Aquifers and Ground-Water Availability within the Reserve

An aquifer is any geologic unit that has the capability of storing water and yielding usable amounts of the stored water to wells (Lohman and others, 1972). The capability of various rock units to store and deliver water to wells varies widely. The term "aquifer" is related to the amount of water or yield needed to satisfy the requirement of the intended use of the water. For instance, a geologic formation that has the capability of delivering limited amounts of water, but enough to satisfy the water requirements of single households or livestock, is considered an aquifer for that purpose. If, however, the intended use of water from the same geologic unit required more water than the unit is capable of delivering, this same unit is not considered an aquifer for that purpose.

Permian rocks in the vicinity of the Concho Reserve yield limited amounts of water to wells (Mogg, Schoff, and Reed, 1960, p. 23–38). Water from these rocks may be highly mineralized. The principal use of ground water from Permian rocks is for livestock and for a few farmsteads north of the Reserve. Available data show little or no probability of developing wells in Permian rocks that will yield sufficient water of suitable quality for the Concho Reserve public water supply.

Terrace deposits along the upland drainage divide between the Cimarron River and the North Canadian River in Canadian County contain water of the best quality within the county (Mogg, Schoff, and Reed, 1960, p. 39–41). Terrace deposits are a minor aquifer in areas where well yields are sufficient to meet the requirements of farmsteads. Terrace deposits within the Concho Reserve are too limited in extent and too thin to store sufficient quantities of water for dependable yields to wells.

Alluvial deposits along the North Canadian River are the major source of ground water in Canadian County (Mogg, Schoff, and Reed, 1960, p. 41–45). The alluvium provides most of the municipal, industrial, and irrigation water for the area. Well yields of 100 to 300 gallons per minute are common and some wells have been developed with yields of more than 500 gallons per minute. Water from the alluvium is hard. Minerals in solution are deposited on well screens and may be deposited in the pore spaces of sediments, resulting in deterioration of wells. Selected data for wells and test holes within and surrounding the study area are listed in table 1; well locations are shown on map A.

Characteristics of the Alluvial Aquifer

Alluvium of the North Canadian River is the principal aquifer within the Concho Reserve. The alluvium extends along a half-mile-wide strip 2 miles long within the southern part of the Reserve and is the present source of water for the Reserve.

The average thickness of the alluvium in an area extending from near U.S. Highway 81 west to near the Darlington State Game Bird Hatchery is from 45 to 38 feet (Mogg, Schoff, and Reed, 1960). Alluvial deposits are about 45 feet thick within the present Concho Reserve well field located near the western edge of the Reserve.

The water table generally is the upper surface of the zone of saturation. When recharge exceeds discharge, the water table rises. Conversely, when discharge exceeds recharge the water table lowers. According to Mogg, Schoff, and Reed (1960), the saturated thickness of alluvium along the southern boundary of the Reserve averaged about 33 feet. The water table within the present Concho Reserve well field has been observed at land surface during extremely wet periods. Occasionally, surface runoff ponds within the well-head area following intense rainfall. In May 1992, the saturated thickness of the alluvial aquifer penetrated by well 13N-07W-19 BBC 1 within the Concho well field was 36 feet.

Lines of equal elevation of the water table within the alluvial aquifer reported by Mogg, Schoff and Reed, (1960) are shown on map B. Ground-water movement is perpendicular to these contour lines in a downstream (east-southeasterly) direction. The water-table contours indicate that ground-water movement ranges from almost parallel to slightly towards the North Canadian River. An exception occurs during periods of high streamflow, when infiltration from the stream recharges the alluvium. A slight downstream bowing of the contours near the alluvium-terrace contact indicates the probability of some recharge into the alluvium from the terrace or red-bed boundary. The water-table slope of the alluvial aquifer within the Concho Reserve is about 5 feet per mile.

The potential of this aquifer to receive, store, and transmit water to pumping wells has been evaluated by specific-capacity measurements and aquifer tests (Mogg, Schoff, and Reed, 1960). In addition to these well tests, test-hole core samples were analyzed to determine the distribution and range of potential permeability in the alluvium. These data, when combined with the knowledge of local climate and the ability of the aquifer to receive and store water, can be used to make an appraisal of the well-yield capabilities of the aquifer.

