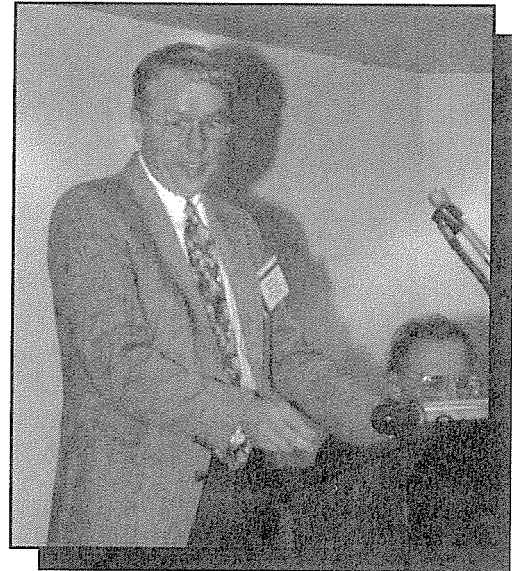


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OVERVIEW OF THE HYDROLOGY OF NORTHEASTERN NEW MEXICO

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I am honored to have been invited to present this overview on the hydrology of northeastern New Mexico. Although I will be discussing both surface and groundwater resources, the emphasis in this presentation will be on groundwater because of its regional economic importance and locally rapid depletion. Much of the information in this paper was developed by the author for the Northeastern New Mexico Regional Water Plan (Eastern Plains Council of Governments 1997). The region addressed in this paper is the same as that included in the Water Plan and consists of Union, Harding, Quay, Guadalupe, De Baca, Curry, and Roosevelt counties and the eastern portion of San Miguel County.

This paper is presented in four parts. First, an overview of water supply will be presented for the major surface and groundwater resources in the area. Second, the use and management of that water will be

reviewed. Third, the current conditions of water supply and demand will be evaluated. And fourth, the implications of the current trends on future water availability will be discussed.

Water Supply – Surface Water

The principal surface water resources in the region are provided by the Pecos, Canadian, and Dry Cimarron rivers. The locations of these rivers are shown in Figure 1. All other surface streams in the region are considered intermittent.

The Pecos River Compact regulates use of Pecos River water, which has been over appropriated. Two major water storage facilities, Santa Rosa and Fort Sumner reservoirs, have been built on the Pecos River within the region. However, conservation storage in both reservoirs is for the Carlsbad Irrigation District and the water is used in the lower Pecos Valley out-

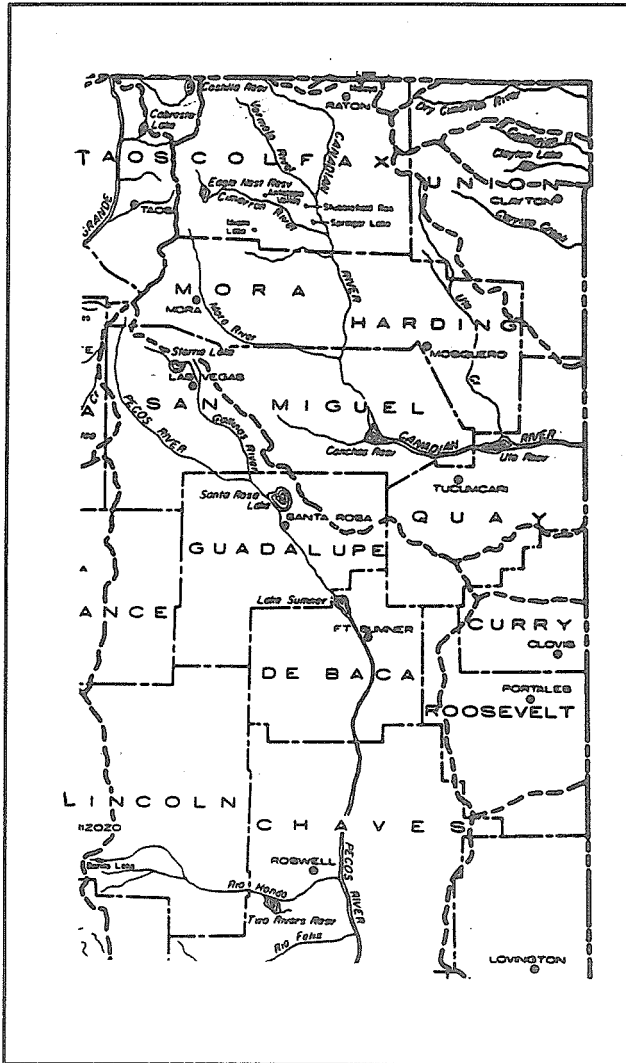


Figure 1. Major surface water drainage basins in northeastern New Mexico (modified from NM State Engineer Office 1994, Figure 2).

