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*Verification of the Potential Yield and Chemical Quality  
of the Shallow Dolomite Aquifer  
in DuPage County, Illinois*

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INTRODUCTION

Scope of Study

Because of its responsibility for allocating the Lake Michigan water which Illinois is permitted to divert from the Great Lakes Basin, the Illinois Division of Water Resources must consider alternative sources of water available to the Chicago metropolitan region. In early 1979, the Division contracted with the Illinois State Water Survey to study the shallow dolomite aquifer in DuPage County, an important alternative source, to verify its potential yield. The plan of the investigation was to analyze the effects of continually increasing pumpage, and to identify areas of existing and potential problems and areas where additional pumpage can be developed.

In the summer of 1979, as part of this study, a detailed data collection program in the shallow dolomite was conducted over a 700-square-mile area, shown in figure 1. The area centered on DuPage County but also included parts of west and northwest Cook County, east Kane County, northeast Kendall County, and north Will County. It was bounded on the west by the Fox River and on the east and southeast by the Des Plaines River. Data obtained included pumpage from major water users and more than 1200 water level measurements. In addition, 282 water samples were collected for subsequent analysis.

The data collected have provided a base of analysis for the following purposes:

- To compare the 1979 piezometric surface map with an earlier piezometric map to show the effect of increased withdrawals on water levels.
- To delineate areas of over-utilization and areas showing little effect from existing pumpage.
- To compare the piezometric surface with the dolomite bedrock surface in order to identify areas where dewatering of the dolomite has taken place.
- To prepare a water budget taking into account pumpage, the potential yield, and the dewatering of both the dolomite aquifer and the overlying sand and gravel.

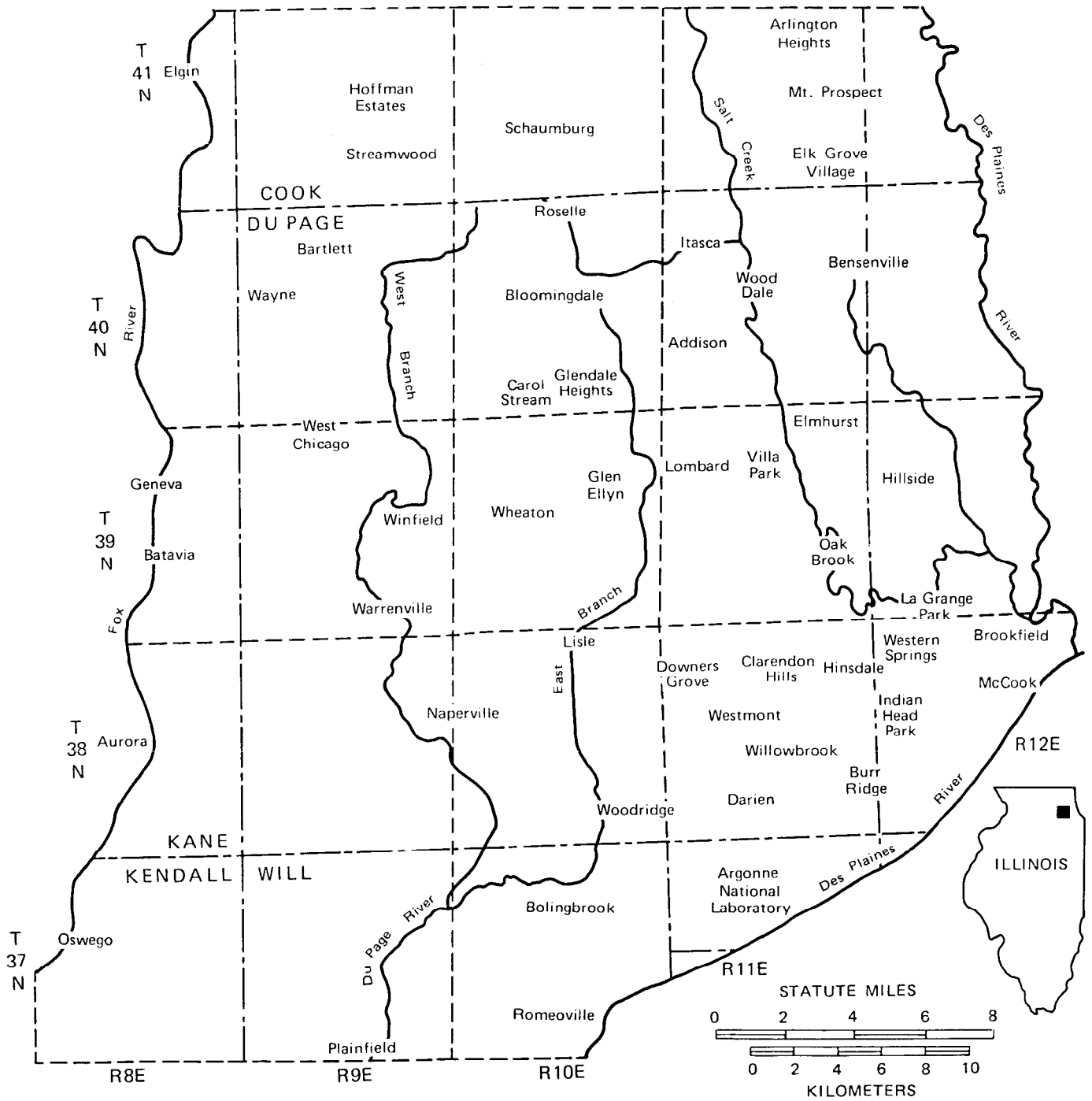


Figure 1. Location map of study area and selected communities

- To prepare chemical concentration maps for TDS, hardness, sulfate, chloride, sodium, total organic carbon, fluoride, total iron, and nitrate.
- To explore possible causes for increased chemical concentrations on a regional and time basis.

Zeizel et al. (1962) provided the first detailed report on the groundwater resources of DuPage County. A study by Sasman (1974) included a 1966 piezometric surface map as well as pumpage and other data concerning the dolomite aquifer in DuPage County. The map and data in Sasman's report were compared with data obtained during the present study in order to analyze the changes that occurred during the 13-year interval.

Prickett et al. (1964) presented an analysis of the shallow dolomite aquifer in the LaGrange area. This study also helped provide some comparisons with present conditions. The data obtained in this and other sections outside of DuPage County provided important basic information for these areas and insured that all regions affected by pumpage within DuPage County would be included in the investigation. Rivers on the east and west sides of the study area helped to assure reasonable hydrologic boundaries.

#### Acknowledgments

Special recognition needs to be given to the numerous individuals and organizations who provided access to their wells during the field work part of this project. Water levels were measured in more than 850 private, domestic wells, and water samples were collected from more than 100 of these wells. Water levels and water samples were collected from shallow dolomite wells in every municipality that has shallow wells in the area.

Most of the water level and samples from domestic wells were obtained by Don Arnold, Tim Larson, (Ralph Laukant), and Rebeccah Prastein, four area college students who were hired for the project. With no prior experience and only a brief orientation period, they performed an outstanding job, and the project could not have been completed in the allotted time span without their ready participation.

Special appreciation is also given to representatives of the Cook County and DuPage County Forest Preserve Districts, DuPage County Public Works Department, Argonne National Laboratory, and Fermi National Laboratory for assisting with water level measuring and sampling of numerous wells on their properties.

Jeanette Prastein reviewed most of the students' measurement calculations and tabulated much of the pumpage data. The Survey's graphic arts staff, under the guidance of John W. Brother, Jr., prepared all the final figures, Gail Taylor edited the final manuscript, and Debbie Hayn prepared the camera copy.

## GEOLOGY AND HYDROLOGY

For a detailed discussion of the geology and hydrology of the aquifers in northeastern Illinois, the reader is referred to Suter et al. (1959) and Zeizel et al. (1962). The following section is based largely upon those two reports.

Unconsolidated deposits, mainly glacial drift ranging in thickness from a foot or less to slightly more than 200 feet, overlie the bedrock in the area. Groundwater in the drift is obtained from sands and gravels that occur as surface deposits or more commonly as deposits underlying or interbedded with glacial till. Moderate to large supplies of groundwater are primarily encountered in sand and gravel at the base of the drift, directly above bedrock. Buried sand and gravel deposits, some associated with buried bedrock valleys, are present in northwestern Cook, northern DuPage, and northeastern Kane Counties. Areas with drift less than 50 feet thick, and poor possibilities for water-bearing sand and gravel, occur primarily in the southern and eastern part of the study area.

Groundwater in sand and gravel aquifers commonly occurs under leaky artesian conditions. Recharge to sand and gravel aquifers is derived mostly by vertical leakage of water from surface deposits through glacial drift deposits overlying the aquifers. Surface deposits are recharged locally from precipitation. Glacial drift aquifers in large areas of northeastern Illinois are in hydraulic connection with underlying shallow bedrock aquifers.

The bedrock immediately beneath the glacial drift consists almost entirely of dolomite rocks of Silurian age. Small areas of the bedrock surface in northern DuPage, eastern Kane, and northeastern Kendall Counties consist of rocks of the Maquoketa Formation.

Rocks of Silurian age are the Alexandrian Series overlain by the Niagaran Series. The thickness of the Silurian dolomite in the western part of the area ranges from less than 50 to 100 feet. It thickens to the east and southeast and is more than 300 feet thick in parts of west-central Cook County. Where valleys occur in the bedrock, the Silurian rocks are thin or missing. In many areas, especially where these rocks are more than 100 feet thick, Silurian dolomite wells yield several hundred gallons per minute.

Groundwater in the shallow dolomite aquifer occurs in joints, fissures, and solution cavities. The water-bearing openings are irregularly distributed both vertically and horizontally, and the yields of shallow dolomite wells vary greatly from place to place. Available geohydrologic data suggest that on a regional basis, the shallow dolomite is permeated by numerous fractures and crevices which extend for considerable distances and are interconnected. These rocks receive recharge from overlying glacial deposits, or directly from precipitation where they are not covered by the drift. The upper part of the aquifer is usually the most productive.

The Maquoketa Formation consisting of shale and dolomite rocks of Ordovician age underlies the Silurian rocks. The thickness of the Maquoketa Formation ranges from less than 100 feet in the western part of the area to more than 200 feet in much of northern and eastern DuPage County and in Cook County. Yields from this formation are usually very limited, although in some



areas the dolomite contributes moderate quantities of water to wells penetrating both Silurian and Maquoketa socks. The relatively impermeable shales of the Maquoketa Formation act as a partial barrier to the downward movement of groundwater from the Silurian dolomite aquifer into the deeper Cambrian-Ordovician aquifer.

The Cambrian-Ordovician and Mt. Simon Aquifers lie beneath the Maquoketa Formation and have been described in detail in many State Water Survey and Geological Survey reports including the report by Suter et al. (1959).

#### SHALLOW AQUIFER PUMPAGE

Combined dolomite and sand and gravel pumpage for public and major non-public supplies in the study area increased from 32.1 million gallons per day (mgd) in 1966 to 61.7 mgd in 1978, an increase of about 92 percent. Ninety-three percent of the 1978 shallow pumpage was from the dolomite aquifers. Table 1 shows the combined pumpage for the study area for the period 1966-1978.

Table 1 Shallow Aquifer Public and Major Non-Public Pumpage (mgd) in the Study Area, 1966-1978

County	1966	1967	1968	1969	1970	1971	1972
Cook	6.90	7.54	8.38	8.67	9.48	10.71	11.73
DuPage	24.00	24.86	27.74	28.74	31.62	34.14	35.12
Kane	.93	.94	1.03	1.02	1.08	1.30	1.47
Kendall	.01	.02	.01	.03	.03	.05	.06
Will	.28	.31	.51	.54	.52	1.09	1.57
Total	32.12	33.67	37.67	39.00	42.73	47.29	49.95
<i>County</i>	1973	1974	1975	1976	1977	1978	
Cook	11.79	11.79	12.36	11.80	11.52	10.78	
DuPage	38.39	36.24	39.64	42.95	44.39	45.79	
Kane	1.54	1.42	1.44	1.36	1.34	1.30	
Kendall	.06	.07	.09	.09	.05	.07	
Will	2.13	2.39	3.66	3.55	3.71	3.75	
Total	53.91	51.91	57.19	59.75	61.01	61.69	

During this same period, pumpage in DuPage County increased from 24 to 45.8 mgd, an increase of about 91 percent. Ninety-five percent of the 1978 shallow aquifer pumpage in DuPage County, or 43.5 mgd, was from the dolomite. Schicht et al. (1976) calculated the potential yield of these shallow aquifers in DuPage County to be approximately 44.4 mgd.

Bensenville is the only municipality within the study area that has always obtained all of its water from deep wells. Nine public water supplies in DuPage County (Addison, Glendale Heights, Glen Ellyn, Hinsdale, Lisle, Warrenville, Wheaton, Winfield, and Woodridge), three in Cook County (Burr Ridge, Indian Head Park, and LaGrange Highlands), and one in Will County (Bolingbrook) have always obtained all of their water from shallow wells. Downers Grove and Itasca have obtained all of their water from shallow wells for more than 40 years. Batavia and Geneva, on the edge of the area in Kane county, obtain all of their water from deep wells. All of the other municipalities in the area obtain water from both shallow and deep wells in widely ranging proportions. Figure 1 shows the general location of most of the municipalities in the area pumping significant volumes of water from the shallow aquifers.

#### PIEZOMETRIC SURFACE, 1979

In order to determine areas affected by groundwater withdrawals and directions of groundwater movement in the Silurian dolomite aquifer, a piezometric surface map was prepared from nonpumping water levels measured in wells during the summer of 1979 (figure 2). The map represents the elevation to which water will rise in a well completed in the Silurian dolomite aquifer. In a few instances, wells are open to basal sand and gravel deposits above the dolomite bedrock. The basal sand and gravel is in direct contact with the dolomite, and the two formations act as one hydrologic unit. The direction of groundwater movement is at right angles to the elevation contour lines. Groundwater movement in the entire area is in all directions from high elevations toward streams, well fields, and quarry dewatering areas (see figure 2).

Before significant groundwater development, the groundwater levels were generally above surface water levels in rivers and streams, and groundwater discharged into these surface waters throughout the region. A significant portion of streamflow was derived from groundwater.

Due to groundwater withdrawals, water levels in numerous areas have lowered considerably below stream level, resulting in reductions in streamflow. In these areas surface water percolates through the stream bed and into the dolomite aquifer. In 1979, shallow dolomite water levels were above those of the surface waterways in only a few areas (along some reaches of the Fox, DuPage, and Des Plaines Rivers and Salt Creek).

Heavy, concentrated groundwater withdrawals have produced cones of depression in many parts of the area. The most significant cones of depression

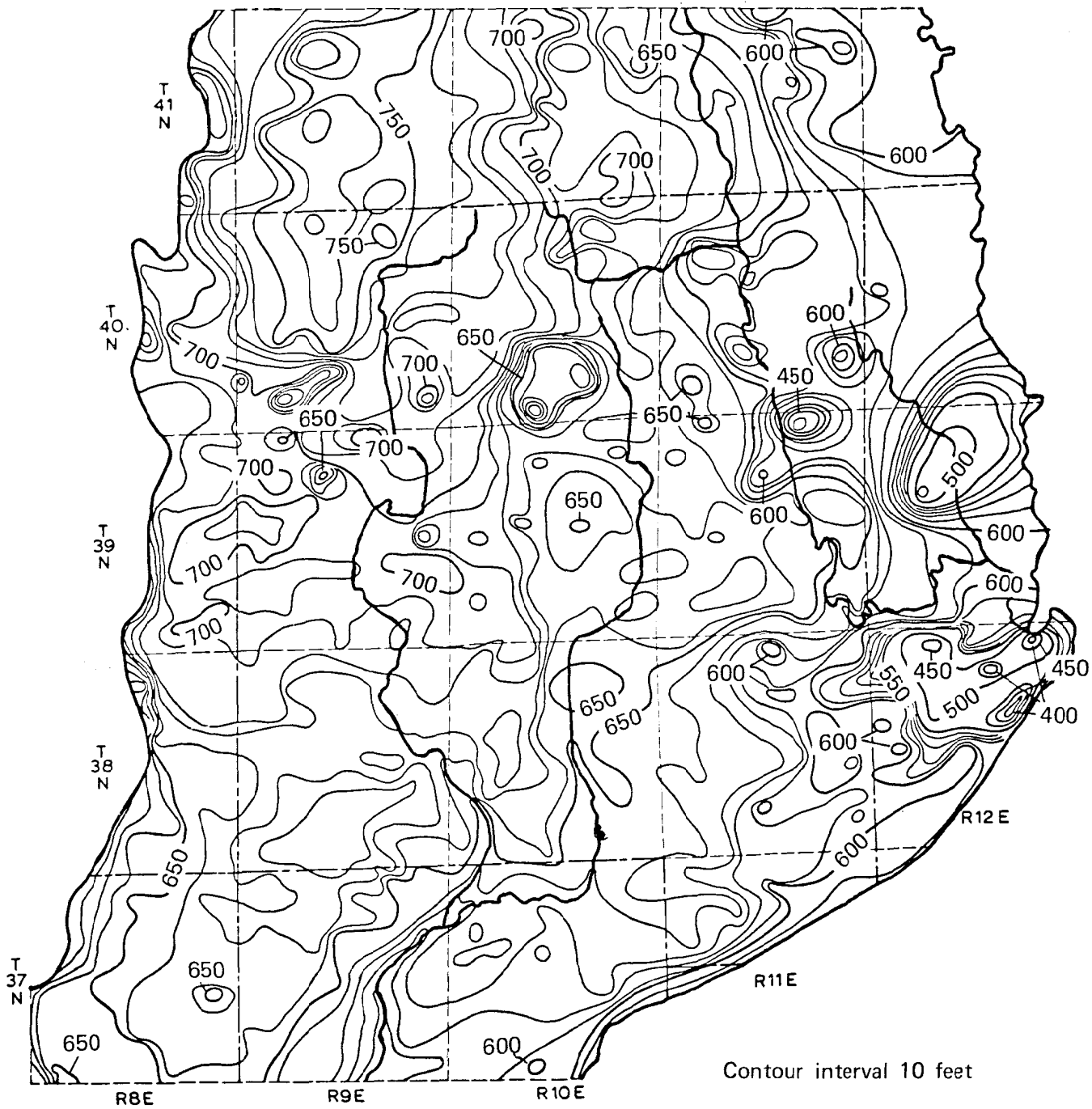


Figure 2. Piezometric surface of the shallow dolomite aquifer during the summer of 1979

are at and adjacent to rock quarries at McCook-Lyons, Elmhurst, and Hillside. Dewatering pumpage at these quarries has been continuous for more than 80 years.

