Chapter 18

The Diablo Plateau Aquifer

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Introduction

Although the Texas Water Development Board has delineated several aquifers in the West Texas area (e.g., Ashworth and Hopkins, 1995; TWDB, 1997; Mace, this volume), there still may be cause to consider adding at least one more aquifer to the mix: the Diablo Plateau aquifer. The Diablo Plateau aquifer coincides with the Diablo Plateau, a relatively flat area that lies between the Hueco Bolson to the west, the Salt Basin to the east, and several mountain ranges to the south, extending northward into New Mexico (fig. 18-1) (Muehlberger and Dickerson, 1989). The Diablo Plateau consists primarily of limestone: some of the same limestones that compose the prolific Bone Spring-Victorio Peak aquifer in the Dell City area. Studies in the late 1980's on siting a low-level radioactive waste disposal facility concluded that the hydrogeology of the Diablo Plateau precluded the area from being suitable for waste disposal because of the potential as a future water resource (Mullican and others, 1987; Kreitler and others, 1987, 1990). These studies found good-quality water, good well yields, and evidence of recent recharge over most of the aquifer.

The purpose of this paper is to summarize past work characterizing the hydrogeology of the Diablo Plateau and to suggest that the Diablo Plateau aquifer be further evaluated as a potentially significant water resource for this region of West Texas. Ultimately, this area may warrant future consideration and possible designation as a minor aquifer of the State.

Climate

The Diablo Plateau area has a subtropical arid climate characterized by high mean temperatures with marked fluctuations over broad diurnal and annual ranges (minimum and maximum average annual temperatures are 45º and 81ºF, respectively) and low mean annual precipitation (10 inches/yr) with widely separated annual extremes (Kreitler and others, 1990). Precipitation occurs primarily during late summer and early autumn rainfall from thundershowers. Rainfall events are locally intense but short lived, and surface water is ephemeral because of consistently high evaporation rates. Mean annual lake-surface evaporation potential in the study area is approximately 83 inches (Larkin and Bomar, 1983). For 19 of the 31 yr from 1951 to 1981, Hudspeth, Culberson, El Paso,

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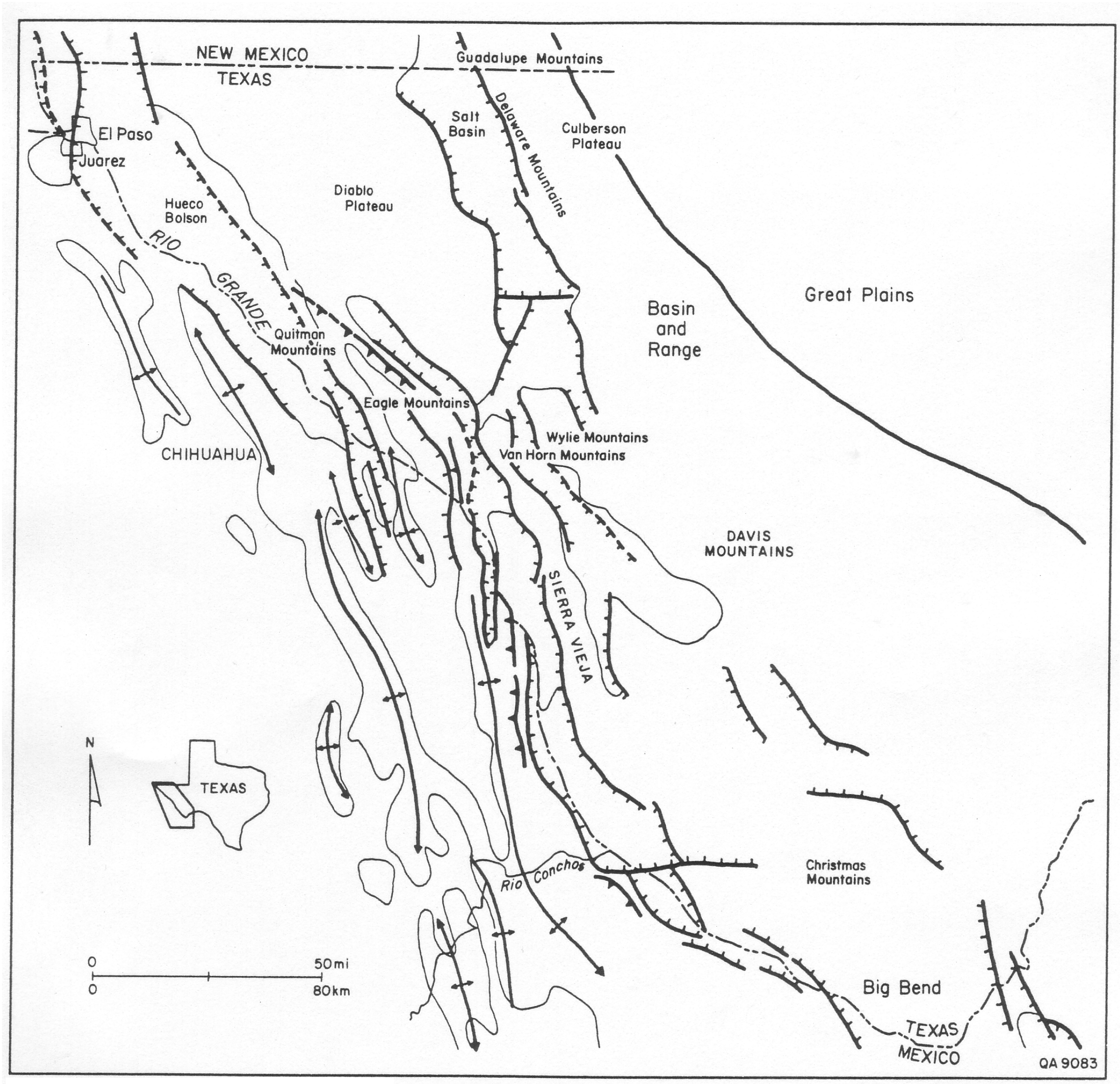

