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WATER RESOURCES OF THE RUIDOSO-CARRIZOZO-TULAROSA AREAS, LINCOLN AND OTERO COUNTIES, NEW MEXICO

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Abstract—Supplies of potable water in the Ruidoso-Carrizozo-Tularosa areas come from both surface storage facilities and ground water. Water from Bonito Lake is piped from the east side of Sierra Blanca to the Tularosa Basin, where it is used by the communities of Nogal, Carrizozo, Alamogordo, Holloman Air Force Base and the Southern Pacific Railroad to supplement ground-water supplies. Ground water is recharged primarily from precipitation falling on Sierra Blanca; as little as 7.5% of this precipitation is estimated to reach the aquifers in the mountain areas. Important aquifers are Tertiary volcanic, igneous and sedimentary rocks, and Cretaceous, Triassic and Permian sedimentary rocks. Concentrations of total dissolved solids in ground waters vary greatly and increase along flow paths away from recharge areas. Human-caused contamination has locally impacted the quality of ground water.

INTRODUCTION

As the population and demand for water resources increase in Lincoln and Otero Counties, the needs for long-range planning and water-resource management become increasingly important. This paper briefly describes the ground- and surface-water resources of the Ruidoso, Carrizozo and Tularosa areas, and outlines some of the major issues relative to water supply, water rights, water quality and contamination of water resources.

Evaluations of the ground-water resources of the Ruidoso-Carrizozo-Tularosa region began in the early 1900s. Meinzer and Hare (1915) described the geology and water resources of the Tularosa Basin; this study included the Carrizozo and Tularosa areas, which are located in the northern part of the basin. Many of the wells and springs they described can still be found. Other studies of the hydrology of the Tularosa Basin include Herrick et al. (1960), Herrick and Davis (1965) and Orr and Myers (1986).

There have been a number of studies of the water resources of the northern part of the Tularosa Basin: in the Carrizozo area—those of Hendrickson (1949), Cooper (1958, 1964, 1965) and Rao (1986); and the Tularosa and Three Rivers areas—Hood and Herrick (1965).

The geology and water resources of the Ruidoso area were evaluated in reports by Jones and Murray (1948) and Mourant (1963). Many workers have conducted local evaluations of water resources in the Ruidoso area (Hall, 1964; Sloane and Garber, 1971; Summers, unpublished consultant's report to Lakeside Corporation, 1977; and Hirsch, 1986).

RUIDOSO

The Ruidoso area, as described here, includes the eastern and northeastern flanks of Sierra Blanca (Fig. 1). The western boundary is the divide at the head of the Rio Hondo watershed on Sierra Blanca. Elevations in the area range from over 3600 m on Sierra Blanca to less than 1800 m along Rio Ruidoso, approximately 15 km east of Ruidoso.

The geology and structure in the Ruidoso area have been described by Kelley and Thompson (1964) and Kelley (1971). Rocks cropping out in the area range in age from Permian to Recent. The major structural features are the Ruidoso fault zone, Sierra Blanca Basin and Mescalero arch; the Ruidoso fault zone roughly separates the basin from the arch. In general, west of the Ruidoso fault zone, Tertiary Sierra Blanca volcanics and Quaternary sediments overlie Tertiary and Cretaceous sedimentary rocks. East of the Ruidoso fault zone, rocks of Permian age are overlain by Quaternary sediments. The Three Rivers, Bonito Lake and Nogal stocks, large felsic intrusive bodies, are exposed west and northwest of the Ruidoso fault zone. These stocks, together with dikes and sills, intruded into the Sierra Blanca volcanics and older Tertiary and Cretaceous sedimentary rocks. In detail, the structure of the area is complex and rocks are locally faulted and highly fractured. Surrounding Capitan, older Tertiary and Cretaceous sedimentary rocks have been intruded by north-northeast-trending dikes (Kelley and Thompson, 1964).

Flow of ground water, west of the Ruidoso fault zone, is principally in fractured rocks with very low primary permeability, and the direction of flow is to the east, parallel with surface drainages. Some flow occurs in Recent alluvium overlying bedrock and within interstitial porosity of the Tertiary and Cretaceous sedimentary and Tertiary volcaniclastic rocks. Transmissivities of fractured volcanic rocks along Eagle Creek, west of Alto, were estimated to be about 130 m^2/day; values of diffusivity (ratio of transmissivity to storage coefficient) were calculated to be 1,300,500 m^2/day between wells near a large linear fracture system (Shomaker, Inc., unpublished data analysis, 1989). In the Alto area, Summers (unpublished report, 1977) estimated transmissivities ranging from 1.2 to 17 m^2/day; ground water in this area is believed to be produced from fractured and faulted Tertiary volcanics/igneous bodies, older Tertiary (Cub Mountain Formation) and Cretaceous (Mancos Shale and Mesaverde Group) sedimentary rocks.