In addition to the effects of quarry dewatering at McCook-Lyons and Elmhurst, heavy well pumpage in these areas has also contributed greatly to lower piezometric surface elevations. Other significant cones of depression can be attributed to pumpage from wells around the communities of Itasca, Wood Dale, Addison, West Chicago, and Glendale Heights. Pumpage has caused major piezometric surface cones of depression in a large area of southeast DuPage County. Numerous smaller cones of depression and distorted contours occur throughout the area as a result of heavy local or regional pumpage.

The average slope of the piezometric surface ranges from a low of about 10 feet per mile in areas of small to moderate pumpage to more than 25 feet per mile near and within major cones of depression.

An analysis of the piezometric surface for 1979 indicated that about 68 percent of the study area was influenced by groundwater withdrawals from the Silurian dolomite aquifer. Figure 3 shows approximate boundaries of areas influenced by pumpage and the total amount of pumpage from major wells and well fields within the identified areas. In DuPage County about 80 percent of the area was influenced by groundwater withdrawals.

#### CHANGES IN WATER LEVELS, 1966-1979

Comparison of the 1966 (figure 4) and 1979 (figure 2) piezometric surface maps for DuPage County and part of western Cook County indicates the water level change during the 13-year period. Areas of water level change are shown in figure 5. More than 98 square miles, or 30 percent of DuPage County, experienced a decline of more than 10 feet. About 8.5 square miles had declines of more than 30 feet. In a few areas, declines of more than 50 feet were recorded.

The most dramatic area of water level decline in DuPage County is in the Glendale Heights area in the north central part of the county. More than 3 square miles have had a decline of over 30 feet. Other large areas of significant decline are in the Carol Stream-Bloomington-Roselle area, the Itasca-Wood Dale-Addison area, the Wheaton-Glen Ellyn area, and the Hinsdale-Clarendon Hills-Westmont-Willow Brook-Darien-Burr Ridge area. Numerous other pumping centers throughout the county have experienced noticeable declines during the past 13 years.

In the 98 square miles of DuPage County where water levels have declined 10 feet or more, the average rate of decline during the past 13 years has been approximately 1.5 feet per year. For all of DuPage County, water levels have declined an average of about 0.5 feet per year.

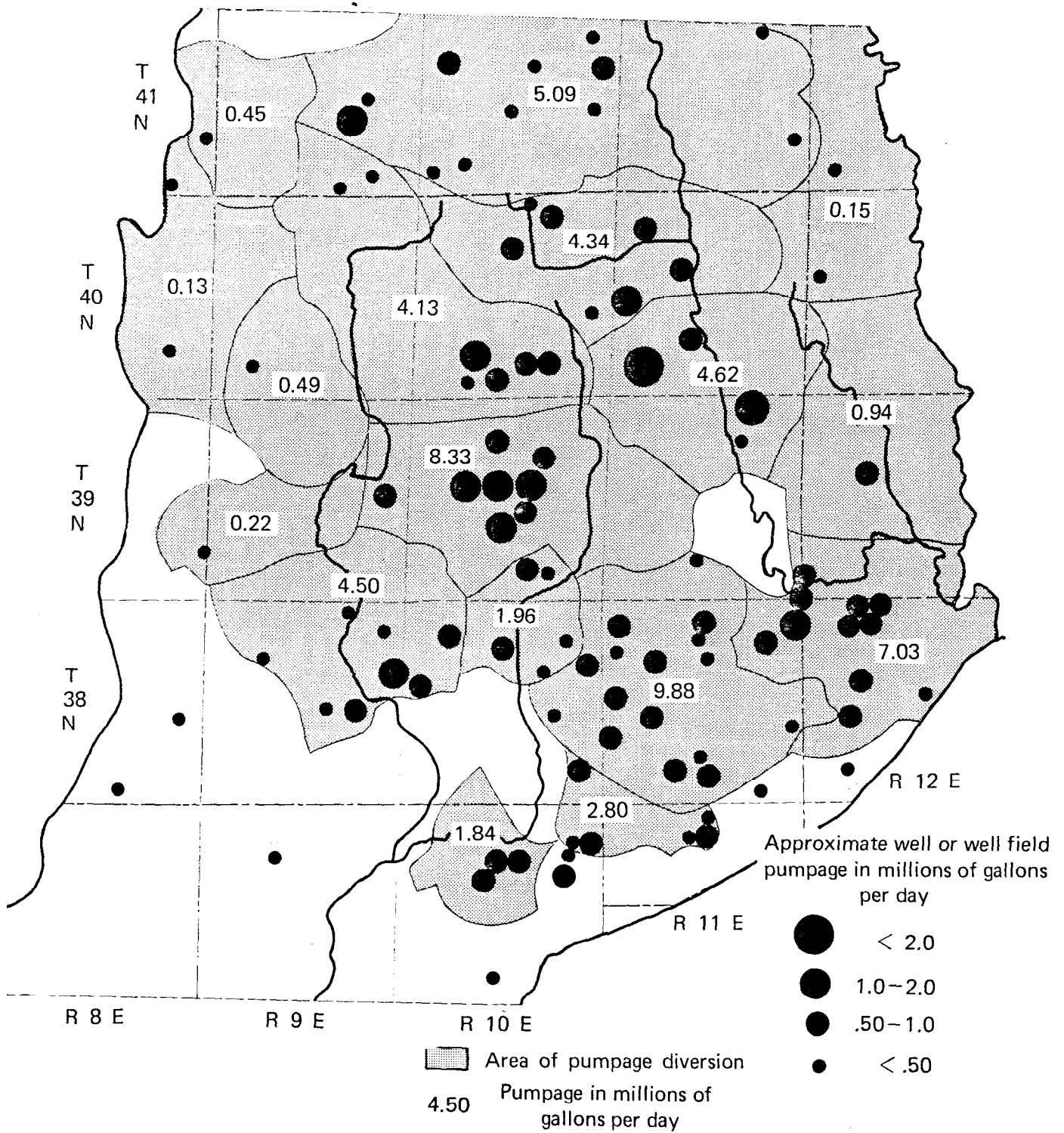


Figure 3. Areas influenced by groundwater withdrawals in 1979

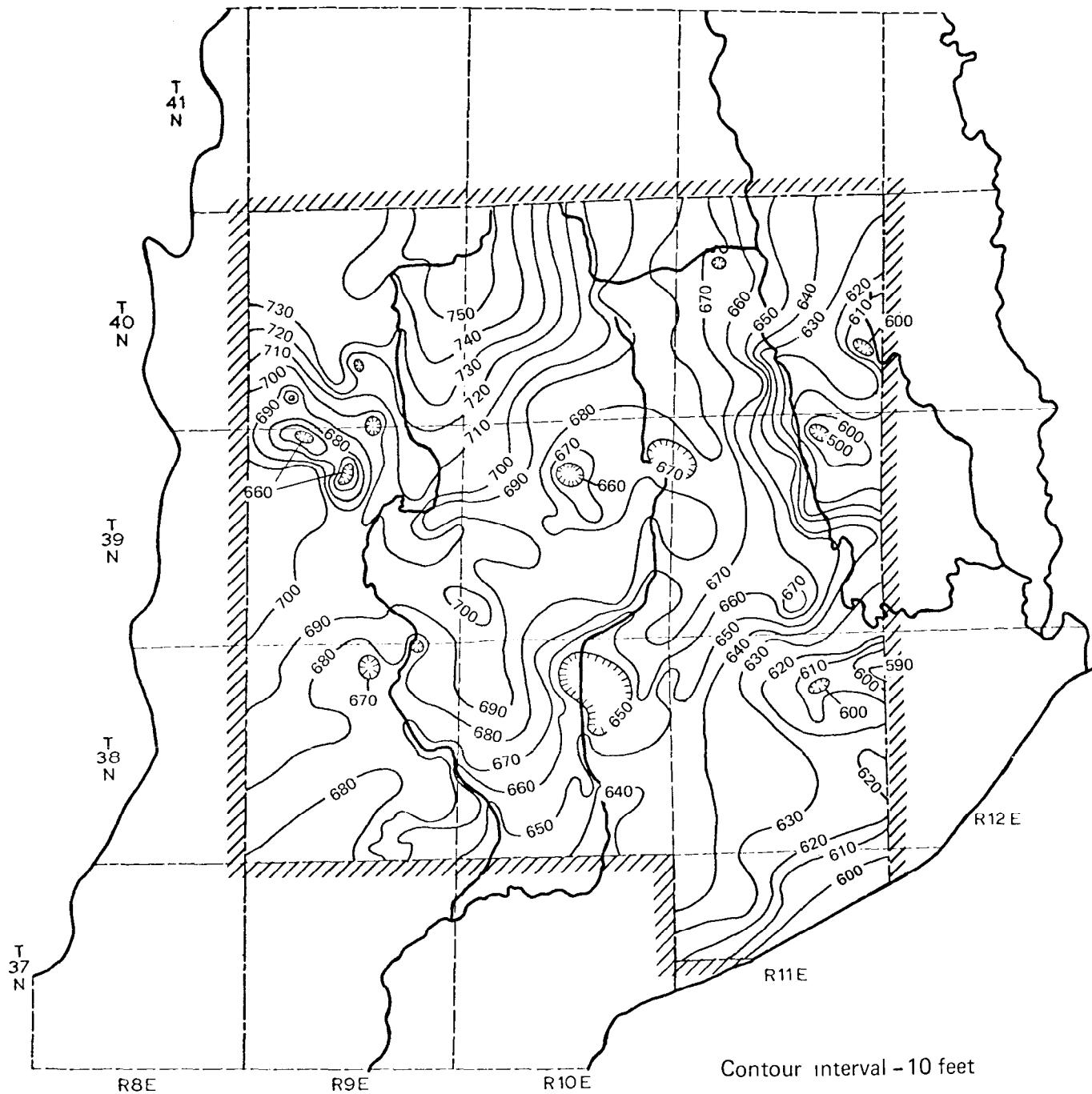


Figure 4. Piezometric surface of the shallow dolomite aquifer in DuPage County, 1966

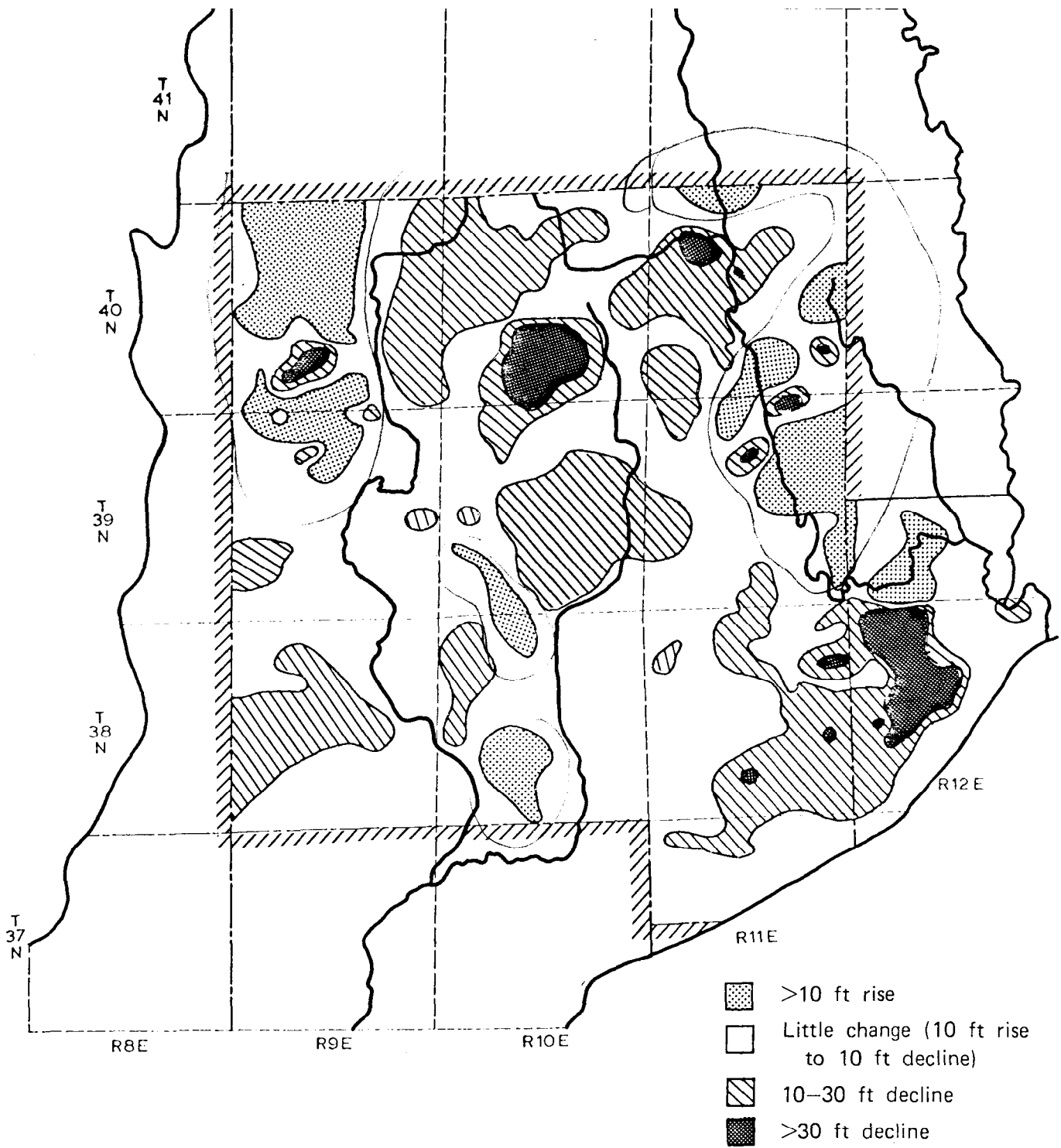


Figure 5. Change in piezometric surface in DuPage County and part of Cook County, 1966-1979

An area of approximately 13 square miles in western Cook County also had a water level decline of more than 10 feet. In much of this area (6.3 square miles), the decline was more than 30 feet.

Water level declines in Cook County are primarily due to water withdrawals at the quarries and to withdrawals for public supplies at LaGrange, LaGrange Highlands, and Indian Head Park. Numerous additional public, industrial, and commercial groundwater supply systems have contributed to the lowering of water levels in this area. During the past 13 years, water levels in this part of Cook County have declined at a rate of approximately 2.3 feet per year.

Comparison of the two piezometric maps (figures 2 and 4) indicates several areas where water levels have risen more than 10 feet since 1966. In the vicinity of West Chicago and Elmhurst-Oak Brook, rises in water levels reflect decreased withdrawals from dolomite wells. In other areas, indicated rises in water levels may be due to collection of more detailed data in 1979 or to variations in precipitation.

Water level measurements in individual wells also provide an indication of water level fluctuations over a period of time. Water level fluctuations in shallow dolomite and sand and gravel wells are influenced by a number of factors, including frequency and duration of the pump operation cycle, pumping rate, influence from other wells in the area, hydrologic and geologic characteristics of the rock formation, and short- and long-term variations in weather conditions (recharge).

Figures 6, 7, and 8 present water level hydrographs of several wells for periods of 7 to 20 years. Water levels in 6 of these wells are measured monthly or recorded on continuous recording instruments. They show considerable variation, ranging from slight rises or essentially no change in a few wells to a decline of more than 100 feet in a well near LaGrange (Figure 7). Five of the selected wells have average declines ranging from 1.2 to 8.5 feet per year for the period 1966-1979. Four others have average declines of 0.1 to 0.9 feet per year. Four wells have no significant change of water level during recent years.

#### WATER LEVEL-BEDROCK SURFACE RELATIONSHIP

Past experience indicates that a great potential exists for a significant decline in well yields when the water level lowers below the top of the dolomite. Previous analysis of well production tests by Zeizel et al. (1962) indicates a higher yield per foot of formation in the upper part of the dolomite aquifer. Data suggest that at least 12 communities in the metropolitan area have experienced intermittent or continuous loss of capacity



