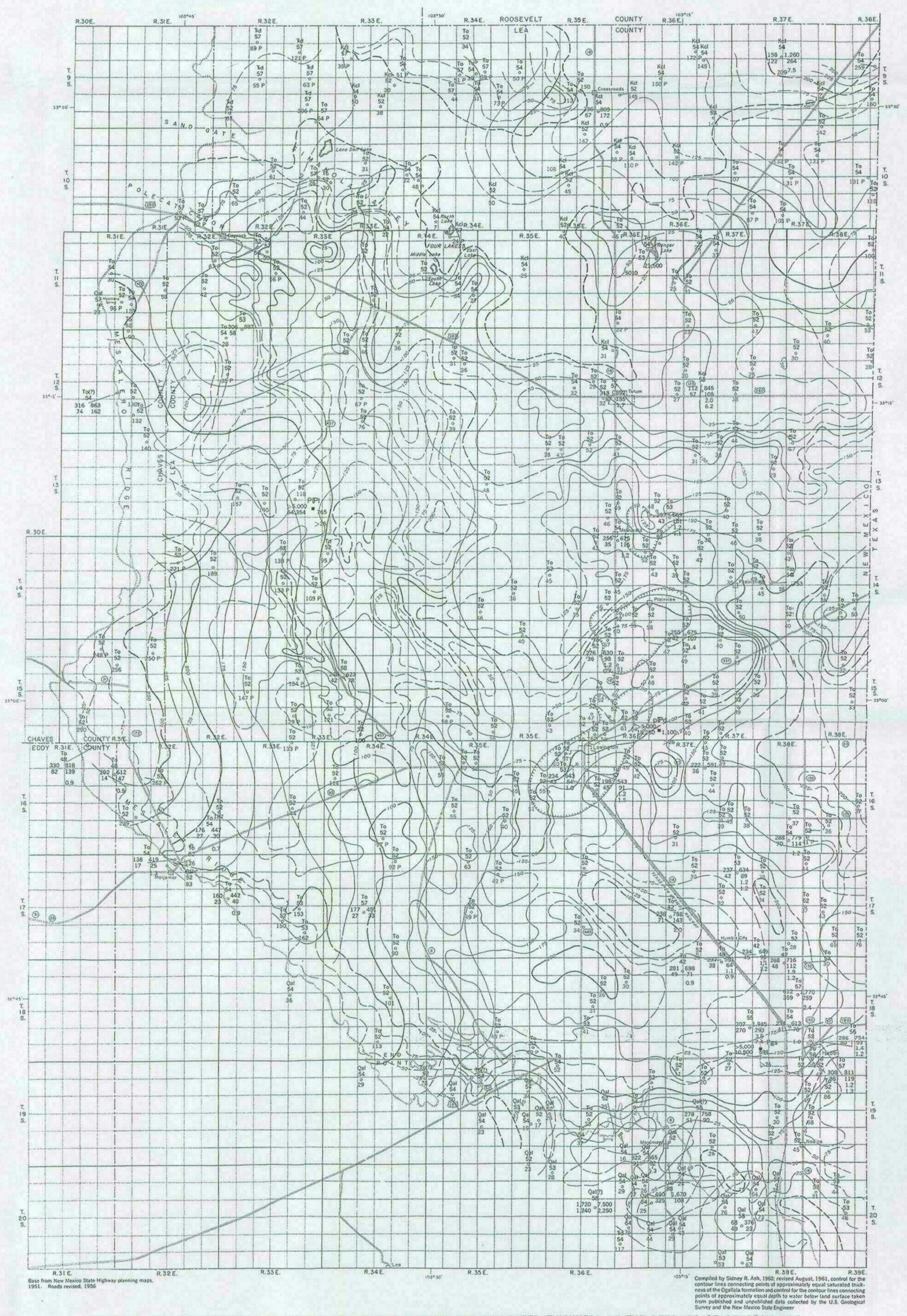


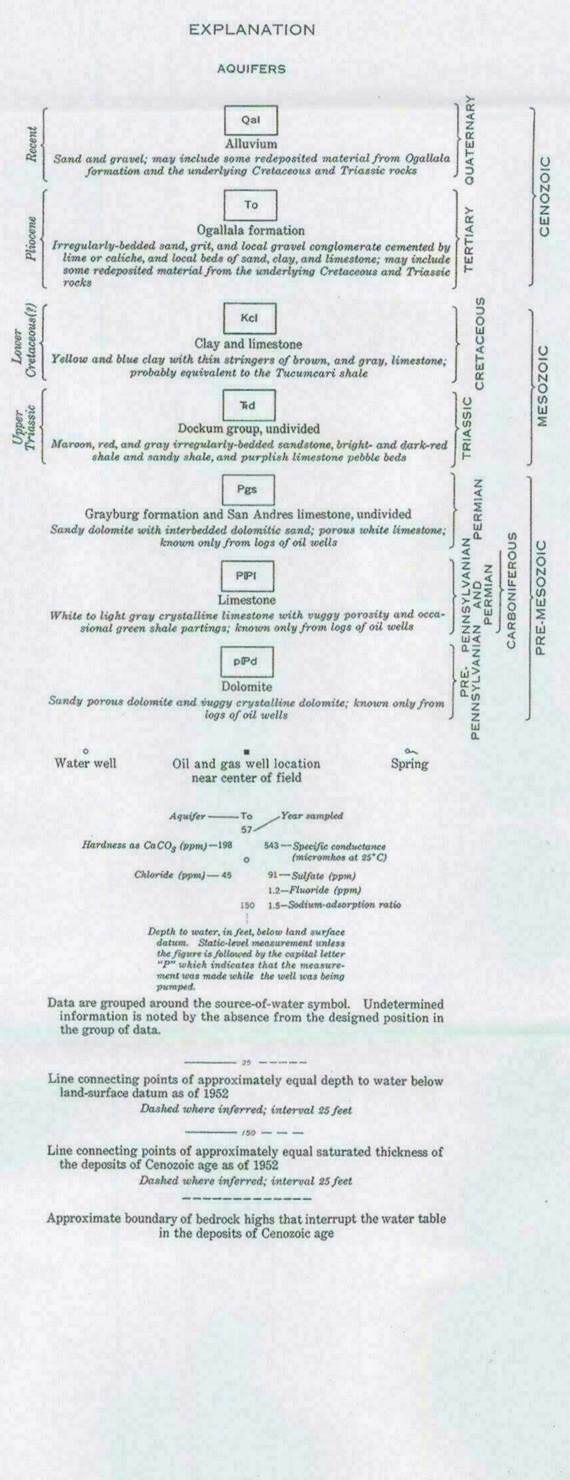


FIGURE 5.—MAP OF NORTHERN LEA COUNTY, NEW MEXICO, SHOWING THE SATURATED THICKNESS OF THE DEPOSITS OF CENOZOIC AGE AND APPROXIMATE DEPTH TO WATER IN 1952 AND THE CHEMICAL QUALITY OF GROUND WATER

THE WATER TABLE IN THE DEPOSITS OF CENOZOIC AGE

The shape and approximate altitude of the water table is shown (fig. 2) by contour lines based on water-level measurements made mostly during 1952. A few measurements in Tps. 9 and 10 S., were made in later years; the data are comparable because the level of the water table in these wells has not changed appreciably for a number of years. The water table slopes generally toward the southeast at about 12 feet per mile, slightly less than the slope of the land surface. The irregularities in the surface of the water table are caused by differences in the permeability of the aquifer and heavy pumping in certain areas.

Records of water levels in observation wells indicate that since 1929 the water table has fluctuated erratically in the east-central part of northern Lea County, but the overall trend during the period 1929-60 has been downward.

The declines during the period 1929-40 were localized because of the relatively slight pumpage and average to above-average precipitation. Above-average precipitation from January 1940 to January 1950, caused the water table to rise generally except in the vicinity of McDonald, Lovington, Humble City, and Hobbs where pumpage increased appreciably during 1947 to 1950 (fig. 4). During the period 1950-60 the water table declined over a much larger area than in the previous 10-year period because of increased pumpage and generally below average rainfall during that time. The greatest decline during the period 1950-60 was 31.7 feet about 14 miles northeast of Lovington.

DEPTH TO WATER AND SATURATED THICKNESS OF THE DEPOSITS OF CENOZOIC AGE

The depth to water ranges from a little less than 12 feet in an area about 13 miles east of Caprock to almost 300 feet along the Mescalero Ridge northwest of Maljamar (fig. 5). When the Lea County Underground Water Basin was declared in 1931 it included an area of about 1,080 square miles where the depth to water was known to be generally 50 feet or less; by 1952 the area in which the depth to water was 50 feet or less had been reduced about one-sixth.

