9/21/76

NOTE

The terminology "proposed sewer" or "proposed sewerage projects" in this and sequel reports (Reports II and III) refers only to areas in which sewers are currently under construction or to areas tentatively delineated for future sewer construction. The dates given each delineated area are estimated times for commencement and completion of ongoing or tentative sewer projects. In these reports, the inclusion or exclusion of artificial recharge within these delineated boundaries is intended only for regional evaluation of various alternatives. It is not meant to reflect the local agency's plan for sewerage facilities.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ANALOG-MODEL ANALYSIS OF EFFECT OF WASTE-WATER MANAGEMENT ON THE GROUND-WATER RESERVOIR IN NASSAU AND SUFFOLK COUNTIES, NEW YORK

REPORT I: PROPOSED AND CURRENT SEWERAGE

cat cat
By Grant E. Kimmel and Arlen W. Harbaugh

Open-File Report 76-441

This document was prepared by the U.S. Geological Survey under a contract with the Nassau-Suffolk Regional Planning Board pursuant to Section 208, Federal Water Pollution Control Act Amendments of 1972 (PL92-500). This Project has been financed in part with Federal Funds from the United States Environmental Protection Agency under grant number P002103-01-0. The contents do not necessarily reflect the views and policies of the United States Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Mineola, New York

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

Computer printouts of the Mineola electric analog model show head changes in metres; contours plotted on maps in this report are in metres; and discussion of these data in text are also in metres. All other data are reported in English units.

SI[1/] units	Multiply by	To obtain English units
metres (m)	3.281	feet (ft)

English units	Multiply by	To obtain SI[1/] units
feet (ft)	.3048	metres (m)
gallons (gal)	3.785	litres (l)
million gallons per day (Mgal/d)	.04381	cubic metres per second (m^3/s)

1/ International system units

ANALOG-MODEL ANALYSIS OF EFFECT OF WASTE-WATER MANAGEMENT ON THE GROUND-WATER RESERVOIR IN NASSAU AND SUFFOLK COUNTIES, NEW YORK

REPORT I: PROPOSED AND CURRENT SEWERAGE

by

Grant E. Kimmel and Arlen W. Harbaugh

ABSTRACT

By 1995, the water table may fall by as much as 5 metres (16 feet) in east-central Nassau County and as much as 1.8 metres (6 feet) in central Suffolk County as a result of proposed sewerage programs. Similar, but generally slightly less, change may occur in the potentiometric head in the Magothy aquifer. Streamflow may decrease by as much as 55 percent in streams draining from Nassau County Sewage Disposal District 3 and as much as 56 percent in streams draining from the Huntington-Northport Sewer District.

INTRODUCTION

Long Island is underlain by a ground-water reservoir that is extensively developed for public water supply and is, therefore, of considerable economic importance. Urbanization, which is spreading eastward from New York City on the western end of the island, has resulted in contamination of the ground-water reservoir by effluent from septic tanks and cesspools. Area-wide sewerage (removal and disposal of sewage), especially in densely populated areas, has been and is being used to combat this contamination problem, but because of this, large volumes of sewage, previously collected in cesspools and septic tanks, are now, or could be shunted through disposal plants to tidewater. Unless a comparable program for recharge of the ground-water reservoir is undertaken, once the proposed sewers are installed water levels in the ground-water reservoir will fall and streamflow will decrease.

The Long Island hydrologic system has been described by Cohen and others (1968). Basically, Long Island's ground-water system is made up of three major aquifers--upper glacial, Magothy, and Lloyd--and two confining units--Gardiners Clay and Raritan clay. The upper glacial is the uppermost aquifer. It has a high hydraulic conductivity and generally is somewhat less than 100 ft thick. Underlying the upper glacial aquifer is the Magothy aquifer, which has a moderate to high hydraulic conductivity, and whose approximate thickness varies from zero at some north shore locations to 1,000 ft along the south shore. The Lloyd aquifer and Raritan clay, the deepest aquifer and confining units on Long Island, are not incorporated in the analog model used in this study.

