Detergents and Associated Contaminants in Ground Water at Three Public-Supply Well Fields in Southwestern Suffolk County, Long Island, New York

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2001-B

Prepared in cooperation with the Suffolk County Board of Supervisors and the Suffolk County Water Authority

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By N. M. PERLMUTTER *and* A. A. GUERRERA

WATER IN THE URBAN ENVIRONMENT

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By N. M. Perlmutter and A. A. Guerrera[1]

ABSTRACT

Sampling of groups of small-diameter shallow observation wells and nearby public-supply wells screened in the upper glacial aquifer at three well fields showed that detergents (MBAS) were distributed through almost the entire saturated thickness of the aquifer. Concentrations of MBAS in water from all the wells sampled ranged from less than 0.02 to nearly 5 mg/l (milligrams per liter), whereas MBAS concentrations in water pumped from shallow public-supply wells ranged from about 0.1 mg/l to about 1.3 mg/l. Upward trends in MBAS concentrations, which were observed at most of the shallow observation wells from 1961 to 1966, nearly stabilized or declined to some extent by 1968. A slight to distinct upward trend in the MBAS content of water pumped from shallow public-supply wells was observed during the same period at two of the three well fields investigated.

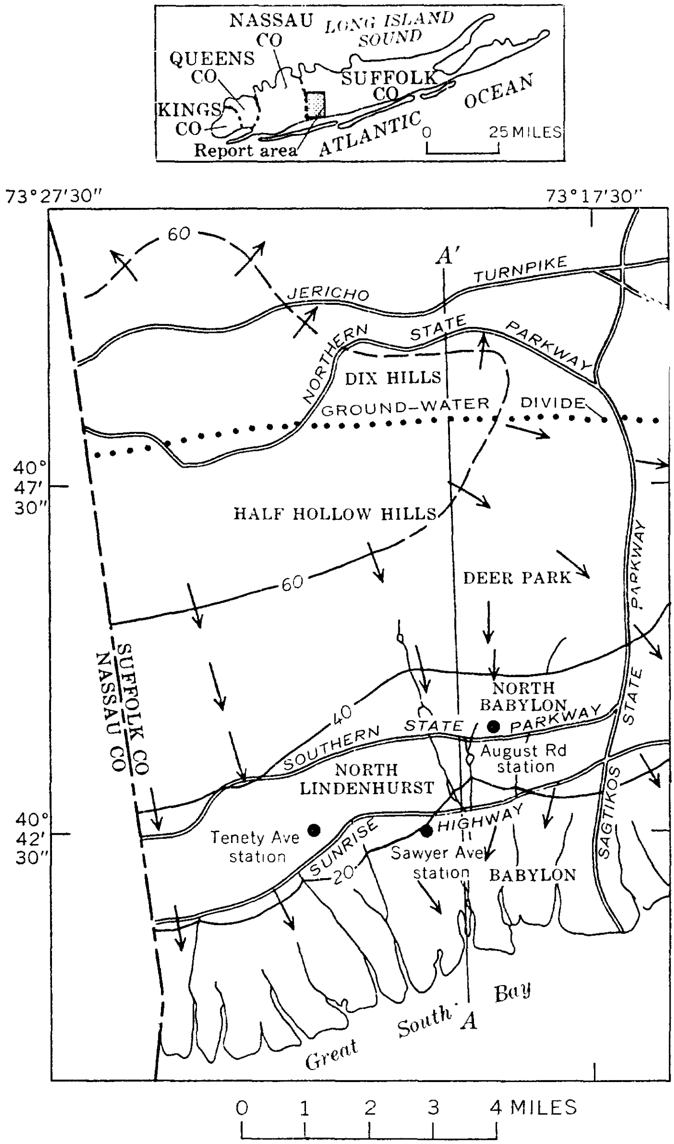
Chloride concentrations in the upper glacial aquifer, which ranged from about 5 to 80 mg/l, had a distinct upward trend at some wells apparently due to infiltration of both sewage effluent and deicing salts which were applied to roads in the winter. Nitrate concentrations also increased slightly but remained below the recommended limit for drinking water.

No MBAS was detected in water from public-supply wells tapping deeper zones in the underlying Magothy aquifer, and significant amounts of MBAS and associated contaminants are unlikely to reach those zones for many years, if present flow patterns and head relationships are not markedly changed.

INTRODUCTION

Deterioration of the quality of the shallow ground water is a problem of growing magnitude and concern in rapidly urbanizing and relatively densely populated southwestern Suffolk County (fig. 1). The area depends entirely on ground water as a source of water

[1] Chemist, Suffolk County Water Authority.



EXPLANATION

—— ——60——— Water-table contour
Shows altitude of water table. Dashed where approximately located. Contour interval 20 feet. Datum is mean sea level

←— Approximate direction of ground-water flow

FIGURE 1.—Location of the report area, water-table contours in the fall of 1967, and location of well fields investigated for contamination. Section *A–A'* shown in figure 2.

supply. Deterioration in water quality results mainly from the daily infiltration into the ground of millions of gallons of sewage effluent from thousands of homes and a relatively small number of commercial and industrial establishments, all of which are serviced by individual cesspools and septic tanks. Similar conditions exist (1969) in most of the remainder of Suffolk County and in parts of northern and eastern Nassau County where public sewers are lacking. In Nassau County, however, an extensive public-sewer system is being developed which should eventually help abate ground-water contamination in that area.

Domestic sewage effluent in the report area contains various dissolved contaminants including detergents, nitrate, phosphate, chloride, and other inorganic and organic constituents, and bacteria and viruses. Conditions in a ground-water environment generally do not favor extensive travel of microscopic organisms beyond their source areas, whereas waterborne chemical contaminants, which were of greater concern in this investigation, can move many hundreds of feet from their source. The mobility of dissolved contaminants constitutes a potential threat not only to the quality of shallow ground water downgradient from cesspools and septic-tank systems, but also to underlying deeper aquifers which are recharged by downward percolation of shallow ground water.

Although other substances such as fertilizers and deicing salts, also contribute to ground-water contamination, emphasis in this investigation was given chiefly to the occurrence of detergents. Locally, detergents in ground water may exceed the recommended limit of 0.5 mg/l (milligrams per liter) in drinking water (U.S. Public Health Service, 1962, p. 7). Although detergents may cause foaming of the water, they are not considered to be toxic at the generally low concentrations found in ground water. Nevertheless, their presence in water suggests contamination of sewage origin.

The following questions were considered in this study: (1) What concentrations of detergents are present in the ground water?, (2) what is the vertical pattern of distribution of detergents in the aquifers?, (3) are concentrations of detergents increasing or decreasing?, and (4) are detergents moving downward locally into the deeper water-bearing zones in response to hydraulic gradients resulting from pumping deep public-supply wells?

The investigation was made in cooperation with the Suffolk County Board of Supervisors and the Suffolk County Water Authority. The report was completed under the direction of Garald G. Parker, former district chief, New York district, and Philip Cohen, hydrologist in charge of the U.S. Geological Survey subdistrict office in Mineola. Appreciation is expressed to the chemists of the Suffolk County Water Authority who made most of the water analyses.

TEST DRILLING, SAMPLING, AND LABORATORY PROCEDURES

Detailed studies including test drilling and sampling were made at the Tenety Avenue, August Road, and Sawyer Avenue pumping stations (fig. 1) of the Suffolk County Water Authority, the principal water-supply agency in Suffolk County. Both shallow and deep wells are pumped at these three stations. The shallow wells yield water containing some of the highest concentrations of detergents reported in public-supply wells in southern Suffolk County.

In order to determine the vertical distribution of detergents in the shallow aquifer and to monitor trends in concentrations for an extended period, groups of 3 to 5 small-diameter observation wells were installed in 1961 and 1962 by driving casing and attached well points to depths ranging from 12 to 87 feet below land surface at the three well fields (table 1 and pl. 1). In addition, one well was installed at a depth of 140 feet at the Tenety Avenue station to monitor water quality in the upper part of the deep aquifer. Another sampling well, subsequently destroyed, was installed at a depth of 82 feet in the shallow aquifer at Fiorito Stadium, about 650 feet north of the Sawyer Avenue station, to monitor the quality of the ground water upgradient from that station. Water-level measurements were made in the observation wells prior to sampling, and hydrographs were obtained from water-level recorders operated for short periods at several observation wells to determine the influence of pumping from nearby supply wells.