The saturated thickness of the deposits of Cenozoic age generally ranges from less than 25 feet to about 250 feet. The zone of saturation is thinnest in the northeast part of the county where the Ogallala formation is thin and is underlain by sediments of Cretaceous age. The thickest zone of saturation generally is where the Ogallala formation is the thickest and where there has been little use of ground water. The zone of saturation locally has become progressvely thinner as water has been withdrawn for irrigation. The average thickness of the zone in the declared basin was about 100 feet in 1952.

MOVEMENT OF GROUND WATER IN THE DEPOSITS OF CENOZOIC AGE

Ground water moves southeastward down the slope of the water table throughout most of the area. The rate of movement of ground water in the deposits of Cenozoic age is controlled by the gradient of the water table and the permeability of the material in the zone of saturation. Variations in the grain size of the material, the degree of sorting of the deposits, and the extent of cementation of the material cause the rate of movement to vary from place to place. This is particularly true of the Ogallala formation especially near the base where water moves more rapidly through stringers of coarse sand and gravel than through the surrounding beds of fine sand and clay. Data available indicate that the average rate of movement of ground water in the Ogallala formation is on the order of 150 feet per year (H. O. Reeder, U.S. Geol. Survey, oral communication, 1960).

DISCHARGE OF GROUND WATER FROM THE DEPOSITS OF CENOZOIC AGE

Ground water stored in the deposits of Cenozoic age is being removed by both natural and artificial discharge. Natural discharge is by subsurface flow out of the area, evaporation and transpiration, and through springs and seeps. Artificial discharge is through wells.

Natural discharge.—The greatest part of the total natural discharge of ground water from northern Lea County is by subsurface outflow at the New Mexico-Texas State line. An additional quantity moves out of the area by subsurface flow along the southern and western boundary where the contact between the Ogallala formation and the rocks of Triassic age is covered by Quaternary alluvium.

The amount of ground water lost by evaporation and transpiration is relatively small because there are no large bodies of surface water and there are few areas where the water table is shallow.

Evaporation from the zone of saturation in general can take place only where the water table is within 10 feet of the land surface; such a condition prevails around the perennial lakes, along Mescalero Ridge, and south of Mescalero Ridge from Rgs. 35 to 38 E.

Most transpiration by native vegetation is near the perennial lakes and the springs and seeps where the depth to water is less than 20 feet. Native grass, weeds, mesquite, and hackberry and cottonwood trees are the principal users of ground water by transpiration.