The Gardiners Clay, and other clay beds or confining units at and near the same stratigraphic position, lie between the upper glacial and Magothy aquifers. These confining units occur along the south shore and occasionally along the north shore of the island. The confining units play an important role in the hydrology of areas in which they occur by restricting flow between the upper glacial and Magothy aquifers.

Estimates of the effect of island-wide sewerage on the hydrology of Long Island are necessary for the planning of water management alternatives and for the evaluation of environmental impact caused by changes in the hydrologic system. For this reason, an evaluation of the effects of projected sewer programs on the ground-water hydrology of Nassau and Suffolk Counties was undertaken under provisions of Section 208 of the Federal Water Pollution Control Act (Public Law 92-500, 1972). An analysis of the sewerage problem in southeast Nassau and southwest Suffolk Counties was made in a previous study (Kimmel and Harbaugh, 1975) but that study did not treat propulation, withdrawal of ground water, or recharge with treated sewage in as great a detail as the present report.

In the present study the effects of population, public-supply pumping, and sewer programs on the ground-water head in the upper glacial and Magothy aquifers were evaluated on an electric analog model of the main part of Long Island's ground-water reservoir. The purpose of this report is to describe the changes in model head and in streamflow that resulted from simulation of furture proposed sewerage throughout Nassau and Suffolk Counties from 1975 to 1995. Less extensive sewerage and local recharge of the sewered water will, of course, reduce the stress on the ground water system and lessen the effect on water levels and streamflow. A second report will describe the effect of recharging treated wastewater on the ground-water reservoir and a third report will describe the effect of reduction and redistribution of withdrawals on the ground-water reservoir.

DESCRIPTION OF ANALOG MODEL

The model used in this study is a three-dimensional, 5-layer electric analog model that simulated the hydrogeology of the ground-water system down to the base of the Magothy aquifer (Getzen, 1975). All of Long Island is included in the model except for the eastern forks. The upper glacial aquifer is modeled as layers one and two, and the Magothy aquifer as layers three, four, and five. Flow through and around confining beds between the upper glqcial and Magothy aquifers is modeled by increasing the electrical resistance between layers two and three. This confining unit (mostly the Gardiners Clay) occurs in the prototype[1/] along the south shore and in the east-central part of the

---

Footnote (next page) near here.

[1/] The extent of the modeled confining unit is shown in Getzen (1975, fig. 8).

Only regional water-level changes can be predicted because the model is insensitive to changes in hydraulic head that occur over less than half the interval between nodes (3,000 ft or 915 m). The results do not indicate accurately the responses of the ground-water system at specific sites but, rather, the regional effect of stresses. Sensitivity tests with the model show that the ground-water system approaches steady state relatively rapidly after it is stressed, generally within 3 to 5 years. Accordingly, the analog model results are of a regional nature and should be interpreted as such.

Footnote.--The word "prototype" in this report refers to the real Long Island hydrologic system, as opposed to that in the model.