Figure 18-1: Tectonic and physiographic map showing the location of the Diablo Plateau (from Kreitler and others, 1990 [which was modified from Henry and Price, 1985]).

and adjacent counties recorded the lowest annual precipitation of any reporting stations in Texas (Bomar, 1995).

Geologic Setting

The Diablo Plateau is in the southeastern part of the Basin and Range Province and is an uplifted, east-northeast-dipping homoclinal structure. The Diablo Plateau is bounded by major normal faults to the west at the Hueco Bolson and to the east at the Salt Basin and by several normal faults to the south near the Eagle Mountains (Barnes, 1983; Henry and

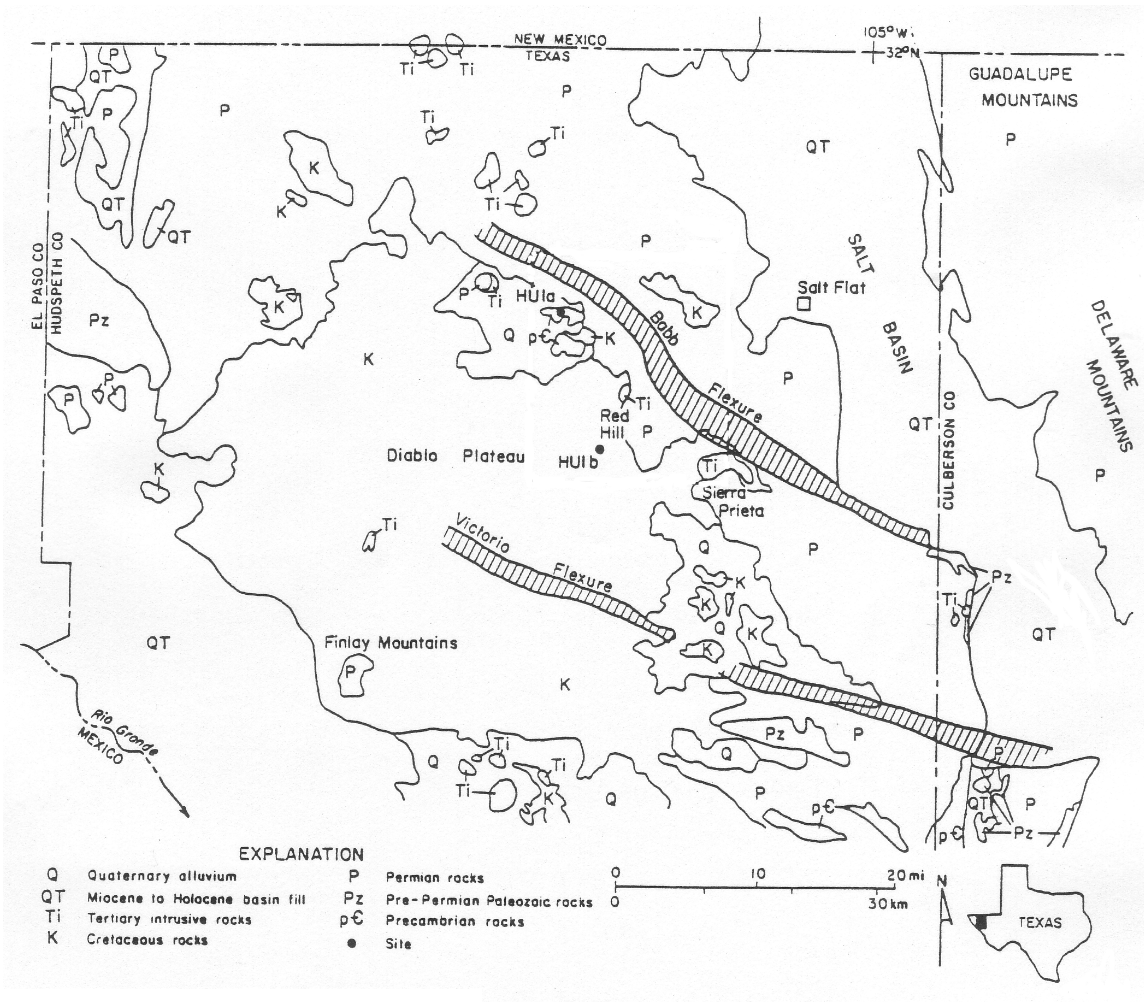

Figure 18-2: Geology of the Diablo Plateau area (modified from Kreitler and others, 1986 [with geology from Henry and Price, 1985]).

Price, 1985). The Diablo Plateau consists of Permian- and Cretaceous-aged limestones interbedded with sandstones and shales, with patches of Miocene to Holocene and Quaternary alluvium, occasional Tertiary intrusive rocks, and an area of Precambrian rhyolite and porphyry (fig. 18-2) (Henry and Price, 1985; Kreitler and others, 1986). Additional details on the geology in the area can be found in King (1965).

There are several structural features within the Diablo Plateau. The Babb flexure is a west-northwest-trending monocline about 1 to 2 mi wide with downward displacement of strata on the north side of the flexure (King, 1949; 1965) that may be traced about 40 mi northwestward from the Salt Basin (fig. 18-2). The flexure may be the Permian or post-Permian expression of a major pre-Permian strike-slip fault (Hodges, 1975). Farther to the south is the Victorio flexure (fig. 18-2). Fractures in the outcrop are associated with the flexures, Tertiary intrusions, and other faulting in the area.

