Effects of Waste Water From A.E.C. Plant on the Hydrology of Glowegee Creek at West Milton New York, 1958-61

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1809-N

Prepared in cooperation with the U.S. Atomic Energy Commission

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By F. H. PAUSZEK *and* F. H. RUGGLES

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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CONTENTS

ILLUSTRATIONS

TABLES

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

EFFECTS OF WASTE WATER FROM A.E.C. PLANT ON THE HYDROLOGY OF GLOWEGEE CREEK AT WEST MILTON, NEW YORK, 1958–61

By F. H. PAUSZEK and F. H. RUGGLES

ABSTRACT

Glowegee Creek rises in the southwest corner of Saratoga County, about 8 miles west of the plant operated by the U.S. Atomic Energy Commission near West Milton, N.Y. During 1958–61 about 288,000 gallons per day of waste water, resulting from plant operations was discharged into Glowegee Creek. This waste water contained a dissolved-solids concentration that ranged from 116 to 356 ppm (parts per million) and about 0.3 to 0.7 ton per day of dissolved solids was discharged into the creek. The temperature of the waste water ranged from 32° to 87° F.

Because of the inflow of waste water, the discharge pattern at the gaging station at West Milton varied from that under natural conditions. At times, during low-flow periods, about 66 percent of the flow of Glowegee Creek was waste water. During periods of moderate flow, the contribution of waste water to the creek was insignificant.

The inflow of waste water also affected the chemical quality of water from Glowegee Creek. Sixty-one percent of the time the dissolved-solids content, measured at West Milton, was higher than would be expected under natural conditions. The average dissolved-solids content was about 142 ppm, and the average hardness was 119 ppm. The chemical quality fluctuated from day to day, but the increase in concentrations of dissolved solids, hardness, or individual constituents did not impair the utility of water from Glowegee Creek.

Although warm waste water flowed into Glowegee Creek, thermal equilibrium was reached within a short distance downstream from the point of entry. At West Milton no significant departure from the normal temperature was determined.

INTRODUCTION

Glowegee Creek rises in the southwest corner of Saratoga County, about 8 miles west of the plant operated by the U.S. Atomic Energy Commission near West Milton, N.Y. (fig. 1). It flows eastward

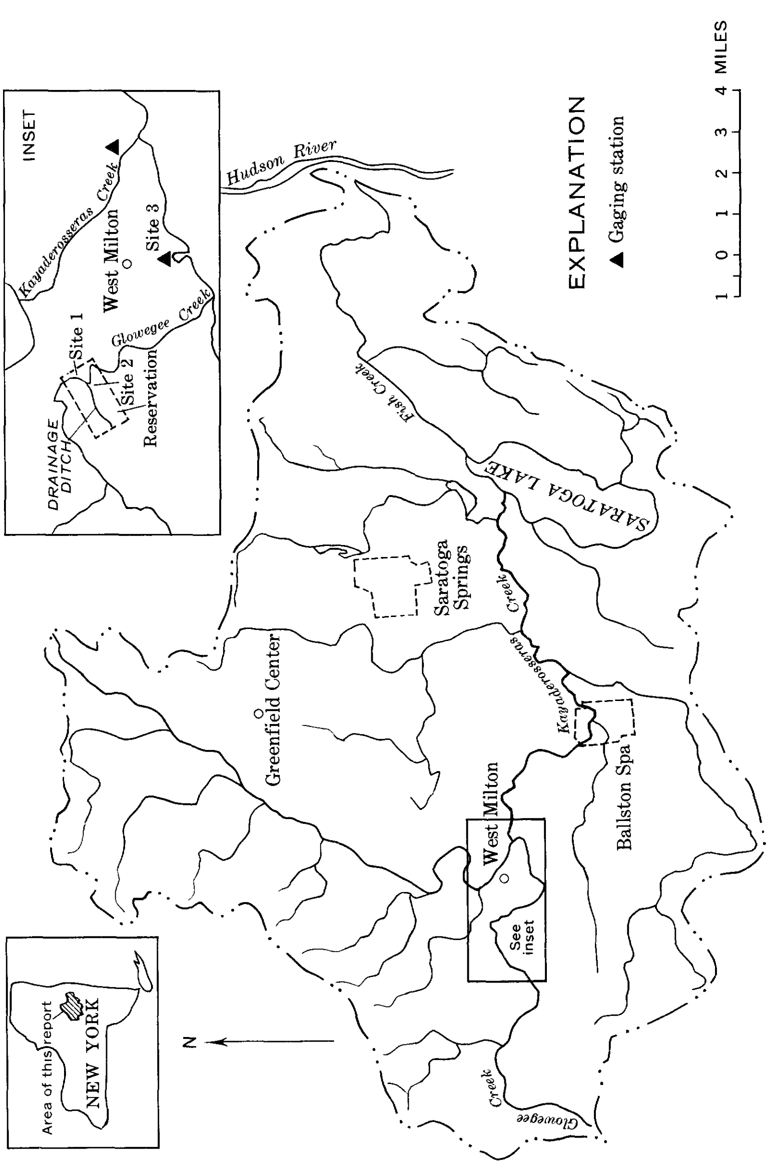

FIGURE 1.—The West Milton area.

through heavily wooded areas, crosses the reservation on which the plant is located, passes the town of West Milton, and flows into Kayaderosseras Creek about 0.8 mile east of West Milton.

