# MONTHLY FLUCTUATIONS IN THE QUALITY OF GROUND WATER NEAR THE WATER TABLE IN NASSAU AND SUFFOLK COUNTIES, LONG ISLAND, NEW YORK

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U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 78-41

Prepared in cooperation with the

Nassau County Department of Public Works
Suffolk County Department of Environmental Control
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16. Abstracts Water samples from wells in a sewered and an unsewered suburban area and an unsewered rural area were collected and analyzed monthly from August 1975 to July 1976 to determine the concentrations of chloride, sulfate, and nitrate in ground water near the water table. Short-term and seasonal fluctuations in their concentrations were evaluated to determine the relation to nonpoint discharges. Major factors that may cause concentrations of these substances to fluctuate at a given site are precipitation, lawn fertilizer, dissolved salts in storm runoff, and effluent from septic tanks and cess-pools. Chloride concentrations during the study fluctuated by as little as 2 milligrams per liter (mg/L) at some sites and as much as 300 mg/L at others. Nitrate and sulfate concentrations showed essentially no change at some sites but fluctuated by as much as 8 and 40 mg/L, respectively, at others. Short-term fluctuations in the concentrations of these substances in ground water seem to have no consistent correlation with type of land use (suburban or agricultural) or precipitation but seem to be related to seasonal variations in input from specific nonpoint sources.

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Syosset, New York
1978

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

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## CONVERSION FACTORS AND ABBREVIATIONS

Factors for converting U.S. Customary units to metric units are shown to three or four significant figures. However, in the text the metric equivalents are shown only to the number of significant figures consistent with the values for the English units.

| U.S. Customary | Multiply by | Metric |
|---|---|---|
| inch (in.) | 2.54 | centimeters (cm) |
| foot (ft) | .3048 | meter (m) |
| mile (mi) | 1.609 | kilometers (km) |
| gallon (gal) | 3.785 | liters (L) |
| gallons per minute (gal/min) | .06309 | liters per second (L/s) |
| million gallons (Mgal) | 3.785 | million liters (mil L) |
| million gallons per day (Mgal/d) | .004381 | cubic meters per second ($m^3/s$) |
| | | meters per day (m/d) |
| | | liters per second per meter [(L/s)/m] |
| pound (lb) | .4536 | kilogram (kg) |
| acre | .405 | square hectometer ($hm^2$) |

# MONTHLY FLUCTUATIONS IN THE QUALITY OF WATER NEAR THE WATER TABLE IN NASSAU AND SUFFOLK COUNTIES, LONG ISLAND, NEW YORK

By

Brian G. Katz, Stephen E. Ragone,

and Juli B. Lindner

ABSTRACT

Water samples from wells in a sewered and an unsewered suburban area and an unsewered rural area on Long Island, N.Y., were collected and analyzed monthly from August 1975 to July 1976 to determine the concentrations of chloride, sulfate, and nitrate in ground water near the water table. Short-term and seasonal fluctuations in concentrations of these substances were evaluated to determine their relation to nonpoint discharges.

Major factors that may cause concentrations of these substances to fluctuate at any particular site are precipitation, lawn fertilizer, dissolved salts in storm runoff, and effluent from septic tanks and cesspools. Chloride concentrations during the study fluctuated by as little as 2 milligrams per liter (mg/L) at some sites and as much as 300 mg/L at others. Nitrate and sulfate concentrations showed essentially no change at some sites but fluctuated by as much as 8 and 40 mg/L, respectively, at others. Short-term fluctuations in the concentrations of these substances in ground water seem to have no consistent correlation with type of land use (suburban or agricultural) or precipitation but seem to be related to seasonal variations in input from specific nonpoint sources.

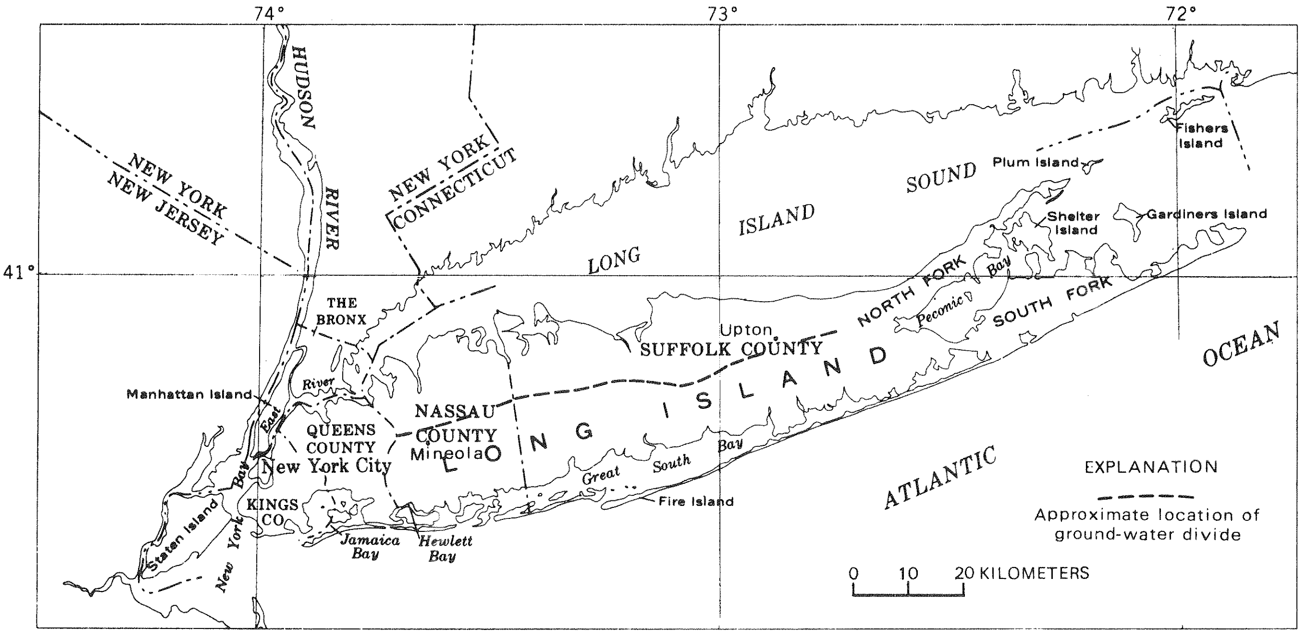


Figure 1.--Location and major geographic features of Long Island, New York.

# INTRODUCTION

Ground water is the sole source of freshwater for more than 2.7 million residents of Nassau and Suffolk Counties, Long Island, New York (fig. 1). Under natural conditions, the ground-water reservoir is recharged only by precipitation. Population growth and urbanization on Long Island have caused a steady increase in the demand for fresh ground water and have affected its quality through the discharge of wastes and other contaminating products to the ground-water reservoir. A significant amount of the changes in water quality are attributed to the increased discharge of dissolved chloride, nitrate, and sulfate to the aquifer from nonpoint sources such as wastewater from cesspools and septic tanks, salts for road deicing, and fertilizers for lawns and agriculture. Precipitation and storm-water runoff are the principal agents in moving these substances through the ground to the water table.

In general, the upper glacial aquifer is the water-table aquifer in most of Long Island. As the uppermost aquifer on the island, it is the most susceptible to contamination.

## Purpose and Scope of Study

To date, information on short-term fluctuations in quality of shallow ground water in Nassau and Suffolk Counties is incomplete. To obtain data on short-term fluctuations in water quality in these counties and to correlate them with their probable main controlling factors, the U.S. Geological Survey collected water samples monthly from August 1975 to July 1976 from 30 wells screened in the upper glacial aquifer. The data obtained from these samples are described, summarized, and interpreted in the sections that follow. Air and ground-water temperatures during the sampling period are correlated to determine the effect of seasonal changes in the temperature of precipitation entering the aquifer. Chloride, nitrate, and sulfate were selected for analysis in this report because they are the major inorganic ions in ground water and can be indicative of ground-water contamination.

## Previous Studies

Short-term fluctuations and seasonal variations in ground-water quality have recently received an increasing amount of attention in the literature. Pluhowski and Kantrowitz (1964) reported on factors affecting monthly ground-water temperatures over a 2-year period. Pettyjohn (1971, 1975, 1976) reported that nitrate and chloride concentrations in ground water increase substantially after periods of precipitation. Walker (1973, 1973a) reported that nitrate in soil moves downward to shallow aquifers during recharge periods in the late fall and early spring. Toler and Pollock (1974) stated that deicing salt that has accumulated in the unsaturated zone is eventually flushed from the soil to the water table by spring recharge. Schmidt (1972, 1977) described short-term variations and seasonal trends of nitrate and chloride in ground water and discussed factors that possibly control these variations. Piskin (1973) discussed factors that affect seasonal variations of nitrate in ground water.

## Method of Study

Ground-water near the water table was monitored at wells along three north-south and two east-west trending lines in a sewered and an unsewered area in Nassau County (fig. 2A) and a rural area in Suffolk County (fig. 2B). These wells range in diameter from 3.2 cm to 15 cm, and the screened interval is generally 0.9 m in the small-diameter wells and 3.0 m in the large-diameter wells. The range in depth to water over the period of sampling, and the average depth of the top of the screens below the water table, are presented in table 1.

## Field Sampling

At 24 of the shallow wells in this study (where depth to water was less than 8 m from land surface), a rubber hose was inserted down the casing to below water level. Before water samples were taken by centrifugal pump, three times the volume of water in the well casing was removed to insure a representative ground-water sample. Specific conductance and pH were measured at discharge; dissolved oxygen and temperature were measured in the well.

At the six deeper wells (where depth to water was greater than 8 m from land surface), water samples were taken by submersible pump lowered down the casing to between 3 and 6 m below water level. Again, three times the volume of water in the well casing was cleared before the samples were taken. Specific conductance, pH, and temperature were measured at discharge.

## Data Treatment

Water-quality data from the 30 wells sampled on a monthly basis were entered in the U.S. Geological Survey's computer in Reston, Va. The data were retrieved as tables, and analyses in which cation anion balances differed by 20 percent or more were deleted. Chloride, nitrate, and sulfate were selected for analysis because they are the major inorganic ions in ground water.

Analytical accuracy and precision for the principal anionic constituents of water--chloride, nitrate, and sulfate ($Cl^-$, $NO_3^-$, and $SO_4^{2-}$)--are presented in table 2 (L. C. Friedman, U.S. Geol. Survey, written commun., 1976). These analyses of standard reference samples were made by the U.S. Geological Survey Laboratory in Albany, N.Y. The standard-deviation values (table 2) were used to determine whether fluctuations above analytical noise were observed in the water-quality data.

Table 1.--Sampling depths at wells monitored during study, August 1975 to July 1976, Nassau and Suffolk Counties, New York

[All depths are in meters]

| Well number | Depth to water1/ | Average depth to top of screen2/ |
|---|---|---|
| SEWERED AREA, NASSAU COUNTY | | |
| N1129 | 7.1 - 7.6 | 5.2 |
| N1143 | 5.9 - 6.4 | 14.7 |
| N1164 | 5.5 - 6.3 | 5.3 |
| N1165 | 5.1 - 5.9 | 6.2 |
| N1167 | 4.1 - 4.7 | 2.1 |
| N1168 | 2.6 - 3.1 | 4.7 |
| N8235 | 4.3 - 5.0 | 10.4 |
| N8598 | 6.7 - 7.4 | 5.8 |
| UNSEWERED AREA, NASSAU COUNTY | | |
| N1160 | 7.1 - 9.6 | 0.15 |
| N1176 | 34.4 - 35.0 | 24.2 |
| N1183 | 4.1 - 4.9 | 4.7 |
| N1194 | 24.0 - 24.7 | 4.6 |
| N1201 | 4.4 - 5.1 | 3.0 |
| N1250 | 3.0 - 4.4 | 5.6 |
| N1251 | 2.4 - 3.1 | 2.1 |
| N1252 | 1.2 - 2.2 | 4.7 |
| N1253 | 3.6 - 5.1 | 3.7 |
| N1254 | 2.6 - 3.7 | 5.0 |
| N7397 | 23.8 - 24.9 | 4.9 |
| N8669 | 2.3 - 3.8 | 7.0 |
| N8789 | 3.0 - 4.0 | 4.7 |
| N8888 | 22.6 - 26.6 | 7.8 |
| S29778 | 34.5 - 35.1 | 13.4 |
| RURAL AREA, SUFFOLK COUNTY | | |
| S46913 | 1.2 - 1.5 | 0.9 |
| S46914 | 1.8 - 2.3 | 0.3 |
| S47226 | 1.0 - 1.5 | 3.3 |
| S47227 | 0.9 - 1.6 | 25.2 |
| S48946 | 2.1 - 3.1 | 7.0 |
| S51583 | 6.1 - 6.9 | 5.2 |
| S51592 | 3.4 - 4.0 | 5.5 |

1/ In meters below land surface.
2/ In meters below water table.

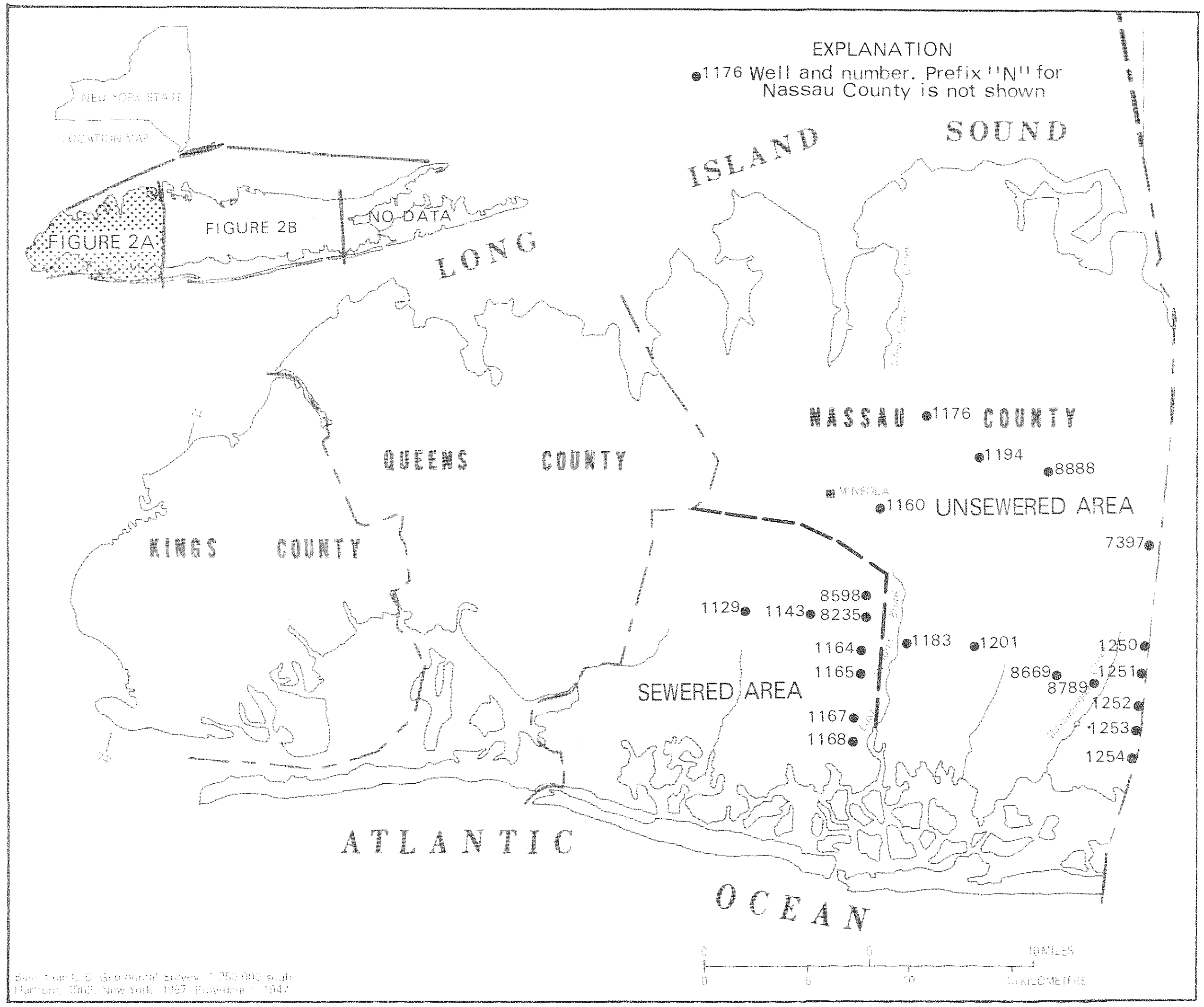


Figure 2A.--Location of wells in sewered and unsewered areas of Nassau County.

