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WATER RESOURCES OF THE SAN LUIS VALLEY, COLORADO*

by

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INTRODUCTION

An investigation of the water resources of the San Luis Valley, Colorado, was begun in 1966 by the U.S. Geological Survey in cooperation with the Colorado Water Conservation Board and the Colorado Division of Water Resources. Preliminary results of the investigations are being published as U.S. Geological Survey Hydrologic Investigations Atlas HA-381 (Emery and others, 1971). This paper is adapted from the atlas, but includes data collected since the atlas was compiled.

The San Luis Valley of Colorado (fig. 1) extends about 100 miles from Poncha Pass to the Colorado-New Mexico State line—an area of about 3,200 square miles. The valley floor, which has an average altitude of about 7,700 feet, is nearly flat except for the San Luis Hills and a few other small areas. Bounding the valley on the west are the San Juan Mountains, and on the east, the Sangre de Cristo Mountains. Most of the valley floor is bordered by alluvial fans, the most extensive being the Rio Grande fan (fig. 1). The Rio Grande fan extends about 30 miles along the west side of the valley and about 20 miles eastward into the valley, and has an average gradient of about 12 feet per mile.

Most of the streamflow is derived from snowmelt from about 4,700 square miles of watershed in the surrounding mountains. The northern part of the valley is internally drained and is referred to as a closed basin. The lowest part of this area is known locally as the "sump." The southern part of the valley is drained by the Rio Grande and its tributaries.

The climate of the San Luis Valley is arid and is characterized by cold winters, moderate summers, and much sunshine. The average annual precipitation on the valley floor ranges from 7 to 10 inches and as much as 50 inches occur in the neighboring highlands. More than one-half of the precipitation occurs from July to September. Owing to the short growing season (90-120 days), crops are restricted mainly to barley, oats, potatoes, and other vegetables. A successful agricultural economy would be impossible without irrigation.

HYDROGEOLOGY

The San Luis Valley is a large north-trending structural depression that is downfaulted on the eastern border and hinged on the western side. The valley contains as much as 30,000 feet (Gaca and Karig, 1966, p. 1) of alluvium, volcanic debris, and interbedded volcanic flows and tuffs of Oligocene to Holocene age. Although Siebenthal (1910, p. 39) subdivided the deposits into the Santa Fe and Alamosa Formations, later information indicates that it is impossible to differentiate the formations except locally. In this paper, all deposits above the Precambrian crystalline rocks are referred to as valley fill (table 1).

The Sangre de Cristo Mountains are composed of igneous, metamorphic, and sedimentary rocks, whereas the San Juan Mountains are composed mainly of volcanic flows, tuffs, and breccias (Larsen and Cross, 1956). Many of the lava flows and tuffs from the San Juans dip generally eastward under the valley floor, and in the southwestern part of the valley they restrict the vertical movement of ground water. Geophysical and drillers' logs indicate that a "clay series," 10 to 80 feet thick, occurs throughout much of the central and northern parts of the valley at depths ranging from 20 to 120 feet below land surface. The "clay series" restricts the vertical movement of ground water.

The total annual water supply to the San Luis Valley averages about 2,500,000 acre-feet. About 1,500,000 acre-feet is streamflow derived chiefly from snowmelt in the surrounding mountains and 1,000,000 acre-feet is from precipitation on the valley floor. Discharge of water from the valley averages about 2,000,000 acre-feet per year by evapotranspiration and about 500,000 acre-feet per year as stream flow and ground-water underflow across the state line. The annual streamflow at the state line averages 445,000 acre-feet and ground-water underflow accounts for the remainder, currently estimated at 55,000 acre-feet. About one-half of the evapotranspiration is nonbeneficial; that is, it does not contribute to the growth of plants having economic value. Much of the nonbeneficial consumption is by phreatophytes, mostly greasewood (*Sarcobatus*), rabbitbrush (*Chrysothamnus*), and saltgrass (*Distichlis*), in areas where the depth to water is less than 12 feet.

Ground water in the San Luis Valley is obtained from unconfined and confined aquifers. These aquifers contain at least 2 billion acre-feet of water in storage in the upper 6,000 feet. They are separated by a confining "clay series" or by confining layers of volcanic rocks. These confining beds are discontinuous and lenticular so it is difficult to differentiate between unconfined and confined aquifers except locally. This discontinuity in the "clay series" creates varying degrees of hydraulic connection between the aquifers.

Shallow unconfined ground water occurs almost everywhere in the valley and extends 50 to 200 feet beneath the land surface. The depth to water in about one-half of the valley is less than 12 feet (fig. 1).

