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GEOHYDROLOGY AND GROUND-WATER POTENTIAL OF PORTER AND LAPORTE COUNTIES, INDIANA

BY

J. S. ROSENSHEIN AND J. D. HUNN

GEOLOGISTS, U. S. GEOLOGICAL SURVEY

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GEOHYDROLOGY AND GROUND-WATER POTENTIAL OF PORTER AND LAPORTE COUNTIES, INDIANA

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ABSTRACT

The principal sources of ground water in Porter and La Porte Counties are the unconsolidated rocks of Quaternary age. These rocks form a single but complex hydrologic system consisting of four units, that is locally more than 400 feet thick. The potential ground-water yield of the area is estimated to be 900 mgd (million gallons per day), of which about 12 mgd id being pumped.

Unit 4 consists of clay till that contains discontinuous zones of sand and gravel. These zones are a potential source of water for small to moderate supplies, particularly in the northern part of Porter County and the northwestern part of La Porte County.

Unit 3, a sand and gravel, is the principal aquifer in the area. This unit is about 15 per cent artesian and about 85 per cent water-table. Recharge is derived from local precipitation. Recharge to the artesian part and in Porter County to much of the water-table part of the aquifer must percolate through the overlying till (unit 2). This recharge is estimated to average 300,000 gpd (gallons per day) per square mile, or about 100 mgd. Recharge to that portion of the water-table part of the aquifer which is exposed at the surface is estimated to average 1.2 mgd per square mile. The potential yield of this part of the aquifer is estimated to be 700 mgd.

Natural discharge from the unit takes place by effluent seepage to streams, evapotranspiration, upward leakage through the overlying till, and downward movement to the underlying rock units. An estimated 38,000 million gallons was discharged by evapotranspiration from the water-table part during the 1960 growing season. Pumpage from unit 3 is about 9.3 mgd, or about 78 per cent of the ground water pumped.

Unit 2, a silt till, is the confirming layer for the artesian part of the principal aquifer. The unit may have as much as 2 million acre-feet of water in storage. Production from the unit is limited to relatively thin, discontinuous, intertill sand and gravel zones and is not a significant part of the ground water pumped in the area.

Unit 1, a sand with local zones of sand and gravel, is chiefly a water-table aquifer. Recharge is derived from local precipitation and probably amounts to less than 600,000 gpd per square mile. Ditching and industrial and urban development during the past 60 years have decreased recharge. Natural discharge takes place by evapotranspiration and by effluent seepage to streams, ditches, and Lake Michigan. Estimated pumpage from the unit is 1.6 mgd, or about 13 per cent of the ground water pumped. Under present hydrologic conditions the potential yield of the unit may be as much as 60 to 70 mgd. Development of this potential may be impeded by the unit's susceptibility to contamination.

INTRODUCTION

Purpose and Scope

A ground-water investigation is currently in progress in northwestern Indiana by the U. S, Geological Survey, in cooperation with the Division of Water, Indiana Department of Natural Resources, as part of the state-wide investigation of the ground-water resources of Indiana. The purpose of this report is to define the aquifers and determine their geohydrology, to estimate their current and potential yields, and to identify the problems relating to their development. This report is the second in a series of interpretive reports scheduled for the area. It presents an evaluation of the ground-water resources of Porter and LaPorte Counties and provides information to serve as a guide for sound development and responsible management of the ground-water resources of these counties.

Porter and LaPorte Counties (fig.1) are adjacent to the heavily industrialized area of Lake County. The growth of industry and population should increase sharply within the next few decades as a result of the general economic development of the Great Lakes region. Increased growth has already taken place in the northern part of Porter County with the recent construction of a steel plant. The eventual construction of an additional steel plant and a deep-water port in the area should also greatly spur economic development and population growth. Because of these factors the demand for water for industrial, urban, and rural nonfarm use will increase. The available ground-water resources in this area could supply much of this demand.

Conclusions

The principal sources of ground water in Porter and LaPorte Counties are the unconsolidated rocks of Quaternary age. The underlying bedrock is only a minor source. The unconsolidated rocks form a single but complex hydrologic system composed of four units. This system has a potential yield of 900 mgd, (million gallons per day) of which about 12 mgd or about one per cent is currently being withdrawn. Although the available ground water should be more than adequate to satisfy the needs of the counties for the next few decades, the increased demands will produce hydrologic problems such as those of contamination, drainage and well spacing which are common to highly urbanized areas. Therefore, in order to tap a major part of the potential yield, sound practices of development and responsible management of water resources will be required.