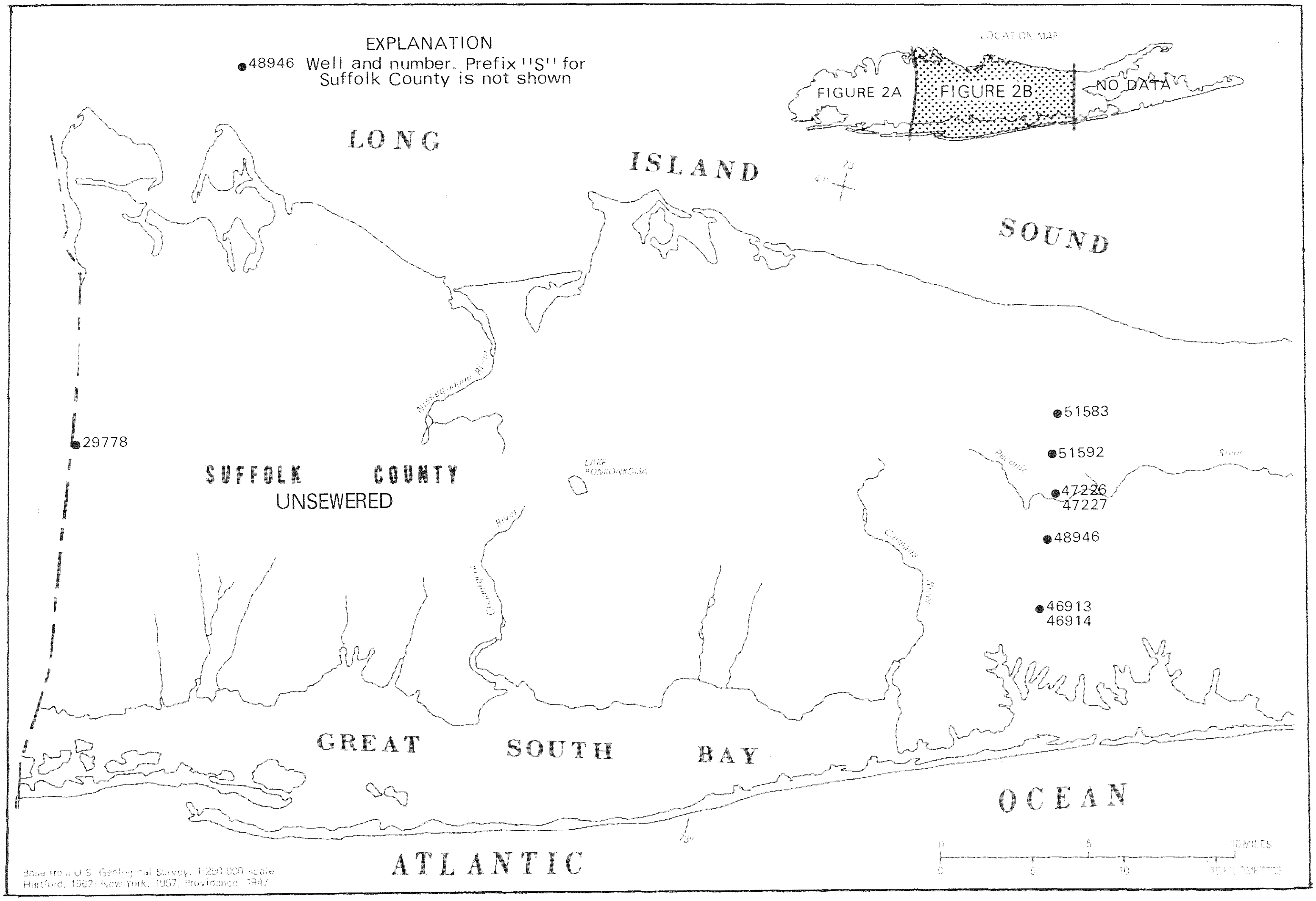


Figure 2B.--Location of wells in a rural area of Suffolk County.

The wells were selected, in part, according to location. The three types of areas represented include a suburban sewered area and a suburban unsewered area (fig. 2A) and a rural unsewered area (fig. 2B). Nonpoint sources from natural and (or) urbanizing factors, specifically sewage, fertilizer, road salt, and precipitation, were evaluated as to their effect on water quality in each of the three areas.

The sewered part of Nassau County includes Sewage Disposal Districts 1 and 2, which cover an area of about 207 $km^2$ (fig. 2A). The unsewered section of Nassau County contains Sewage Disposal Districts 3 and 4 and covers an area of about 544 $km^2$. Domestic wastes in this area are currently (1976) disposed of by shallow septic-tank systems as in the rural area, in eastern Suffolk County, which is unsewered and predominantly agricultural.

Table 2.--Accuracy and precision of analyses for selected ground-water constituents

| Constituent | Mean value of standard reference sample (mg/L) | Standard deviation (mg/L) | Percent standard deviation |
|---|---|---|---|
| Chloride (Cl) | 1.84 | ± 0.34 | ± 18.5 |
| | 8.17 | .61 | 7.5 |
| | 74.0 | 1.8 | 2.4 |
| | 124 | 5 | 4 |
| | 179 | 3 | 1.6 |
| Nitrate ($NO_2$+$NO_3$-N) | 0.097 | ± 0.013 | ± 13.4 |
| | .49 | .04 | 8.2 |
| | 1.19 | .03 | 2.5 |
| | 2.94 | .08 | 2.7 |
| | 12.5 | .6 | 4.8 |
| Sulfate ($SO_4$) | 16.3 | ± 1.2 | ± 7.4 |
| | 22.0 | 1.8 | 8.2 |
| | 67.8 | 1.3 | 1.9 |
| | 98.1 | 1.3 | 1.3 |
| | 105 | 10 | 9.5 |

All analyses performed by U.S. Geological Survey Laboratory in Albany, N.Y.

## HYDROGEOLOGY

The hydrogeology of the water-table aquifer is described only generally in this report. More detailed descriptions are given in reports by McClymonds and Franke (1972) and Franke and Cohen (1972). Figure 3 depicts the hydrogeologic system of Long Island and the position of the upper glacial aquifer.

The upper glacial (water-table) aquifer is composed of Pleistocene-age deposits (fig. 3). These consist of (1) till deposits, which are composed of clay, sand, gravel, and boulders and occur in the northern half of the island in moraines; (2) outwash deposits, which consist of quartzose sand and gravel and occur between and south of morainal deposits (fig. 4), and (3) glacio-lacustrine deposits, which consist of silt and clay and are scattered but found mostly in eastern Long Island (McClymonds and Franke, 1972).

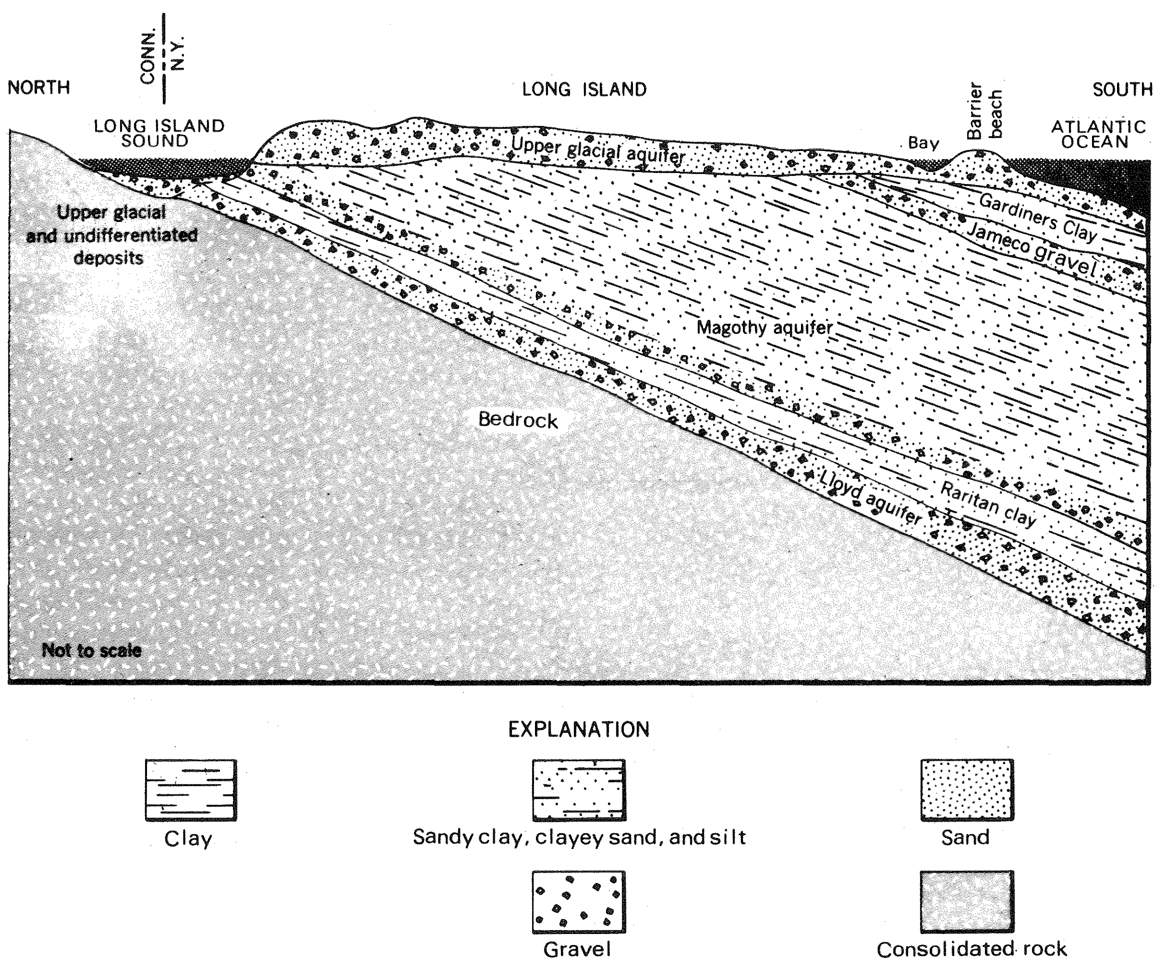


**Figure 3.--Schematic representation of aquifers on Long Island (vertical scale greatly exaggerated).**

The water-bearing properties of these deposits range from poorly permeable (till) to highly permeable (outwash deposits). Specific capacities of wells tapping these deposits range from very low (almost no yield) in the till to more than 41 (L/s)/m in the outwash (McClymonds and Franke, 1972). Hydraulic conductivities range from 41 to 82 m/d (McClymonds and Franke, 1972). In the northern half of Long Island (fig. 4), depth to water may be as much as 36 m in these poorly permeable deposits, but in the southern half (outwash deposits), depth to water can range from less than 1 m to about 9 m.

Recharge to the upper glacial aquifer results mainly from infiltration of precipitation, infiltration of storm runoff, injection of water used for industrial purposes, and discharge of domestic and industrial wastewater from cesspools and septic-tank systems (Franke and Cohen, 1972). Depending upon factors such as lithology and soil moisture, the time required for water to move through the unsaturated zone to the water table ranges from a few hours (Seaburn and Aronson, 1974) to an estimated maximum of 16 months (Isbister, 1966, p. 49). Consequently, short-term variations in water quality due to cyclic variations in input rate, and concentration of typical substances, may be difficult to predict.

In general, north of the regional ground-water divide (fig. 1), ground-water movement is toward Long Island Sound. South of this divide, regional ground-water movement is generally toward the south shore of Long Island (Franke and Cohen, 1972).

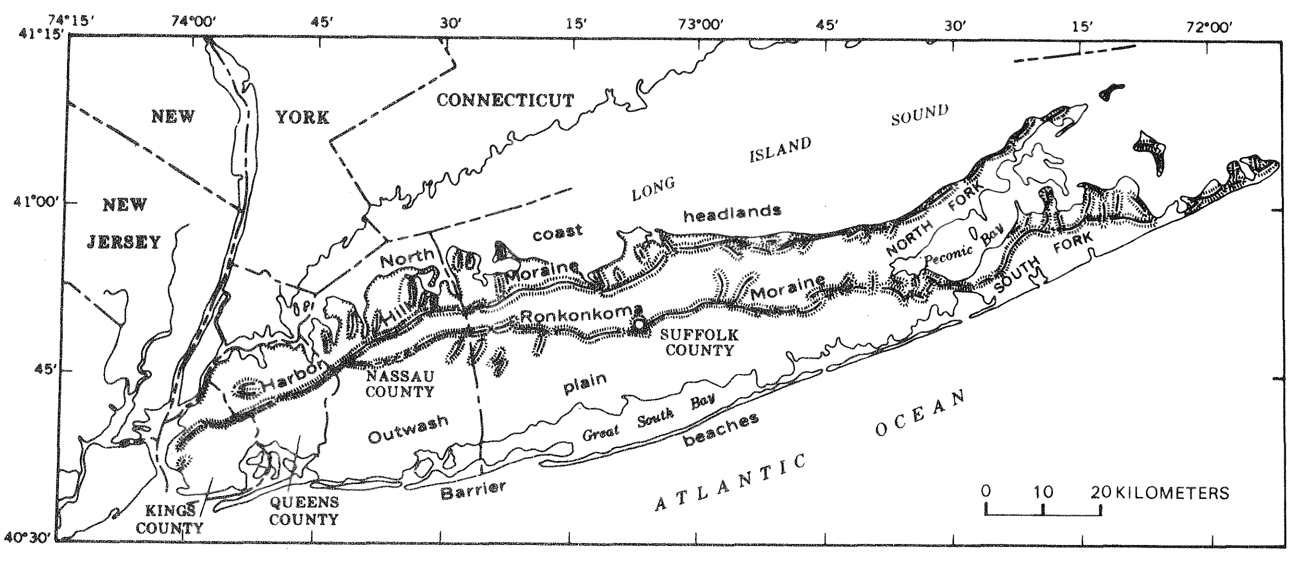


Figure 4.--Major physiographic features of upper glacial aquifer on Long Island.