side the region. The only consumptive uses of Pecos River water allowed by the compact in the region are supplies to eleven acequias, to the Fort Sumner Irrigation District, and to the City of Santa Rosa. Although there are many natural lakes and springs in the Santa Rosa area, the quality of most of this water is not suitable for municipal use and Santa Rosa's primary drinking water supply currently is obtained from wells northwest of town in the vicinity of Colonias. Because of the annual delivery requirements to Texas and heavy demand on the available supply in New Mexico, the Pecos River has limited potential to meet additional demand. New consumptive uses could only be met by purchasing existing

senior water rights or through aggressive conservation efforts.

The Canadian River Compact regulates water conservation storage and use of Canadian River water. Two major water storage facilities, Conchas and Ute reservoirs, have been built on the Canadian River within the region. The compact allows New Mexico to use all water originating above Conchas Dam, and all surface water in this reach of the river is considered fully appropriated. Water stored in Conchas Reservoir supplies the Arch Hurley Conservancy District and Bell Ranch near Tucumcari. Conservation storage in Ute Reservoir currently is allocated to provide an annual yield of 24,000 acre-feet to communities within the region that currently are depending on diminishing groundwater supplies, although the necessary water conveyance and treatment facilities have not yet been constructed. Additional conservation storage on the Canadian River is restricted by the Canadian River Compact.

The Dry Cimarron River has no major storage facilities and supplies irrigation water through direct diversion. If adequate storage were available, an estimated additional annual yield of about 6,000 acre-feet could be developed from this stream. Additional new supplies from the Dry Cimarron or other streams in the region would be limited to the conservation stor-age of flood waters.

Water Supply – Groundwater

The principal sources of groundwater in the region are the High Plains Aquifer along the Texas border, the Entrada Aquifer near Tucumcari, and alluvial groundwater along the Pecos and other major river valleys. The principal groundwater resource areas in the region for which extensive monitoring data are available are shown in Figure 2. These areas were identified for depletion evaluations in the North-eastern New Mexico Regional Water Plan and are lettered A through L. These areas are briefly described as follows.

- Area A. High Plains Aquifer in Union County southeast of Clayton
- Area B. High Plains Aquifer in Union County east of Stead
- Area C. High Plains Aquifer in Union County southeast of Amistad

