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ENGINEERING GEOLOGY PROBLEMS AT DAM AND RESERVOIR SITES IN EAST-CENTRAL NEW MEXICO

by

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INTRODUCTION AND ACKNOWLEDGMENTS

Some of the background of this summary is given by Spiegel (1969) elsewhere in this Guidebook. Many of the conclusions herein are based on hydrologic and geologic data collected by E. A. Chavez, S. E. Galloway, and R. L. Borton of the State Engineer Office, and by Phil Smith, caretaker of Ute Dam, as well as on information in the cited reports on Conchas and Ute Dams. Studies at the Dunes and Ute Dam and reservoir sites and their alternates and at Los Esteros reservoir site on the Pecos River were made for the New Mexico Interstate Stream Commission. Many data and reports are accessible to the public in the files of the New Mexico Interstate Stream Commission, and State Engineer in Santa Fe, U.S. Bureau of Reclamation in Amarillo, and the U.S. Corps of Engineers in Albuquerque.

The writer's first reconnaissance trip down the Canadian channel from Logan to Dunes damsite, in February, 1957, resulted in the discovery of a network of partially exhumed deep buried channels. One of the buried channels is entrenched across a rock spur at the site of the north wing of the proposed Dunes Dam. These channels were mapped in detail (Spiegel, 1957b) during a search for an alternate dam site at which the river had re-excavated its older buried canyon. Four sites were found downstream from the original site in which less ground would need to be excavated, but costs at all sites exceeded funds available, so a site above Logan was selected—the present Ute Dam. Since the writer's initial studies of the Dunes site, Sanford dam also has been built near Borger, Texas by the U.S. Bureau of Reclamation. (Eck and Redfield, 1965).

ENGINEERING PROBLEMS AT DAM AND RESERVOIR SITES

General

As would be expected from the similarity of the geology at the four dam and reservoir sites studied by the writer, the engineering problems at all four sites are similar, and may be classified according to the time-stratigraphic units involved (Permian, Triassic, Cenozoic). However, some collapse features caused by solution of rocks in the Permian section have affected the structure and stratigraphy of overlying rocks adversely to various degrees with respect to the dam and reservoir sites.

INFLUENCE OF PERMIAN ROCKS ON DAMS AND RESERVOIRS

The depth to the Permian rocks below the dam sites increases in the following order: Los Esteros, Dunes, Ute, and Conchas. The magnitude of possible problems related to solution collapse and leakage at the dams decreases with increasing depth of the Permian beds. Except for possible collapse features in the Santa Rosa Sandstone at the Los Esteros dam site, problems are not likely to be serious at any of the dam sites. However, Los Esteros reservoir site has a high probability of leakage at high lake stages because the cavernous limestone of the San Andres formation crops out in the reservoir site (Spiegel, 1957c) and is connected hydraulically with a karst zone to the southwest. The Dunes reservoir site has several collapse areas that could result in leakage to Permian evaporite aquifers.

Rocks similar to the upper part of the section of Permian rocks exposed in the Bravo dome (Gould, 1907, pp. 16-21) were penetrated in a drill hole on the axis of Dunes dam site in Section 2, T. 13 N., R. 35 E., during test drilling in 1957 (see log by E. A. Chavez in Spiegel, this Guidebook). The drill hole commenced in the upper part of the Tecovas (about 15 feet below the base of the Trujillo), penetrated about 145 feet of Tecovas, 10 feet of dolomite (Alibates), and 80 feet of shale, siltstone, and fine sandstone of the Quartermaster Formation. Regional subsurface mapping of the Permian section (Bates, 1946) indicates that much of Quay County is underlain by a Permian sulfate facies equivalent to the Bernal-San Andres-Glorieta-Yeso section of central New Mexico, and transitional to a salt facies farther east. Intra- and post-Triassic collapse, probably due to solution of the Permian gypsum beds, has created a number of interesting sedimentary and tectonic structures that are well-exposed but difficult to get to in the Canadian River Canyon.

Collapse features are also well exposed (and more accessible) in the Los Esteros reservoir site on the Pecos River north of Santa Rosa. The severity of collapse features in Triassic rocks at the Los Esteros site correlates well with local variations in the distribution of gypsum in the San Andres and Bernal Formations. Between the Los Esteros dam site and the crest of a small dome south of the River Ranch, numerous drill holes indicate that the San Andres is generally massive anhydrite, shale, and dolomite, locally extensively fractured. In this area, the undulations of the overlying Triassic and Bernal are minor. However, severe collapse features are common nearby, especially to the north, where the River Ranch solution depression has developed over cavernous gypsum and dolomite on the north flank of a small dome. (The writer and Alfred Clebsch, Jr. discovered previously unmapped outcrop of cavernous San Andres limestone on the right bank of the Pecos River at the River Ranch in 1954.)