## MONTHLY FLUCTUATIONS OF SELECTED PHYSICAL AND CHEMICAL CHARACTERISTICS OF GROUND WATER

Data on monthly variations in several physical and chemical characteristics of water from selected wells are presented in following sections. Data on chemical concentrations in samples from each well are given in table 3; factors that may affect these fluctuations are also discussed.

### Temperature

Samples of water from all 30 wells had seasonal fluctuations in temperature. In general, the most pronounced fluctuations were in water less than 3.0 m below land surface (fig. 5). Seasonal high and low water temperatures coincided with seasonal high and low air temperatures recorded in Nassau and Suffolk Counties (fig. 6).

Water deeper than 3.0 m had smaller seasonal temperature fluctuations than shallower water. Patterns of water-temperature fluctuations from deeper wells lagged behind those of air temperature by 2 to 3 months (fig. 7), and, at well N8888, the temperature lag was as much as a year.

These fluctuations in the temperature of ground water result mainly from (1) the large variations in temperature of water that recharges the ground-water reservoir and (2) variations in the ability of the subsurface to conduct heat from the land surface (Stevens and others, 1975). Seaburn and Aronson (1974) found that average rates of infiltration of surface runoff through the unsaturated zone below recharge basins were slightly lower during colder months (November to March) than during warmer months (April to October). This lower rate of infiltration and consequently of traveltime to the sampling point during the November-March period may account in part for the observed time lapse between minimum air temperature and minimum ground-water temperature. Pluhowski and Kantrowitz (1964) describe a similar lag at shallow wells in southwestern Suffolk County, which they attribute in part to an insulating effect provided by the zone of aeration.

### Chloride

Chloride is a nonreactive constituent; thus, changes in its concentration reflect changes in input concentration and (or) in rates of infiltration to the water table. Monthly fluctuations of chloride in shallow ground water during the study period are shown in figures 8A and 8B.

Fluctuations in chloride concentration above a background concentration of 5 to 10 mg/L (Pluhowski and Kantrowitz, 1964; DeLuca and others, 1965) may result from altered input rates of agricultural or lawn fertilizers, road-deicing salts, and effluent from septic-tank and cesspool systems and are also affected by precipitation and storm runoff.

Table 3.--Depth to water and concentration of selected constituents of water from selected wells in Nassau and Suffolk Counties, August 1975 to July 1976

[All concentrations are in milligrams per liter]

| Well number | Depth to water1/ | Constituents: Chloride (Cl) | Nitrate ($NO_3$ as N) | Sulfate ($SO_4$) |
|---|---|---|---|---|
| SEWERED AREA, NASSAU COUNTY | | | | |
| N1129 | 7.1 - 7.6 | 7.5 - 13 | 3.8 - 5.1 | 59 - 68 |
| N1143 | 5.9 - 6.4 | 15 - 22 | 0.0 - 7.8 | 68 - 91 |
| N1164 | 5.5 - 6.3 | 29 - 71 | 2.5 - 6.8 | 43 - 56 |
| N1165 | 5.1 - 5.9 | 27 - 46 | 4.0 - 10 | 54 - 59 |
| N1167 | 4.1 - 4.7 | 10 - 34 | 2.0 - 4.4 | 36 - 58 |
| N1168 | 2.6 - 3.4 | 26 - 44 | 0.87 - 1.7 | 37 - 50 |
| N8235 | 4.3 - 5.0 | 27 - 64 | 2.3 - 10 | 34 - 53 |
| N8598 | 6.7 - 7.4 | 33 - 43 | 2.3 - 7.0 | 33 - 38 |
| UNSEWERED AREA, NASSAU COUNTY | | | | |
| N1160 | 7.1 - 9.6 | 6.9 - 19 | 1.3 - 2.6 | 8.4 - 15 |
| N1176 | 34.4 - 35.0 | 3.9 - 4.7 | 1.2 - 1.4 | 0.6 - 1.1 |
| N1183 | 4.1 - 4.9 | 11 - 39 | 7.5 - 13 | 32 - 50 |
| N1194 | 24.0 - 24.7 | 85 - 110 | 1.2 - 2.6 | 18 - 21 |
| N1201 | 4.4 - 5.1 | 1.3 - 86 | 0.10 - 0.86 | 1.8 - 15 |
| N1250 | 3.0 - 4.4 | 16 - 42 | 3.8 - 10 | 27 - 37 |
| N1251 | 2.4 - 3.1 | 8.2 - 30 | 2.2 - 4.9 | 26 - 55 |
| N1252 | 1.2 - 2.2 | 11 - 56 | 0.05 - 6.6 | 18 - 39 |
| N1253 | 3.6 - 5.1 | 65 - 120 | 0 - 0.16 | 24 - 27 |
| N1254 | 2.6 - 3.7 | 30 - 37 | 2.9 - 8.6 | 32 - 62 |
| N7397 | 23.8 - 24.9 | 8.1 - 12 | 2.8 - 3.9 | 0.1 - 1.0 |
| N8669 | 2.3 - 3.8 | 26 - 45 | 3.8 - 7.1 | 32 - 41 |
| N8789 | 3.0 - 4.0 | 27 - 39 | 3.6 - 13 | 40 - 64 |
| N8888 | 22.6 - 26.6 | 23 - 37 | 2.4 - 11 | 49 - 61 |
| S29778 | 34.5 - 35.1 | 11 - 16 | 15 - 22 | 0.8 - 4.4 |
| RURAL AREA, SUFFOLK COUNTY | | | | |
| S46913 | 1.2 - 1.5 | 1.1 - 130 | 0.07 - 0.99 | 1.6 - 11 |
| S46914 | 1.8 - 2.3 | 2.1 - 300 | 0.09 - 0.67 | 1.5 - 14 |
| S47226 | 1.0 - 1.5 | 3.4 - 9.0 | 0.0 - 0.01 | 2.4 - 4.0 |
| S47227 | 0.9 - 1.6 | 2.4 - 10 | 0.0 - 0.44 | 2.6 - 11 |
| S48946 | 2.1 - 3.1 | 2.1 - 24 | 0.20 - 3.3 | 4.8 - 45 |
| S51583 | 6.1 - 6.9 | 5.4 - 17 | 0.01 - 0.29 | 2.6 - 9.0 |
| S51592 | 3.4 - 4.0 | 8.0 - 13 | 0.33 - 0.58 | 9.4 - 12 |

1/ In meters below land surface.

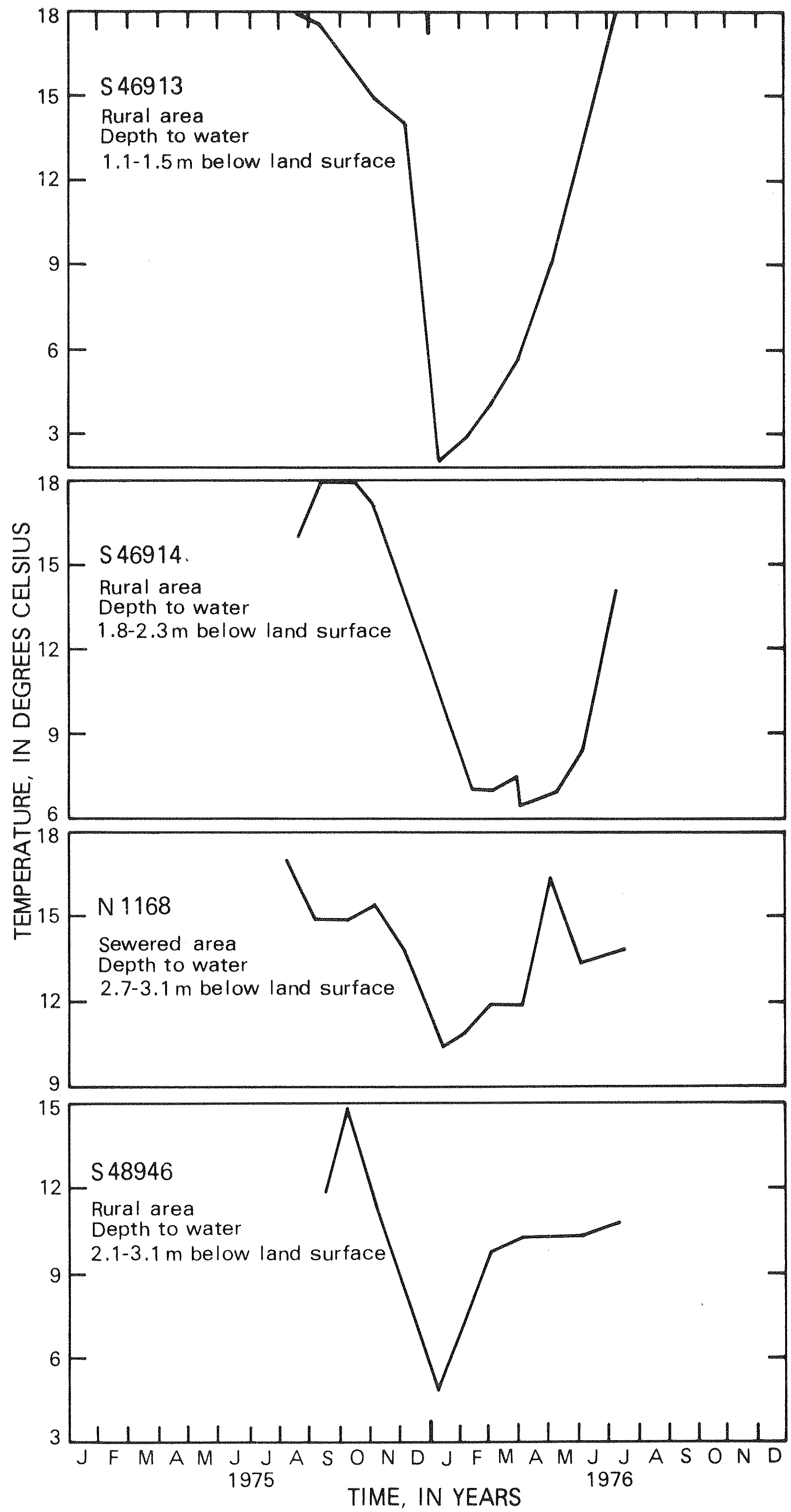


Figure 5.--Monthly fluctuations of water temperature at selected shallow wells where depth to water was less than 3 meters, Nassau and Suffolk Counties.

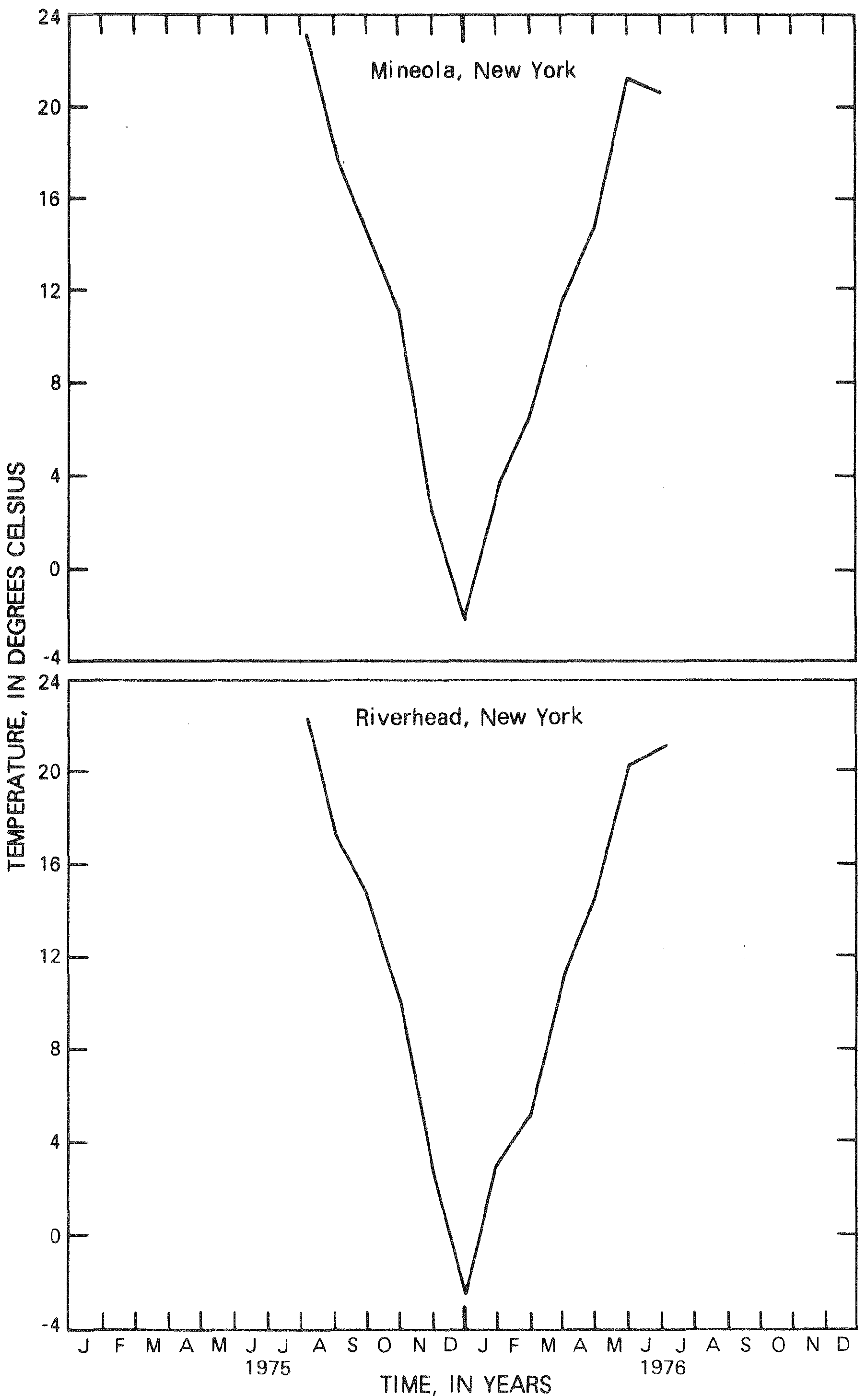


Figure 6.--Monthly air temperatures recorded at Mineola in Nassau County and Riverhead in Suffolk County.