Water samples were collected from the observation wells generally at monthly intervals from about the spring of 1961 to the spring of 1966 and, thereafter, about twice a year through 1968. The water was analyzed mostly for detergent and chloride content and occasionally for other constituents. The part of the detergent compound determined in water samples collected prior to June 1965 was the surfactant ABS (alkylbenzenesulfonate). Some of the samples collected after that date probably also contained the surfactant LAS (linear alkylsulfonate), which replaced ABS in household detergent compounds beginning about mid-1965. LAS is reportedly more biodegradable than ABS in activated sludge sewage-treatment plants, but no significant differences in biodegradability of the two surfactants in a ground water environment have been reported. Moreover, residual ABS remains in the ground water on Long Island. Both LAS and ABS respond similarly to the methylene-blue test (American Public Health Association, Inc., 1965, p. 297) and are referred to collectively in this report as MBAS (methylene blue active substance).

TABLE 1.—*Records of selected public-supply wells and observation wells*

Well: WRC, New York State Water Resources Commission; SCWA, Suffolk County Water Authority; USGS, U.S. Geological Survey (national well-numbering system based on latitude and longitude).
Altitude of land surface: Datum is mean sea level.
Water-bearing unit: ug. upper glacial aquifer; M, Magothy aquifer.
Altitude of water level: Datum is mean sea level.
Method of construction: R, rotary; RR, reverse rotary; D, driven.
Use: PS, public supply; O, observation.

Well WRC	Well SCWA	Well USGS	Year completed	Altitude of land surface (feet)	Drilled depth (feet)	Diameter (inches)	Screen setting below land surface (feet)	Water-bearing unit	Approximate pumping rate (gpm)	Specific capacity (gpm per foot)	Altitude of water level Date	Altitude of water level Feet	Method of construction	Use
Tenety Avenue station														
S19554	1	404236N732257.1	1961	46	120	16	67–97	ug	1180	93	9–19–68	28.7	RR	PS
S20460	2	404235N732256.1	1962	45	765	16–12	432–495	M	1100	31	2–7–68	28.3	RR	PS
S22606		404236N732256.2	1962	45	23	2	20–23	ug			11–21–67	29.1	D	O
S22607		404236N732256.3	1962	45	67	1¼	64–67	ug			11–21–67	29.1	D	O
S22608		404236N732256.4	1962	45	87	1¼	84–87	ug			11–21–67	29.1	D	O
S22609		404236N732256.5	1963	45	151	6–3	130–140	M			11–21–67	28.7	R	O
August Road station														
S12710	1	404403N731931.1	1955	41	102	16	41–66	ug	900	99			RR	PS
S16256	2	404403N731935.1	1958	43	650	16–12	549–601	M	1050	34	2–7–68	29.8	RR	PS
S20635	3	404403N731930.1	1962	42	700	6–12	555–627	M	1100	62			RR	PS
S24724		404404N731935.2	1961	35	15	1¼	12–15	ug			11–21–67	29.6	D	O
S24725		404404N731935.3	1961	35	38	1¼	35–38	ug			11–21–67	29.6	D	O
S24726		404404N731935.4	1961	35	77	1¼	74–77	ug			11–21–67	29.6	D	O
Sawyer Avenue station														
S15505	1	404232N732040.1	1957	25	103	16	52–78	ug	900	91			RR	PS
S18003	2	404231N732038.1	1959	25	671	16–12	612–668	M	1080	41	2–7–68	19.3	RR	PS
S24718		404231N732038.2	1961	25	12	1¼	9–12	ug			11–21–67	18.0	D	O
S24719		404231N732038.6	1961	25	15	1¼	12–15	ug			11–21–67	17.9	D	O
S24720		404231N732038.3	1961	25	44	2	41–44	ug			11–21–67	18.0	D	O
S24721		404231N732038.5	1961	25	67	2	64–67	ug			11–21–67	18.0	D	O
S24722		404231N732038.4	1961	25	72	2	69–72	ug			11–21–67	18.0	D	O
S24723 [1]		404237N732044.7	1962	25	82	1¼	79–82	ug			10–17–66	19.0	D	O

[1] Florito Stadium well.

371-857—70——2

HYDROGEOLOGIC ENVIRONMENT

WATER-BEARING UNITS

The principal water-bearing units concerned in the movement of contaminated water in southwestern Suffolk County are the upper glacial aquifer and the underlying Magothy aquifer (fig. 2 and pl. 1). The upper glacial aquifer is composed of stratified and highly permeable beds of sand and gravel that contain unconfined water. The upper limit of the unconfined water is the water table (figs. 1 and 2, and pl. 1), which is about 5 to 20 feet below land surface at the well fields investigated. The water table declined about 2 to 4 feet at the well fields during the period of this investigation, owing to a regional drought that lasted from about 1962 to 1966 (Cohen and Franke, 1969). Shallow public-supply wells (table 1) that tap the upper glacial aquifer are generally pumped at rates of about 800 to 1,200 gpm (gallons per minute) mainly during the summer months to meet peak

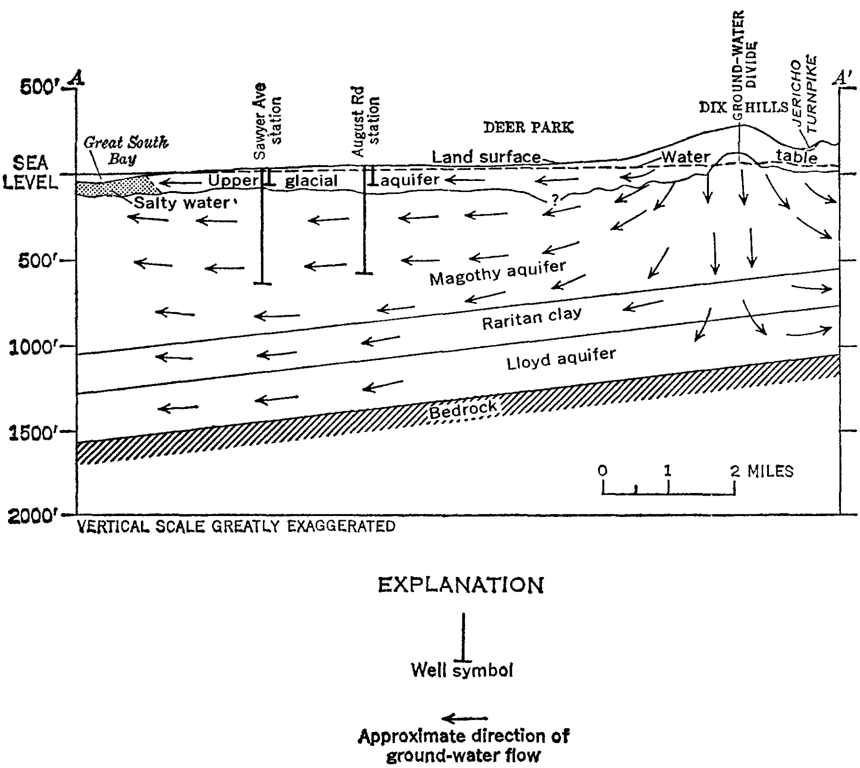


FIGURE 2.—Water-bearing units and generalized natural flow pattern of ground water. See figure 1 for location of section.

demands. The pumpage for an individual well averages several tenths of a million gallons daily on an annual basis (table 2) and about 0.6 mgd on a seasonal basis. Graphs of monthly pumpage from the upper glacial aquifer by well fields are shown on plate 2.