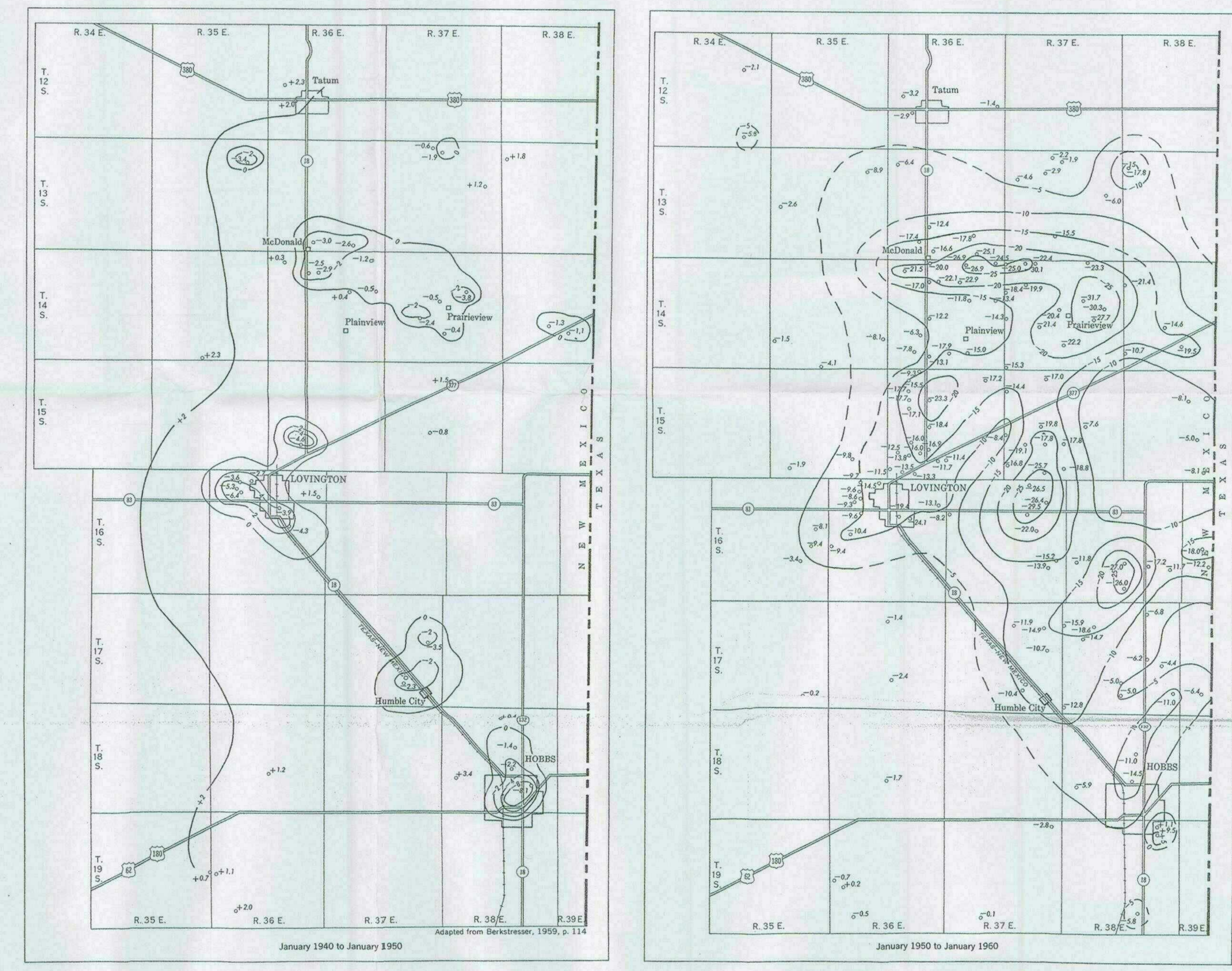
Flow from springs and seeps is small in proportion to the total discharge from the Ogallala formation. Some of the springs and seeps discharge along the contact between the sediment of Tertiary and Triassic age exposed in the escarpment of Mescalero Ridge in Tps. 11 and 12 S., R. 31 E., other springs discharge into the lakes; Ranger Lake and North Lake receive the greater part of the water discharging to the lakes.

Artificial discharge.—The ground water discharged through wells from the deposits of Cenozoic age is utilized for irrigation, public supplies, rural-domestic supplies, industrial uses, and stock. The amount pumped each year is estimated by the U.S. Geological Survey; and the data are published by the New Mexico State Engineer.

The quantity of water pumped from the deposits of Cenozoic age during 1952 was about 185,000 acre-feet; of this amount 166,000 acre-feet was used for irrigation. About the same quantities of water were pumped each year during the period 1953-57. Because of above average precipitation during the growing season of 1958, however, the amount of water pumped for irrigation decreased to about 107,000 acre-feet; the use for other purposes remained about the same—19,000 acre-feet.

The estimated amount of water pumped from the deposits of Cenozoic age for irrigation during the years of record was as follows:

Year	Acre-feet	Year	Acre-feet
1937	1,800	1949	60,000
1938	1,700	1950	95,000
1939	2,200	1951	153,000
1940	3,200	1952	166,000
1941	1,500	1953	165,000
1942	3,500	1954	163,000
1943	6,000	1955	170,000
1944	3,500	1956	160,000
1945	6,500	1957	140,000
1946	3,500	1958	107,000
1947	19,000	1959	149,000
1948	39,000	1960	105,000



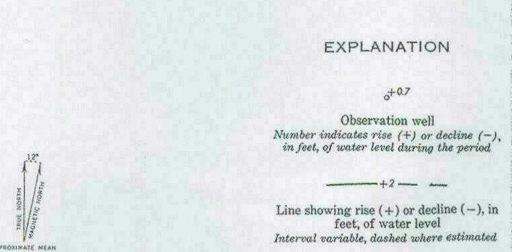


FIGURE 4.—MAPS SHOWING WATER LEVEL CHANGES IN EAST-CENTRAL LEA COUNTY, NEW MEXICO

RECHARGE OF GROUND WATER IN THE DEPOSITS OF CENOZOIC AGE

The deposits of Cenozoic age are recharged chiefly by precipitation; in addition there is some recharge from subsurface flow into the area from Chaves and Roosevelt Counties, from irrigation return, and from seepage from brine disposal pits.

