

San Angelo Project

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The San Angelo Project

The San Angelo Project is a multipurpose project in the Concho River Basin of west-central Texas. In a region historically known for intermittent droughts and floods, the project provides protection against both weather extremes. The San Angelo Project supplies water for municipal and industrial use as well as irrigation agriculture. Project facilities also provide flood control. Since completion of the project, the region has prospered.

Project Location

The San Angelo Project is located in west-central Texas near the city of San Angelo. The project lies approximately 200 miles northwest of Austin and San Antonio and about the same distance southwest of Ft. Worth. The primary features of the project area are the Twin Buttes Dam and Reservoir, located six miles southwest of the city of San Angelo. The dam and reservoir capture and store the waters of the Middle Concho River, Spring Creek, and the South Concho River which are part of the Concho River Basin. Other features of the project include diversion headworks at Nasworthy Reservoir, constructed and operated by the city of San Angelo, and an irrigation and distribution system which serves about 12,000 acres of project land.¹ Operated in conjunction with nearby O.C. Fisher Dam and Lake, constructed by the U. S. Army Corps of Engineers, and Nasworthy Reservoir, Twin Buttes Reservoir and Dam strives to meet the municipal water needs of San Angelo, provide flood protection, and irrigate project lands.

The Concho River Basin encompasses approximately 5,900 square miles including all or

1. United States Department of the Interior, Bureau of Reclamation, *1992 Summary Statistics: Water, Land, and Related Data*, (Denver: U.S. Government Printing Office, 1995), 317.

part of 14 counties.² The North and South Concho Rivers join within the city limits of San Angelo to form the Concho River. The Middle Concho and Spring Creek join the South Concho River a few miles upstream of the city. From San Angelo, the Concho River flows eastward and empties into the Colorado River of Texas.

The project area has a semiarid climate with an annual average precipitation of about 21.5 inches, though this varies from year to year. The average temperatures range from 83.7 degrees in July to 46.3 degrees in January, but temperature extremes of 111 degrees and one degree have been recorded.³ The growing season usually lasts from late March to early November.

Historic Setting

In 1629 and 1632, Franciscan missionaries from New Mexico traveled to the San Angelo area at the request of Jumano Indians. The missionaries stayed in the area for a couple of months baptizing the Jumano in the Concho River. Later, Spanish settlers returned periodically to hunt and trade with the Jumano and search for Concho pearls produced by freshwater mussels.⁴ In 1684, Juan Domingo de Mendoza and his expedition camped at the confluence of the Concho. After the Mendoza party continued on their way, the region remained the exclusive domain of Native Americans until after the Civil War.

Permanent settlement began in 1867, with the establishment of Fort Concho between the Middle and South Concho Rivers. The military post provided protection for settlers from Native

2. National Archives and Records Administration, Rocky Mountain Region, Records of the Bureau of Reclamation, Record Group 115, "Project Histories: San Angelo Project," 1959, 6 (hereafter cited as "Project History" with year and page).

3. United States Department of the Interior, Bureau of Reclamation, *Technical Record of Design and Construction: Twin Buttes Dam, Constructed 1960-1963, San Angelo Project, Texas* (Denver: U.S. Government Printing Office), 3.

4. Arnoldo De Leon, *San Angelenos: Mexican Americans in San Angelo*, (San Angelo, Texas: Fort Concho Museum Press, 1985), 14.

American attacks. About the same time as the development of Fort Concho, the village of Santa Angela was founded along the banks of the North Concho. Santa Angela eventually became the town of San Angelo. In 1882, San Angelo became the county seat of Tom Green County when a flood washed away the former county seat of Ben Ficklin.⁵ Ranchers first settled the Concho River region with farmers following close behind. Most of the region is used for grazing, but the land currently cultivated was first broken and farmed between 1880 and 1910. Except for the city of San Angelo, the Concho River watershed remains sparsely settled.

To meet growing municipal needs, the city of San Angelo constructed Nasworthy Reservoir on the South Concho River below its confluence with the Middle Concho River in 1930. Held by a small earthfill dam, Nasworthy Reservoir provides 12,400 acre-feet of storage for municipal use. However, the continued growth of San Angelo necessitated the construction of additional water conservation works.