The thicker, but less permeable, Magothy aquifer is composed chiefly of beds and lenses of sand, silt, clay, and some gravel (pl. 1) all of Late Cretaceous age. The aquifer contained confined (artesian) water. Because of the lenticularity and fine-grained character of the deposits, the vertical permeability of the Magothy aquifer is much lower than the horizontal permeability. The upper glacial and Magothy aquifers are not separated by distinct confining layers (beds of low permeability) at the well fields, hence, water may move slowly from one aquifer to the other depending on head relations. The deep supply wells that tap the Magothy aquifer are generally pumped all year round at rates of about 1,000 to 1,100 gpm, or about 0.3 to 1 mgd; the largest withdrawals in 1967 were made at the August Road station (table 2).

The Lloyd aquifer, the deepest water-bearing unit (fig. 2), consists of sand, gravel, and clay and is separated from the overlying Magothy

TABLE 2.—*Summary of annual and average-daily pumpage, in millions of gallons, by well fields and aquifers, 1961–67*

	Water-bearing unit				Total pumpage of station	
	Upper glacial aquifer		Magothy aquifer			
Year	Annual	Average daily	Annual	Average daily	Annual	Average daily
			Tenety Avenue station			
1961						
1962	29.8	0.08	130.3	0.36	160.8	0.44
1963	10.2	.03	213.6	.58	223.8	.61
1964	11.7	.03	140.8	.39	152.5	.42
1965	41.7	.11	250.8	.69	292.5	.81
1966	57.3	.16	124	.34	181.3	.50
1967	39.1	.11	170.6	.47	207.1	.57
			August Road station			
1961	100	0.28	310.4	0.85	410.4	1.1
1962	65	.18	393.2	1.1	458.2	1.3
1963	37.5	.10	402.2	1.1	439.7	1.2
1964	69.1	.19	426.1	1.2	495.2	1.4
1965	96.4	.26	414.1	1.1	510.5	1.4
1966	57.1	.16	274.6	.75	331.7	.91
1967	36.4	.10	240.6	.66	273.5	.75
			Sawyer Avenue station			
1961	125.4	0.34	148.7	0.41	274.1	0.75
1962	81.5	.22	128.5	.35	210.0	.57
1963	82.8	.23	105.1	.29	187.9	.52
1964	63.6	.17	88.2	.24	151.8	.41
1965	63.2	.17	146.3	.40	209.5	.57
1966	46.8	.13	106.4	.29	153.2	.42
1967	22.8	.06	26.5	.07	49.0	.13

aquifer by the Raritan clay, a thick confining unit. The Lloyd aquifer was not used as a source of supply in the area investigated, and was not involved in the contamination problems discussed in this report.

REGIONAL AND LOCAL PATTERNS OF GROUND-WATER MOVEMENT

An understanding of the present distribution of the contaminated ground water and estimates of possible future movement require a knowledge of the general aspects of both the natural regional flow pattern and the pattern of movement locally under pumping conditions. Natural recharge to the ground-water reservoir in southwestern Suffolk County occurs solely by infiltration of precipitation on that area (fig. 2). An estimated 22 inches of the average annual precipitation of about 44 inches percolates down to the water table, and most of the remainder of the precipitation returns to the atmosphere by evaporation and transpiration, except for about 8 to 10 percent that runs off overland into streams.

Under natural conditions most of the recharge from precipitation in southwestern Suffolk County (fig. 1) moves southward and nearly horizontally in the upper glacial aquifer to discharge areas in streams and bays at the south shore. A small part of the recharge near the ground-water divide (figs. 1 and 2) moves vertically downward into the underlying Magothy aquifer. From there, part of the water percolates down to the Lloyd aquifer, and the remainder moves southward and almost horizontally through the Magothy aquifer. Near the south shore, water in the Magothy aquifer moves upward and ultimately discharges into bays and the Atlantic Ocean. Similarly, most of the recharge north of the ground-water divide (fig. 1) ultimately discharges northward into bays and Long Island Sound.

As a result of pumping, part of the water in the Magothy aquifer that formerly discharged by natural subsurface outflow is now returned to the upper glacial aquifer as seepage from cesspools and septic tanks. Therefore, although average annual ground-water recharge and discharge still are approximately in balance in southwestern Suffolk County, the internal routing of the water has changed from natural conditions. The above description of the natural flow pattern, adapted in part from Pluhowski and Kantrowitz (1964, p. 39–42), suggests that numerous opportunities for chemical modification of the original source water from precipitation are available as the water moves from intake to discharge areas (see section "Contamination of the ground water").

The pattern of flow near and beneath the well fields under pumping conditions varies considerably from the natural flow pattern described previously. Figure 3 shows four schematic patterns of flow in the vertical plane, which probably occur in the aquifers beneath and near the well fields under various operating conditions. Actually, the ground-water movement is three dimensional; consequently, the flow patterns are highly generalized.

Figure 3*A* represents the natural flow pattern beneath the well fields when both shallow and deep wells are shut down. Under these conditions vertical components of flow are negligible and, therefore, movement of significant quantities of water between the aquifers in either direction is unlikely.

Figure 3*B* shows conditions under which only the shallow supply well is operating. A cone of depression develops in the water table and flow lines near the well are diverted radially inward toward the screened interval. Upward components of flow from the upper part of the Magothy aquifer shown in diagram *B* are confirmed by the hydrographs in figure 4, which show about a 1-foot decline in water level at observation well S22609 (screened in the upper part of the Magothy aquifer) when shallow supply well S19554 is pumped at about 1,100 gpm. The flow pattern illustrated in figure 3*B* is rare as the shallow supply wells are generally never pumped alone because of water-quality problems.

Figure 3*C* illustrates the hydraulic relations when only the deep well is pumping, which is the most common situation except during the summer. A cone of depression develops in the piezometric surface of the Magothy aquifer, and the nearby ground-water flows radially inward toward the screen of the deep supply well. The diagram suggests that under present conditions (1968) virtually no measurable drawdown of the water table in the upper glacial aquifer is observed when the deep well is pumped at about 800 gpm. (See hydrograph of observation well S22606 at the Tenety Avenue station, fig. 4.)

Figure 3*D* illustrates the flow pattern during the summer when both shallow and deep wells are operating simultaneously. Cones of depression are developed both in the water table and in the piezometric surface of the Magothy aquifer. Most of the water entering the shallow supply well moves in laterally toward the well screen from the upper glacial aquifer, with only minor inflow from the upper part of the Magothy aquifer. The deep well apparently receives most of its water by lateral inflow from beds opposite the well screen, and minor contributions from beds above and below the screen zone.

The relationship of the flow patterns described above to the movement of contaminated water is discussed in more detail in the next section.

