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Illinois Groundwater Quality Data Summary

by

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Summary

The Water Survey has been maintaining records of chemical analyses of groundwater since 1890. Records of some 28,000 analyses conducted by the Water Survey, Illinois Department of Public Health, and Illinois Environmental Protection Agency have been placed in a machine readable storage and retrieval system. These records include data for public water supply wells, industrial wells, irrigation wells, and privately owned domestic wells. Assessment of the available data can demonstrate the degree and types of additional data needs, the general quality of the state's groundwater resources, the areas of the state where groundwater quality changes have taken place, and the general approaches that can be used to monitor and protect groundwater quality.

For this study, data from the past 40 years (1940 through 1979) were sorted into five aquifer categories; 1) drift wells < 50 feet deep, 2) drift wells 50 feet deep, 3) Pennsylvanian aquifer, 4) shallow limestone and dolomite aquifers, and 5) deep sandstone aquifer. Median chemical concentrations per township were plotted and mapped for six parameters; 1) Total dissolved solids (Tds), 2) hardness (as CaCO_3), 3) sulfate, 4) nitrate, 5) chloride, and 6) iron. The variability of each parameter also was determined in areas where adequate data was available.

Historical groundwater quality trend analyses also were performed for 21 municipal water supply well fields. Seven well fields tap sand and gravel deposits in the drift, one taps Pennsylvanian age rocks, one taps Mississippian age rocks, three tap Silurian age dolomite, and nine tap the deep sandstone aquifer systems. Water quality trends were detected for two sand and gravel well fields, three Silurian dolomite, and two deep sandstone aquifer well fields.

Based on the results of this study, the following conclusions and recommendations are made.

Conclusions:

1. Specific areas in Illinois where additional water quality data is needed include: extreme southern and western Illinois for wells tapping drift deposits less than 50 feet deep; southern and western Illinois for wells tapping the Pennsylvanian rocks; northwestern and north-central Illinois for wells tapping the Galena-Platteville dolomite; and northwestern Illinois for wells tapping the Cambrian-Ordovician sandstones. Due to the regional trend in water quality from wells tapping the Silurian dolomites in northeastern Illinois, updated water quality data is needed in that area.

2. The maps of chemical constituents prepared for this study are adequate for regional planning and management purposes except those for the Silurian dolomite aquifer of northeastern Illinois. This aquifer system has been increasing in chloride content since about 1960, primarily due to the application of deicing road salt on the highways of the area. The 40 year median chemical values therefore do not represent current water quality conditions.

3. The general statewide ranges in chemical parameters for water from the drift deposits are: total dissolved solids, 400-600 mg/l; hardness, 300-500 mg/l; sulfates, 50-200 mg/l; nitrates, 0-20 mg/l; chlorides, 0-20 mg/l; and iron, 0.3-10.0 mg/l. The general statewide ranges in chemical parameters for water from the bedrock aquifer (Pennsylvanian, shallow dolomites and limestones, and deep sandstones) are: total dissolved solids, 350-3,000 mg/l; hardness, 150-1,000 mg/l; sulfates, 25-600 mg/l; nitrates, 0-5 mg/l; chlorides, 0-1,000 mg/l; and iron, 0.3-5.0 mg/l.

4. Due to the numerous variables involved in determining groundwater quality (geology, hydrology, recharge rates, well construction features, sampling procedures, and analytical deviations), statistical treatment of groundwater quality data to characterize its localized variability and skewness is not very useful.

5. Trend analyses of water quality data for municipal well fields are a usable tool for determining both regional and local groundwater quality trends. Of the 21 well fields examined in this study, water quality trends were detected for 2 drift, 3 shallow dolomite, and 2 deep sandstone well fields. The 3 shallow dolomite well field water quality trends support the regional trend in water quality noted in this aquifer system.

Recommendations:

1. To minimize the variability of groundwater quality data and maximize its use, complete and accurate information should be recorded at the time samples are collected. Such information should include well number, depth, location, date, and any special conditions associated with sampling (i.e. well just completed, contamination problem suspected, routine sampling, well just rehabilitated). An effort to standardize sample collection methods also is recommended.

2. Detailed groundwater quality trend analyses for additional municipal well fields should be undertaken. Routine sampling of municipal water supply wells (at least once a year per well) also should be continued to properly identify local and regional groundwater quality trends.

3. Field verification of suspected groundwater quality trend causes are recommended. Identification of these causes should facilitate their

control or elimination. It also provides needed information for designing an effective monitoring system.

4. Due to the adverse affects of road salt applications on the groundwater quality from shallow aquifer systems in northeastern Illinois and other isolated areas, control of its application or alternative methods of snow and ice removal from roads should be considered.

5. A statewide groundwater quality monitoring network should be developed. Such a network should collect samples in areas where data is sparse or old. Mass sampling programs should be designed and conducted in areas and aquifers where regional water quality trends are noted. Updating of information in these areas is essential to accurately evaluate the effects on an aquifer system.

6. A study comparing regional groundwater quality with base flow condition surface water quality should be conducted. The results of this study could be applied towards the development of a statewide groundwater monitoring program.

7. To assess the effectiveness of any proposed groundwater quality monitoring system, a study similar to this one should be undertaken every five years. Such studies can assess the distribution of new data, detect changes in regional and local groundwater quality parameters, and provide the basis for continued or altered monitoring schemes.

8. As soon as sufficient data is available, similar studies for additional chemical parameters should be undertaken.

Introduction

Groundwater in Illinois is the source of water for approximately 1,600 public water supply systems. It also is a principal source of water for industry, agriculture, and almost all private water supply systems in the state. In 1978, an estimated 945 million gallons per day of groundwater was used in Illinois (Kirk, et al., 1979).

Traditionally, groundwater has been considered to be a safe, sanitary source of water requiring little or no treatment prior to use. However, during the past 5 to 10 years environmentalists and the general public have been confronted with uncounted cases of groundwater pollution. Still, up until the last 2 or 3 years there generally has been a lack of concern about protecting the state's groundwater resources.

To effectively protect the quality of these resources, it is necessary to determine the natural quality of groundwater. Assessment of available data can demonstrate the degree and types of additional data needs, the general quality of the state's groundwater resources, the areas of the state where groundwater quality changes have taken place, and the general approaches that can be used to monitor and protect groundwater quality.

The purpose of this study is to summarize the groundwater quality data contained in the Water Survey files to facilitate future groundwater planning, management, and regulation efforts in Illinois. It also provides the needed evaluation of existing data to plan future data gathering and research projects.

The specific goals of the study are to:

- 1) delineate areas in Illinois where additional groundwater quality data are needed.

- 2) show the general chemical character of groundwater for six chemical constituents in five aquifer categories on a statewide basis.
- 3) determine the local variability of the six chemical parameters within each aquifer.
- 4) examine data for municipal well fields to determine if historical trends in groundwater quality can be observed and explained.

Acknowledgements

The authors wish to thank Robert Sinclair, Systems Analyst, Illinois State Water Survey, Urbana, for his invaluable assistance in the management and use of the groundwater quality data base, the creation of the geologic data files, and the sorting of the data by municipality and aquifer category. The authors also are grateful for the cooperation of Susan Wickham, Assistant Geologist, Illinois State Geological Survey, Urbana, in providing the geologic maps used in the construction of the geologic data base. Barbara Lence, Melissa Birch, Alison Randolph, and Ann Bogner, students at the University of Illinois, assisted in tabulating data from the geologic maps and plotting chemical data on the statewide aquifer maps and for historical trend analyses.

The project was conducted under the general supervision of Richard J. Schicht, Head of Hydrology, Illinois State Water Survey. Mr. Schicht also reviewed the final report. The art work was prepared by William Motherway and John Brother. The draft and final manuscripts were typed by Pamela Lovett and Pamela Morrissey.

Description of Data Bases

Groundwater quality data base

The Water Survey has been maintaining records of chemical analyses of groundwater since 1890. Records of some 28,000 analyses conducted by the Water Survey, Illinois Department of Public Health, and Illinois Environmental Protection Agency have been placed in a machine readable storage and retrieval system. These records include data for public water supply wells, industrial wells, irrigation wells, and privately owned domestic wells.

The creation of the groundwater quality data file was the first step toward making this information available for use on a large scale. However, as with any large data base, there are limitations and problems with inaccuracies, omissions, and errors. It is important for users of the groundwater quality data file to understand its composition and limitations.

The information in the data base is a collection of data from three agencies, the State Water Survey, the Illinois Department of Public Health, and the Illinois Environmental Protection Agency, operating seven different laboratories over a period of 90 years. In addition to the variance in results among laboratories, changing personnel and laboratory procedures may also contribute to differing analytic results.

Unfortunately, the information in the data file is not the result of years of random sampling. Certain biases have been introduced into the file over the years. Chemical analyses of samples collected from domestic wells were performed principally by the Department of Public Health and the Water Survey laboratories. Most of the samples were submitted voluntarily by owners of domestic wells. There are no controls on what parts of the state, what aquifers, or what wells are sampled. In many cases, "problem" wells

having poor quality water are sampled to gain information needed to solve the problem. Wells producing good quality water are less likely to be sampled. Likewise, data collected for special groundwater quality studies are likely to be for areas of suspected poor water quality or areas affected by pollution.

Water quality data from municipal wells is likely to be less biased than that described above. Routine sampling of municipal water supply wells to determine necessary treatment, changes in water quality, and in response to recent regulation requirements has resulted in a more representative municipal groundwater quality data base.

Parameters stored in the groundwater quality data file are shown in Table 1. This list is inclusive of all parameters stored. The elemental analyses performed on each sample are quite variable. From this list, six parameters (total dissolved solids, hardness, sulfate, nitrate, chloride, and iron) were selected for study. Preliminary scanning of the data suggested that analyses for these constituents were conducted for most samples submitted.

Evaluation of information contained in the data file showed that the bulk of the data had been accumulated since 1940 (see figure 1). For the purpose of creating the statewide groundwater quality maps, only data collected since 1940 was used. This eliminated less than 17 percent of the total data base and allowed the use of more current data to minimize trend effects. For historical trend analyses, all data were used.

Geologic data base

Five aquifer categories were selected for mapping of water quality parameters. These are:

- 1) drift wells < 50 feet deep
- 2) drift wells 50 feet deep

Table 1. Parameters stored in the groundwater quality data file

General Information

Location (county, township, range, section, 10 acre plot no.)

Municipality number

Well number

Source code

Date of analysis

Analysis number (source of analysis)

Chemical Parameters

| | | |
|-------------------------|----------|-----------|
| Residue | Aluminum | Lithium |
| Residue (nonfilterable) | Ammonium | Magnesium |
| Alkalinity | Barium | Manganese |
| Chloride | Boron | Mercury |
| Cyanite | Cadmium | Nickel |
| Fluoride | Calcium | Potassium |
| Hardness | Chromium | Silver |
| Nitrate | Copper | Sodium |
| Nitrite | Iron | Strontium |
| Phosphate (filtered) | Lead | Zinc |
| Phosphate (unfiltered) | | |
| Silica | | |
| Sulfate | | |
| Arsenic | | |
| Selenium | | |

Physical Parameters

Gases

| | |
|-------------|----------------------|
| Color | Free CO ₂ |
| Ordor | Methane |
| PH | Hydrogen sulfide |
| Temperature | |
| Turbidity | |

- 3) Pennsylvanian aquifers
- 4) shallow dolomite and limestone aquifers
- 5) deep sandstone aquifers

Experience suggests that water obtained from large-diameter dug or bored wells (usually less than 50 feet deep) often is affected by infiltration of surface derived pollutants. For this reason, data from wells tapping the drift or glacial deposits were divided into two categories (1 and 2 from above).

Data from wells tapping the underlying bedrock units were divided into categories 3, 4, and 5. Data from wells tapping Pennsylvanian age limestones and sandstones were sorted into category 3.

Category 4 contains data from wells tapping different geologic units in three distinct areas of the state. In northeastern Illinois where the Silurian age rocks are the uppermost bedrock unit (see figure 2), data from wells tapping the Silurian and Devonian age dolomites were used. In northwestern Illinois where the Maquoketa and Galena-Platteville (middle Ordovician) units comprise the rock surface, data from wells tapping the Galena-Platteville dolomites were used. For the remainder of the state, data from wells tapping Mississippian age limestones were used.

Category 5 contains data from wells tapping the deep sandstones or Cambrian-Ordovician aquifer systems. In northeastern Illinois where the Silurian age rocks lie beneath the drift, the Cambrian-Ordovician aquifer includes all units from the Galena-Platteville through the deeper-lying Ironton-Galesville. In northwestern Illinois, the Galena-Platteville units are not considered to be part of the Cambrian-Ordovician aquifer. In this area, it includes all units from the Glenwood-St. Peter through the Ironton-Galesville. Data for wells tapping the underlying Elmhurst-Mt. Simon aquifer were not mapped but were considered in the trend analyses portion of the study.