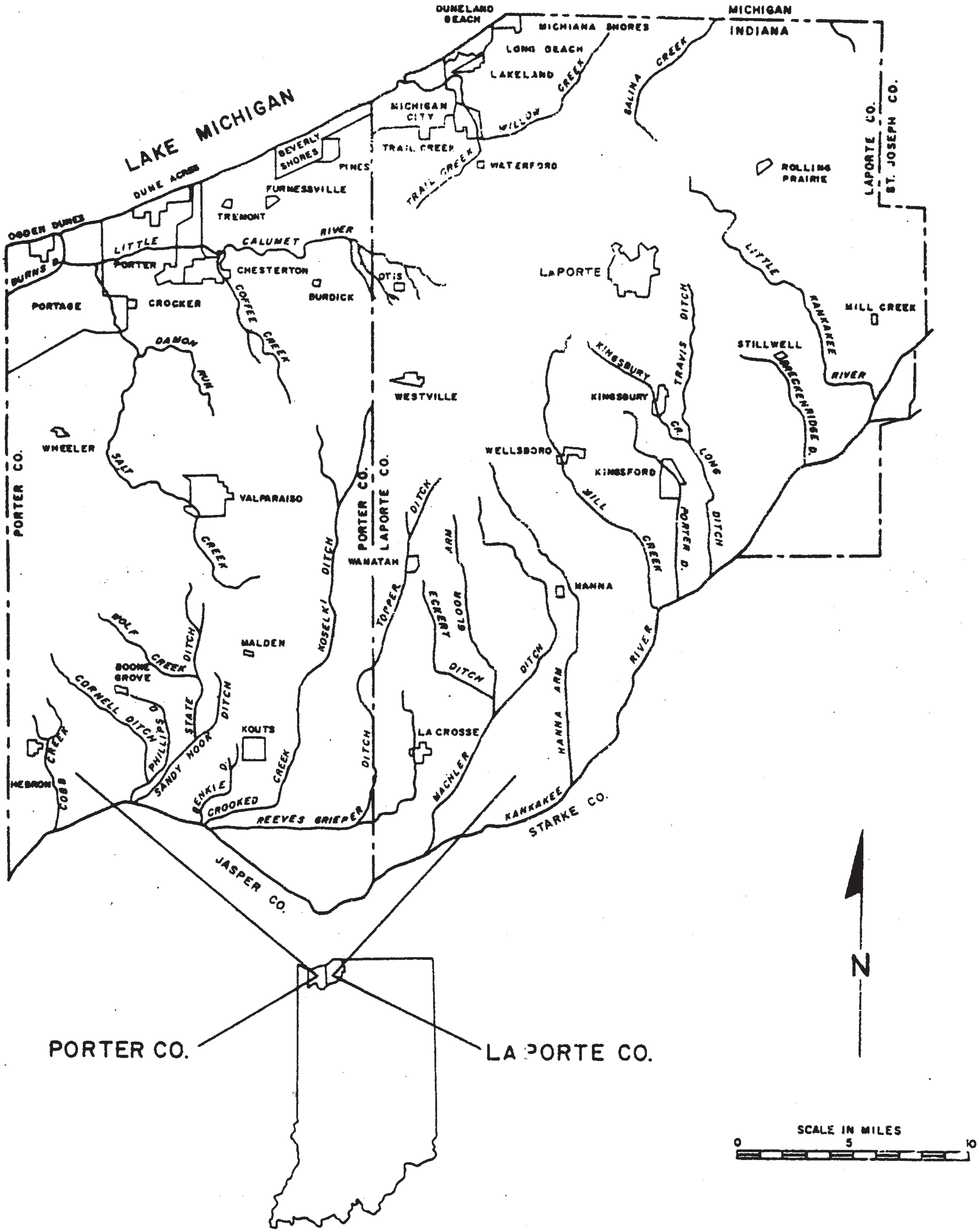

Fig. I Map of Indiana showing the area covered by this report.