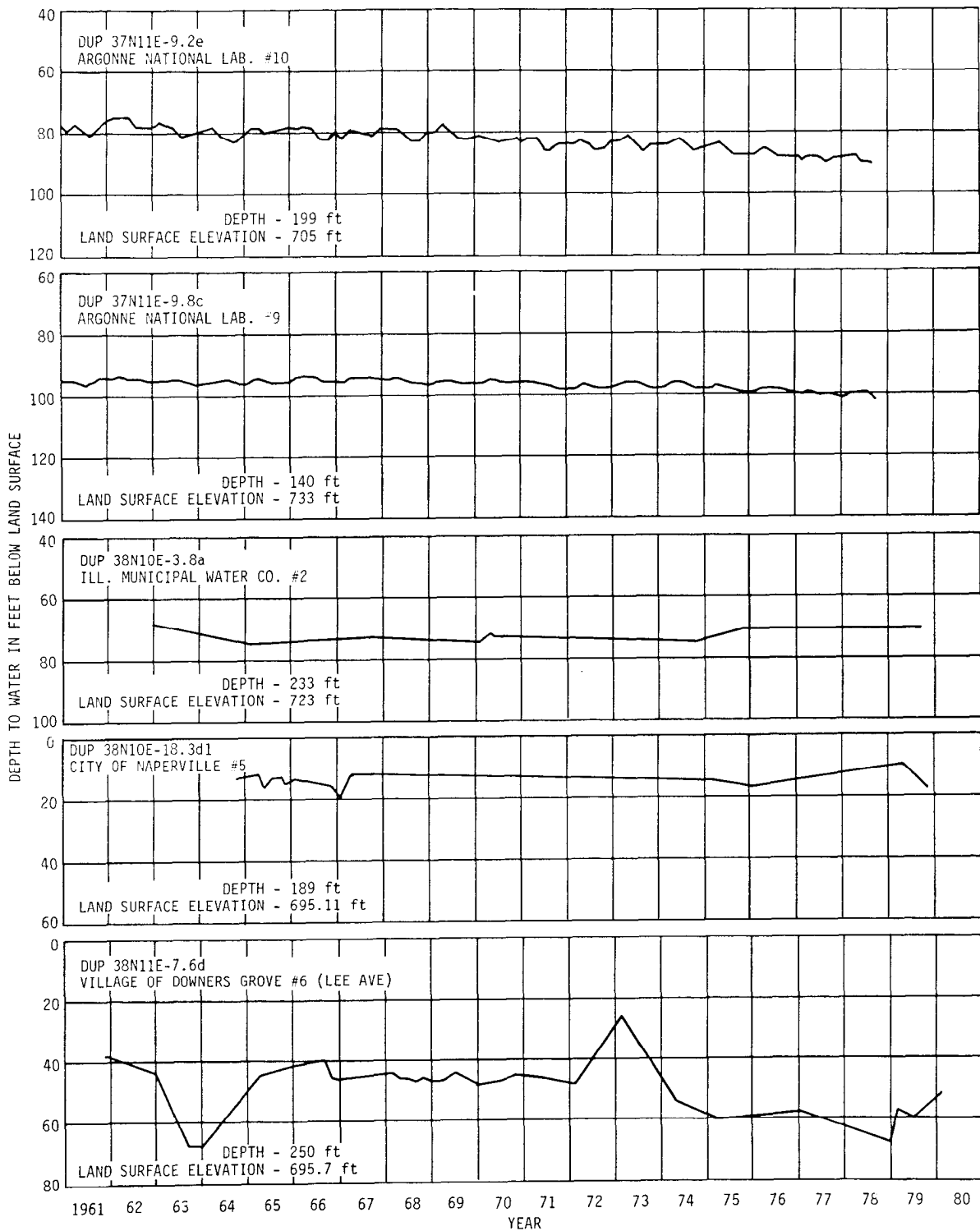


Figure 6. Hydrographs of water levels in selected wells

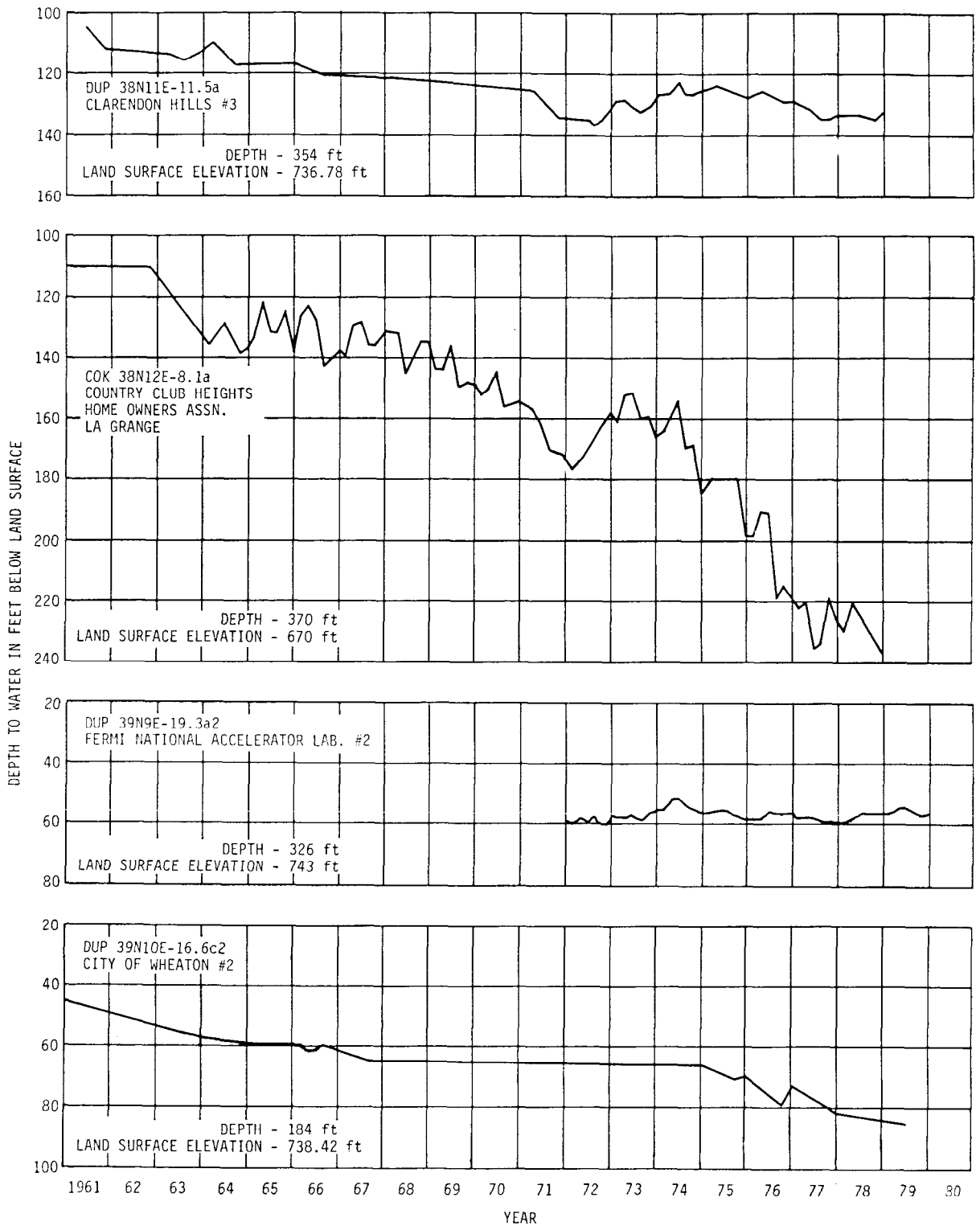


Figure 7. Hydrographs of water levels in selected wells

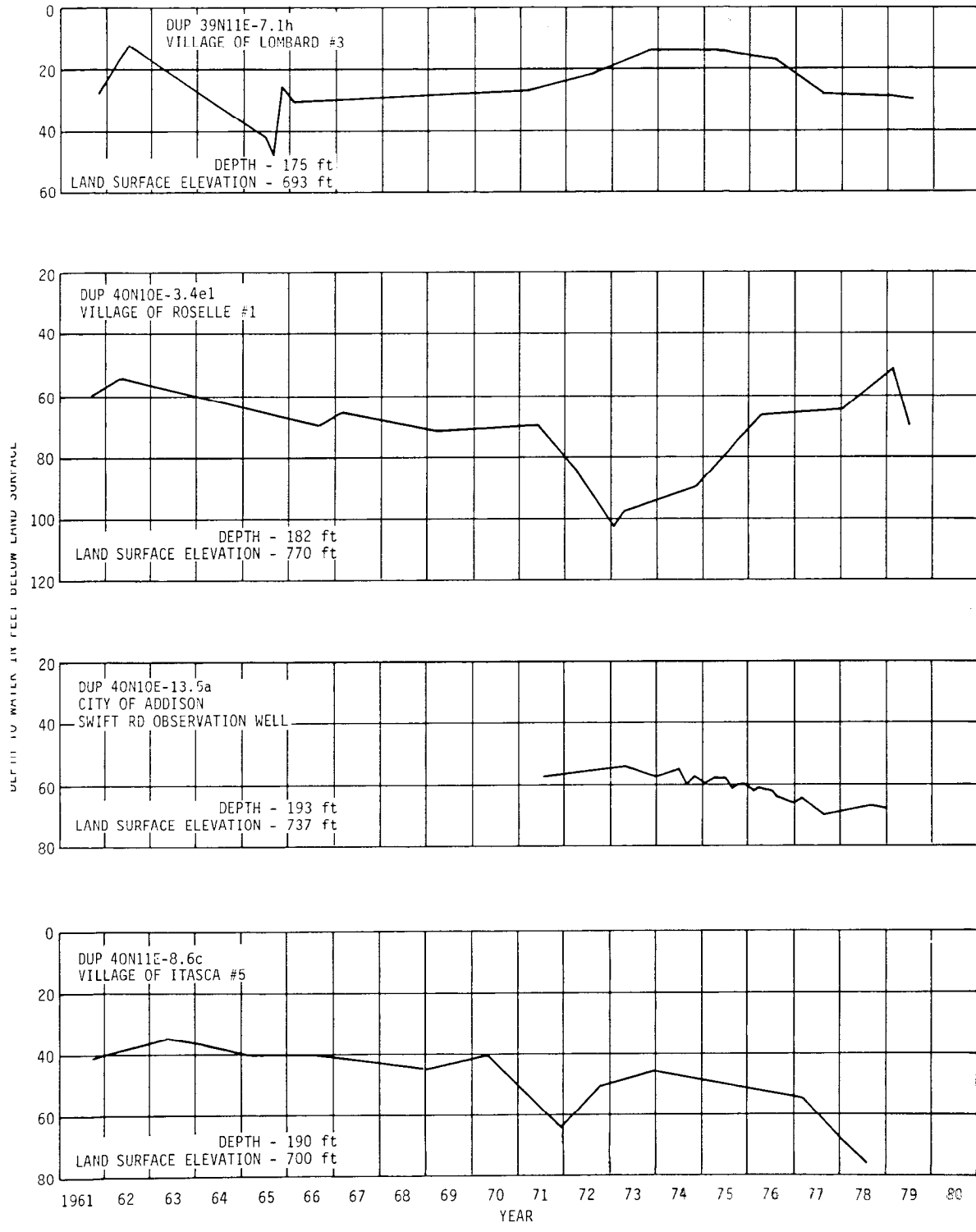


Figure 8. Hydrographs of water levels in selected wells

as a result of partial aquifer dewatering. Nearly all of the communities are in the west suburban area, and most are in DuPage County. They are:

Addison	Lisle
Clarendon Hills	Oak Brook
Downers Grove	Schaumburg
Glen Ellyn	Villa Park
Hinsdale	West Chicago
Itasca	Wood Dale

To determine areas where the dolomite has been dewatered, piezometric surface maps were compared with the map of the bedrock surface (figure 9). The 1979 water level-bedrock surface relationship map is shown in figure 10. Water levels have been lowered below the top of the rock over more than 77 square miles, or 11 percent of the entire area. Water levels are more than 50 feet below the bedrock surface for over 14 square miles and more than 100 feet below the bedrock surface for over 6 square miles. An average thickness of nearly 39 feet of rock has been dewatered for 77 square miles.

The largest areas and thickest sections of dewatered dolomite are associated with the quarry operations in the east and southeast parts of the region. Heavy well pumpage, primarily for public supplies, has greatly expanded the area in the southeast. This one area accounts for more than 25 square miles.

Other significant areas of dewatered rock, due primarily to pumpage for public supplies, are in the north central and south central areas of DuPage County. A few areas are associated with high bedrock surface elevations.

By 1979, water levels in DuPage County were below the bedrock surface over more than 28 square miles. This is approximately 8.6 percent of the county area. The average thickness of dewatered rock is about 27 feet.

A 1966 water level-bedrock surface relationship map was also prepared (figure 11). Data from the 1966 and 1979 maps (figures 10 and 11) permit calculation of the volume of rock dewatered during the 13-year period. This area increased from approximately 19 to 28.5 square miles, or nearly 50 percent. The average thickness of the additional 9.5 square miles of dewatered rock was 27.6 feet.

#### WATER LEVEL-BASAL SAND AND GRAVEL RELATIONSHIP

Yields of dolomite wells have generally been higher in areas where the overlying glacial drift contains moderate to thick deposits of sand and gravel in close proximity to the bedrock surface. Thus it is reasonable to expect an even greater loss of well capacity where dewatering of sand and gravel has taken place above dewatered bedrock.

In order to identify these areas, a review was made of well logs in these areas of dewatered rock. Of particular interest were those logs that showed 10

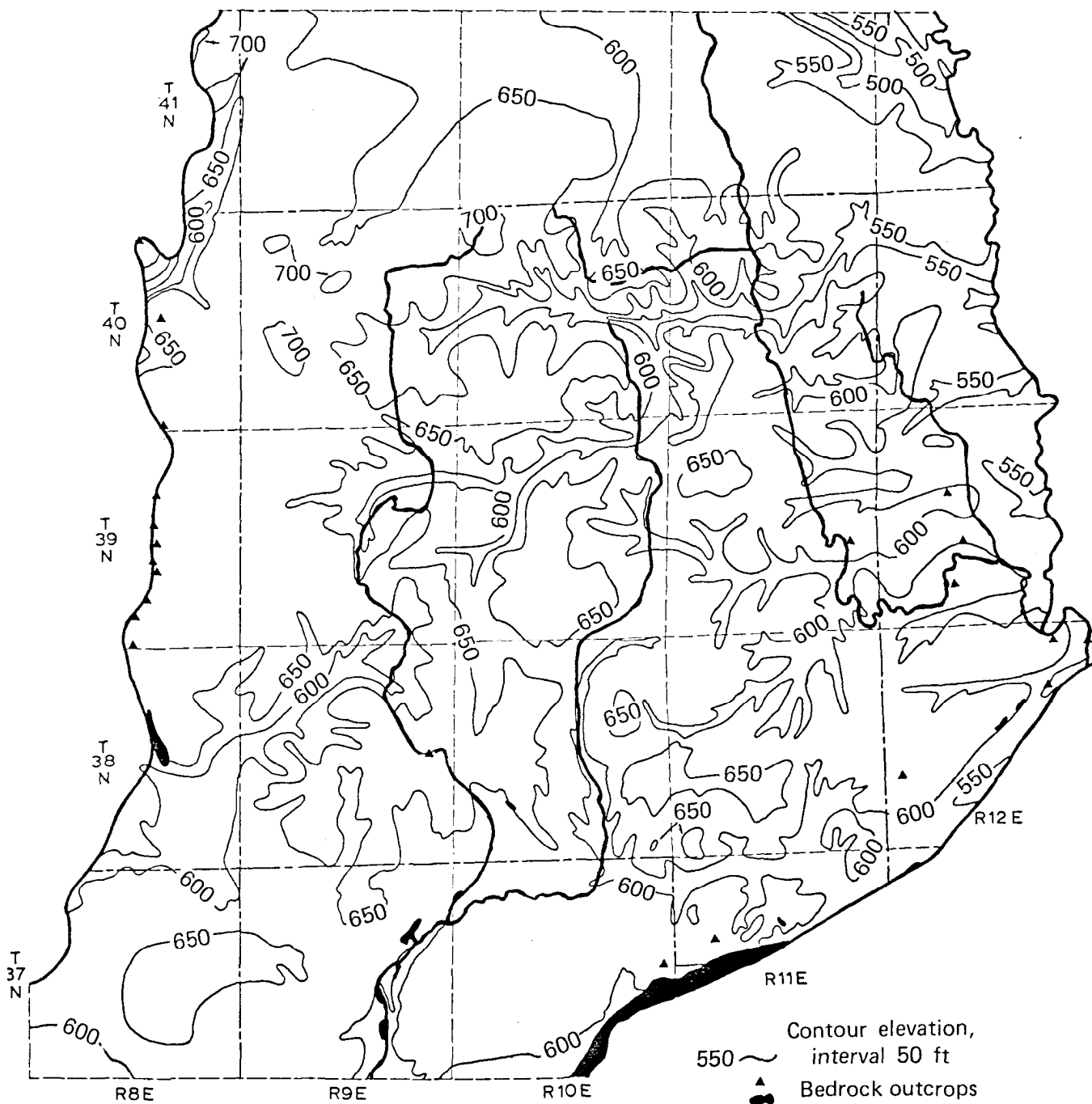


Figure 9. Bedrock surface (after Zeizel et al., 1962)

