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GROUNDWATER HYDROLOGY
CARSON CITY QUADRANDLE
NEVADA

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GENERAL FEATURES

The dominant hydrographic features of the Carson City Quadrangle are: The Carson Range, a spur of the Sierra Nevada, bordering the west side of the quadrangle; Washoe Valley on the north end of the quadrangle; and Eagle Valley, which occupies the remainder of the quadrangle. A small spur of the Virginia Range forms the topographic and hydrologic boundary between Washoe and Eagle Valleys in the northeastern section of the quadrangle. Washoe Valley is tributary to the Truckee River and Eagle Valley is tributary to the Carson River. The remaining part of Washoe Valley is described in the Washoe City Folio (Rush, 1975).

The Carson Range is the precipitation catchment area for most of the locally derived water supply. Land-surface elevations range from 4,650 ft (1,417 m) on the east edge of Eagle Valley to 9,170 ft (3,795 m) on an unnamed peak of the Carson Range at the head of North Kings Canyon 5.5 mi (8 km) west of Carson City.

The slope of alluvial valley fill in Washoe and Eagle Valleys ranges from less than 5 percent in mid-valley to about 15 percent near the mountains. The principal ground-water reservoirs are unconsolidated deposits underlying the valleys. Most of the high-density land development has occurred in Eagle Valley, and additional development in both valleys is anticipated.

RUNOFF

The mean annual water yield from mountain drainage basins to Eagle Valley has been estimated by Arteaga and Durbin (1978, table 1, p. 14) to be about 9,000 acre-ft per year (11.10 hm^3/year). If the part of Eagle Valley not on the Carson City Quadrangle is excluded, then the estimated runoff is about 5,000 acre-ft per year (6.16 hm^3/year). Of this amount the perennial flows of Ash and Kings Canyon Creeks contribute about 75 percent.

Surface-water runoff into the part of Washoe Valley on the Carson City Quadrangle has not been determined; however, using techniques developed by Moore (1968), the mean annual flow for Big Creek, the major stream in that part of the valley, is estimated to be 500 acre-ft per year (600,000 m^3/year).

PRECIPITATION

The Sierra Nevada exerts the dominant control over precipitation within the Carson City Quadrangle. Storms move upslope from west to east across the Sierra Nevada, dropping substantial moisture on west-facing slopes but little, because of adiabatic warming, on east-facing slopes. Because the Carson Range forms the western boundary of the quadrangle, the valley areas and Virginia Range lie mainly in a zone of diminished precipitation (a "rain shadow") with respect to east-moving storms. Average annual precipitation ranges from 10 inches (25 centimeters) in the valley areas to 30 inches (75 centimeters) in the higher elevations of the Carson Range.

Snow, between November and April, accounts for the greatest percentage of precipitation within the quadrangle over the long term; however, the amount of water that results from winter rains can be significant. Also, intense, generally unpredictable winter rains on snowpacks commonly cause severe flooding. Summer thunderstorms usually affect small areas, often less than a square mile, but commonly deliver large volumes of water relative to the size of drainage area in a very short time. They are a relatively unimportant water source in augmenting the available supply, but can cause severe local floods and are one of the main natural landforming agents.

GROUND-WATER RESOURCES

The principal ground-water reservoirs are located in the alluvium, or unconsolidated valley-fill deposits, in Eagle and Washoe Valleys, and the ground-water flow systems of the valleys are similar. Recharge to the ground-water reservoirs in the alluvium or unconsolidated valley-fill deposits occurs in several ways. First, a percentage of the precipitation falling on the mountain blocks infiltrates the complex fracture and joint system of the bedrock, eventually flowing in the subsurface to the valley-fill deposits; however, the fracture and joint system commonly causes small bodies of ground water to be perched or semiperched within the mountain block. The rest of the water evaporates back to the atmosphere, is used by plants, and some is stored in the soil-moisture zone. Second, perennial streams recharge the ground-water system wherever the water table is below the bed of the stream. Third, irrigation diversions from these streams, during the spring runoff and irrigation seasons, spread water over large areas, and much of the infiltrating water that is excess to the plants' use undoubtedly reaches the zone of saturation. And last, recharge occurs from precipitation falling directly on the valley fill. Some of this water probably will reach the zone of saturation during prolonged wet spells.