Along the way, several small tributaries and overland runoff contribute to the flow of Glowegee Creek. Ground-water inflow, at all times, adds to the flow and during low-flow periods is the major component of the creek water. These are natural contributions. In addition, waste water from a plant operated by the Atomic Energy Commission discharges into the creek through a drainage ditch (fig. 1).

This inflow became a point of concern. What effect did it have on the hydrology of Glowegee Creek? Specifically three questions required answers. Did the inflow of waste water affect the streamflow characteristics of Glowegee Creek? Was the chemical quality of the creek affected? Finally, what effect did the temperature of waste water have on the water temperature of Glowegee Creek?.

The volume of waste water discharged by the plant into Glowegee Creek during 1958–61 varied from day to day but averaged about 288,000 gallons per day.

The waste water contained a dissolved-solids concentration that ranged from 116 to 356 ppm (parts per million) and about 0.3 to 0.7 ton per day of dissolved solids were discharged into the creek. Generally, this range in concentration was greater than that of the raw water supply (ground water), which averaged 120 ppm and was of moderate hardness—about 97 ppm.

To prevent scaling and to control the buildup of dissolved solids, the raw water was treated before passing into the plant distribution system. Hydrated lime was added to precipitate calcium as calcium carbonate. Sodium hexametaphosphate was also added to the raw water as an inhibitor; it forms a complex with the residual calcium in solution and prevents precipitation of the calcium as calcium carbonate. The sludge of precipitated calcium carbonate was then collected in a cooling-water basin and discharged periodically, along with the overflow from the cooling tower, into a drainage ditch leading to Glowegee Creek (fig. 1).

The temperature of the waste water flowing into the creek ranged from 32° to 87° F.

Because of the questions just mentioned, the U.S. Geological Survey was requested by the Atomic Energy Commission to determine and report on the effects of waste water on the hydrology of Glowegee Creek.

Among those who participated in the planning of the program were: B. M. Ball, and B. F. Knapp, and W. J. Scheiber of the Atomic Energy Commission and L. J. Cherubin, health physicist, General Electric Co.

In this report, the hydrology of Glowegee Creek and the drainage ditch will be discussed in the following order:

1. Hydrology of Glowegee Creek before inflow of waste water. A site was selected about 20 yards upstream from the drainage ditch to determine streamflow, chemical quality, and water temperature of Glowegee Creek prior to inflow of waste water from the drainage ditch. For convenience, this location was designated and is referred to in this report as site 1 (fig. 1).
2. The quantity and quality of waste water flowing into Glowegee Creek. The flow, chemical quality, and temperature of waste water were measured at a point referred to as site 2 (fig. 1).
3. The hydrology of Glowegee Creek at West Milton (location of gaging station and site 3). This location is about 2.7 miles downstream from the confluence of the drainage ditch and the creek. Here, too, streamflow, chemical quality, and temperature measurements were made. Data obtained at this location were compared with those at site 1 in order to appraise the effects of waste water on the hydrology of Glowegee Creek.

HYDROLOGY OF GLOWEGEE CREEK BEFORE INFLOW OF WASTE WATER (SITE 1)

RUNOFF

At site 1, Glowegee Creek drains an area of 21.5 square miles (fig. 1). At this location, streamflow of Glowegee Creek was not recorded on a continuous basis. However, as previously reported by Mack and others (1964), there is a good correlation between discharge at site 1 and the gaging station at West Milton (site 3), about 2.7 miles downstream. The discharge at site 1 is 0.83 times that at site 3. At least 0.3 cfs (cubic feet per second) can be expected all the time at site 1, and 13 cfs can be expected 50 percent of the time. The figure of 0.3 cfs represents at least 135 gallons per minute of water that is available for dilution of plant effluent draining from the ditch. At low flows (less than about 10 cfs) the discharge relationship between site 1 and site 3 is affected by the inflow of waste water, which may be a large percentage of the flow at site 3. To correct for this effect, the discharge from the ditch, measured at site 2, should be subtracted from the discharge at site 3.

CHEMICAL QUALITY

Calcium and bicarbonate are the principal constituents in solution that make up the dissolved-solids content of water collected from Glowegee Creek at site 1. Limestone and some dolomite, which consist respectively of calcium carbonate and of calcium and magnesium carbonate, occur in the drainage basin and are the source of the calcium and bicarbonate.

The concentration of dissolved solids fluctuated from 84 to 167 ppm (based on specific conductance measurements and an average ratio of 0.6 ppm per unit micromho of specific conductance). Only a few of the water samples contained concentrations of dissolved solids in the lower part of the range; 98 percent of the time the dissolved-solids content exceeded 104 ppm. The average for the period of record was 136 ppm with a standard deviation of 16.1 ppm.