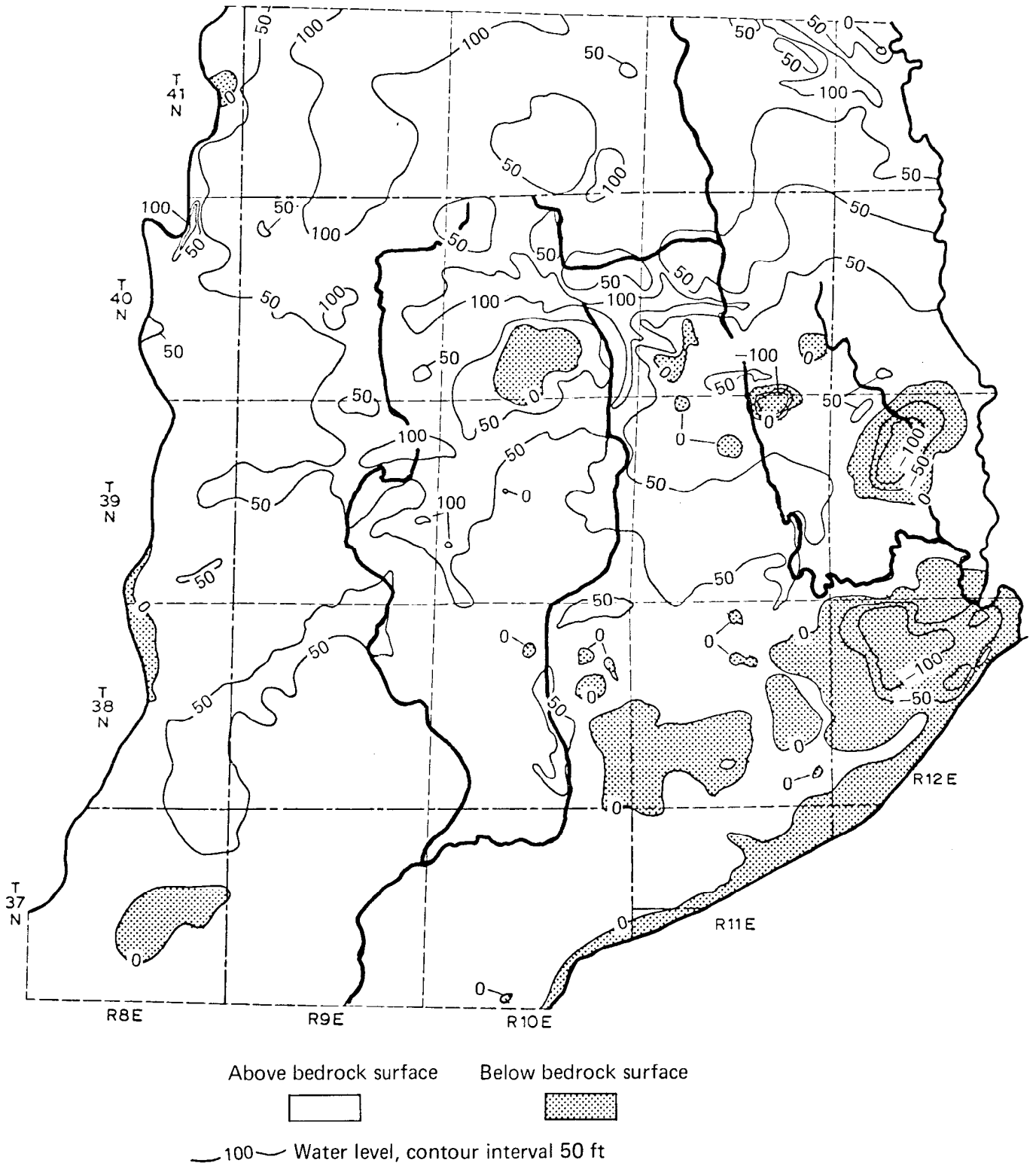


Figure 10. Water level-bedrock surface relationship in 1979

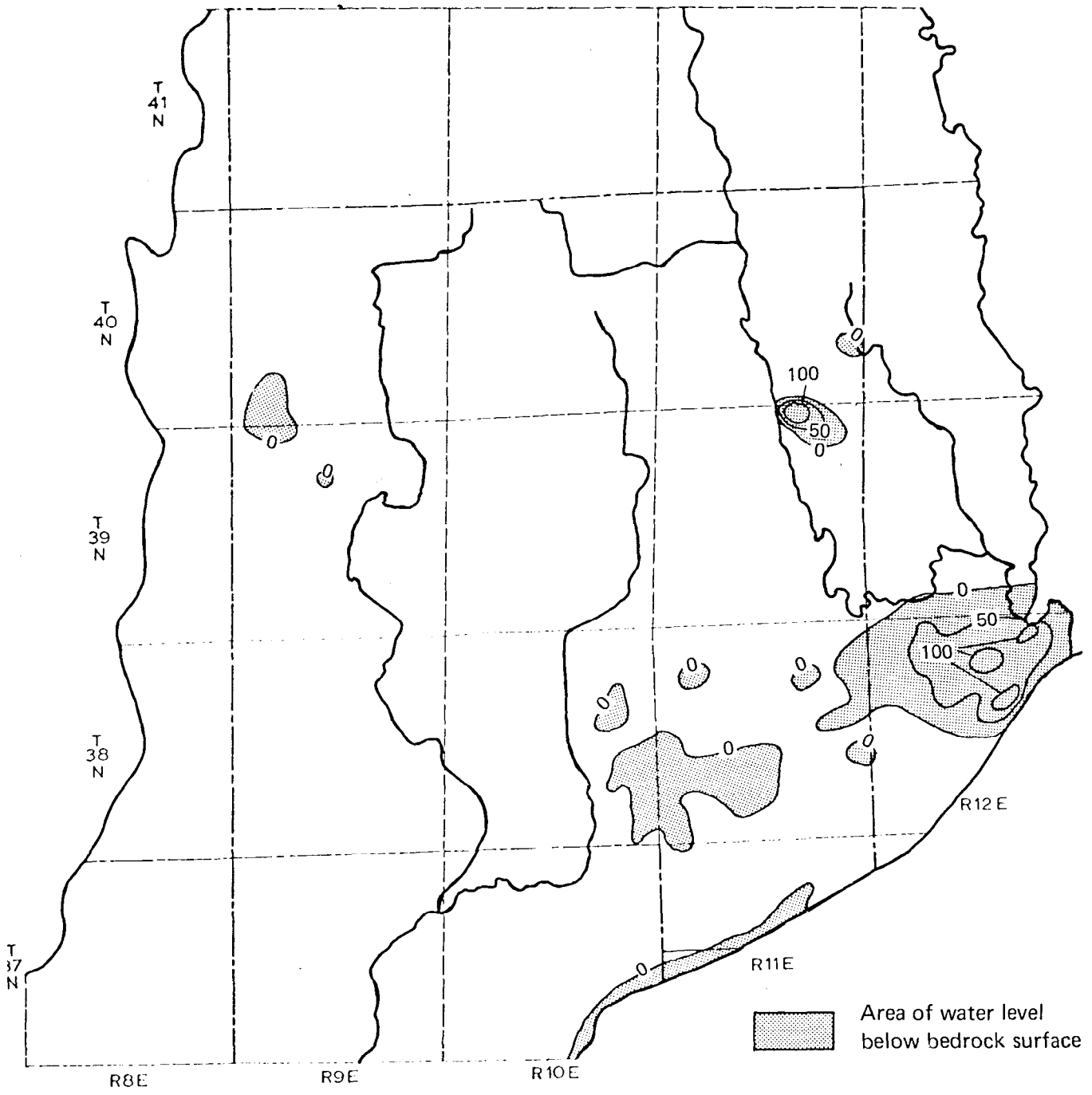


Figure 11. Water level-bedrock surface relationship in 1966

or more feet of sand and gravel immediately above the bedrock. These data were then compared with the 1966 and 1979 water level-bedrock surface relationship maps.

It is estimated that of the 28.5 square miles in DuPage County where dolomite dewatering had occurred by 1979, approximately 10 square miles or 35 percent of the area contained basal sand and gravel deposits at least 15 feet thick. The average thickness was approximately 30 feet. About 40 percent of this area, or 4 square miles, was dewatered during the period 1966-1979. Since the water level was below the bedrock surface over this entire area, it can be assumed the entire thickness of sand and gravel has been dewatered.

#### WATER BUDGET

The potential yield of an aquifer is defined as the maximum amount of groundwater that can be developed from a reasonable number of wells and well fields without creating critical water levels or exceeding recharge. A previous study by Schicht et al. (1976) gave the potential yield of the shallow aquifers in DuPage County as 44.4 mgd. In order to verify previous analyses, a groundwater budget for DuPage County was prepared by balancing withdrawals against potential yield plus the volume of material dewatered multiplied by the specific yield.

Groundwater withdrawals from the shallow aquifers in DuPage County averaged 36.7 mgd during the past 13 years; 34.3 mgd was from dolomite and 2.4 mgd was from sand and gravel.

The volume of rock dewatered during the 13-year period is  $7. \times 10^9$  cu ft (9.5 square miles x 27.6 ft). At least an additional  $3.3 \times 10^9$  cu ft (4.0 square miles x 30 ft) of sand and gravel has been dewatered.

Todd (1959) defines specific yield as the ratio expressed as a percentage of the volume of water which can be drained by gravity after saturation to its own volume. According to Todd, and based on the experience of the authors, a specific yield of 20 percent for sand and gravel is reasonable. Less information on the specific yield of dolomite is available. The equation given below was solved to determine the specific yield of dolomite bedrock.

$$Q = R \times a + \frac{V_d \times 7.48 \times Y_{gd}}{t} + \frac{V_s \times 7.48 \times Y_{gs}}{t}$$

where

Q = average withdrawals, 1966-1979 = 36.7 mgd

R = potential yield = 39.4 mgd\*

\*Reduced by 5 mgd, which is estimated to be the recharge to surficial sand and gravels. The average withdrawals (Q) include sand and gravel pumpage which is from wells finished in basal sand and gravel.



a = percent of potential yield diverted into cones of depression, 90 percent

$v_d$  = change in volume of dewatered rock =  $7.3 \times 10^9$  cu ft

$v_s$  = change in volume of dewatered sand and gravel =  $3.3 \times 10^9$  cu ft

$Y_{gd}$  = specific yield for the dewatered rock = unknown

$Y_{gs}$  = specific yield = 0.2 for sand and gravel

7.48 = gal/cu ft

t = 13 years, 1966-1979 x 365 days per year

The specific yield of the dolomite bedrock was computed to be 0.017. This would appear to be a reasonable value when compared with the value of 0.03 given by Prickett et al. (1964) for the Chicago Heights area.

Pumpage over most of DuPage County is in excess of the potential yield. In order to balance the demand with the available supply, approximately 5.9 billion gallons has been withdrawn from storage within the dolomite and sand and gravel aquifers. This is equivalent to an average pumpage of 1.2 mgd during the past 13 years.

#### WATER QUALITY

During the summer of 1979, approximately 282 public, commercial, and private domestic water wells finished in the Silurian dolomite aquifer in the study area at depths ranging from 66 to 500 feet (see figure 12) were sampled to obtain information on the areal distribution of the major dissolved inorganic chemical constituents and total organic carbon. Roughly 44 percent of the samples collected were from public supplies, 39 percent were from industrial or commercial wells, and the remaining 17 percent were from private domestic wells. Data for total dissolved solids (TDS), hardness (as  $CaCO_3$ ), sulfate, chloride, sodium, total organic carbon (TOC), fluoride, total iron, and nitrate were plotted and hand-contoured.

There are many factors which can affect the chemical composition of a water sample collected from a particular well, and it is impossible to delineate all of the conditions which may be significant for all wells sampled. However ) some general comments regarding groundwater quality sampling are appropriate.

Samples collected from high capacity wells, such as most public and industrial water supply wells, represent an "average" groundwater quality for a

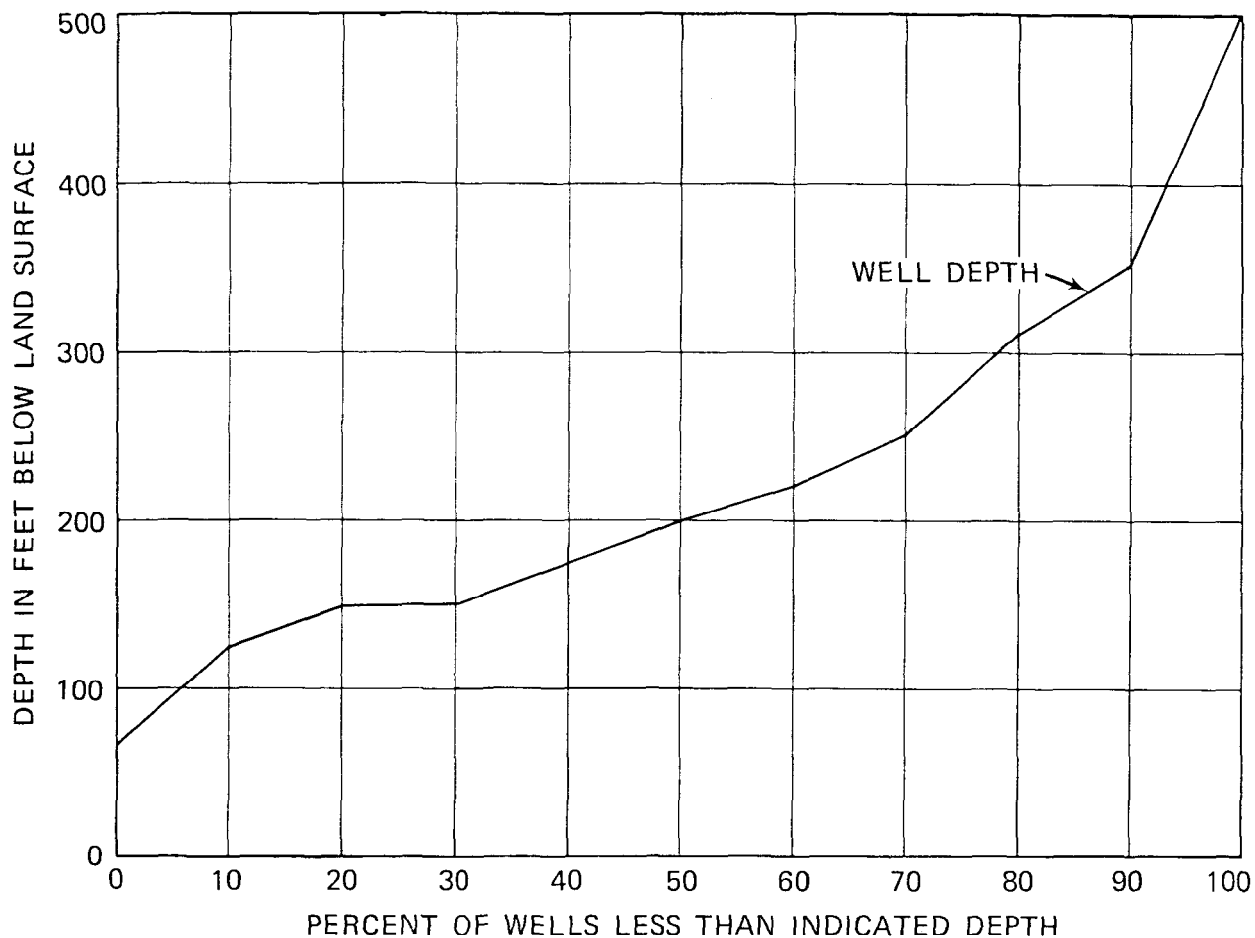


Figure 12. Frequency distribution of well depths

cone of influence which may be quite large. Leachate from a pollution source located in a well's cone of influence may represent a very small portion of the water produced by the well. Significant dilution of the polluted recharge by large volumes of less mineralized water may result in a sample with low concentrations of chemical constituents. In these cases, the water quality in the immediate vicinity of the pollution source is masked.

Similar to this areal averaging, vertical integration also may occur as water from a more highly mineralized production zone is diluted by water from other less mineralized water-yielding zones open to the well. When comparing data from many wells, an undefined amount of error is introduced because the volume of aquifer tapped and the effects of dilution vary among the wells sampled.

Although the results of the sample analyses are treated as point values, it is important to understand that in reality they represent average concentrations for a certain unknown volume of the aquifer which primarily

depends on the depth of the well in question, the hydraulic conductivity of the aquifer, and the rate of pumping. Despite these potential sources of variability and uncertainty, the results of the sample analyses can provide valuable information regarding present-day patterns in the regional distribution of the chemical parameters of interest.

The geohydrologic conditions which exist in northeastern Illinois result in a moderate to high potential for contamination of the Silurian dolomite aquifer. In fact, if the lowest concentrations measured in the study area are assumed to represent base-line conditions, the results of the chemical analysis of the collected samples reveal significant groundwater quality degradation in the southeastern quadrant of the study area.

Concentrations of total dissolved solids (TDS), hardness (as CaCO<sub>3</sub>), sulfate, chloride, sodium, and total iron in samples from this region are high. In many cases they are several times greater than the applicable primary (mandatory) or secondary (suggested) standards for finished drinking water. On a local scale, higher values for most of the nine chemical parameters of interest are also found in the immediate vicinity of the major municipalities in the central and western portions of the study area.

Of the nine parameters studied, only fluoride and nitrate exhibited areal distribution markedly different from the other seven constituents. Fluoride concentrations were highest in the southwestern corner of the study area while nitrate was greatest in the south and south-central regions. Generally, the lowest concentrations of most of the nine parameters studied are located in the western and southwestern regions between the Fox River and the West Branch DuPage River.

The areal distributions of the chemical parameters indicate that groundwater quality in the shallow dolomite aquifer is related to the density of development of aquifer pumpage and of the overlying land surface. That is, the greatest concentrations generally are found in those areas with the greatest development, for example in the southeastern portion. Conversely, the lowest concentrations seem to occur in those areas where the land surface and the aquifer itself are less densely developed. In these less developed areas, there are no large zones of influence for wells to collect "pollutants" from large areas at the land surface, and there are fewer sources of "polluted" recharge.

The age of development may also be a factor. For example, the highly mineralized southeastern portion has been heavily developed for several decades, while a newly developed area near Glendale Heights is just beginning to exhibit higher concentrations of minerals.

Notably, aquifer dewatering is occurring in several of those areas exhibiting the "worst" groundwater quality, though a causal relationship is not necessarily indicated. The effects of aquifer dewatering on groundwater chemistry are complex, but it has been shown that the aeration of a volume of aquifer which was previously under anaerobic conditions can lead to increases in certain dissolved minerals.

In addition, dewatering can result in markedly decreased well yields from the Silurian dolomite, as the most productive part of the aquifer is usually in the upper zones of the formation. If the higher concentrations in the southeastern areas are due to one or more surface sources of pollution, then the decrease in well yields caused by the dewatering of the aquifer could result in less dilution of the highly mineralized recharge water.

Abandoned and active landfills may be sources of polluted recharge in the study area. In the past, common practice was to utilize existing excavations for waste disposal. Because their potential for polluting groundwater was not fully recognized, quarries and gravel pits often were considered "ideal" for disposal of municipal and/or industrial waste materials. Disposal of wastes directly into or onto the Silurian dolomite aquifer near the study area has been documented in several cases (Cunningham et al., 1977; Maynard, 1977; Shuster, 1976) and probably has occurred in numerous undocumented instances. These waste disposal sites, combined with those in the glacial drift, may be affecting the chemical quality of the groundwater contained in the highly-creviced dolomite aquifer.

It should be noted that those areas which are the most severely dewatered also are areas where the glacial deposits are thin and the dolomite aquifer is very close to the land surface. Less attenuation of non-conservative solutes occurs in areas of thin drift. Contaminants from the surface may enter the dolomite aquifer more quickly and move rapidly toward points of withdrawal or nearby streams.

The higher concentrations of dissolved minerals in the southeastern portion of the study areas may be related to the thickness of the glacial drift covering the dolomite aquifer, the dewatering of the aquifer, and the development of the overlying land surface. Conversely, a portion of the low TDS area in the southwestern region also has been dewatered (see figure 13). However, the dewatering has not affected the water quality, implying that the degree of land and aquifer development and the presence of pollution sources may be more important than dewatering as determinants of groundwater quality in the study area.

It is obvious that a combination of several factors are responsible for the areal distribution of groundwater quality parameters. It must be kept in mind that the effects of human activities have been superimposed upon the "natural" patterns of chemical distribution that existed before development. The resulting composite patterns have been further disturbed by other activities such as heavy pumping and dewatering, quarrying, and mining of sand and gravel deposits. The extreme variability in the geohydrologic properties of fractured dolomite also adds to the difficulty in interpreting chemical data. In addition, the pre-development chemical conditions in the aquifer are virtually unknown, and it is difficult to determine the significance of the numerous factors affecting the water quality patterns of the aquifer.