Hydrogeology

Water-level information suggests that there are two aquifers in the Diablo Plateau (Kreitler and others, 1986, 1990; see next section). These aquifers appear to correspond to the geology in the area: one aquifer is located in the Cretaceous rocks on the southwestern part of the plateau and another is located, at land surface, in the Permian rocks on the northern and northeastern part of the plateau. The aquifer in the Permian rocks underlies the aquifer in the Cretaceous rocks. However, the nature of the aquifer in the Permian rocks beneath the aquifer in the Cretaceous rocks is not known in great detail. Wells close to each other but drilled at different depths support two aquifers because of considerably different water levels (Kreitler and others, 1986). Both aquifers are primarily unconfined, although the aquifer in the Cretaceous rocks is locally perched confined to semiconfined (Kreitler and others, 1990). The aquifer in the Permian rocks is most likely confined beneath the Cretaceous rocks.

Water Levels and Groundwater Flow

Water levels show that the Diablo Plateau aquifer is laterally connected to a number of aquifers in the area. The Cretaceous part of the aquifer is hydraulically connected to the Hueco Bolson aquifer (Mullican and Senger, 1990, 1992) to the west and to the Salt Basin and the Bone Spring–Victorio Peak aquifer in the Dell Valley area to the east (Peckham, 1963; Young, 1975; Kreitler and others, 1990; Mayer, 1995; Ashworth, this volume). The Bone Spring and Victorio Peak Formations or their equivalents are also part of the Diablo Plateau aquifer.