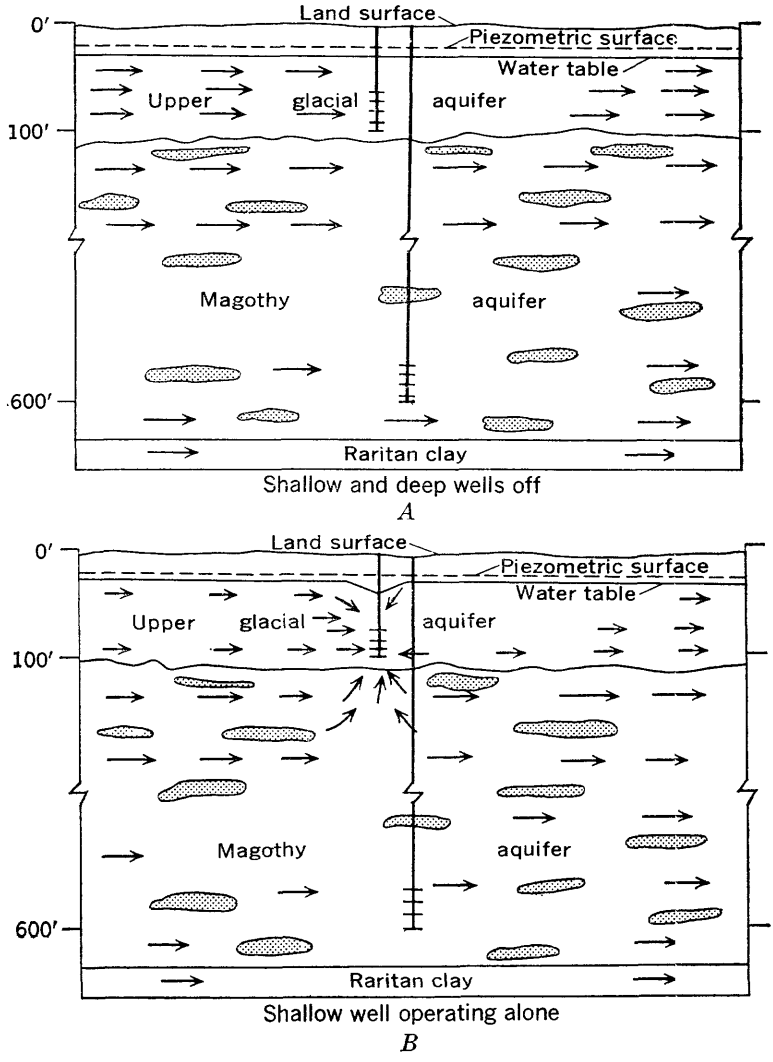
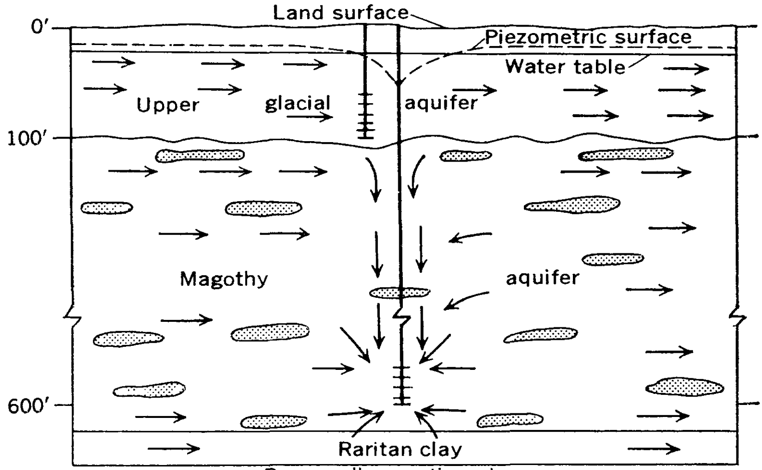
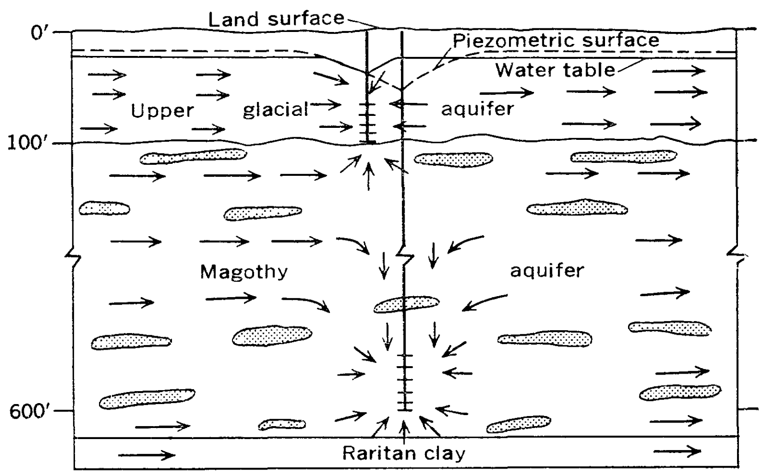


FIGURE 3.—Schematic flow patterns in the upper glacial and Magothy aquifers at a typical well field.



Deep well operating alone

C



Shallow and deep wells operating

D

EXPLANATION

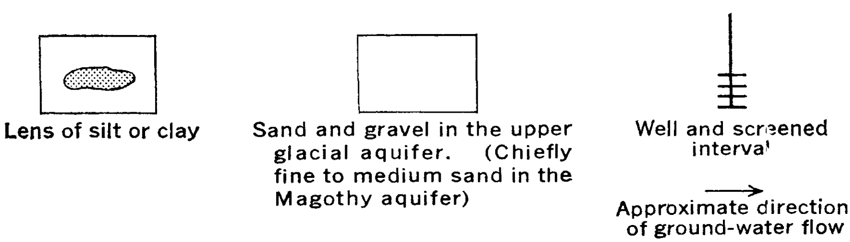


FIGURE 3.—Continued.

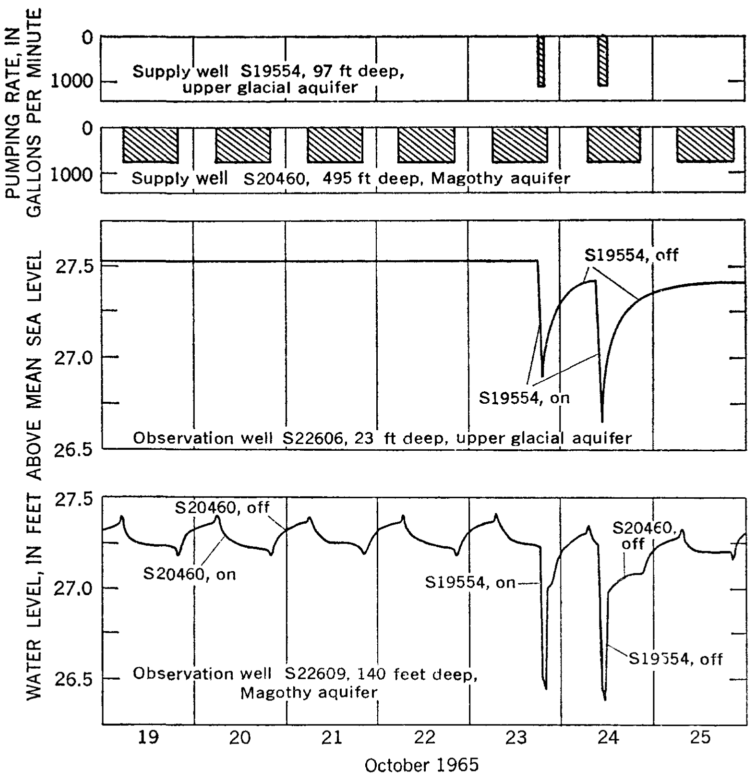


FIGURE 4.—Water-level fluctuations in observation wells caused by pumping nearby shallow and deep supply wells, Tenety Avenue station.

CONTAMINATION OF THE GROUND WATER

GENERAL COMPARISON OF THE QUALITY OF SHALLOW AND DEEP GROUND WATER

The comparative quality of the shallow and deep ground water is indicated by the analyses listed in table 3. In using these results it should be kept in mind that the chemical composition of the water is a transient or changeable characteristic, and this is particularly true of the shallow ground water. The concentrations of dissolved substances in such water can vary from day to day or from season to season, and some constituents may have a distinctive trend over longer periods, depending upon a variety of factors discussed in the next section. It is important to note also that waters from the observation wells were collected from screen zones only 3 feet long and probably represent relatively accurate point samples of the aquifer water. In contrast,

Table 3.—*Partial chemical analyses, in milligrams per liter, of ground water from observation and supply wells*

Well: WRC, New York Water Resources Commission.
SCWA, Suffolk County Water Authority.
Aquifer: ug, upper glacial aquifer; M, Magothy aquifer.

Use: O, observation well; S, supply well.
MBAS: Methylene blue active substances.
Analyst: SCWA, Suffolk County Water Authority;
NCDH, Nassau County Department of Health.