Maximum yields from wells of identical construction and depth may vary from well to well because of variability in the physical characteristics of the alluvial deposits. Therefore, well-yield data from a single well may not be indicative of potential well yields for all locations. However, aquifer tests and pumping tests at a variety of sites may provide information on the range of well yields to be expected.

Data obtained from aquifer tests of wells located near the Concho Reserve were published by Mogg, Schoff, and Reed (1960). Wells used for the aquifer tests were located in 13N-07W-33, about 1 mile southeast of the Reserve boundary and in 13N-08W-24, about 3/4 mile southwest of the current Concho well field. Data from these tests, and specific capacity data and core-sample analyses from many small test holes drilled through the alluvium to the top of the underlying red beds were used to obtain average aquifer characteristics applicable to the alluvial deposits along the southern edge of the Concho Reserve. These characteristics are:

Aquifer characteristics	Average value
[Data from Mogg, Schoff, and Reed (1960)]	
Specific yield[1]	0.15
Hydraulic conductivity[2]	134 feet per day
Safe yield	270 acre-feet per year per square mile

[1] Equivalent to coefficient of storage used by Mogg, Schoff, and Reed (1960).
[2] Equivalent to coefficient of permeability expressed in gallons per day per square foot used by Mogg, Schoff, and Reed (1960).

Water Quality

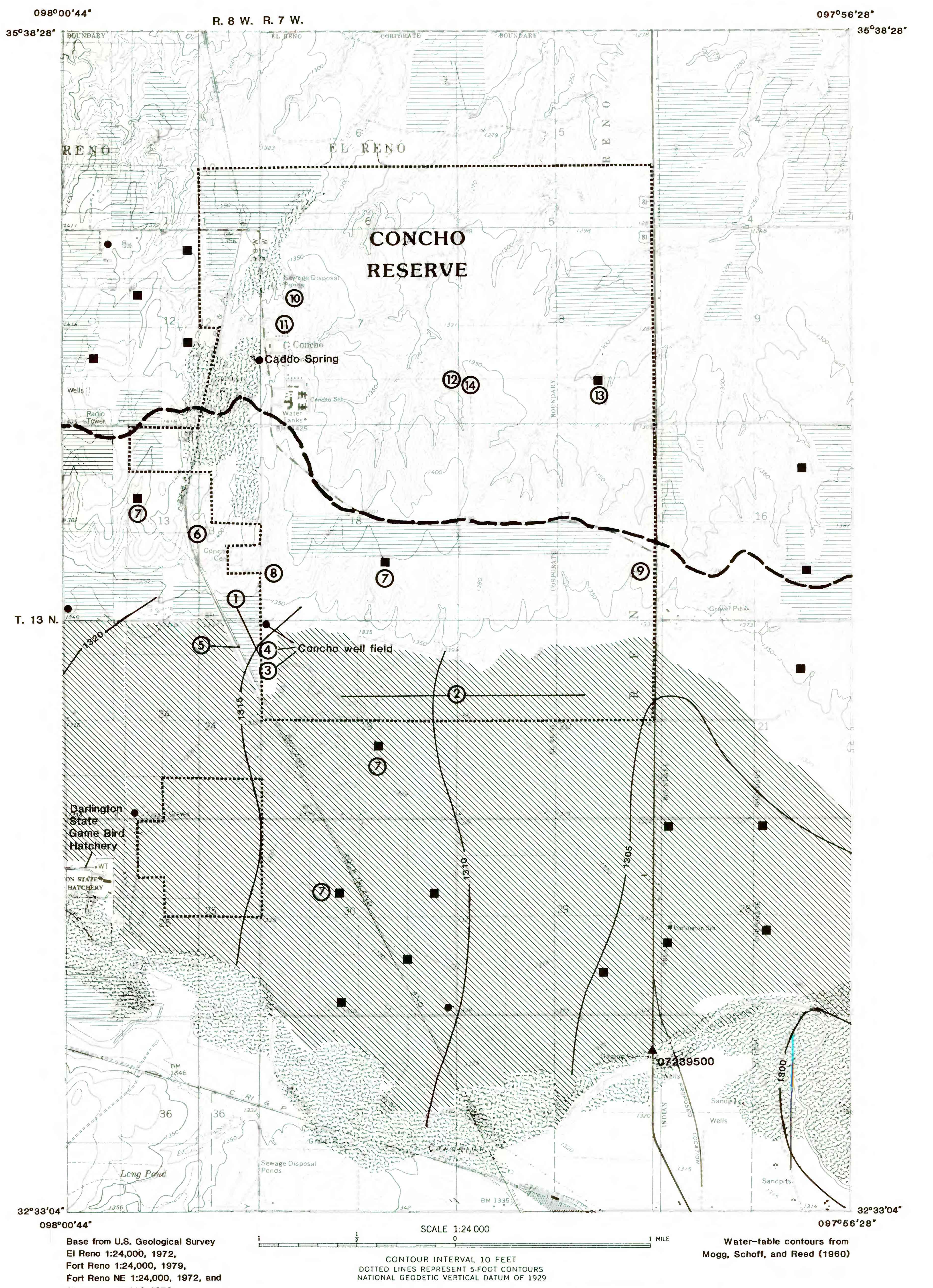
Ground-water quality within an aquifer is directly related to the type and quantity of minerals and gasses contained within the aquifer and within surrounding rocks that recharge the aquifer. Most recharge to ground water in the alluvium is from precipitation and infiltration of streamflow from the river. The quality of ground water in the alluvium is similar to the quality of water in the North Canadian River. Ground water in the alluvium is generally a hard to very hard calcium magnesium bicarbonate type. Total dissolved solids are generally less than 1,000 milligrams per liter. Ground water within the terrace has about one-third the hardness of that within the alluvium. Recharge to the terrace is from precipitation. Ground-water-quality analyses from files of the U.S. Geological Survey for the area within and near the Concho Reserve are shown in table 2. Sampled well locations are shown on map B.

