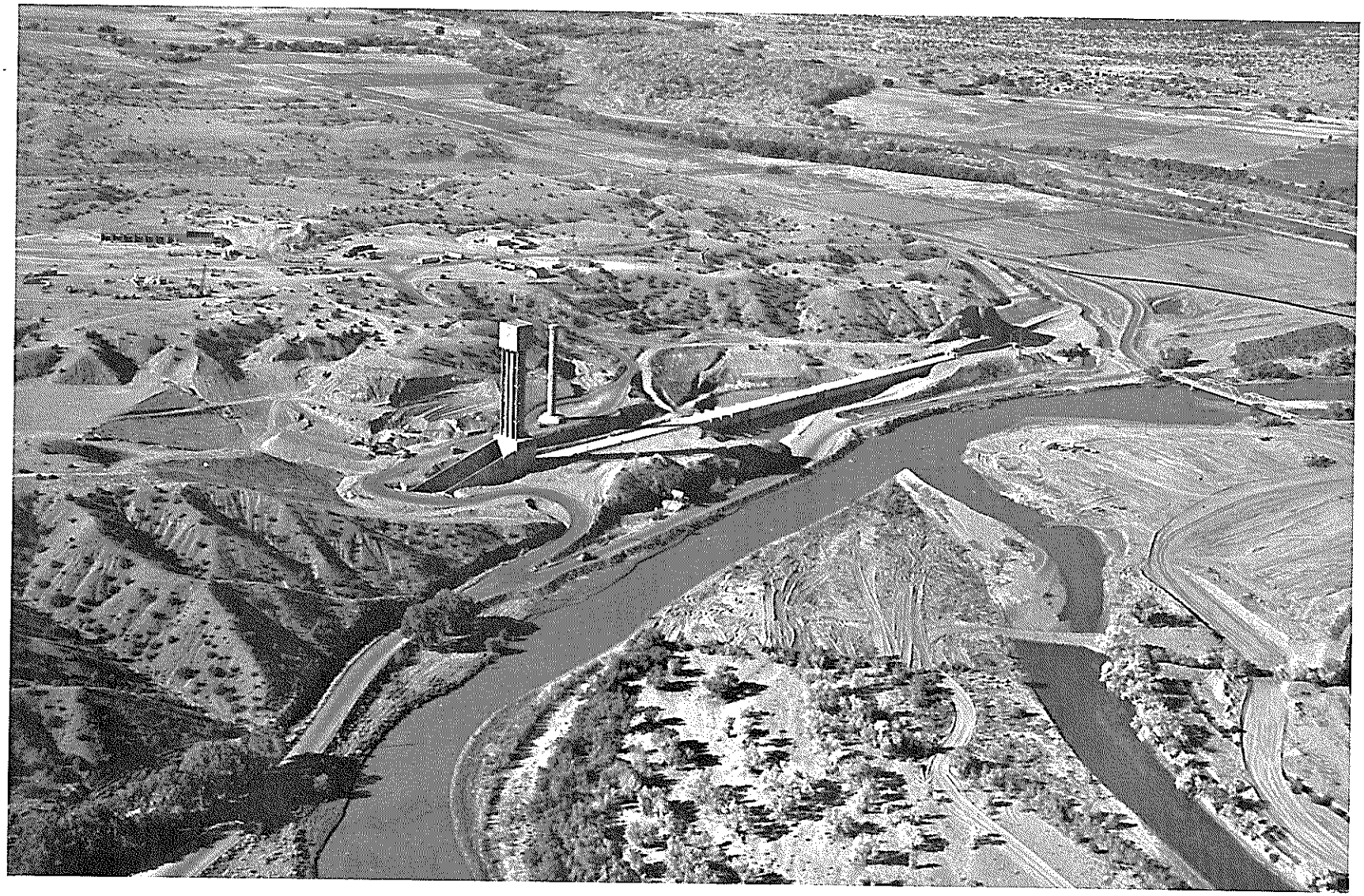
Spillway - already completed.