Well WRC	Well SCWA	Date of collection	Depth below land surface (feet)	Aquifer	Use	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Specific conductance (micromhos at 25° C)	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	MBAS	pH	Analyst
Tenety Avenue station														
S22606		Sept. 11, 1968	23	ug	O	57	22	218	370	60		0.02		NCDH
S22607		Sept. 6, 1968	67	ug	O	28	30	142	245	46	12	.21	6.1	NCDH
S22608		Sept. 11, 1968	87	ug	O	19	14		170	42	6	.11	4.7	NCDH
S19554	1	Sept. 16, 1968	97	ug	S	30	13	120	225	50	22	.81	6.0	SCWA
S22609		do	140	M	O	12	<.02		110	40	28	<.02	6.1	SCWA
S20460	2	Aug. 2, 1968	495	M	S	4	<.02			0	8	<.02	5.4	SCWA
		Oct. 15, 1965	495	M	S			22						SCWA
August Road station														
S24724		Aug. 15, 1968	15	ug	O	24	16		340	86	60	.69	6.4	SCWA
		July 20, 1965	15	ug	O	20						4.6		SCWA
S24725		Aug. 15, 1968	38	ug	O	20	12		255	54	34	1.3	5.9	SCWA
S12710	1	Aug. 16, 1968	66	ug	S	20	11	168	225	54	38	1.2	6.2	SCWA
S24726		Aug. 15, 1968	77	ug	O	13	8		110	36	24	.48	6.0	SCWA
S20635	3	Aug. 11, 1968	627	M	S	6	<.02			6	20	<.02	5.4	SCWA
		Oct. 7, 1965	627	M	S			34						
Sawyer Avenue station														
S24718		Aug. 15, 1968	12	ug	O	13	4.3		138	28	12	.17	5.6	SCWA
S24719		Sept. 14, 1968	15	ug	O	31	18	167	275	70	18	.10	6.3	NCDH
S24720		do	44	ug	O	44	20	217	375			.44	6.5	NCDH
S24721		do	67	ug	O	18	25	124	158	42	16	.20	5.7	NCDH
S24722		do	72	ug	O	10	21	88	110	30	13	<.02	6.7	NCDH
S24723		Oct. 6, 1965	82	ug	O	8	14	76		14	10	<.02	5.7	SCWA
S15505	1	May 9, 1968	78	ug	S	27	7.5		200			.65	6.3	SCWA
S18003	2	Aug. 3, 1968	670	M	S	3	<.02			0	20	<.02	5.2	SCWA
		Oct. 15, 1965	670	M	S			22						SCWA

samples from the supply wells represent a mixture of waters of slightly or moderately different quality from zones about 30 to 60 feet thick opposite the well screens.

In general, the dissolved-solids content of the ground water decreases from about 100 to 200 mg/l in the upper glacial aquifer to less than 40 mg/l in the lower part of the Magothy aquifer. The range in dissolved-solids content of water in the upper glacial aquifer, which is indicated also by the range in specific conductance (table 3 and fig. 5), suggests that the upper glacial aquifer is mildly polluted compared to uncontaminated water in the Magothy aquifer. Among the contaminants, only the detergent and chloride content are discussed in greater detail.

VERTICAL DISTRIBUTION AND TRENDS IN CONCENTRATION OF MBAS

OBSERVATION WELLS

MBAS is distributed virtually throughout the entire saturated thickness of the upper glacial aquifer at the three well fields as shown by the concentration graphs (pl. 2) for observation wells 12 to 87 feet deep. These graphs show concentrations of MBAS which ranged from less than 0.02 to nearly 5 mg/l. The greatest concentrations were generally observed in the middle to upper part of the aquifer. The highest concentration of MBAS was observed at a depth of 15 feet in well S24724 at the August Road station (table 3 and pl. 2) in 1965. Significant concentrations of MBAS were also observed at depths as great as 87 feet, near the bottom of the upper glacial aquifer at the Sawyer Avenue station (well S22608, pl. 2). Annual variations in MBAS ranged from a few tenths to as much as 4 mg/l. The smallest annual range in MBAS concentration was generally observed in water from the deepest observation wells.

Slight to moderate upward trends in MBAS content were observed at about half the observation wells from 1961 to 1966 (pl. 2), but since then the concentrations have declined to lower levels or have fluctuated within a relatively small range. In 1968, water from one observation well, S24725 at the August Road station, contained about 1 to 2 mg/l of MBAS, which was significantly higher than the limit recommended for drinking water. The same well had the largest net change in MBAS from 1961 to 1968 (fig. 5), which probably reflected increased discharge of sewage from new homes constructed upgradient from the well field.

At observation well S22609, screened in the upper part of the Magothy aquifer at the Tenety Avenue station, the MBAS content of the water ranged from less than 0.02 to about 0.2 mg/l (pl. 2). Samples

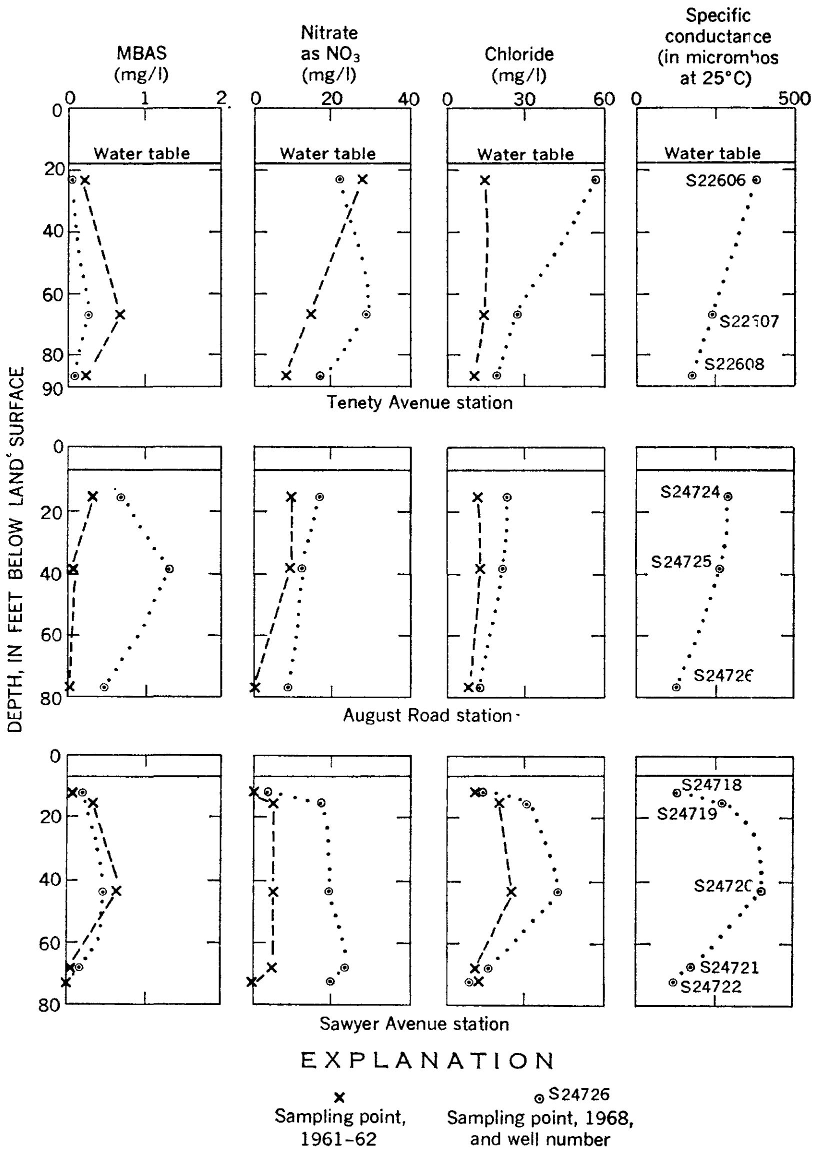


FIGURE 5.—Vertical distribution of selected contaminants, 1961 and 1968, and specific conductance of the water in the upper glacial aquifer, 1968.

collected from that well intermittently from 1966 to 1968, however, contained less than 0.02 mg/l; a concentration which suggests little or no significant net downward movement of MBAS from the overlying upper glacial aquifer at that site.