Recharge to the reservoir by the downward percolation of water generally cannot take place where the land surface is underlain by a thick layer of caliche. Only where the caliche is absent, relatively soft, broken by joints, or removed or disturbed by man can water move downward to the water table.

The average annual recharge from precipitation to the zone of saturation in the southern High Plains is between ¼- and ½-inch per year, depending on the amount of precipitation (Theis, 1937). The area of northern Lea County is about 1,800,000 acres; therefore, the amount of annual recharge probably varies between 38,000 and 75,000 acre-feet per year. The area of the Lea County Underground Water Basin is about 1,400,000 acres; therefore, the average annual recharge to the declared basin is approximately 29,000 to 58,000 acre-feet.

The greatest amount of recharge from precipitation occurs in the areas covered by dune sand, and in those areas where the shallow closed depressions are most numerous.

The deposits of Cenozoic age receive a small amount of recharge from surface inflow derived from precipitation that falls on the Llano Estacado outside Lea County, but near its northern boundary. The southeast-trending stream channels carry some runoff into the northern part of the area where it is caught in shallow closed depressions. Some of this water reaches the water table by infiltration but most probably is lost by evaporation and transpiration.

Ground water in the Ogallala formation in adjacent areas in Roosevelt and Chaves Counties, New Mexico, flows in a southeasterly direction and a small amount enters the area as underflow along its northern boundary.

Some of the water pumped from the deposits of Cenozoic age for irrigation, domestic, stock, municipal, and industrial uses is not consumed but instead percolates back to the aquifer. It may be called return discharge, but it does not constitute an addition to the supply of water, rather, it represents a decrease in the net discharge.

Brine-disposal pits for oil-field water also are a source of recharge. Data supplied by Alexander Nicholson, Jr., and Alfred Clebsch, Jr., (1961, p. 102-103) indicate that about 96 percent of the brine discharged to disposal pits for evaporation instead seeps to the water table.

GROUND WATER IN STORAGE

The total quantity of water in storage in the deposits of Cenozoic age can be estimated by using the formula

$$V = Apm$$

where V is the quantity of water in storage, A is the surface area of the aquifer, p is the porosity of aquifer, and m is the saturated thickness of the aquifer. The area (A) of the Lea County Underground Water Basin is about 1,400,000 acres; the average porosity (p) is about 35 percent; and in 1952, the saturated thickness (m) averaged about 100 feet. On the basis of the above figures, it is estimated that about 49,000,000 acre-feet of water were in storage in the aquifer at the end of 1952. However, not all of the water in storage in the reservoir can be recovered for large scale irrigation development because of two principal factors. First, it usually is not economically feasible to pump large quantities of water in areas where the zone of saturation is or becomes less than 30 feet in thickness. Thus, on the average, only the water in the upper 70 feet of the reservoir can be considered as available for large scale pumping. Secondly, much of the water will be retained by adhesion on the surfaces of the grains which make up the reservoir. The yield of water from the sediments is estimated to be 0.2 of the volume of saturated sediment. Thus about 40 percent of the total amount of water in storage in the deposits of Cenozoic age in the northern Lea County Underground Water Basin can be recovered for large-scale irrigation, or about 20,000,000 acre-feet. If ground water pumping was distributed evenly throughout the Basin, the amount in storage would last approximately 100 years at the present rate of use. But some of the water underlies areas that are unsuited for farming and will not be used for this purpose while in other areas the supply will be exhausted in 40 years or less, from 1952, because of extensive local development.

Probably enough water for domestic and municipal uses will be available in the reservoir for a considerable length of time after water is no longer available for large-scale irrigation use.

CHEMICAL QUALITY OF THE WATER

Ground water in the deposits of Cenozoic age is suitable for most uses. Water from the Triassic and Cretaceous formations generally is harder and has a higher dissolved-solids content than water from the younger rocks, and the water is unsuitable for some uses. Water from aquifers of pre-Mesozoic age are generally saline, but have been used to a limited extent in water flooding of oil fields. The chemical quality of the waters is indicated by the analyses in figure 5 which show the concentration of sulfate (SO_4), of chloride (Cl), and of fluoride (F), the hardness, the specific conductance, and the sodium-adsorption ratio.