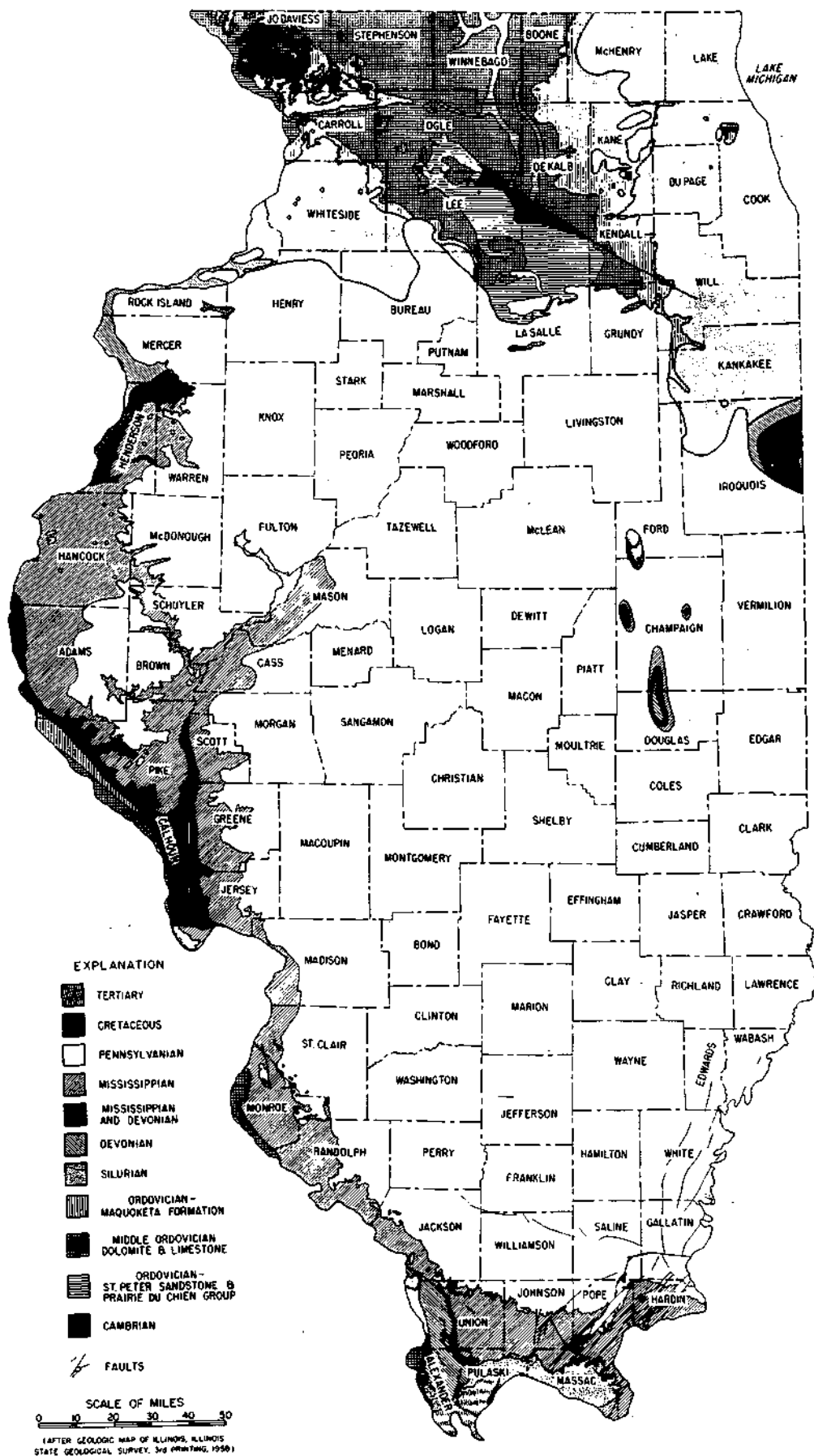


Figure 2. Geologic map of Illinois.

To sort the data in the groundwater quality data file into these aquifer categories, it was necessary to construct a geologic data base. Maps were obtained from the Illinois State Geological Survey describing the surface elevations and thicknesses of the major geologic contacts and units in the state. Table 2 lists the maps used to describe each geologic contact or unit thickness. A data file of land surface elevations of all bench marks printed on the 15 minute quadrangle topographic maps of the state also was obtained from the Illinois State Geological Survey.

From these maps and data file a geologic data base giving the average land surface elevation and average elevation of each major geologic contact for each township (36 square miles) in Illinois was compiled. This file was used to construct a second geologic file tabulating the average depths per township to the top and bottom of each aquifer category.

The depths of the wells given in the groundwater quality data file were compared to those generated for each aquifer category in the townships of interest and the well data sorted accordingly. It should be noted that the data was sorted according to the deepest geologic unit penetrated by the well in question. In the case of bedrock wells, no attempt was made to account for the possibility of the well bore being open to overlying units.

Table 2. Sources of data used to construct the
geologic data base

| | |
|-----------------------------------|--|
| Land surface elevation | computer cards listing elevations of all bench marks printed on 15-minute quadrangle topographic maps of Illinois, ISGS. |
| Bedrock surface elevation | "Bedrock Surface of Illinois," ISGS Bulletin 73, C. L. Horberg, 1957. |
| Bedrock surface code | "Geologic Map of Illinois," ISGS, H. B. Wilman and others, 1967. |
| Base of Pennsylvanian rocks | "Structure Contours on Top of Colchester (No. 2) Coal," ISGS, unpublished, W. H. Smith, 1973. |
| Base of Mississippian rocks | "Geologic Structure of the Devonian-Silurian Hunton Limestone Mega Group in Illinois," ISGS Illinois Petroleum Series 87, D. L. Stevenson and L. L. Whiting, 1967. |
| Thickness of the Maquoketa rocks | "Handbook of Illinois Stratigraphy," Fig. 0-26, ISGS Bulletin 95, Willman, et al., 1975. |
| Top of Galena rocks | "Structure on Top of the Galena Group (Trenton) in Illinois," ISGS Illinois Petroleum Series 99, H. M. Bristol and T. C. Buschback, 1973. |
| Top of St. Peter rocks | "Surface of the Ancell Group," ISGS working map, unpublished, 1975. |
| Thickness of the Eau Claire rocks | "Evaluation of the Ohio Valley Region Basal Sand as a Waste Water Injection Interval," Ohio River Valley Water Sanitation Commission, 1976. |
| Top of Elmhurst-Mt. Simon rocks | modified from "Evaluation of the Ohio Valley Regional Basal Sand as a Waste Water Injection Interval," Ohio River Valley Water Sanitation Commission, 1979. |

Methods of Analyses

Aquifer water quality maps

Data for each aquifer category was grouped by township, and the median chemical concentration values for each township were determined. To indicate the variability of the data, the coefficient of variability (CV), the standard deviation expressed as a percent of the arithmetic mean, was calculated for those townships for which 10 or more analyses were on file. The medians and coefficients of variability were then plotted on separate 1:500,000 scale base maps and contoured by hand in those parts of the state where adequate information was available. The greater the number of observations used in the determination of a particular value, the more weight this value was given when the contours were drawn. The contour intervals chosen for the median chemical concentrations maps were dependent upon the data for each particular map. The objective was to preserve to the maximum extent possible the information contained in the plotted data while keeping the maps as simple as possible. The CV values were contoured using a 25 percent interval and combined with the median value maps into single composite maps using overlay patterns to represent the CV percentage ranges.

Brief narratives discussing the more obvious features of each map are presented in the next section of this report. Mylar copies of the maps at a scale of 1:500,000 were provided to the Illinois EPA with this report.

In addition to the data summarized on the aquifer water quality maps, statistical analyses were performed for each aquifer category, chemical constituents, and township combination where 20 or more observations were available. Results of these analyses also were provided to the Illinois EPA with this report. Those results include for each township: 1) the mean,

2) the median, 3) the mode, 4) the maximum value, 5) the minimum value, 6) the number of observations, 7) the standard deviation, 8) the coefficient of variability, 9) the coefficient of skewness, and 10) the 10, 20, 30, 40, 50, 60, 70, 80, and 90 percent values.

Historical trend analyses

All water quality data for public water supply wells contained in the groundwater quality data file were considered in the search for evidence of significant, long-term trends in groundwater quality. However, there are an estimated 2,000 public groundwater supplies in Illinois with each supply involving several wells. Plotting the available data for all of these wells was beyond the scope of this project.

Initially, it was proposed to plot data for individual municipal wells with ten or more analyses spanning a period of at least ten years. Any significant changes in groundwater quality probably would occur over an extended period of time, and 10 years seemed to be a reasonable minimum time frame. However, only five wells in the state met these criteria.

As a result, the criteria was amended and data for those municipal well fields with at least 20 chemical analyses distributed over a twenty-year period was used. For the purpose of this study, a well field is defined as a group of wells which tap the same aquifer units and which are situated in relative close proximity to each other. Since, in general, groundwater from shallow aquifer units is likely to exhibit more chemical variation from point to point than groundwater derived from the deeper aquifer units, wells tapping shallow aquifers were required to be in closer proximity to each other than wells tapping deeper aquifer units.

In addition, the chemical analyses were required to be relatively evenly distributed over time. In order to qualify as a well field with sufficient

data for meaningful trend analysis, the data was required to exhibit a twenty-year period of record in which the time between consecutive analyses was no longer than ten years apart.

Some of the chemical analyses in the data file were considered unusable for the purpose of trend analysis. For example, for some analyses, the well number, depth, and location were not recorded when the sample was collected. This made it impossible to identify the source of the water sample and, therefore, made the data unusable. Frequently, changes in well depths or casing configurations will result in different aquifer units being tapped by the well following such changes. In this case, only that data was used that was collected at the time that the well tapped the geologic units being considered as part of the well field in question. In the case of a well with more than one sample analysis in a given month, the most recent analysis was used in the trend study. Any previous analyses for that particular well in that month was considered unusable. Due to the extreme variability of iron concentrations in most wells, historic trend analyses for iron were not attempted.

Municipal well field data which satisfied all of the requirements were then plotted, and the resulting plots were checked for apparent trends. When a significant, long-term trend in one or more of the chemical parameters was suspected, the data in question was checked for reliability and accuracy and an attempt was made to determine possible causes for the trend. Narratives which summarize the well and water quality data for those well fields with sufficient data are presented in the following sections of this report.

Aquifer Map Summaries

In Illinois, groundwater begins as precipitation which falls on the land surface and slowly seeps into the ground. As the water moves downward and laterally, it dissolves minerals and gases from the earth materials causing changes in its chemical character. In general, the deeper the water penetrates or the longer it is in the ground, the more highly mineralized it becomes. Therefore, the chemical quality of groundwater is a function of the mineralogy of the earth materials through which it passes and the time it has to dissolve minerals from those materials.

In a mineralogically and hydrologically homogeneous aquifer system, groundwater would be expected to become uniformly more highly mineralized as it moves from the point of recharge to the point of discharge. However, due to the variability in mineralogy and hydrology, it is almost impossible to predict the chemical quality of groundwater at a given location.

The maps discussed in this report illustrate the generalized median concentration values for total dissolved solids, hardness, sulfate, nitrate, chloride, and iron in each of the five aquifer categories studied. To emphasize the variation in the chemical quality of groundwater for a specified area, the coefficient of variability also has been contoured on the maps in areas where data was adequate to calculate this statistic. In areas where data was limited, the contour lines on the maps are dashed indicating less confidence in the median values. No meaningful information about the variability of the data can be presented in these areas.

Drift wells < 50 feet deep

Wells less than 50 feet deep tapping glacial drift deposits generally are of two types; large-diameter dug or bored wells and small-diameter drive

point wells. The large-diameter bored wells primarily are used in western and southern Illinois and other parts of the state where the glacial deposits have low permeabilities and are thin (see figure 3) and where bedrock yields are low or bedrock water quality poor. The drive point wells commonly are used where sand is encountered at or near the land surface and extends below a relatively shallow water table.

Chemical quality data for these types of wells is sparse but fairly well distributed with the exception of extreme southern Illinois (see figure 4). Little data is recorded from wells of these types in northern Illinois as they are seldom used in that part of the state.

The total dissolved mineral content of water from these types of wells generally ranges between 400 and 600 mg/l. One large area in the Havana Lowland area in Mason County appears to have less highly mineralized water (less than 400 mg/l Tds) due to the rapid recharge of low mineralized precipitation through the sandy soils of this area. More highly mineralized water (in excess of 800 mg/l Tds) is noted in the McLean, Livingston, and Putnam County areas. This phenomenon may be a result of the presence of highly organic surficial soils and near surface deposits in this part of Illinois (Willman, 1973). The area of highly mineralized waters delineated in Washington County represent data collected for a special study in this area. This study was geared towards investigating the presence of nitrates in old, brick-lined, hand-dug wells of the area, and is obviously not a representative sampling of all wells of the area.

In most parts of the state, the coefficient of variability for Tds appears to increase as the median concentration values increase. Two exceptions are the extremely variable areas in Washington County and East St. Louis. The East St. Louis area probably is affected by industrial activity while the

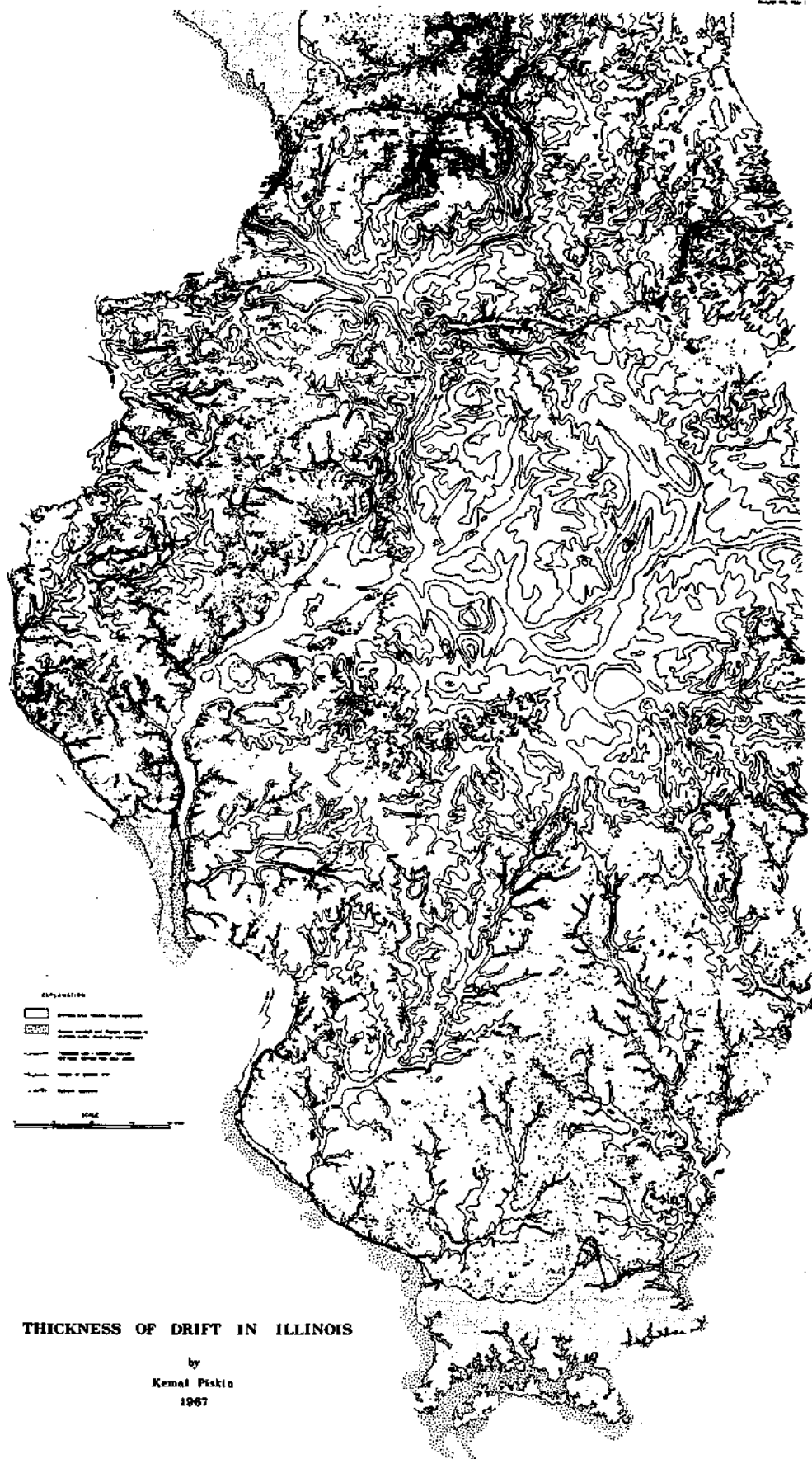


Figure 3. Thickness of drift deposits in Illinois.