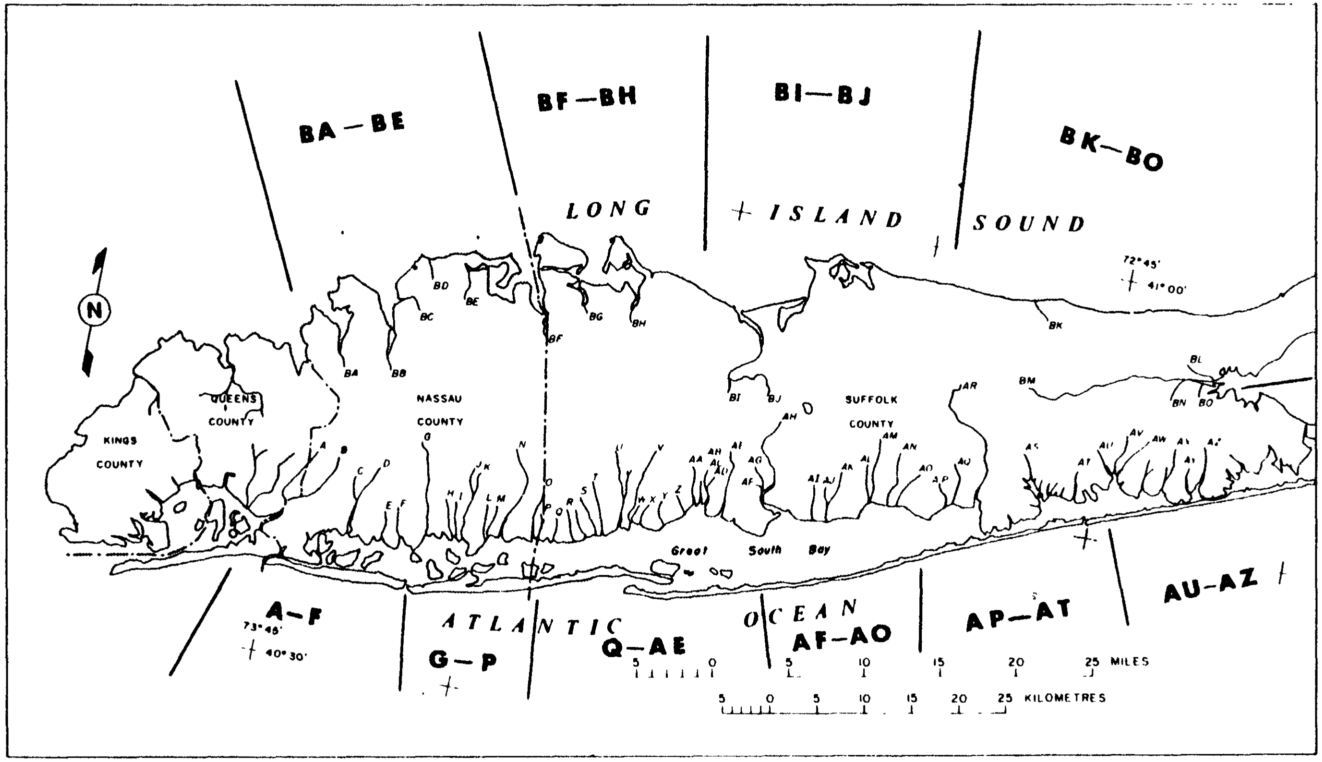
Long Island streams incorporated in the model are shown in figure 1,

---

Figure 1 (on next page)

---

and stream names are given in table 1. Modifications of streamflow in the initial model (Getzen, 1975) have improved the simulation of prototype streamflow (A. W. Harbaugh and R. T. Getzen, written commun., 1975). These streams are modeled strictly as gaining streams with flow proportional to elevation of the water table above the streambed. Current is cut off from stream nodes when the simulated ground-water level drops below the streambed at that node.



Base from U.S. Geological Survey
1:250,000 series: Hartford, 1962;
New York, 1957; Newark, 1947

Figure 1.--Stream groups and letter code for streams on Long Island used in the analog model. The presence or absence of planned or constructed sewers is as follows: A-F, NassauCounty Sewage Disposal District 2; G-P, Nassau County Sewage Disposal District 3; Q-AE, Suffolk County Southwest Sewer District; AF-AO, Suffolk County South Central Sewer District; AP-AT, Suffolk County Sewer District 3; AU-AZ, BI-BJ, and BK-BO except part of BM, no sewerage; BF-BH, Huntington-Northport District;BA-BE, sewerage not planned before 1995 except in local communities where it is already in effect.