Well-Numbering System

Each well referred to in this report is assigned a number that indicates its location according to the official rectangular public-land survey. A comprehensive description of this well-numbering system is given for Porter County by Rosenshein (1962a, p. 4), and for LaPorte County by Rosenshein and Hunn (1962, p. 4).

Acknowledgments

The authors thank all persons who contributed time, information, and assistance during the preparation of this report. The investigation was under the immediate supervision of C. M. Roberts, district geologist of the Ground Water Branch, U. S. Geological Survey. R. J. Vig, formerly of the U. S. Geological Survey, assisted in the geologic reconnaissance. Well drillers supplied logs and other information.

The authors also thank the following government agencies which provided information: Geological Survey and Divisions of Oil and Gas and Water, Indiana Department of Natural Resources; Indiana State Highway Department; Indiana Toll Road Commission; and Indiana State Board of Health.

This report has been prepared as a part of the statewide investigation of the ground-water resources of Indiana, conducted by the U. S. Geological Survey in cooperation with the Indiana Department of Natural Resources, Division of Water.

CLIMATE AND GEOGRAPHY

Porter and LaPorte counties have a climate characteristic of the northern midcontinent region. The average annual precipitation is about 39 inches at Valparaiso and about 50 inches at LaPorte. The average annual air temperature is about 50° F. at both Valparaiso and LaPorte.

The Valparaiso morainal system is the chief topographic feature of the area. It extends from southwest to northeast across the two counties. A principal drainage divide follows the crest of this morainal system and separates the St. Lawrence River basin from the Mississippi River basin. This divide has been altered somewhat by ditching. The maps in this report show the drainage pattern of the principal streams and ditches. Points of highest elevation are in the morainal system in LaPorte County. The lowest elevation in the two counties is the shore line of Lake Michigan. Maximum relief is about 370 feet.

GEOHYDROLOGY OF THE PRINCIPAL WATER-BEARING UNITS

General Aspects

The principal sources of ground water occur in the unconsolidated rocks of Quaternary age, which are locally more than 400 feet thick and were deposited chiefly as a result of glaciation during Pleistocene time. These rocks form a single but complex hydrologic system from which about 12 mgd is currently being withdrawn.

The geology of the unconsolidated rocks is described to some extent by Blatchley (1897) and Leverett and Taylor (1915). The soils formed on these rocks have been mapped by Bushnell and Barrett (1918) and Ulrich, Leighty, and Shearin (1944). Generalized descriptions of the ground-water resources of these rocks are published in reports by Leverett (1899) and Harrell (1935). A preliminary evaluation of the ground-water resources of Porter County is published in a report by Rosenshein (1962a) and that of La Porte County in a report by Rosenshein and Hunn (1962). Rosenshein (1962b) subdivided the rocks into the four lithologic units used in this report. The units are discussed in ascending order. The stratigraphy, character and distribution, and geohydrologic properties of the units are summarized in table 1. The areal extent of those units that are exposed at the surface is shown on plate 1.

The underlying dolomite, dolomitic limestone, and shale of Devonian and Mississippian ages are potential sources of only small quantities of water (Rosenshein and Hunn, 1965) of uncertain quality. The underlying Ordovician and Silurian rocks are not used as a source of supply in Porter and La Porte Counties and the water they contain generally has more than 5,000 ppm (parts per million) dissolved solids (Rosenshein, 1962a, p. 6; Rosenshein and Hunn, 1962, p. 6).

Unit 4

Water-bearing characteristics.--This unit is a clay till that contains discontinuous zones of sand and gravel. The till underlies about 80 percent of the area. The vertical permeability (definition, p. 20) of the till is probably similar to that estimated by Rosenshein (1963 p. 15) for that part of the same unit underlying Lake County--0.003 gpd (gallons per day) per square foot. The porosity (definition, p. 20) of the till may be as much as 30 to 40 percent (Rosenshein and Hunn, 1965), and the unit may have as much as 12 million acre-feet of water in storage.