Regardless of these difficulties, the collected data reveal water quality problems for a significant portion of the study area which eventually may affect water treatment costs and aquifer usability. In light of these results,

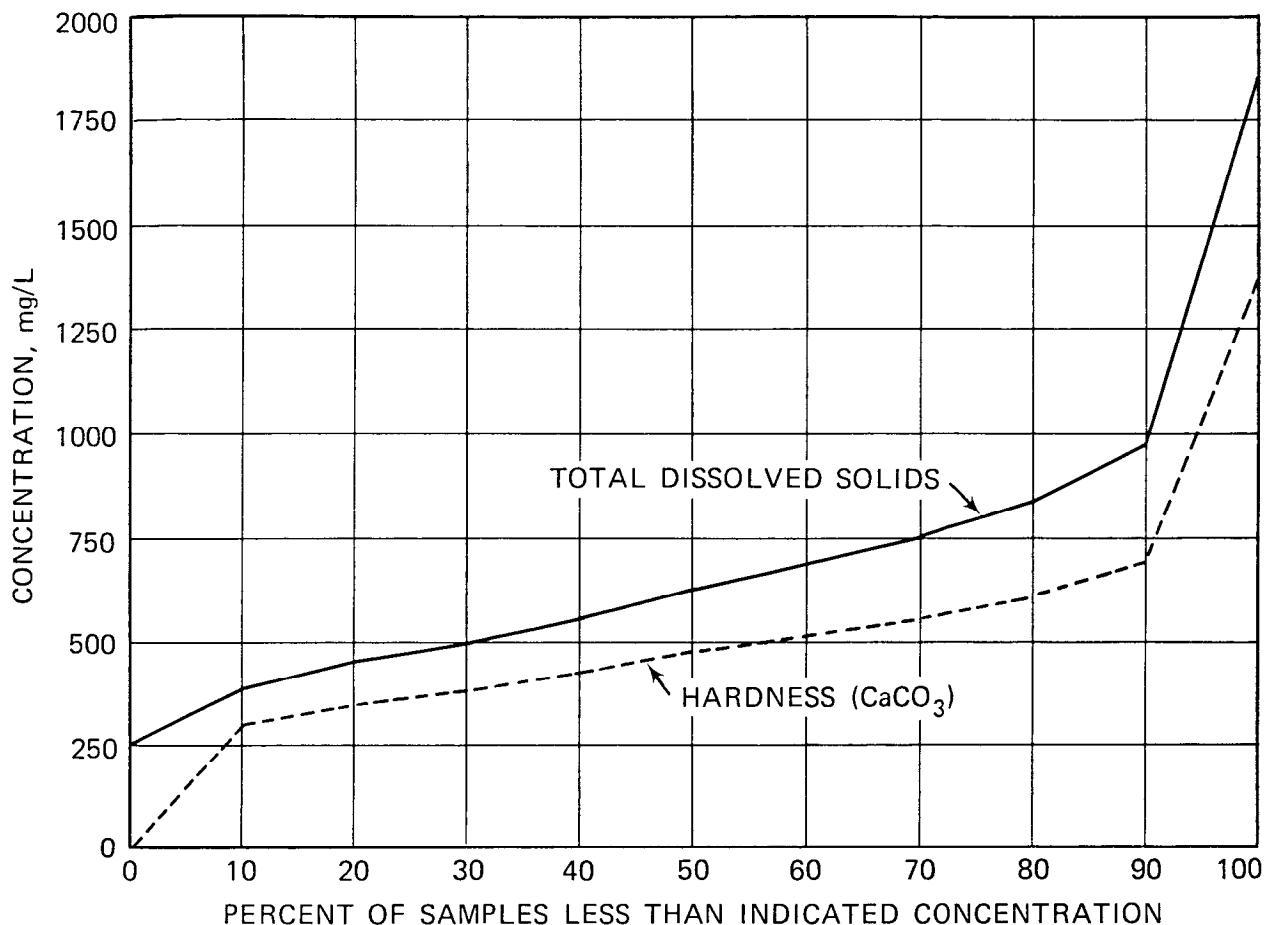


Figure 13. Frequency distribution of total dissolved solids and hardness contents in shallow dolomite wells

a more detailed investigation of the groundwater quality deterioration in the southeastern portions of the study area may be warranted.

Discussions of individual water quality parameters are presented in the following subsections.

#### Total Dissolved Solids (TDS)

The total dissolved solids (TDS) in samples collected for this study ranged from 259 milligrams per liter (mg/L) (Oswego) to 1832 mg/L (LaGrange Park), with a median value of 625 mg/L. Ten percent of the samples contained 388 mg/L TDS or less and 10 percent had more than 968 mg/L (see figure 13). The USEPA has suggested that TDS concentrations in excess of 500 mg/L may have undesirable effects on the aesthetic qualities of drinking water. Approximately 70 percent of the samples exceeded this secondary drinking water standard.

The highest TDS values are found in the southeastern section of the study area in a Y-shaped zone centered in the Hinsdale-LaGrange-Indian Head Park-Burr Ridge region (see figure 14). The TDS values in this area generally are greater than 1000 mg/L, with most of the groundwater containing more than 1200 mg/L. This area of higher TDS values corresponds very closely to an area in which the dolomite has been dewatered (see figure 10).

High TDS concentrations also are found in the Elmhurst-Addison-Lombard region. Most of this area exhibits TDS values greater than 1000 mg/L with local highs of more than 1200 mg/L. These highly mineralized areas are very near to areas where the bedrock has been dewatered; however, the correspondence is not quite as strong as in the Indian Head Park area described above.

Another area with high TDS concentrations is the Lisle-Downers Grove-Darien region. Total dissolved solids are greater than 800 mg/L with small areas greater than 1000 mg/L. Much of this high TDS region also has been dewatered, as shown by figure 10.

Scattered smaller areas where high TDS concentrations are found include Arlington Heights (1192 mg/L), Aurora (912 mg/L), Elgin (909 mg/L), and Naperville (888 mg/L).

The lowest concentrations of TDS occur in the southwestern portion of the study area between the Fox River and the West Branch DuPage River. This area generally is characterized by low density development and rural land uses. Lower TDS values also are found in a similar area of low density development south of and including the Bartlett-Hanover Park region in the northwest portion of the study area.

#### Hardness (as CaCO<sub>3</sub>)

Hardness concentrations in the dolomite aquifer ranged from 134 mg/L (Oswego) to 1360 mg/L (LaGrange Park) with a median value of 481 mg/L, which is considered very hard. Ten percent of the samples had 299 mg/L hardness (as CaCO<sub>3</sub>) or less and 10 percent had more than 690 mg/L (see figure 13). The distribution of hardness (see figure 15) is very similar to that for TDS, which is to be expected since, in Illinois, hardness usually is the major contributor to TDS.

The area of highest hardness concentrations coincides with the area of highest TDS concentrations in the southeastern portion of the study area. The Y-shaped zone of highest concentrations is centered in the Hinsdale-LaGrange-Indian Head Park-Burr Ridge area and reaches south as far as the Argonne National Laboratory. All of this region is characterized by hardness concentrations greater than 600 mg/L, with most of the area exhibiting values of over 800 mg/L. Smaller zones of greater than 1000 mg/L are found in the Western Springs area (1190 mg/L) and the LaGrange Park area (1360 mg/L).

High concentrations of hardness are also characteristic of the Lombard-Elmhurst region in the east-central portion of the study area. In this

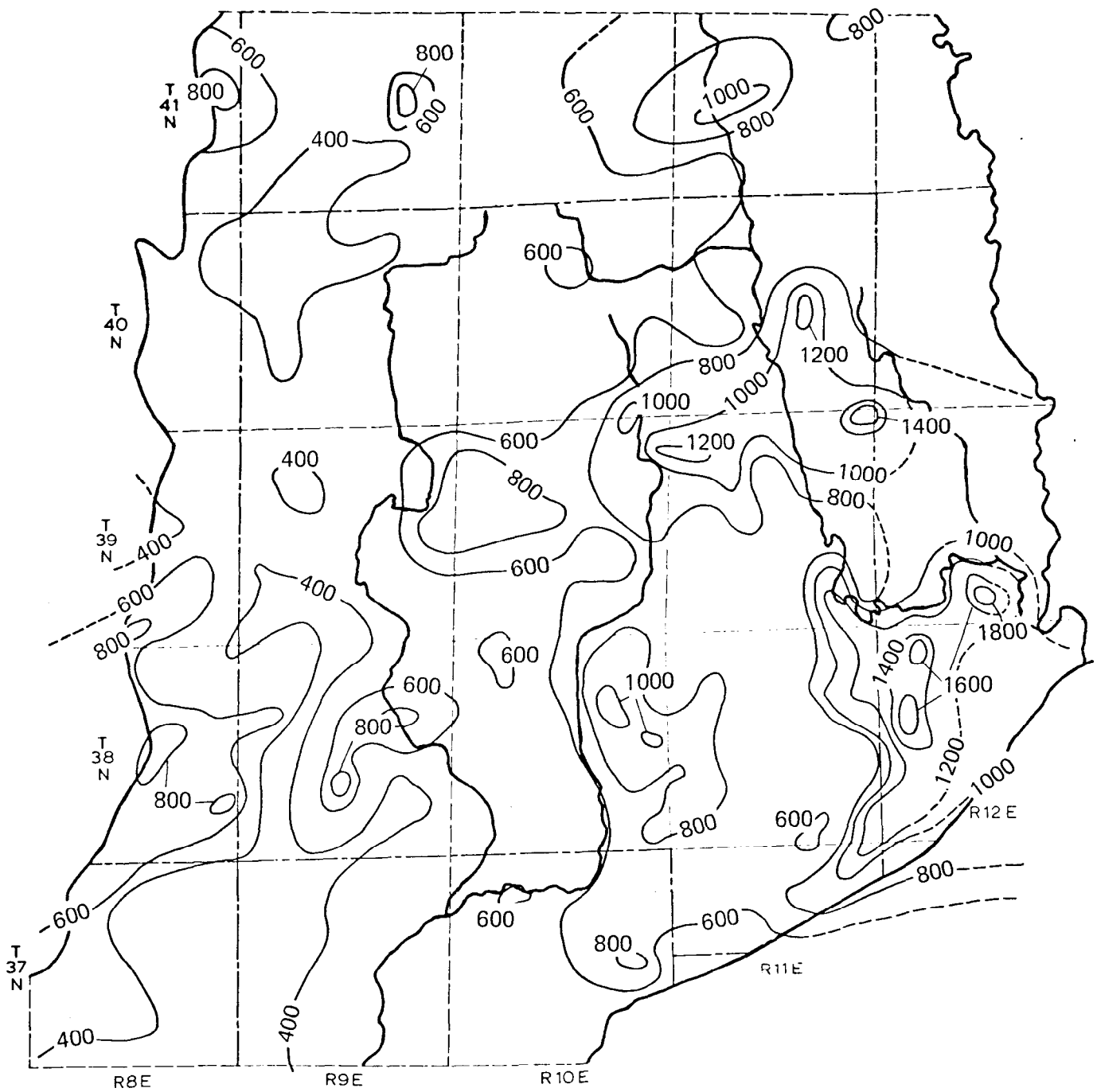


Figure 14. Generalized areal distribution of total dissolved solids  
in the shallow dolomite aquifer

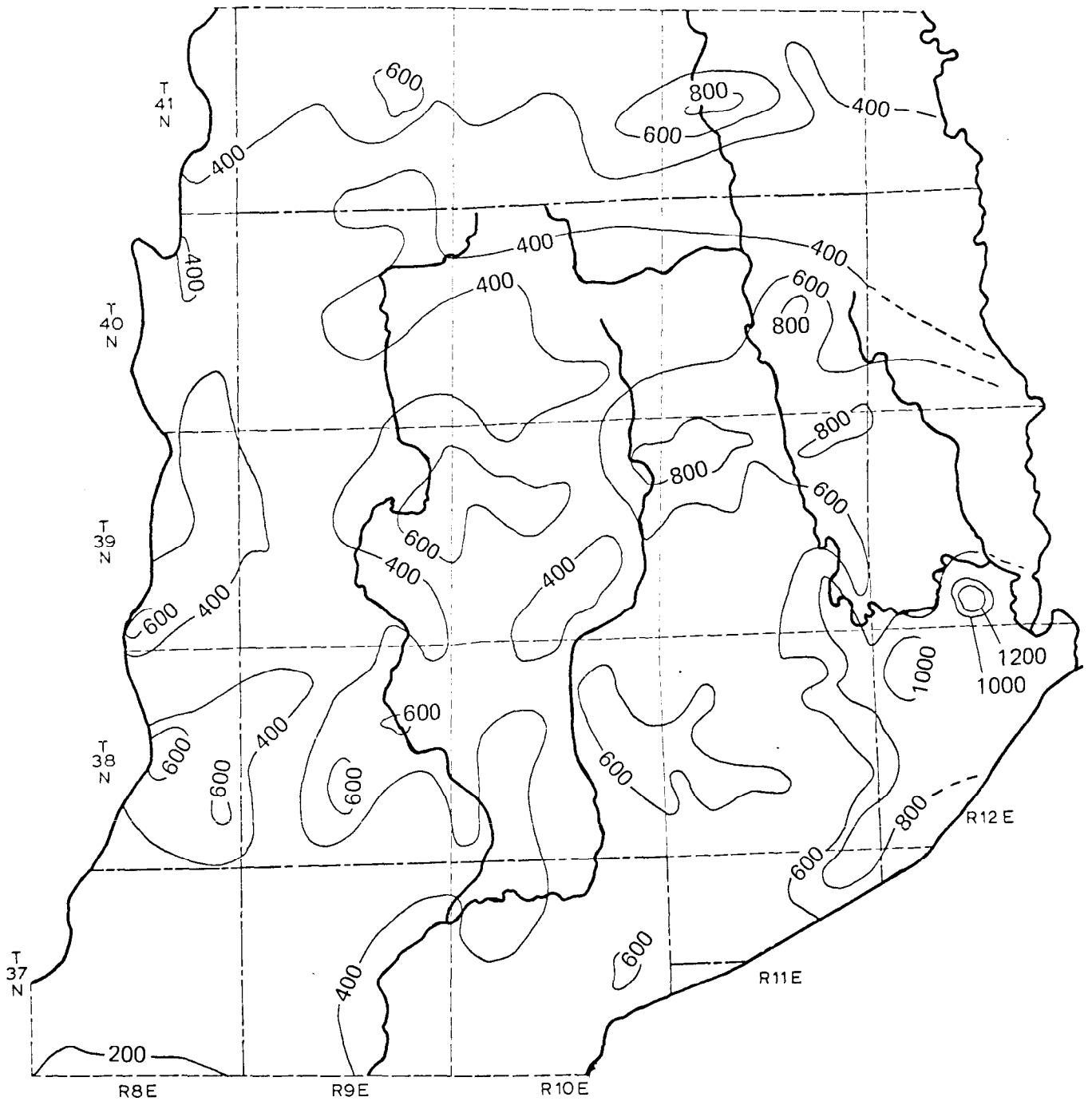


Figure 15. Generalized areal distribution of hardness (as CaCO<sub>3</sub>) in the shallow dolomite aquifer



region, hardness concentrations greater than 600 mg/L are common. Smaller peaks of over 800 mg/L are noted in Lombard (945 mg/L), Elmhurst (840 mg/L), and Bensenville (812 mg/L). Local highs of greater than 700 mg/L are located in the Elk Grove Village area and near Wheaton and Glen Ellyn.

Similar to the TDS distribution map (see figure 14), the lowest hardness values generally occur in the western and southwestern parts of the study area between the Fox River and the West Branch DuPage River. In these regions, hardness values are typically less than 400 mg/L although small areas of greater than 600 mg/L occur locally near Aurora, West Chicago, Naperville, and Streamwood. The regions of lower hardness values generally occur in areas of low density development of the aquifer and the overlying land surface.

## Sulfate

Like TDS, hardness, and many other minerals, sulfate occurs naturally in groundwater, mainly as a result of chemical reactions with the aquifer materials. Sources of sulfate associated with human activities include leachate from solid waste and effluent from sewage disposal.

Sulfate concentrations in groundwater samples from the dolomite aquifer ranged from 0.1 mg/L (Wayne) to 864 mg/L (LaGrange Park) with a median value of 166 mg/L. About 10 percent of the samples contained less than 49 mg/L, while 10 percent contained more than 396 mg/L sulfate (see figure 16). The USEPA has suggested that sulfate concentrations in excess of 250 mg/L may have an undesirable effect on the aesthetic qualities of drinking water. About 25 percent of the samples exceeded this secondary standard.

Generally, sulfate concentrations increase from west to east across the study area with the highest concentrations located in the southeastern portion in a Y-shaped region stretching from LaGrange Park to Argonne National Laboratory (see figure 17). Concentrations in this area are commonly greater than 400 mg/L, with smaller areas of over 500 and 600 mg/L sulfate.

High sulfate concentrations are also found in the Schaumburg-Elk Grove Village-Arlington Heights region located in the northeastern section of the study area. Values are greater than 400 mg/L over most of this area with a smaller area exhibiting concentrations greater than 500 mg/L.

Isolated high values occur at Bensenville (716 mg/L), Lombard (472 mg/L), Elmhurst (418 mg/L), Lisle (317 mg/L), Bolingbrook (310 mg/L), and the Wheaton-Glen Ellyn area (342 to 365 mg/L).

The lowest sulfate values are found in the western portions of the study area, especially the southwest, between the Fox River and the West Branch DuPage River. In these areas, sulfate concentrations less than 100 mg/L are common and most of the areas have values less than 200 mg/L.

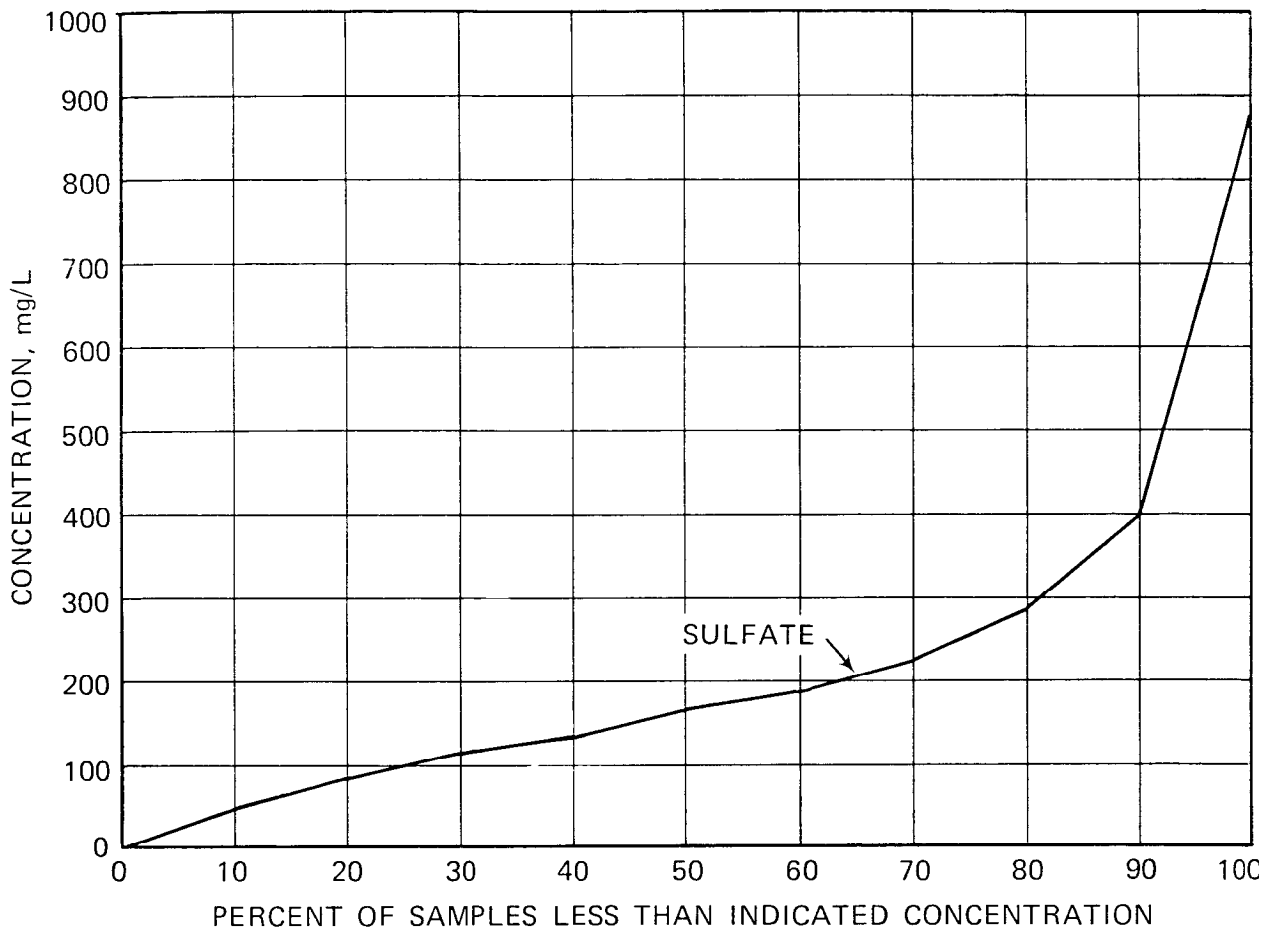


Figure 16. Frequency distribution of sulfate content in shallow dolomite wells

### Chloride

The concentrations of chloride in the samples from the dolomite aquifer ranged from 0 to 450 mg/L (Elmhurst) with a median of 22 mg/L. Ten percent of the samples had 1 mg/L chloride or less and 10 percent had more than 128 mg/L (see figure 18). The USEPA has suggested that chloride in excess of 250 mg/L has an undesirable effect on the aesthetic qualities of drinking water. Less than 1 percent of the samples exceeded this secondary drinking water standard. The distribution of chloride values (see figure 19) is similar to that of TDS and many of the controlling factors are the same. However, road salt storage and application may be a major contributing factor in the elevated levels of chloride found in the study area, especially where sodium concentrations are unusually high. Septic tank effluent, landfill leachate, and water softener brine are also potential sources of chloride.