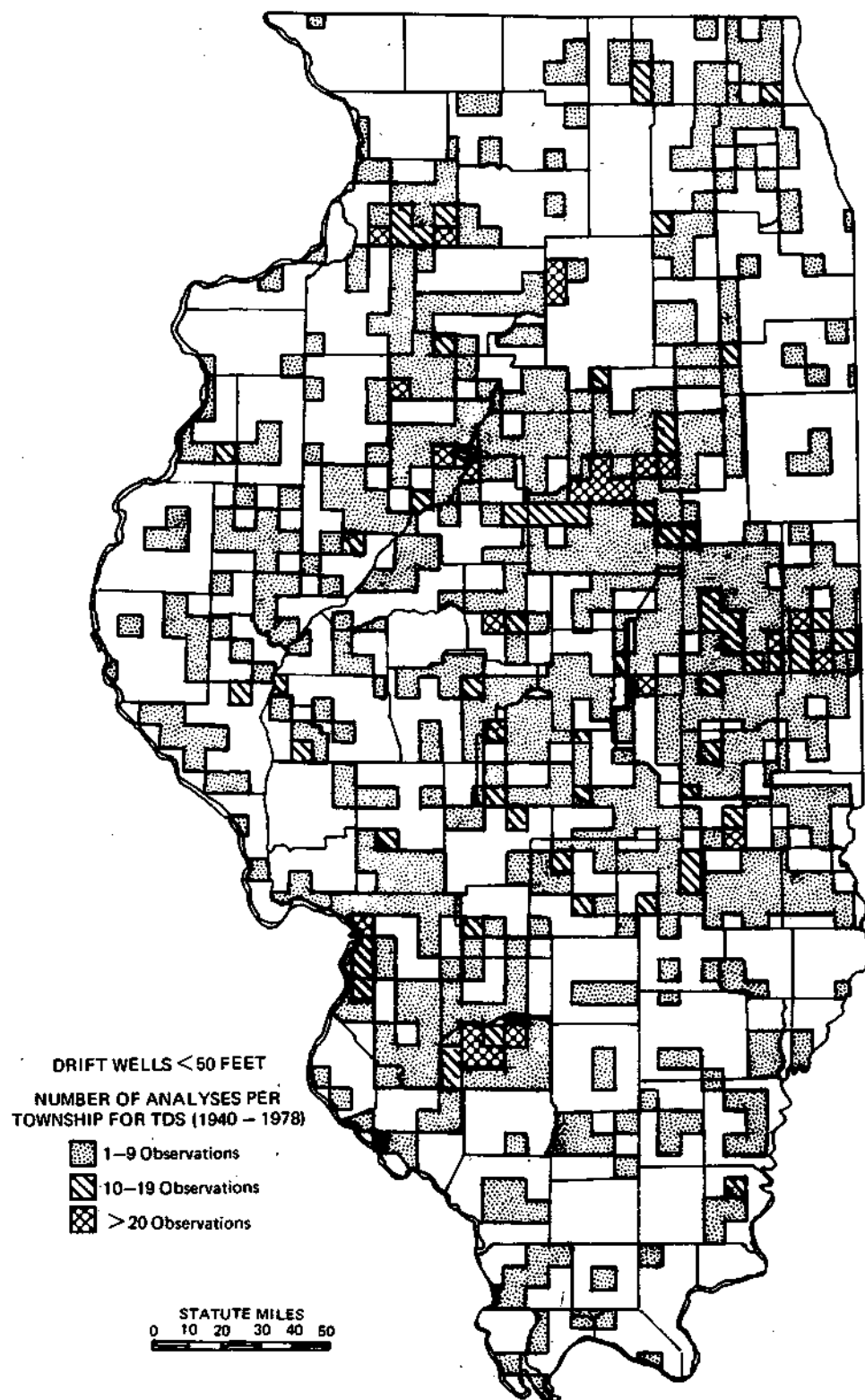


Figure 4. Distribution of chemical analyses for drift wells < 50 feet deep since 1940.

Washington County area most likely is the result of the types of wells sampled in the special study mentioned previously.

The hardness of water from drift wells < 50 feet deep appears to be near 400 mg/l in most of Illinois. Two areas, Washington County and Livingston-Putnam Counties, show higher median concentrations. The causes of these highs probably are the same as for Tds. The coefficients of variability for hardness generally are less than those for Tds with the exceptions of the Washington Count and East St. Louis areas.

The sulfate concentration in water from drift wells < 50 feet deep generally is less than 20 mg/l. Areas of higher median values (Washington County and McLean-Livingston Counties) result from large amounts of data from hand-dug, brick-lines wells. The coefficients of variability for nitrates are extremely high indicating the sensitivity of this constituent to proper well construction.

The chloride concentration in water from drift wells < 50 feet deep generally is near 20 mg/l. The Washington County study again results in data showing higher chloride concentrations as a result of septic tank effluent and feed lot runoff into the wells in that area. The high coefficients of variability for chlorides in the rest of the state probably are a result of the low median values.

The iron content of water from drift wells < 50 feet deep appears to be near 0.3 mg/l in the northern part of the state and increases from 1.0 to 10.0 mg/l in the clay pan areas of southern Illinois. The soils of the clay pan area are high in iron content and have been weathered sufficiently to release the iron and allow it to be carried into the shallow wells of the area. The coefficients of variability for iron are very high in the few areas where adequate data was available to calculate them.

Drift wells 50 feet deep

Drilled wells greater than 50 feet deep tapping sand and gravel deposits in the glacial materials are used throughout most of Illinois for domestic, municipal, and industrial uses. The areal distribution of water quality data for these types of wells is fairly good (see figure 5). The areas of best data coverage are in east-central Illinois, the East St. Louis area, the Peoria area, and Lake and McHenry Counties. In southern and extreme northern Illinois, very few of these wells exist which accounts for the lack of data in those areas.

In most of the state, the total dissolved solids content of water from these wells ranges from about 400 to 600 mg/l. A small area along the Illinois River in Mason County has Tds values below 200 mg/l due to the rapid infiltration of precipitation through the sandy soils of this area. Another area along the northern portions of Livingston and Ford Counties appears to contain more highly mineralized water (800 to more than 1000 mg/l Tds). It appears that upward movement of more highly mineralized water from the underlying Modesto and Carbondale Formations of the Pennsylvanian rocks may be the reason for this local anomaly. The increased values of chloride and sulfate in these wells in the same area supports this hypothesis. The coefficients of variability of Tds are of the same order of magnitude as those for the shallower drift wells and also tend to increase as median Tds values increase.

The hardness of water from drift wells 50 feet deep is fairly uniform throughout the state and generally varies from about 300 to 400 mg/l. In the Mason County area along the river it is below 200 mg/l and in northern Ford and Iroquois Counties it exceeds 600 mg/l. These high values in northern Ford and Iroquois Counties probably reflect the combined effects of migration

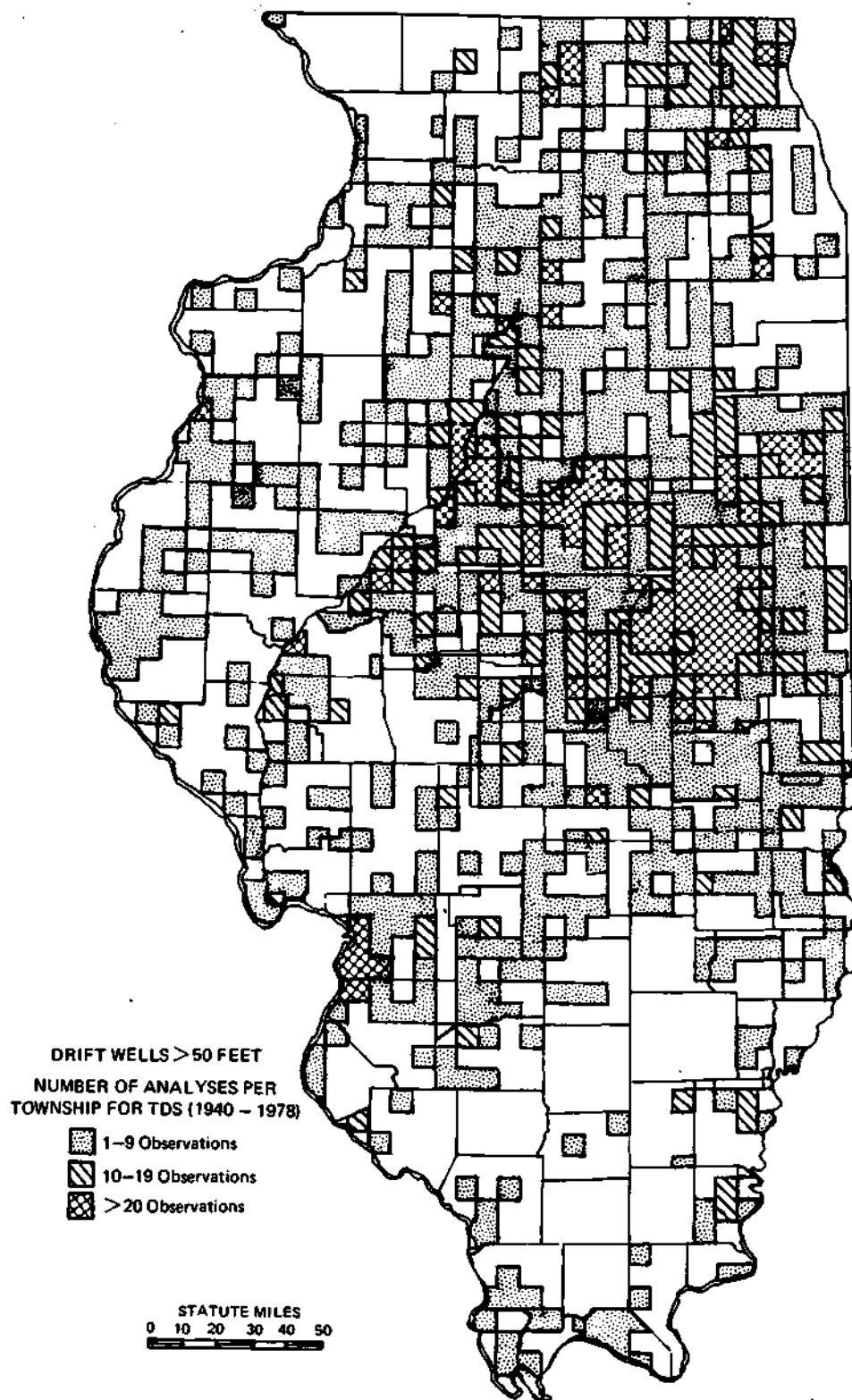


Figure 5. Distribution of chemical analyses for drift wells 50 feet deep since 1940.

of water from the underlying Pennsylvanian rocks and the presence of buried peat zones in western Iroquois County. The coefficients of variability for the hardness values are generally less than 75 percent.

The sulfate content of water from drift wells 50 feet deep generally ranges from about 50 to 100 mg/l. In northeastern Illinois, sulfate concentrations increase in an easterly direction as water containing higher sulfate concentrations in the underlying Silurian dolomite is hydraulically interconnected with the drift deposits. In northern Ford and western Iroquois Counties, high sulfates probably result from migration of water from the underlying Pennsylvanian rocks. The coefficients of variability for the sulfates from this type of well are higher (generally 75 to 100 percent).

The nitrate content of water from drift wells 50 feet deep are uniformly low (generally less than 10 mg/l). Due to the low concentrations and mean values, the coefficients of variability are large (75 to 100 percent).

The chloride content of water from drift wells 50 feet deep generally is less than about 20 mg/l. In parts of southern Illinois where the underlying Pennsylvanian rocks discharge to the drift units, chloride values occasionally exceed 40 mg/l. In isolated areas, oil well operations also cause increased amounts of chloride in the drift deposits. Again, due to the relatively low values, the coefficients of variability are large (generally 75 to 100 percent).

The iron content of water from drift wells 50 feet deep generally ranges between 1 and 5 mg/l. In the Mason County area along the Illinois River, the iron content usually is less than 0.3 mg/l. The higher iron concentrations in DeWitt, Coles, and Edgar Counties appear to be associated with glacial moraine deposits in these areas (see figure 6). In St. Clair and Monroe Counties along the Mississippi River, high iron contents (in excess

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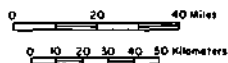
GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899),
Ekblow (1959), Leighton and Brophy (1961),
Willman et al. (1967), and others

- EXPLANATION**
- HOLOCENE AND WISCONSINAN**
- Alluvium, sand dunes, and gravel terraces
 - WISCONSINAN**
 - Lake deposits
 - WOODFORDIAN**
 - Moraine
 - Front of morainic system
 - Groundmoraine
 - ALTONIAN**
 - Till plain
 - ILLINOIAN**
 - Moraine and ridged drift
 - Groundmoraine
 - KANSAN**
 - Till plain
 - DRIFTLESS**
 - Driftless area