Development and potential.--The intertill sand and gravel zones are used locally as a source of water. Wells tapping these zones discharge an estimated 0.7 mgd, or about six percent of the ground water used in the counties. Of this amount 0.6 mgd is pumped for domestic and farm use and 0.1 mgd for industrial and commercial use. Wells tapping these zones have been reported to flow from 10 to as much as 270 gpm (gallons per minute) with water levels rising from several feet to more than 30 feet above the land surface. The permeability of these zones ranges from less than 100 to about 800 gpd per square foot. Locally the sand and gravel may be as much as 50 feet thick. The potential of these zones for development is limited, however, by their restricted area extent and by the small vertical permeability of the enclosing till which largely determines the rate of recharge. Recharge is derived chiefly from local precipitation that percolates downward through the overlying units. Some recharge may be derived from the underlying bedrock. Highly mineralized water in some of the intertill sand and gravel zones may be caused by recharge from this source. Fluctuations of water levels in two observation wells that tap these intertill zones are shown on figure 2. Available water analyses are summarized on table 2, p. 12.

Table 1.--Stratigraphic section and summary of water-bearing properties of rocks of Quaternary age, Porter and La Porte Counties, Indiana

System	Series	Stratigraphic unit	Thickness (feet) Range	Thickness (feet) Average	Character and distribution	Geohydrologic properties and significance	Remarks
Quaternary	Recent and Pleistocene	Unit 1	0-125+	----	Sand, generally fine to medium, somewhat silty, slightly to moderately calcareous, grains generally subrounded; interbedded with zones of beach gravel, silt, and clay; locally organically rich; contains small areas of relatively thick, thinly laminated silt and clay; underlies about 125 square miles of northern part of area.	Second most utilized aquifer in the area; potential source of water supplies requiring yields of less than 50 to more than 500 gpm; contributes to base flow of streams. Estimate of average hydraulic properties: permeability, about 450 gpd per square foot; coefficient of storage, about 0.12.	Geohydrology and topographic expression modified as result of industrial and urban growth in northern part of county.
		Unit 2	1-150+	40	Till; silt, clayey and sandy, grading into sandy, silty clay along western edge of area; moderately to highly calcareous, pebbly, and cobbly; generally olive-gray in lower part, yellowish-gray to pale- to dark-yellowish-gray in upper part; contains discontinuous lenses of sand and gravel of small areal extent; underlies about 350 square miles of area.	Discontinuous sand and gravel lenses utilized locally as a source of water for some domestic and farm supplies; mantles artesian and water-table parts of unit 3; contributes to base flow of streams; locally forms spring horizons where intertill sand and gravel crop out and at contact of unit with overlying unit 1.	Forms dissected ground moraine and terminal moraines; hydrology altered by drainage of upper part of unit.
		Unit 3	0-230	100	Sand, generally medium to coarse, somewhat pebbly, silty and clayey, calcareous, and sand and gravel; grains subrounded to rounded; composed of fragments of shale, quartz, dolomite, limestone, and igneous and metamorphic rocks; locally contains thick clays of limited areal extent; underlies about 880 square miles of area.	Principal aquifer; potential source of water supplies requiring yields of less than 50 to more than 3,000 gpm; locally forms spring horizons; contributes to base flow of streams. Estimated average permeability; Porter County - 600 gpd per square foot, La Porte County - 800 gpd per square foot. Estimated average coefficient of storage; 0.003 for artesian part, 0.12 for water-table part.	
		Unit 4	0-230	65	Till; clay, silty, sandy, pebbly, slightly to moderately calcareous, locally hard and compact, olive-gray to greenish-gray; contains some relatively thin, discontinuous, intertill sand and gravel zones in northern part of area; underlies about 845 square miles of area; not exposed at the surface.	Intertill sand and gravel zones utilized locally as source of water by some domestic and farm supplies.	