The frequency distribution of specific conductance values (and equivalent concentrations of dissolved solids) was greatest in the range of 210 to 250 micromhos (about 125 to 150 ppm of dissolved solids) (fig. 2). This clustering of values is a reverse image of the discharge pattern of Glowegee Creek (fig. 2).

This distribution is significant insofar as the chemical quality of Glowegee Creek is concerned. At any time, stream discharge consists of surface runoff and ground-water inflow. During high flow, the contribution from ground water is an insignificant part of the total discharge. It becomes more significant during periods of moderate runoff and during base flow is the sole component of streamflow.

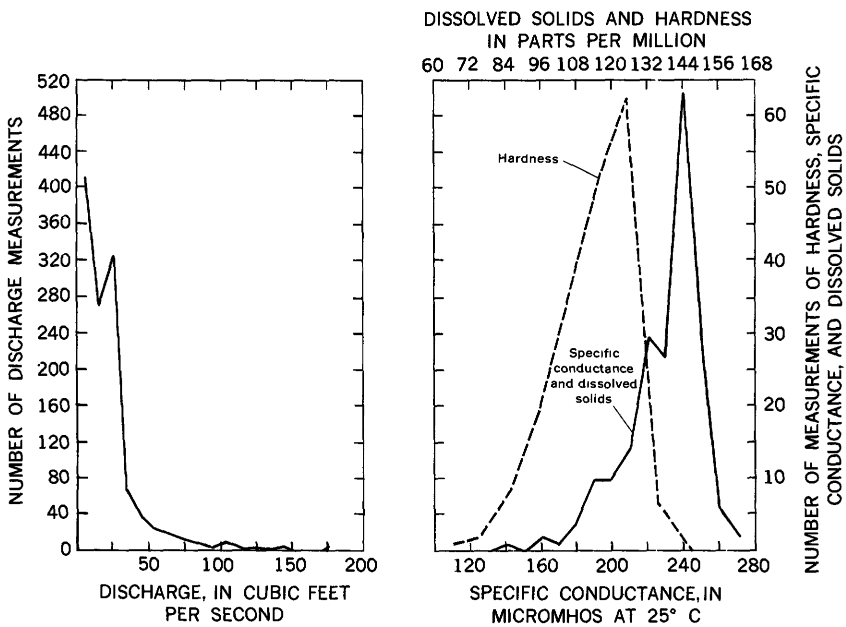

FIGURE 2.—Frequency distribution of discharge, hardness, and specific conductance and dissolved solids, Glowegee Creek at site 1, near West Milton, August 1958–June 1961.

Because discharge was in the lower range (20 cfs or less) about 55 percent of the time, a large part of the flow consisted of ground water. Because ground water in the basin is more mineralized than surface water, its inflow tended to increase and sustain the dissolved-solids content of water from the creek at the level of 125 to 150 ppm.

Because of the high concentrations of calcium (and to a lesser extent of magnesium), water from Glowegee Creek at site 1 was moderately hard. The average hardness was 119 ppm with a standard deviation of 13 ppm. In contrast to the distribution pattern of the concentrations for dissolved solids, that for hardness showed only a slight negative skewness (fig. 2). Fluctuation of the monthly mean hardness suggests a seasonal variation (fig. 3). However, streamflow conditions are directly responsible for this variation, as previously discussed, the lowest hardness occurring during the spring when surface runoff from snowmelt produces the highest stream discharges of the year.