Project Authorization

In 1939, the U.S. Army Corps of Engineers reported favorably on the construction of O. C. Fisher Dam and Lake on the North Concho River for flood control. Congress authorized construction of the structures in the Flood Control Act of August 18, 1941. Subsequent to the Corps report, the Bureau of Reclamation began an investigation into the development of an irrigation plan for water which exceeded the municipal and industrial needs of the region. The study resulted in a request by Reclamation for a modification of the plan for O. C. Fisher Lake to include 80,400 acre feet of conservation storage.⁶ The Corps made the modification to the reservoir plan. Construction was completed in 1952.⁷

5. *Ibid.*

6. "Project History," 1963, 3.

7. *Project Data*, 1105.

During June and July of 1946, the city of San Angelo expressed its desire to Reclamation that part of the conservation storage in O. C. Fisher Lake be reserved for municipal and industrial use. As a result of this request, Reclamation investigations focused on determining the amount of water needed by the city and the amount available for irrigation use. In July, Reclamation completed a draft report on the North Concho Unit of the San Angelo Project. The study concluded that 12,000 acres of land could be irrigated with water supplied by the conservation storage of the O. C. Fisher Lake. Additional water could be obtained from Nasworthy Reservoir with the addition of flash boards to the original structure. During this time the Upper Colorado River Authority purchased the right to 80,400 acre-feet of conservation storage in O. C. Fisher Lake. In November of 1949, representatives of the city of San Angelo, the Upper Colorado River Authority, and Reclamation reviewed the findings of Reclamation's investigation. During the meeting the Authority requested the postponement of further Reclamation investigations until the city and the Authority reached an agreement concerning the use of the conservation storage in O. C. Fisher Lake.

In January of 1953, the consulting firm of Forrest and Cotton, from Dallas, Texas, completed the report "The Surface Water Supply of the San Angelo Area." The study concluded that sufficient water supplies existed in the North and South Concho Rivers to meet foreseeable municipal needs and irrigate a substantial amount of land. This report also recommended that the city and the Authority reach an agreement regarding where surplus stored waters could be used for irrigation and to permit the integration of the operations of O. C. Fisher Lake and Nasworthy Reservoir. Additionally, the report suggested enlargement of Nasworthy Reservoir to 85,000 acre feet. As a result of the study and previous Reclamation findings the Authority gave the city full and unrestricted use of the conservation storage previously purchased by the

Authority.⁸

However, San Angelo voters rejected the enlargement plan for Nasworthy Reservoir and called for a plan which would more fully meet the needs of the region. In September of 1954, the San Angelo Water Supply Corporation (SAWSC), acting on behalf of the city, asked Reclamation to reopen investigations. The resulting reconnaissance studies designed a plan which optimized the water resources of the Concho River Basin. The proposed project called for the creation of a dam and reservoir on the Middle and South Concho Rivers above Nasworthy Reservoir at the Twin Buttes site. The construction of a dam and reservoir at this site would maintain the surface of Nasworthy Reservoir at a constant level, store enough water to meet city municipal and industrial needs, and irrigate 10,000 acres. Reclamation estimated that the construction cost of the project could be repaid within a fifty-year period. The findings were presented to the city commission on October 22, 1954, and the commission advised Reclamation that they considered the project economically feasible.

Detailed investigations of the project were initiated in December 1954 as part of the Texas Basins Project.⁹ The Texas Basins Project was an investigation into the development of a statewide water plan through the construction and operation of an interbasin water supply works that Texas could use to supply water to meet anticipated urban and industrial growth as well as offset the predicted loss of most of the state's ground water sources resulting from irrigation development.¹⁰ The proposed project included a canal along the Gulf Coast, and distribution and drainage facilities extending from the Sabine River in the eastern part of the state to the Lower Rio Grande. The San Angelo Project superseded the San Angelo Unit, Colorado Division of the

8. "Project History," 1959, 3

9. *Technical Record of Design and Construction*, 5.

10. United State Department of the Interior, Bureau of Reclamation, *Texas Basins Project, Texas*, vol. I, (Amarillo, Texas: U.S. Government Printing Office, 1965), 1-2.

Texas Basins Project. The Texas Basins Project never developed beyond initial investigations.