Natural discharge from the ground-water system to the atmosphere occurs in areas where the water table is close to the land surface; some ground water is discharged directly into springs, streams, and, as in Washoe Valley, directly into Washoe Lake. The flood plains of the perennial streams are also areas of discharge. Shallow ground water, within a few feet of land surface, is hydraulically connected with streams in the same areas. This allows roots of certain herbaceous plants, riparian shrubs, and broad-leaf trees to withdraw ground water.

Subsurface outflow from Eagle Valley has been estimated by Worts and Malmberg (1966, p. 29) as about 2,000 acre-feet per year (2.47 hm^3/year). Recently, Arteaga and Durbin (1978) estimated this outflow to be about 2,700 acre-feet per year (3.33 hm^3/year), thus for the part of Eagle Valley in the Carson City Quadrangle the outflow value is considerably less. The subsurface outflow from Washoe Valley was estimated by Rush (1967, p. 22) to be minor.

Shallow-ground-water areas, not identified on the map, are also present in the mountains; mostly in areas of low slope along the principal perennial stream channels and in small basins or other flat areas where the conditions are favorable for some recharge and storage of ground water. After the spring snowmelt and during wet years, many other mountain areas contain saturated joints and fractures near the land surface. However, water levels in these areas may fluctuate markedly, both from season to season and year to year. It is uncertain whether reliable ground-water supplies could be developed in these areas.

Lines of equal depth to the water table for Washoe and Eagle Valley are shown on the hydrologic map. Additionally, the rock units for the entire quadrangle have been classified on the basis of their general water-yielding character, and those units are represented by well-yield factors on the hydrologic map. This classification relies on the permeability of the alluvium and the joint-and-fracture system of the bedrock, on the geometry and occurrence of the alluvium and the bedrock, and on the severity of land slope. Generally, steep slopes allow water to drain from shallow fractures, which causes greater depths to water with a corresponding smaller ground-water reservoir to sustain pumping.

Springs in Washoe Valley were discussed by Rush (1967, p. 22) and in Eagle Valley by Worts and Malmberg (1966, p. 30). In general, these springs contribute very little water to the hydrologic system and are important only locally. Of special interest is the geothermal potential of the Carson Hot Springs, which has not been investigated to date (1979).

Eagle Valley

The ground-water resources of Eagle Valley have been described by Worts and Malmberg (1966), Glancy and Katzer (1975), and by Arteaga and Durbin (1978).

The main ground-water reservoir is the alluvium composed of gravel, sand, and clay. The thickness of these deposits varies throughout the valley; several wells have been drilled to 600 ft (183 m) without encountering bedrock. One well in southeast Carson City was still in unconsolidated deposits at 803 ft (245 m), and recently (1976) a well was drilled in the east-central part of the city to 830 ft (253 m) and did not fully penetrate the alluvium.

The population of Carson City has increased dramatically since the mid-1960's, with a corresponding increase in use of the ground water. The main public supply wells are located between Carson City and the Carson Range to the west. An observation well, 15/20-7BCD, was drilled in 1972 to monitor ground-water levels in this area, and figure 1 contains a hydrograph of this well. In the first 5 years after the well was drilled, the ground-water level at this site dropped about 30 ft (9 m), or an average of 6 ft (2 m) per year. Long-term observation wells located 1 to 2 mi (1.6 to 3.2 km) east of the west-side well field did not have this decline, as the hydrograph for one of the wells, 15/20-8BAA, shows in figure 1.

The lack of decline in water levels in the long-term observation well may result from structural and lithologic controls which restrict the hydraulic conductivity between the wells. The Geological Survey is currently (1979) making a hydrologic investigation, including the development of a mathematical ground-water model, which will describe, quantify, and simulate the hydrology of Eagle Valley.