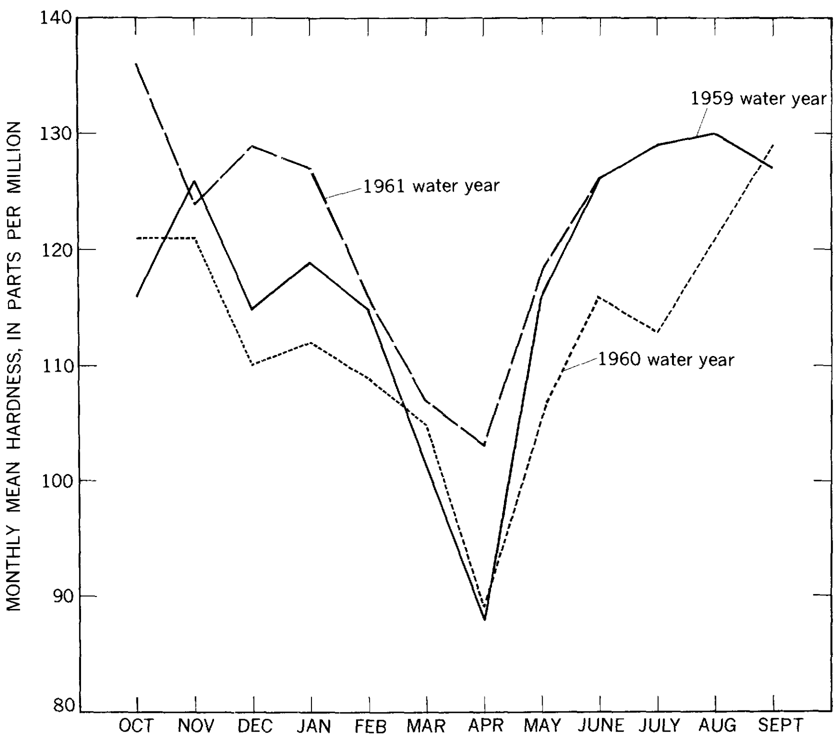

Figure 3.—Monthly mean of hardness of water from Glowegee Creek (samples collected weekly), at site 1, 1959–61 water years.

Since calcium and bicarbonate were the principal constituents, water from Glowegee Creek was alkaline. About 99 percent of the time, the pH ranged from 7.1 to 8.8.

To provide data for comparison of phosphate in water from Glowegee Creek before and after inflow of the waste water, phosphate determinations were made in water samples collected at site 1. The phosphate concentrations usually ranged from 0.00 to 0.11 ppm. Those higher than 0.11 ppm were determined in water samples collected in September through December 1958 and 1959, and one sample collected January 30, 1961, had a concentration of 0.32 ppm. The time of the year suggests that drainage from decaying vegetation may add to the phosphate content of water from the creek; phosphate is an essential element in the growth of plants. Table 1 shows the frequency of phosphate concentrations in water samples collected at site 1.

TABLE 1.—*Distribution of phosphate concentrations, for Glowegee Creek at site 1, August 1958–June 1961*

Range (ppm)	*Number of samples*	*Range (ppm)*	*Number of samples*
0.00–0.03	92	0.20–0.23	1
.04– .07	62	.24– .27	0
.08– .11	19	.28– .31	3
.12– .15	5	.32– .35	1
.16– .19	3		

WATER TEMPERATURE

Usually, Glowegee Creek is a shallow stream; and except during periods of freezing air temperatures, water temperatures correlate with average daily air temperatures. Temperature of water from Glowegee Creek at site 1 was determined periodically prior to May 4, 1961. Since that date, a continuous recorder has been in operation. The data accumulated from that date to June 30, 1961, are insufficient for analysis.

WASTE WATER DISCHARGED INTO GLOWEGEE CREEK (SITE 2)

RUNOFF

The quantity of waste water discharged into the ditch and flowing into Glowegee Creek varied with the extent of plant operation. At site 2 (location of stage recorder) the mean daily discharges ranged from 0.1 to 2.1 cfs. However, all the water passing this point was not from plant operation. The ditch also received water from a storm sewer, overland runoff, and ground-water inflow; the contributions from these sources were not determined.

One question that may be raised in regard to the discharge of waste water is: What is the time of travel of the waste water from the point of entry into the ditch to the stage recorder, a distance of about 2,100 feet? It ranged from 18 to 50 minutes, depending on the discharge into the ditch. For a discharge of 0.7 cfs, the time of travel would be about 30 minutes based on velocity measurements in the ditch (table 2). Figure 4 shows locations of measuring points in the ditch.

TABLE 2.—*Velocity measurements, in feet per second, of waste water in drainage ditch*

Observed discharge at site 2 (cfs)	Locations						
	1	2	3	4	6	7	8
0.37	0.5	0.6	0.7	0.8	0.9	1.0	1.2
1.04	1.0	1.2	1.4	1.6	1.8	2.1	2.3
.70	.7	.8	1.0	1.1	1.3	1.5	1.7

After the waste water enters Glowegee Creek, what would be the elapsed time before a mass of water would reach the gage at West Milton, site 3? Time would be an important factor if waste water containing a critical contaminant had been released inadvertently, and this water should be prevented from flowing downstream from West Milton. (The dilution factor, which would be another important consideration, and the means of containment are not discussed here.)

For estimating the time of travel between sites, two dye experiments and records of flood peaks passing the sites are available. At flows of 8 and 95 cfs, fluorescein dye was introduced at site 2 and the elapsed times until the first definable dye passed site 3 were noted. This approximated the fastest flow in the stream for the discharge at which the experiment was run; the time of travel for the peak dye concentration, which would have represented the average stream velocity, would have been considerably longer. At flows above 300 cfs flood peaks on Glowegee Creek also are recorded at site 2, and therefore time of travel of flood peaks from site 2 to site 3 could be determined from recorded graphs at those sites. This represents a lower limiting value for time of travel, because flood peaks are known to travel at a faster rate than the mass of water. The relation between time of travel and discharge, based on the dye experiments and the recorded flood peaks, is shown in figure 5.