The SAWSC, which is responsible for municipal and industrial features of the project, entered into contracts with Reclamation for development of a multipurpose dam in October of 1955. In December of the following year farmers in the proposed project area created the Tom Green County Water and Improvement District No. 1 (TGCWC & ID). TGCWC & ID is responsible for the agricultural aspects of the project. The San Angelo Project was authorized by Public Law 85-152 on August 16, 1957. The repayment contract executed on April 25, 1959, stipulated that the SAWSC would repay Reclamation \$13,189,000 for the construction of Twin Buttes Dam and Reservoir. Executed June 18, 1959, the terms of the TGCWC & ID contract required the corporation to payback \$4,000,000 in construction costs over a 40-year period exclusive of a ten-year development period which followed the first deliveries of water to project lands. During June of 1959, TGCWC& ID created a 10,000 acre irrigation district for the project and contracted with Reclamation for the construction of irrigation facilities. Passage and approval of the public works appropriation bill of \$ 4,239,000 for the project came in August of 1959. In February of 1960, a definite plan for the project was approved and construction began in May.

Construction History

The development plan for the San Angelo Project called for construction of Twin Buttes Reservoir and Dam, and a diversion headworks at the south end of Nasworthy Dam, and an irrigation and distribution system. Working in conjunction with the existing O.C. Fisher Dam and Lake and Nasworthy Reservoir, Twin Buttes Dam and Reservoir would provide the water needed to meet anticipated growth in the region, provide flood control, and some recreational benefits.

The construction of the Twin Buttes Dam necessitated the relocation of the Panhandle Railroad and the Santa Fe Railroads which crossed the axis of the damsite. Construction crews relocated the Santa Fe Railroad around the north end of the dam and the Panhandle line around the south end of the dam.¹¹ In addition to the railroad relocation, dam construction required the relocation of a portion of a road.

Construction bids for Twin Buttes Dam opened on March 17, 1960. H.B. Zachry Company of San Antonio, Texas was awarded the contract on April 1, 1960, with the low bid of \$11,836,428. Clearing operations of the damsite began on May 9, 1960, which required the grubbing of approximately 268 acres covered with vegetation. After chaining, piling, burning, and handpicking the site, construction crews then cleared topsoil and any remaining vegetation using a root plow and root rake to ensure the removal of all organic material.

On June 7, 1960, stripping of the dam foundation began with the removal of all topsoil, plant life, and organic materials to a depth of six to eighteen inches.¹² In all, 313 acres were stripped. Excavation of the spillway and placement of material for the embankment began on June 22, 1960. That same day groundbreaking ceremonies for the project were held. The excavation of the cutoff trench in the dam's foundation commenced on June 28, 1960. Positioned 100 feet upstream of the dam's axis the trench extended across the river valley sections for 2.5 miles with an average depth of 25 feet. Of the 743,612 cubic yards of material excavated and used in dam construction.¹³ Stripping of the spillway and outlet works sites areas also commenced in June.

On July 9, 1960, installation of the embankment toe drains began. Installation of drains

11. *Technical Record of Design and Construction*, 1.
12. *Technical Record of Design and Construction*, 135.
13. *Technical Report of Design and Construction*, 136.

occurred in all areas of the dam foundation below elevation 1,930. The toe pipe drains consisted of 12 and 18-inch diameter perforated, asbestos-bounded, corrugated-metal pipe. Installed on both sides of the three streams, the outfall pipe was of same dimensions and material but not perforated. Excavation of materials began in borrow areas B, C, and D on July 15. Borrow areas B and D were located upstream from the damsite and borrow area C, located in the flood plain along the right side of the South Concho River, was the only downstream area utilized for the procurement of construction materials.

The river basins of the three filling streams have two different levels of dead storage and are permanently separated by the hilly terrain, which required the construction of a 250-foot channel between the South Concho River and the Middle Concho and Spring Creek drainage area to equalize the surface level of Twin Buttes Reservoir. After releases either through the diversion works on the southern pool or the spillway on the northern pool, water transported through the channel to equalize the surface level of the Reservoir. Excavation of the equalizing channel began on August 4, 1960.

The first concrete placements in the outlet works occurred on November 30, 1960, using concrete mixed from materials excavated in the project area.¹⁴ Riprap bedding placement, using materials procured from under part of borrow area B and the stream bed of Spring Creek, began on December 21, 1960. Between elevation 1,960 and the crest of the upstream face of the dam embankment construction crews placed a three foot layer of riprap. A small amount of placement also occurred below elevation 1,875 on the downstream face of the dam next to structures in the approach outlet channels of the spillway, outlet works, and on the slopes of the embankment ramp for Knickerbocker Road.