Water for domestic use.—The quality standards for drinking water recommended by the U.S. Public Health Service (1946) have been adopted by the New Mexico Public Health Department. These standards were reviewed recently by Welsh and Thomas (1960) and they agree (p. 299) that "the present limits appear to be satisfactory. . ." although limits for certain other substances should be considered. The recommended limits for the substances shown in the analyses in figure 5 are 1,000 ppm (parts per million) (preferably 500 ppm) of dissolved solids, or a specific conductivity of less than 1,500 micromhos and preferably less than 750 micromhos; 250 ppm of sulphate; 250 ppm of chloride; and 1.5 ppm of fluoride. The preferred limits for one or more substances were exceeded in 19 of the 36 analyses of water from the Cenozoic deposits. They were exceeded in the three analyses of water from the Tucumcari shale, and in the three analyses of water from rocks of pre-Mesozoic age. None of the water occurring in the Triassic rocks in the area has been analyzed.

Water which has an excess of some of these substances may not have an undesirable taste or odor; a chemical analysis generally is necessary to determine its suitability for drinking. The New Mexico Department of Public Health will analyze, free of charge, drinking water for residents of the State. Sample containers and instructions for sampling can be obtained from the New Mexico Department of Public Health in Santa Fe or Albuquerque.

Water for industrial use.—Water from deposits of Cenozoic age may be considered satisfactory for most industrial uses, even though the water is hard. Water from the formations of Mesozoic age are generally harder and have a higher dissolved-solids content than water from Cenozoic rocks. Water from the rocks of pre-Mesozoic age generally is of such poor quality that it is suitable for most use only where quality of water is of little or no importance, such as drilling shotholes and water-flooding of oil and gas fields.

Water for irrigation.—Water from deposits of Cenozoic age generally is suitable for irrigation according to the criteria of the U.S. Department of Agriculture (Richards, 1954). The total concentration of soluble salts (salinity hazard) ranges from medium to high; however, the quantity of exchangeable sodium (alkali hazard) is low, (Richards, 1954, p. 80). The few wells near Hobbs that have a relatively high concentration of chloride also tend to have a moderately high alkali hazard. A high concentration of sulfate in association with a high concentration of sodium lessens the alkali hazard. Boron is not known to occur in concentrations high enough to affect the plant growth.

Without exception, the water in the rocks of pre-Mesozoic age which was analyzed has been of very poor quality with respect to use for irrigation. Most of the water, which commonly is called brine, has an extremely high salinity and alkali hazard. Ground water in rocks of pre-Mesozoic age is not considered suitable for irrigation.

Contamination.—In some wells potable water in the Ogallala formation is being contaminated with water containing a high concentration of chloride, sodium, calcium, magnesium, and other dissolved solids. A well in NW¼SE¼NE¼ sec. 15, T. 18 S., R. 38 E., approximately 2 miles north of Hobbs, was sampled during 1951, and the analyses showed the water to be potable. The well was sampled again in 1954 and the chloride content had increased from 75 to 152 ppm, the sulfate content had increased to 359 ppm since 1954, and the concentration of chloride had increased to 259 ppm. The hardness (as $CaCO_3$) had increased from 296 ppm to 612 ppm during the 7-year period and the SAR (sodium adsorption ratio) had increased from 1.3 to about 2.4. The water had become impotable according to the U.S. Public Health Service standards (1946).

Contamination apparently is taking place only where the production of brine with oil has continued for a relatively long time, as in the vicinity of Hobbs and Monument. Analyses of samples collected periodically from 1951 to 1957 from a well in SW¼SW¼SW¼ sec. 31, T. 14 S., R. 37 E., and a well in NW¼NW¼NW¼ sec. 8, T. 15 S., R. 36 E. show little or no change in the quality of water. There is little oil production in the vicinity of these two wells.

Contamination may not be detected for many years after its inception unless water wells are located within a few hundred feet of the source of the contamination because of the slow rate of movement of ground water in formations of Cenozoic age. When the quality of the water from a well begins to deteriorate, it is usually too late for remedial measures.

Further contamination of the potable ground-water supplies can be prevented by using any of the following methods or a combination of the methods:

(1) Line the disposal pits with impervious material so that the brine does not seep downward.