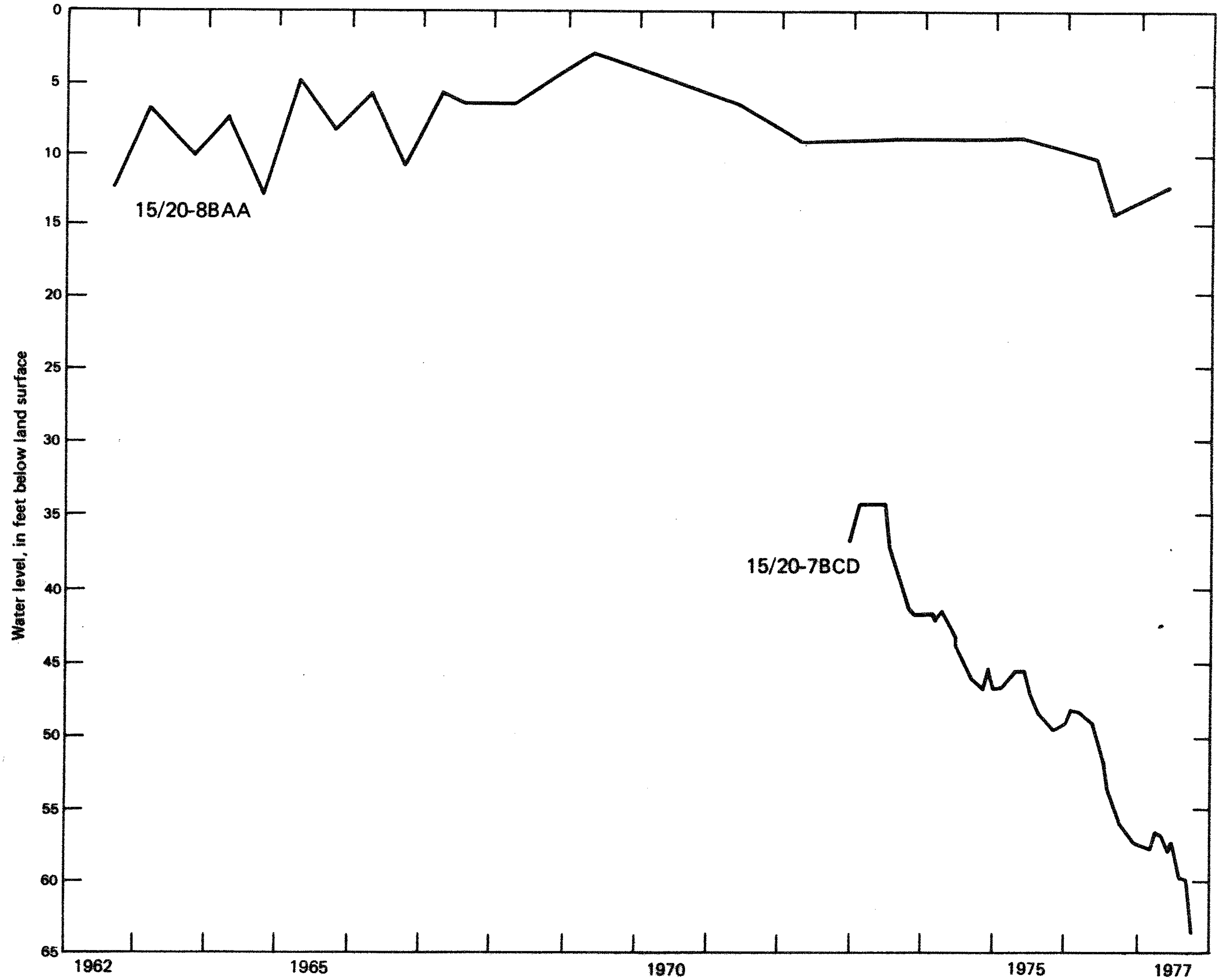

Figure 1. Water level changes in wells 15/20-7BCD and 15/20-8BAA.

The depths to water shown on the 1976 map are greater, in most areas, from those shown in 1964 by Worts and Malmberg (1966, fig. 5). Several factors have contributed to this difference. Above-normal precipitation in 1963 may, in part, have caused water levels in 1964 to be higher than normal. There has been increased pumping from the ground-water system, in combination with less-than-normal precipitation and runoff, in the past few years. Agricultural lands west of Carson City are gradually going out of production, and urbanization is spreading. Much of the potential recharge from precipitation on these lands will now be intercepted by roofs, driveways, roads and gutters and be carried away in storm drains. Agricultural irrigation will cease on these lands, and thus another potential recharge source will be lost.