14. *Technical Report of Design and Construction, 161-163.*

On the last day of the year the first concrete placements were laid in the spillway. Six days later grouting of the spillway began. The second day of February 1961, saw the first concrete placements in the equalizing channel. Completion of relocation of the Santa Fe and Panhandle rail lines occurred on the last day of February.

While construction on the dam continued, Reclamation awarded the contract for clearing the reservoir site. Joe York and Son of Brackettville, Texas received the contract with the low bid of \$89,000 in March 29, 1961. Clearing of the damsite began on April 17. Clearing crews encountered minor difficulties performing their duties because Reclamation gave the original owners of the land the right to keep all improvements until completion of the dam.¹⁵ The preservation of fences and the presence of livestock in the area made clearing a cumbersome task.

Construction at the damsite continued with completion of all grouting on April 8, 1961, and actual riprap placement started on April 25. Problems with the riprap subcontractor resulted in the cessation of placement activities on July 12. Construction did not resume until August 1, 1961, when H. B. Zachry assumed responsibility for riprap placement. Reclamation also awarded H.B. Zachry the contracts for the construction of the main canal on May 24, 1961, with a low bid of \$1,487,994 and the irrigation distribution system on August 30, 1961, with a low bid of \$985,173.50.

Meanwhile, completion of the equalizing channel bridge and reopening of Knickerbocker Road occurred on June 9, 1961. On June 13, 1961, crews diverted Middle Concho River into Spring Creek and began work on the closure section across the Middle Concho River. Construction of the main canal commenced on June 20 and on September 28 work began on the

15. *Technical Report of Design and Construction*, 133.

irrigation distribution system.

By the spring of 1962, contractors began wrapping up the clearing and construction operations of the project. On the last day of March, Joe York & Son finished clearing the reservoir site. On May 3 the final concrete placements were made in the spillway. On June 11, 1962, the work on the closure section of Spring Creek began, as did the closure section across the South Concho River on August 8. Construction continued on the project through the winter months of 1962 and by 1963 the project neared completion. Clearing and construction contractors of the project features encountered no major labor disputes or weather problems. All work on the dam was completed and accepted on February 13, 1963, with all project facilities completed later that year.¹⁶

An earthfill structure, Twin Buttes Dam on the Middle Concho and South Concho Rivers is 8.2 miles long with a maximum height of 130 feet the Middle Concho River and 30 a foot wide crest. The total volume of the dam 21,442, 000 cubic yards.¹⁷ The materials used in the construction of the structure were categorized into four different types. Zone 1 materials consisted of selected clay, silt, and sandfill which were used for the main portion of the dam. Materials classified as zone 2 materials consisted of sand, gravel and processed gravel and cobble fill. Construction of the drainage blanket portion of the dam used zone 2 materials. Materials designated as zone 3 materials included gravelly materials excavated during construction of the spillway and outlet works and were used in the dam's foundation. Zone 4 materials consisted of caliche, a cement like type of soil, were used in the construction of the equalizing channel.

Twin Buttes Reservoir has a controlled capacity of 632,220 acre-feet which includes

16. "Project History," 1963, 7.

17. *Technical Record of Design and Construction*, 6.

20,000 acre-feet for 100 years of sediment deposition and 50,000 acre-feet of conservation storage for municipal water supply. When the conservation storage level is less than 50,000 acre-feet, no water may be used for irrigation. A conservation storage capacity of 127,850 acre-feet is designated for joint use of irrigation, and municipal and industrial supply; and 454,370 acre-feet of capacity are reserved for flood control.¹⁸

The irrigation facilities of the project include a headworks near the south end of Nasworthy Dam, feeding into a main irrigation canal with a distribution system composed of laterals, siphons, and culverts under the canal and bridges over it. The diversion at Nasworthy directs water flows into the main irrigation canal which travels northeast past San Angelo to the project lands. Lined with concrete the 15.9 mile long canal has a capacity of 165 cubic feet per second.¹⁹ In all, the concrete-lined lateral distribution system totals 39 miles.