Table 1.--Stream code for figure 1

Code	Stream name
B	Valley Stream
C	Pines Brook
D	South Pond
E	Parsonage Creek
F	Milburn Creek
G	East Meadow Brook
H	Cedar Swamp Creek
I	Newbridge Creek
J	Bellmore Creek
L	Seamans Creek
M	Seaford Creek
N	Massapequa Creek
O	Carman Creek
P	Amityville Creek
Q	Great Neck Creek
R	Strongs Creek
S	Neguntatogue Creek
T	Santapogue Creek
U	Carlls River
V	Sampawams Creek
W	Shookwams Creek
X	Willets Creek
Y	Trues Creek
Z	Cascade Creek
AA	Penataquit Creek
AB	Awixa Creek
AC	Orowoc Creek
AD	Pardees Pond
AE	Champlin Creek
AF	West Brook
AG	Rattlesnake Brook
AH	Connetquot River
AI	Green Creek
AJ	Brown Creek (west)
AK	Brown Creek (east)
AL	Tut Hills Creek
AM	Patchogue Creek
AN	Swan River
AO	Mud Creek
AP	Motts Brook
AQ	Beaverdam Creek
AR	Carmans River
AS	Forge River
AT	Terrel River
AU	Little Seatuck
AV	Seatuck Creek
AW	East River
AX	Beaverdam Creek
AY	Aspatuck Creek
AZ	Quantuck Creek
BA	Whitney Lake
BB	Roslyn Brook
BC	Glen Cove Creek
BD	Island Swamp Brook
BE	Mill Neck Creek
BF	Cold Spring Brook
BG	Mill Creek
BH	Stony Hollow Run
BJ	NE Nissequogue
BK	Wading River
BL	Saw Mill Creek
BM	Peconic River
BN	Little River
BO	White Brook

Because of the wide spacing of nodes, streams cannot be considered individually or in great detail. The close spacing of some streams requires assigning a few streams to a single node or a series of nodes in the model. For example, flow in streams I, J, and K (fig. 1) reads out as one stream in the model. Moreover, gaging stations from which streamflow data are obtained are above tidewater, whereas total streamflow in the model is measured at the mouth of the stream. Gain in streamflow between gaging station and mouth was estimated by Getzen (1975) and is incorporated in the model by adjusting model streamflow to correspond to average annual streamflows measured at gaging stations plus the estimated gain in streamflow from the gage to the mouth of the stream. Stream discharge used in this study is the 1940-65 average (Getsen, 1975, table 2) except for south-shore streams west of stream H (fig. 1), whose discharge is the 1967-75 average. This was done in order to include the effect of sewerage in Nassau County Sewage Disposal District 2, which was sewered by 1964. Because the hydrologic system's period of response to stress is only 3 to 5 years, sewerage in this district will have little further effect on the hydrologic system.

The model shows changes in hydraulic head, through time, resulting from the input stress. The diversion of cesspool and septic tank effluent to sewer systems reduces ground-water recharge; increased withdrawals due to sewerage and to increased ground-water pumpage decrease head.

MODELING PROCEDURE

The effect of sewerage on the ground-water system was determined on the basis of assumptions concerning the use of water and the degree of sewerage that is to take place. The time period modeled is the 20 years between 1975 and 1995. Changes that are presently taking place in the ground-water system in response to previous pumping were ignored because the system response is quick, and therefore, errors due to neglecting pumpage before 1975 are small.

The current (1976) and the maximum extent of proposed sewerage estimated by the year 2000 was obtained from the Nassau County Department of Public Works and the Suffolk County Department of Environmental Control. Areas and dates of proposed sewer construction through year 2000 are shown in figure 2. The model areas were delineated by combining

---

Figure 2 (in pocket) belongs near here.

---

areas of estimated withdrawal and proposed sewerage into common areas that could be treated uniformly (fig. 3). The quantities used for

---

Figure 3 (in pocket) belongs near here.

---

withdrawal and recharge in these areas are given in table 2.