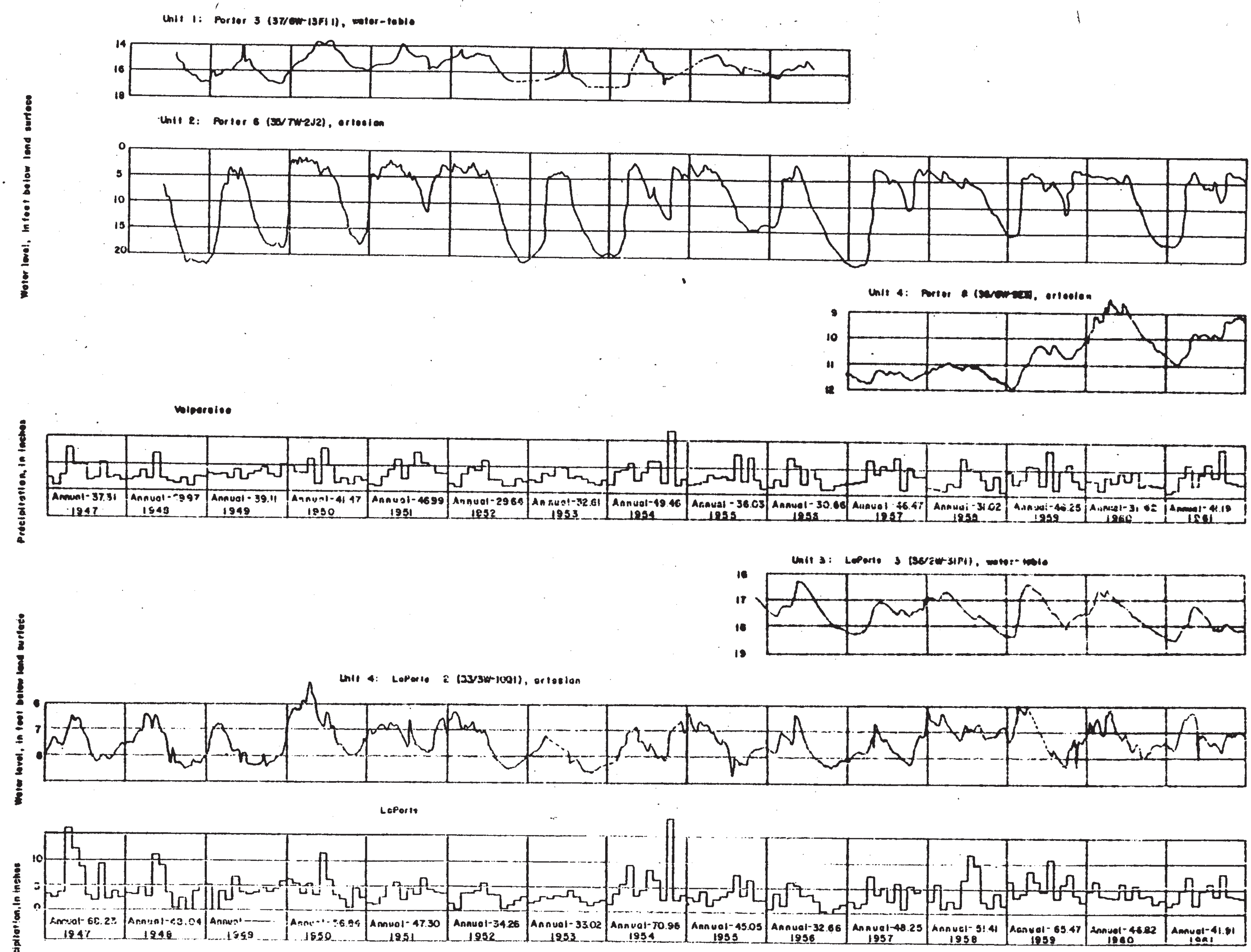

FIGURE 2.--Fluctuations of water levels in observation wells and monthly precipitation in Porter and LaPorte Counties, Indiana

The table below summarizes the water-bearing properties

Well	Estimated coefficient of transmissibility (gpd per foot)	Thickness of aquifer penetrated (ft)	Estimated coefficient of permeability (gpd per square foot)
33/3W-10Q1	1,800	21	90
35/1W-31E1	13,300	44	300
37/4W-4N1	6,600	42	160
5H1	27,500	58	470
7B1	4,400	10	440
38/4W-26A1	8,100	15	540
36B1	1,100	8	140
36B2	7,900	10	790
36P1	13,600	25	540

of the sand and gravel zones in unit 4. The information in this table indicates the feasibility of exploring the thicker parts of the unit as a potential source for small to moderate water supplies, particularly in the northern quarter of Porter County and northern and western quarters of La Porte County.