Overview of the Hydrology of Northeastern New Mexico

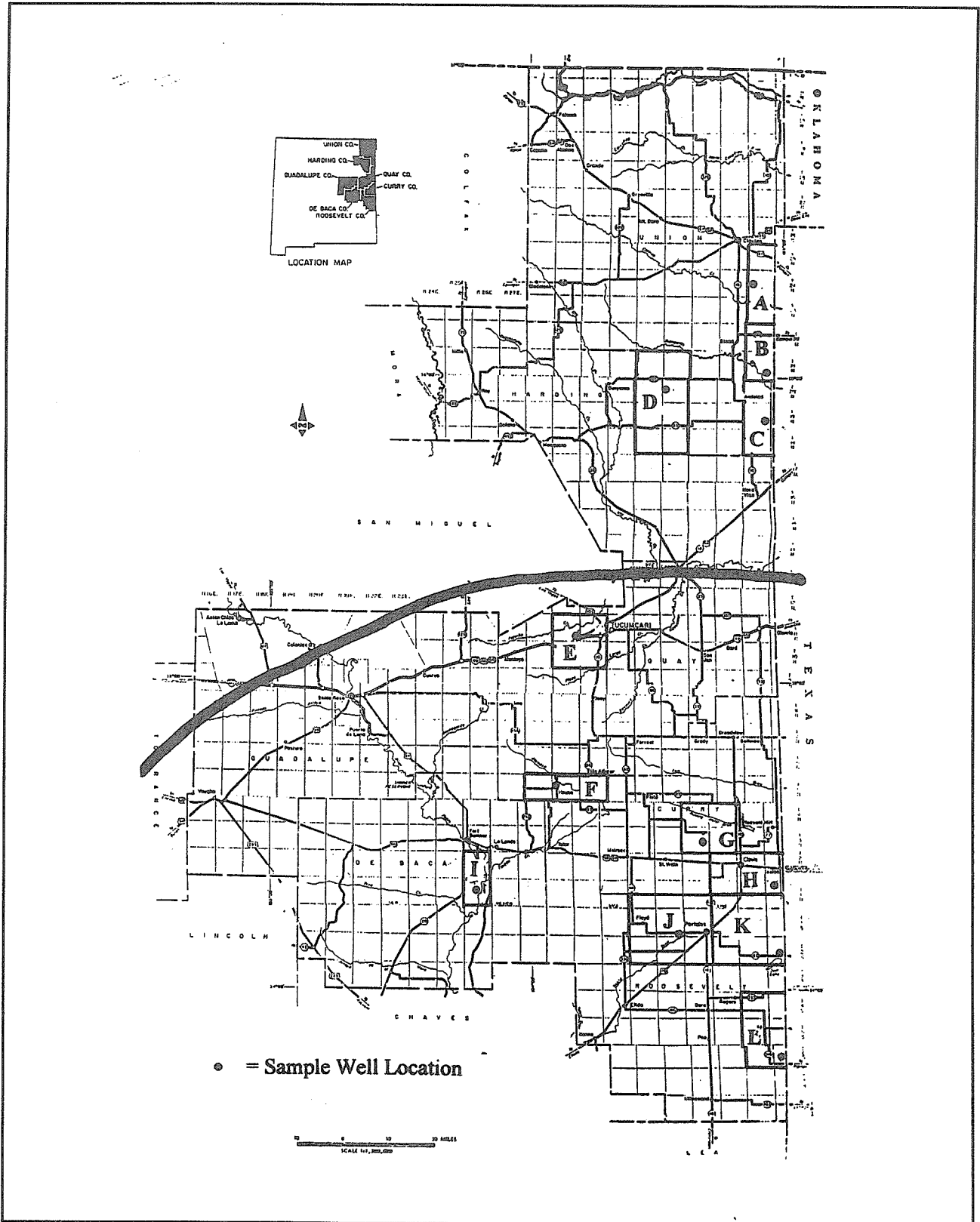


Figure 2. Principal groundwater resource areas in northeastern New Mexico (modified from Eastern Plains Council of Governments 1997).

- Area D. High Plains Aquifer in the Rosebud area of Harding County
- Area E. Entrada Aquifer in Quay County west of Tucumcari
- Area F. High Plains Aquifer in House area of Quay County
- Area G. High Plains Aquifer in Curry County northwest of Clovis
- Area H. High Plains Aquifer in Curry County southeast of Clovis
- Area I. Pecos River Alluvial Aquifer in De Baca County south of Fort Sumner
- Area J. High Plains Aquifer in Roosevelt County west of Portales
- Area K. High Plains Aquifer in Roosevelt County east of Portales
- Area L. High Plains Aquifer in Causey-Lingo area of Roosevelt County

The High Plains Aquifer is a national resource of high-quality water extending from South Dakota to New Mexico and Texas. The New Mexico portion is present in two subregions as shown in Figure 3: a southern subregion in Quay, Curry, Roosevelt, and Lea counties, and a northern subregion in Union, Harding, and Quay counties. The importance of the High Plains Aquifer is evidenced by its identification as the major groundwater source in ten of the twelve principal groundwater resource areas in the Northeastern New Mexico Regional Water Plan. The geologic formations that form the principal aquifers are described in Groundwater Reports and Hydrologic Reports published for selected counties by the New Mexico Bureau of Mines and Mineral Resources. Within the northeastern New Mexico region, such reports have been published for Union County (Cooper and Davis 1967), Quay County (Berkstresser and Mourant 1966), San Miguel County (Griggs and Hendrickson 1951), De Baca County (Mourant and Shomaker 1970), and Guadalupe County (Dinwiddie and Clebsch 1973). General information on regional geology can be found in the New Mexico Highway Geologic Map published by the New Mexico Geological Society (1996).

Although the Tertiary Ogallala Formation provides the principal source of water in the High Plains Aquifer, in the northern subregion water of adequate quality for many uses also can be obtained from