Modified from Bull. 94. - pl. 2

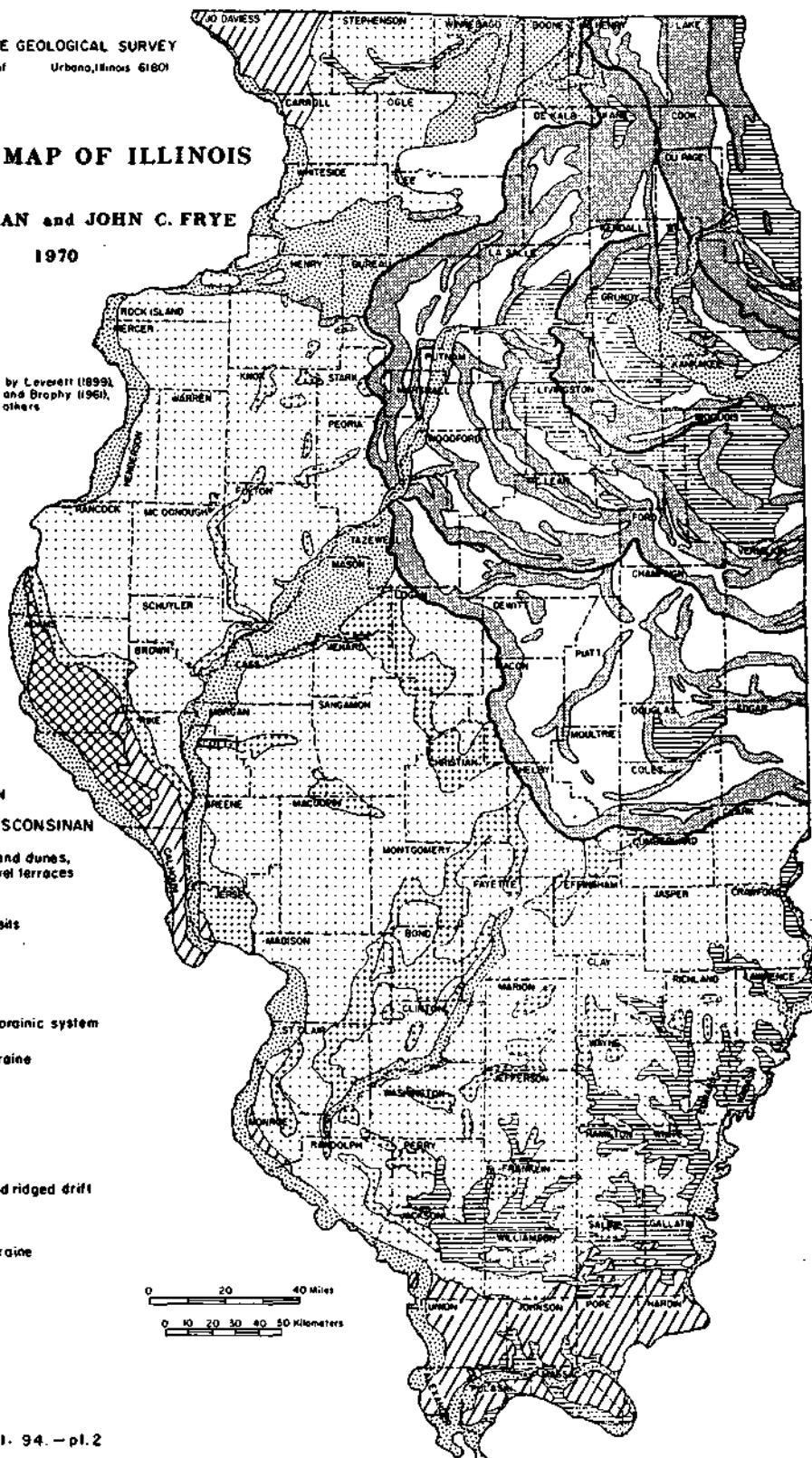


Figure 6. Glacial map of Illinois.

of 10 gm/l) also are encountered. The coefficients of variability for iron from all wells of this type are quite high (usually 75 to 100 percent).

Pennsylvanian aquifers

Pennsylvanian age limestones and sandstones are tapped as sources of small to moderate sized water supplies in the southern two-thirds of the state except for east-central Illinois where sand and gravel deposits of the glacial materials are used. Water quality data for these aquifers is limited to a small area in north-central Illinois (Livingston, Marshall, Peoria, Putnam, and Stark Counties) and the southern one-third of the state (see figure 7). Very little data exist for these aquifers in western Illinois.

The total dissolved solids content of water from these aquifers is extremely variable regionally and with depth. Two wells in the same general area tapping limestone or sandstone units at different depths often produce water of significantly different quality. For this reason, the maps for these aquifers as presented should be considered even more general than those presented for the other aquifer categories. In north-central Illinois, the Tds ranges from less than 500 mg/l in the west to more than 1500 mg/l in parts of Livingston County where the Pennsylvanian rocks are thicker. In southern Illinois, the Tds ranges from less than 500 mg/l along the southwest and east to more than 3000 mg/l toward the thicker portions of the Pennsylvanian rocks. The coefficient of variability for Tds from these aquifers is very high (75 to 100 percent). A portion of the variability can be attributed to the increased mineralization with depth and the different depths of wells in this category.

The hardness of water from the Pennsylvanian aquifers in north-central Illinois ranges from about 150 to 400 mg/l. In southern Illinois, it ranges

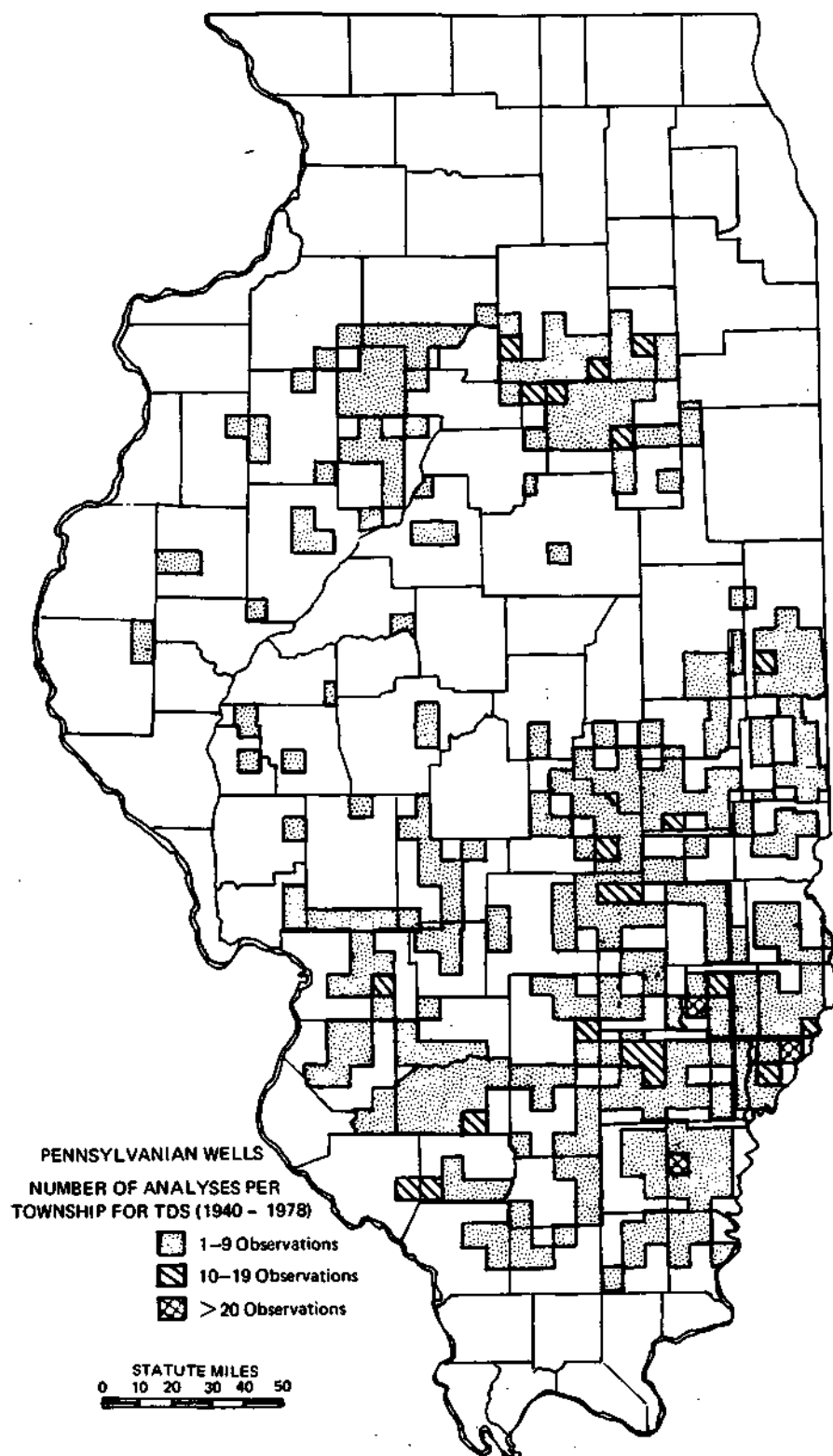


Figure 7. Distribution of chemical analyses for Pennsylvanian wells since 1940.

from about 150 mg/l to more than 1000 mg/l. In both areas, the higher hardness concentrations occur in areas where high hardness concentrations are encountered in the overlying drift deposits. The drift deposits are the recharge source for the underlying Pennsylvanian rocks in most of the state. The coefficient of variability for hardness in these aquifer ranges from 25 to 100 percent.

The sulfate concentrations of water from the Pennsylvanian aquifers generally is less than 5 mg/l. The isolated areas of higher nitrate contents (greater than 20 mg/l) may be the result of analyses of shallow drift wells which were erroneously placed in the Pennsylvanian aquifers category. The CV values where adequate data exist are near 100 percent.

The chloride content of water from the Pennsylvanian aquifers range from about 50 mg/l to more than 500 mg/l. The regional variability of chloride contents is similar to that for Tds. Higher concentrations are encountered in areas where the Pennsylvanian rocks are thicker. In order to tap the same sandstone or limestone unit in these areas, a deeper well is required and recharge water must penetrate a thicker section of rocks. The chloride CV values are extremely variable (25 to 100 percent).

The iron content of water from the Pennsylvanian aquifers generally range from 1 to 5 mg/l. No regional patterns of variability are noted. The CV values where determined are generally near 100 percent.

Shallow dolomite and limestone aquifers

The shallow dolomite and limestone aquifers are composed of four distinct areas and geologic units: 1) Silurian dolomites of northeastern Illinois, 2) Galena-Platteville dolomites of northwestern Illinois, 3) Mississippian limestones of western Illinois, and 4) Mississippian limestones of southern Illinois. The chemical character of each aquifer

of each aquifer system is unique and discussed separately, though all are plotted on the same series of maps. The distribution of chemical quality data for these aquifers is shown in figure 8. There is good coverage of data for the Silurian dolomites but very sparse data for the rest of these aquifers. The total dissolved solids content of water from the Silurian dolomites ranges from about 350 to over 1000 mg/l. The majority of the dissolved minerals consist of hardness and sulfate. The small area of high Tds in townships 37 and 38 North, range 12 East may be the result of quarry operations in this area which expose the dolomites to the air, thus, permitting the release and movement of calcium carbonates into the aquifer. The coefficients of variability for Tds in water from the Silurian dolomites range from about 25 to 75 percent.

The Tds in water from the Galena-Platteville dolomites ranges from about 350 to 450 mg/l and consists primarily of hardness. Insufficient data was available to assess the variability of Tds values in this aquifer system.

The Tds concentration in water from the Mississippian limestones of western Illinois ranges from about 400 mg/l in the west near the recharge zone to over 3000 mg/l toward the east down-dip into the Illinois Basin. Toward the east, wells tapping this aquifer system generally are deeper and the water increases in total mineral content, particularly chlorides. Insufficient data is available to calculate coefficients of variability in this area.

The Tds concentration in water from the Mississippian limestones of southern Illinois ranges from about 400 mg/l to over 1000 mg/l. In general, the lesser mineralized water is obtained from this aquifer along the Mississippi and Ohio Rivers where the aquifer system is exposed to more direct recharge because of outcrops below drift. To the west and north down-dip

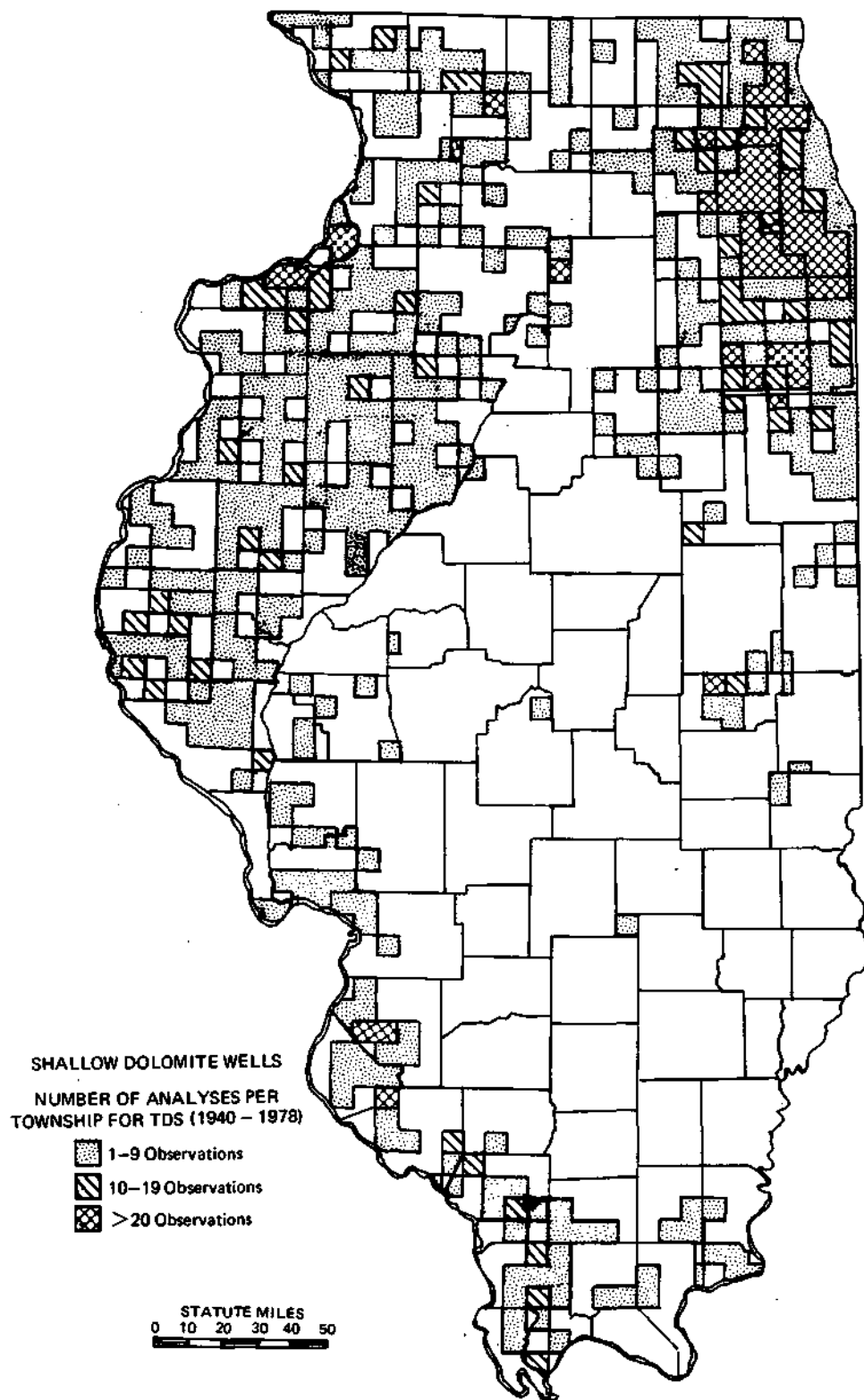


Figure 8. Distribution of chemical analyses for shallow dolomite wells since 1940.

into the Illinois Basin, the water becomes more highly mineralized and saline. The small area of highly mineralized water in Randolph County may be the result of reduced recharge rates through a small area of overlying Pennsylvanian rocks. The coefficients of variability for Tds in this aquifer range from 25 to 75 percent.