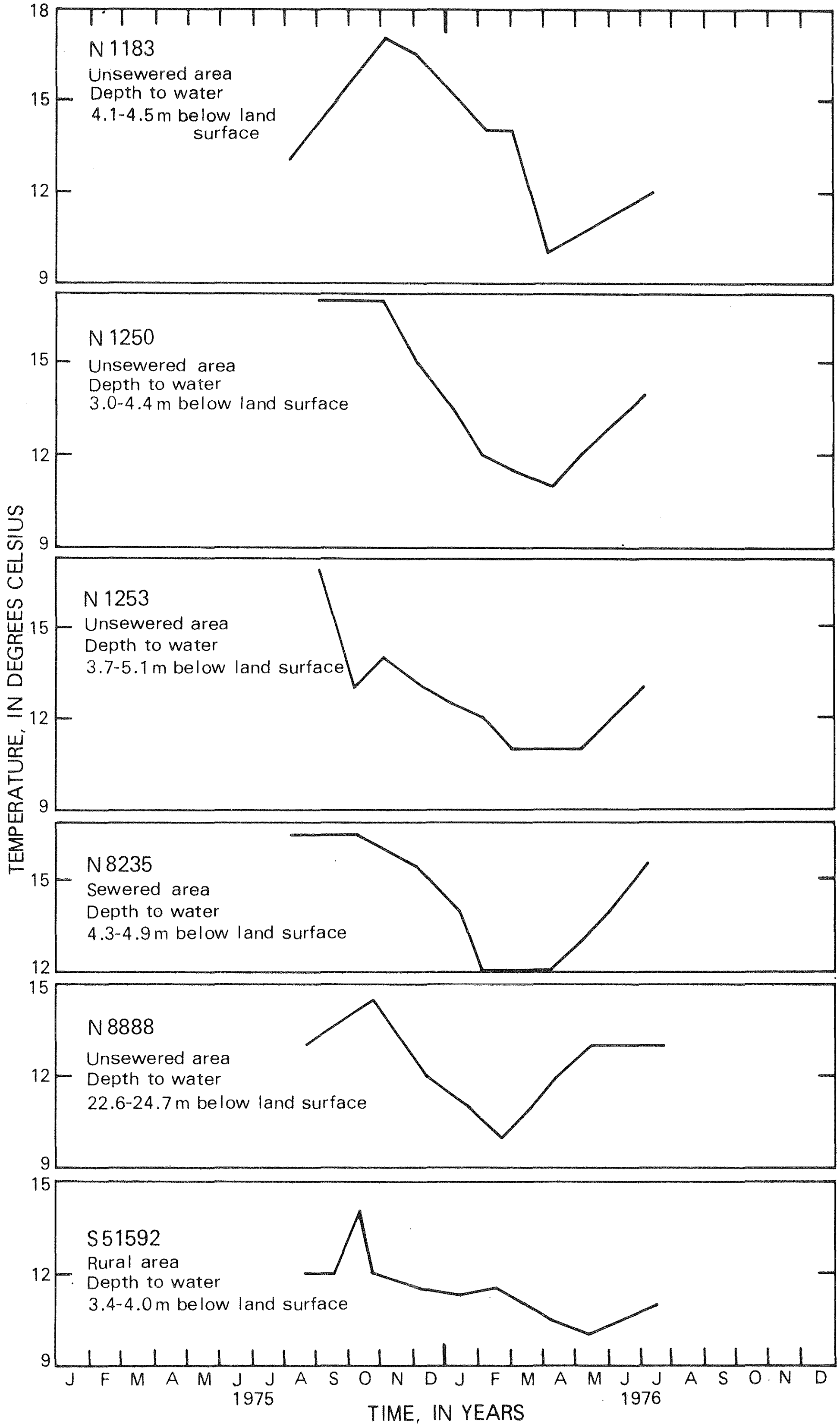


Figure 7.--Monthly fluctuations of water temperature at selected wells where depth to water was greater than 3 meters, Nassau and Suffolk Counties.

Generally, chloride in precipitation varies with proximity to saltwater bodies. Over the period of sampling (August 1975 to July 1976), chloride concentration in precipitation ranged from 0.38 to 5.65 mg/L at two stations more than 5 miles inland (table 4).

Fertilizers applied to residential and farmed areas may contribute significant amounts of chloride to ground-water bodies (Saffigna and Keeney, 1977). Because the application of fertilizer varies seasonally, the amounts of chloride that reach ground-water bodies should also vary accordingly. Hoffman and Spiegel (1958) found that chloride concentrations of 40 to 65 mg/L were common in ground water in eastern Suffolk County in areas where fertilizers were used.

Another important source of chloride in ground water is effluent from septic-tank and cesspool systems; chloride concentration in ground water near these sources ranges from 50 to about 120 mg/L (Nassau-Suffolk Research Task Group, 1969). Chloride concentrations in effluent from the sewered area fluctuated monthly by as much as 30 mg/L over the period of sampling (S. A. Fangman, Nassau County Department of Public Works, written commun., 1977).

Chloride concentration in storm runoff has ranged from 4 to 310 mg/L at various intervals during storms (V. I. Minei, Suffolk County Department of Environmental Control, written commun., 1976). Consequently, chloride concentration in ground water may vary significantly after storms, especially near recharge basins, which are the major pathways by which storm runoff infiltrates to the aquifer (Seaburn and Aronson, 1974).

Chloride from the solution of calcium and sodium chloride salts applied to highways in winter and occasionally in specific areas, such as racetracks for dust control in summer (Hoffman and Spiegel, 1958; DeLuca and others, 1965) may also be a major source of chloride in ground water. Hoffman and Spiegel (1958) estimate that in the immediate vicinity of treated highways, water infiltrating to the aquifer could have an average chloride concentration as high as several hundred mg/L.

Large monthly fluctuations in chloride concentrations ranging from 20 to as much as 300 mg/L were observed in water from 14 of the 30 wells sampled (fig. 8A); water from the remaining 16 wells showed slight monthly fluctuations (fig. 8B). Trends that might be interpreted as seasonal in water from the first 14 wells were not consistent. Water from half of them (fig. 8A) had high chloride concentrations in the summer and low chloride concentrations in the winter, whereas water from the remaining half had high chloride concentrations in winter, spring, and fall.

Ten of the 14 wells yielding water ranging in chloride concentration from 20 to 30 mg/L are in the unsewered area of Nassau County. Depth to water in these wells ranges from 1.2 m to about 24 m. Variations in chloride concentration in water from wells in this area may be related to variable inputs from septic and cesspool systems; similar variations

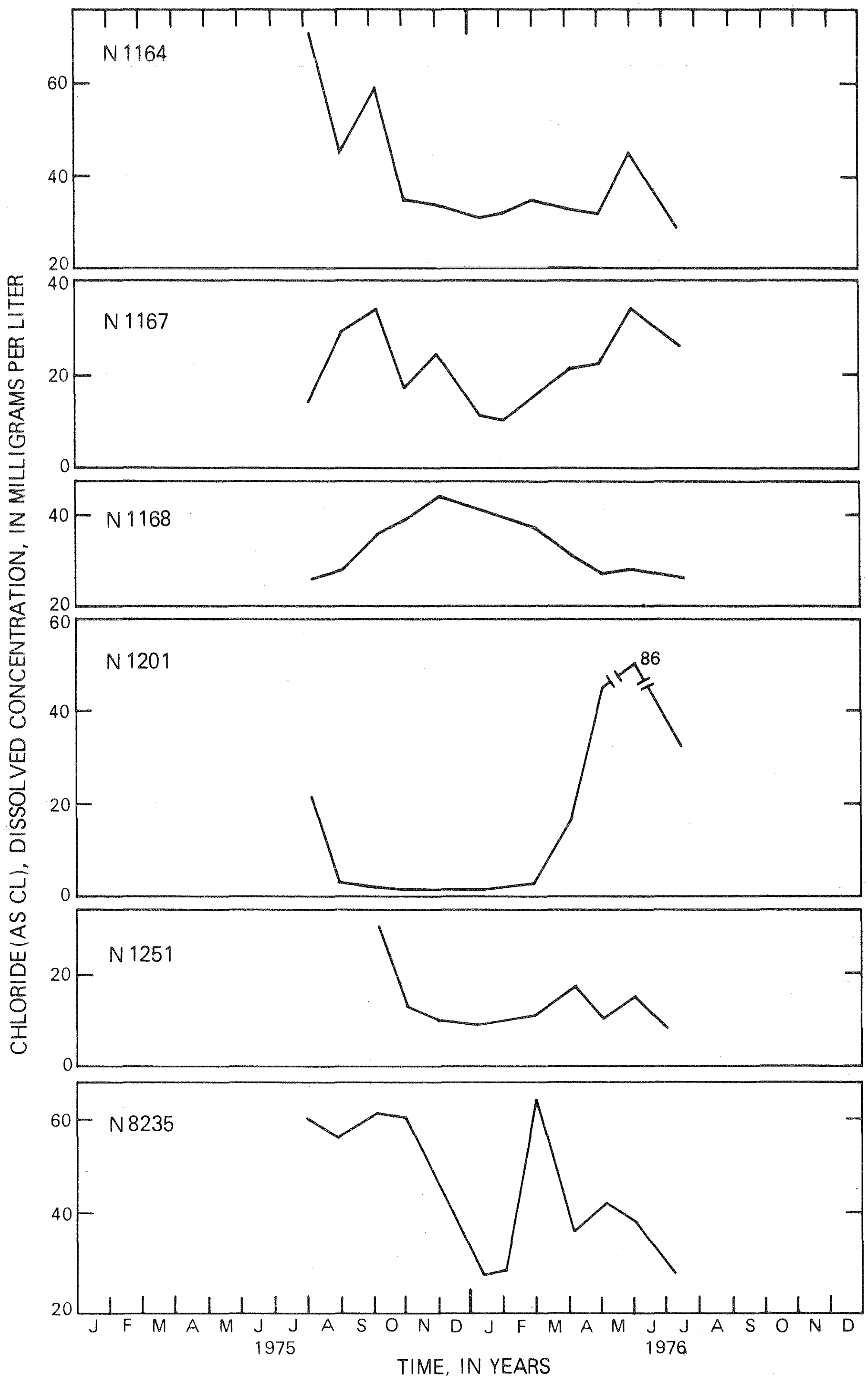


Figure 8A.--Monthly fluctuations of chloride concentration in water from 14 selected wells that show large fluctuations over period of record.

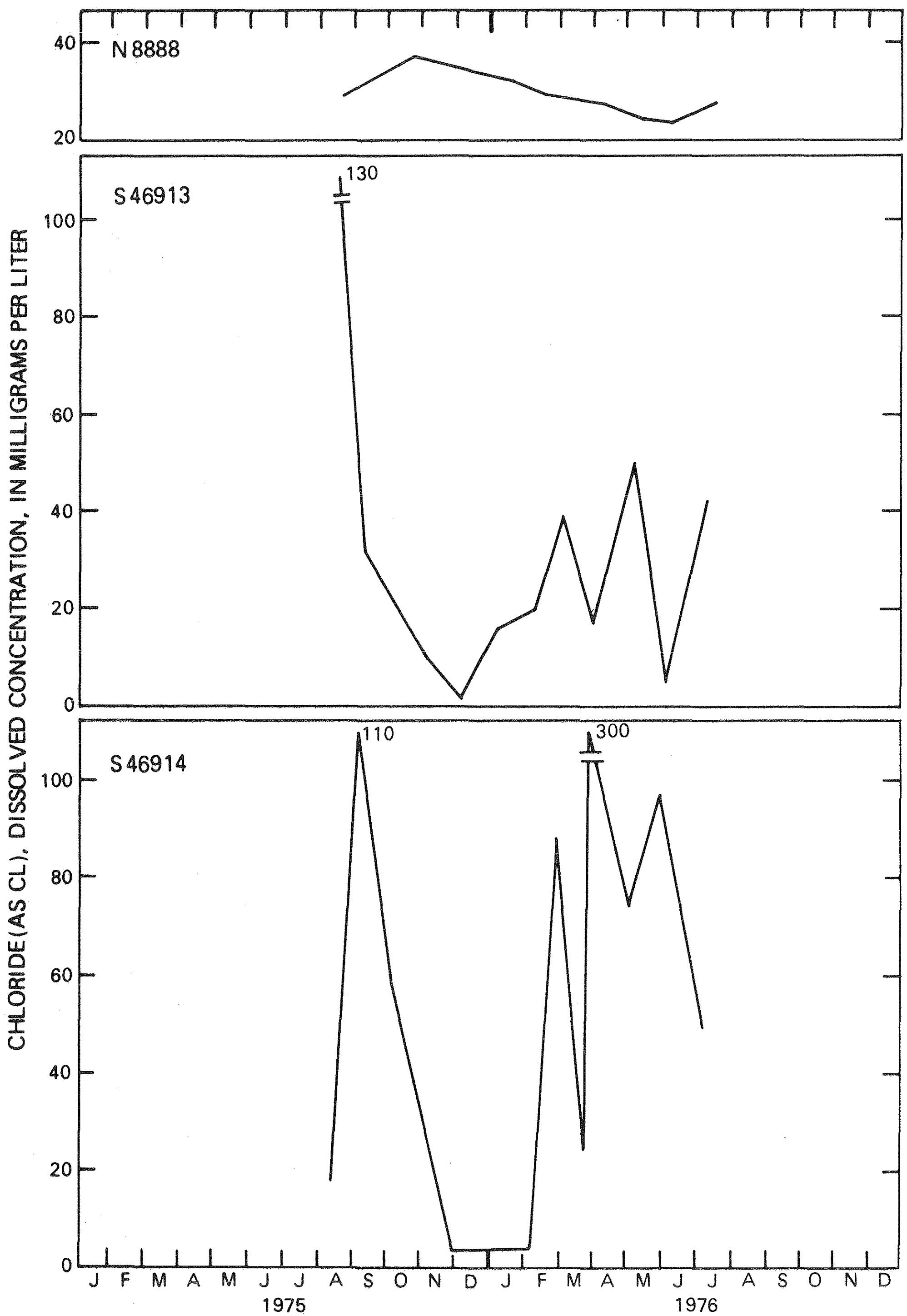


Figure 8A (continued)