A problem resulting from declining water levels that Carson City may have to face in the future is land subsidence. When pumping causes a large drop in the water table, water drains or is squeezed out of the overlying deposits. The loss of this hydraulic support causes vertical settling and compaction of the unconsolidated valley fill, which ultimately can damage wells, pipelines, roads and other structures.

Shallow-ground-water areas with a depth to water of about 10 ft (3 m) commonly discharge water directly to the land surface. This capillary rise continues under buildings and can create moisture problems unless special precautions are taken to prevent damage.

Washoe Valley

The ground-water resources of Washoe Valley have been described by Rush (1967 and 1975). In the 10 years since Rush's work, the valley has undergone extensive development; however, the section of Washoe Valley on the Carson City Quadrangle has had only minor development and is still predominantly agricultural.

Washoe Lake forms the principal base level for the local hydrologic system in Washoe Valley. Both surface water and ground water flow into the lake. Washoe Lake drains north to Little Washoe Lake (not on the quadrangle) which drains into Steamboat Creek and finally into the Truckee River. Because of drought, Little Washoe Lake dried up in the summer of 1977, and the level of Washoe Lake fell below the elevation of the channel that connects the lakes. The natural rim of Washoe Lake is below the control works on Little Washoe Lake, which allows storage regulation between elevations 5,017.5 ft (1,529.3 m) and 5,028.9 ft (1,532.8 m). The maximum depth of Washoe Lake at spillway elevation (Rush, 1972) is 11.4 ft (3.5 m). The lake also forms a modified constant-head boundary to the ground-water system. This means that if wells near the shore are pumped heavily and draw down the ground-water levels below the lake level, then lake water will temporarily recharge the ground-water system within the depth limits of the lake. Consequently, drawdowns are lessened during periods of heavy pumping and, over the long-term, intermittent recharge of lake water helps to prevent significant ground-water storage depletion as a result of pumping.

The main ground-water reservoir is the alluvium composed primarily of gravel, sand, and clay. The alluvium is thin at the bedrock contact and thickens toward the valley center, with depths of as much as 500 ft (152 m) being reported (Rush, 1967, p. 9).

Unconsolidated deposits overlying the mountain block are generally quite small in aerial extent and have a very thin saturated thickness, they are relatively unimportant as a prolonged water-supply source.

Depths to ground water shown on the map are generally similar to those shown by Rush (1967, fig. 2) and they also match reasonably well with those shown by Rush (1975) on the Washoe City Quadrangle which adjoins the Carson City Quadrangle on the north.

Consolidated rocks in the Washoe Valley drainage area are the granodiorites of the Carson Range and a volcanic assemblage with minor amounts of granodiorite in the Virginia Range (Trexler, 1977).

WATER QUALITY

Water quality for Eagle Valley has been categorized by Worts and Malmberg (1966, p. 35) as "generally satisfactory for irrigation, domestic, and most common uses. Locally, the shallow ground water reportedly contains iron in excess of 0.3 ppm (parts per million), which may cause laundry staining (U.S. Public Health Service, 1962)." A detailed analysis of selected public supply wells by Worts and Malmberg (1966, table 12a, p. 31) suggests that water at depths below 300 ft (91 m) generally is of good chemical quality for municipal use.

The water quality of Washoe Valley was described by Rush (1967, p. 25) as follows: "Except for unknown concentrations of minor constituents, such as fluoride, iron, and nitrate, the surface and ground waters are mineralogically suitable for domestic use, as defined by the U.S. Public Health Service (1962). Iron is a problem in some wells throughout the valley."

WELL NUMBERING SYSTEM

The numbering system for the few wells referred to in this report indicates location on the basis of the rectangular subdivision of public lands, referenced to the Mount Diablo base line and meridian. Each number consists of three units: The first is the township north of the base line; the second unit, separated from the first by a slant, is the range east of the meridian; the third unit, separated from the second by a dash, designates the square-mile section. The section number is followed by letters that indicate the quarter section, quarter-quarter section, and so on; the letters A, B, C, and D designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 15/20 7BCD is in SE1/4 SW1/4 NW1/4 sec. 7, T15N, R20E.

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