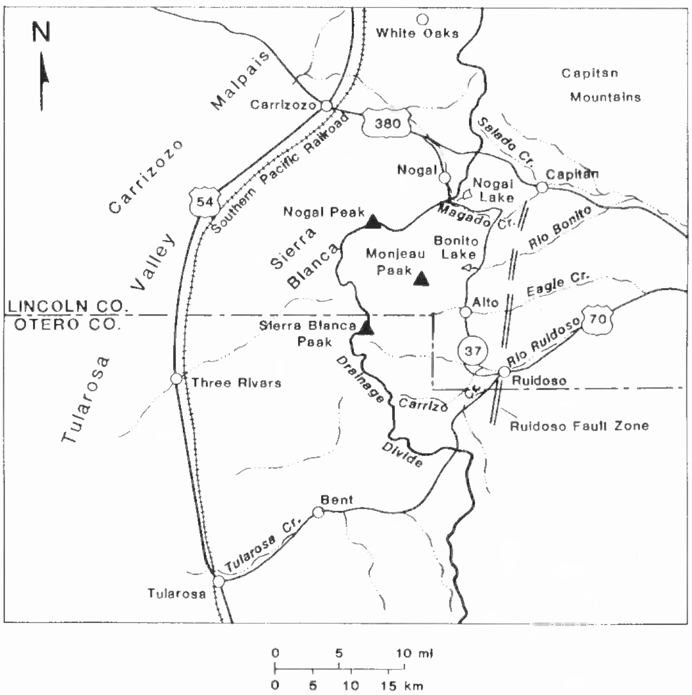

FIGURE 1. The Ruidoso-Carrizozo-Tularosa area, Lincoln and Otero Counties, New Mexico.

Ground water is recharged primarily from precipitation in the mountains west of the Ruidoso fault zone. A portion of this precipitation infiltrates through the channels of the major streams and ephemeral drainages in the mountains and to a lesser degree on rock outcrops. The important drainages include the Rio Bonito, Rio Salado, Rio Ruidoso and several smaller tributaries.

A number of surface water bodies within the same area, including Bonito Lake, Nogal Lake, Alto Reservoir, the lake at the Inn of the Mountain Gods and many small impoundments, contain water during seasonal wet periods. With the exception of Nogal Lake, the reservoirs are located within the drainages. Nogal Lake, a regulating reservoir on the Bonito Lake pipeline, is in a depression near the drainage divide separating the Rio Hondo Basin from the Tularosa Basin.

Water from Bonito Lake is piped around the north end of the mountains into the Tularosa Basin to serve rights belonging to Nogal (1.45 ac-ft/yr), Carrizozo (130.31 ac-ft/yr), Alamogordo (1449.02 ac-ft/yr), Holloman Air Force Base (1449.02 ac-ft/yr), and the Southern Pacific Railroad (57.92 ac-ft/yr) (unpublished State Engineer Office records). Of the total allocation of 3087.72 ac-ft/yr, the average annual diversion is about 2300 ac-ft. The average inflow is on the order of 5000 ac-ft/yr; the difference between the inflow and the diversion by the pipeline is largely contributed to ground-water recharge along the Rio Bonito drainage.

The Dakota Sandstone crops out in places along the western side of the Ruidoso fault zone and dips steeply to the west. Wells completed in the Dakota, near fault zones, have yielded water at rates of more than 100 gpm. Away from fault zones, unfractured Dakota Sandstone is not expected to have enough permeability to yield large quantities of water.

Ground water west of the Ruidoso fault zone is generally of good quality (Hall, 1964). Water-supply wells completed in Sierra Blanca volcanics in the Eagle Creek drainage west of Alto, produced water with total dissolved solids ranging from 326 to 888 mg/l (Village of Ruidoso records). The dominant cation and anion in these waters were calcium and sulfate, respectively.