Post Construction History

Though completed in 1963, the project remained in construction status through 1965, when SAWSC assumed operation of project storage facilities while Reclamation maintained control of the rest of the project facilities. Reclamation transferred the project to standby conditions on New Year's Day 1966. The reason for implementation of standby conditions on the project was drought in the region which hindered complete operation of all project facilities. With the end of the drought in 1971, Reclamation transferred complete control of Twin Buttes Dam and Reservoir to SAWSC for operation and maintenance (O & M). The following year operation of irrigation facilities was transferred to TGCWC & ID with the first deliveries of project water made on March 6, 1972.²⁰ Reclamation also notified TGCWC & ID that the ten-

18. "Project History," 1981-3, 3.

19. "Project History," 1962, 6.

20. "Project History," 1965-96, 17.

year development period had begun after which the irrigation district must begin its repayment. On January 1, 1973, Reclamation turned over all O & M responsibilities to TGCWC & ID.

Seepage problems have plagued Twin Buttes Dam and Reservoir since the reservoir began to fill in 1964, when seepage first appeared on the down stream face of the dam. Because of the severe drought conditions experienced in the San Angelo region for the first nine years after completion of the project, the reservoir's active capacity remained low and therefore seepage was minimal. After excessive rains began filling the reservoir did seepage appear below the dam. Reclamation installed observation wells downstream to monitor seepage levels.

In 1974, Twin Buttes Reservoir for the first time reached the conservation capacity of elevation 1,940.02, and seepage troubles accelerated. Seepage was detected along the side of the mid valley ridge of the dam embankment. Within a month standing pools of water developed in two areas downstream from the dam. By the following year the surface and water levels in the observation wells had stabilized. However, water began surfacing and forming in pools 4,000 feet from the dam in the hanger complex of San Angelo Airport.²¹ Attempting to drain the standing water, the city constructed open and subsurface tile drains totaling approximately 40,000 feet in length. Taking into account the surfacing seepage water and water exiting into Lake Nasworthy below measuring weirs, the rate of water seeping from Twin Buttes was estimated at 21.4 cubic feet per second (cfs).²²

The continued seepage from the Twin Buttes site caused other problems in addition to the formation of standing pools of water in the hanger complex of the San Angelo Airport. Angene Anderson filed a claim against Reclamation for damages caused by seepage to the land she

21. "Project History," 1977-80, 146.

22. *Ibid.*

leased from the city of San Angelo on October 12, 1976.²³ Solved out of court, the suit indicated that the seepage had evolved into a serious problem in the project area.

A pilot grouting program began on August 19, 1976, to investigate possible solutions to the seepage problem. Determining the most efficient drilling and grouting method, grout mix, and design and effectiveness of grouting served as the primary purpose behind these investigations. After drilling holes in the crest of the dam through the embankment, investigators dewatered the holes and injected them with grout. Results from this initial study and two subsequent grouting projects in 1977 and 1980, revealed that nearly all the seepage occurred in the alluvial material portion of the foundation which had been constructed without a cutoff trench.²⁴ Because of caving during drilling of grout holes in areas of loose uncemented sands and gravel, Dam Safety officials discontinued the grouting program. Also, higher reservoir operations showed that grouting remained ineffectual in stopping the seepage.

In an attempt to reduce uplift pressure on the embankment, installation of 61 relief wells in two areas along the downstream toe of the dam occurred in 1984. However, the wells were not intended to control the seepage beyond the downstream toe. A drainage system was also installed to protect the area from becoming saturated and inaccessible. Nevertheless, seepage continued below the downstream toe of the dam.

In 1986, 1987, and 1990, Twin Buttes Reservoir rose to elevation 1,936 and seepage levels increased. Piezometric levels downstream of the dam indicated that continued uplift pressure on the embankment might result in dam failure if reservoir levels rose to elevation 1,945.²⁵ Total seepage flows were estimated at 60 cfs or more. An investigation concluded that

23. "Project History," 1977-80, 15.

24. Elizabeth A. Dinneen, P.E. and Matthew Sheskie, P.E., "Design of Soil-Cement-Bentonite Cutoff Wall For Twin Buttes Dam," n.d., 5.