Depth to water in the aquifer can range from less than 5 ft to more than 800 ft. The fresh-water part of the aquifer may be quite thick: the U.S. Soil Conservation Service drilled a borehole to 1,800 ft in the Dell City irrigation district on the northeastern side of the plateau and never crossed the base of the fresh/brackish water (Logan, personal communication, 1986).

Water levels show that there is a mound of water in the part of the Diablo Plateau aquifer south of Highway 62/180 corresponding to a local topographic high (fig. 18-3). Groundwater flows outward from this high to the southwest toward the Hueco Bolson, to the northeast toward the Salt Basin, and to the southeast toward the Finlay Mountains and northwest Eagle Flats (fig. 18-3). Limited information also suggests that a component of groundwater flows to the north (fig. 18-3). Groundwater flow north of Highway 62/180 generally flows eastward toward the Dell City area (Mayer, 1995).

Most of the water flows down the structural dip of the monocline toward the northeast, with only a minor amount of water flowing into the Hueco Bolson (Mullican and others, 1987; Kreitler and others, 1990). Hydraulic gradients are higher in the central Cretaceous part of the plateau and much lower along the Hueco Bolson and in the Permian part of the plateau.

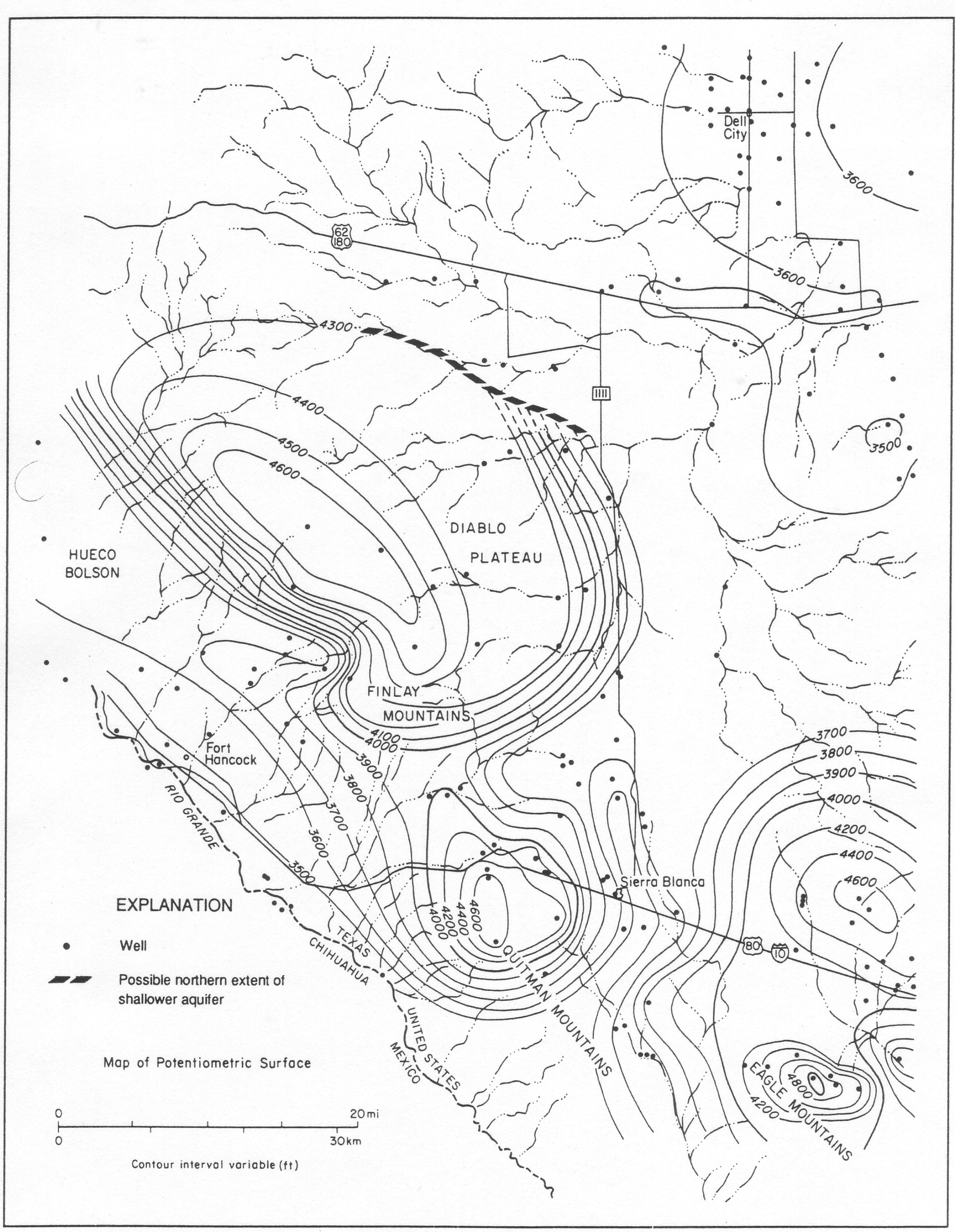

Figure 18-3: Potentiometric surface map of the Diablo Plateau area (from Kreitler and others, 1990).

Kreitler and others (1986, 1990) reported discontinuities in the potentiometric surface and suggested changes in hydraulic conductivity to partly explain the discontinuity (fig. 18-3). We think that the geology and topography can help explain the differences, acknowledging that the permeability of the Permian rocks is likely higher than the permeability of the Cretaceous rocks.

Hydraulic Properties

The limestones of the Diablo Plateau may have the ability to transmit large amounts of water. Wells in the Bone Spring-Victorio Peak aquifer in the Dell City area have produced about 98,500 acre-ft/yr for 30 yr, with only about 33 ft of drawdown (Kreitler and others, 1990) from similar formations. The high production of the aquifer in this area is primarily due to fractures caused by faulting and subsequent dissolution of the host limestones. Well production is much greater in and near fracture zones