East of the Ruidoso fault zone, the important aquifers are principally in Permian sedimentary rocks (Yeso Formation and San Andres Limestone) and in Quaternary alluvium along major drainages. The shallowest aquifers within valleys and along drainages are unconfined and are in hydraulic connection with surface drainages. Wells completed in the Yeso Formation generally yield water in smaller quantities and of inferior quality to wells completed in Quaternary alluvial aquifers and the San Andres Limestone. Reported well yields for the alluvial and San Andres aquifers range from 10 to 1000 gpm (Mourant, 1963). Yields of wells completed in the Yeso generally are an order of magnitude less.

Ground water derived from Permian rocks east of the Ruidoso fault zone generally is of poor quality. The quality of ground water is influenced by the presence of soluble sulfate minerals (Hall, 1964). Sulfate minerals in the Yeso Formation and in Recent alluvium and soils contribute large quantities of salts to the ground water. Ground water derived from the Yeso Formation and San Andres Limestone typically contain dissolved solids in excess of 1000 mg/l; calcium and sulfate are the dominant ions, although bicarbonate may be greater locally in waters in the San Andres aquifer (Mourant, 1963, table 3).

The quality of shallow ground water in the Ruidoso area has been influenced by human activity. There has been contamination by hydrocarbons from leaky underground-storage tanks and spills at several sites (Shomaker, Inc., unpublished reports, 1988, 1989, 1990). This contamination resulted in concentrations of volatile-aromatic hydrocarbons and halocarbons in soils and ground water which exceeded applicable environmental standards. Near residential areas located along the drainages, the shallow ground water has been contaminated with nitrates and salts resulting from septage leachate. Other potential sources of ground-water contamination include acid mine-drainage and heavy metals derived from mining- and mineral-processing wastes in the higher elevations west of Ruidoso, along the headwaters of many of the drainages tributary to Rio Ruidoso and Bonito Creek. A number of mining districts are located in those areas (Griswold, 1959).

CARRIZOZO

The Carrizozo area includes the northern flanks of Sierra Blanca where surface drainage in Lincoln County is tributary to the Tularosa Basin (Fig. 1). Surface elevations range from 3035 m at Nogal Peak to less than 1500 m southwest of Carrizozo.

The geology and structure of the Carrizozo area were described by Weber (1964). The oldest bedrock units exposed in the area are Permian sedimentary rocks. These are locally overlain by Upper Cretaceous and lower Tertiary sedimentary and volcanic rocks. Valley fill includes unconsolidated sediments, and basaltic flows and related deposits.

Carrizozo is located near the northern part of the Sierra Blanca Basin on the western limb of the synclinal trough. Therefore, rocks older than the valley fill dip to the east or southeast. Near the town of Nogal, older Tertiary and Cretaceous sedimentary rocks are intruded by dike swarms, which trend to the north-northeast.

Important aquifers include the unconsolidated valley alluvium and older Tertiary and Cretaceous sandstones. The alluvium ranges in thickness from a few meters to nearly 40 m, and is thickest along the axis of the valley. Cretaceous sedimentary rocks underlie valley fill over much of the area. Rao (1986) reported the unconfined aquifer in the valley fill is likely connected directly to water in sandstones in the underlying Cretaceous rocks. The saturated thickness of the unconfined alluvial aquifer is less than 40 m over the area. Discharge from the alluvium occurs in the form of evapotranspiration, springs, leakage to the underlying bedrock and flow into the basalt flows west of Carrizozo.

Direction of ground-water flow is to the north and northwest, generally radially away from Sierra Blanca and toward the axis of the Tularosa Basin. Near the mountains, ground-water flow is parallel to the surface drainages. Transmissivities in the alluvial aquifer are estimated to range from 70 to 250 m^2/day (Rao, 1986).

Rao (1986) evaluated several methods of estimating the ground-water recharge. Most recharge appears to occur directly to the alluvial aquifer near the mountain fronts, although a small amount may enter the bedrock aquifer directly in mountain areas. The Darcy model, as described by Rao (1986), yielded recharge estimates of 7.5% of the 40,000 ac-ft of water estimated to fall as precipitation on the watershed. There are no perennial streams in the Carrizozo area.

Ground-water flow in Cretaceous rocks is probably limited principally to sandstone units. These rocks are recharged by flow from the alluvial aquifers, infiltration on outcrops and "malpais" (where it immediately overlies Cretaceous rocks), and by upward flow from deeper rocks. Transmissivities in the sandstone units reach about 90 m^2/day (Rao, 1986), but doubtless vary greatly depending on the degree of fracturing and the development of secondary porosity. Transmissivities of other Cretaceous units, including shales and coal-bearing units, would be orders of magnitude lower.