The study area includes all of Suffolk and Nassau Counties. The entire study area was examined for changes in the quantity of recharge and withdrawal. If net difference between quantity of recharge and quantity of withdrawal was determined to be insignificant, it was not included in the model stress. Because estimated changes in sewerage in northern Nassau County are relatively small, as are projected changes in population throughout Nassau County, it was not necessary to model the hydrologic stress in western or northern Nassau County. Southwestern Nassau County was sewered before 1964 (Nassau County Sewer District 2, fig. 2); therefore, further changee in the hydrology by sewerage in this district will probably be small.

Population growth between 1970 and 2000 was estimated by the Nassau-Suffolk Regional Planning Board, and this was the basis for determining future water needs. In the area modeled, population in water districts or water-supply areas is expected to decrease by 22,300 persons in Nassau County and increase by 724,200 persons in Suffolk County by the year 2000 (table 2). Present per capita usage in the various water service areas ranges from 67 to 425 gal/d (254 to 1610 l/d). For most of Suffolk County, evaluation of present pumpage and population does not yield a plausible per capita usage when compared with water districts in Nassau County for which more accurate data are available. This may be because many home sites in Suffolk County have wells that supplement or supply water in areas delineated as service areas. For this reason, per capita water use in Suffolk County was estimated to be 100 gal/d (380 l/d) for most entries in table 2. The total modeled change in withdrawal by 1995 is 9.54 Mgal/d (.418 m^3/s) in Nassau County and 46.42 Mgal/d (2.034 m^3/s) in Suffolk County. The total modeled decrease in recharge by 1995 is 39.9 Mgal/d (1.75 m^3/s) and 42.67 Mgal/d (1.869 m^3/s) in Nassau and Suffolk Counties, respectively.

Table 2.--Values used in stressing analog model.

Area on figure 3	Change in population 1970-2000	Per capita demand for water (gal/d)	Change in recharge 1975-1995 (Mgal/d)	Change in withdrawal 1975-1995 (Mgal/d)
Nassau County				
1	-11,500	80	-11.77	3.43
2	-1,900	84	-3.11	.786
3	1,700	94	-.68	.30
4	-2,600	106	-2.49	.41
5	-2,200	105	-3.93	.992
6	-4,300	101	-3.95	.65
7	-3,800	120	-3.76	.52
8	-2,300	122	-5.05	1.26
9	-4,800	112	-3.56	.42
10	9,400	156	-1.56	.77
Total (Nassau)	-22,300	--	-39.9	9.54
Suffolk County				
1	11,100	110	-1.96	1.00
2	34,600	95	1.02	1.98
3	23,400	100	.61	1.57
4	2,700	100	-.25	.18
5	30,200	100	-1.71	2.20
6	8,300	100	No significant change	
7	1,200	100	No significant change	
8	245,300	100	0	1/ 8.85

(cont'd)

Table 2. (continued)--Values used in stressing analog model

Area on figure 3	Change in population 1970-2000	Per capita demand for water (gal/d)	Change in recharge 1975-1995 (Mgal/d)	Change in withdrawal 1975-1995 (Mgal/d)
Suffolk County (Cont'd.)				
9	19,600		no significant change	
10	4,600	100	-.006	[1/] .32
11	29,400	100	-.12	[1/] .40
12	31,000	100	-.0-	[1/] 2.6
13	17,000	100	-.44	[1/] 1.03
14	78,700	100	-4.70	5.91
15	51,600	100	-2.73	4.32
16	4,100		no significant change	
17	30,300	100	-9.69	4.55
18	-3,600	100	-1.08	.0
19	8,500	100	-1.63	1.01
20	52,000	75	-11.00	5.52
21	1,600	425	-1.19	.80
22	11,000	112	-2.71	1.46
23	7,100	118	-1.50	.55
24	5,500	104	-1.82	.89
25	7,300	67	-1.60	.76
26	3,700	114	-.14	[1/] .10
27	8,000	100	-.0-	[1/] .42
Total (Suffolk)	724,200	----	-42.67	46.42