To utilize the time-of-travel curve, the discharge at the gage at West Milton must be known. Then, it is possible to enter the curve and de-

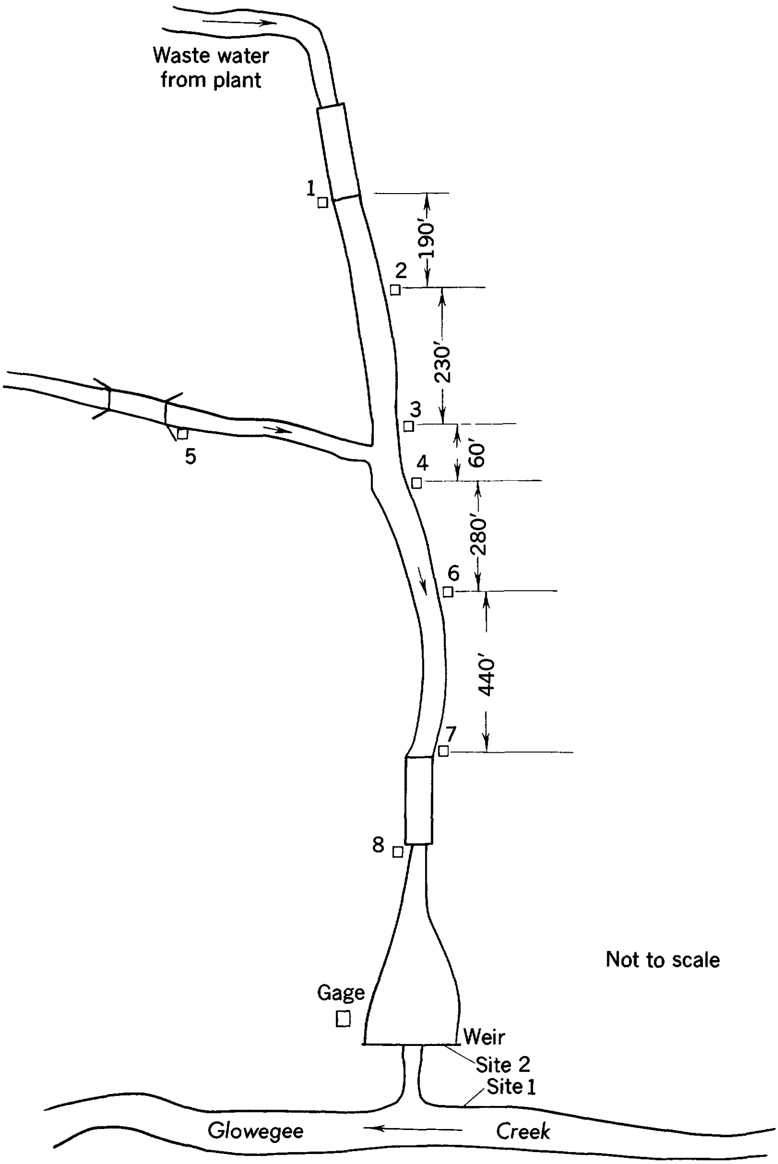

FIGURE 4.—Locations of velocity-measurement points in drainage ditch.

termine the time of travel of a mass of water from the mouth of the ditch to the gaging station at West Milton. For a discharge of 8 cfs,