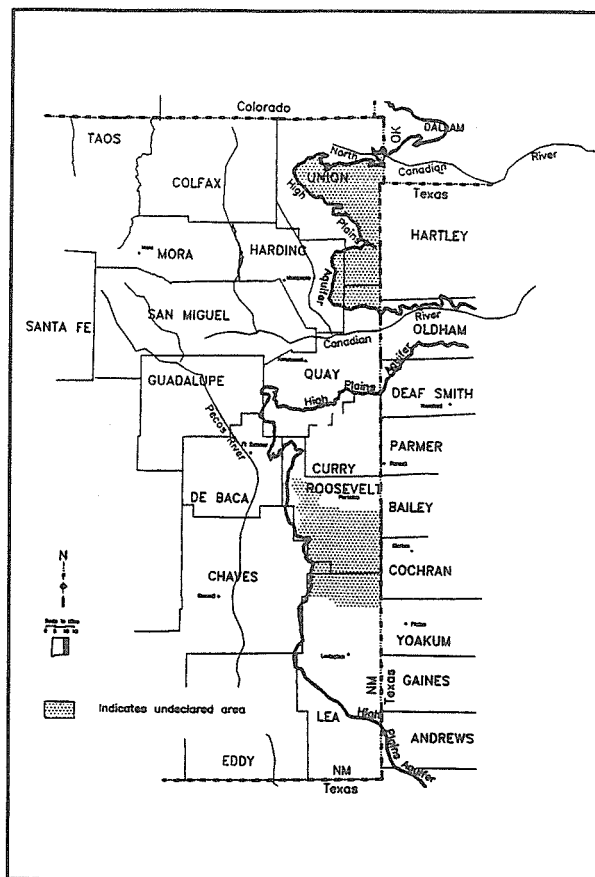


Figure 3. Extent of the High Plains Aquifer in New Mexico (modified from Chudnoff and Logan 1995, Figure 7).

deeper formations including the Cretaceous Dakota and Purgatoric sandstones, the Jurassic Entrada Sandstone, and the Triassic Santa Rosa Sandstone. South of a zone roughly delineated by a dark band on Figure 2, the deeper sandstones thin out and the older underlying Permian sediments become increasingly thicker and more saline. This makes the deeper groundwater increasingly brackish and unusable. To the north, the Ogallala Formation is hydrologically continuous with the Cretaceous aquifers, but to the south the Cretaceous and Jurassic aquifers are not present and the Ogallala lies directly on the former erosion surface of the Triassic redbeds of the Chinle and Redonda formations. These redbeds form a low permeability base for the Ogallala and also separate the high quality Ogallala water from the potentially plentiful but saline deeper water.

Outside the High Plains Aquifer, groundwater is locally obtained from many formations but in generally lower yields and of varying quality. The

Jurassic Entrada Aquifer near Tatumcari has a potentially large volume of water in storage but may require treatment for some uses. Groundwater is pumped from the Permian San Andres Limestone to supply the City of Santa Rosa, however this pumping occurs north of the zone where the Permian formations become unacceptably saline. Alluvial groundwater along the Pecos River also is potentially plentiful but south of the Santa Rosa area it is often of inadequate quality for many uses due to natural saline water inflows. In addition, pumping of alluvial groundwater is restricted to minimize depletion of the Pecos River. Groundwater supplies also are successfully obtained in many other locations in the region, such as from basalt aquifers in the Capulin area and alluvium along the Canadian and Dry Cimarron rivers. However, most of these supplies are limited in volume and of seasonally varying quality.

Water Use and Management

Most of the surface and groundwater resources in the region are used to support irrigated agriculture. Pecos and Canadian River water is allocated under state law and interstate compact, and as previously stated, new consumptive uses could only be met by purchasing existing senior water rights or through aggressive conservation efforts. Groundwater is regulated under state law within declared groundwater basins. A map showing the locations of declared groundwater basins within New Mexico as of June 1994 is presented in Figure 4. Permits must be obtained from the State Engineer Office to pump groundwater within declared basins. The largest undeclared areas in the state, where groundwater pumping currently is not regulated, are in northeastern New Mexico. The principal regulated basins in the region are the High Plains Aquifer in Curry and Roosevelt counties and the Entrada Aquifer at Tatumcari. Although groundwater is being pumped from the High Plains Aquifer at a much faster rate than it is being recharged, its use is recognized to be of significant regional economic importance and the state's management policy has been to continue to allow groundwater mining in Curry and Roosevelt counties. When the aquifer thickness becomes too small to support irrigated agriculture, the area is expected to return to dryland farming or revert to pasture land. At that time a much reduced water

demand limited to satisfying primarily municipal and industrial needs is expected to be met by a combination of surface water importation from Ute Reservoir and groundwater pumping at locations where groundwater is still available. Local initiative will be required, however, to construct the necessary surface water conveyance facilities and to locate and tap the remaining sources of groundwater.

Current Conditions

Surface water, although not available in large quantities within the region, is considered to be a renewable resource. Groundwater, except where locally recharged by abundant surface water sources such as in river valleys, is not generally considered to be a renewable resource because of insufficient direct rainfall. In preparing the Northeastern New Mexico Regional Water Plan, the average changes in groundwater levels over time were determined for example wells in each of the twelve principal groundwater resource areas shown in Figure 2. The example wells were selected to be representative of the overall groundwater level changes in the areas and their locations are shown as large dots on the figure. Example results for three of these areas are shown in Figure 5. Results for all groundwater pumping areas are presented on Table 1 and discussed in summary below. Example well hydrographs for all areas may be found in the Northeastern New Mexico Regional Water Plan.