A variety of factors acting independently or together are responsible for the short-term trends and other irregularities shown by the concentration graphs on plate 2. Among these are: (1) differences in concentration of MBAS moving along different flow lines in the upper glacial aquifer; (2) intermittent dilution of inflowing contaminated water by recharge of varying magnitude (for example, the large decrease in natural recharge during the drought of 1962–66 presumably resulted in less dilution of the contaminated water derived from cesspools and septic tanks); (3) seasonal pumping of shallow supply wells which disturbed the normal distribution pattern of the contaminants in the ground water at and near the well fields; and (4) possibly small seasonal variations in the volume and composition of the sewage effluent that percolates into the ground water upgradient from the well fields, and ultimately moves southward beneath the well fields.

PUBLIC-SUPPLY WELLS

Concentrations of MBAS and chloride in water from the shallow public-supply wells are listed in table 4. MBAS concentrations determined from 1959 to 1968 ranged from about 0.1 to about 1.3 mg/1. The highest concentrations were observed at the August Road station and the lowest were observed at the Sawyer Avenue station. Peak concentrations of MBAS commonly were observed during and shortly after periods of heavy pumping from the upper glacial aquifer in the summer and early fall.

A net upward trend in MBAS concentrations was indicated by the results of analyses of samples from the shallow public-supply well (S12710) at the August Road station where the MBAS content has increased about three to four times from 1959 to 1968 (table 4). A slight upward trend is also indicated by the results for shallow supply well S19554 at the Tenety Avenue station. The relatively low concentrations of MBAS reported at times for supply well S15505 at the Sawyer Avenue station suggest the possibility that some of the samples may have represented a mixture of shallow and deep waters at that station. No MBAS was detected in water from any of the deep public-supply wells, which have been in service since about 1959. Water supplied from the well fields investigated never contains MBAS in excess of drinking water standards, owing to mixing of the water from shallow and deep wells prior to distribution.

CHLORIDE AND OTHER MINOR CONTAMINANTS

Chloride is commonly associated with MBAS in ground water contaminated by sewage, but abnormally high concentrations of chloride may also result from infiltration of dissolved deicing salts applied

TABLE 4.—*MBAS and chloride concentrations, in milligrams per liter, in water from selected public-supply wells screened in the upper glacial aquifer, 1959–68*

[Analyses by Suffolk County Water Authority]

TENETY AVENUE STATION

Well S19554

Date	MBAS	Chloride	Date	MBAS	Chloride
1962			*1966*		
May 18	0.83	-----------	Jan. 3	0.67	18
21	.68	-----------	19	.46	17
June 27	.59	12	Mar. 7	.78	-----------
July 3	.42	-----------	Apr. 4	.45	35
Sept. 5	.47	10	June 6	.67	-----------
			Aug. 3	.71	-----------
1963			Dec. 5	.50	-----------
June 5	.39	-----------			
26	.32	-----------	*1967*		
July 3	.70	-----------	Jan. 22	.76	18
30	.43	-----------	Mar. 29	.81	-----------
Aug. 1	.52	-----------	Apr. 22	.78	20
1964			May 15	.58	-----------
June 25	.58	-----------	June 25	.48	-----------
July 27	.33	-----------	Aug. 30	.71	-----------
Aug. 23	.59	-----------	Sept. 2	.71	26
Oct.	-----------	8.5	Nov. 5	.91	-----------
Nov. 17	.26	-----------	Dec. 5	.29	-----------
1965			*1968*		
Jan. 1	.27	12	May 6	.86	28
Apr. 13	.43	-----------	June 4	.99	-----------
June 8	.50	-----------	Aug. 16	.81	50
July 5	.43	15			
Oct. 6	.55	15			

AUGUST ROAD STATION

Well S12710

Date	MBAS	Chloride	Date	MBAS	Chloride
1959			*1963*		
June 16	0.28	-----------	Feb. 20	0.49	-----------
			July 10	.29	-----------
1960			30	.36	-----------
Feb. 17	.26	-----------	Aug. 1	.20	-----------
Apr. 27	.31	-----------	15	.31	-----------
May 4	.33	-----------	Sept. 5	.47	10
June 1	.48	-----------	Oct. 3	.49	-----------
15	.34	-----------	Nov. 19	.46	-----------
			1964		
1961			Apr. 19	.28	-----------
Feb.	-----------	11	June 18	.36	14
Mar. 22	.32	-----------	July 21	.49	-----------
May 14	.49	10	*1965*		
25	.36	-----------	Jan.	-----------	15
July 12	.37	-----------	Apr. 19	.41	13
Aug.	-----------	25	June 6	.29	-----------
Nov.	-----------	14	July 4	.28	-----------
			Sept. 27	.61	16
1962			Oct. 3	.37	11
Jan.	-----------	9			
Mar.	-----------	6	*1966*		
May 14	.49	-----------	Jan. 6	.6	15
25	.36	11	Mar. 27	.52	----
June 20	.37	-----------	Apr. 3	1.1	18
July 5	.32	13	*1967*		
18	.33	-----------	Aug. 15	1	-----------
Aug. 1	.24	-----------			
29	.30	-----------	*1968*		
Sept. 26	.37	-----------	May 6	1.2	21
Oct. 24	.41	11	June 4	1.3	-----------
Nov. 7	.40	-----------	July 11	1.2	22
28	.38	-----------	Aug. 16	1.2	20

TABLE 4.—*MBAS and chloride concentrations, in milligrams per liter, in water from selected public-supply wells screened in the upper glacial aquifer*—Con.

SAWYER AVENUE STATION

Well S15505

Date	MBAS	Chloride
1959		
July 7	0.38	
Nov. 11	.30	
1960		
Jan. 20	.33	
Feb. 24	.65	
Mar. 3	.36	
Apr. 6	.36	
Dec. 28	.32	
1961		
Jan. 4	.32	
Feb		15
May		14
June 21	.36	
July 12	.28	
Aug. 12	.30	10
Sept. 6	.35	
Oct. 4	.22	
Nov. 22	.52	19
Dec. 13	.47	16
1962		
Jan. 3	.42	15
Mar		12
May	.66	14
June 14	.26	
July 18	.27	15
Aug. 22	.44	
Oct. 16	.22	12
Nov. 21	.17	
Dec. 13	.23	
26	.28	
1963		
Jan. 2	.28	14
10	.41	
22	.52	
Feb. 7	.25	
Mar. 27	.28	16
Apr. 10	.52	
24	.54	
May 15	.19	
June 12	.28	13
July 10	.33	
Aug. 1	.34	
Sept. 19	.25	14
Oct. 10	.46	
23	.20	
Nov. 14	.38	
Dec. 5	.46	
1964		
Mar		19
Apr. 9	.57	
June		16
July 28	.61	
Aug. 13	.44	
Sept.		17
Nov. 17	.19	
1965		
Jan. 1		6.5
Apr. 13	0.20	6
June 1	.16	
July 6	.47	17
Oct. 6	.40	6
1966		
Jan. 19	.14	6
Mar. 27	.81	
Apr. 5	.69	5
May 3	.36	
June 8	.31	
July 5	.67	22
Aug. 3	.71	
Oct. 5	.26	10
Nov. 11	.51	
Dec. 11	.52	
1967		
Jan. 10	.41	11
Feb. 15	.40	
Mar. 8	.14	
Apr. 5	.17	10
May 2	.18	
June 7	.45	
July 4	.52	10
Sept. 23	.10	
Oct. 11	.13	9
Nov. 7	.09	
Dec. 5	.10	
1968		
Jan. 2	.46	14
Feb. 7	.13	
Mar. 6	.09	
Apr. 3	.20	20
May 9	.65	28
June 5	.52	
July 3	.69	26
Aug. 7	.48	
Aug. 16	.69	24

to roads in the winter, and from leaching of salts from soils enriched by spreading fertilizers for agricultural or home-gardening purposes. Natural ground water in the area generally contains about 5 mg/l or less of chloride as suggested by results of analyses of uncontaminated water in the Magothy aquifer (table 3). The chloride content of the contaminated shallow ground water which ranged from about 10 to 80 mg/l in most of the observation wells (pl. 2) is most likely of composite origin. Concentrations of chloride generally decreased with depth below the water table. The maximum observed chloride content in the waters analyzed was substantially below the recommended limit of 250 mg/l in drinking water (U.S. Public Health Service, 1962, p. 7), consequently, chloride does not pose a problem to most consumers.