Rao (1986) estimated ground-water extraction in the Carrizozo area at about 1350 ac-ft/yr, with about 85% for irrigation use. Water levels in a number of wells declined during the late 1970s and early 1980s, but it is not known to what degree the declines were the result of natural influences.

Leedshill-Herkenhoff, Inc. (unpublished report to Otero County, 1990) estimated year-1990 water demand for the Carrizozo area, including Carrizozo, Nogal and surrounding area but exclusive of agriculture, at 156,700 gal/day or about 176 ac-ft/yr. By 2030, the demand was expected to fall to 137,920 gal/day because of population loss. Of these amounts, about one-third is drawn from ground water, the remainder coming from surface water through the Bonito pipeline.

The quality of ground water in the Carrizozo area is moderate to poor with total dissolved solids ranging from 500 to 7000 mg/l (Rao, 1986; Cooper, 1958, 1964, 1965; Hendrickson, 1949). The alluvial aquifer has slightly poorer quality than the bedrock sandstone aquifers. Ground water in the shallow alluvial aquifer is principally a calcium-sulfate type with a component of sodium chloride. Waters produced from Cretaceous rocks are dominantly a calcium-sulfate type with total dissolved solids generally ranging from 1000 to 2000 mg/l.

Human activities that have impacted the quality of ground water in the Carrizozo area include: nitrates and other salts resulting from the infiltration of leachate derived from irrigation and septic systems; hydrocarbons from leaky underground-storage tanks and other spills; and cyanide and metals contamination associated with mineral-processing activities such as the Cimarron Mining mill at Carrizozo, now a Superfund site (see Brandvold, this volume).

TULAROSA

The Tularosa area includes the area on the west side of Sierra Blanca from the Lincoln County line near Three Rivers, to Tularosa (Fig. 1). Studies of the water resources of this area include those of Meinzer and Hare (1915), Hood and Herrick (1965), McLean (1970) and Orr and Myers (1986).

Rocks in this area range in age from Pennsylvanian to Recent. The major structures in the area include the major north-northwest-trending fault zone and subparallel faults which define the eastern edge of the Tularosa Basin. The major boundary faults juxtapose rocks of relatively low permeability to the east against unconsolidated Quaternary alluvial sediments to the west. Where major drainages enter the basin, large alluvial fans have developed; the heads of these fans typically extend some distance eastward of the major boundary fault.

A small area near Three Rivers has potential for freshwater development from shallow Quaternary alluvium occupying a reentrant along the mountain front, and from underlying Tertiary and Cretaceous sedimentary rocks, with recharge from the large surface drainage. Hood and Herrick (1965) indicated that the alluvial aquifer is less than 91 m thick, with well-yields no greater than about 200 gpm. Irrigation rights totaling approximately 2000 ac-ft/yr have been declared (State Engineer Office records). There has been surface-water development on a very small scale, and Hood and Herrick (1965) implied that a few thousand acre-feet per year may be available in some years.

There has been almost no ground-water development between Three Rivers and the vicinity of Tularosa. In the Tularosa area, the principal aquifer is the Quaternary alluvium, west of the major basin-bounding faults. Ground water generally is unconfined and the direction of flow is southwest, parallel to the surface drainages and toward the axis of the Tularosa Basin.

Recharge to these aquifers principally occurs in the mountains east of the basin-bounding faults either as direct infiltration on outcrops or as infiltration into alluvial sediments near the heads of alluvial fans. Some recharge of the alluvial aquifer may occur short distances west of the mountain front. Most of the precipitation and runoff reaching mid-fan areas and distal parts, for the most part is evaporated or transpired. Dissolved solids content of recharged water increases significantly as water moves through the aquifer, so that potable water is found only in a band a few kilometers wide along the mountain front.

Tularosa Creek has an average annual discharge, at Bent, of 8480 ac-ft/yr for 1949–1989 (Borland and others, 1990). The Village of Tularosa controls 701.25 ac-ft/yr, subject to senior rights, and there is irrigation use above Tularosa on the order of 2200 ac-ft/yr (Leedshill-Herkenhoff, Inc., unpublished report to Otero County, 1990). The Village of Tularosa and the original irrigation were established in 1863, in the form of a Spanish-Mexican acequia system as they existed elsewhere in New Mexico, prior to the Treaty of Guadalupe Hidalgo in 1848 (G. Emlen Hall, personal comm., 1990). Water rights in Tularosa Creek have not been adjudicated. The Mescalero Apache Tribe controls the upper reaches of the stream, and may claim much or all of the flow.