AQUIFER VULNERABILITY

Ground water within the Concho Reserve is vulnerable to contamination because of the large permeability of the aquifer. The permeable alluvial and terrace deposits in and surrounding the Concho Reserve area readily accept and transport pollutants. Various pollutants can be introduced from industrial, agricultural, and domestic sources in the recharge area that make the water unsuitable for many uses. Sampling and analysis of the current ground-water quality within and adjacent to the Concho Reserve was not within the scope of this study.

Water-supply wells for the Concho Reserve are shown on map A and in table 1 as site numbers 5, 6, and 7. Water samples colleced by the Oklahoma State Health Department from two of these public water-supply wells within the Concho Reserve well field were analyzed for 56 volatile organic carbon compounds (VOC) on January 14 and February 18, 1992. Analyses were performed by the Oklahoma State Environmental Laboratory of the Oklahoma State Health Department in accordance with U.S.Environmental Protection Agency method 502.2 (U.S. Environmental Protection Agency, 1988). This method was used to analyze for the presence of VOC compounds with detection limits of 0.5 microgram per liter (µg/L) or greater. No VOC were detected. Below is a a listing of compounds included in the analyses.

Benzene	1,1,1,2-Tetrachloroethane
Bromobenzene	1,1,2,2-Tetrachloroethane
Bromoform	1,1,1-Trichcloroethane
Chlorobenzene	1,1,2-Trichcloroethane
1,2-Dichlorobenzene	C-1,2-Dichloroethene 1,3-
Dichlorobenzene	1,1-Dichloroethene
1,4-Dichlorobenzene	Tetrachloroethylene
Ethyl benzene	Trichloroethene
N-Butylbenzene	Dichlorodibromomethane
N-Propylbenzene	Dichlorodifluoromethane
Isopropylbenzene	Trichlorofluoromethane
SEC-Butylbenzene	Napthalene
T-Butylbenzene	1,2-Dibromo-3-chloropropane
1,2,3-Trichlorobenzene	1,2-Dichloropropane
1,2,4-Trichlorobenzene	1,3-Dichloropropane
1,2,4-Trimethylbenzene	2,2-Dichloropropane
1,3,5-Trimethylbenzene	1,2,3-Trichloropropane
Methyl bromide	1,1-Dichloropropene
Hexachlorobutadiene	C-1,3-Dichloropropene
Carbontetrachloride	Dichloropropene
Chloroethane	T-1,3-Dichloropropene
Chloroform	Styrene
Methyl chloride Toluene	
Methylene chloride	P-Isopropyltoluene
1,2-Dibromoethane	Vinyl chloride
1,1-Dichloroethane	Xylene
1,2-Dichlorethane	M & P Xylene
1,2-Dichlorethene, (TRN)	O-xylene



Map B.—General land use and locations of potential sources of ground-water contamination within the Concho Reserve.