Unit 3

Water-bearing characteristics

Unit 3 consists chiefly of sand and gravel (table 1) that locally contains thick zones of gravel, especially in La Porte County. This unit forms the principal aquifer of the area and contains an artesian and a water-table part. The artesian part of the aquifer occurs principally in the western half of Porter County, and extends in a narrow band along the northern edge of the unit in the rest of the area.

The permeability of the unit ranges from less than 100 to more than 2,000 gpd per square foot and is estimated to average 600 gpd per square foot in Porter County and 800 gpd per square foot in La Porte County. The <u>coefficient of transmissibility</u> (definition, p. 20) ranges from less than 10,000 to more than 150,000 gpd per foot. The unit has an estimated regional transmissibility of 45,000 gpd per foot in Porter County and 65,000 gpd per foot in La Porte County.

Rosenshein and Hunn (1965) have estimated that in an adjacent area the <u>coefficient of storage</u> (definition, p. 20) for the artesian part of the aquifer averages 0.003 and for the water-table part 0.12. These estimates should also be sufficiently accurate to evaluate regional characteristics of the aquifer in Porter and La Porte Counties.

Recharge and discharge

Fluctuations of the water level in the aquifer caused by seasonal variations of recharge and discharge are shown on figure 2. Recharge to the unit is derived from local precipitation as shown by the configuration of the piezometric surface (fig. 3).

