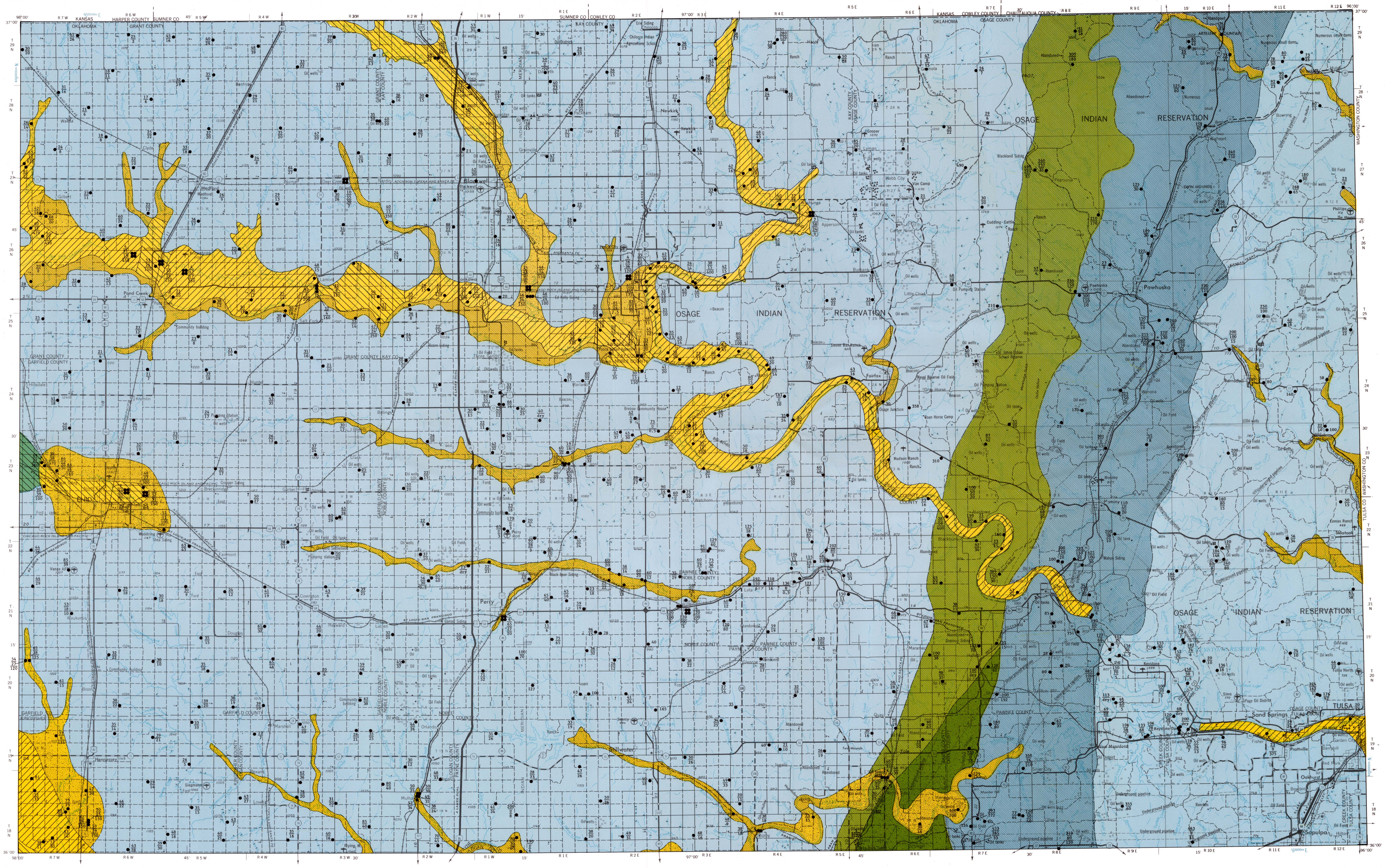

Figure 5. Map showing availability of ground water and pertinent data for drilled wells.

EXPLANATION

Principal Aquifers

Alluvial aquifer

Fine to coarse sand and gravel in alluvium. This area also includes the terrace deposits at Enid and some terrace deposits along the major streams. Saturated sand and gravel 1.5 to 60 feet (0.5 to 18 m) thick.

Cedar Hills aquifer

Fine-grained sandstone. Yields water for irrigation in an area a few miles west of the Enid quadrangle.