EXPLANATION

NATURAL GRASSLANDS AND IMPROVED PASTURES

NON-IRRIGATED CROPLAND

IRRIGATED CROPLAND

TREES AND BRUSH

BOUNDARY OF THE CONCHO RESERVE

DRAINAGE DIVIDE—Separates North Canadian and Cimarron River drainage areas

1310 CONTOUR LINE—Showing altitude of the water table in the alluvium (Mogg, Schoff, and Reed, 1960)

5 LOCATION OF POTENTIAL SOURCES OF GROUND-WATER POLLUTION—Number corresponds to site number in table 3

SPRING

OIL AND GAS WELL

▲07239500 STREAM-GAGING STATION—Number is station identification number

Table 2.—*Selected chemical analyses of ground water for selected wells within and near the Concho Reserve*
[µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; deg. C, degrees Celcius]

Site identification number	Local number	Date	Specific conductance (µS/cm)	Hardness, total (mg/L as $CaCO_3$)	Alkalinity[1] (mg/L $CaCO_3$)	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Solids, residue at 180 deg. C, dissolved (mg/L)
353358097583801	13N-07W-30 DDD 1	07-28-80	2,700	700	550	140	84	870	200	1.2	2,180
353452098002201	13N-08W-24 CDC 2	07-04-58	1,640	690	404	170	65	330	120	.8	1,120
353527097591901	13N-07W-19 BBB 1	04-16-43	865	430	264	110	36	200	15	.7	565
353545098003501	13N-08W-13 CCC 1	04-16-43	222	85	54	22	7.2	19	5.0	.4	130
353714098003401	13N-08W-12 BBA 1	02-20-54	339	110	41	29	8.5	29	12	.3	251

[1] Alkalinity collected as a whole water, fixed end point titration.

Table 3.—*Sources of potential contamination to ground water within the Cheyenne-Arapaho Reserve*

Map number	Description	Remarks
1	Paved road and road cut	Conveys surface runoff, which may contain material from accidental transportation spills, animal remains or animal matter, and roadside dumping, directly into the well-head area where it ponds until infiltrated or evaporated.
2	Agricultural land	Most of the alluvium is irrigated agricultural land where pesticides, herbicides, and fertilizers are applied. Some cropland is located within 100 feet of the Concho well field.
3	Present water-supply wells	Located in low area where the water table is at ground level during wet periods. Well heads may be inundated by surface runoff that ponds in well field at times.
4	Abandoned and unplugged wells in present well field and at nearby unused hydroponics installation	Provides open conveyance into the aquifer.
5	Railroad	Possibility of accidental spills and herbicide use along right-of-way within the recharge area of the Concho Reserve well field.
6	A horse boarding corral and septic tanks from about 20 homes	Possibility of bacteria and nutrient introduction into the terrace and to surface runoff that drains into the recharge area of the Concho Reserve well field.
7	Oil and gas wells and storage tanks	Possibility of surface spill or structural failure contaminating aquifer recharge areas.
8	Stock pond in pasture	Discharges seepage and runoff containing animal waste onto alluvium at well field.
9	Small sewage lagoon serving smoke shop	Possibility of bacteria and nutrient introduction into the terrace.
10*	Concho sewage lagoon	Possibility of bacteria and nutrient introduction on the red beds and into streamflow of a tributary to the Cimarron River.
11*	Mechanical repair shops	Possibility of contaminating terrace with petroleum waste products: gasoline, solvents, and other hydrocarbons.
12*	Hog farm building and pen area with small waste lagoon	Possibility of bacteria and nutrient introduction on red beds and into a tributary of the Cimarron River by surface runoff.
13*	Oil and gas well with storage tanks	Possibility of surface spills on red beds and into a tributary of the Cimarron River.
14*	Grain storage bins	Possibility of introducing fumigant and insect-control material into ground water.