Figure 5 shows example groundwater hydrographs for three areas in Roosevelt County. These areas illustrate the extremes of groundwater level changes in the region. Area J west of Portales illustrates the stabilization of groundwater levels in an area where the saturated thickness has decreased under heavy pumping in the 1950s and 1960s to the point that some wells were put out of production. With a reduced demand on the aquifer, groundwater is flowing back into old pumping troughs and small rises in water levels are seen. However, because of the small recharge, the water level rises do not reflect the addition of new water but primarily a redistribution of existing water.

Area K east of Portales illustrates the continued rapid decline in groundwater level in an area where the saturated thickness of the aquifer remains great enough to support large-scale pumping. The rate of

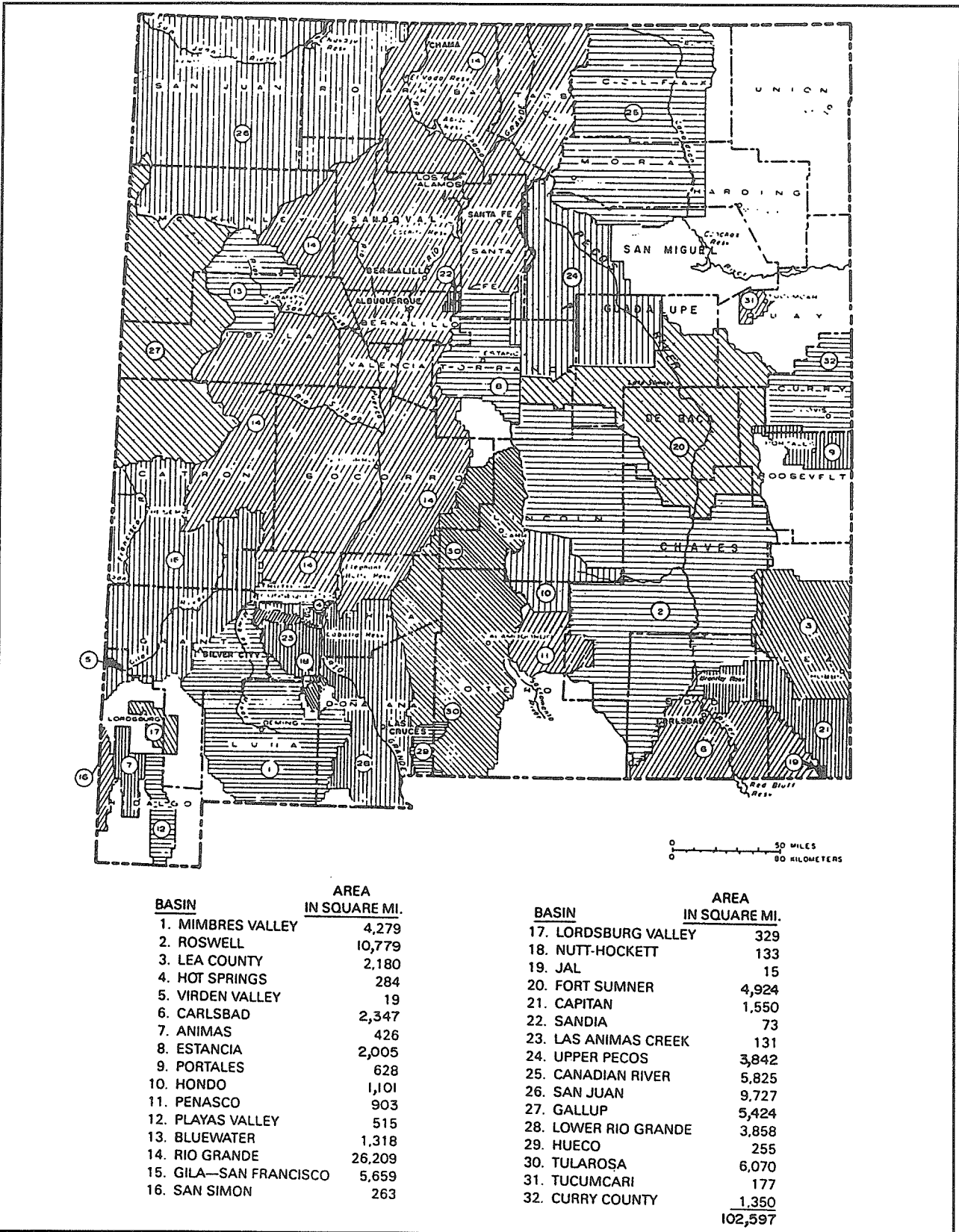


Figure 4. Declared groundwater basins in New Mexico as of June 1994 (NM State Engineer Office 1994, Figure 3).