Ada aquifer

Fine-grained sandstone. Yields are highest in Creek County where the sandstone layers are thicker and more numerous.

Vamoosa aquifer

Fine- to coarse-grained sandstone. Yields are highest in Creek County where some of the sandstone layers are coarse grained.

Ada and Vamoosa aquifers combined

In this area, wells 700 to 750 feet (210 to 230 m) deep obtain water from both aquifers.

Minor aquifers

Includes shale, minor sandstone, thin alluvium and terrace deposits, and less productive areas of other aquifers.

Potential Well Yield, in Gallons per Minute (Liters per Second)

Note: Locally, an individual well in any area shown on the map might yield more or less water than indicated on the map.

300 to 600 (19 to 38)

150 to 300 (9.5 to 19)

50 to 150 (3.2 to 9.5)

25 to 50 (1.6 to 3.2)

0 to 25 (0 to 1.6)

Boundary for principal aquifer; dashed where approximately located.

$\frac{32}{\frac{8}{125}}$

Well

Upper number is depth of well below land surface, in feet; middle number is water level below land surface, in feet; lower number is yield of the well, in gallons per minute; < indicates well yield less than the amount shown; > indicates well yield greater than the amount shown; U = unknown. Where only two numbers are shown, they are well depth and depth to water; where only one number is shown it is well depth.

4 / 47 / 17 / 350

Well field

Upper number is number of wells in field; second number is average depth, in feet; third number is average water level below land surface, in feet; fourth number is average yield per well, in gallons per minute; U = unknown.

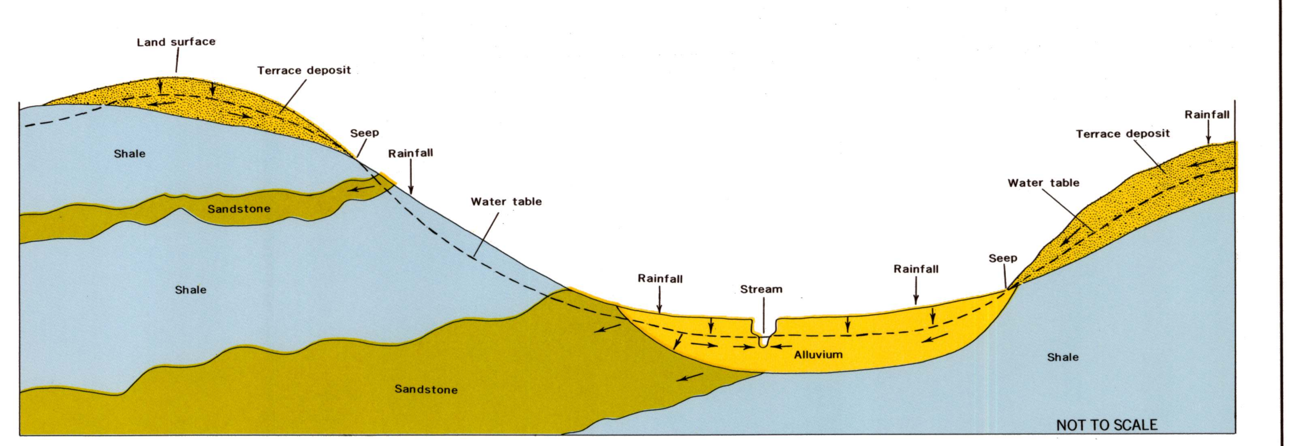

Figure 4. Diagrammatic section showing the occurrence and movement of ground water in the Enid quadrangle. Arrows indicate the general direction of water movement. Ground-water discharge points are seeps and streams.