than away from these zones. Individual wells located by lineament analysis can produce 2,000 to 3,000 gpm. Using aerial photography to locate areas of intense fractures, the U.S. Soil Conservation Service has successfully located 11 of 12 floodwater injection wells. Only 44 percent of the wells first drilled in the Dell City area were considered successful (Scalapino, 1950). In many cases, one well could produce greater than 2,000 gpm, while a well only 100 ft away would produce less than 100 gpm.

Specific capacity of the Bone Spring-Victorio Peak aquifer in the Dell City area ranges from 5 to 64 gpm/ft (Peckham, 1963). Using the Thomasson and others (1960, C = 1.2) approach to estimate transmissivity from specific capacity, these specific-capacity values correspond to transmissivities of 1,200 to 15,000 ft^2/d. Using the Bone Spring-Victorio Peak aquifer, similar transmissivities may be attainable in the Permian part of the Diablo Plateau aquifer. Mullican and others (1987) and Kreitler and others (1987, 1990) reported that in a majority of the pump tests conducted on wells completed in the Diablo Plateau aquifer, a majority were indicative of fracture flow. Several wells recently drilled and tested in the Diablo Plateau aquifer in northwestern Hudspeth County can produce 40 to 300 gpm for 48 h with no drawdown (LBG-Guyton Associates, 2001). Although the aquifer is not extensively used today, it has the potential to produce large volumes of fresh water.

Recharge

Recharge occurs over the entire ~2, 900 mi^2 catchment area of the Diablo Plateau, as shown by the occurrence of tritium in nearly every well sampled on the plateau (fig. 18-4) (Mullican and others, 1987; Kreitler and others, 1990) (tritium is a relatively short lived radioisotope that suggests recent [<50 yr] recharge; see Scanlon and others, this volume, for a discussion on tritium as a tracer of recharge). This is in contrast to many of the bolson aquifers, where recharge is focused along mountain fronts (e.g., Darling, 1997, this volume; Scanlon and others, this volume). Most recharge probably occurs during flooding of the arroyos that traverse the Diablo Plateau. Chloride concentrations are significantly lower in soils in the arroyo than in soils between the arroyos, suggesting that the arroyos recharge at a much greater rate (Mullican and others, 1987; Kreitler and