25. *Ibid.*

the system of relief wells could not adequately control water pressures on the foundation and that the system would not function as intended if the reservoir elevation rose rapidly in a flood situation. Geotechnical analyses of the dam concluded that substantial, uncontrolled seepage occurring in the foundation of the dam could lead to failure of Twin Buttes Dam due to high uplift pressures leading to embankment instability or from a blowout at the downstream drainage toe resulting in piping of the foundation.²⁶

In 1991, Reclamation restricted the reservoir pools to elevation 1,930 until the implementation of measures to address safety deficiencies of the dam. This restriction would allow for the safe passage of a 50-year flood event. In 1994, the Dam Safety Office considered three different structural alternatives to correct safety deficiencies. The first consisted of constructing a cutoff wall, upstream blanket and grouting. The second would control seepage by installing drainage features downstream; design variations included the installation of a seepage berm, deep drainage trench, sand and wick drains, and relief wells. The final structural modification considered would eliminate all project benefits by breaching the dam. A combination of two alternatives, construction of a cutoff wall and breaching of both pools of the reservoir, were identified as the only technically viable solutions to the seepage and encompassing threats to the structure of the dam. Investigators recommended construction of the cutoff wall in areas where a positive cutoff trench had not been built during the original construction of Twin Buttes Dam.

Construction of the cutoff wall started in July 1996, with completion anticipated in 1999. Located at the upstream toe of the dam, upon completion the wall will be four miles long and up

26. Dinneen and Sheskier, "Design of Soil-Cement-Bentonite Cutoff Wall For Twin Buttes Dam," 3.

to 100 feet deep.²⁷ Cutoff wall materials consist of a combination of onsite gravel, bentonite, and cement. The completion of this dam modification will help ensure the continued success of the project.

In 1994, during an examination for sinkholes, cracks were discovered in the embankment of the dam. The Dam Safety Office examined the site in October 1998, for additional cracking after construction crews working on the cutoff wall discovered a four foot deep crack in the downstream edge of the dam crest.²⁸ The Dam Safety Office recommend additional investigations to determine if additional cracks existed and whether there were possible threats to the safety of the dam.

Settlement of Project Lands

With the additional municipal water provided by the project, the city of San Angelo experienced moderate growth. The city's population increased from an estimated 52,500 in 1950 to approximately 93,000 in 1998.²⁹ However, the rural population of the project region has remained the same since the completion of project facilities.

Project Benefits and Use of Project Water

The San Angelo Project provides municipal and industrial water for the city of San Angelo. Given the erratic weather patterns of the region, the conservation storage provided by Twin Buttes Reservoir ensures that the people of San Angelo will have an adequate water supply even during drought years.

The flood control benefits provided by the project enabled the city and nearby agricultural areas to develop in relative safety from floods. In 1992, nearly 12,000 acres of land

27. Dinneen and Sheskier, "Design of Soil-Cement-Bentonite Cutoff Wall For Twin Buttes Dam," 1.

28. United States Department of the Interior, Bureau of Reclamation, "SEED Report: Twin Buttes Dam," Dam Safety Office, February 1999.

29. *Technical Report of Design and Construction*, 3 and San Angelo Chamber of Commerce, "San Angelo Texas," <http://www.sanangelotx.com/cpindex.html>, June 1999.

were cultivated using project water. Cotton and cereals are the primary crops cultivated on project lands. In 1992, the value of the crops grown on project lands was \$4,555, 608.³⁰

Twin Buttes Reservoir provides several recreational opportunities including fishing, camping, boating, hiking, and hunting. Open year round for fishing, the reservoir contains bass, crappie, sunfish, catfish, carp, shad, and drum.³¹

Conclusion

The San Angelo Project supplied water which enabled the city of San Angelo to develop and prosper. Project waters also fostered agricultural growth and provided flood control in a region where floods often caused significant damage to urban and agricultural developments.

However, continuing structural problems of Twin Buttes Dam pose a potential threat to project benefits in the region. But construction of the cutoff wall and continued monitoring and remedial actions to ensure the structural integrity of the dam will ensure continued benefits well into the future.

About the Author

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30. United States Department of the Interior, Bureau of Reclamation, *1992 Summary Statistics: Water, Land, and Related Data*, (Denver: U.S. Government Printing Office, 1995), 317.

31. Recreation.Gov, "Twin Buttes Reservoir," <http://www.recreation.gov>, June 1999.

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