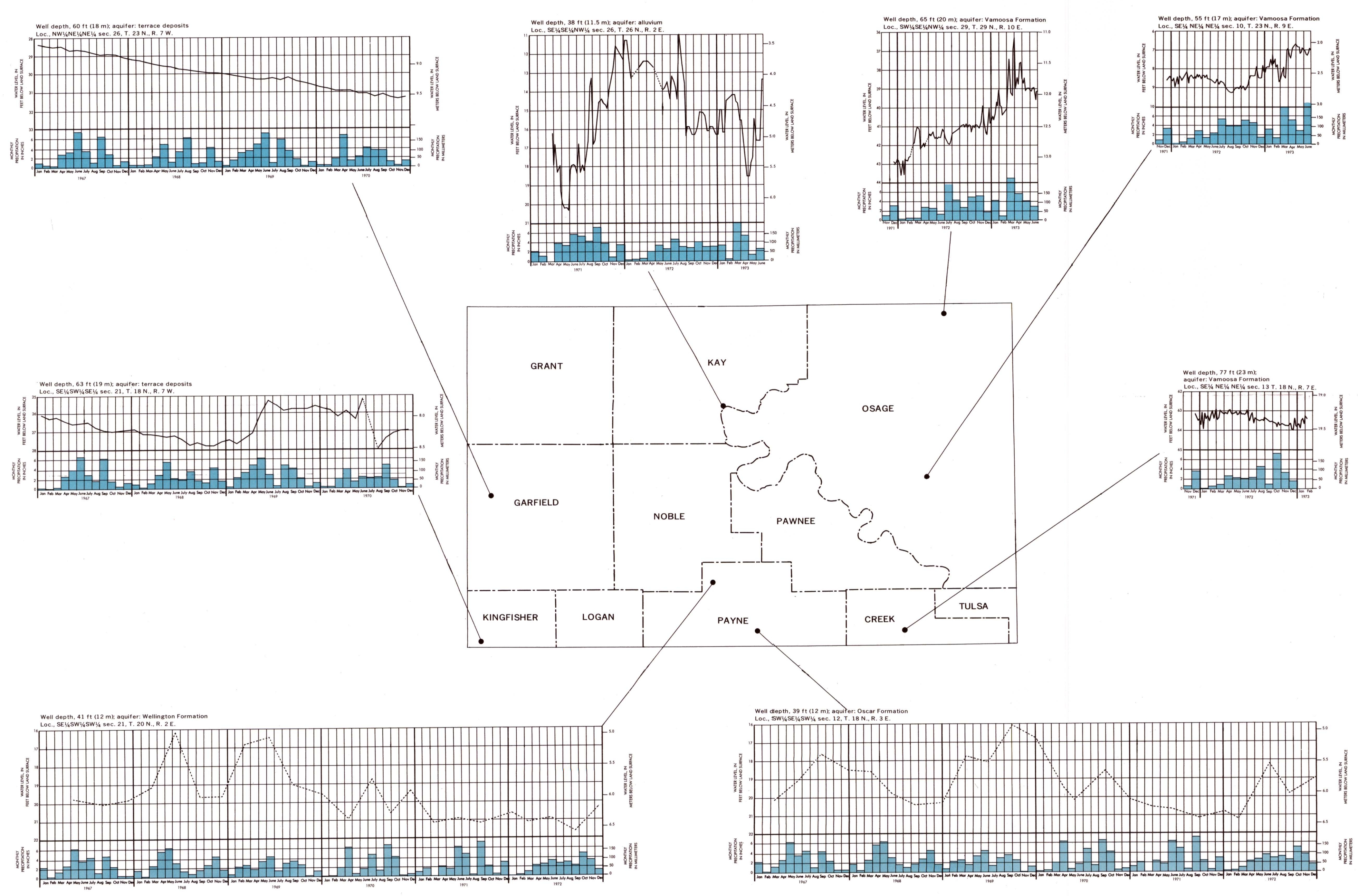

Figure 6. Hydrographs and precipitation data at selected sites.

GEOHYDROLOGIC SETTING

The occurrence of ground water in the Enid quadrangle is controlled primarily by climate; the movement of ground water is controlled primarily by geology. Climate, particularly the amount, frequency, and distribution of precipitation, determines the amount of water available for recharging of the various aquifers. Geology, particularly the physical characteristics, including composition of the rocks in the area, determines the amount of water that can be stored in the rocks and movement through the pores and cracks within. These factors allow the water to move from points of recharge to points of discharge (fig. 4).

Precipitation is the source of nearly all ground water in the Enid quadrangle. The average annual precipitation ranges from about 28 inches (700 mm) in the western part of the quadrangle to about 36 inches (900 mm) in the eastern part. Spring is the wettest season, receiving about 40 percent of the total precipitation, and winter is the driest season, receiving about 15 percent. Although winter is the driest season, most ground-water recharge occurs from November to April when evaporation and transpiration are at a minimum. Water entering the soil first replaces the soil moisture previously depleted by evaporation or transpired by plants. When water entering the soil is in excess of that needed to replace depleted soil moisture, the aquifers are recharged.