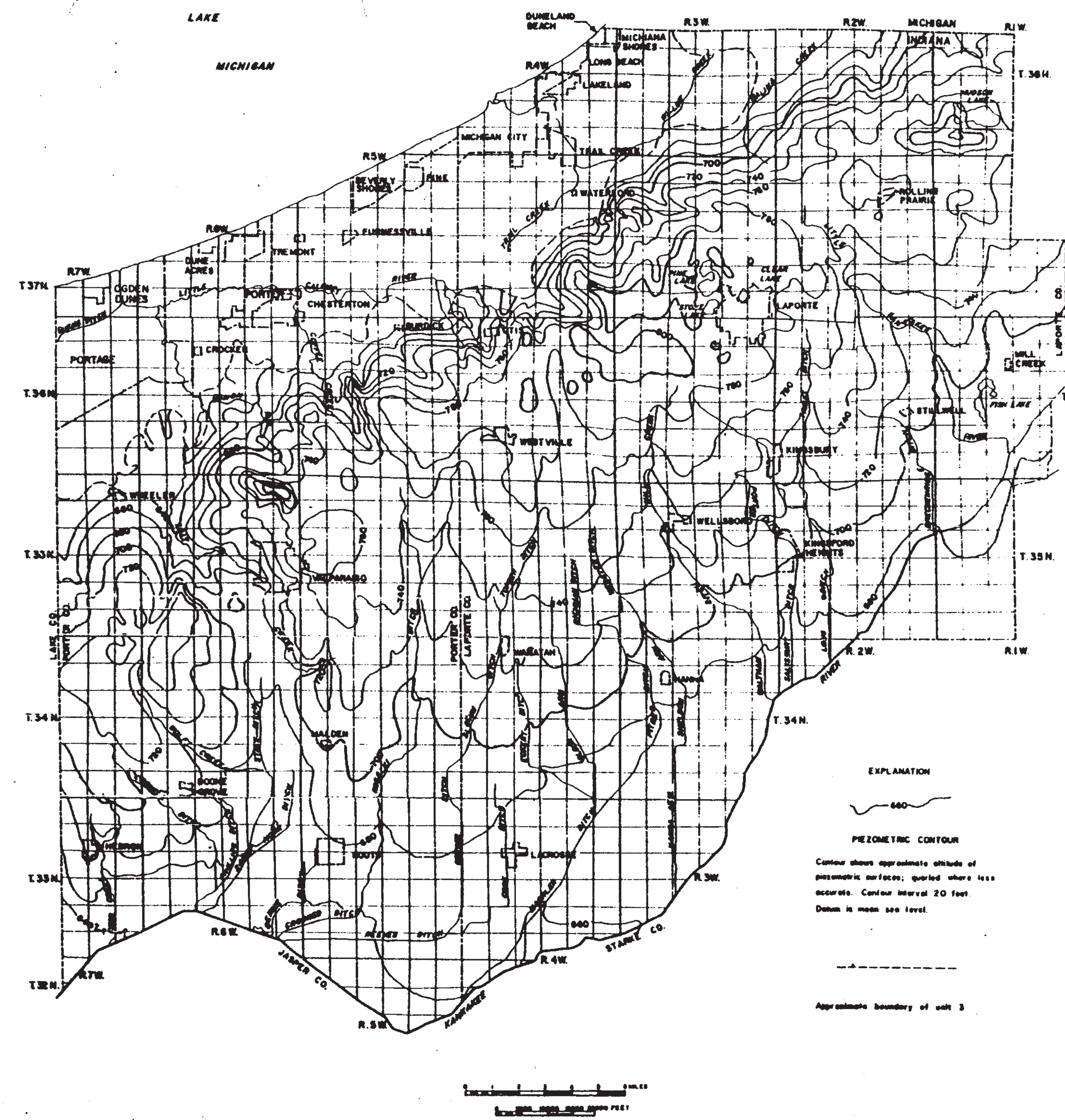

FIGURE 3.--Map showing configuration of the piezometric surface of unit 3, Porter and Laporte Counties, January 1960

Recharge to the artesian part of the aquifer, and in Porter County to much of the water-table part, must take place by slow percolation through the overlying till (unit 2, p. 15). This recharge is estimated to average 300,000 gpd per square mile. *

The water-table part of the unit exposed at the land surface (plate 1) is recharged by direct percolation of precipitation through the upper part of the unit. This recharge is estimated to average 1.2 mgd per square mile. *

Natural discharge from the artesian part occurs along the northern edge of the unit as upward leakage through the overlying till. Many of the numerous springs, seeps, and marshes that occur along Salt and Coffee Creeks in Porter County and in the northwestern part of La Porte County are partly the result of this upward discharge. Some discharge by evapotranspiration takes place locally where the confining layer is less than 20 feet thick. However, the quantity discharged by this means must be relatively small. Discharge to streams must also be relatively small and can take place only locally where the head in the artesian part exceeds that in the overlying till. Some discharge from both the artesian and the water-table parts also occurs as downward movement to the underlying rock units.

Natural discharge from the water-table part occurs chiefly as <u>effluent seepage</u> (definition, p. 20) to the ditches and streams that penetrate the unit and as direct evapotranspiration. Effluent seepage constitutes most of the discharge in the non-growing season and only a small part in the growing season. The significance of the streams and ditches as points of discharge from the unit is indicated by their effects upon the configuration of the piezometric surface (fig. 3). This discharge produces most of the stream flow from July through September.

Discharge by evapotranspiration from the water-table part in the growing season occurs chiefly where the water level is less than 20 feet below the land surface. Although no detailed evaluation of this discharge has been made, it should be similar per square mile to that estimated by Rosenshein and Hunn (1965, p. 24) for the water-table part of this unit in Lake County, and was probably about 38,000 million gallons or about 250 mgd during the 1960 growing season.

Wells tapping unit 3 discharge an estimated 9.3 mgd, accounting for about 78 percent of the ground water used in the counties. It is pumped mostly from the water-table part of the aquifer. Of this amount 2.9 mgd is pumped for domestic and farm use, 5.3 mgd for municipal use, and 1.1 mgd for industrial and commercial use. Of the amount pumped by communities for municipal use, Hebron pumps 0.1 mgd, Kingford Heights 0.1 mgd, Kouts 0.1 mgd, La Crosse 0.03 mgd, La Porte 3.3 mgd, Valparaiso 1.6 mgd, and Westville 0.1 mgd.

Quality of water

The principal constituents of the water in unit 3 are bicarbonate, calcium, and magnesium, but locally sulfate is a major constituent. Concentrations of the dissolved constituents and their significance are summarized in tables 2 and 3.

Geohydrologic control.--Much of the bicarbonate content of the water in the artesian part of this aquifer is dissolved from unit 2, a silt till which contains finely-divided calcareous particles. These particles expose a relatively large surface area per unit volume of material to react with the water. As a result, water in the artesian part of unit 3 generally contains high concentrations of bicarbonate, calcium, and magnesium derived from unit 2. Variation of bicarbonate content in the artesian part of the aquifer may be caused by differences from place to place in the amount of calcareous material in the overlying till. Percolating ground water has slowly dissolved this material since deposition of the till, and the amount of calcareous material dissolved depends on the amount of water that has passed through the till. Wherever much of the calcareous material in the till has been dissolved in the past, the concentration of bicarbonate in the water presently in the underlying aquifer should be relatively low. The factors controlling the amount of water passing through the till in a given amount of time are the thickness and permeability of the till and the difference in hydraulic head between the till and the underlying aquifer.