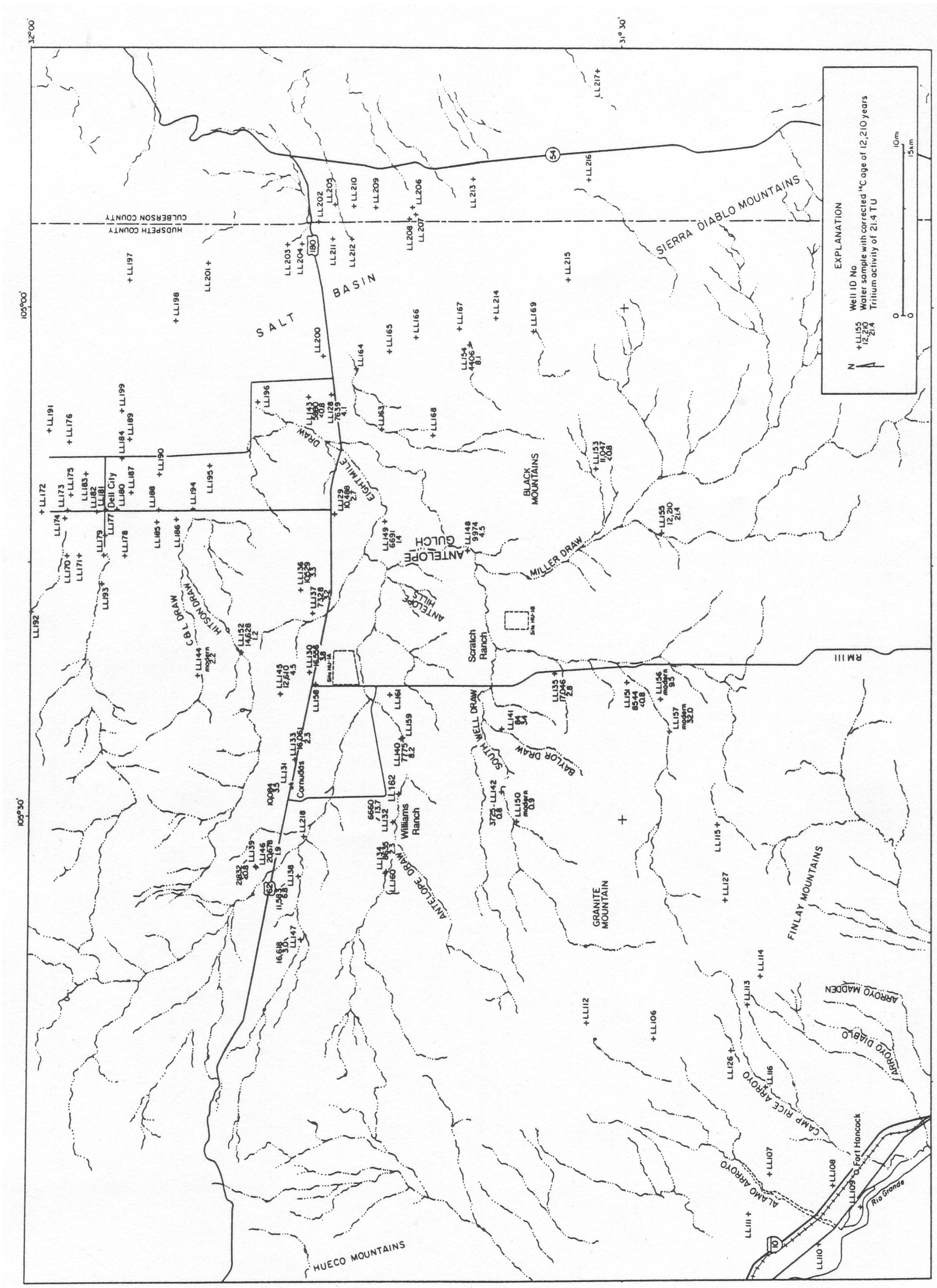

Figure 18-4: Areal distribution of tritium in water wells in the Diablo Plateau aquifer (from Kreitler and others, 1986).

others, 1987, 1990). Fractures, typically concentrated in arroyos, permit surface water to move rapidly through the thick unsaturated section. Peckham (1963) noted that the Bone Spring-Victorio Peak aquifer is partly fed by recharge in the Diablo Plateau to the west. To our knowledge, no one has estimated total recharge to the Diablo Plateau aquifer.