(2) Return the brine to deep-lying formations either by using the brine to repressure oil pools or by using wells solely for waste disposal.

(3) Demineralize the brine. This method would significantly improve the water situation by removing a contamination hazard and would increase the supplies of potable water.

SELECTED REFERENCES

Adams, J. E., 1929, Triassic of West Texas: Am. Assoc. Petroleum Geologists Bull., v. 13, no. 8, p. 1,045-1,055, 2 figs.

Barnes, V. E., and others, 1959, Stratigraphy of the pre-Simpson Paleozoic subsurface rocks of Texas and southeast New Mexico: Bur. of Econ. Geology, Texas Univ. Pub. 5924, 836 p.

Bates, R. L., 1942, The oil and gas resources of New Mexico: N. Mex. Inst. of Mining and Technology, State Bur. Mines and Mineral Res. Div. Bull. 18, 320 p., 35 pls., 23 figs.

Berkstresser, C. F., Jr., 1959, Tatum-Lovington-Hobbs area, Lea County, *in* H. O. Reeder and others, Annual water-level measurements in observation wells, 1951-55, and atlas of maps showing changes in water levels for various periods from beginning of record through 1954, New Mexico: N. Mex. State Engineer Tech. Rept. 13, p. 91-115, tables 6-7, figs. 46-55.

Bretz, J H., and Horberg, C. L., 1949, Caliche in southeastern New Mexico: Jour. Geology, v. 57, no. 5, p. 491-511.

[California] State Water Pollution Control Board, 1952, Water quality criteria: Pub. 3, 512 p.; Addendum no. 1, 164 p. [1954]; 2d printing (including Addendum no. 1), 1957.

Conover, C. S., and Akin, P. D., 1942, Progress report on the ground-water supply of northern Lea County, New Mexico: N. Mex. State Engineer 14th and 15th Bienn. Repts., 1938-42, p. 283-309, 3 figs.

Dane, C. H., and Bachman, G. O., 1958, Preliminary geologic map of the southeastern part of New Mexico: U.S. Geol. Survey Misc. Geol. Inv. Map I-256.

Darton, N. H., 1928a, Geologic map of New Mexico: U.S. Geol. Survey.

———1928b, "Red beds" and associated formations in New Mexico: U.S. Geol. Survey Bull. 794, 356 p., 62 pls., 173 figs.

Dixon, G. H., Baltz, D. H., Stipp, T. F., and Bieberman, R. A., 1955, Map of New Mexico showing test wells for oil and gas, oil and gas fields, and pipelines: U.S. Geol. Survey Oil and Gas Inv. Map OM-159.

Fenneman, N. M., 1931, Physiography of western United States: New York, McGraw-Hill Inc., 534 p.

Flawn, P. T., 1956, Basement rocks of Texas and southeast New Mexico: Bur. of Econ. Geology, Texas Univ., Pub. 5605, 261 p.

Hale, W. E., and Nicholson, Alexander, Jr., 1953, Three maps of a portion of Lea County, New Mexico: (1) Contour map of the bottom of the Ogallala formation, (2) Contour map showing elevation of the water table, and (3) Map showing the thickness of the zone of saturation in the Ogallala formation: U.S. Geol. Survey open-file report, 3 figs.

Harper, W. G., and Smith, L. H., 1935, Soil survey of the Lovington area, New Mexico: U.S. Dept. of Agriculture, Bur. Chemistry and Soils, series 1932, no. 2, 21 p., 1 map.

Hoots, H. W., 1925, Geology of a part of western Texas and southeastern New Mexico, with special reference to salt and potash (preface by J. A. Udden): U.S. Geol. Survey Bull. 780-B, p. 33-126, 1 fig., 15 pls.

Judson, S. S., Jr., 1950, Depressions of the northern portion of the southern High Plains of eastern New Mexico: Geol. Soc. America Bull., v. 61, no. 3, p. 253-274.

King, P. B., 1942, Permian of west Texas and southeastern New Mexico, pt. 2 *of* De Ford, R. K., and Lloyd, E. R., eds., West Texas-New Mexico symposium: Am. Assoc. Petroleum Geologists Bull., v. 26, no. 4, p. 535-763, 2 pls., 34 figs.

King, R. E., 1945, Stratigraphy and oil-producing zones of the pre-San Andres formations of southeastern New Mexico—a preliminary report: N. Mex. Inst. of Mining and Technology, State Bur. Mines and Mineral Res. Bull. 23, 34 p.