[1/] Withdrawal taken from layer 2 on model

Calculations of changes in population, withdrawal, and recharge use the following symbols:

C = per capita demand (gal/d)

P_o = population in 1970

P = population at any time between 1970 and 2000

ΔP = population change

Q = withdrawal (Mgal/d)

Q_o = withdrawal in 1970 (Mgal/d) = CP_o

ΔQ = Change in withdrawal (Mgal/d)

R = recharge at any time (Mgal/d)

R_o = recharge in 1970 (Mgal/d)

ΔR = change in recharge (Mgal/d)

a = percent increase in water consumption after sewerage

r = percentage of withdrawal used for lawn sprinkling and other outdoor use that recharges ground water

s = percentage of withdrawal used for lawn sprinkling and other outdoor use

The rate of removal of water from the ground-water system is calculated by assuming that the changes in population from 1970 to 2000 are linear. The population change at any time from 1970 to 2000 is:

$$\Delta P = P - P_o \qquad (1)$$

Data on water use (Linaweaver and others, 1967) show that in metered areas, water consumption increases 20 percent after sewerage. In the calculations, this increase due to sewerage was applied from the time that sewerage began in a given area (fig. 2). If the percent increase is a, then for any time after sewerage began and before year 2000,

$$Q = (a + 1)[C\ (P_o + \Delta P)]$$

$$\Delta Q = Q - Q_o$$

$$= (a + 1)\ [C\ (P_o + \Delta P)] - CP_o$$

$$= aCP_o + (a + 1)\ C\Delta P$$

$$= aQ_o + (a + 1)\ C\Delta P$$

Using 20 percent for increased consumption, the equation used to calculate model stress due to withdrawal after sewerage is:

$$\Delta Q = 0.2\ Q_o + 1.2\ C\Delta P \qquad (2)$$

In Nassau County and most of Suffolk County, this stress was applied to layer 4 of the analog model, which is equivalent to about the middle of the Magothy aquifer. Although some water for public supply is withdrawn from the upper glacial aquifer (layers 1 and 2) in central and western Suffolk County, there is a trend toward deeper wells as the quality of water in the upper glacial aquifer becomes affected by contaminants already present in the system; therefore, it seems reasonable to simulate future withdrawals from the prototype by modeling future pumpage from layer 4. In eastern Suffolk County, however, withdrawals were modeled from layer 1 (upper glacial aquifer) exclusively.

Water is discharged through septic tanks and cesspools into the ground after use in unsewered areas. The amount of waste water discharged in this manner, however, is not equal to the amount of public-supply pumpage. Presumably, some of this pumpage is used in sprinkling of lawns and (or) other irrigation and for other outdoor uses such as car washing. The New York State Department of Environmental Conservation (D. J. Larkin, written commun., 1974) estimates that 20 percent of the public water-supply pumpage is used for these purposes. Of this amount, perhaps only 20 percent finds its way back to the ground-water system.

Utilizing these two factors, before sewerage artificial recharge (R) to ground water is defined as:

$$R = (1 - s)\ Q + rsQ$$

A change in recharge before sewerage begins is caused by changes in population ($C\Delta P = Q - Q_o$).