The amount of ground-water recharge in the Enid quadrangle has not been determined. However, Reed and others (1952, p. 28) estimated the amount of recharge to the Cimarron terrace in the southwest corner of the area to be 14.5 percent of the average annual precipitation. That estimate, which was based on the period from July 1950 to December 1951, may be low because the heaviest rains during the period occurred in the summer months when evapotranspiration loss was high. Recharge to other terrace deposits and to alluvium in the Enid quadrangle may be about the same amount because the surface soils are sandy and capable of absorbing large amounts of water and because the lithologies of the aquifers are similar.

Amounts of recharge to bedrock aquifers are unknown but undoubtedly are considerably less than recharge to terrace deposits and alluvium. The amount of water that can enter the soil and percolate downward to the underlying bedrock is limited because soils in the recharge area of the bedrock generally consist mostly of clay which has low permeability.

Ground-water movement in the Enid quadrangle generally is from the uplands toward the streams (fig. 4). Seepage to the streams and evapotranspiration account for most of the ground-water discharge. During dry periods, seepage from the aquifers is the source of base flow in the streams. Small streams in the quadrangle frequently go dry because the fine-grained sandstone and shale underlying the area have a limited capacity to absorb and transmit ground water.

Along the major streams the alluvium is thick enough to absorb and transmit large amounts of water maintaining base flow in the major streams. During wet periods, however, when the stream level is higher than the water table in the adjacent alluvium, seepage from the stream through the stream bank is a source of recharge to the alluvium.

AVAILABILITY OF GROUND WATER

The principal aquifers in the Enid quadrangle include alluvium and terrace deposits along the major streams and sandstone units in bedrock. Because of the similarity of the water-bearing properties of alluvium and terrace deposits, they are combined and referred to as the alluvial aquifer.

The approximate distribution of the aquifers and the range in yields of wells penetrating them is shown in figure 5. Delineation of aquifers in figure 5 is based on yields of existing wells and on the assumptions that well yields from an aquifer are similar in areas where the lithology of the aquifer is similar, and drilled wells penetrate the total saturated thickness of the aquifer.

Alluvial aquifer

The alluvial aquifer is composed of silt, clay, and fine sand, with coarse sand and gravel at the base in some areas. Well yields in the alluvial aquifer are largest in those areas where the saturated coarse sand and gravel are thickest. According to Renich (1925, p. 23), the saturated coarse sand and gravel at Enid is 2 to 25 feet (0.5 to 8 m) thick, and yields to drilled wells are 50 to 300 gallons/minute (3.2 to 19 l/s). Along the Cimarron, Chikaskia, Salt Fork of the Arkansas, and Arkansas Rivers, the alluvial aquifer is about 15 to 60 feet (5 to 18 m) thick with a layer of coarse sand and gravel as much as 25 feet (8 m) thick at the base. Where the basal sand and gravel zone is thick, the aquifer yields 150 to 600 gallons/minute (9.5 to 38 l/s); where the basal coarse sand and gravel zone is thin or absent, well yields are less than 50 gallons/minute (3.2 l/s).

The alluvial aquifer located along minor streams is composed of fine-grained sand containing varying amounts of silt and clay; thus, the permeability is generally low. In areas where the aquifer is less than 30 feet (9 m) thick, the yields to wells are less than 25 gallons/minute (1.6 l/s). Locally along some of the minor streams, the aquifer is 30 to 60 feet (9 to 18 m) thick, and well yields generally range from 25 to 50 gallons/minute (1.6 to 3.2 l/s).

Development and use of wells in the alluvial aquifer located along streams might result in depletion of streamflow or deterioration in ground-water quality. Some of the water pumped from wells in the alluvial aquifer is water that would have discharged to the streams, and pumping from wells near the streams may induce water into the aquifer from the stream. Inducing recharge from a stream may cause a deterioration of water quality in the alluvial aquifer. During periods of base flow, water in the major streams contains more dissolved minerals and probably more pollutants than water stored in the adjacent alluvial aquifer. Deterioration of water quality probably has occurred along the Salt Fork of the Arkansas River where water from wells within 100 to 200 feet (30 to 60 m) of the river reportedly became "salty" after several weeks of continuous pumping.

Bedrock aquifers

Aquifers in the bedrock are composed of saturated sandstone layers irregularly interbedded with shale, siltstone, and limestone. Most of the sandstone layers are fine grained, thin, and commonly yield only enough water for household use. Locally, however, part of the sandstone is medium to coarse grained and yields as much as 200 gallons/minute (13 l/s) to industrial, irrigation, and public-supply wells.