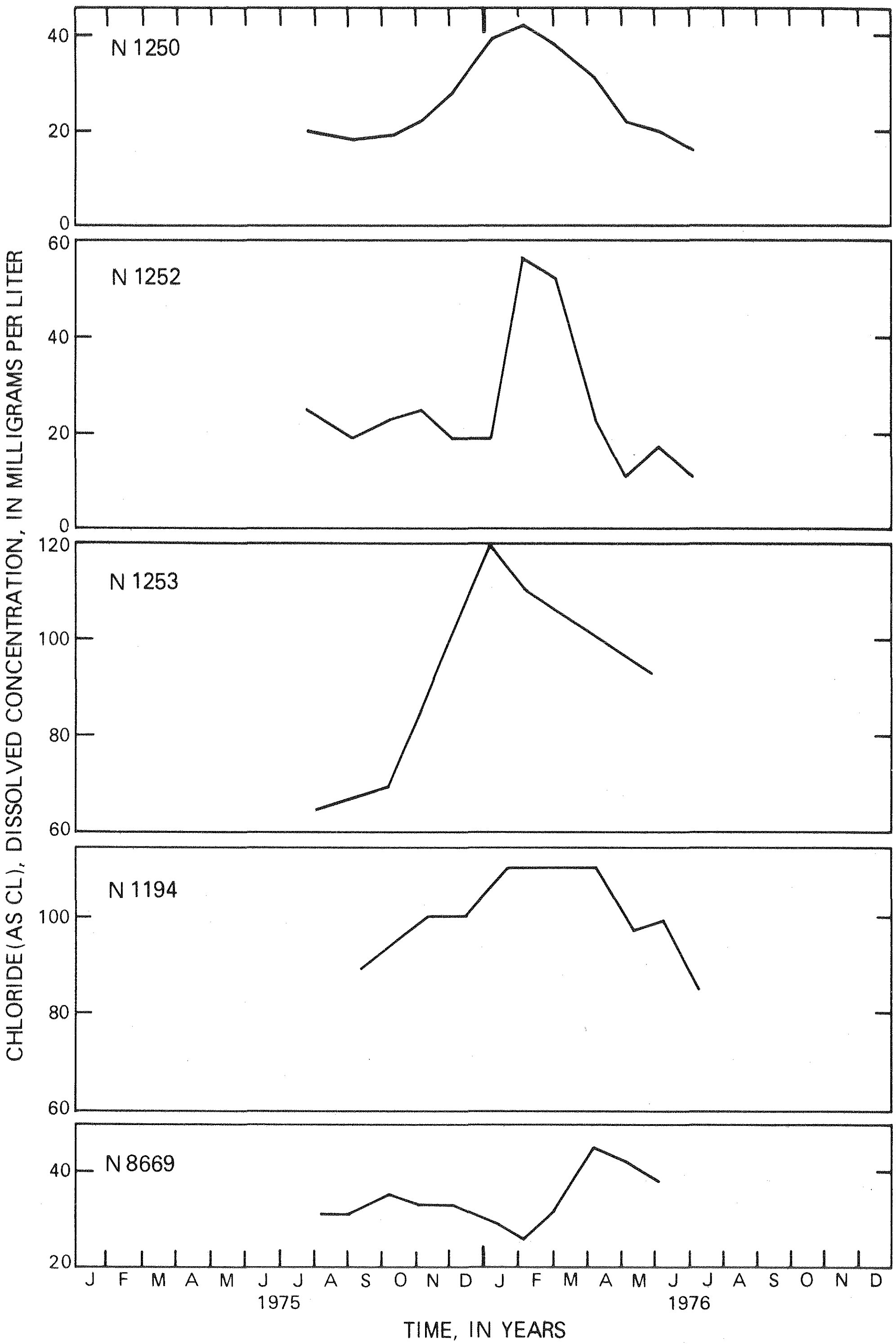


Figure 8A (continued)

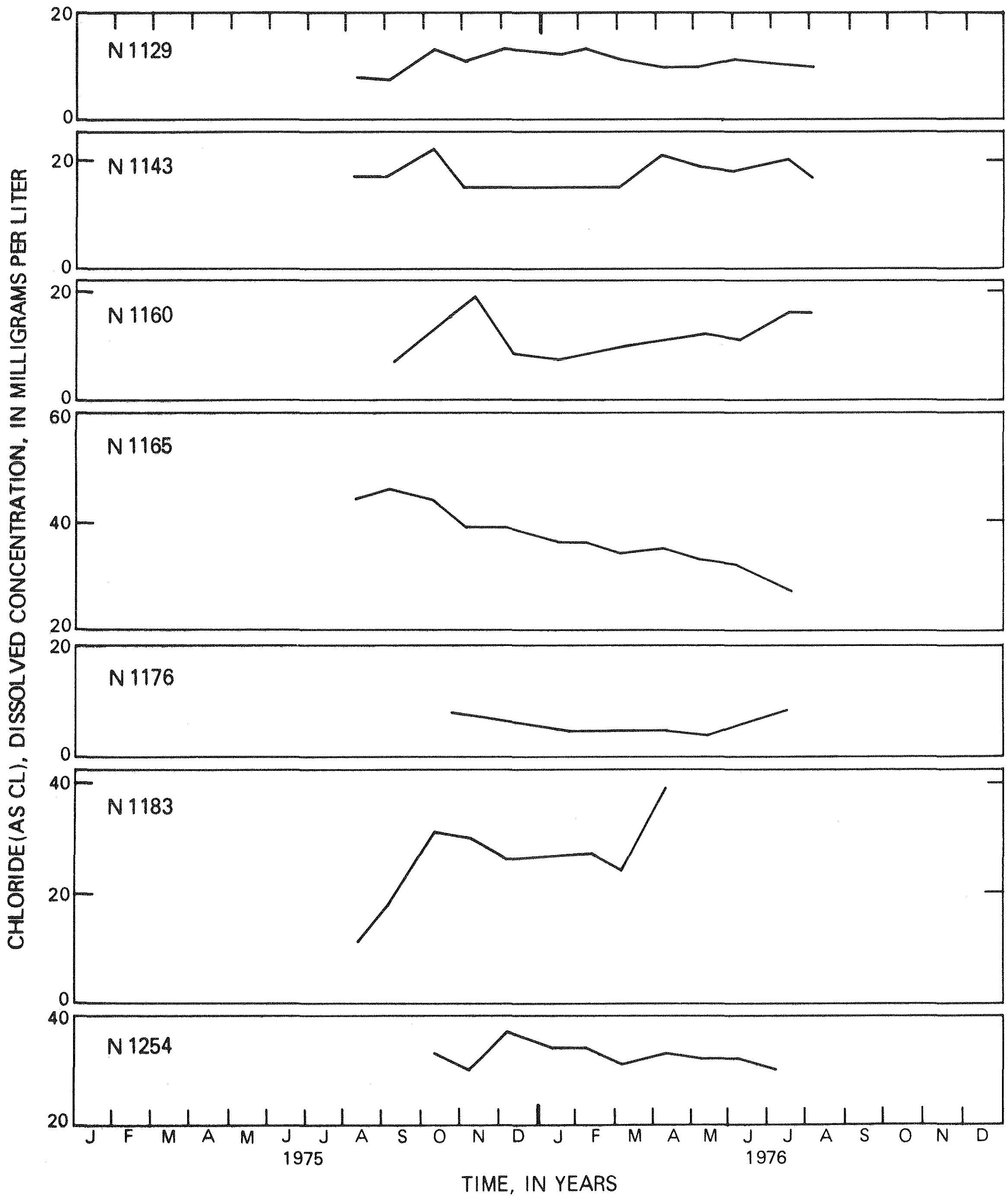


Figure 8B.--Monthly fluctuations of chloride concentration in water from 16 selected wells that show little or no monthly fluctuations over period of record.

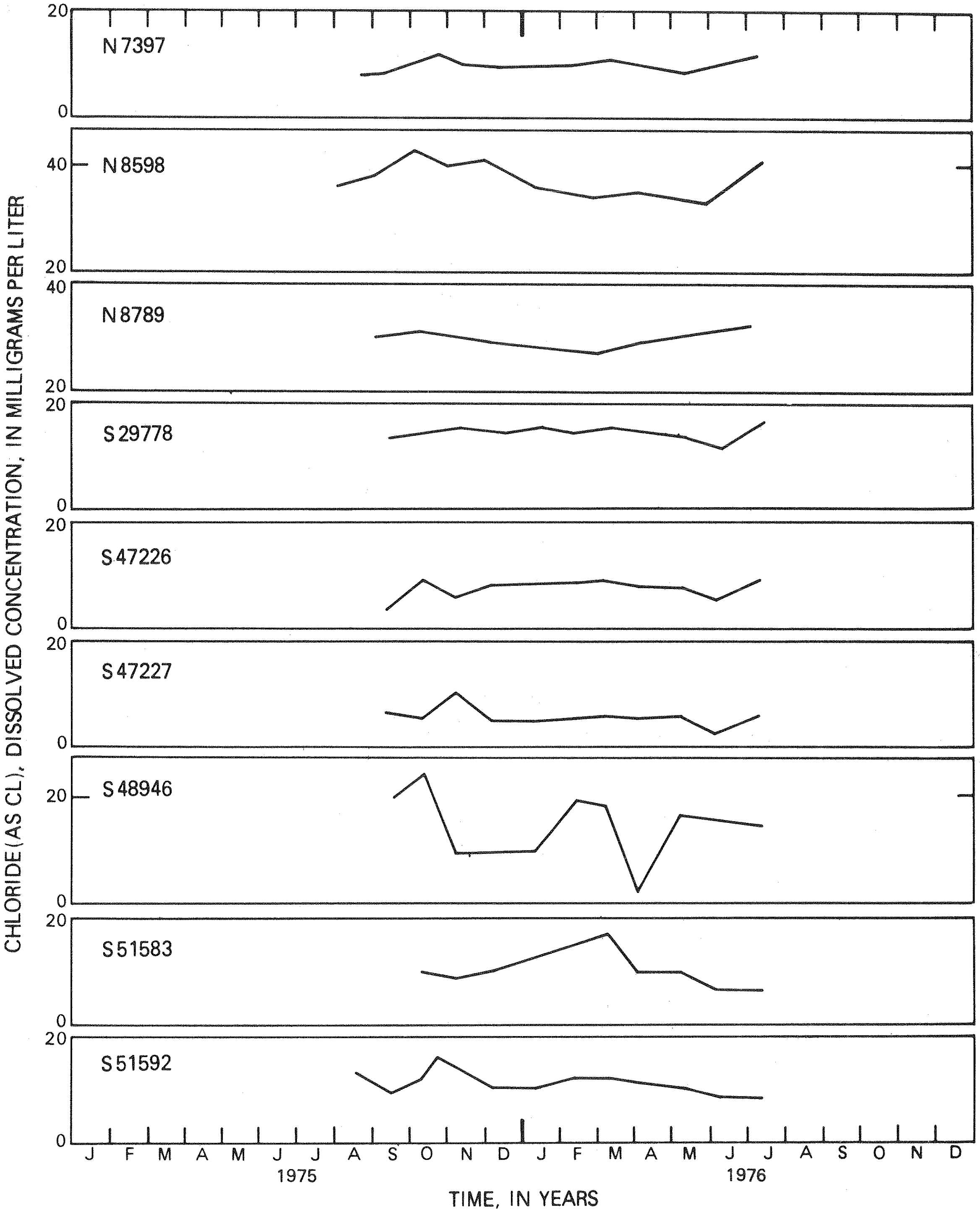


Figure 8B (continued)

Table 4.--Chemical quality of precipitation collected at Mineola and Upton, N.Y., August 1975 to July 1976[1/]

[All concentrations are in milligrams per liter]

| Date | Mineola Amount (cm) | Mineola Chloride (Cl) | Mineola Sulfate ($SO_4$) | Mineola Nitrate ($NO_3$ as N) | Upton Amount (cm) | Upton Chloride (Cl) | Upton Sulfate ($SO_4$) | Upton Nitrate ($NO_3$ as N) |
|---|---|---|---|---|---|---|---|---|
| 8-75 | 12.5 | 0.49 | 7.10 | 0.754 | 5.11 | 1.40 | 6.6 | 0.818 |
| 9-75 | 23.0 | .81 | 2.00 | 2.50 | 14.2 | 1.14 | 1.6 | .223 |
| 10-75 | 9.14 | 2.07 | 3.43 | -- | 9.17 | 2.00 | 1.83 | .214 |
| 11-75 | 10.5 | 1.85 | .40 | -- | 15.0 | 2.20 | .10 | .253 |
| 12-75 | 9.98 | 3.80 | 2.80 | -- | 12.5 | 3.90 | 1.60 | .337 |
| 1-76 | 14.6 | 3.00 | 3.50 | 1.598 | 15.2 | 1.60 | 1.70 | .297 |
| 2-76 | 7.49 | 5.65 | 6.70 | 1.700 | 9.07 | 2.00 | 2.30 | 1.000 |
| 3-76 | 6.17 | 3.70 | 6.20 | .900 | 8.38 | 2.20 | 2.10 | .770 |
| 4-76 | 5.16 | 1.70 | 5.40 | 1.000 | 5.77 | 2.10 | 4.10 | .720 |
| 5-76 | 10.3 | 1.58 | 4.20 | .610 | 9.88 | 1.11 | 3.30 | .712 |
| 6-76 | 5.66 | .72 | 5.80 | .950 | 8.31 | 1.09 | -- | .629 |
| 7-76 | 4.83 | .60 | 8.80 | 1.270 | 11.0 | .38 | 4.40 | .665 |

1/ Analyzed by U.S. Geological Survey Laboratory, Albany, N.Y.

in chloride concentration in an unsewered area elsewhere were observed by Schmidt (1972).

The remaining four wells of the 14 are adjacent to major highways or in a recharge basin. Variations of chloride in water from these wells are probably the result of deicing salts that have infiltrated directly into the ground or are carried by surface runoff into the recharge basins.

No correlations were observed between chloride concentration in ground water and (1) type of area (sewered, unsewered, or rural areas); (2) chloride concentration in precipitation; or (3) monthly water-temperature fluctuations. However, the previously discussed sources of chloride are undoubtedly an important factor in the observed monthly variations in chloride concentration.

## Nitrate

Sources that may contribute to the observed fluctuations in inorganic nitrate concentrations in ground water are precipitation, fertilizers, storm runoff, and cesspool and septic-tank effluent. Monthly fluctuations of nitrate in shallow ground water during the study period are shown in figures 9A and 9B.

The concentration of inorganic nitrate (as N) in precipitation (table 3) is generally low but may differ greatly from storm to storm and from area to area on Long Island (U.S. Geological Survey, 1976). During the 12-month sampling period, concentrations of nitrate (as N) in precipitation ranged from 0.21 to 2.50 mg/L (table 4).

In some areas, lawn fertilizers may contribute quantities of nitrogen comparable to those derived from septic-tank and cesspool systems. K. S. Porter (Cornell University Cooperative Extension Service, written commun., 1977) estimates that on an average yearly basis, 12.2 kg nitrogen per square hectameter is applied to lawns in Nassau County (based on 1970 median income levels). However, the amounts of inorganic nitrate that would ultimately enter the ground-water reservoir would be highly variable because of different application rates and certain nitrate-conversion processes, which include ammonia volatization, denitrification, and transformation of inorganic nitrogen to and from organic forms (K. S. Porter, Cornell University Cooperative Extension Service, written commun., 1976). Baier and Rykbost (1976) observed significant monthly fluctuations of nitrate in ground water over a 1-year period at test-farm sites in eastern Suffolk County. At each site, the source of nitrate concentrations (as N) in ground water, ranging from 10 to 30 mg/L, was fertilizer (Baier and Rykbost, 1976).

In a study of the influence of recharge basins on the hydrology of Long Island, Seaburn and Aronson (1974) reported that inflow to recharge basins (collected during selected storms) ranged in nitrate (as N) concentrations from 0.02 to 2.5 mg/L. In a similar study, storm runoff collected over a period of 2 hours was found to contain nitrate (as N) concentrations ranging from 1.2 to 8.3 mg/L (Vito Minei, Suffolk County Department of Environmental Control, written commun., 1976).