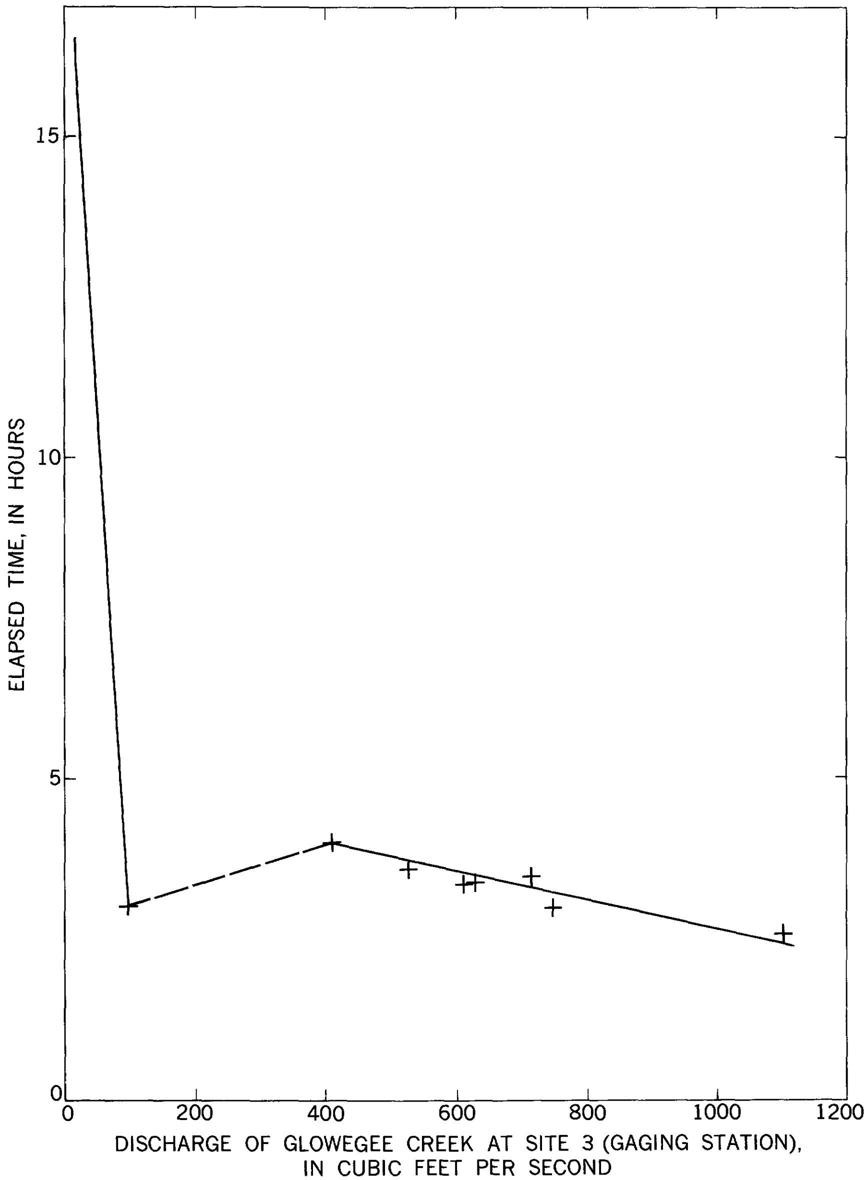

FIGURE 5.—Time of travel in Glowegee Creek from site 2 to site 3.

the time of travel from site 2 to site 3 would be about 16 hours. At a flood discharge of 500 cfs about 3.8 hours would be required.

CHEMICAL QUALITY

The concentrations of dissolved solids in waste water in the ditch were very erratic (fig. 6). This condition is not unusual in view of the water treatment previously described and the varying quantities of water discharged from the plant. In addition, some of the calcium carbonate precipitated in the ditch may be redissolved by overland runoff and adds to the dissolved-solids content. The approximate ranges of dissolved solids (computed from the specific conductance) in water samples from the ditch are given below:

Water year (Oct. 1–Sept. 30)	*Dissolved solids (ppm)*
1959	106–289
1960	134–356
1961	134–236

In tons per day the maximum discharges of dissolved solids were:

Water year	*Maximum dissolved-solids discharges (tons per day)*	*Water discharge (cfs)*
1959	0.3	0.37
1960	.7	.74
1961	.3	.50

Minimum load figures are not available for water years 1959 and 1961. During water year 1960, the minimum load was 0.4 ton per day; the water discharge from the ditch at the time was 1.12 cfs.

The hardness of water discharged from the ditch was equally erratic as the waste water consisted of varying quantities of sludge discharged from the cooling basin (fig. 7).

Because of the large concentrations of calcium carbonate, the pH of water in the ditch was alkaline at all times. The following table gives ranges of pH that were determined:

pH range	*Number of determinations*	*Percent of total*
7.0–7.4	11	7
7.5–7.9	39	25
8.0–8.4	43	28
8.5–8.9	34	22
9.0–9.4	26	17
9.5–9.9	2	1
	155	100

Because sodium hexametaphosphate was used in the treatment, water from the ditch was analyzed for its phosphate content. The concentrations of phosphate were also erratic and ranged from 0.00 to 3.2 ppm. Table 3 shows the frequency distribution of concentrations of phosphate. Eighty-three percent of the water samples contained less than 2.0 ppm of phosphate.