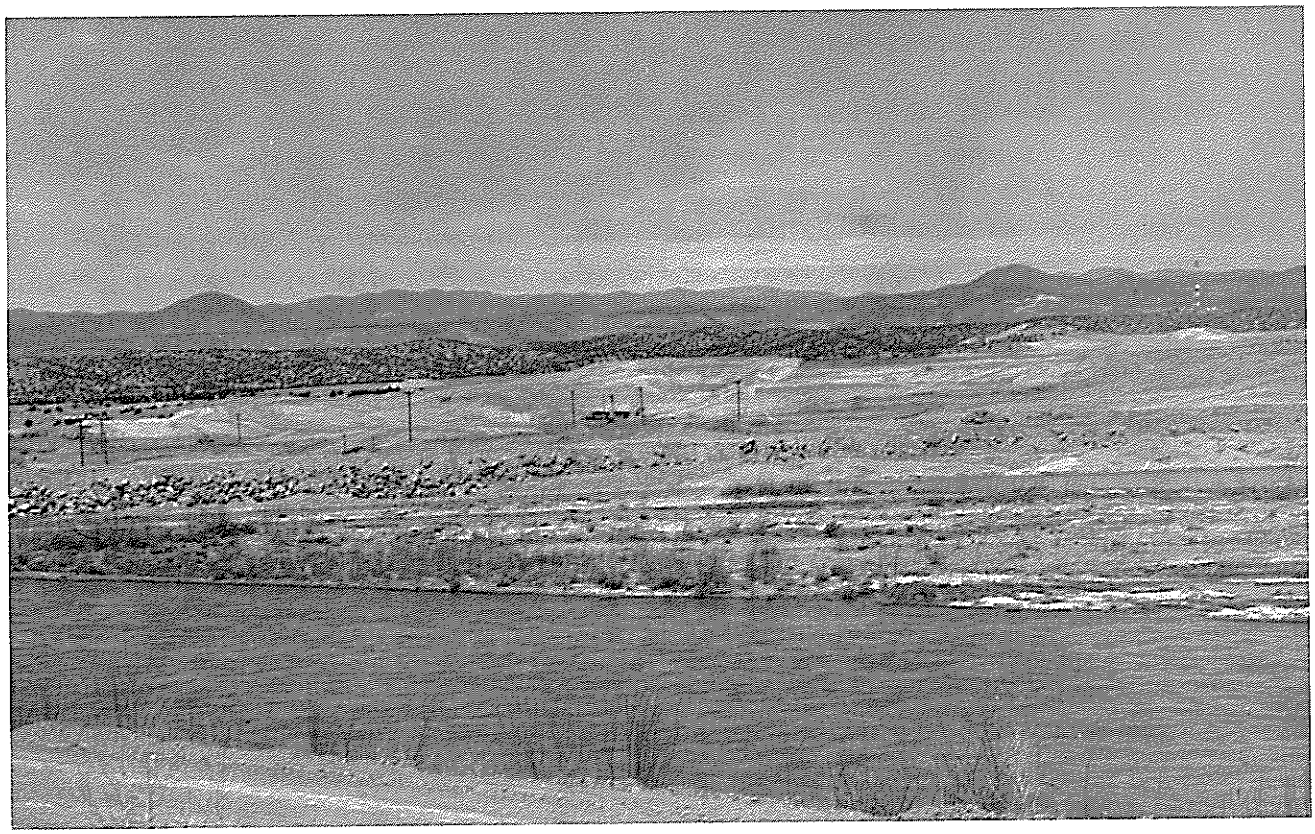
Aerial Photo - Embankment, Cochiti Dam and Reservoir (December 8, 1970) This photo shows the overall project and particularly is a good example of the terrain.



Aerial Photo - Embankment, Cochiti Dam and Reservoir (March 16, 1971)