Overview of the Hydrology of Northeastern New Mexico

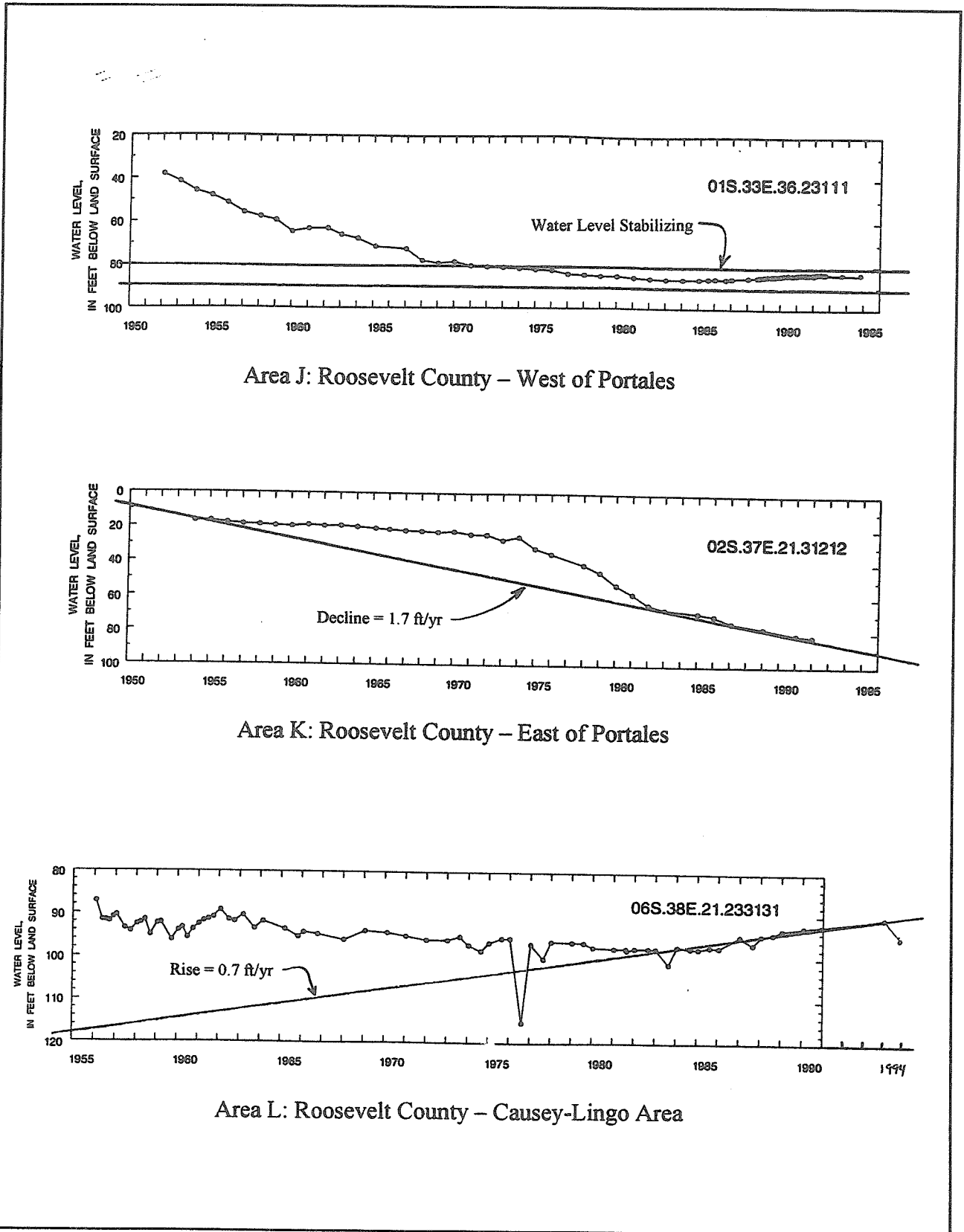


Figure 5. Hydrographs of example wells in areas J, K and L of Roosevelt County (modified from Wilkins and Garcia 1995).