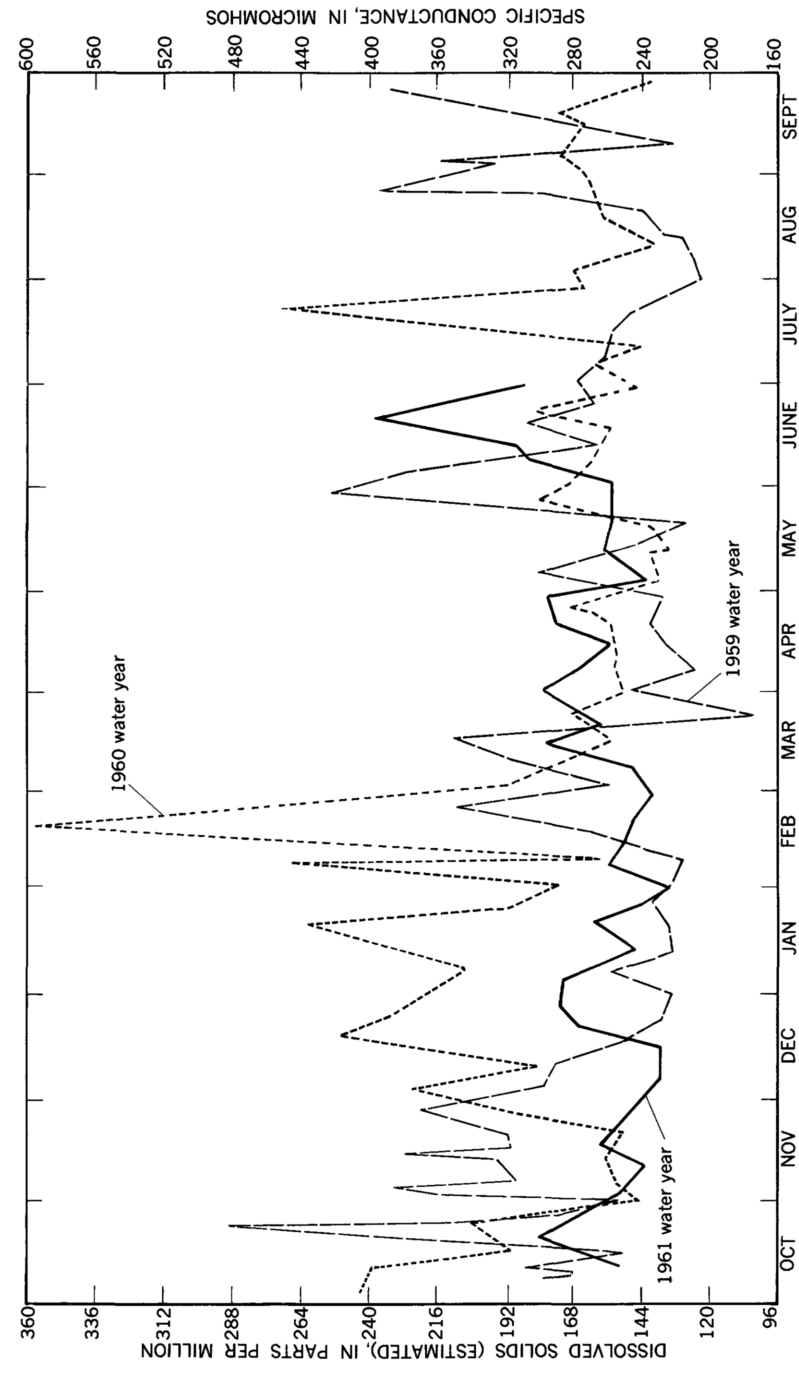

FIGURE 6.—Specific conductance and dissolved solids of water in ditch, site 2, based on weekly samples, 1959–61 water years.

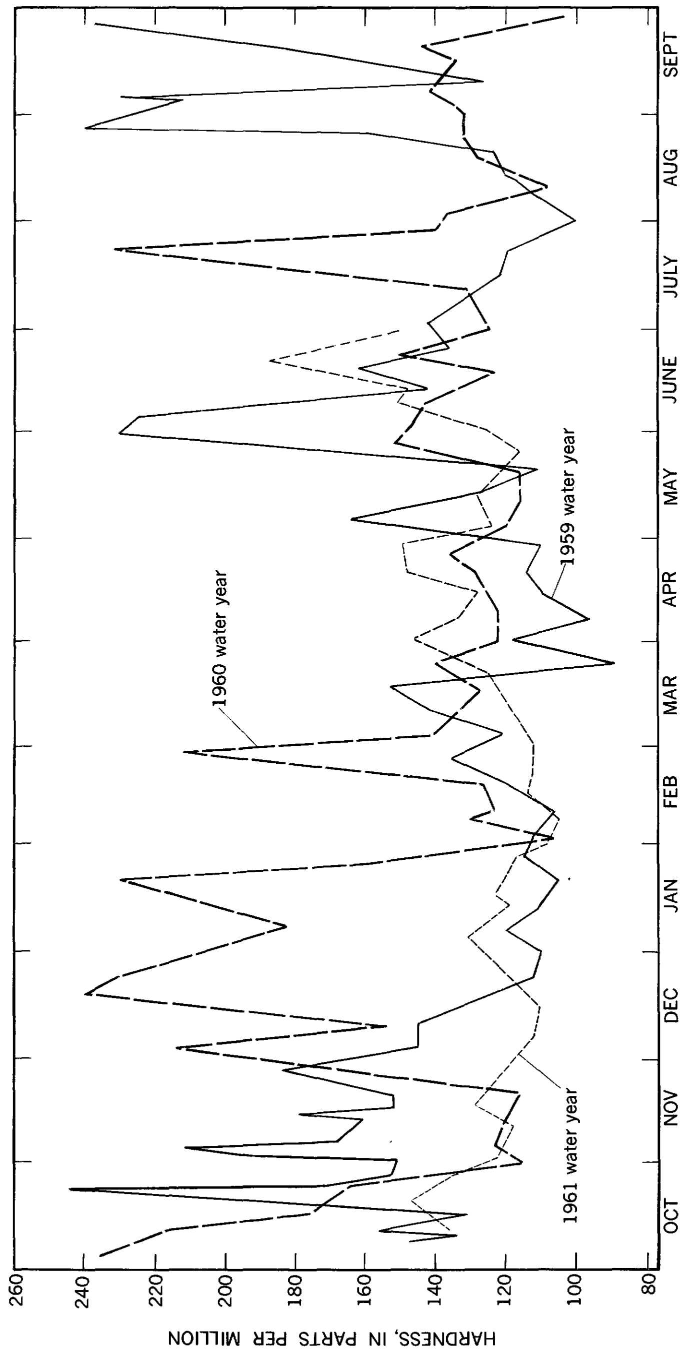

FIGURE 7.—Hardness of water in ditch, site 2, based on weekly samples, 1959–61 water years.