The difference in trend in chloride concentrations compared with that of MBAS (pl. 2), however, is of hydrologic interest. The small upward trend in chloride content observed at some observation wells prior to 1966 contrasts sharply with the relatively steep rise observed in 1967–68. The small rise in chloride content during the earlier years probably was due chiefly to slowly increasing contamination from infiltration of sewage during a period when dilution from natural recharge was below normal owing to drought conditions. In contrast, the peak concentrations of chloride observed in water from the observation wells in 1967 and 1968 were most likely due to infiltration of deicing salts applied to major roads upgradient from the well fields during winter snowstorms. Scattered determinations of the chloride content of water from the shallow public-supply wells (table 4) also show a slight upward trend since 1961, which reflects increasing contamination of the upper glacial aquifer, but the concentrations have remained below about 30 mg/l. The chloride content of water from the deep supply wells was less than 8 mg/l and showed no significant increase through 1968.

The nitrate content of the shallow ground water (table 3), which was chiefly derived from infiltration of sewage and fertilizers, did not exceed the recommended limit of 44 mg/l in drinking water (U.S. Public Health Service, 1962, p. 7) during the period of investigation. The graphs in figure 5 show, however, that the nitrate content of water from nearly all the shallow observation wells has increased since 1961. The highest concentration, 30 mg/l, was found in observation well S22607 at the Tenety Avenue station. Only trace concentrations of nitrate, generally less than 0.02 mg/l and probably of natural origin, were present in water from the deep public-supply wells in 1968.

Phosphate, which also may be derived from sewage and fertilizers, had a concentration of less than 0.1 mg/l in most of the water samples analyzed. The sanitary quality of the water from both the shallow and deep supply wells was excellent as indicated by the negative results for coliform bacteria reported periodically by the Suffolk County Water Authority.

POTENTIAL CONTAMINATION OF THE MAGOTHY AQUIFER

Possible contamination of the deep water-bearing zones of the Magothy aquifer, particularly by nitrates and MBAS, is a problem of great concern to water managers because that aquifer presently (1969) is the principal source of water for public supply in southwestern Suffolk County. Traces of MBAS and slightly higher than normal chloride content suggest that the upper part of the Magothy aquifer is slightly contaminated at the Tenety Avenue station (well S22609, pl. 1). Deeper zones in the Magothy aquifer, however, showed no significant evidence of contamination in 1968, according to the results of analyses of water from public-supply wells in southwestern Suffolk County (table 3).

Although no immediate threat exists, conceivably contamination of deep zones in the Magothy aquifer at the well fields investigated might occur in the future by two possible mechanisms: (1) Lateral inflow of deep contaminated water from upgradient sources, and (2) downward movement of contaminated water from the upper glacial aquifer at and near the well fields, under the influence of gradients caused by pumping the deep supply wells. Lateral inflow of contaminants is not likely to be a major factor for many years owing to the lack of significant contamination of deep zones in the Magothy aquifer in the recharge area upgradient from the well fields (fig. 2). Moreover, such contamination, even if present in that area now or in the future, would require many decades to reach the well fields investigated, owing to the slow regional rate of ground-water movement (probably about 1 ft per day or less). Natural dilution of the contaminants in transit also would tend to reduce the risk of movement of significant concentrations of contaminants downgradient.

Contamination of deep production zones in the Magothy aquifer in the report area by downward leakage of contaminants from the upper glacial would also be a slow process which is not likely to occur in the near future. Assuming no leakage due to defective well construction, the rate of downward leakage would depend chiefly on the hydraulic gradient and on the permeability of the aquifer materials in the vertical direction. Under present conditions, pumping the deep supply wells apparently causes little or no measurable drawdown of water levels in the upper glacial aquifer (fig. 4). Conceivably, heavy withdrawals from deep wells in the future might cause some steepening of the hydraulic gradient which might induce downward movement of contaminants.

The low vertical permeability of the Magothy aquifer and natural dilution, however, should deter rapid downward movement of significantly contaminated water. Indeed, chemical and hydraulic data for observation well S22609 at the Tenety Avenue station suggests that under present conditions pumping the shallow supply well tends to retard and possibly reverse downward movement of contaminated water which may be induced by pumping the deep well at that station.

Although the full impact of proposed public-sewer construction on water levels and the pattern of ground-water movement in southwestern Suffolk County cannot be predicted with certainty, sewering should help improve the quality of the water in the upper glacial aquifer and perhaps restore it to fuller use than at present. Such improvement in quality in the shallow ground water should indirectly benefit the quality of water in the Magothy aquifer which receives its recharge from the upper glacial aquifer.

CONCLUSIONS

1. Detergent contamination was found throughout virtually the entire saturated thickness of the upper glacial aquifer in the area investigated.
2. Samples from small-diameter observation wells showed that the highest concentrations of MBAS were in the upper and middle parts of the upper glacial aquifer. A maximum concentration of about 5 mg/l was determined in an observation well (15 ft deep) at the August Road station in 1965.
3. Concentrations of MBAS, which had increased at many observation wells from about 1961 to 1966, apparently nearly stabilized or declined in the period 1967–68, possibly reflecting increased dilution of the ground water following a period of drought from 1962 to 1966.
4. The MBAS content of samples pumped from shallow public-supply wells screened in the upper glacial aquifer ranged from about 0.1 mg/l to about 1.3 mg/l. The highest concentration of MBAS was found in a sample from a public-supply well at the August Road station in 1968. Results of analyses of samples from the shallow public-supply wells at two of the three well fields investigated suggest an upward trend in MBAS concentrations.
5. A trace of MBAS was found intermittently in samples from an observation well screened in the uppermost part of the Magothy aquifer at one well field, but none was found in underlying deep water-bearing zones tapped by public-supply wells.
6. Above-normal chloride and nitrate concentrations were also found in the upper glacial aquifer, but the concentrations were substantially below the limits recommended for drinking water. The results through 1968 suggest an upward trend in these contaminants.

7. Significant contamination of the deep water-bearing zones in the Magothy aquifer at the three well fields investigated seems unlikely for many years under present hydrologic conditions. However, large declines in water levels in the future due to prolonged heavy pumping could produce hydraulic gradients which might induce downward movement of contaminants at rates faster than those estimated from present conditions.
8. Construction of public sewers should help improve the quality of ground water in the upper glacial aquifer and, thus, indirectly benefit and preserve the excellent quality of water in the underlying Magothy aquifer.