Lang, W. B., 1953, A reconnaissance and elevation map of southeastern New Mexico: U.S. Geol. Survey map. (Reprinted with corrections from 1936 edition.).

Leopold, L. B., and Langbein, W. B., 1960, A primer on water: U.S. Geol. Survey.

Lloyd, E. R., 1949, Pre-San Andres stratigraphy and oil-producing zones in southeastern New Mexico—a progress report: N. Mex. Inst. of Mining and Technology, State Bur. Mines and Mineral Res. Bull. 29, 79 p.

New Mexico Oil and Gas Engineering Committee, Annual Rept., 1952, 999 p.

———1954, 580 p.

———1955, 504 p.

Nicholson, Alexander, Jr., 1955, *Cited in* Water; the Yearbook of Agriculture, 1955: U.S. Dept. of Agriculture, p. 625-626.

Nicholson, Alexander, Jr., and Clebsch, Alfred, Jr., 1961, Geology and ground-water conditions in southern Lea County, New Mexico: N. Mex. Inst. of Mining and Technology, State Bur. Mines and Mineral Res. Ground Water Report 6, 123 p., 2 pls., 30 figs., 9 tables.

Nye, S. S., 1930, Shallow ground-water supplies in northern Lea County, New Mexico: N. Mexico State Engineer 9th Bienn. Rept., 1928-30, p. 363-387, 1 pl.

———1932, Progress report on the ground-water supply of northern Lea County, New Mexico: N. Mex. State Engineer 10th Bienn. Rept., 1930-32, p. 229-251.

Reynolds, S. E., 1960, New Mexico, *in* Water Resources Activities in the United States—[U.S.] Senate select committee on National Water Resources—views and comments of the states: U.S. 86th Cong., 2d sess., p. 228-254.

Richards, L. A., ed., 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. of Agriculture Handbook 60, 160 p.

Stipp, T. F., and Haigler, L. B., 1956, Preliminary structure contour map of a part of southeastern New Mexico showing oil and gas development: U.S. Geol. Survey Oil and Gas Inv. Map OM-177 [1957].

Stipp, T. F., Helmig, P. D., Alcorn, Rex, and Murphy, R. E., eds., 1956, The oil and gas fields of southeastern New Mexico, a symposium: Roswell Geol. Soc., 376 p.

Theis, C. V., 1934, Progress report on the ground-water supply of Lea County, New Mexico: N. Mex. State Engineer 11th Bienn. Rept., 1932-34, p. 127-153.

———1937, Amount of ground-water recharge in the southern High Plains: Am. Geophys. Union Trans., v. 18, p. 564-568, 3 figs.

———1939, Progress report on the ground-water supply of Lea County, New Mexico: N. Mex. State Engineer 12th and 13th Bienn. Repts., 1934-38, p. 121-134.

———1945, Ground-water conditions at carbon-black plants near Eunice, Lea County, New Mexico: U.S. Geol. Survey open-file report, 17 p., 1 fig.

U.S. Public Health Service, 1946, Public Health Service drinking water standards, 1946: Public Health Service Repts., v. 61, no. 11, p. 371-384. Also available as Public Health Service Reprint 2697.

U.S. Weather Bureau, 1952-57, Climatological data, New Mexico—Annual Summary 1953-59: Climatolog. Data, v. 56-63, no. 13, [1953-60].

———1955, Climatic Summary of the United States—Supplement for 1931 through 1952: Climatolography of the United States, no. 11-25.

Welsh, G. B., and Thomas, J. F., 1960, Significance of chemical limits in U.S. Public Health Service drinking water standards: Am. Water Works Assoc. Jour., v. 52, no. 3, p. 289-300.

White, W. N., Broadhurst, W. L., and Lang, J. W., 1946, Ground water in the High Plains of Texas: U.S. Geol. Survey Water-Supply Paper 889-F, p. 381-420, 5 pls., 7 figs.

Wilcox, L. V., 1955, Classification and use of irrigation waters: U.S. Dept. of Agriculture Circ. 969, 19 p.

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—62289

GROUND-WATER CONDITIONS IN NORTHERN LEA COUNTY, NEW MEXICO

By
Sidney R. Ash

1963

For sale by U. S. Geological Survey, price $1.00 per set