Bicarbonate concentration (pl. 2) is generally highest in the aquifer where the till is thickest, and generally decreases from west to east as the till becomes thinner and more permeable. Calcium and magnesium in this aquifer are associated with sulfate as well as with bicarbonate. Thickness of till apparently is not related to the concentration of sulfate, which may be derived from several sources. As a result the calcium and magnesium concentrations are not as directly related to thickness of till as is the concentration of bicarbonate. Sulfate, iron, and chloride concentrations are often relatively high in poorly drained areas where organic decay takes place.

Development and potential

Plate 3 shows estimated transmissibilities and relates these to specific capacities and possible yields obtainable from properly constructed wells. The specific capacities are those to be expected for a 12-inch diameter well after pumping for one day. The yield for a specified drawdown will be greater for a larger diameter well than for a smaller diameter well and will decrease with time of pumping. Because the aquifer is chiefly water table, the possible yields for most of the area are estimated from the specific capacities using a drawdown limited to one half the saturated thickness of the unit. Owing to these and other limitations, such as well efficiency, plate 3 gives only an approximation of the capability of the aquifer as a source of water.

Much of the unit is a possible source of water for users requiring 500 gpm or more. However, without proper well construction, actual yields may be considerably less than those indicated on plate 3. Proper construction requires careful choice of well diameter, screen diameter and length, and slot size of screen openings. Guide lines to aid in proper selection of the above factors are given by Walton (1963, p. 28-30). Wells tapping the unit require development to remove the clay, silt, and very fine sand from the immediate vicinity of the screen.

The depth to the water-bearing zone in unit 3 can be estimated from plate 4. This information may then be used in conjunction with information on plate 3 to estimate the depth to which a well must be drilled in order to develop a water supply. For supplies requiring maximum possible yield, the full thickness of the aquifer should be penetrated and as much screened as is economically and

Table 2.--Summary of water quality in the rocks of Quaternary age, Porter and La Porte Counties, Indiana

Independent laboratories: Dearborn Chemical Co., Brookside Farms Laboratory Association, Industrial Chemicals, Inc., and Pennsylvania Railroad.
Partial analyses determined in the field office of the U. S. Geological Survey.
Total dissolved solids for all partial analyses estimated by the formula: $HCO_3 - 1/6\ HCO_3 + SO_4 + 0.4\ SO_4 + Cl + 0.6\ Cl$ (Collins, p. 260, 1928).
Constituents and properties expressed as parts per million (ppm).
Mode: most common value.

Unit	Source of Analysis	Number of samples
1	Partial analyses	52
	U. S. Geological Survey	1
	Indiana State Board of Health	1
2	Partial analyses	25
3	Partial analyses	418
	U. S. Geological Survey	7
	Indiana State Board of Health	11
	Independent laboratories	7
4	Partial analyses	58
	U. S. Geological Survey	5
	Indiana State Board of Health	8
	Independent laboratories	6

Unit		Iron (Fe)	Total alkalinity as Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Total Dissolved Solids	Hardness as Calcium Carbonate ($CaCO_3$)
1	Max.	7.5	449	180	108	653	401
	Min.	<.1	37	15	<4	120	48
	Mode	.3	152	54	9	257	136
	Avg.	.8	212	63	13	292	206
2	Max.	2.0	686	105	28	565	580
	Min.	.1	163	5	<4	226	172
	Mode	1.3	325	25	9	327	254
	Avg.	1.1	342	43	10	362	276
3	Max.	>7.5	610	545	328	1,050	792
	Min.	<.1	83	5	<4	114	72
	Mode	.2	277	61	9	352	232
	Avg.	1.3	302	93	15	391	295
4	Max.	3.5	590	430	948	1,680	832
	Min.	.1	61	1	<4	221	68
	Mode	.8	384	8	9	373	229
	Avg.	1.0	351	45	13	481	271