The Cedar Hills aquifer is mostly fine-grained sandstone interbedded with siltstone and shale. Although the aquifer is limited to a small area west of Enid (fig. 5), the potential well yields are estimated at 150 to 200 gallons/minute (9.5 to 13 l/s) based on yields from irrigation wells about 2 miles (3 km) west of the quadrangle.

The Ada aquifer (fig. 5) is composed of fine-grained sandstone interbedded with shale. Wells in the Ada aquifer generally yield 25 to 35 gallons/minute (1.6 to 2.2 l/s). In Creek County where the aquifer is locally thicker and part of the sandstone is medium to coarse grained, wells 400 to 500 feet (120 to 150 m) deep yield as much as 50 gallons/minute (3.2 l/s). In the southern one-half of Osage County, the base of fresh water in the Ada aquifer generally is 200 to 300 feet (60 to 90 m) below land surface; thus, only the upper part of the aquifer contains fresh water. Wells in this part of Osage County yield about 25 gallons/minute (1.6 l/s).

The Vamoosa aquifer is composed of fine- to coarse-grained sandstone irregularly interbedded with shale and limestone. Wells in the aquifer generally yield 25 to 50 gallons/minute (1.6 to 3.2 l/s). Locally, in Creek County where the aquifer is thick and coarse grained, individual wells might yield 200 gallons/minute (13 l/s). In Osage County, the base of fresh water generally is 150 to 300 feet (45 to 90 m) below land surface. Wells yield about 25 gallons/minute (1.6 l/s) of fresh water from the upper part of the aquifer.

In areas where sandstone beds are thin or fine grained, yields are less than 10 gallons/minute (0.6 l/s). In parts of Noble, Garfield, and Kay Counties, the yields of wells in sandstone are too small to furnish enough water for household use. In areas where the fine-grained sandstone is thickest or where the rocks are broken by faults, an individual well might yield as much as 25 gallons/minute (1.6 l/s).

WATER-LEVEL FLUCTUATIONS

Water levels in wells fluctuate in response to variations in the rate of recharge to and discharge from the aquifers. The hydrographs of 8 wells (fig. 6) show the effects of rainfall, natural discharge, and pumping of nearby wells on the water level in some aquifers in the Enid quadrangle.

The water level in the well in Kay County rose during the last half of 1971 when rainfall was above normal and recharge to the aquifer was greater than discharge. The water level declined during most of 1972 when rainfall was below normal and discharge of water through seeps, streams, and evapotranspiration was greater than recharge.

The hydrographs of the two wells in Osage County show a general rise in water level in 1972–73 because rainfall was above normal.

The water level in the well in Creek County is affected very little by rainfall. The small fluctuation in water level is probably due to rapid discharge of water through fractures in the upper part of the aquifer.

The hydrograph of the well in Garfield County shows the effect on the water level of continuous pumping in the alluvial aquifer. The well is located near water-supply wells in Enid, and during 1967–70 the water level declined at the steady rate of almost 1 foot (0.3 m) per year. The amount of water pumped from the aquifer was greater than recharge from precipitation.

Water level in the alluvial aquifer in Kingfisher County declined during 1967–68. The well shown in figure 6 is located near irrigation wells which were probably pumped heavily during those years. The water level rose during most of 1969–70 as pumping rates were reduced in the irrigation wells nearby.

Water-level fluctuations in the two wells in Payne County are affected by variations in precipitation and by intermittent pumping of water from wells nearby. During 1967–69, water-level fluctuations generally correspond to seasonal variations in precipitation. During 1970–72, however, water-level fluctuations in the two wells probably show the effect of increased pumping of water from the aquifer.

REFERENCES CITED

Reed, E. W., and others, 1952, Ground-water resources of the Cimarron terrace: Oklahoma Planning and Resources Board, Division of Water Resources Bulletin 9, 101 p.

Renick, B. C., 1925, Additional ground-water supplies for the city of Enid, Oklahoma: U.S. Geological Survey Water-Supply Paper 520, p. 15-26.

RECONNAISSANCE OF THE WATER RESOURCES OF THE ENID QUADRANGLE, NORTH-CENTRAL OKLAHOMA

By

Roy H. Bingham and DeRoy L. Bergman

U.S. Geological Survey

1980