The hardness content of water obtained from the Silurian dolomites generally ranges from 200 to 400 mg/l. Higher hardness values are noted in the same area (T. 37 and 38 N, R. 12 E.) as the higher Tds values. The coefficients of variability for hardness ranges from 25 to 75 percent in most of the area.

The hardness content of water obtained from the Galena-Platteville dolomites generally ranges from 300 mg/l in the south, Lee and Whiteside Counties, to more than 400 mg/l near the Illinois-Wisconsin border. Only limited data was available for coefficient of variability determinations.

The hardness content of water from the Mississippian limestones in both western and southern Illinois generally ranges from 200 to 400 mg/l. The lower hardness values are encountered toward the east and north down-dip into the Illinois Basin, where the Tds and chloride values increase. Only scattered areas have sufficient recorded data to determine coefficients of variability.

The sulfate content of water from the Silurian dolomite generally ranges from about 50 mg/l along the west where the Silurian rocks are thin to more than 300 mg/l along the Lake Michigan shoreline where the Silurian rocks are thicker (150 to 300 feet thick). The coefficient of variability ranges from 25 to 100 percent.

The sulfate content of water from the Galena-Platteville dolomites generally is less than 50 mg/l. An isolated area near Galena, in Jo Daviess County, has sulfate contents in excess of 100 mg/l. The data is insufficient to determine coefficients of variability of sulfates in these rocks.

The sulfate content of water from the Mississippian limestones in western and southern Illinois ranges from about 25 to 125 mg/l with no discernable explanation for changes in concentrations. The data is insufficient to determine coefficients of variability in most of the areas.

The nitrate concentrations of water from the Silurian dolomites generally is less than 5 mg/l. Due to the low concentration values, coefficients of variability normally are high (near 100 percent).

The nitrate concentrations of water from the Galena-Platteville dolomites range from less than 5 mg/l in the western, southern, and extreme eastern portion of the area to more than 20 mg/l in parts of Stephenson, Winnebago, and Ogle Counties. The shape and location of the area of higher nitrate values is similar in shape to, and located along, the eastern limits of the Maquoketa rocks. It is possible that the Maquoketa rocks, principally shale, may be retarding the downward movement of nitrates into the Galena-Platteville dolomites in the western portion of this area. Movement of the nitrates would be toward the east into the Galena-Platteville not overlain by the Maquoketa rocks. Inadequate data was available to determine coefficients of variability for nitrates in this aquifer system.

The nitrate concentrations of water from the Mississippian limestones in western and southern Illinois normally are less than 5 mg/l. One area of unexplained higher concentrations (greater than 20 mg/l) is noted in southwestern Pike County. Only limited areas have sufficient data to determine coefficients of variability. Due to the low concentrations, the CV's are high (usually near 100 percent).

The chloride concentrations of water from the Silurian dolomites range from less than 5 mg/l to more than 30 mg/l based on median values from 40 years of data for this area. During the historical trend analysis for well fields tapping this aquifer, it became apparent that this map does not reflect current

conditions. Three well fields satisfying the data criteria for trend analysis and 9 others having too little data show trends of increasing chlorides in this aquifer system. A 1979 sampling of dolomite wells in the DuPage County area conducted by the Water Survey also revealed chloride concentrations in excess of 100 mg/l for several large areas in northeastern Illinois. In general, the areas of higher chloride concentrations are encountered along the major toll roads and highways suggesting that winter applications of road salt may be the cause of increasing chlorides in this aquifer system. Schicht (1979) also reported similar areas of increased chlorides along the major highways in the Madison-St. Clair County area. More discussion of trends in chloride concentrations in this aquifer system is presented later in this report. The coefficient of variability for chlorides in the Silurian dolomites ranges from 25 to 100 percent. The CV values also probably reflect the change of concentrations with time and are not representative of variabilities today.

The concentrations of chlorides in the Galena-Platteville dolomites generally range from 5 to 10 mg/l. There are insufficient data to determine CV values in most of this area.

The chloride concentrations of water from the Mississippian limestones of western Illinois range from less than 50 mg/l along the Mississippi River to more than 1000 mg/l along most of the Illinois River. The increase in chloride content appears to be associated with the thickness of the overlying Pennsylvanian rocks. As the Pennsylvanian rocks become thicker, direct recharge to the underlying Mississippian rocks is retarded and chloride concentrations increase in the Mississippian limestones. The CV values for chlorides in this aquifer system generally are not available due to the lack of data.

The chloride concentrations of the Mississippian rocks in southern Illinois range from less than 50 mg/l to more than 100 mg/l. Similar to the

regional trends for Tds values, the chlorides increase toward the north and in areas overlain by Pennsylvanian rocks. The lack of adequate data limits the determination of CV values for chlorides in most of the aquifer system.

The iron concentrations of water from the Silurian dolomites, the Galena-Platteville dolomites, and the Mississippian age limestones of western and southern Illinois generally range from about 0.3 mg/l to 1.0 mg/l. Two isolated areas in southern Illinois have values in excess of 5 mg/l. No obvious explanations are noted to explain the small regional changes. In areas where data are adequate to determine CV values, they are high (75 to 100 percent).

Deep sandstone aquifers

The deep sandstones or Cambrian-Ordovician aquifer system is tapped in the northern third of Illinois as a source for moderate to large water supplies. Wells tapping this aquifer may have all or any combination of the following water bearing units open to them: Galena-Platteville dolomites, Glenwood-St. Peter sandstone, Prairie du Chien dolomite, Eminence-Potosi dolomites, and the Ironton-Galesville sandstones. The quality of water from each of these units may vary slightly in parts of Illinois, but, in general, the hydrologic communications between units is sufficient to minimize chemical variability. The distribution of chemical quality data for the deep sandstones is illustrated in figure 9. Northeastern Illinois has good coverage of data while northwestern Illinois is rather sparsely covered.

The total dissolved solids concentrations in the deep sandstones vary from 400 and 500 mg/l in the northwest to more than 2000 mg/l toward the south. The lesser mineralized water is present in the principal recharge areas of this aquifer and more highly mineralized water is encountered

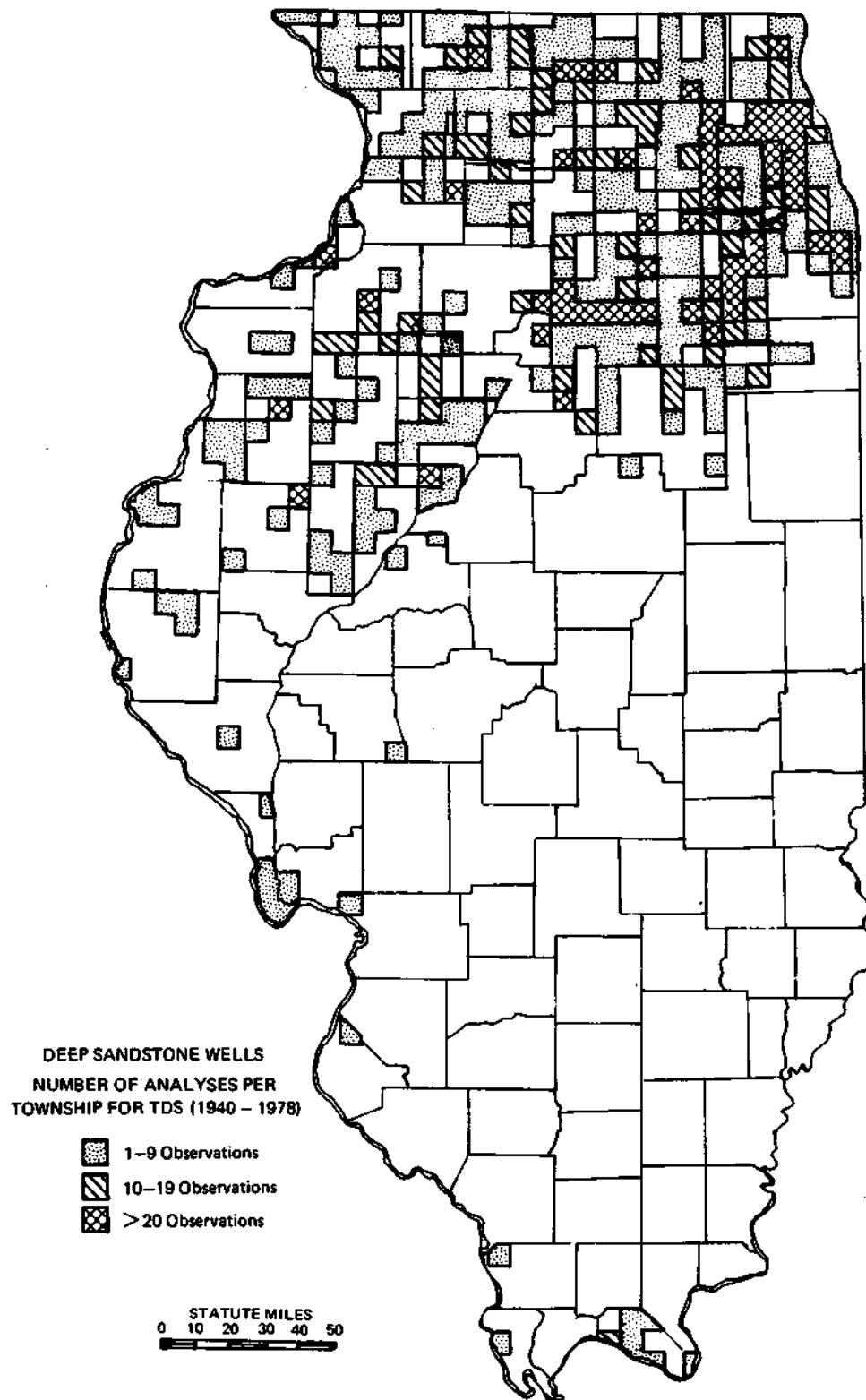


Figure 9. Distribution of chemical analyses for deep sandstone wells since 1940.

downgradient. The coefficients of variability for Tds range from near 0 to 100 percent. In general, the variability of water quality in this aquifer is less than that in other types of aquifers in Illinois. The deep sandstones are relatively homogeneous and, therefore, experience less change in water quality for a given area. The areas of high CV values lie south of the northern limits of the Pennsylvanian rocks and may be the result of these units being open to some wells in this category.

The hardness concentrations of water from the deep sandstones vary from about 175 mg/l in the recharge areas in northwestern Illinois to more than 600 mg/l in eastern Cook County and southern Fulton County. The CV values are relatively low, 0 to 75 percent, indicating the uniformity of water quality in this aquifer system.

The sulfate content of water from the deep sandstones varies in a fashion similar to that for Tds and hardness. Sulfates range from about 20 mg/l in the northwest to more than 600 mg/l in eastern Cook County and the southwest. The variability of sulfates generally is low, 0 to 25 percent, in areas of low concentrations.

The nitrate content of deep sandstone water generally is low, less than 5 mg/l, and regionally uniform. High coefficients of variability are a function of the statistic and low mean values.

The chloride content of water from the deep sandstones varies in a manner similar to that for Tds, hardness, and sulfates. The chlorides range from near 0 mg/l in the northwest to more than 200 mg/l in eastern Cook County. In the Livingston and Fulton County areas, concentrations in excess of 600 mg/l are encountered due to recharge of high chloride content water from the overlying Pennsylvanian rocks. The variability of chlorides generally is high due to the low mean values in the northwest and due to chlorides from the Pennsylvanian rocks in the south.

The iron concentrations of water from the deep sandstones generally is less than 1.0 mg/l and regionally uniform. The coefficients of variability are high due to the low mean concentrations values.

Historical Trend Analyses

Historical trend analyses were performed for 21 well fields having adequate data to satisfy selection criteria. Seven of these well fields tap sand and gravel deposits in the drift, one taps Pennsylvanian age rocks, one taps Mississippian age rocks, three tap Silurian age dolomite, and nine tap the deep sandstone aquifer systems. The location of these well fields are shown on figure 10.

Drift wells

The following municipalities have sand and gravel well fields with sufficient data for trend analyses in which no long-term trends in concentrations were noted for the five chemical constituents examined: Champaign-Urbana, Clinton, Edwardsville, Fairbury, and Farmer City. The variations in constituent values noted probably are the result of differences in the length of pumping time before sample collection, differences in laboratory procedures with time and agency, comparison of data from different wells, and random error inherent in all sampling. A summary of the data for each of these municipal well fields is presented in table 3.

The cities of Champaign-Urbana in Champaign County and Clinton in Dewitt County obtain their water supplies from wells in the sand and gravel deposits associated with the Mahomet buried valley system. It is interesting to note the slightly higher Tds, hardness, and chloride concentrations from the Clinton wells. The Clinton wells generally are deeper and downgradient in the regional flow system of this aquifer than the Champaign-Urbana wells. Both phenomena create longer residence times of regional flow and recharge water allowing more minerals to be dissolved from the earth materials.