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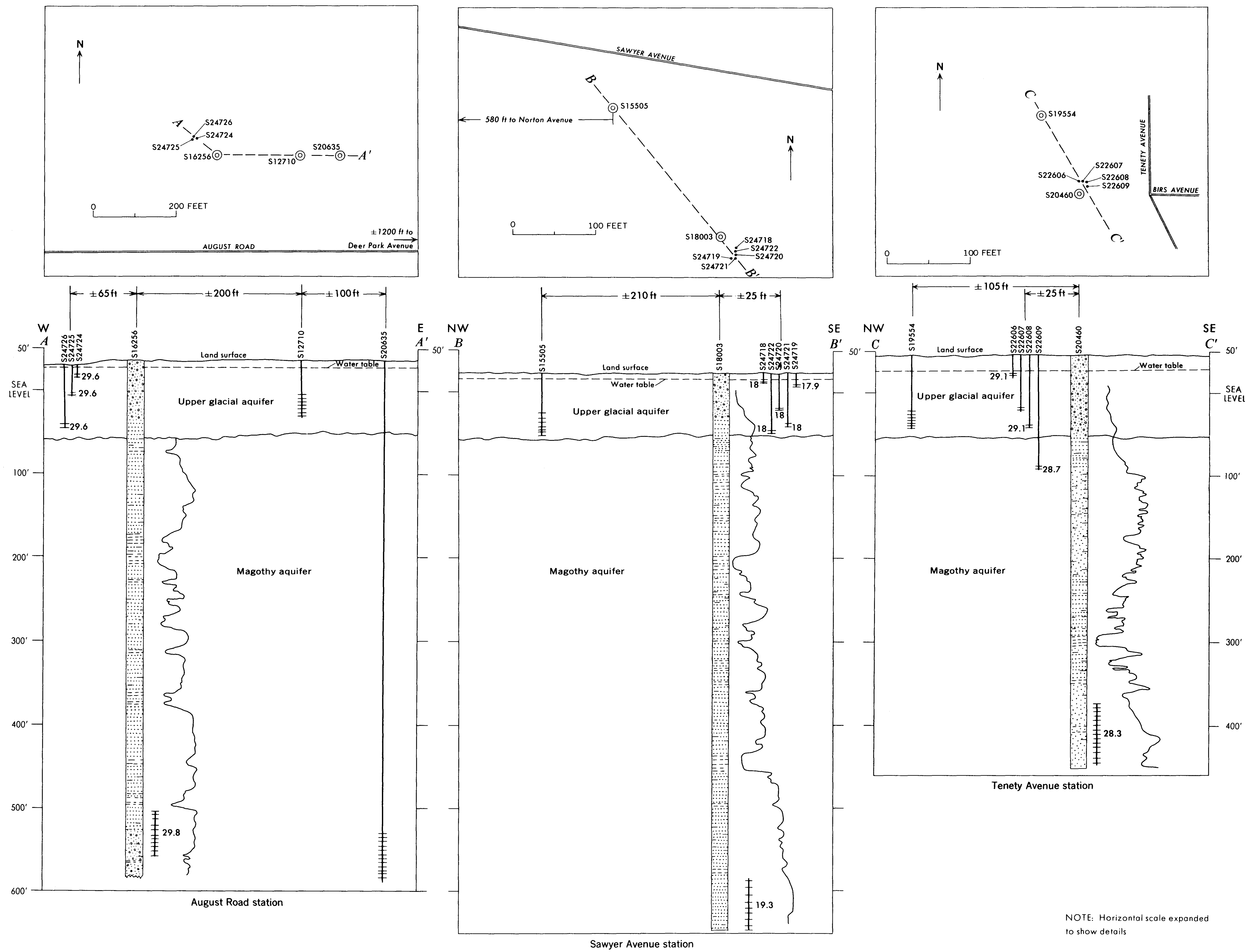
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
SUFFOLK COUNTY BOARD OF SUPERVISORS
AND THE
SUFFOLK COUNTY WATER AUTHORITY

WATER-SUPPLY PAPER 2001-B
PLATE 1



EXPLANATION

MAPS

S15505
Supply well and number

S24719
Observation well and number

SECTIONS

Gravel

Sand

Silt, sandy clay, clayey sand

Clay

29.1
Well and screened interval
Number is head, in feet above mean sea level, in observation wells, November 1967, and in supply wells, February 1968

Electrical resistivity curve

DIAGRAMS SHOWING HYDROGEOLOGIC RELATIONS AT THREE WELL FIELDS IN SOUTHWESTERN SUFFOLK COUNTY, LONG ISLAND, NEW YORK

371-857 O - 70 (In pocket) No. 1

UNITED STATES DEPARTMENT OF THE INTERIOR
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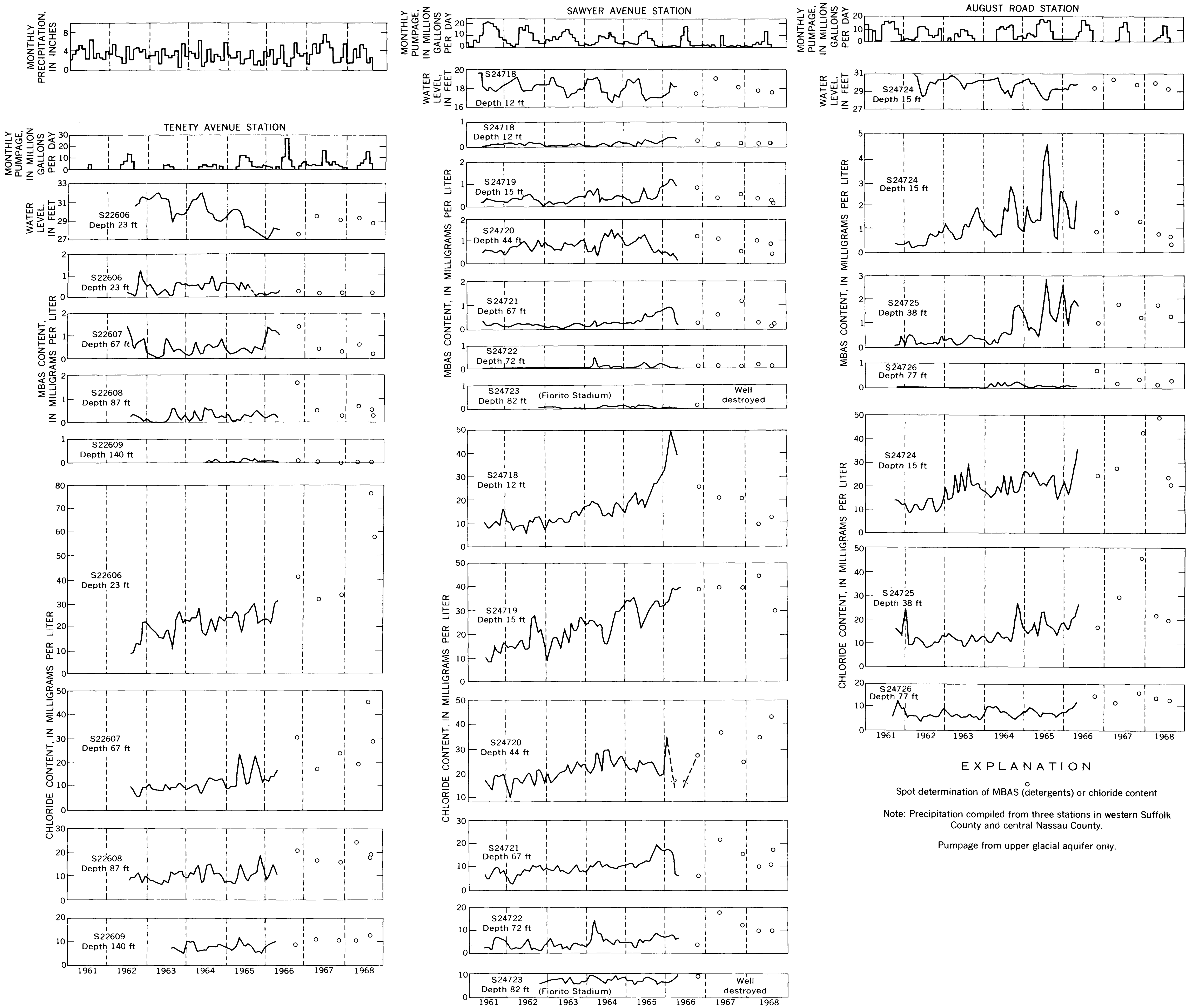
WATER-SUPPLY PAPER 2001-B
PLATE 2



EXPLANATION

o
Spot determination of MBAS (detergents) or chloride content

Note: Precipitation compiled from three stations in western Suffolk County and central Nassau County.

Pumpage from upper glacial aquifer only.

GRAPHS SHOWING CHANGES IN PRECIPITATION, PUMPAGE, WATER LEVELS, MBAS, AND CHLORIDE CONTENT OF GROUND WATER IN OBSERVATION WELLS, 1961–68, SOUTHWESTERN SUFFOLK COUNTY, LONG ISLAND, NEW YORK

371-857 O - 70 (In pocket) No. 2