Spectacular sink holes are prevalent northwest, west, and southwest of the River Ranch, where numerous test wells for irrigation and Santa Rosa supply have encountered cavernous limestone and gypsum. The Pecos River loses water to the San Andres in coalesced sink holes in the upper part of the River Ranch, but the water returns to the Pecos River at the lower end. However, the area is within the conservation pool of proposed Los Esteros reservoir, and when the River Ranch area is submerged, ground-water movement will be reversed and reservoir water will leak through the San Andres to the karst area to the west and southwest, and along lesser solution zones to the south and east. Hydraulic effects of the leakage will be transmitted rapidly to the mineral spring areas from Santa Rosa to Puerto de Luna and increased spring flow to the Pecos River will degrade the quality of the Pecos River (Hernandez, 1971).

A regional geohydrologic study of the Permian rocks in eastern New Mexico and adjacent states (Spiegel, 1967) indicates that some natural movement of salt water southeastward of the Pecos River occurs in the Permian rocks, and that this water leaks upward to streams in Texas. Locally, poor quality of ground water in the Triassic of the Canadian River valley, and springs below Conchas and Ute Dams, and in the Canadian River channel below Ute Dam probably is derived from natural upward leakage from Permian evaporites, augmented by increased circulation across thick Triassic beds below Conchas and Ute reservoirs.

The leakage and quality degradation of the Pecos River caused by the proposed Los Esteros reservoir will be far more severe than in the Canadian River because cavernous limestone of the San Andres crops out in the Pecos River channel in the reservoir area. The rise in hydraulic potential in the San Andres at River Ranch due to the reservoir will increase the quantity of ground water moving eastward and will result in a slightly increased discharge of highly mineralized water to the Canadian River downstream from Conchas Dam (see Spiegel, 1967, Fig. 3).

As noted above, the regional subsurface geology indicates the probable occurrence of soluble evaporites under the Canadian River, especially downstream from Logan, and this interpretation is corroborated by the prevalence of the collapse features described above. However, Los Esteros reservoir site appears to have the most serious problem of all the sites studied. Not only will leakage through the San Andres Formation cause a serious loss of conservation storage, (Spiegel, 1957c) but dissolved solids of the Pecos River below Santa Rosa will be greatly increased, to the detriment of downstream irrigators (Hernandez, 1971).

PROBLEMS IN TRIASSIC ROCKS

Problems at all the dam sites include: (1) alternating layers of slightly dipping sandstone and mudstone, (2) artesian conditions in the foundation rocks, (3) slacking clays, (4) potential collapse chimneys (see above), and (5) local well-developed jointing in sandstone. Standard precautions or treatment of adverse conditions should result in safe structures, but at varying costs.

Several of the potential dam sites examined were the result of local anticlines in Triassic rocks that may have been created between collapses into deep solution cavities. One large post-Triassic collapse depression in the Dunes reservoir site (Section 2, T. 13 N., R. 35 E.), probably of late Pleistocene age, posed the potential problem of water losses through fractures to underlying evaporites of Permian age. Similar features were specially treated to minimize water losses at Sanford Dam, Texas (Eck and Redfield, 1965). However, many of the slump areas in the Dunes site were intra-Triassic depositional features, with chimney fracturing only in deeper beds, possibly below the base of the buried Pleistocene channel.

Ground-water discharge from fractured sandstone of the Trujillo Formation provided a substantial natural contribution to the Canadian River below Logan prior to construction of Ute Dam. Since the construction of the dam in 1962, ground-water discharge below the dam has increased more than 5 cfs at full reservoir stage, due to reservoir leakage. As the reservoir has remained nearly full, due to lack of demand for diversion of the water, the base flow of the Canadian River below Ute Dam is stable. Several small to moderate spills have eroded the spillway and exposed weak layers which threaten the thin spillway apron.

Slacking of Triassic clays when wet and exposed to the air was a considerable problem during Conchas Dam construction (Crosby, 1940), and can be expected at any Quay County sites. Adequate foundation design is required to avoid frost leave of capillary layers. Bluff slumping at dam abutments could also be a problem where sandstone ledges are underlain by mudstone, particularly where dips toward the river have been created tectonically or by nearby collapses, as at the Dunes Site. However, the abandonment of the Dunes site and four nearby alternatives resulted from excessive total cost and the poor quality of stored water rather than specific engineering problems. However, the buried Pleistocene channel contributed to the high cost estimate for the Dunes site.