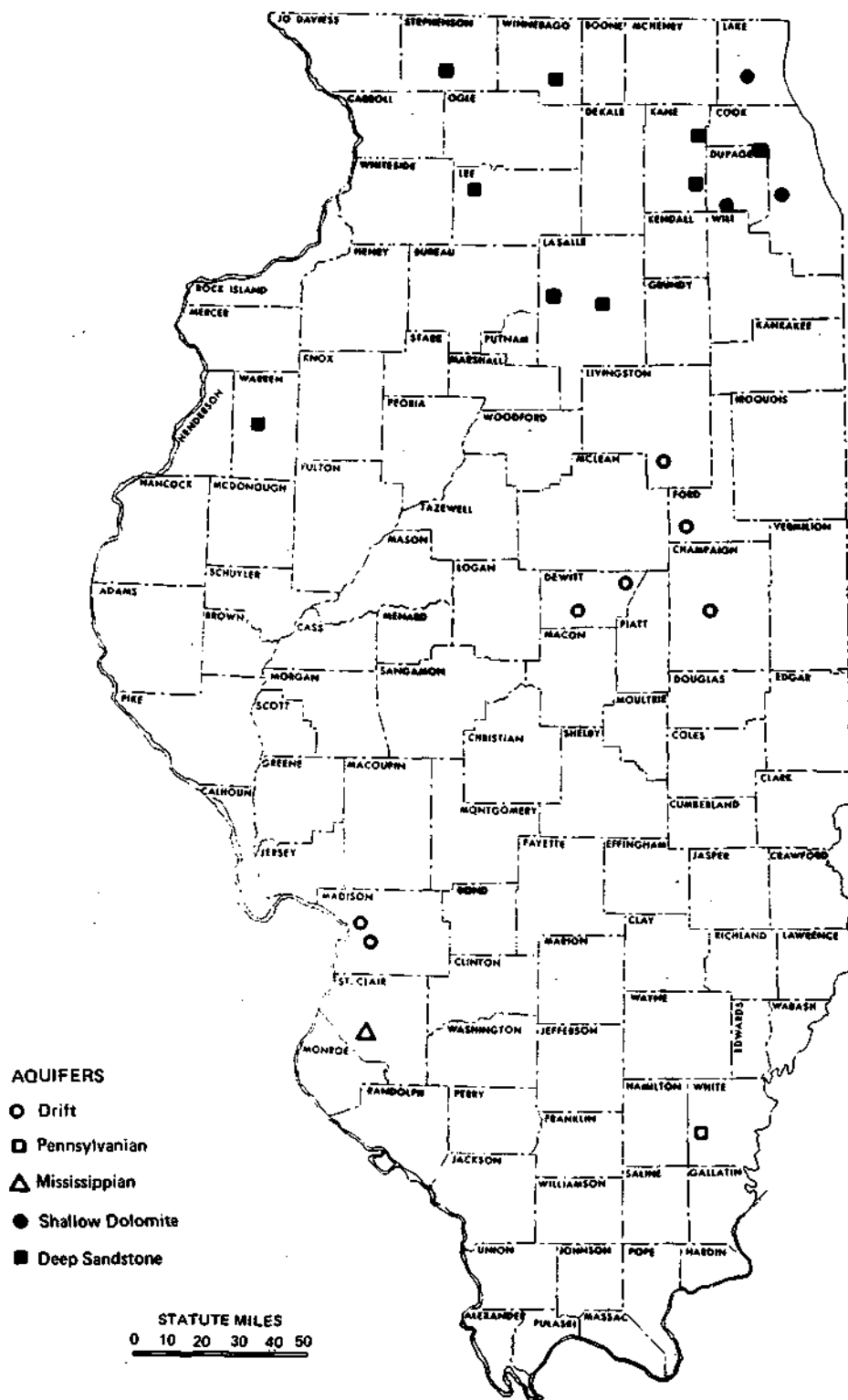


Figure 10. Location of well fields used in trend analyses.

Table 3. Summary of data for well fields exhibiting no long-term trends in the chemical constituents studied

| <u>Municipality</u> | <u>County</u> | <u>Wells Studied</u> | <u>Well Depths Min-Max (ft)</u> | <u>Units Open*</u> | <u>No. of Useable Analyses</u> | <u>Dates of Analyses Min-Max</u> | <u>Total Dissolved Solids Min-Max (mg/l)</u> | <u>Hardness Min-Max (mg/l)</u> | <u>Sulfate Min-Max (mg/l)</u> | <u>Nitrate Min-Max (mg/l)</u> | <u>Chloride Min-Max (mg/l)</u> |
|---------------------|---------------|---|---------------------------------|--------------------|--------------------------------|----------------------------------|--|--------------------------------|-------------------------------|-------------------------------|--------------------------------|
| Champaign-Urbana | Champaign | 48,53,56,57, 58,61 | 233-329 | D | 21 | 5/47-6/76 | 242-432 | 238-262 | 0.0-10.0 | 0.0-20.0 | 1.0-4.0 |
| Clinton | Dewitt | 1,2,3,4,5,6, 7,8 | 327-361 | D | 29 | 11/46-2/77 | 442-615 | 229-344 | 0.0-5.0 | 0.0-9.2 | 37.0-70.0 |
| Edwardsville | Madison | 2,3,4,5,6,7 | 105-117 | D | 20 | 2/40-11/76 | 233-380 | 164-305 | 39.0-73.0 | 1.2-37.0 | 2.0-56.0 |
| Fairbury | Livingston | 1,2,3,4 | 38-58 | D | 21 | 5/35-5/77 | 346-787 | 319-590 | 86.0-160.0 | 0.0-10.9 | 4.0-19.0 |
| Farmer City | Dewitt | 1,2,3,4,5, 6,7,8, one unnumbered well | 150-180 | D | 27 | 6/17-10/76 | 610-873 | 180-330 | 0.0-26.0 | 0.0-2.9 | 36.0-213.0 |
| Enfield | White | 1,2,3,4 | 353-410 | P | 23 | 2/49-12/76 | 1135-1330 | 4-127 | 0.0-161.0 | 0.0-3.3 | 130.0-166.0 |
| Millstadt | St. Clair | 1,2,3,4,5,6, 7,8,9 | 300-615 | M | 25 | 1/14-5/75 | 310-418 | 220-312 | 0.0-25.0 | 0.0-5.3 | 1.0-22.0 |
| Dixon | Lee | 4,5,6,7,8 | 1472-1874 | GSP,PC, IG,EC, EMS | 22 | 7/38-6/77 | 310-380 | 284-352 | 2.0-33.0 | 0.0-2.0 | 1.0-8.0 |
| Elgin | Kane | 1A,2A,3A, 4A,5A, St. Charles 3, Slade 5, Slade 6 | 1225-1378 | GP,GSP, PC,IG,EC | 20 | 9/49-11/76 | 280-374 | 244-266 | 0.0-13.0 | 0.0-1.2 | 2.0-40.0 |
| Geneva | Kane | 2,4,5 | 2217-2292 | GP,GSP, IG,EC, EMS | 23 | 3/28-1/78 | 261-570 | 216-450 | 16.0-100.0 | 0.0-79.0 | 8.0-70.0 |
| Monmouth | Warren | 4,5,6 | 2445-2465 | GP,GSP, PC,IG | 28 | 5/25-6/77 | 905-1287 | 237-474 | 290.0-554.0 | 0.0-5.0 | 103.0-157.0 |
| Ottawa | LaSalle | 7,8B | 1138-1186 | PC,IG | 21 | 11/37-4/77 | 398-611 | 276-352 | 6.0-77.0 | 0.0-3.6 | 41.0-126.0 |
| Peru | LaSalle | 5,6,7 | 2591-2665 | GP,GSP, PC,IG,EC | 20 | 1/32-4/77 | 692-1030 | 262-410 | 37.0-71.0 | 0.0-4.2 | 180.0-310.0 |
| Rockford | Winnebago | Unit Wells 3,4,5,9,10, 13,15,16,17, 18,20,21,22, 25,26,27,29, 30,36 | 1127-1600 | GSP,IG EC,EMS | 34 | 6/30-2/77 | 250-457 | 240-395 | 0.0-48.0 | 0.0-16.2 | 0.7-16.0 |

* D-drift, P-Pennsylvanian, M-Mississippian, GP-Galena-Platteville, GSP-Glenwood-St. Peter, PC-Prairie duChien, IG-Ironton-Galesville, EC-EauClaire, EMS-Elmhurst-Mt. Simon

Edwardsville in Madison County obtains its water from wells tapping sand and gravel deposits associated with the American Bottoms in Madison County. Fairbury in Livingston County obtains its water from wells tapping shallow sand and gravel deposits associated with the present day Vermilion River valley. The larger ranges in fluctuations in chemical constituents for the Fairbury wells probably is the result of seasonal fluctuations in water quality due to the relatively shallow aquifer and rapid recharge.

Farmer City in Dewitt County obtains its water from wells tapping sand and gravel deposits of Illinois age.

Two municipalities, Bethalto in Madison County and Gibson City in Ford County, have sand gravel well fields with sufficient data for historical trend analyses which revealed long-term trends for one or more of the five chemical constituents examined.

The village of Bethalto obtains its water supply from wells tapping the sand and gravel deposits of the American Bottoms area. Data for well nos. 1, 2, 3, 5, 6, 7, 8, and 9 were used to search for evidence of historical groundwater quality trends. These wells range in depth from 91 to 96 feet and collectively have 29 usable analyses spanning a period from March, 1942 through June, 1976.

No long-term trends were noted for hardness, sulfate, and nitrate concentrations. The minimum and maximum values for these constituents are 300 to 510 mg/l, 65.0 to 150.0 mg/l, and 0.0 to 7.0 mg/l, respectively. Increasing trends in Tds and chloride concentrations were noted (see figure 11) beginning sometime between 1953 and 1957 and increasing even more between 1963 and 1969.

Information available in the Water Survey files suggests two possible causes for noted trends. Heavy pumpage of groundwater from wells in the Wood River area has created a cone of water level depression about 2 miles south-

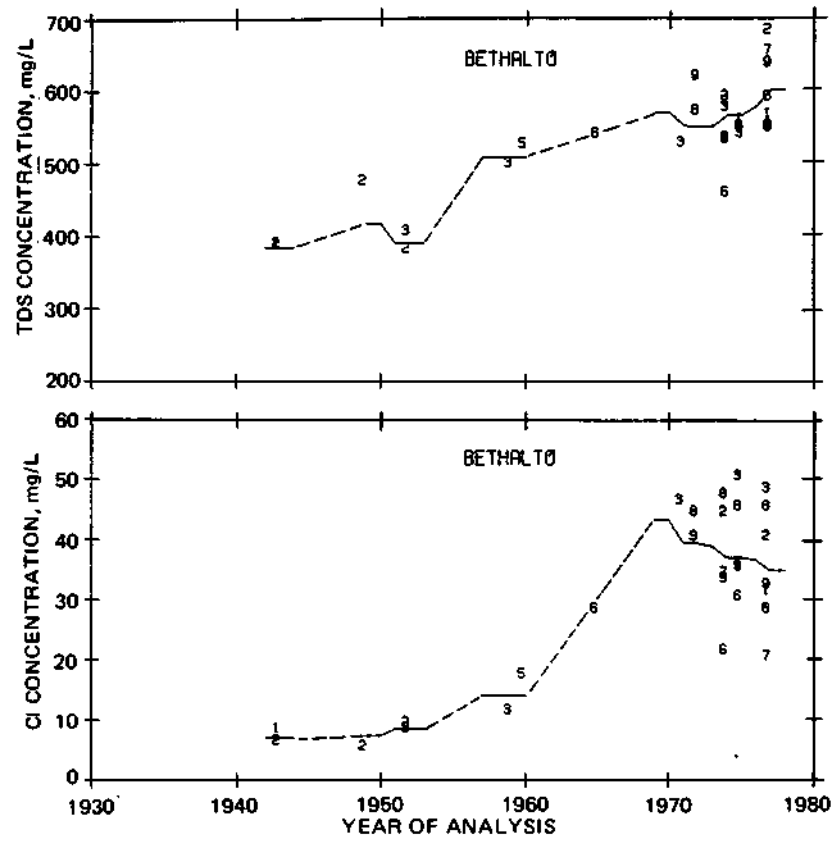


Figure 11. Groundwater quality trends for Tds and chlorides at Bethalto.

east of the Bethalto well field. The development of this cone has slowly altered the direction of groundwater flow in the Bethalto well field area from northeast-southwest to northwest-southeast, thus changing the source of regional flow toward the Bethalto wells and probably the water quality.

In addition, sometime between 1955 and 1968 a surface runoff holding pond was constructed about 1200 feet northwest of the Bethalto well field. Surface water runoff from the Civic Memorial Airport and Route 111 are collected in this pond and pumped to the river when water levels in the pond are too high. The increased use of highway deicing salts and drainage of those salts into this pond could be a significant source of chlorides and Tds. Movement of water from pond infiltration would be toward the Bethalto well fields. Well nos. 2, 3, and 8 are located on the northwest side of the well field and appear to be most affected (see figure 11).

Gibson City obtains its water from wells tapping relatively shallow sand and gravel deposits in the glacial drift. Data for well nos. 1, 2, and 3 were used to search for evidence of historical groundwater quality trends. These wells range in depth from 56 to 58 feet and collectively have 26 usable analyses spanning a period from August, 1938 through November, 1976.

No long-term trends were noted for nitrate content. The minimum and maximum values for this constituent are 0.0 to 3.2 mg/l. However, increasing trends in Tds, hardness, sulfates, and chlorides were noted (see figure 12) beginning sometime between 1963 and 1974.

Information contained in the Water Survey files suggests one possible cause for the noted increases. Well no. 2 was acidized in 1974 to remove chemical incrustations from the well screen. The well was first chlorinated, allowing the chlorine to sit in the well overnight, acidized with 1,000 gallons of muriatic acid, surged every 15 minutes for 4 hours, pumped to waste for

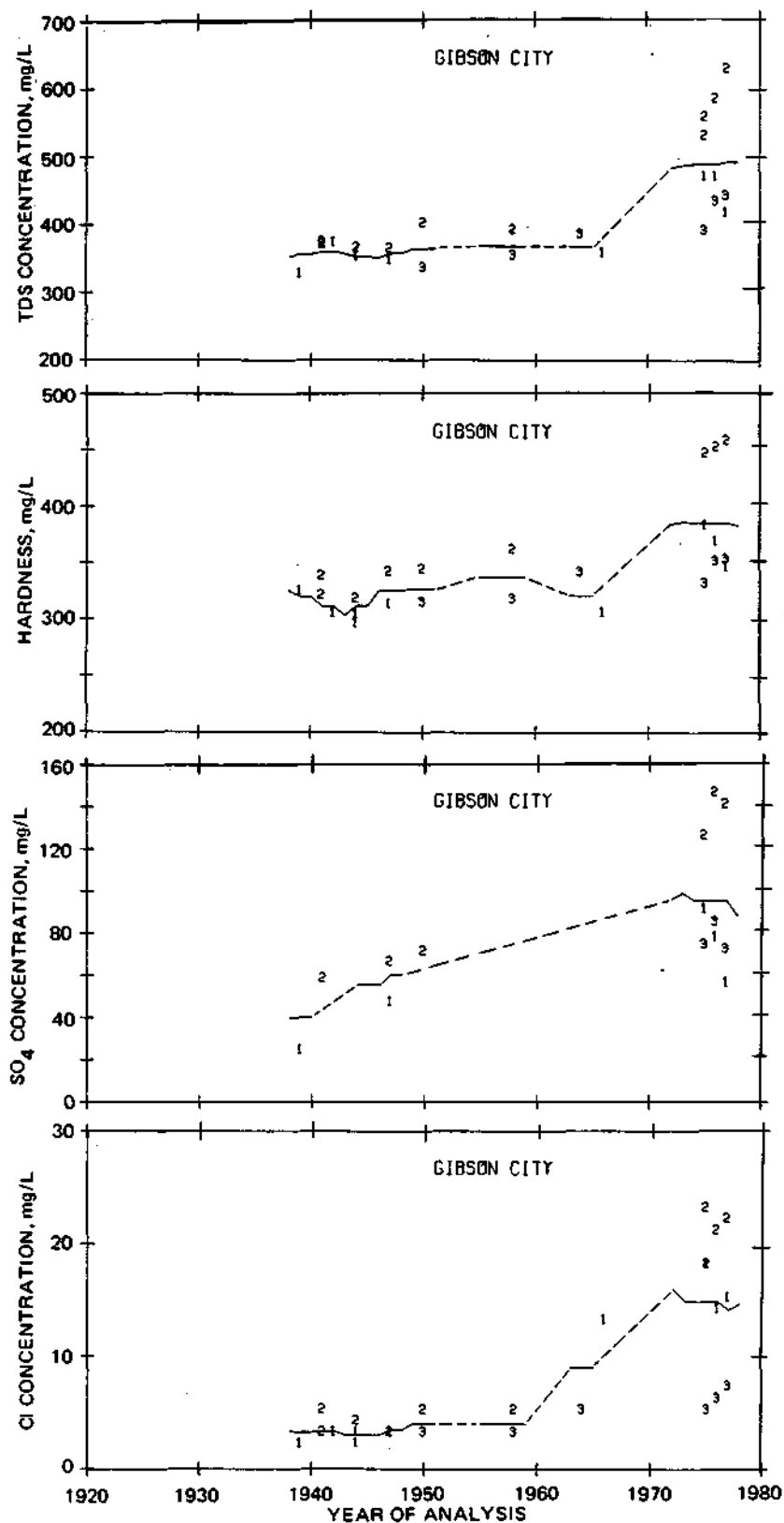


Figure 12. Groundwater quality trends for Tds, hardness, sulfates, and chlorides at Gibson City.

about 3 hours, chlorinated overnight again, and pumped to waste for 3 hours. Waste water pumped from the well reportedly was discharged into a tile storm sewer located about 56 feet north of well no. 2. It is very possible that the applications of chlorine and acid to the well and storm sewer have created an avenue for migration of storm water from the sewer to well no. 2.