* Locations within the Concho Reserve that do not present a threat of ground-water contamination south of the Cimarron-North Canadian River divide.

SOURCES OF CONTAMINATION

Identification and evaluation of potential sources of ground-water contamination is necessary for proper land use, land management, and zoning in areas of ground-water recharge and in areas of existing and future well sites. Currently, application of methyl parathion by aerial spraying and Glean are the predominate pesticides, and ammonium nitrate is the principal fertilizer applied in the agricultural areas of the alluvium (Fred Escott, Escott Aerial Spraying Inc., El Reno, Okla., personal commun., 1992). In at least two instances, fecal coliform bacteria were detected in water samples from the Concho Reserve well field (Oklahoma State Health Department State Environmental laboratory, written communs., 1989 and 1990). The source of contamination was not identified, but the presence of coliform bacteria is indicative of contamination occurring from and near land surface. Potential sources of ground-water contamination have been identified within and adjacent to the Concho Reserve. Several of these sources are not within the ground-water recharge area of the present well field and none are documented as actual sources of ground-water pollution. Potential sources of ground-water contamination are identified in table 3. Locations of potential sources of ground-water contamination are shown on map B.

SUMMARY

The location of the present Concho Reserve water-supply wells makes the well-head recharge area vulnerable to several potential sources of contamination. Contaminants carried by ponded surface runoff in the well-head area are the principal danger. Some analyses of ground water from the water-supply wells in past years contained fecal coliform bacteria, an indication of pollution from or near the land surface. The degradation of ground-water quality from the Concho Reserve water-supply wells identified in this report has not been documented. Ground-water-quality analyses from the Concho Reserve water-supply wells would be required to determine if contaminants are present.

Relocation of the existing Concho Reserve water-supply wells is currently being considered by Reserve managers. The proposed location of the wells is about half a mile east of the present well field in an area that would not be subject to ponding of surface runoff around the well heads during wet periods. The proposed location would afford increased protection from catastrophic road or railroad spills. The proposed well relocation would place a greater part of the well-head recharge area within the Concho Reserve jurisdiction and simplify management of land-use practices within the recharge area.

The magnitude and extent of possible contamination of ground water from activities of man within Concho Reserve tribal lands has not been determined. The determination of current ground-water quality in wells at selected sites within the recharge area of the Tribe's water-supply wells would help identify the existence of contaminants at the wells and delineate potential contaminant plumes. Periodic water-quality monitoring at existing and future well locations would help maintain quality control over the public water supply.

DEFINITION OF TERMS

[From Meinzer, 1923, and Lohman and others, 1972]

Aquifer: A body of rock that is sufficiently permeable to conduct ground water and to yield economically significant quantities of water to wells and springs.

Contact spring: A gravity spring flowing from a lithologic contact where a more permeable rock overlies a less permeable rock.

Depression spring: A gravity spring flowing where the water table is intercepted by a steeply sloping land surface.

Drainage basin: The land area within a topographic divide from which surface runoff drains into a particular stream system.

Drainage divide: A boundary line along a topographic high that separates adjacent drainage basins.

Ephemeral spring: A spring that does not flow continually.

Hydraulic conductivity: The rate of flow in cubic feet per day through a cross section of one square foot under a unit hydraulic gradient, at the prevailing temperature.

Phreatophytes: Plants that obtain their water supply from the water table by means of a deep root system.

Safe yield: The amount ground water that can be withdrawn from an aquifer without exceeding recharge to the aquifer.

Saturated thickness: The saturated zone extending from the water table down to the base of an aquifer.

Specific capacity: An expression of the productivity of a well calculated by dividing the pumping rate of a well by the water-level drawdown.

Specific yield: A ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of rock or soil.

Water table: The water surface in an unconfined aquifer or confining bed at atmospheric pressure. The water table is determined by measuring standing water levels in non-pumping wells.

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*U.S. GOVERNMENT PRINTING OFFICE: 1993-759-826

LAND-USE AND GROUND-WATER DATA, CHEYENNE-ARAPAHO TRIBES, CONCHO RESERVE, CANADIAN COUNTY, OKLAHOMA

By
D.L. Bergman and M.E. Savoca

1993