Discharge

Based on the potentiometric surface map, it has been determined that most of the groundwater ultimately discharges naturally from the Diablo Plateau aquifer by evaporation and by interbasin flow. Groundwater flows from the Diablo Plateau aquifer into the Salt Basin. In the topographic low between the plateau and the Guadalupe and Delaware Mountains (the Salt Basin), the water table in the Salt Basin approaches the land surface (<3 ft depth to water), and large amounts of groundwater are evaporated. This evaporation precipitates gypsum, halite, and carbonates (Chapman, 1984; Boyd and Kreitler, 1986; Chapman and Kreitler, 1990). Gypsum may also be precipitating and reducing the permeability of sediments in the Salt Basin (Kreitler and others, 1990). The Diablo Plateau aquifer is thought to be the primary source of water to the Salt Basin. A minor portion of the groundwater in the Diablo Plateau flow to the south-southwest to ultimately discharge through cross-formational flow into the Hueco Bolson aquifer and ultimately the Rio Grande.

Groundwater may also discharge from the Diablo Plateau aquifer by interbasin flow beneath the gypsum flats of the Salt Basin to the south through Permian carbonates (Nielson and Sharp, 1985; Kreitler and others, 1990). This interbasin flow would eventually discharge to Balmorhea Springs or the Cenozoic Pecos Alluvium in Pecos County. Evidence of this is (Kreitler and others, 1990) (1) the absence of springs along the western edge of the Salt Basin, (2) the apparent restriction of flow in the Salt Basin due to limited thickness (3,280 ft, Veldhuis and Keller, 1980) and low permeability, and (3) the potential for a connection between the limestone of the Diablo Plateau and the limestones beneath the Salt Basin. Water levels in the Salt Basin suggest that water may flow to the south and to the east toward Balmorhea Springs. The Ca-SO_4 composition of the spring water supports the existence of such a large regional flow system.

Groundwater is also discharged from the aquifer by pumping. There is substantial pumping in the Dell City area, but much less in the rest of the Diablo Plateau.

Water Quality

Groundwater from the Diablo Plateau aquifer ranges from a Ca-HCO_3 composition in the area of the groundwater divide between the Hueco Bolson and the Diablo Plateau to a Ca-SO_4 to a Na-SO_4 composition along the flow path to the Salt Basin. Water quality is generally fresh to brackish with total dissolved solids ranging from 715 to 3, 803 mg/L. Freshwater in the Diablo Plateau aquifer is generally restricted to Cretaceous rocks although freshwater is found in the Permian section in the more upgradient area of the aquifer. Water from the Cretaceous part of the aquifer has elevated NO_3, probably from animal waste or septic heads (Kreitler and others, 1986).

Conclusions

The need for additional water resources in West Texas has been clearly established by many recent water-supply planning efforts. The rocks of the Diablo Plateau clearly warrant further evaluation as a potential water resource for West Texas. The Diablo Plateau aquifer has high well yields, good water quality, and is actively recharged. The aquifer consists primarily of Cretaceous and Permian limestones. Water levels indicate that the aquifer is laterally connected to neighboring aquifers, including the Hueco Bolson, Bone Spring-Victorio Peak, and Salt Basin aquifers. Water levels also indicate that there are two hydraulically distinct parts to the aquifer: one part in Cretaceous rocks and another in Permian rocks. Water quality is good, especially in the Cretaceous part of the aquifer, although nitrates might locally be a concern. Potential well yields in the aquifer are promising with wells in the Permian part of the aquifer producing as much as 300 gom without any measurable drawdown. Well yields are affected by faulting with much higher yields coming from wells that intersect fractures. The aquifer is widely and actively recharged over the entire Diablo Plateau. Most of the water that recharges the Diablo Plateau discharges to the Salt Basin with a lesser amount discharging to the Hueco Bolson. There is some evidence to suggest that water that originates on the Diablo Plateau discharges as far away as the springs in Balmorhea and into the Cenozoic Pecos Alluvium aquifer.

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