$$\Delta R = R - R_o$$

$$R = (1 - s)\ Q + rsQ$$

$$\Delta R = (Q - Q_o)\ (1 - s + rs)$$

From the percentages given above,

$$\Delta R + 0.84\ \Delta Q \qquad (3)$$

After sewerage, that portion of the ground water previously derived from septic tanks $[(1 - s)Q]$ is removed, and recharge is:

$$R = rsQ.$$

The change in recharge is defined as:

$$\Delta R = R - R_o$$

where, for a nonsewered area,

$$R_o = [(1 - s) + rs]Q_o$$

then:

$$\Delta R = rsQ - [(1 - s) + rs]Q_o$$

$$= rs\ (Q - Q_o) - (1 - s)Q_o$$

$$= rs\Delta Q - (1 - s)Q_o$$

From the percentages given above,

$$\Delta R = 0.04\Delta A - 0.8\ Q_o \qquad (4)$$

Calculations for areas in figure 3 based on equation 4 are given in table 2. Graphs of the stress in terms of Mgal/d per node for an area to be sewered between 1970 and 2000 were made and were divided into five 3-year increments from 1975 to 1990 and one 5-year increment from 1990 to 1995. Average stress values for each time period were converted to electrical current and were incrementally applied to the analog model; voltage (head) readings were made near the end of each modeled time period in order to minimize the effect of the increments of stress. Changes in withdrawal were measured in layer 4 (middle part of the Magothy aquifer) for most of the area modeled, and changes in recharge were measured in layer 1 (upper part of upper glacial aquifer).

MODELING RESULTS

Estimated changes in the position of the water table and in the head in the Magothy aquifer for 1995 are shown on figures 4 and 5 on 1:125,000-scale maps. Maps showing estimated incremental changes in ground-water

---

Figures 4 and 5 - in pocket, (captions on next page)

---

level from 1975 to 1990 at a scale of 1:250,000 are given in figures 6 through 11. Simulated net changes in ground-water levels in the aquifers

---

Figures 6 through 11 - in pocket, (captions on next page)

---

do not become large enough to map until the beginning of 1984 (fig. 6).

An orthogonal diagram (fig. 12), generated by data used for figure

---

Figure 12 (in pocket).

4, shows net change in the water-table from 1975 to 1995 at a highly exaggerated vertical scale of 3,660:1.

The greatest change in ground-water level would occur in the central part of the island, where the initial heads in the aquifers are highest. The model predicts a 5-m (16-ft) maximum decline in the water table in the west-central part, and a 1.8-m (6-ft) maximum decline in the east-central part of Long Island (fig. 4).

Figure 4.--Estimated water-table decline resulting from proposed sewer construction in Nassau and Suffolk Counties, Long Island, New York from 1975 to 1995.

Figure 5.--Estimated head decline in Magothy aquifer resulting from proposed sewer construction in Nassau and Suffolk Counties, Long Island, New York from 1975 to 1995.

Figure 6.--Estimated water-table decline resulting from proposed sewer construction in Nassau and Suffolk Counties, Long Island, New York from 1975 to 1984.

Figure 7.--Estimated water-table decline resulting from proposed sewer construction in Nassau and Suffolk Counties, Long Island, New York from 1975 to 1987.

Figure 8.--Estimated water-table decline resulting from proposed sewer construction in Nassau and Suffolk Counties, Long Island, New York from 1975 to 1990.

Figure 9.--Estimated head decline in Magothy aquifer resulting from proposed sewer construction in Nassau and Suffolk Counties, Long Island, New York from 1975 to 1984.

Figure 10.--Estimated head decline in Magothy aquifer resulting from proposed sewer construction in Nassau and Suffolk Counties, Long Island, New York from 1975 to 1987.

Figure 11.--Estimated head decline in Magothy aquifer resulting from proposed sewer construction in Nassau and Suffolk Counties, Long Island, New York from 1975 to 1990.

The predicted decline of ground-water head in the Magothy aquifer by 1995 is essentially the same as the water-table decline predicted for the region of maximum decline in west-central Long Island (fig. 5). Predicted head declines in the Magothy east of central Long Island differ in pattern and extent from those at the water table (fig. 4) because of the confining layers in the prototype which were simulated in the analog model. The areal extent of simulated confining layers (Getzen, 1975, fig. 8) controls the circulation of modeled ground water and retards direct downward recharge to the Magothy. East of model area 13 (fig. 3), only layer one (upper glacial aquifer) was stressed by withdrawals, yet as much as 2-m (6-ft) drop in head resulted in the model analysis of the Magothy aquifer in that region (fig. 5). The analog model includes the simulation of extensive confining layers in this region, and undoubtedly the difference in pattern is partly a result of their retarding recharge.