The effluent from septic tanks and cesspools can contain variable amounts of forms of dissolved nitrogen. Average ammonia concentrations (as $NH_4$) in this type of effluent have been reported to range from 52 to 115 mg/L (Nassau-Suffolk Research Task Group, 1969). If all this ammonia were oxidized to nitrate, the average nitrate equivalent concentration (as N) in the effluent would range from 40 to 90 mg/L. Over the period of sampling, monthly concentrations of ammonia (as N) in effluent from Sewage Disposal District 2 fluctuated between 15 and 30 mg/L (S. A. Fangman, Nassau County Department of Public Works, written commun., 1977). If this variation were taken into account along with the fact that nitrification of ammonia-nitrogen is accelerated at higher (summer) temperatures (Schmidt, 1972), the input of nitrate to ground-water bodies would probably be found to vary seasonally.

Water from 10 of the 30 wells sampled showed large monthly variations in nitrate concentration (fig. 9A), but water from the remaining 20 wells showed little or no variations (fig. 9B). Depth to water in the first 10 wells was less than 6.6 m; water from seven of these, located in both sewered and unsewered areas of Nassau County, had high nitrate concentrations during the summer (July-August) and low concentrations in February and March. The range between the low and high values in water from these seven wells was 0 to 8 mg/L (table 3). Water from the remaining three, in the unsewered area of Nassau County, showed opposite trends, that is, low nitrate concentrations in the summer and high concentrations in the winter. Nitrate concentrations (as N) in water from these three wells also fluctuated as much as 8 mg/L during the period of sampling. Nitrate concentration in ground water from the rural area of Suffolk County ranged from 0 to 0.99 mg/L (table 3) and showed no significant variation during the period of study.

Variations in nitrate concentration in the sewered area could be different from those in the unsewered area because septic-tank and cesspool system effluent is a major source of nitrate to the ground-water system. However, no correlation was observed between nitrate concentration in ground water and type of area (sewered or unsewered areas) or nitrate concentration in precipitation. However, storm runoff and fertilizers may be controlling the significant monthly variations. All 10 wells yielding water having large fluctuations in nitrate concentration are in residential areas, where the contribution of nitrate from lawn fertilizers may be significant. K. S. Porter (Cornell Univ. Cooperative Extension Service, written comm., 1977) estimates that on the average, 12.2 kg total nitrogen from lawn fertilizer is applied per square hectometer and that most of this nitrogen will be leached into ground-water bodies. In addition, two of these wells are less than 300 m downgradient from recharge basins, and monthly samples of their water had large variations in nitrate concentration. These variations may result from the wide fluctuations of nitrate concentration in storm runoff (0 to 8.3 mg/L as N) that enters the recharge basins.

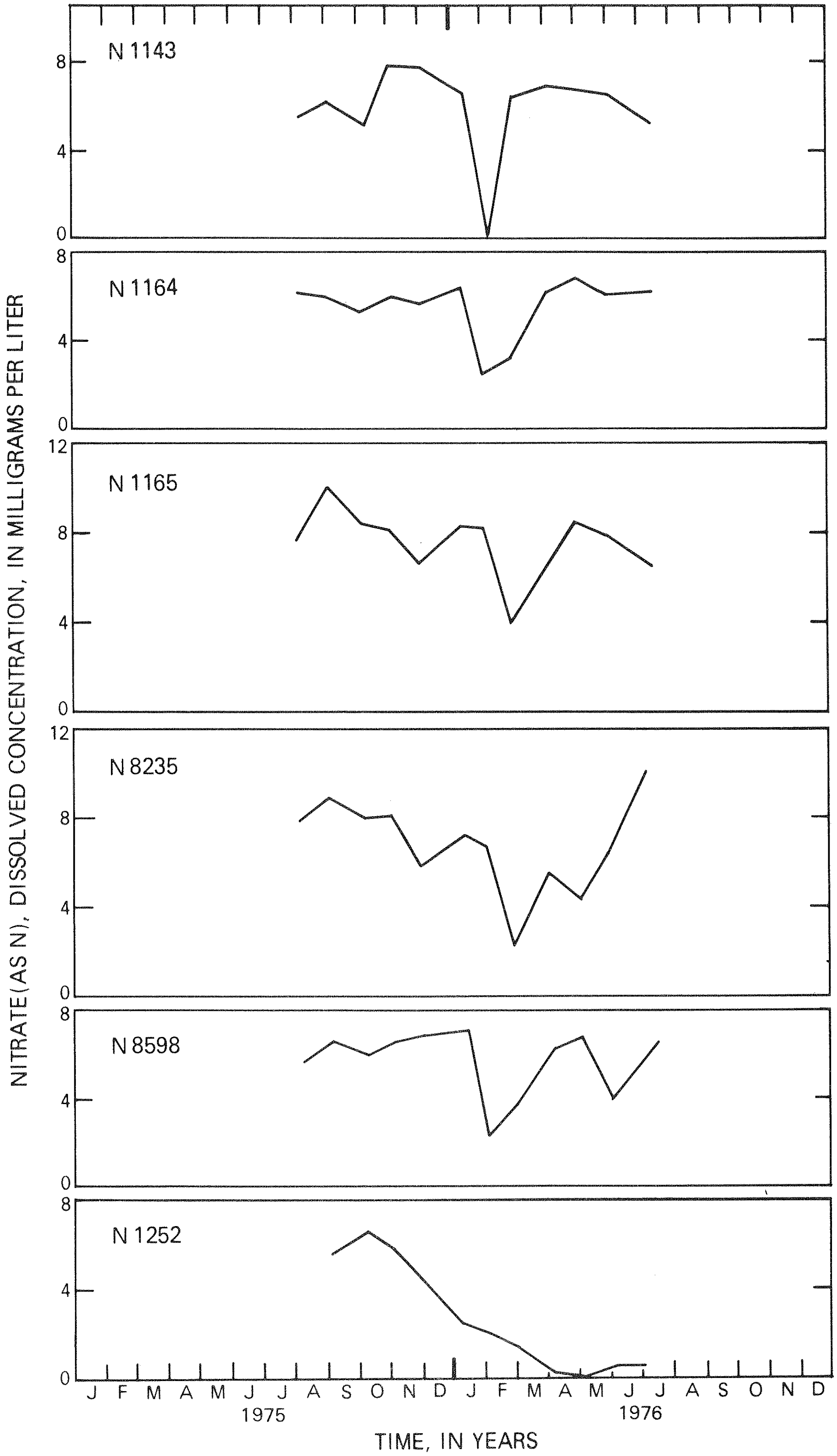


Figure 9A.--Monthly fluctuations of nitrate (as N) concentrations in water from 10 selected wells that show large fluctuations over period of record.

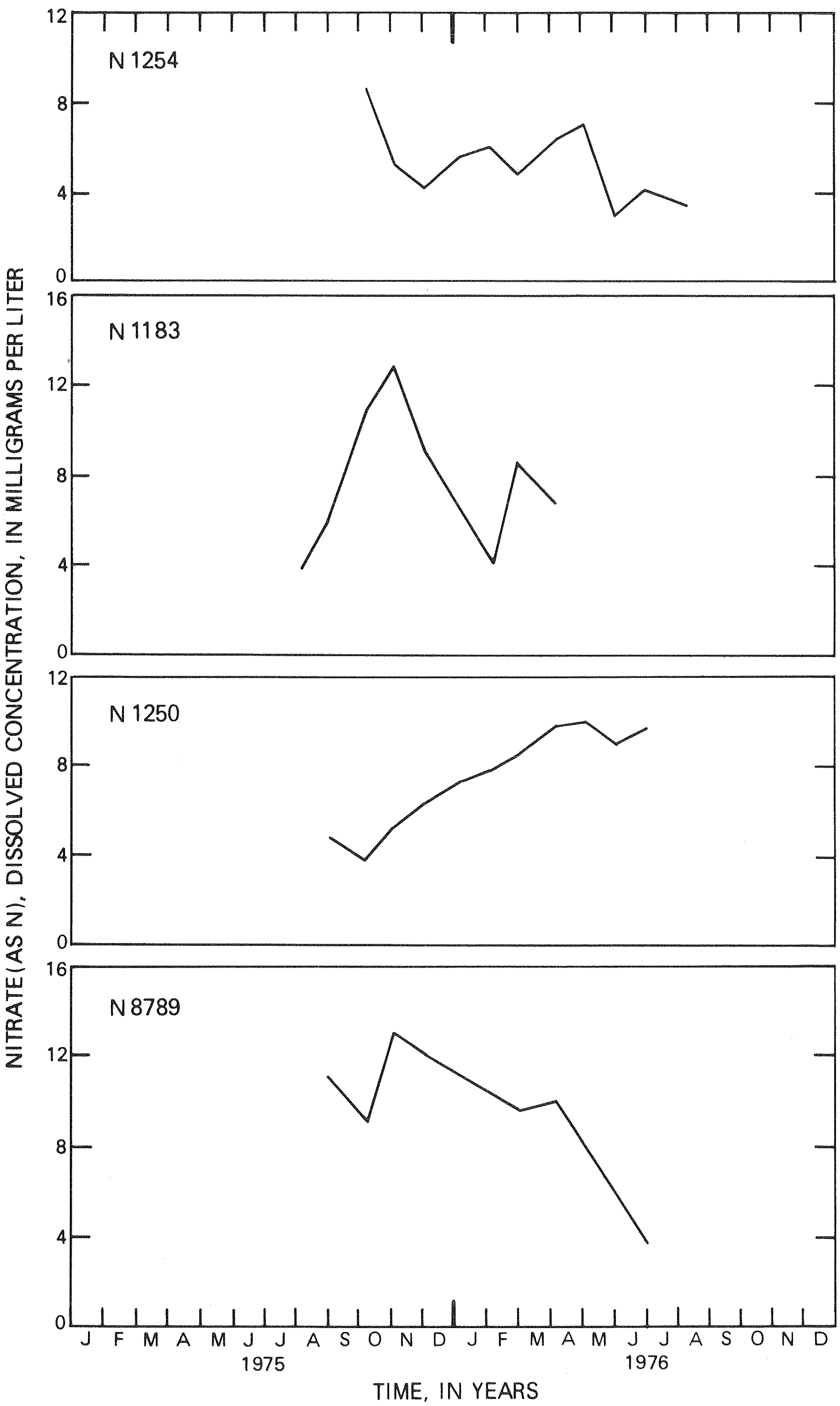


Figure 9A (continued)

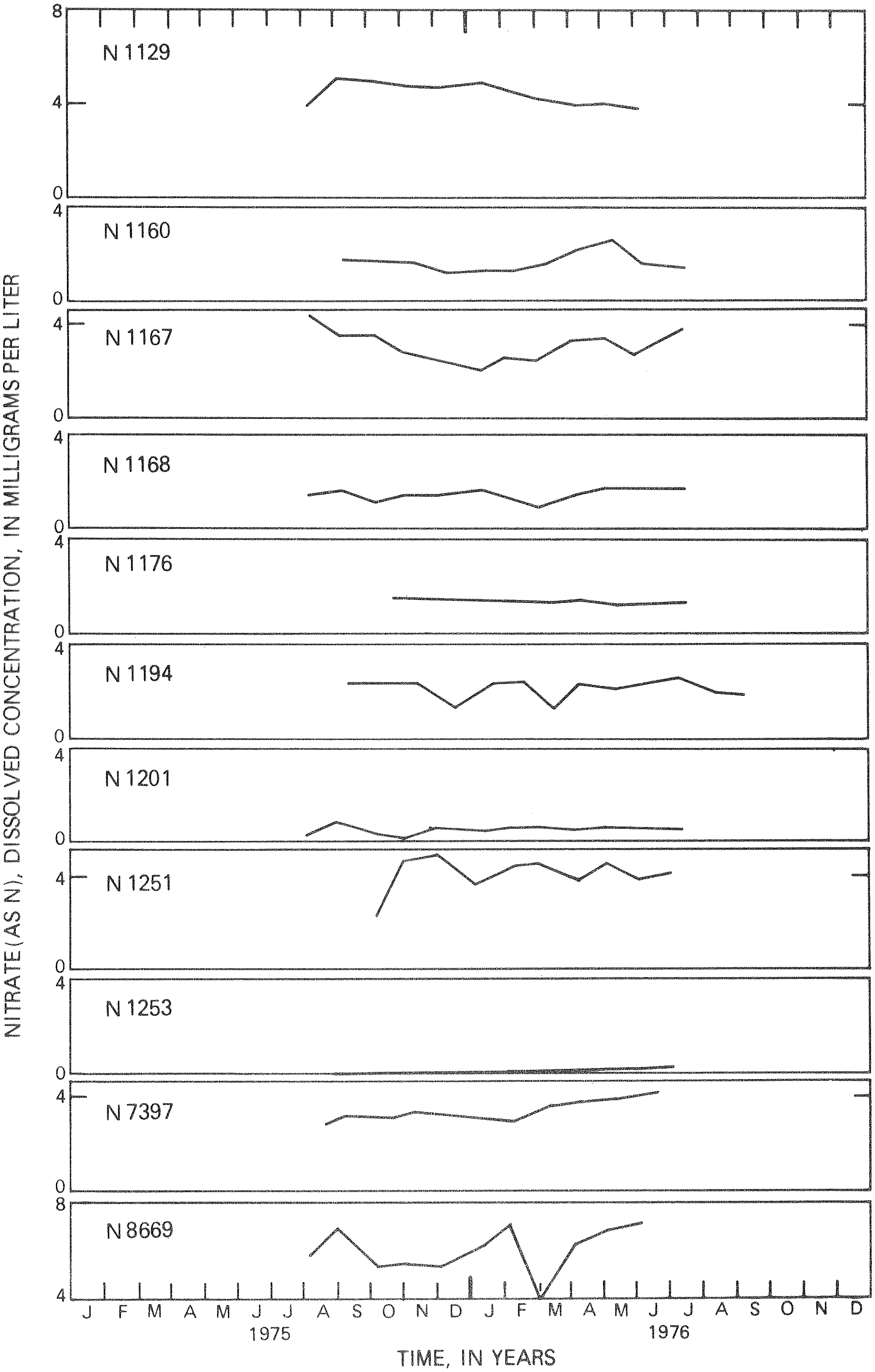


Figure 9B.--Monthly fluctuations of nitrate (as N) concentrations in water from 20 selected wells that show little or no monthly fluctuations over period of record.