Recharge to the unconfined aquifer is mainly by infiltration of applied irrigation water and leakage from canals and ditches. Water infiltrating from the many streams en-

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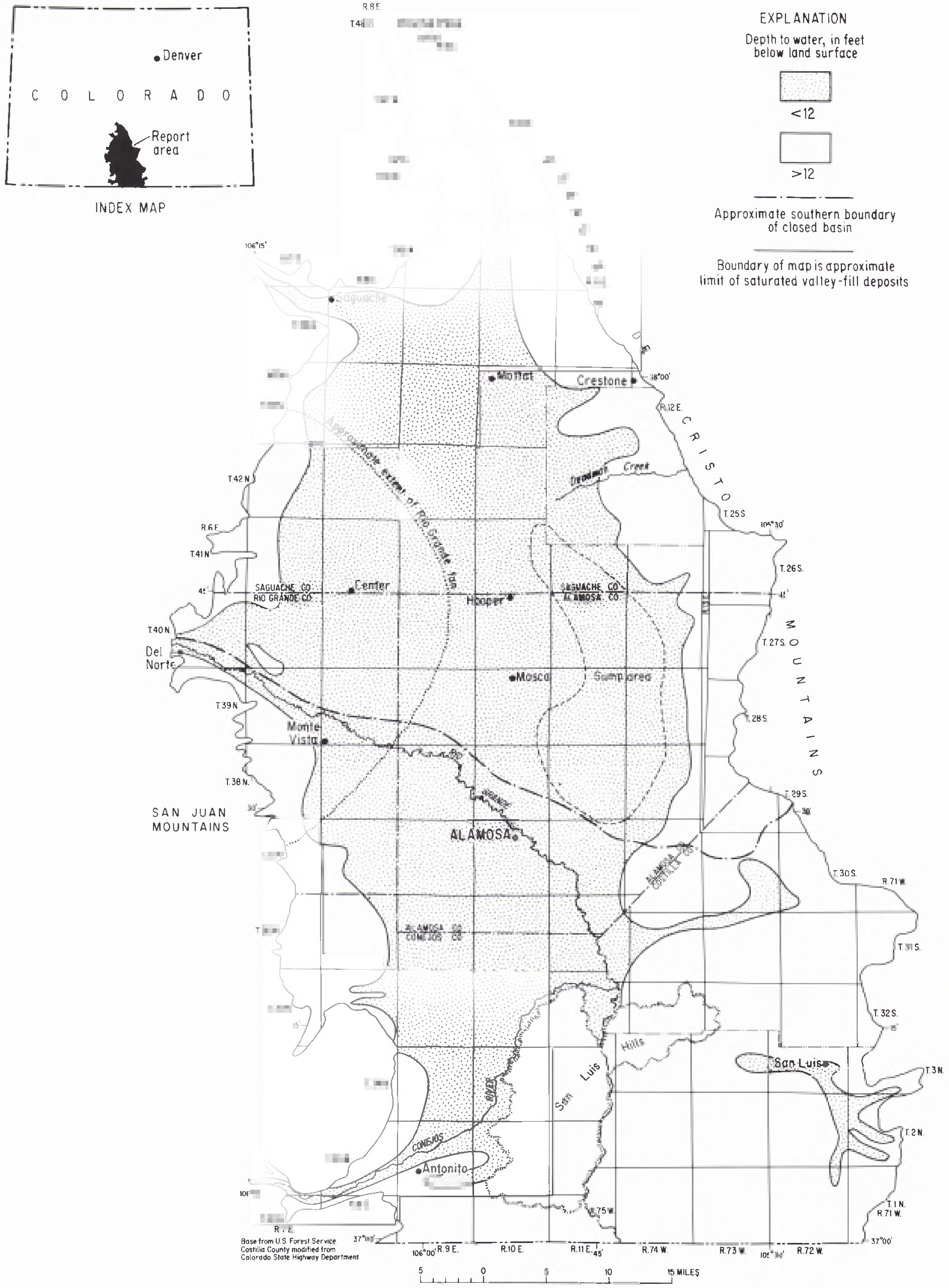

FIGURE 1.

Map of San Luis Valley showing depth to water,December 1969, and major physiographic features.

TABLE 1.

Summary of the hydrologic character of the geologic units, San Luis Valley, Colorado.

SYSTEM OR SERIES	GEOLOGIC UNIT	HYDROLOGIC UNIT	THICKNESS (FEET)	PHYSICAL CHARACTER	HYDROLOGIC CHARACTER	WATER SUPPLY
Holocene to Oligocene	Valley fill	Unconfined aquifer	0–200	Unconsolidated clay, silt, sand, and gravel.	Transmissivity ranges from 1,000 to 250,000 gallons per day per foot (134-33,500 square feet per day). Specific yield is estimated to be 0.20.	Yields as much as 3,000 gallons per minute to wells.
		Confined aquifer	50–30,000	Unconsolidated clay, silt, sand, and gravel interbedded with volcanic flows and tuffs.	Transmissivity ranges from 1,500 to 1,500,000 gallons per day per foot (201-201,000 square feet per day) in zones tapped by existing wells. Storage coefficient is estimated to be 0.008. Water is under pressure.	Yields as much as 4,000 gallons per minute to wells.
Precambrian	Crystalline rocks			Granite, gneiss, and schist.	Not tapped by wells. Probably not water bearing.	None.

tering the valley and precipitation on the valley floor provide recharge to the unconfined aquifer. Upward leakage from the confined aquifer is also a source of recharge. Discharge from this aquifer is by wells, evapotranspiration, and seepage to streams.