The fact that well no. 2 has been affected the greatest and well no. 1, the closer well to no. 2, affected to a lesser extent but more than well no. 3 supports the hypothesis that the source of chemical increases probably is in the immediate vicinity of well no. 2. Field verification of this hypothesis could be easily accomplished and is recommended.

Pennsylvanian aquifers

The village of Enfield in White County is the only municipal well field tapping Pennsylvanian age rocks that had sufficient data for historical trend analysis. No long-term trends were noted for any of the five chemical constituents examined. The variations in constituent values probably are the result of differences in the length of pumping time prior to sample collection, differences in laboratory procedures with time and agency, comparison of data from different wells, and random error inherent in all sampling. A summary of data for the Enfield well field is presented in table 3.

Shallow dolomite and limestone aquifers

The city of Millstadt in St. Clair County obtained its water supply from wells tapping Mississippian age sandstone up until April, 1977. Since that time all the city wells have either been abandoned or deeded to private individuals and disconnected from the distribution system. Water is now obtained from the American Water Company of Belleville.

Sufficient data for the Millstadt wells prior to abandonment were available for historical trend analysis. No long-term trends were noted for any of the five chemical constituents examined. The variations in constituent values are probably the result of differences in the length of pumping time prior to sample collection, differences in laboratory procedures with time and agency, comparison of data from different wells, and random error inherent in all sampling. A summary of data for the Millstadt well field is presented in table 3.

Three municipalities, La Grange in Cook County, Libertyville in Lake County, and Naperville in DuPage County, have well fields tapping Silurian age dolomite with sufficient data for historical trend analysis. Data for all three well fields revealed long-term trends for one or more of the five chemical constituents examined.

The city of La Grange obtains its water supply from wells tapping the Silurian age dolomite. Data for well nos. 3, 5, 6, and 7 were used to search for evidence of historical groundwater quality trends. These wells range in depth from 352 to 475 feet and collectively have 30 usable analyses spanning a period from July, 1947 through December, 1976.

No long-term trends were noted for hardness, sulfate, or nitrate concentrations. The minimum and maximum values for these constituents are 808 to 1050 mg/l, 403 to 600 mg/l, and 0.00 to 1.50 mg/l, respectively. Increasing trends for Tds and chlorides were noted (see figure 13) beginning sometime shortly after 1960. The wells affected most appear to be nos. 3 and 5.

Data contained in the Water Survey files suggest one possible source for the increase in Tds and chlorides.

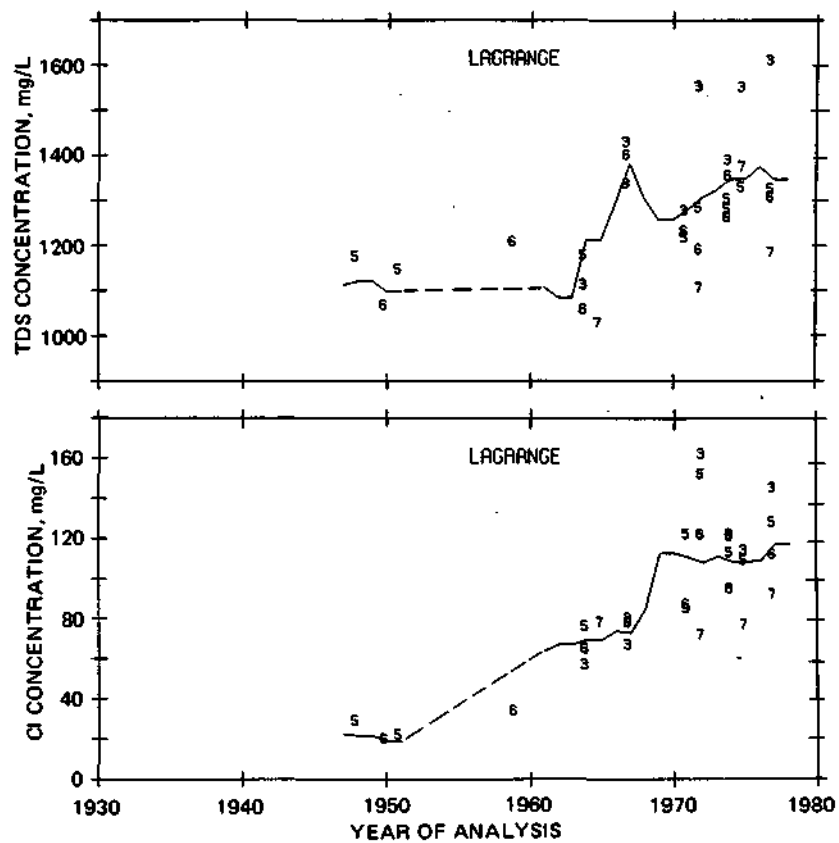


Figure 13. Groundwater quality trends for Tds and chlorides at La Grange.

An ion-exchange type water softening unit is used to treat water for La Grange. This unit is located near well no. 3 and brine used to regenerate the unit reportedly is discharged into storm sewers in the area. It is quite likely that the discharged brine has penetrated the unconsolidated materials and are entering the dolomite aquifer in this area.

Based on a July 1979 piezometric surface map of the Silurian dolomite of the area, well no. 3 is upgradient from well nos. 5 and 6. The general direction of water movement for this aquifer in the La Grange well field area is to the west. Well no. 7, the least affected well, is located northwest of well no. 3, upgradient of the area of suspected sources. The available data supports the theory that the source of the noted trends is in the vicinity of well no. 3.

The city of Libertyville obtains a portion of its water supply from wells finished in the Silurian age dolomite. Data for well nos. 1, 3, 4, 5, 6, 7, 8, and 9 were used to search for evidence of historical groundwater quality trends. These wells range in depth from 227 to 330 feet and collectively have 20 usable analyses spanning a period from October, 1935 through June, 1974.

No long-term trends were noted for sulfate or nitrate concentrations. The minimum and maximum values for these constituents are 310 to 433 mg/l and 0.00 to 2.10 mg/l, respectively. Increasing trends for Tds, hardness, and chlorides were noted (see figure 14) beginning sometime around 1968.

Data available in the Water Survey files for Libertyville show no singularly obvious possible sources for these trends. All of the wells of interest are located in the northeast part of Libertyville towards the Des Plaines River. Drainage of surface water runoff from the city streets is directed toward the river and the wells of interest. In this area the

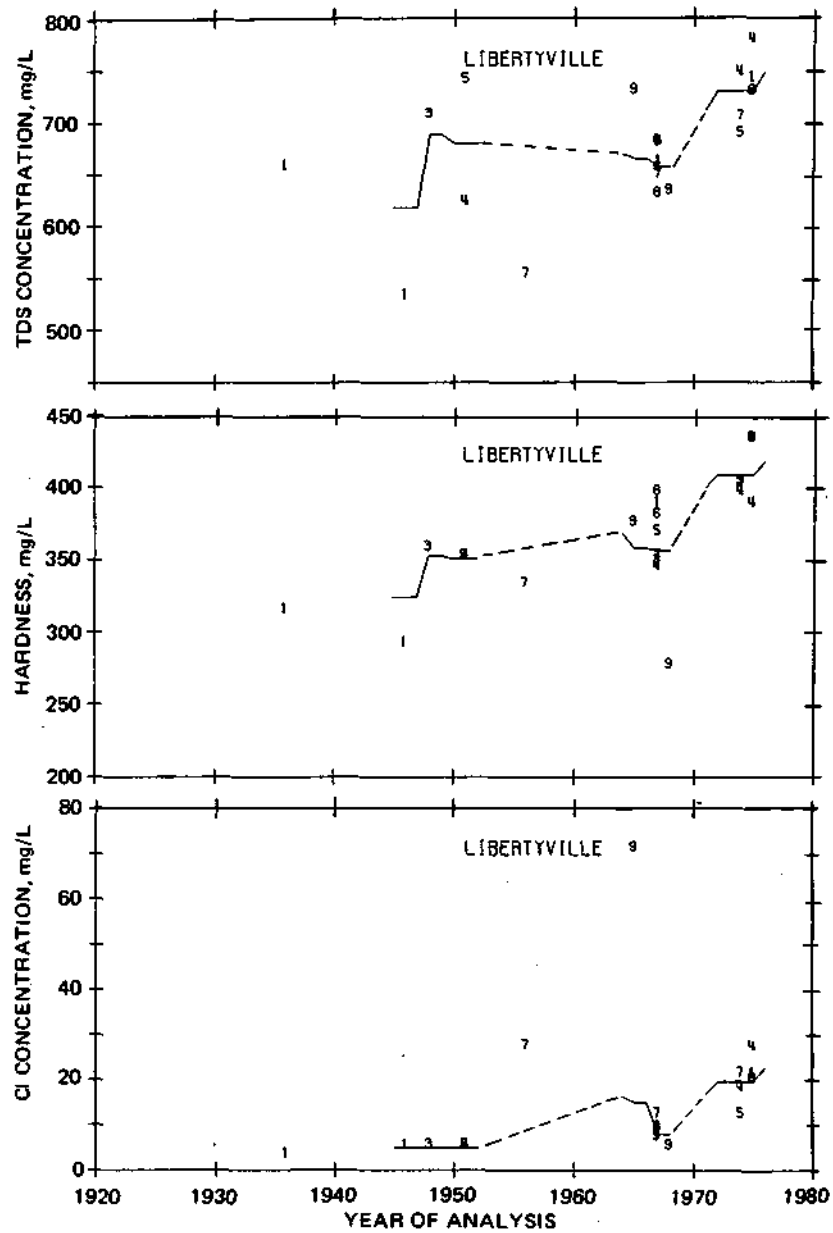


Figure 14. Groundwater quality trends for Tds, hardness, and chlorides at Libertyville.

dolomites are overlain by sand and gravel deposits from the surface downward, making the dolomite susceptible to pollution from surface sources. This phenomena could be a possible explanation for the noted trends. Lowering of water levels in the dolomite wells (from about 20 feet in 1950 to more than 125' in 1976) also could accelerate the downward movement of pollutants through the overlying drift deposits.

The city of Naperville obtains a portion of its water supply from wells finished in the Silurian age dolomite. Data for well nos. 5, 6, 8, 9, 10, 11, 12, 13, 14, and 15 were used to search for evidence of historical ground-water quality trends. These wells range in depth from 190 to 351 feet and collectively have 43 usable analyses spanning a period from April, 1931 through January, 1978.

No long-term trends were noted for sulfate or nitrate concentrations. The minimum and maximum values for these constituents are 42 to 262 mg/l and 0.00 to 16.80 mg/l, respectively. The large variations of these constituent's values are random and probably are the result of differences in the length of time of pumping before sample collection, differences in laboratory procedures with time and agencies, and comparison of data from different wells. Increasing trends for Tds, hardness, and chlorides were noted (see figure 15) beginning sometime around 1970.

Data available in the Water Survey files for Naperville show several possible related sources for the trends of the wells examined. Well no. 15 is located in close proximity to and downgradient from Naperville's sewage disposal facility, a surface source for Tds, hardness, and chlorides. Well nos. 10 and 13 are located within ½ mile and downgradient from the East-West Tollway. Applications of deicing road salts could be the surface source of Tds, hardness, and chlorides to these wells. All the other wells of interest

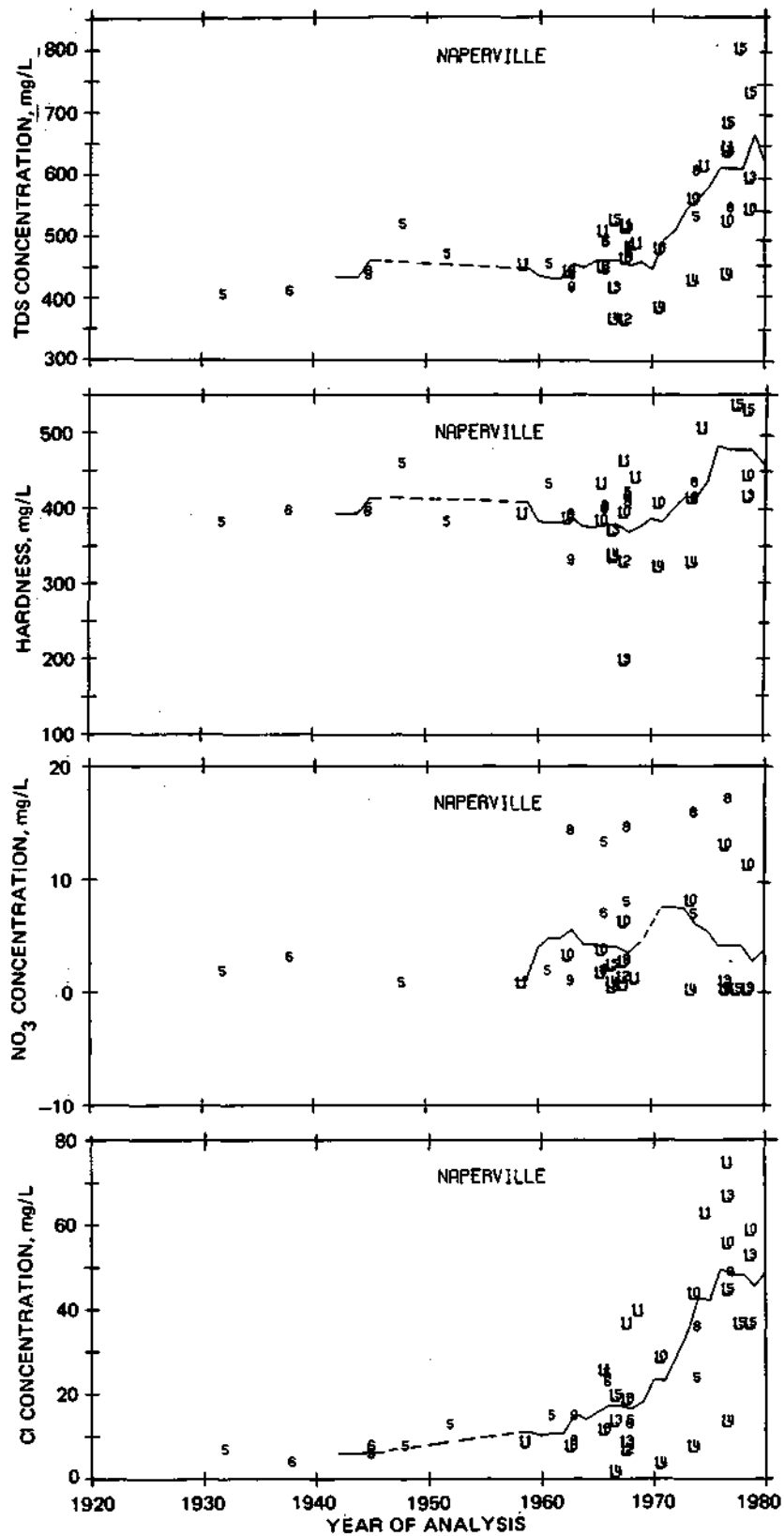


Figure 15. Groundwater quality trends for Tds, hardness, nitrates, and chlorides at Naperville.

are located in metropolitan areas or near major roads where application of deicing salts is commonly used. It is likely that the shallow dolomite aquifer of the area has been regionally affected by these surface sources of pollutants.