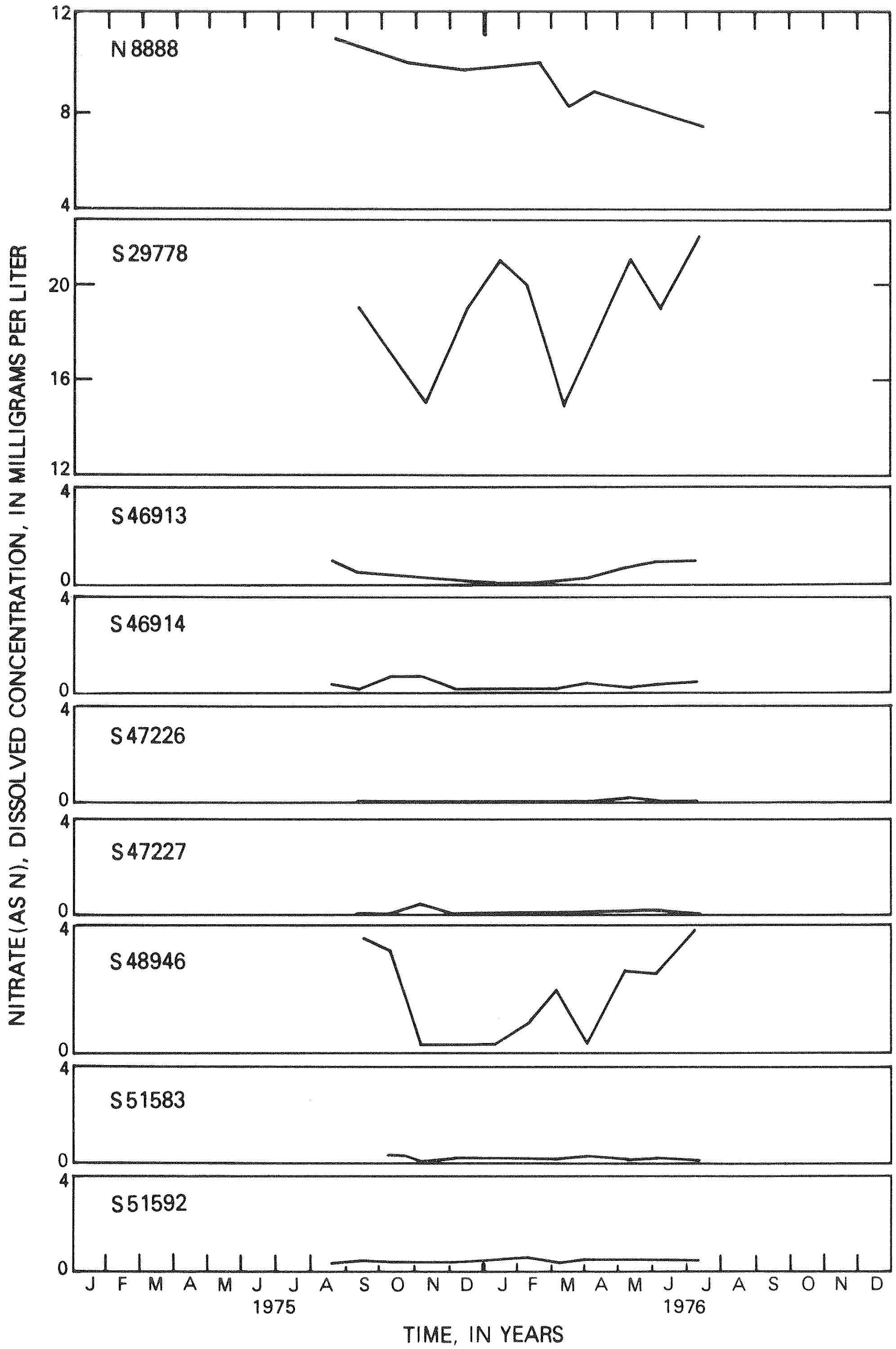


Figure 9B (continued)

## Sulfate

Sulfate concentrations above a background level of about 5 mg/L (Pluhowski and Kantrowitz, 1964) probably result from precipitation, storm runoff, and effluent from septic-tank and cesspool systems. Monthly fluctuations of sulfate in shallow ground water during the study period are shown in figures 10A and 10B.

Because of Long Island's proximity to sea water and to a heavily industrialized area, the concentration of sulfate in precipitation is high and varies widely with time. Over the period of sampling (August 1975 to July 1976), sulfate concentrations in precipitation ranged from 0.10 to 8.80 mg/L at both precipitation stations (table 4). After evaporation, the concentration of sulfate in precipitation entering the aquifer is about twice as high as that in precipitation above land surface (Pearson and Fisher, 1971). To a large extent, monthly variations of sulfate in precipitation may be responsible for fluctuations of sulfate in water in the shallow aquifer.

Another source of sulfate in ground water is storm runoff. Seaburn and Aronson (1974) report that composite samples of runoff from selected storms ranged in sulfate concentration from 3 to 30 mg/L; this high variation may partly account for the observed fluctuations in sulfate concentration in ground water.

A major source of sulfate in unsewered areas is effluent from cesspool and septic-tank systems. This source is also highly variable; sulfate concentration in sewage has been reported to range from 2 to 180 mg/L (Nassau-Suffolk Research Task Group, 1969). Data on sulfate concentration of effluent were not available during the period of sampling; however, sulfate in areas served by septic tanks and cesspools might be expected to correspond to the fluctuations in chloride and nitrate concentration.

Water from nine of the 30 wells sampled had large fluctuations in sulfate concentrations (fig. 10A). All nine wells are relatively shallow (depth to water was 4.5 m or less) and all are in the sewered and unsewered areas of Nassau County and the rural area of Suffolk County. Five of the nine wells yielding water having the largest variations in sulfate are in the unsewered area of Nassau County. Water from the remaining 21 wells had little or no monthly fluctuations (fig. 10B). The lowest monthly values of sulfate in ground water were in the rural area of Suffolk County (table 3), where the density of cesspool and septic-tank systems is very low.

The trends observed in water from these nine wells are inconsistent. Water from some wells had high sulfate values in the spring and low values in the fall; others had the opposite. Still others had low sulfate values in the summer. The fluctuations in water from most of these wells are as much as 40 mg/L (fig. 10A).

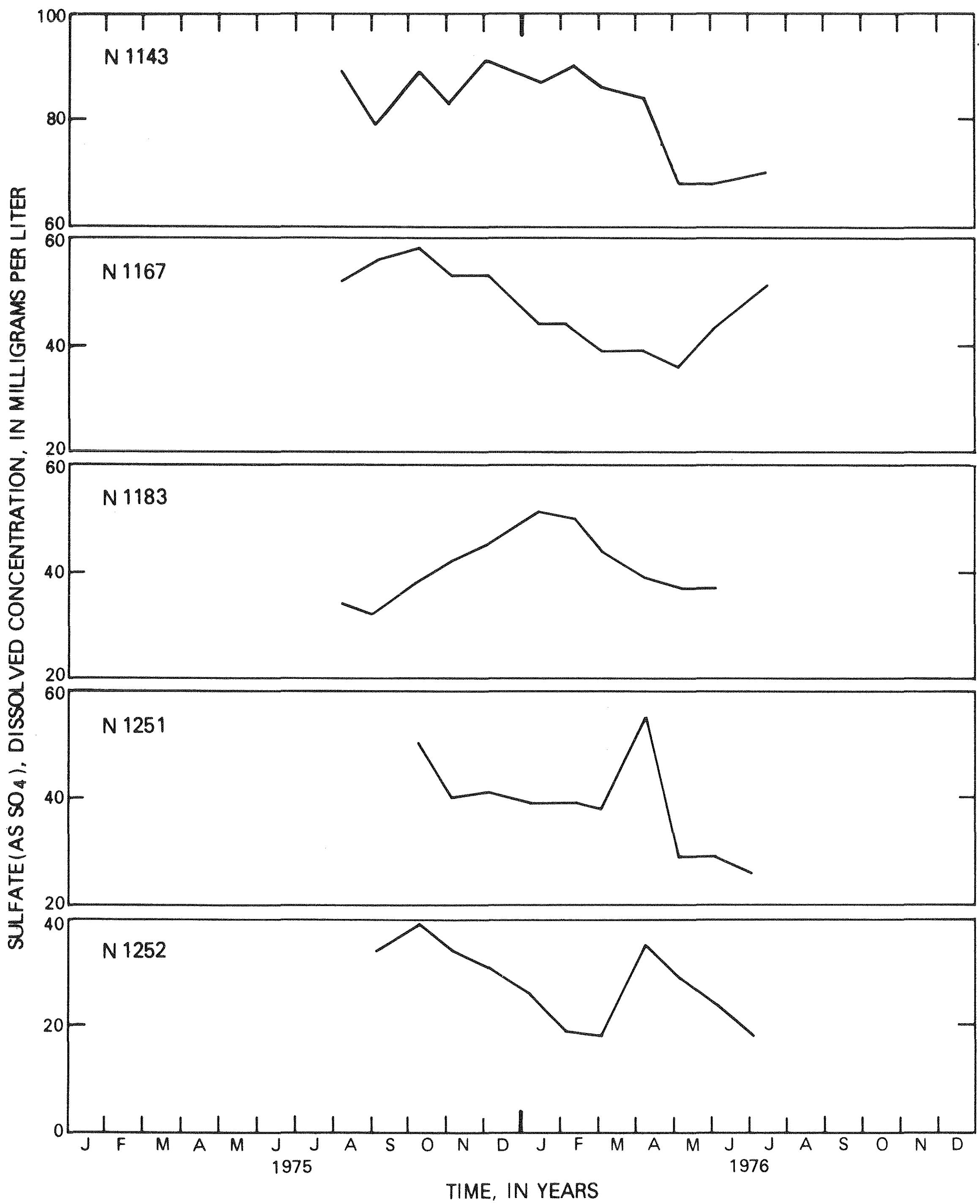


Figure 10A.--Monthly fluctuations of sulfate concentrations in water from 9 selected wells that show large fluctuations over period of record.

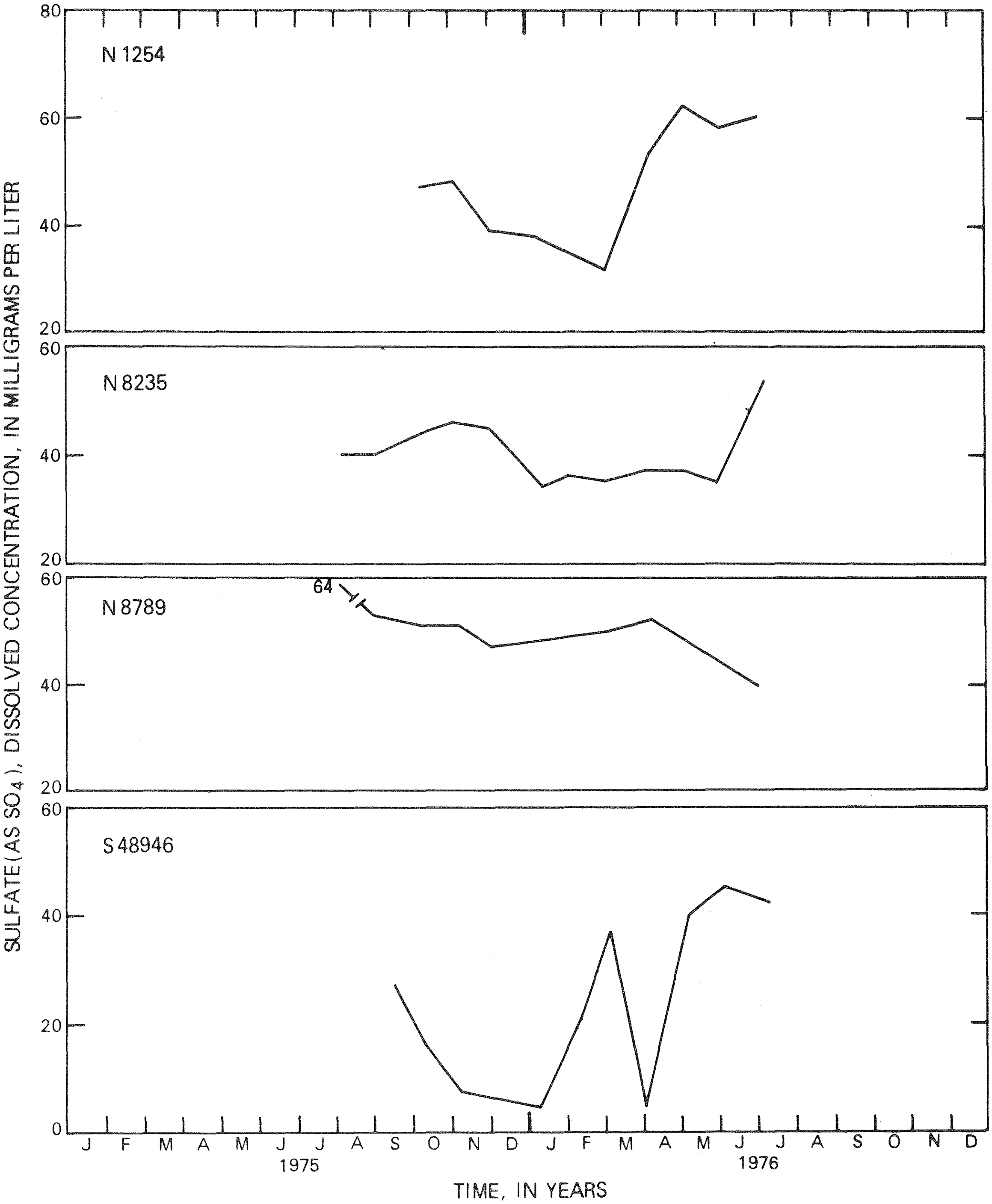


Figure 10A (continued)

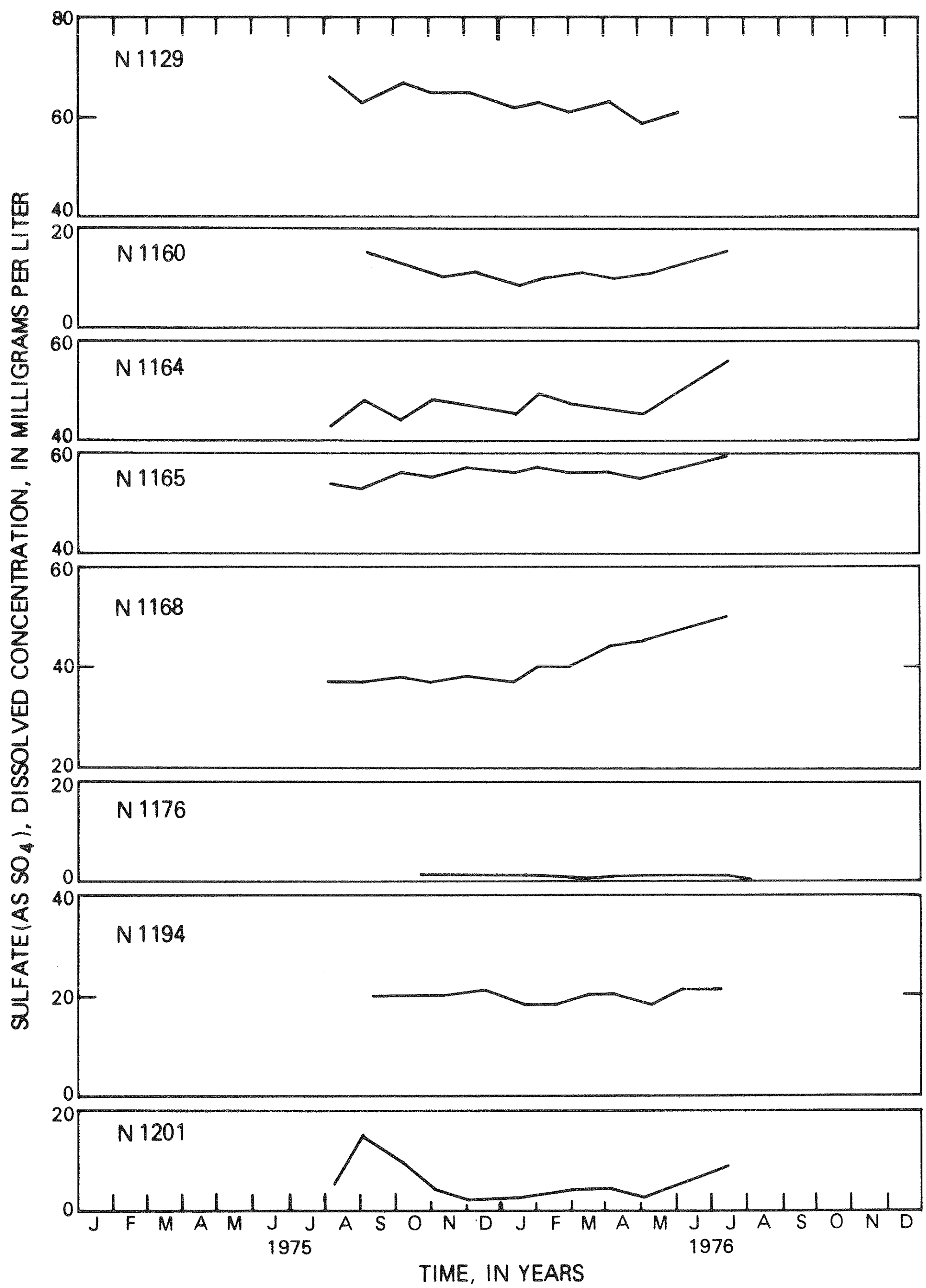


Figure 10B.--Monthly fluctuations of sulfate concentrations in water from 21 selected wells that show little or no monthly fluctuation over period of record.