Engineering problems of construction at Conchas Dam are described by Matthes (1936) and Crosby (1940). Most of the discussion also applies to the other sites. Water quality has been poor and the supply inadequate for the Tucumcari Project during some periods of drought. Leakage of poor quality water from artesian sandstone below the dam contaminates the Canadian River for a few miles downstream.

The principal engineering problems at Ute Dam have been inadequate thickness of spillway slab to prevent freezing of foundation rock and drains (Burke, 1962), and erosion of spillway rock downstream from the slab toe. Drainage under the spillway slab was accomplished by constructing deep gravity-drain wells which conduct spillway leakage downhole to aquifers with lower head near river level. Prior to the construction of drain wells, the slab was protected by an earth cover in winter. Some drain-hole maintenance is required under current conditions. Although specifications for Ute Dam were intended to permit addition of radial gates to raise spillway level, it is doubtful that uplift pressures and water levels in the spillway foundations can be maintained at safe levels at the higher stages envisioned.

PROBLEMS WITH CENOZOIC DEPOSITS

Some terrace deposits needing removal or core-trenching, are present at all sites, but the Dunes site and four alternatives had extreme thicknesses (60 feet) locally.

At the Los Esteros site and Conchas Dam thin river channel deposits occur that could be readily trenched to bedrock, but at Ute Dam and the Dunes sites partial cutoffs or upstream blankets for uplift relief were or would be required. Leakage under and around Ute Dam is moderate and serves in lieu of low-flow releases.

Except for good riprap, which is in scarce supply, most fill and aggregate needs can be supplied locally at all sites. Substantial deltas and upstream channel fill are being deposited at Conchas and Ute Dams. Similar deposits will occur at any reservoir in this region.

REFERENCES

Bechtel Corporation, 1962a, Ute Dam Basic Design Report: January, 1962.

Bechtel Corporation, 1962b, Notice to Contractors, etc., for Ute Dam Spillway and Appurtenant Works for Canadian River Project, Quay County, New Mexico: June, 1962.

Bechtel Corporation, 1963, Completion Report, Ute Dam, Quay County, New Mexico: December, 1963.

Burke, H. H., 1962, Estimate of reservoir losses due to seepage, Ute Dam: Letter from Bechtel Corp. to State Engineer Office, 5 pp., 1 plate, April 18, 1962.

Crosby, I. B., 1940, Engineering Geology Problems at Conchas Dam, New Mexico: Trans. ASCE, vol. 105, pp. 581-605 (with discussion by H. L. Johnson and Crosby).

Eck, W., and R. C. Redfield, 1965, Engineering Geology problems at Sanford Dam, Borger, Texas: Eng. Geol., vol. 2, no. 1.

Hernandez, J. W., 1971, Management alternatives in the use of the water resources of the Pecos River Basin in New Mexico: N.M. Water Resource Inst. Rept. 12.

Matthes, G. H., 1936, Problems at Conchas Dam: Civil Engineering, Vol. 6, No. 7, pp. 436-441.

Spiegel, Zane, 1957a, Preliminary evaluation of geology and hydrology of the Dunes Dam and reservoir site on the Canadian River, Quay County, N. Mex.: New Mexico State Engineer Office, typed memo., 6 pp., March 25, 1957.

Spiegel, Zane, 1957b, Geologic map of the Dunes reservoir site, Canadian River, Quay County, N. Mex.: Office of the State Engineer, Santa Fe, New Mexico, 2 sheets, scale 1:16500.

Spiegel, Zane, 1957c, Preliminary estimate of leakage from the proposed Los Esteros reservoir: Typed report, N.M. State Engineer Office, Santa Fe, N.M.

Spiegel, Zane, 1967, Fundamental concepts of geohydrology applied to the Pecos Valley and related aquifer systems: New Mexico State Engineer report, 47 pp.

Spiegel, Zane, 1969, Resolution of some stratigraphic problems along the Canadian River in Quay County, New Mexico: Paper presented to 23rd Annual Meeting of New Mexico Geological Society, April 24, 1969. Abstract *in* Guidebook of the Twentieth Field Conf. of NMGS, 1969, p. 215.

State Engineer Office, 1961, Canadian River Storage Sites Investigation, Ute Reservoir, Quay County, New Mexico, 5 vol.

U.S. Corps of Engineers, 1936, South Canadian River, Conchas Dam, Plans for construction of Saddle Dam, North Dikes, and excavation for engineering spillway: Half-scale Folio in files of State Engineer Office and USCE, 16 pages.