As stated earlier in this report, a 1979 sampling of wells tapping the Silurian dolomite aquifer in the Du Page County area revealed that this aquifer system has been affected by the application of road salt. The areas of high chloride content are near the major interstates, toll roads, and state highways and their intersections. The increases in chlorides for all cities studied, including those not satisfying the selection criteria, began in about 1960. This date agrees with the time of increased use of road salt in Illinois. Walker (1975) also noted an increase in chloride content of the Illinois River beginning about the same time. The trend in the minimum annual chloride content of the Illinois River probably reflects the trend in the average annual chloride content of the Silurian dolomite aquifer. This aquifer system contributes a high percentage of base flow to the Illinois River and therefore affects its low flow chemical character.

Deep sandstone aquifer

The following municipalities have deep sandstone well fields with sufficient data for historical trend analysis in which no long-term trends in water quality were noted for any of the five chemical constituents examined: Dixon, Elgin, Geneva, Monmouth, Ottawa, Peru, and Rockford. The variations in constituent values probably are the result of differences in the length of pumping time prior to sample collection, differences in laboratory procedures with time and agency, comparison of data from different wells, and random error inherent in all sampling. A summary of the data for each of these municipal well fields is presented in table 3.

The city of Dixon in Lee County obtains its water supply from wells tapping the Cambrian-Ordovician and Elmhurst-Mt. Simon aquifer systems. Data for well nos. 4, 5, 6, 7, and 8, open to the Ancell (Glenwood-St. Peter) and Prairie du Chien groups, the Ironton-Galesville, Eau Claire, and Elmhurst-Mt. Simon formations, were used to search for evidence of historical groundwater quality trends.

The city of Elgin in Kane County obtains a portion of its water supply from wells tapping the Cambrian-Ordovician aquifer system. Data for well nos. 1A, 2A, 3A, 4A, 5A, St. Charles 3, Slade Ave. 5, and Slade Ave. 6, open to the Galena-Platteville, Ancell (Glenwood-St. Peter) and Prairie du Chien groups, and the Ironton-Galesville and Eau Clair formations, were used to search for evidence of historical groundwater quality trends.

The city of Geneva in Kane County obtains its water supply from wells tapping the Cambrian-Ordovician and Elmhurst-Mt. Simon aquifer systems. Data for well nos. 2, 4, and 5, open to the Galena-Platteville and Ancell (Glenwood-St. Peter) groups, and the Ironton-Galesville, Eau Claire, and Elmhurst-Mt. Simon formations, were used to search for evidence of historical groundwater quality trends.

The city of Monmouth in Warren County obtains its water supply from wells tapping the Cambrian-Ordovician aquifer system. Data for well nos. 4, 5, and 6, open to the Galena-Platteville, Ancell (Glenwood-St. Peter), and Prairie du Chien groups, as well as the Ironton-Galesville formation, were used to search for evidence of historical groundwater quality trends.

The city of Ottawa in LaSalle County also obtains a portion of its water supply from wells tapping the Cambrian-Ordovician aquifer system. Data for well nos. 7 and 8B, open to the Prairie du Chien group and the Ironton-Galesville formation, were used to search for evidence of historical groundwater quality trends.

The city of Rockford in Winnebago County obtains a portion of its water supply from wells tapping the Cambrian-Ordovician and Elmhurst-Mt. Simon aquifer systems. Data for Unit well nos. 3, 4, 5, 9, 10, 13, 15, 16, 17, 18, 20, 21, 22, 25, 26, 27, 29, 30, and 36, open to the Ironton-Galesville, Eau Claire, and Elmhurst-Mt. Simon formations, were used to search for evidence of historical groundwater quality trends.

Two municipalities, Bensenville in DuPage County and Freeport in Stephenson County, have deep sandstone well fields with sufficient data for historical trend analyses which revealed long-term trends for one or more of the five chemical constituents examined.

Bensenville obtains its water from wells in the Cambrian-Ordovician aquifer system. Data for well nos. 2, 3, 4, and 5, open to the Galena-Platteville and Ancell (Glenwood-St. Peter) groups, and the Ironton-Galesville and Eau Claire formations, were used to search for evidence of historical groundwater quality trends. These wells range in depth from 1449 to 1494 feet and collectively have 26 usable analyses spanning a period from January, 1938 through February, 1977.

No long-term trends were noted for Tds, hardness, sulfate, or nitrate concentrations. The minimum and maximum values for these constituents are 361 to 578 mg/l, 194 to 354 mg/l, 48.0 to 160.0 mg/l, and 0.0 to 7.00 mg/l, respectively. An interesting trend in chlorides were noted (see figure 16) starting about 1965. The chloride content of water from well no. 2 began to increase and fluctuate over a large range of values (29 to 130 mg/l).

Data contained in the Water Survey files suggest several possible sources for the chlorides and an explanation for the fluctuation of concentrations. Well no. 1 is located 75 feet from well no. 2. Well no. 1 has been abandoned

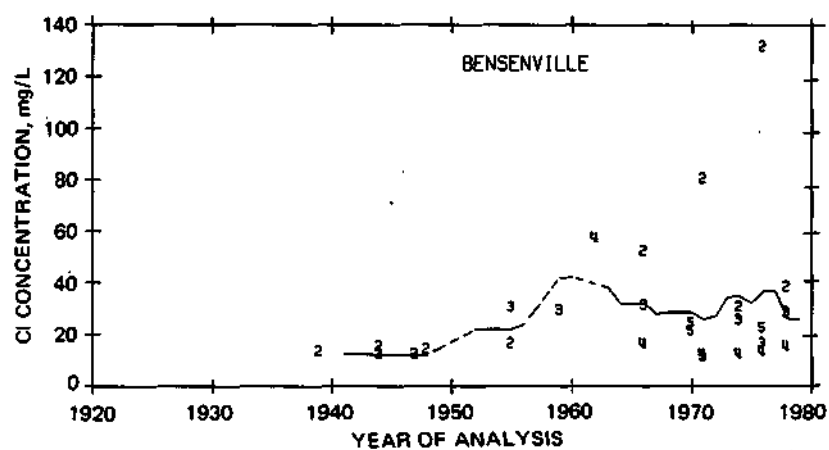


Figure 16. Groundwater quality trends for chlorides at Bensenville.

and reportedly sealed at the surface. However, it is possible than an ineffective seal or a deteriorating casing could allow entrance of surface derived chlorides from the drift and shallow dolomite aquifer into the well and aquifer system. Well no. 2 has itself been repaired to seal a hole in the casing opposite the shallow Niagaran limestone. Entrance of poor quality water from this limestone to the well was reported. In addition to problems with well nos. 1 and 2, several wells owned by the railroad, located about 3/4 mile east of well no. 2, have been abandoned and probably not sealed. These wells are hydraulically upgradient from well no. 2 and any chlorides entering these wells would eventually be detected in Bensenville well no. 2.

In addition to the above mentioned possible sources, the water levels for the deep sandstone have declined severely due to overpumping of the aquifer in the area. As a result, upward migration of higher chloride content water from the underlying Elmhurst-Mt. Simon is likely. The erratic chloride concentrations of water from well no. 2 supports this theory. During periods when the well was not used as much, lower chloride concentrations were noted.

Freeport obtains a portion of its water supply from wells tapping the Cambrian-Ordovician aquifer system. Data for well nos. 2, 3, 4, and 6, open to the Glenwood-St. Peter sandstone formation, were used to search for evidence of historical groundwater quality trends. These wells range in depth from 415 to 472 feet, and collectively have 21 usable chemical analyses spanning a period from March, 1925 to October, 1977.

No long-term trends were noted for nitrate concentrations. The minimum and maximum nitrate values are 0.00 to 24.10 mg/l, respectively. Trends were detected for Tds, hardness, sulfates, and chlorides for the wells examined.

The increasing trends for Tds, hardness, and chlorides were noted about 1966 and the trend for sulfates in about 1952 (see figure 17).

Data available in the Water Survey files suggest that the increased mineralization of water in well no. 4 probably is coming from the Galena-Platteville dolomite which supposedly is cased out from the well. The five year moving averages plotted on figure 16 were calculated using data for wells tapping only the Glenwood-St. Peter. Up until 1962, well no. 2 was not cased through the Galena-Platteville and the resulting increases in Tds, hardness, sulfates, and chlorides can be seen in figure 16. Similarly, in 1965 the casing in well no. 3 was pulled back exposing the Galena-Platteville and again increased mineral contents were noted (see figure 16). Our files contain no record of reworking the well casing in well no. 4. However, it reportedly was rebuilt last in 1947 and a leak in the casing or casing seal could have developed during these 23 years, thereby affecting well no. 4. Similarly, a shift in pumping schedules, i.e. using well no. 4 more than in the past, could be pulling the highly mineralized water from well no. 3 which is located about 455 feet east northeast of well no. 4.

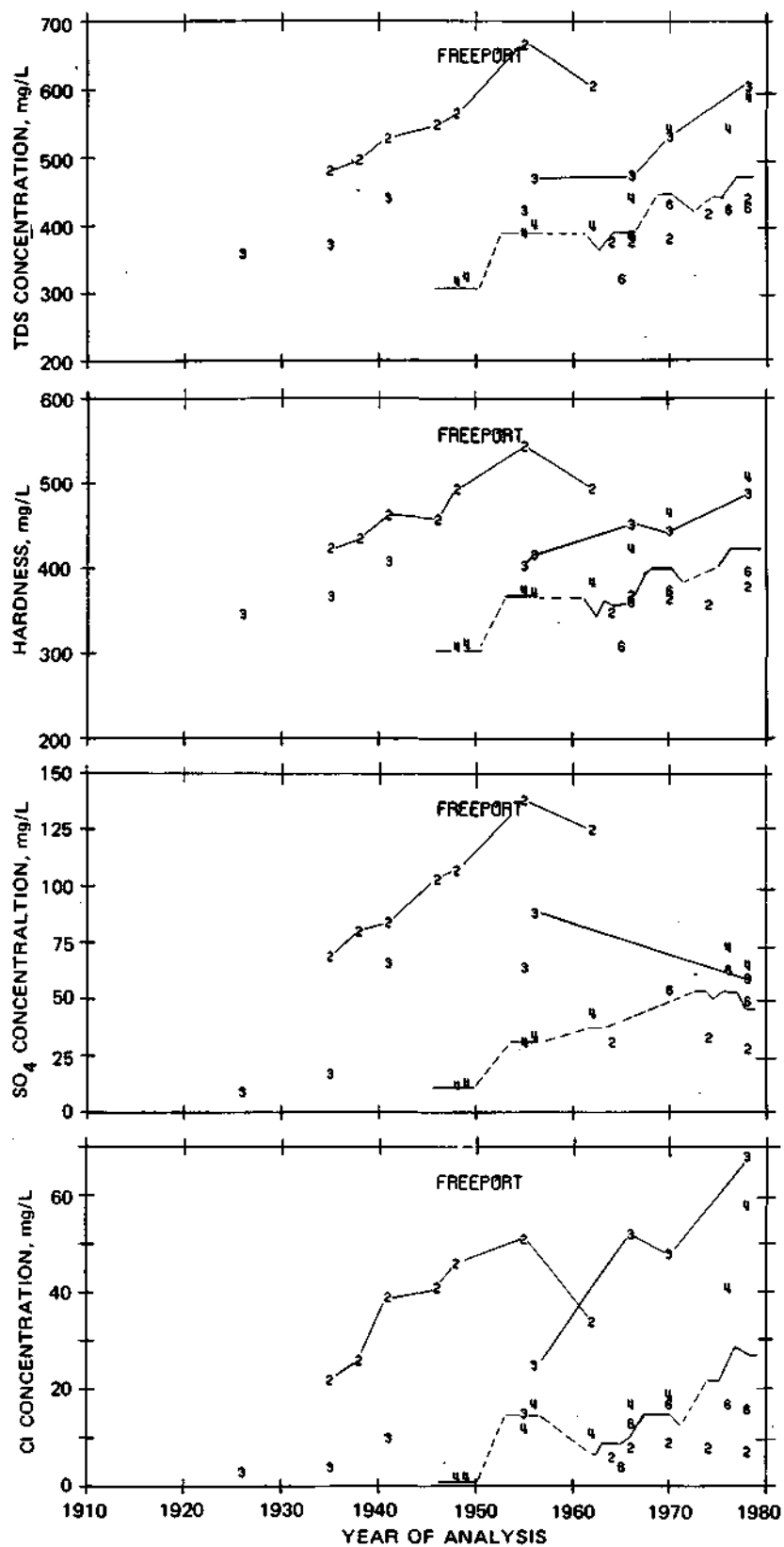


Figure 17. Groundwater quality trends for Tds, hardness, sulfates, and chlorides at Freeport.

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