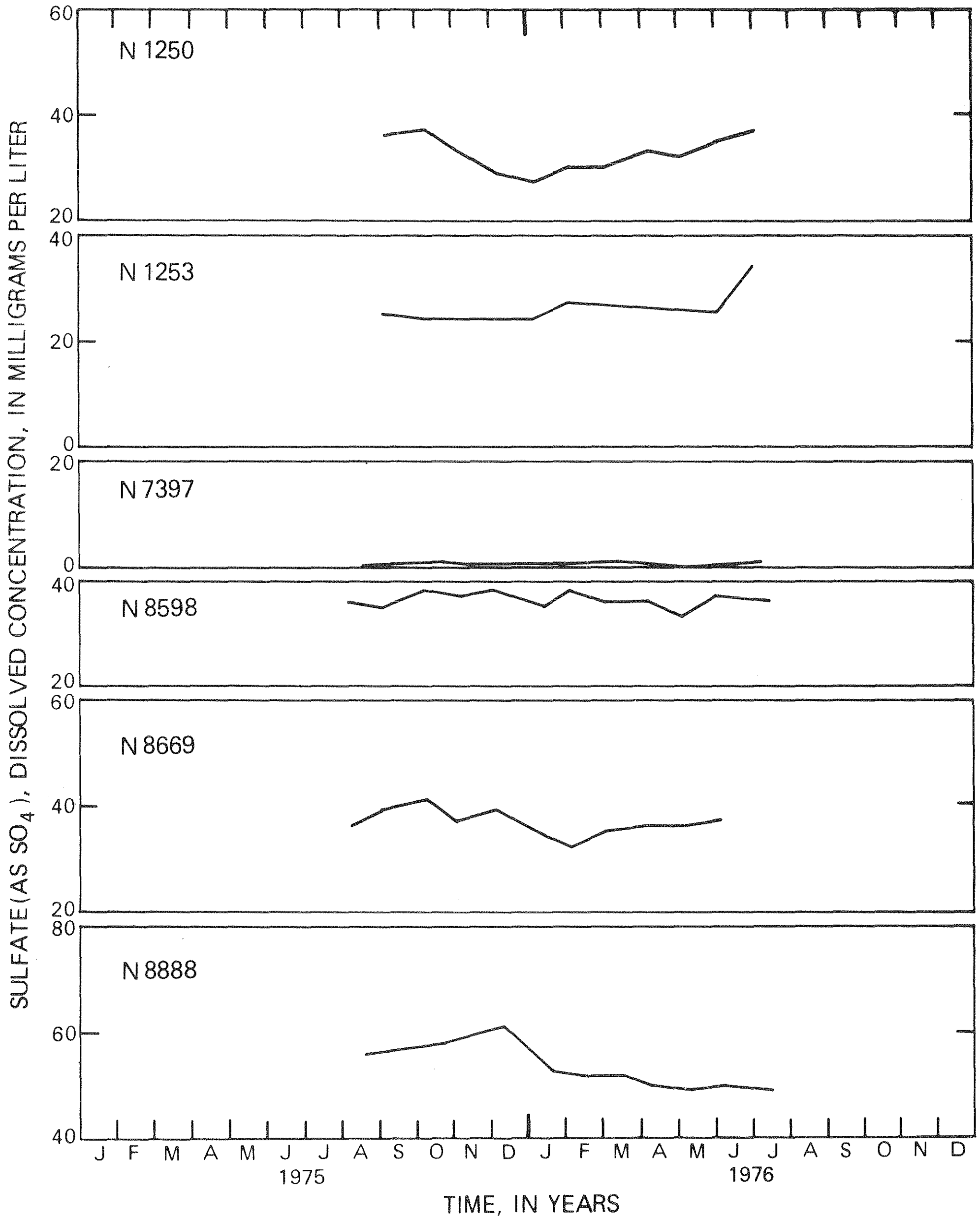


Figure 10B (continued)

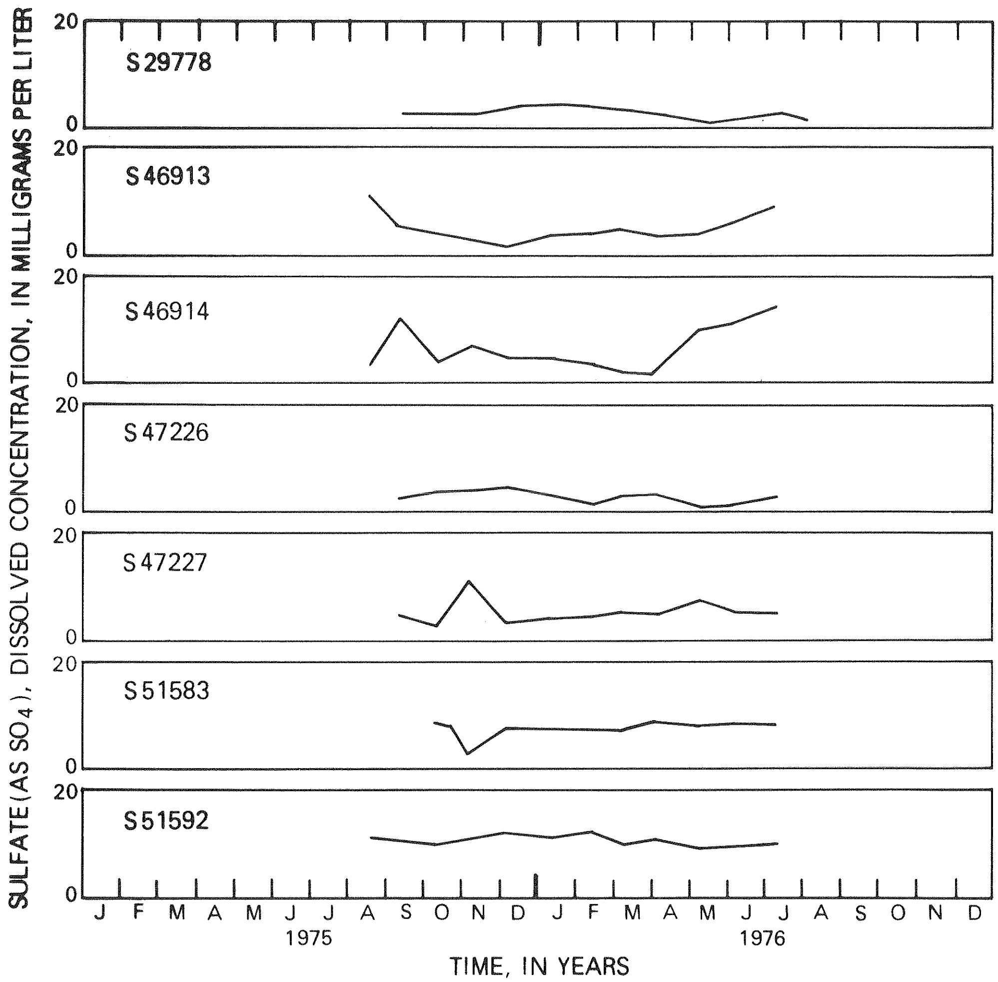


Figure 10B (continued)

## SUMMARY AND CONCLUSIONS

Concentrations of chloride, nitrate and sulfate in shallow ground water were monitored for 1 year in areas receiving these dissolved constituents from nonpoint sources. Samples were collected monthly in sewered and unsewered suburban areas and in a rural unsewered area. During the period of sampling, maximum fluctuations of chloride concentrations in any particular well ranged from 2 to 300 mg/L; nitrate, from 0.2 to 10 mg/L; and sulfate, from 1 to 40 mg/L. Factors giving rise to these fluctuations include variations in (1) quality of precipitation, (2) application rates of fertilizers, (3) concentration of dissolved constituents in storm runoff, and (4) quality of sewage discharged to the ground.

The monthly and seasonal fluctuation of chloride, nitrate, and sulfate concentrations in ground water seems to correlate with temporal variations in discharge from specific nonpoint sources such as fertilizers, sewage, and storm runoff. No consistent correlation was noted between monthly variations of these substances in ground water and seasonal fluctuations in temperature or of the concentration of these substances in precipitation.

When long-term trends in ground-water quality are derived from scant data, it is of utmost importance to observe the magnitude of the short-term variations that may result from nonpoint sources. The magnitude of these short-term fluctuations could be larger than the actual long-term change in concentration, and this would lead to an incorrect assessment of possible trends toward an improvement or degradation in water quality.

## SELECTED REFERENCES

Baier, J. H., and Rykbost, K. A., 1976, The contribution of fertilizer to the ground water of Long Island: Ground Water, v. 14, no. 6, p. 439-447.

Cohen, Philip, Franke, O. L., and Foxworthy, B. L., 1968, An atlas of Long Island's water resources: New York State Water Resources Commission Bulletin 62, 117 p.

DeLuca, F. A., Hoffman, J. C., and Lubke, E. R., 1965, Chloride concentration and temperature of the waters of Nassau County, Long Island, New York: New York State Water Resources Commission Bulletin 55, 35 p.

Franke, O. L., and Cohen, Philip, 1972, Regional rates of ground-water movement on Long Island, New York, in U.S. Geological Survey Professional Paper 800-C, p. C271-C277.

Hoffman, J. F. and Spiegel, S. J., 1958, Chloride concentration and temperature of water from wells in Suffolk County, Long Island, New York, 1928-53: New York State Water Power and Control Commission Bulletin GW-38, 55 p.

Isbister, John, 1966, Geology and hydrology of northeastern Nassau County, Long Island, New York: U.S. Geological Survey Water-Supply Paper 1825, 89 p.

McClymonds, N. E., and Franke, O. L., 1972, Water-transmitting properties of aquifers on Long Island, New York: U.S. Geological Survey Professional Paper 627-E, 24 p.

Nassau-Suffolk Regional Planning Board, 1976, Population estimates and projections, 1975 to 1995; interim report series 1: Hauppauge, N.Y., 58 p.

Nassau-Suffolk Research Task Group, 1969, The Long Island water pollution study: New York State Department of Health, 395 p.

Pearson, F. J., Jr., and Fisher, D. W., 1971, Chemical composition of atmospheric precipitation in the northeastern United States: U.S. Geological Survey Water-Supply Paper 1535-P, 23 p.

Perlmutter, N. M., and Guerrera, A. A., 1970, Detergents and associated contaminants in ground water at three public-supply well fields in southwestern Suffolk County, Long Island, New York: U.S. Geological Survey Water-Supply Paper 2001-B, 22 p.

Pettyjohn, W. A., 1971, Water pollution by oil field brines and related industrial wastes in Ohio: Ohio Journal of Science, v. 71, no. 5, p. 257-269.

_________ 1975, Chloride contamination in Alum Creek, central Ohio: Ground Water, v. 13, no. 4, p. 332-339.

_________ 1976, Monitoring cyclic fluctuations in ground-water quality: Ground Water, v. 14, no. 6, p. 472-480.

Piskin, Rauf, 1973, Evaluation of nitrate content of ground water in Hall County, Nebraska: Ground Water, v. 11, no. 6., p. 4-13.

Pluhowski, E. J., and Kantrowitz, I. H., 1964, Hydrology of the Babylon-Islip Area, Suffolk County, Long Island, New York: U.S. Geological Survey Water-Supply Paper 1768, 119 p.

Schmidt, K. D., 1972, Nitrate in ground water of the Fresno-Cloris metropolitan area, California: Ground water, v. 10, no. 1, p. 50-64.

_________ 1977, Water-quality variations for pumping wells: Ground Water, v. 15, no. 2, p. 130-137.

Saffigna, P. G. and Keeney, D. R., 1977, Nitrate and chloride in ground water under irrigated agriculture in central Wisconsin: Ground Water, v. 15, no. 2, p. 170-177.

Seaburn, G. E. and Aronson, D. A., 1974, Influence of recharge basins on the hydrology of Nassau and Suffolk Counties, Long Island, N.Y: U.S. Geological Survey Water-Supply Paper 2031, 66 p.

Stevens, H. H., Jr., Ficke, J. F., and Smoot, G. F., 1975, Water temperature, influential factors, field measurement, and data presentation: U.S. Geol. Survey Techniques of Water-Resources Investigations, Book 1, Chap. D1, 65 p.

Sumi, L., Corkery, A., and Monkman, J. L., 1959, Calcium sulfate content of urban air: Baltimore, Md., American Geophysical Union, Geophysics Monograph 3, p. 69-80.

Toler, L. G., and Pollock, S. J., 1974, Retention of chloride in the unsaturated zone: U.S. Geological Survey Journal of Research, v. 2, no. 1, p. 119-123.

U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations: Federal Register, v. 40, no. 248, p. 59566-59574.

U.S. Geological Survey, 1976, Water resources data for New York, Water year 1975: U.S. Geological Survey Water-Data Report NY-75-1, 735 p.

Walker, W. H., 1973, Ground-water nitrate pollution in rural areas: Ground Water, v. 11, no. 5, p. 19-22.

___________ 1973a, Where have all the toxic chemicals gone?: Ground Water, v. 11, no. 2, p. 11-20.

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