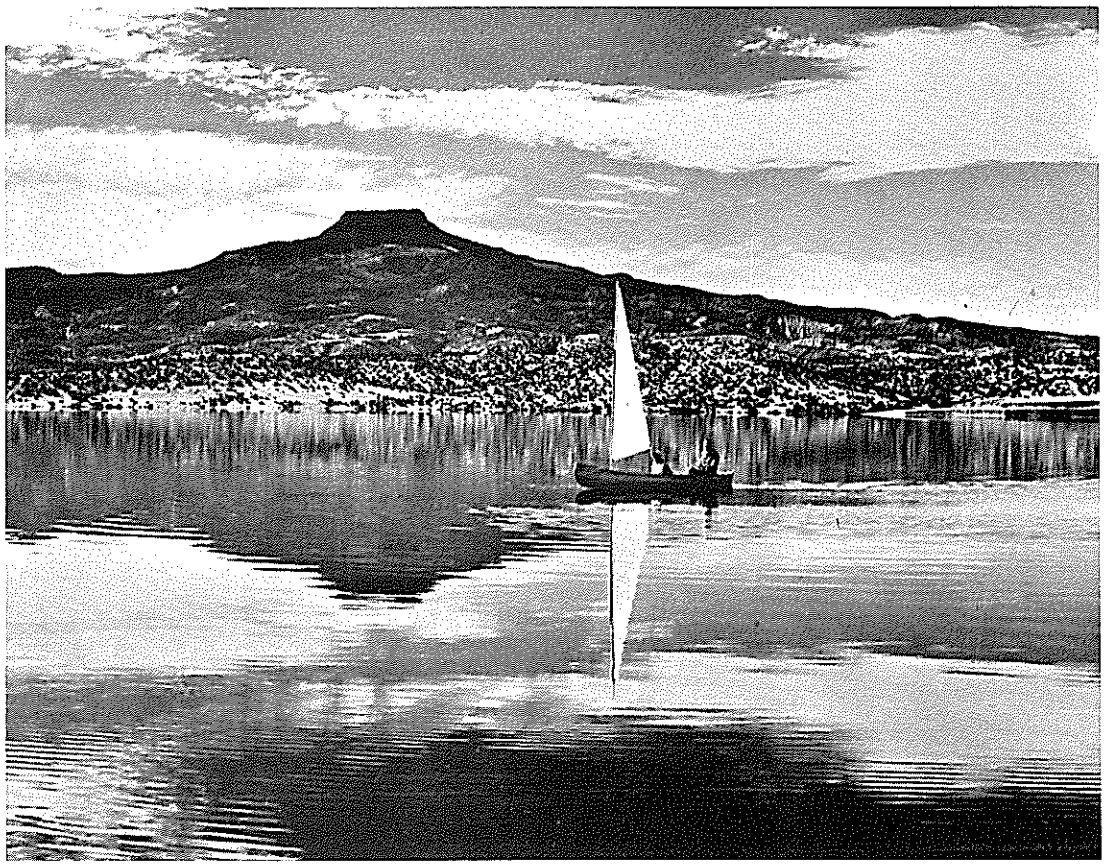


The completed outlet works at Cochiti Dam stands out against the broken terrain on the Rio Grande. This view looking downstream in a southwesterly direction shows the intake structure which will become a part of the embankment now under construction. The outlet works contains three 6.5 x 12 ft conduits about 1300 ft long. The control tower is 270 ft high and the pillar shown to the right of it will support a 430 ft bridge from the control house on top of the intake structure to the top of the 5.2 mile dam embankment. Steel bridge shown at right will be relocated and a new permanent bridge and road will be built later. A temporary bridge (not shown) has been built for use during construction. Completion date of this $85.5 million Corps of Engineers project is June 1975. The Cochiti Pueblo is visible in the upper right hand corner.



A good view of the cofferdam surrounding the contractors work area to insure the area remains dry while excavating to bedrock.

An illustration of the gigantic size of some of the contractors equipment. As a note, this is not the largest equipment of this type being used on this project.



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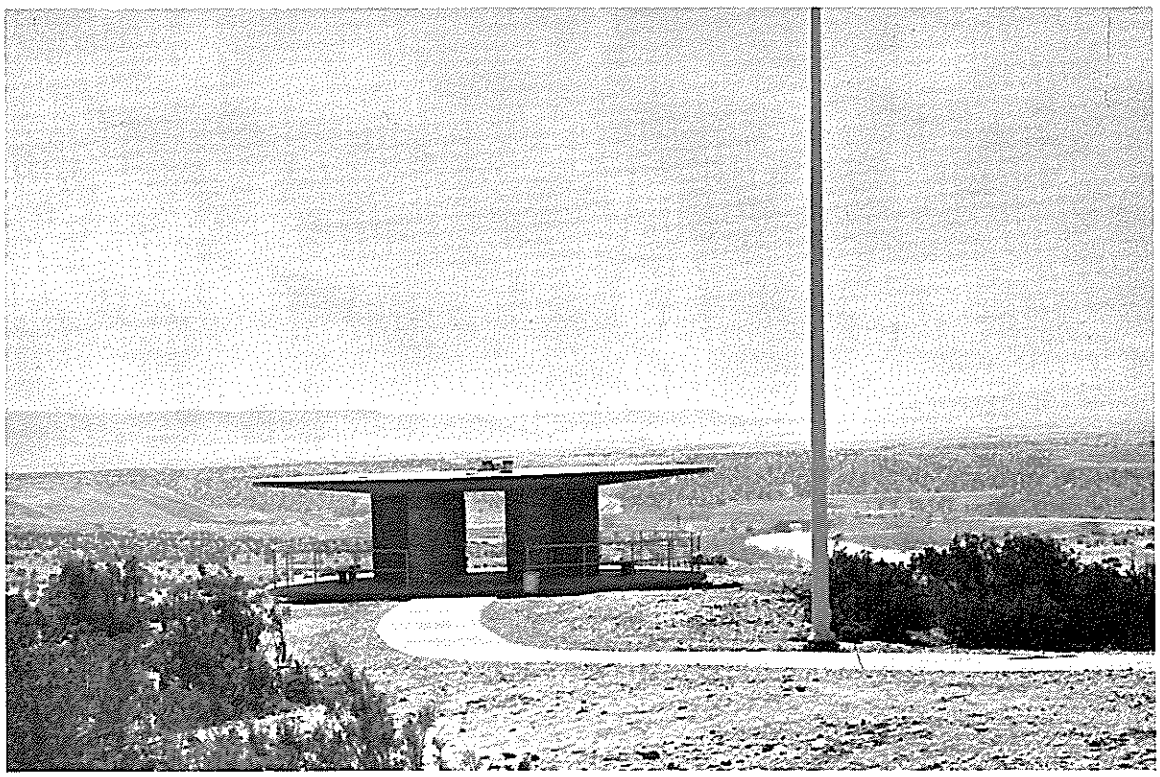

Recently completed overlook at Cochiti.

Close-up view of the recently completed Cochiti Overlook.