Table 1. Long Term Average Changes in Groundwater Levels

<u>Area</u>	<u>Location</u>	<u>Average Water Level Change (feet/year)</u>	<u>Average Remaining Lifetime (years)</u>
A	Union County southeast of Clayton	-0.6 (1970-1994)	--
B	Union County east of Stead	-1.6 (1980-1990)	40*
C	Union County southeast of Amistad	-0.3 (1980-1994)	--
D	Harding County – Rosebud area	-0.2 (1970-1991)	--
E	Quay County west of Tucumcari	-0.3 (1988-1993)	--
F	Quay County – House area	+0.0 (1952-1992)	--
G	Curry County northwest of Clovis	-0.4 (1982-1994)	--
H	Curry County southeast of Clovis	-2.4 (1954-1992)	33
I	De Baca County south of Fort Sumner	-0.2 (1980-1990)	--
J	Roosevelt County west of Portales	+0.0 (1970-1994)	--
K	Roosevelt County east of Portales	-1.7 (1981-1991)	35
L	Roosevelt County – Causey-Lingo area	+0.7 (1984-1994)	--

* Estimate very approximate due to lack of current data.

groundwater level decline over the 10-year period from 1982 to 1992 was a fairly consistent 1.7 feet per year. This is a rapid rate where the remaining saturated thickness may average only about 60 feet, indicating that the average remaining lifetime of wells in this area may be only a few decades.

Area L in the Causey-Lingo area of southern Roosevelt County illustrates a long, slow water level decline followed by a long, slow rise. The current rate of water level rise was the greatest of any of the areas evaluated. This is an area where the saturated thickness is less than normal and groundwater use is less extensive.

In summary, the following results were found for the remaining areas. Areas A, B, and C on Figure 2, in Union County, showed continuing long-term declines similar to Area K, but only Area B, with a decline of 1.6 feet per year, is of near-term concern. Areas A and C showed average declines of 0.6 and 0.3 foot per year, respectively. Aquifers in areas with consistent declines of less than 1 foot per year are being depleted but the water supply is not expected to be threatened within a 40-year planning horizon. The example well in Area D in Harding County has declined at a consistent rate of 0.2 foot per year since 1970; however, this rate is very low and is not considered significant. Despite a decline of 0.3 foot per year since 1987, Area E west of Tucumcari shows little longer-term fluctuation and has remained essentially stable since 1943. In Area F, water levels in the

High Plains Aquifer near House have been relatively stable since 1952. Area G northwest of Clovis shows a low but steady decline of about 0.4 foot per year since 1970. Area H southeast of Clovis shows a remarkably consistent decline of 2.4 feet per year since 1954. This is the highest and longest-term rate of decline of any of the areas studied. Area I in De Baca County south of Fort Sumner shows an average decline of only 0.2 foot per year, which is not considered significant.

The Future

The value of renewable surface water resources is expected to grow as groundwater resources are depleted. Rates of groundwater level decline in three of the principal groundwater resource areas in the region exceeded 1 foot per year. These were Area B in Union County east of Stead, Area H in Curry County southeast of Clovis, and Area K in Roosevelt County east of Portales. The average remaining aquifer lifetime in each of these areas was estimated by dividing the average remaining saturated thickness by the long-term average annual water-level change. These lifetimes ranged from 33 years in Curry County to about 40 years in Union County, and represent the time it will take for wells in roughly half of each of these study areas to dry up at the current rate of depletion. Wells in the deeper parts of the aquifer will last longer, and wells in the shallower parts will