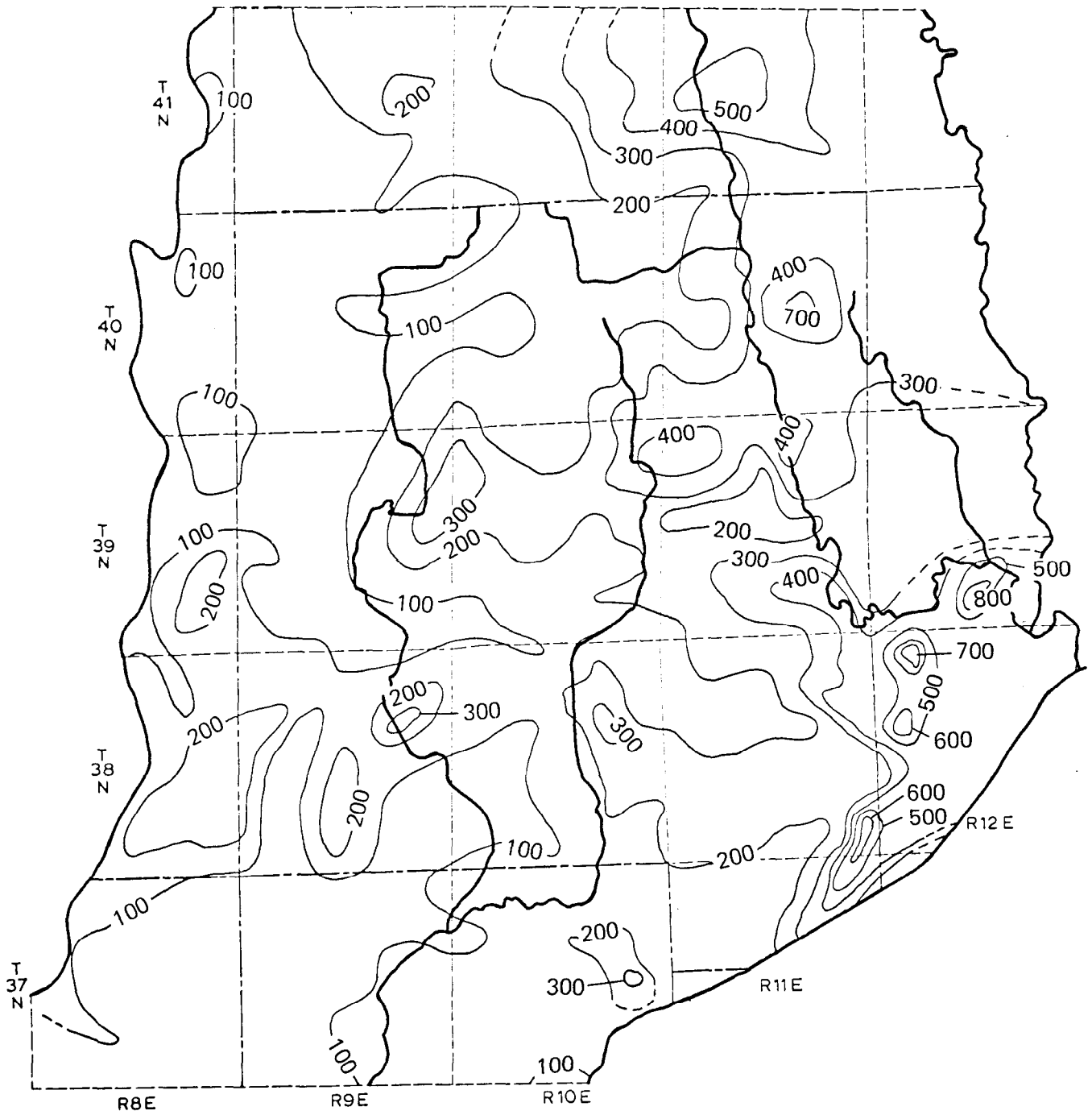


Figure 17. Generalized areal distribution of sulfate in the shallow dolomite aquifer

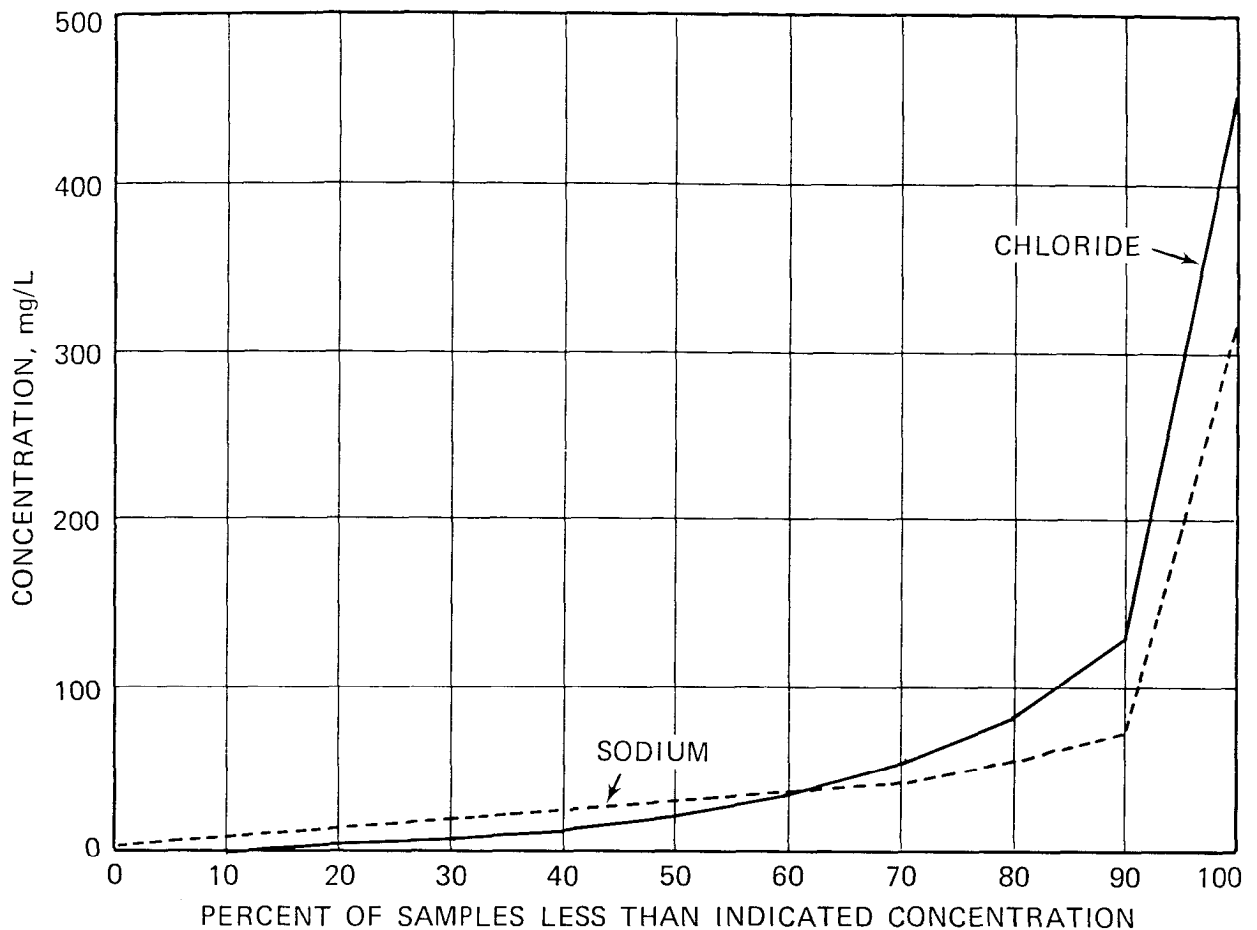


Figure 18. Frequency distribution of chloride and sodium in shallow dolomite wells

As is the case in the distribution of TDS and hardness, the highest chloride concentrations generally are located in the southeastern quarter of the study area. The highest concentrations, typically greater than 150 mg/L, are found in the Hinsdale-Western Springs-LaGrange-Indian Head Park region. Another area of high chloride concentrations is located nearby in the Lombard-Villa Park-Elmhurst region. These areas are traversed by several major state and interstate highways such as Interstates 294, 55, and 290. Because of the high density of highways in this area, deicing salt application and storage may be a major cause of the high chloride concentrations in this portion of the study area.

Increasing chloride trends were discovered and reported previously for Silurian dolomite public water supply well fields at LaGrange and Naperville (Gibb and O'Hearn, 1980). The major cause of these trends is suspected to be road salt storage and application. One co-author of this report counted 5 uncovered salt stockpiles adjacent to I-294 in one h-mile segment near the study area during the spring months of 1981.

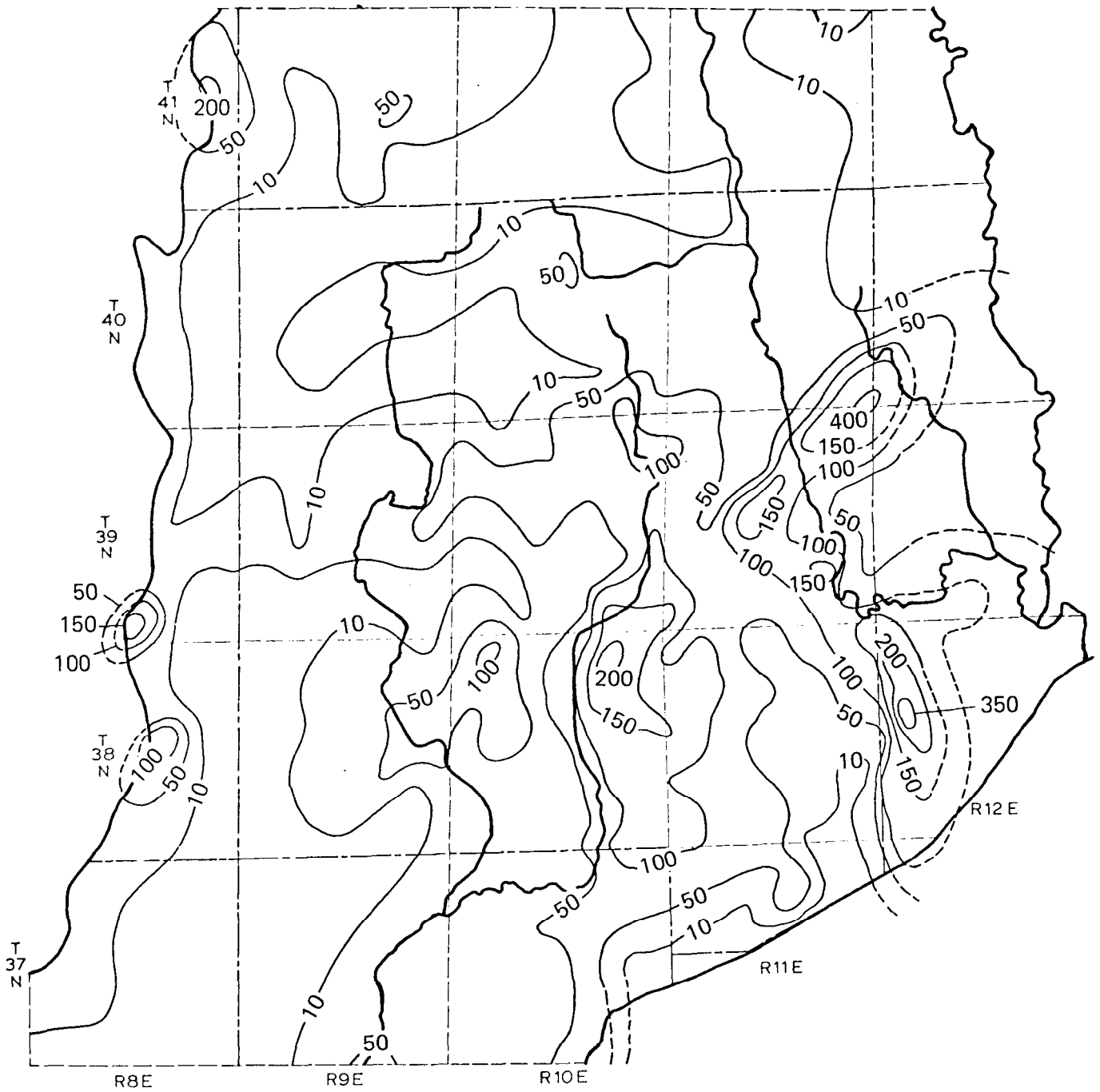


Figure 19. Generalized areal distribution of chlorides in the shallow dolomite aquifer

A third area of high chloride is centered on the Glen Ellyn-Lisle-Downers Grove region located just west of the area mentioned above. This area is characterized by chloride in excess of 150 mg/L with concentrations greater than 100 mg/L extending south to the Bolingbrook area. The two high chloride regions described above are separated by a small area near Westmont where chloride values are less than 50 mg/L.

Isolated values of high chloride are found at Elgin (235 mg/L), North Aurora (200 mg/L), Aurora (143 mg/L), and Naperville (105 mg/L).

The lowest chloride concentrations are located in the western portions of the study area, especially the southwestern region. In these areas, generally lying between the Fox River and the West Branch DuPage River, chloride concentrations are commonly less than 10 mg/L with many samples containing virtually no chloride. There is a marked contrast between the lowest chloride concentrations in the western portion and the highest concentrations in the eastern portion of the study area.

### Sodium

Potential sources of sodium in the groundwater environment include sewage, industrial waste, deicing compounds (road salt), and the aquifer material itself. Where high sodium concentrations are accompanied by high chloride values, such as the southeastern corner and numerous other portions of the study area (see figure 19), improper road salt storage and application may be a controlling factor. It should be noted that sodium, like chloride, appears to be directly related to the density of highways in the study area, increasing both from west to east and in the vicinity of large municipalities. High sodium concentrations can also result from collecting samples after the water has been softened. The authors have attempted to screen the data for any samples where such occurrences are suspected.

Sodium concentrations in the dolomite aquifer ranged from 4.1 mg/L (Naperville) to 317 mg/L (Glendale Heights) with a median value of about 30.2 mg/L. Ten percent of the samples contained less than 10.1 mg/L and 10 percent contained more than 73.2 mg/L sodium (see figure 18). Presently, there are no standards for sodium in drinking water; however, people on a sodium-restricted diet should be aware of the amount of sodium ingested daily via their water supply.

Sodium concentrations generally increase from northwest to southeast across the study area with the highest concentrations centered in the Hinsdale-Western Springs-Indian Head Park region (see figure 20). Sodium concentrations greater than 75 mg/L are common in this area but concentrations greater than 100 mg/L are found near Western Springs (246 mg/L) and Indian Head Park (134 mg/L).