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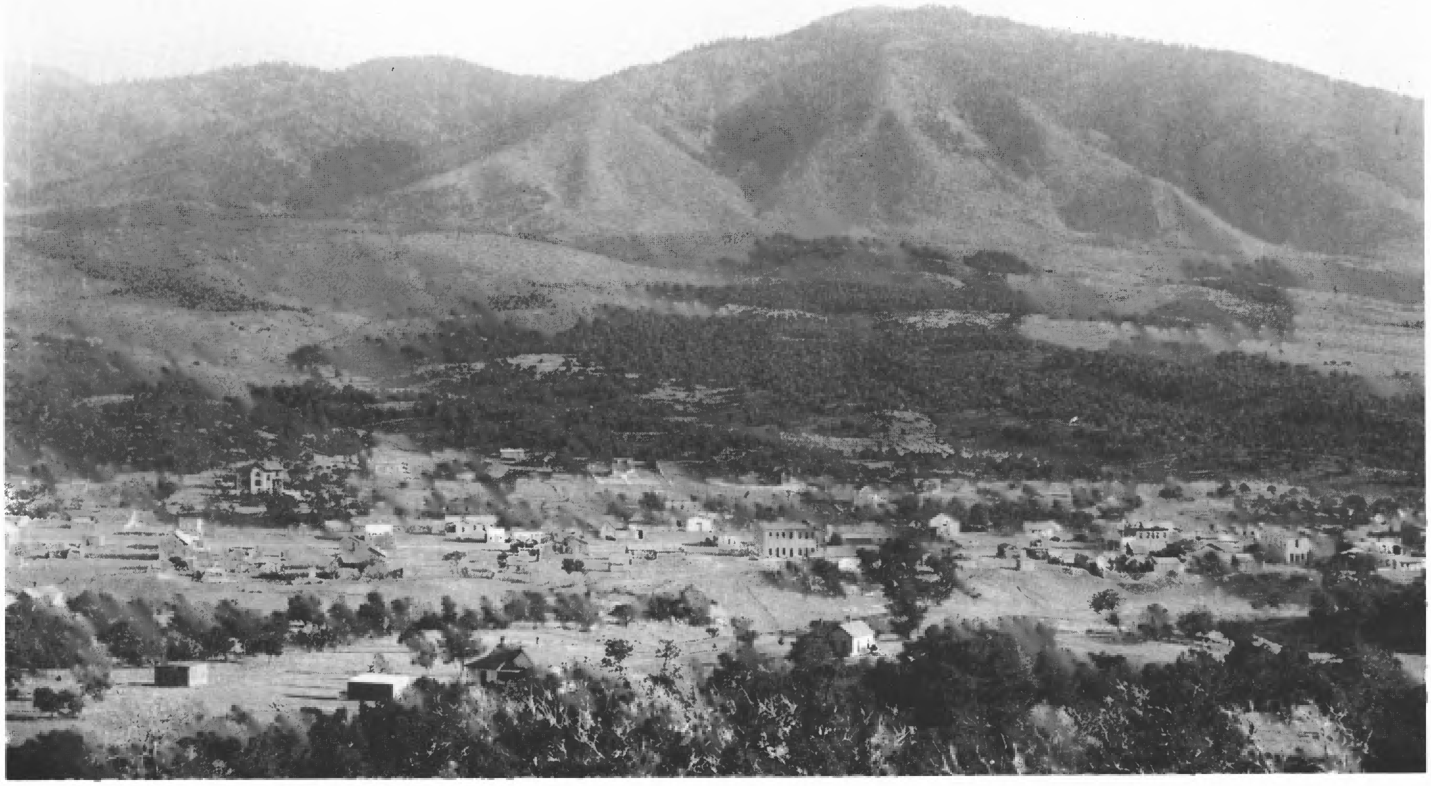

Named for the trees growing around the nearby springs, White Oaks, New Mexico, was in its heyday when the above view, looking south toward Carrizo Mountain, was made circa 1890. Beginning in the early 1880's, water from the springs was hauled to Baxter Gulch and sold to placer miners at 50 cents per barrel (volume unspecified). Placering soon gave way to lode mining with the discovery of the North and South Homestake, Rita, Lady Godiva and, the most famous of them all, the Old Abe. White Oaks is one of New Mexico's largest gold producers, credited with about 150,000 oz. Photo courtesy of Rio Grande Historical Collections, Ms 110, 7.3-28, New Mexico State University, Las Cruces.