The principal source of recharge to the confined aquifer is seepage from mountain streams that flow across the alluvial fans flanking the valley floor. The "clay series" is absent at the edge of the valley, permitting recharge to beds that constitute the confined aquifer in the main part of the valley. The mountain streams show significant losses as they cross the porous surface of the fans. For example, seepage measurements made July 6, 1967, on Deadman Creek south of Crestone (northeast part of valley) showed that the 7 cfs (cubic feet per second) measured at the canyon mouth was completely dissipated within about 8 miles; all but 1 cfs was lost in the first 3.7 miles. The confined aquifer underlies most of the valley and the water has sufficient head to flow at the land surface in an area of approximately 1,400 square miles. The major discharge from the confined aquifer is by wells, springs, and upward leakage through the confining beds into the unconfined aquifer. A small amount may discharge as underflow into New Mexico.

The quality of water in the confined aquifer generally is better than that in the unconfined aquifer according to Powell (1958). The concentration of dissolved solids in 41 samples from the confined aquifer ranged from 70 to 437 mg/1 (milligrams per liter) and, in 271 samples from the unconfined aquifer, ranged from 52 to 13,800 mg/1. The least mineralized water in the unconfined aquifer occurs on the west side of the valley. The mineral concentration increases toward the sump area of the closed basin probably because of solution of aquifer materials and by evaporative concentration in areas of a shallow water table.

DEVELOPMENT OF WATER SUPPLIES

The principal source of water for irrigation in the San Luis Valley between 1880 and 1950 was surface water. A large network of canals was built in 1880-90 to irrigate lands in the eastern and central parts of the closed basin. By 1915 most of the area around Mosca and Hooper (central part of valley) became waterlogged because of this irrigation. Drainage systems constructed between 1911 and 1921 to reclaim waterlogged lands alleviated some of the problems but created waterlogging in areas downgradient. Other areas are intentionally waterlogged in the process of subirrigation. The subirrigation practice continues because locally it is considered to be essential to successful growth of crops.

The number of large-capacity wells (yield more than 300 gallons per minute) in the San Luis Valley has more than quadrupled during the last 20 years. By the end of 1969 there were about 2,920 large-capacity irrigation wells in the valley. Of this total, about 2,270 tap the unconfined aquifer and about 650 tap the confined aquifer. Of the 650 large-capacity irrigation wells tapping the confined aquifer, 94 range in depth from 1,000 to 2,000 feet, and 19 are over 2,000 feet deep. Most of these deep wells flow, some exceeding 3,000 gallons per minute. In addition to the large-capacity wells, there are more than 7,000 small-capacity wells, most of which provide water for domestic and stock use.

Ground-water withdrawal for recent years averaged about 750,000 acre-feet per year. Withdrawal by large-capacity irrigation wells was about 450,000 acre-feet per year and withdrawal by small-capacity wells was an estimated 300,000 acre-feet per year. In 1970 the unconfined aquifer accounted for 78 percent of the ground water withdrawn from large-capacity wells. Many of the small capacity wells are uncontrolled and flow continuously. Perhaps 150,000 acre-feet per year from these wells might be considered waste. It does not contribute to crop production but causes additional waterlogging.

The annual water use of the valley is substantial. Despite the abundant supply, water-use practices over the past 100 years have created water problems. Surface-water use has resulted in the waterlogging of large areas of the valley. The valley-fill deposits in the northern part of the valley are recharged with water yielded from watersheds tributary to the closed basin and from diverted Rio Grande water. Crop productions are good in part of the area, but generally it results in high nonbeneficial water usage. Furthermore, the soils in the waterlogged areas have become alkaline, and the ground water has become highly mineralized because of evaporative concentration of salts. A major part of the valley south and west of Alamosa, likewise, is waterlogged.

Deliveries of water under the Rio Grande Compact with New Mexico and Texas have been deficient, accruing a deficit of 944,000 acre-feet by the end of 1967. Colorado has managed to improve the situation by making the required deliveries in recent years and has reduced the deficit to approximately 830,000 acre-feet by the end of 1970.

The U.S. Geological Survey, as part of its present study of the San Luis Valley, has constructed a multiaquifer electric analog model, simulating the upper 3,120 feet of valley fill. A single aquifer version of the model (Emery, 1970) has been utilized to evaluate a water-salvage plan proposed by the U.S. Bureau of Reclamation (U.S. Bureau of Reclamation, 1963). When testing of the model is complete, it will be used for more complex analyses related to water management.

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