West of this area, another area of elevated sodium content area is centered in the Glen Ellyn-Lisle region and stretches as far south as Bolingbrook. Sodium concentrations in this region typically are greater than

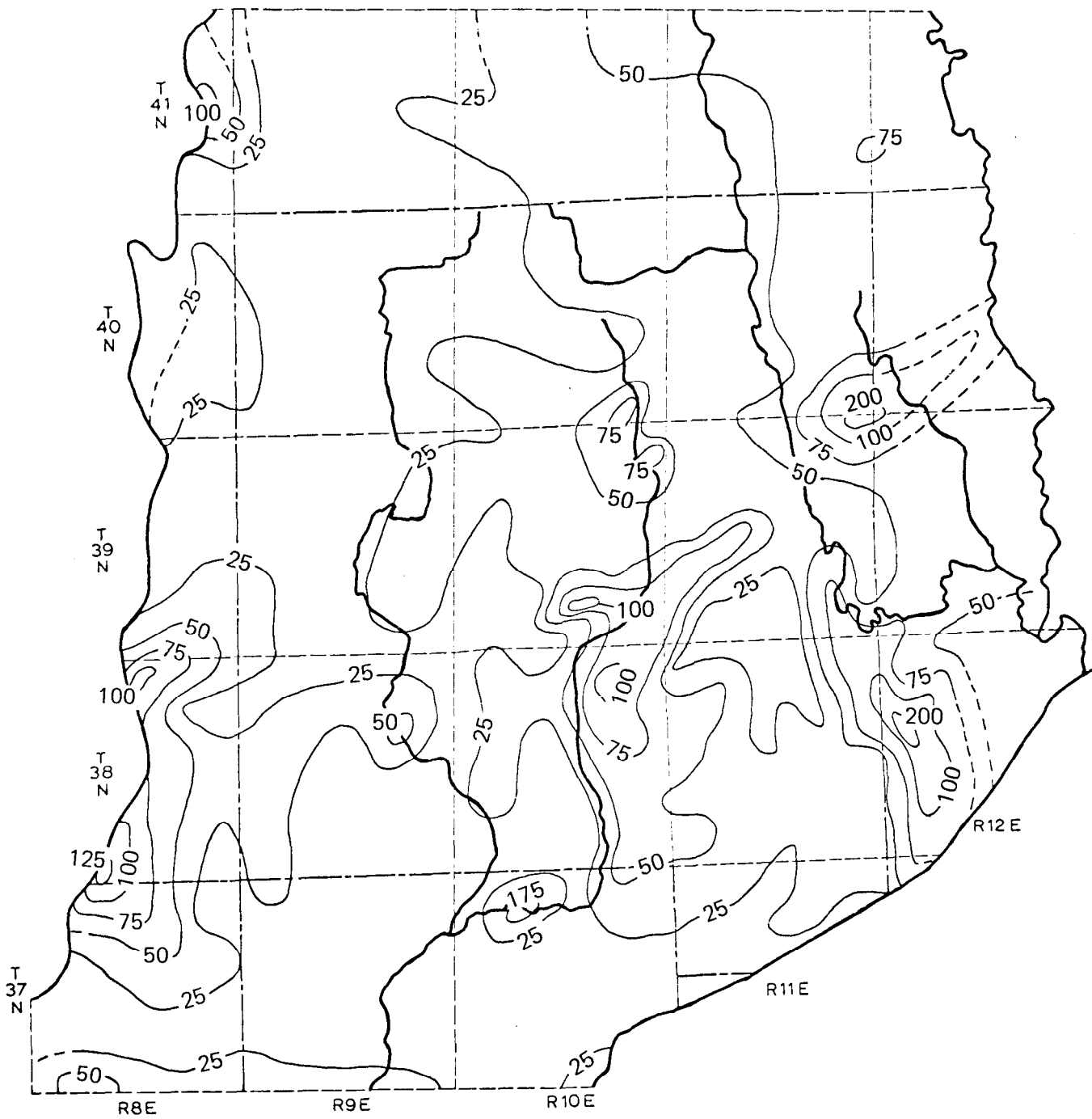


Figure 20. Generalized areal distribution of sodium in the shallow dolomite aquifer

50 mg/L, with values greater than 75 mg/L found over much of the area. Small peaks within this area are located at Bolingbrook (186 mg/L), Glen Ellyn (171 mg/L), and Lisle (104 mg/L).

Between the two high-sodium areas described above there is a small area of lower concentrations centered near Westmont where the sodium content is less than 25 mg/L.

Elevated sodium concentrations are also found in the Aurora-Batavia region, where values over 50 mg/L are typical. Local highs of greater than 100 mg/L are found near Aurora (142 mg/L) and North Aurora (108 mg/L). Greater than 40 mg/L sodium is found in virtually all areas east of Salt Creek and in a small area in the Glendale Heights region. In addition, isolated high sodium concentrations are found at Elmhurst (202 mg/L) and Elgin (126 mg/L).

The lowest concentrations of sodium typically are found between the Fox River and the West Branch DuPage River, except in those areas of higher concentration described above.

### Total Organic Carbon

The collection and analysis of the water samples for total organic carbon (TOC) probably resulted in the loss of most or all of the volatile components. Therefore, the data presented are more representative of the nonvolatile fraction and, as such, may be as much as 25 to 50 percent lower than the actual TOC contained in the aquifer.

The total organic carbon content of the groundwater samples from the Silurian dolomite aquifer ranged from 0.2 (near Naperville) to 16.5 mg/L (near Oak Brook) with a median value of 1.6 mg/L. Ten percent of the samples contained 0.9 mg/L or less and 10 percent contained more than 2.7 mg/L (see figure 21). There are no TOC standards for drinking water; however, concentrations in Illinois groundwater typically are less than 3.0 mg/L with most values less than or equal to 2.0 mg/L.

Yost of the study area exhibits TOC concentrations less than 3.0 mg/L (see figure 22). Higher concentrations are found in the South Elgin-Wayne-West Chicago area where concentrations greater than 4.0 mg/L are common and values as high as 6.1 mg/L (near Wayne) are recorded.

Total organic carbon values 5.0 mg/L and greater are also found in the vicinity of Villa Park and Downers Grove. Concentrations of 4.2 and 16.5 mg/L occur in the vicinity of Oak Brook, although surrounding values are typically 3.0 mg/L or less. A local peak of 4.6 mg/L is found in the vicinity of Wheaton located in the center of the study area.

The lowest TOC values are located in the extreme southern portion, in a small area immediately south of an isolated high at Elgin (12.5 mg/L), and in small isolated pockets across the study area. Concentrations of TOC in these regions are less than 1.0 mg/L.



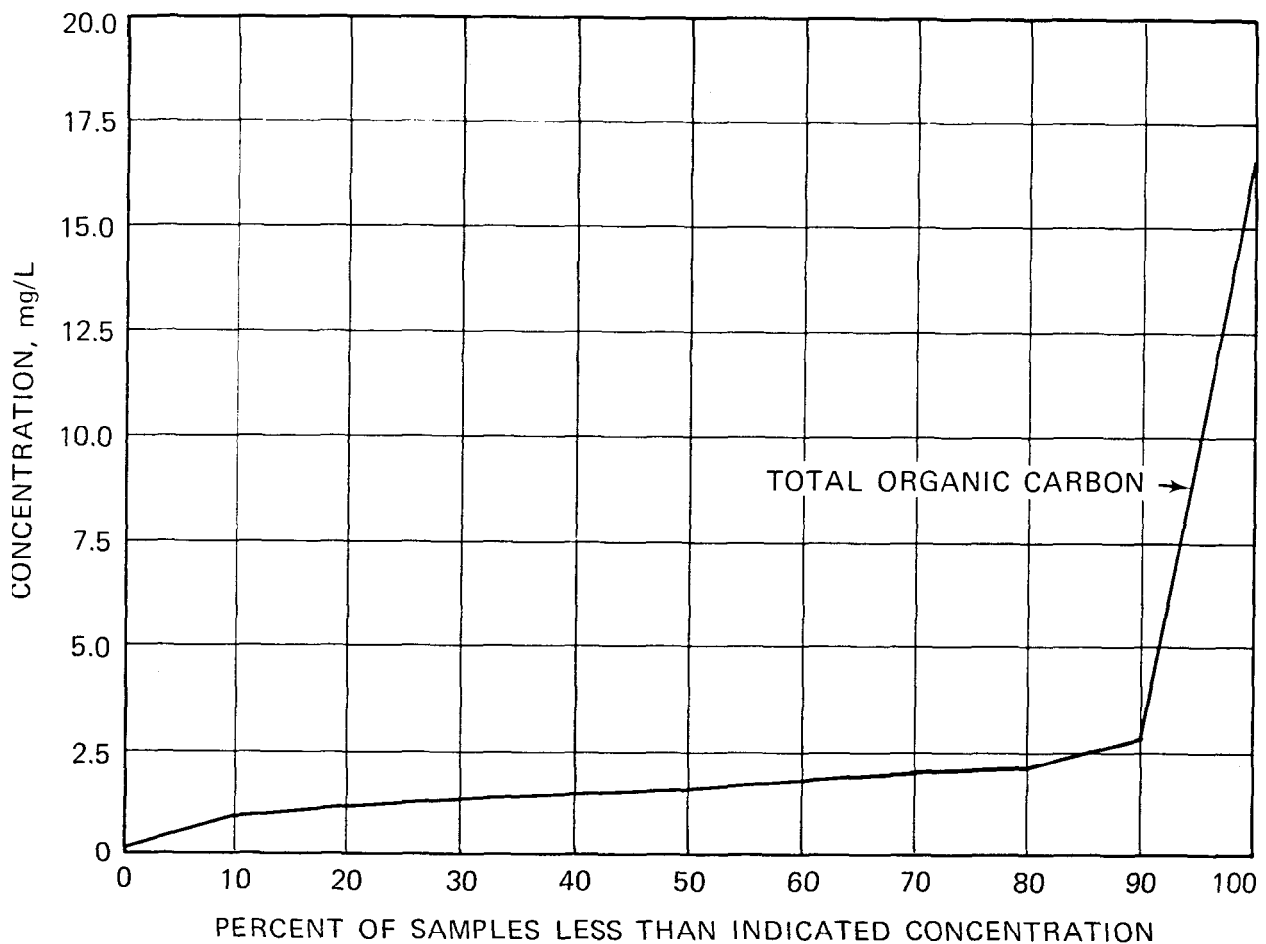


Figure 21. Frequency distribution of total organic carbon in shallow dolomite wells

The highest TOC values generally occur as isolated phenomena surrounded by lower values. This characteristic of TOC distribution suggests that local sources of organic contaminants are responsible for these occurrences.

#### Fluoride

The concentration of fluoride in the dolomite aquifer in the study area ranges from 0.1 mg/L to 1.6 mg/L (Glen Ellyn), with a median value of 0.3 mg/L. Ten percent of the samples collected have 0.2 mg/L or less and 10 percent have more than 0.7 mg/L (see figure 23). The maximum concentration allowed in finished public water supplies is 2.0 mg/L. Fluoride is occasionally added to public water supplies as a tooth decay preventative when natural concentrations are below 0.5 mg/L. In these cases, finished water is required to contain between 0.9 and 1.2 mg/L fluoride. Other possible sources of fluoride in groundwater are municipal and industrial wastes and fluoride-containing aquifer materials.

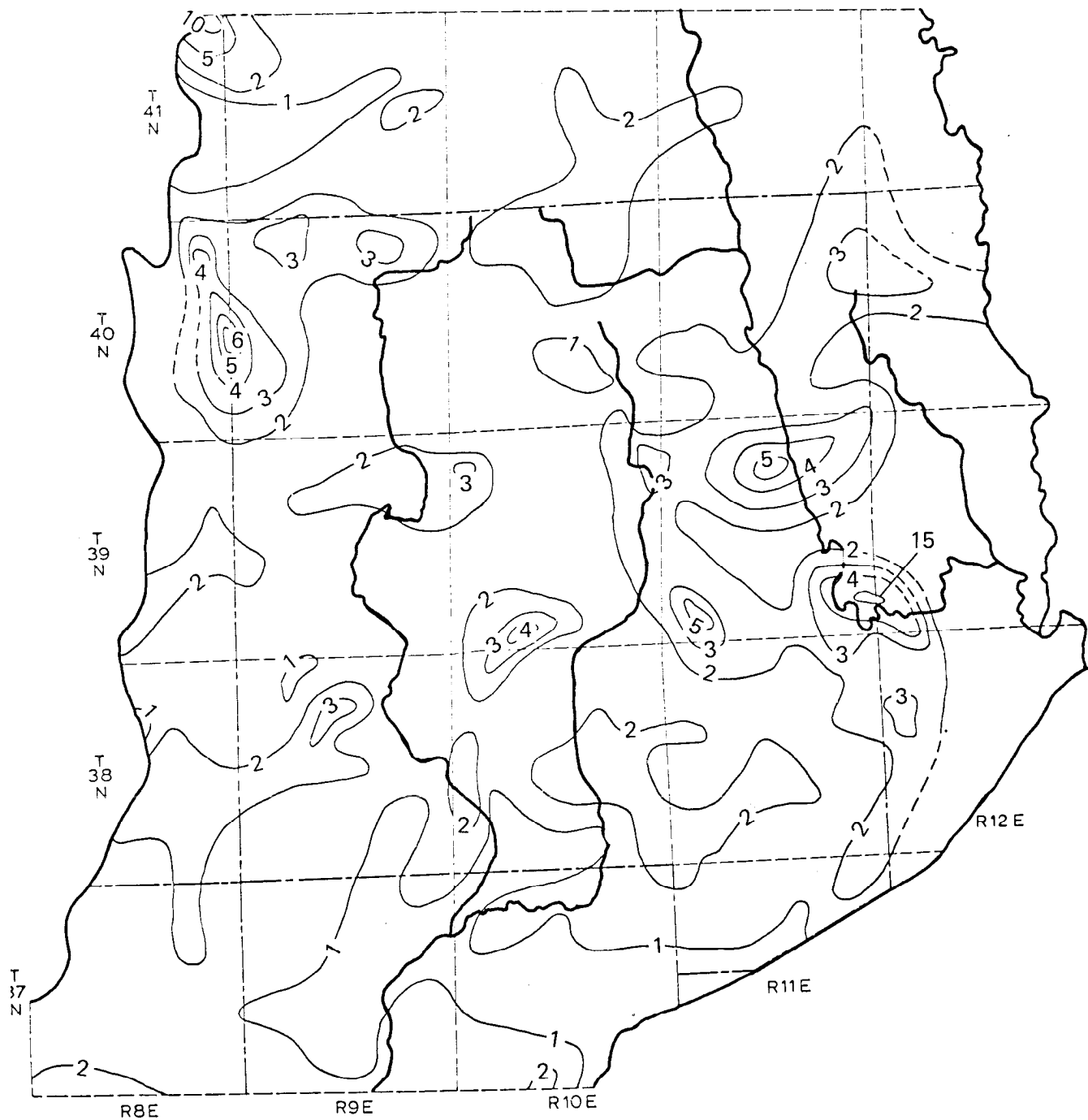


Figure 22. Generalized areal distribution of total organic carbon in the shallow dolomite aquifer

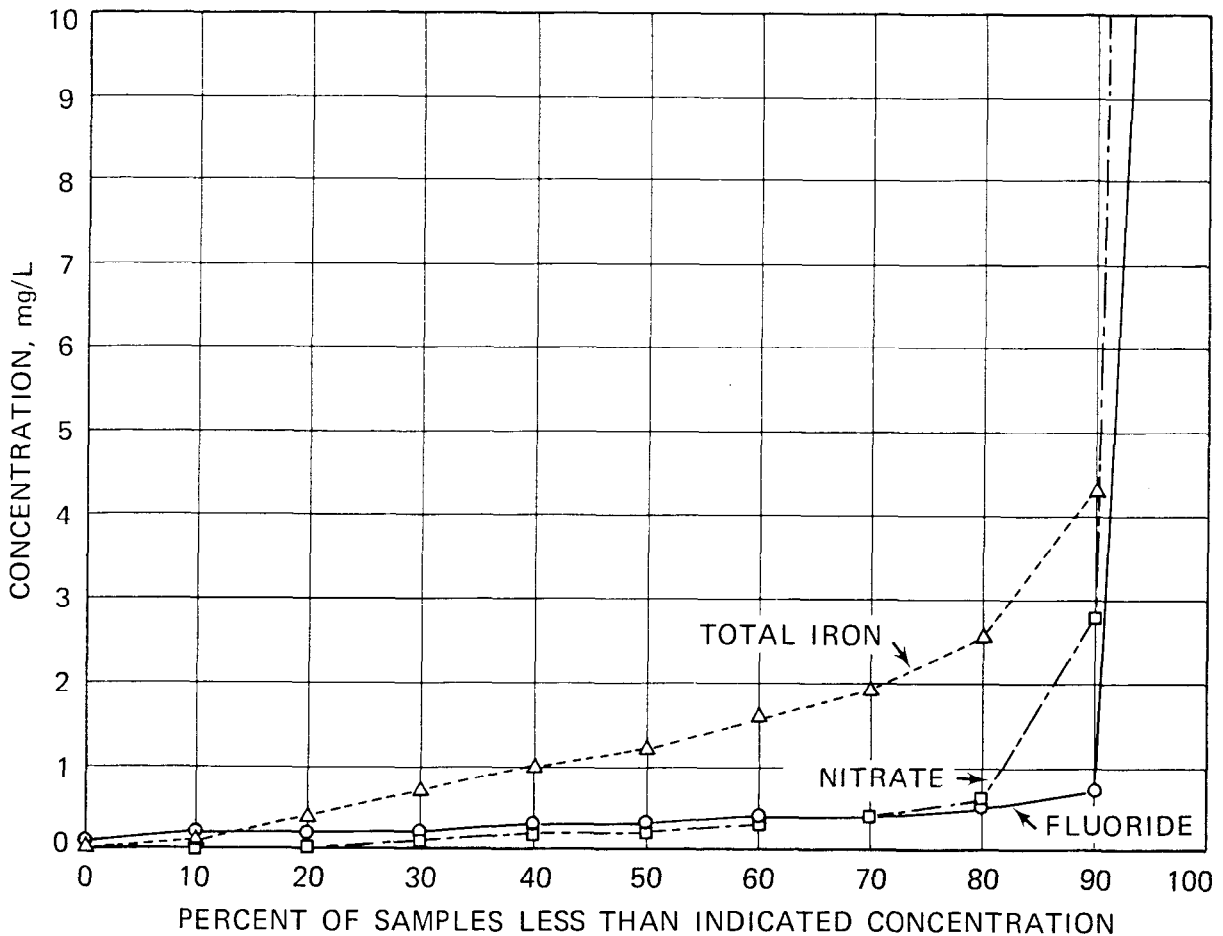


Figure 23. Frequency distribution of fluoride, total iron, and nitrate in shallow dolomite wells

Contrary to the distribution of most other dissolved inorganics, the highest concentrations of fluoride are located in the extreme southwestern corner of the study area, where values greater than 0.75 mg/L are common (see figure 24). In the same region, several values greater than or equal to 1.0 mg/L are reported, with the highest concentration in this area, 1.4 mg/L, found near Oswego. Isolated higher values also occur in the Glen Ellyn area (1.6 mg/L) and the North Aurora area (1.0 mg/L). Sample contamination is suspected in the case of a sample from Bolingbrook containing 28.0 mg/L fluoride. A sample with 5.5 mg/L fluoride from a well near Glendale Heights is probably not representative of water from the dolomite aquifer since an extremely low hardness value in this sample indicates that the sample may have been collected after ion-exchange softening.

The lowest concentrations of fluoride generally are found in the southeastern quarter and the extreme northwestern corner of the study area.