Reduction in flow in Long Island streams during the modeled period 1975-95 is summarized by the groups of streams in table 3. The method of stream simulation in the electric analog model permits a reasonable estimate of regional change in the water table, but it does not permit accurate prediction of local streamflow response to water-table changes. For this reason, streams are grouped in table 3, and the predicted percentage of streamflow change is given for groups rather than for individual streams. The grouping along the south shore of Long Island and the north shore of Suffolk County is by sewer district. The entire north shore of Nassau County is treated as one group because sewerage in that area is not planned before year 2000. In regions stressed, maximum reduction in streamflow was in stream group G through P (55 percent) and in group BF through BH (56 percent). Changes of less than 5 percent are probably not significant.

Table 3.--Percent decline in streamflow, 1975-1995

(Location of streams shown in figure 1.)

Stream group	1975-78	1978-81	1981-84	1984-87	1987-90	1990-95
South shore						
A through F	0	0	0	5	7	10
G " P	4	17	21	47	54	55
Q " AE	0	0	8	27	33	35
AF " AO	0	0	0	4	10	18
AP " AT	0	0	0	0	6	14
AU " AZ	0	0	0	0	0	3
North shore						
BA through BE	0	0	0	0	5	10
BF " BH	0	0	2	15	34	56
BI " BJ	0	0	0	1	4	8
Peconic Bay						
BK through BO	0	0	0	0	2	5

Declines in the water table are mitigated by the ground-water-fed streams, particularly along the south shore, where streams are numerous. This phenomenon is illustrated by the model output in figure 4, where large indentations in the net-change contours occur near streams. The streams act as a buffer against the regional decline in the water table that takes place when the system is stressed. As ground-water levels in the vicinity of streams decline, less water is discharged to streams.

SUMMARY

Simulated ground-water recharge and pumping was applied to an electric analog model to predict the effects of planned sewerage construction and estimated population change on the Long Island hydrologic system. The period modeled was 1975 to 1995.

Results of these stresses on the hydrologic system are depicted on maps showing net water-level change and a table showing the percentage decline in streamflow from 1975 to 1995. In the area of proposed sewerage in Nassau County, as much as 5 m (16 ft) of water-table decline is predicted. Declines would be greatest along the middle of the island. A second major area of net water-table change would develop in east-central Suffolk County, where as much as 1.8 m (6 ft) of water-table decline is predicted. Changes in head in the Magothy aquifer would be of about the same magnitude as those at the water table in the central and northern parts of the island and would be somewhat greater than those at the water table along the south shore of the island and in eastern Suffolk County, where confining layers occur. Proposed sewer construction would decrease streamflow along the south shore by about 55 percent in drainage from Nassau County Sewer District 3 and, in the Huntington-Northport Sewer District, by as much as 56 percent.

REFERENCES CITED

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

Getzen, R. T., 1975, Analog-model analysis of regional three-dimensional flow in the ground-water reservoir of Long Island, New York: U.S. Geol. Survey open-file rept. 75-617, 154 p.

Kimmel, G. E. and Harbaugh, A. W., 1975, Analog-model analysis of hydrologic effects of sewerage in southeast Nassau and southwest Suffolk Counties, Long Island, New York: U.S. Geol. Survey open-file rept. 75-535, 22 p.

Linaweaver, F. P., Jr., Geyer, J. C., and Wolff, J. B., 1967, A study of residential water use: U.S. Dept. of Housing and Urban Devel., Federal Housing Adm. Rept., U.S. Govt. Printing Office, Washington, D. C., 79 p.