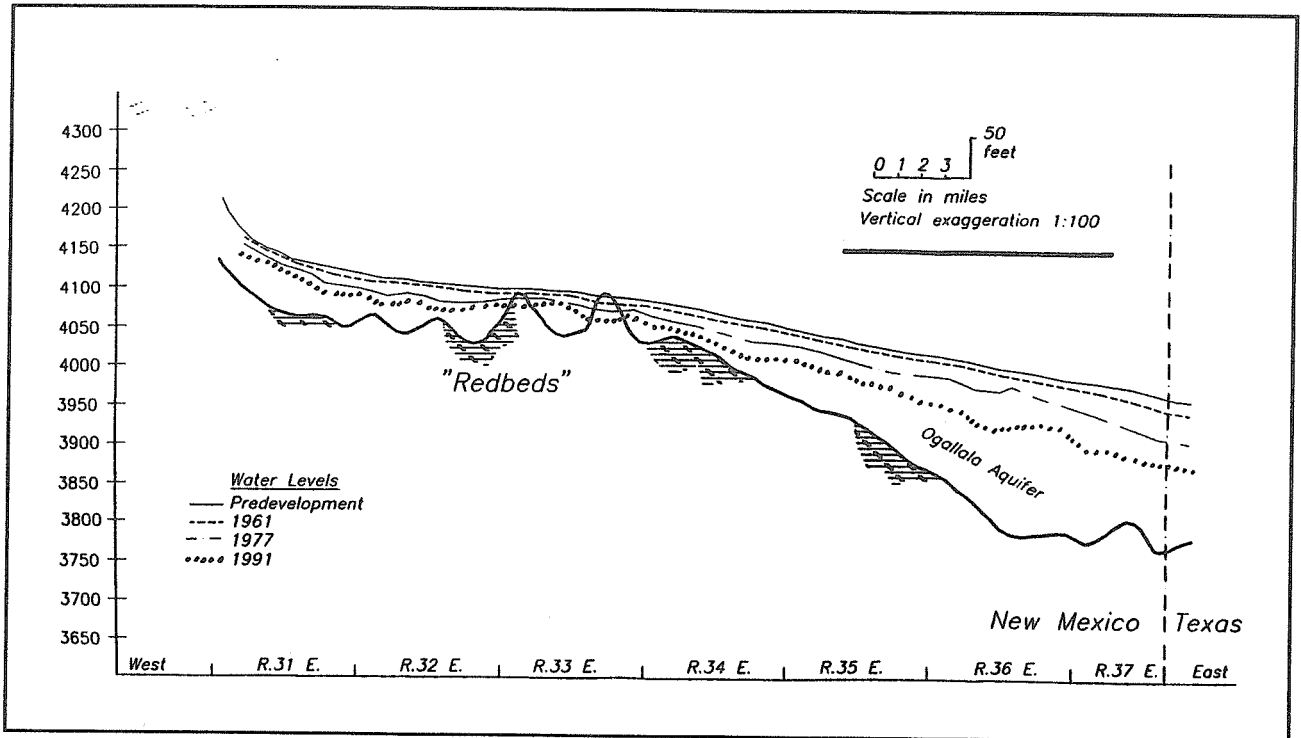


Figure 6. East-west water table profile along the Curry-Roosevelt county line (modified from Chudnoff and Logan 1995, Figure 3).

dry up sooner. An illustration of this is presented in Figure 6, which shows the progressive decline of groundwater in the Ogallala Formation since “pre-development” times (before 1950). For clarity, the vertical scale has been exaggerated 100 times. The redbeds forming the bottom of the aquifer are not smooth but have topographic relief. As the water level declines, the area of the redbeds above the water table increases, and wells in those areas dry up. Even if wells are deepened into the redbeds, the permeability is very low and the well yields will be similarly low. For most practical purposes, the redbeds are the bottom of the aquifer.

In general, the use of groundwater outside the High Plains Aquifer is limited, and poses no immediate threat at the current level of use. However, inside the High Plains Aquifer groundwater is considered a mined resource that will eventually be depleted in most of the area. It will become a limited supply, localized to the deeper parts of the aquifer, and wells in many locations where the aquifer is thinner will dry up.

What are the options? It is likely that most of the area will return to dryland farming or revert to pasture land because fewer and fewer wells will be

capable of economically yielding the quantity of water required for large-scale irrigation. Enhancing water conservation will prolong the supply but not halt the trend unless consumptive use is drastically cut. Cloud seeding is a potentially viable approach to enhancing groundwater conservation and should be evaluated as a means of reducing agricultural demand and increasing recharge. A pilot cloud seeding project was initiated over part of the area by Soil and Water Conservation Districts in New Mexico during the summer of 1997 in cooperation with the High Plains Undergroundwater District No. 1 based in Lubbock, Texas. A multiyear program will be needed to evaluate the success of this project.

In areas where large-scale agricultural pumping declines, a relatively thin saturated zone is expected to persist in the locally deeper parts of the aquifer for many years and will remain available for small-scale use. However, larger-scale municipal, industrial, and agricultural uses will require relatively large numbers of low-yield wells to recover this water effectively, significantly increasing current water costs. In addition, reliance on groundwater will become increasingly risky because the details of the subsurface topography are not precisely known. Relatively large

quantities of saline water are potentially present in the deeper Permian formations, however treatment of that water for use would be expensive.

Importing renewable surface water from the Canadian River for municipal and industrial use in the region's larger communities has been shown to be feasible but action must be taken soon to secure that supply and construct the conveyance and treatment facilities before the options to acquire that water expire in 2007. The most urgent water supply needs are expected to be in the communities in the southern High Plains Aquifer subregion where depletion rates are high and viable alternatives are limited. A groundwater model of this subregion is being developed by the State Engineer Office as a management tool. It is recognized that any alternative to aquifer depletion will be costly and involve risks. This model can be used to help local community leaders evaluate their options and determine the best course of action for the future.

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