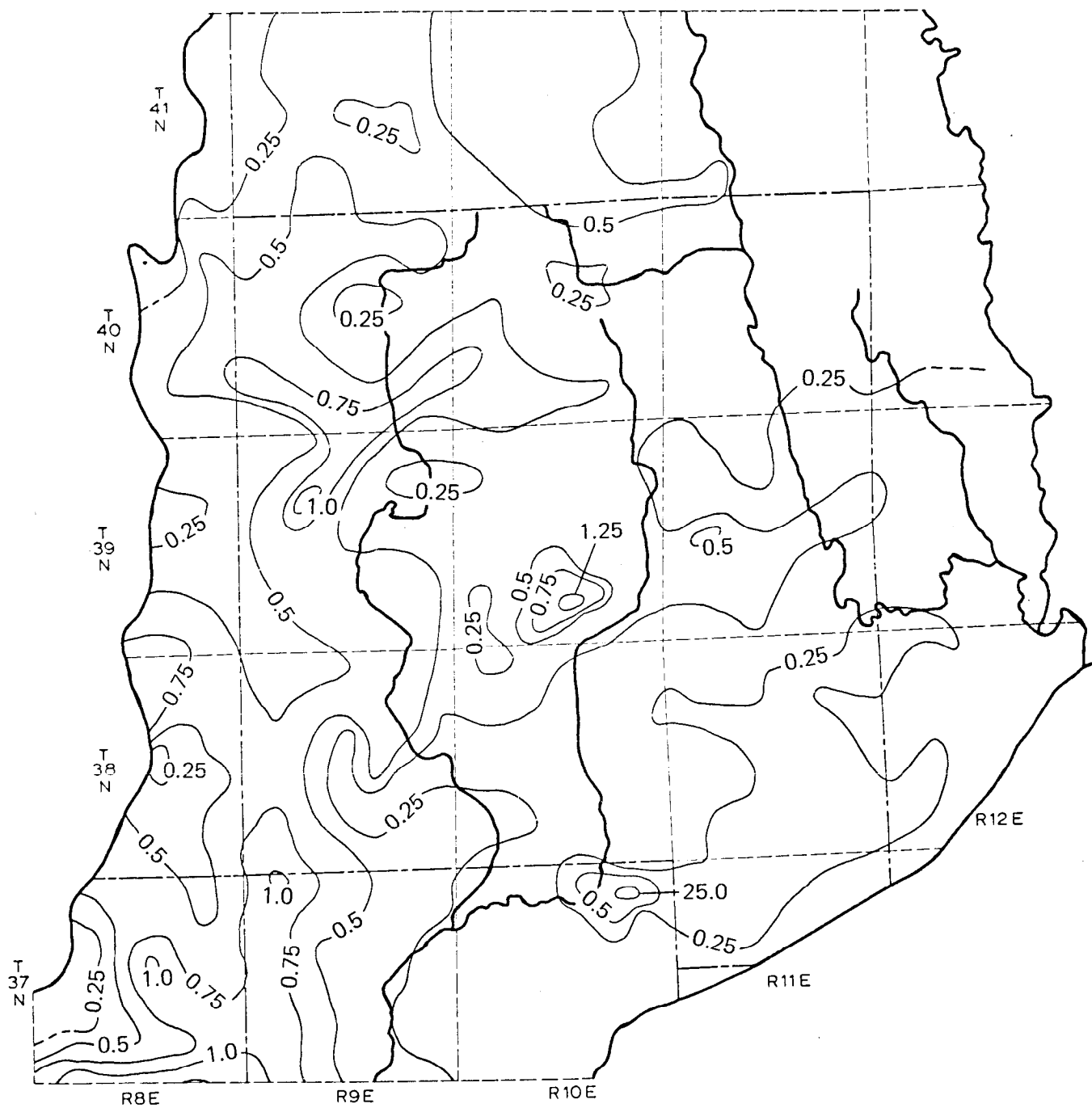


Figure 24. Generalized areal distribution of fluoride in the shallow dolomite aquifer

## Total Iron

The concentration of total iron in samples collected from the dolomite aquifer ranges from 0.0 mg/L to 53.6 mg/L (near Downers Grove), with a median value of 1.2 mg/L. Ten percent of the samples contained 0.1 mg/L total iron or less and 10% had total iron concentrations in excess of 4.3 mg/L (see figure 23). Roughly 5 percent of the samples contained greater than 10.0 mg/L total iron.

The maximum allowable concentration of total iron in treated samples from public water supplies is 1.0 mg/L. Concentrations in excess of 0.3 mg/L may have an undesirable effect on the aesthetic qualities of drinking water. The concentration of iron is affected by numerous factors including but not limited to: geology and hydrology of the aquifer, presence of oxygen and other mineral components, pH, redox potential (Eh), presence of organic materials, microbial activity, and the turbidity of the sample. The variability of these conditions from point to point within an aquifer results in large variations in the iron content of groundwater. In addition, landfill leachates from municipal and industrial wastes can add significant amounts of iron to the groundwater although these contributions usually are difficult to separate from those of natural sources.

The highest concentrations of total iron generally are located in the southeast quarter of the study area in the Downers Grove-Oak Brook-Lombard-Glen Ellyn region (see figure 25). Total iron values in this region typically are greater than 5.0 mg/L. Of the 14 samples with greater than 10.0 mg/L total iron, 7 of them are located in this region. Five of these 7 samples contained iron in excess of 20.0 mg/L, and 2 samples exceeded 40.0 mg/L (Downers Grove-53.6 mg/L, Oak Brook-42.0 mg/L).

High total iron values are also found in the vicinity of Naperville (19.2 mg/L) just west of the Downers Grove-Oak Brook-Lombard region. A small area in the Batavia-North Aurora region exhibited iron values in excess of 15 mg/L with a well near Batavia showing 24.3 mg/L. Isolated high concentrations of total iron are located in the vicinity of South Elgin (13.0 mg/L), Winfield (13.0 mg/L), Mt. Prospect (12.6 mg/L), and Roselle (11.1 mg/L).

The lowest iron concentrations seem to be scattered throughout the study area, but generally are concentrated in the southern portions and along the Fox River, except near the major municipalities of Aurora and Elgin. Iron concentrations are consistently lower between the Fox River and the West Branch DuPage River and in the northeastern corner of the study area where values typically are less than 3.0 mg/L.

## Nitrate

The concentration of nitrate in samples collected from the Silurian dolomite aquifer ranges from 0.0 mg/L to 63.2 mg/L (south of Aurora) with a

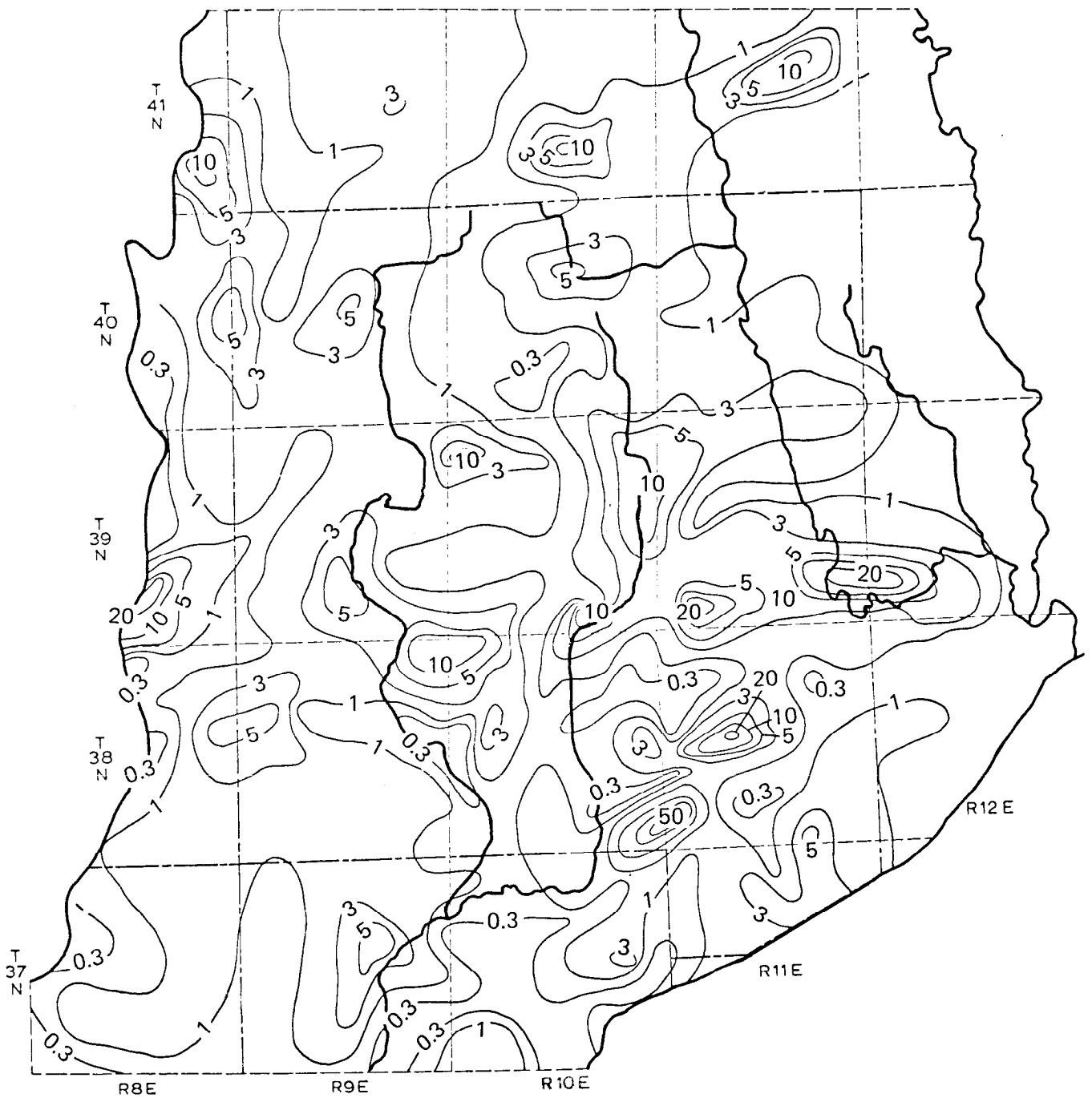


Figure 25. Generalised areal distribution of total iron in the shallow dolomite aquifer

median value of 0.2 mg/L. More than 10 percent of the samples had no detectable nitrate content and 10 percent contained at least 2.8 mg/L (see figure 23). The maximum allowable concentration of nitrate in finished public water supply samples is 45.0 mg/L. Only 2 percent of the 282 raw water samples exceeded this primary standard for finished drinking water.

Nitrates are formed naturally by bacteria during the aerobic decomposition of organic nitrogenous wastes such as those present in most domestic, municipal, and industrial wastewaters. Nitrates may also be leached from soils, especially where nitrogen fertilizer has been applied. High levels of nitrate in a particular well may be an indication that the well itself is inadequately sealed from contamination by surface runoff. If numerous wells in the same area contain higher concentrations of nitrate, a regional source of contamination may be present.

The highest concentrations of nitrate are found in the south-central portion of the study area, particularly in the Romeoville-Bolingbrook-Plainfield region (see figure 26). In this area of moderate agricultural activity, nitrate concentrations in excess of 10.0 mg/L are very common, and 3 samples contained more than 20.0 mg/L nitrate. A sample collected from a well northeast of Plainfield contained 62.7 mg/L nitrate. Directly north of this region, high concentrations of nitrate are found in the Downers Grove-Naperville region with typical values of over 10.0 mg/L. Isolated high values occur south of Aurora (63.2 mg/L), near Elgin (31.0 mg/L) and South Elgin (17.1 mg/L), and in West Chicago (17.1 mg/L).

The rest of the study area generally has low values of nitrate with many samples showing little or no nitrate as indicated by the concentration frequency distribution in Figure 23.

#### SUMMARY AND CONCLUSIONS

Groundwater withdrawals from the shallow dolomite aquifer in the west suburban area of the Chicago metropolitan region have had a severe impact on water levels and on the long-range capability of wells and well fields to continue to meet demands for increasing volumes of water by municipalities, industries, and individuals.

Shallow aquifer pumpage in the study area increased 92 percent during the period 1966-1978 and was 61.7 mgd in 1978; 57.3 mgd was from the dolomite, and 4.4 mgd was from sand and gravel. Pumpage in DuPage County increased 91 percent during the same period. The 1978 pumpage of 45.8 mgd was 103 percent of the potential yield.

As a result of the continual increase in pumpage, water levels have lowered considerably, and major sections of the aquifer system have been at least partially dewatered. Well yields in several municipalities have declined as the result of heavy pumpage. Large volumes of rock, sand, and gravel have been dewatered as water is withdrawn from storage within the aquifer to make up the deficit between water demand and the potential yield.

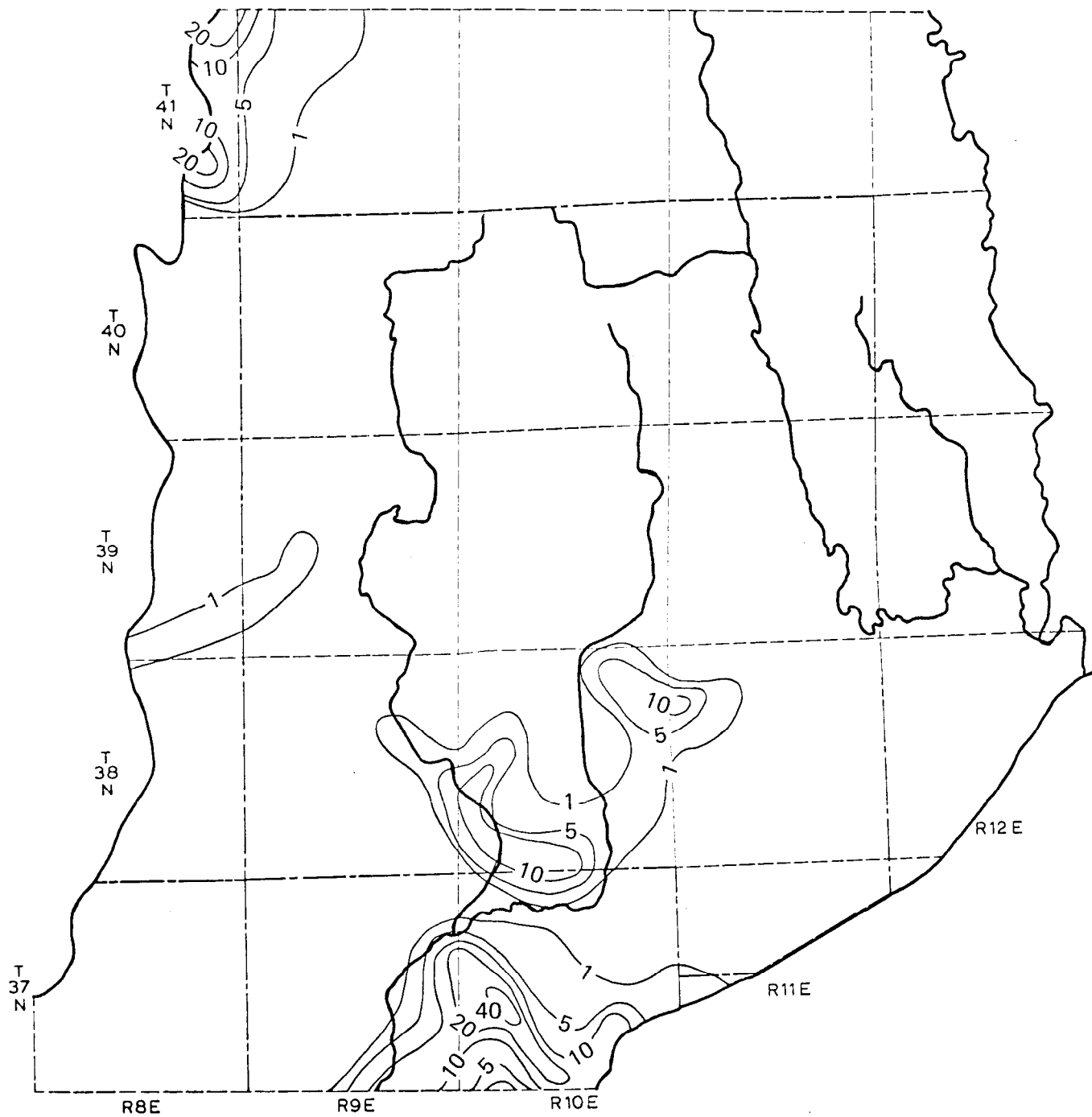


Figure 26. Centralized areal distribution of nitrate in the shallow dolomite aquifer



In DuPage County, water levels in the shallow dolomite declined more than 10 feet over an area of 98.4 square miles during the period 1966-1979. This includes nearly 30 percent of the entire county. The average decline for the 98.4 square miles was approximately 1.5 feet per year. Water levels declined more than 30 feet over 8.5 square miles.

The decline in water levels has resulted in water levels being lowered below the bedrock surface over approximately 9.5 square miles of DuPage County since 1966. An average of 27.6 feet of rock has been dewatered over this area. In addition to the dewatered rock, approximately 4 square miles of sand and gravel above the dewatered bedrock has been dewatered an average of about 30 feet.

A volume of 7.3 billion cubic feet of dolomite and 3.3 billion cubic feet of sand and gravel has been dewatered in DuPage County during the period 1966-1979. Approximately 5.9 billion gallons of water has been withdrawn from the shallow aquifer system in excess of that available from natural recharge. This is equivalent to average pumpage of 1.2 mgd.

Schicht et al. (1976) predicted that the groundwater demand in DuPage County would be 97.2 mgd by the year 2000. If pumpage was in the same ratio as in 1978, shallow aquifer pumpage would be approximately 63 mgd. This would be approximately 18 mgd more than the potential yield of these aquifers. Withdrawal of 18 mgd from storage within the aquifers would result in extremely severe dewatering over extensive areas. Major decreases in yields would be experienced in nearly all wells and well fields throughout the county.

The areal distribution of the chemical parameters studied indicates that groundwater quality in the shallow dolomite aquifer is related to the density of development of the land surface and the aquifer. Areas of highest chemical concentration generally are found in areas with the heaviest development. Degradation of shallow dolomite water quality is particularly noticeable in the southeastern part of DuPage County. Concentrations of total dissolved solids, hardness, sulfate, chloride, sodium, and total iron in samples from this region are high.

In addition to the southeastern portion of the study area, locally high values of all nine chemical parameters studied were found in the immediate vicinity of the major municipalities in the other portions of the study area. Generally, the lower concentrations of most of the nine parameters studied were found in the western and northwestern regions between the Fox River and the West Branch DuPage River.

Available data suggest that the age of land surface and aquifer development also is a factor in determining water quality for this aquifer. Relatively good quality water is found in the undeveloped and newly developed portions of the study area. The results of this portion of the study suggest that deteriorating water quality will eventually affect water treatment cost and aquifer usability. In light of these results, periodic studies of this type are recommended to assess the effectiveness of water quality control programs and provide updated information on the chemical state of groundwater from this important aquifer.

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