As is apparent from the preceding discussion, the chemical quality of waste water in the ditch varied considerably. Because of this wide variation what would be the concentration of dissolved solids that could be expected in water from Glowegee Creek at West Milton? Of course, the information is already at hand for the period 1958–61 and will be discussed later in this report. However, if such information would be required for some future date, the dissolved-solids content could be computed, within limits, from the following factors: The chemical quality and discharge of the creek water upstream from the effluent ditch, the chemical quality and discharge of water in the ditch, and the chemical quality and discharge of ground-water inflow in the stretch between sites 2 and 3. The effects of the last two factors are assumed to be of lesser importance.

TABLE 3.—*Distribution of phosphate concentrations in water at site 2 based on weekly samples*

Range (ppm)	*Number of samples*	*Percent*	*Range (ppm)*	*Number of samples*	*Percent*
0. 00–0. 19	8	5. 1	2. 00–2. 19	11	7. 0
. 20– . 39	12	7. 6	2. 20–2. 39	6	3. 7
. 40– . 59	13	8. 2	2. 40–2. 59	5	3. 2
. 60– . 79	8	5. 1	2. 60–2. 79	1	. 6
. 80– . 99	20	12. 7	2. 80–2. 99	3	1. 9
1. 00–1. 19	3	1. 9	3. 00–3. 19	0	. 0
1. 20–1. 39	18	11. 4	3. 20–3. 39	1	. 6
1. 40–1. 59	19	12. 0			
1. 60–1. 79	23	14. 6		158	100. 0
1. 80–1. 99	7	4. 4			

The relationship of the several factors is expressed in the following equation (specific conductance is used as a measure of dissolved solids):

$$SC_3=\frac{(SC_2\times Q_2)+(SC_1\times Q_1)}{Q_2+Q_1},$$

where

SC_3= specific conductance at site 3,
SC_2= specific conductance at site 2,
SC_1= specific conductance at site 1,
Q_2= water discharge at site 2, and
Q_1= water discharge at site 1.

A comparison of the computed and measured values of specific conductance shows excellent agreement; correlation coefficient was 0.8.

Then, using the computed conductance, the approximate range of concentrations of dissolved solids and hardness that can be expected in water from Glowegee Creek at West Milton can be obtained from the nomograph (based on the relationships of specific conductance and on dissolved solids and hardness) shown in table 4. For example, if the computed conductance for water from Glowegee Creek, at site 3 is 280 micromhos, the approximate ranges of concentrations of dissolved solids and hardness are 161 to 175 ppm and 129 to 155 ppm, respectively.

TABLE 4.—*Computed specific conductance and equivalent values of dissolved solids and hardness (approximate), Glowegee Creek at West Milton*

[Results for dissolved solids and hardness are within ±7 and ±13 ppm of actual values, respectively]

Specific conductance (micromhos at 25° C)	*Dissolved solids (ppm)*	*Hardness as* $CaCO_3$ *(ppm)*	*Specific conductance (micromhos at 25° C)*	*Dissolved solids (ppm)*	*Hardness as* $CaCO_3$ *(ppm)*
280	168	142	200	125	99
270	163	137	190	120	94
260	157	132	180	114	88
250	152	126	170	109	83
240	147	121	160	103	78
230	141	116	150	98	72
220	136	110	140	93	67
210	130	105	130	87	62

WATER TEMPERATURE

The temperature of the water in the ditch was measured continuously at site 2. Initially, the sensing element was installed within the intake pipe leading to the recorder well, about 10 feet above the weir and near the bottom of the pool. A plot of the temperature at the bottom and top of the weir plate showed that a temperature gradient was present (fig. 8). At the top the temperature was 68°F and at the bottom, 62°F. A schematic two-dimensional flow net indicates the source of the stratified layers (fig. 9). The gradients were a result of diurnal water temperature variations, evaporation, the insulating effect of the upper layer of water within the pool, and cooler water entering from below. Because of the location of the sensing element, the temperatures recorded during the period September 4 to October 8, 1958, represented only one stratified layer. This situation was remedied by reinstalling the sensing element downstream from the weir. At this location, the average temperature of water entering Glowegee Creek was recorded. Monthly ranges of water temperatures are shown in figure 10. Although monthly variations are apparent, the trend was repetitive for the period 1958–61.

HYDROLOGY OF GLOWEGEE CREEK AT WEST MILTON (SITE 3)

RUNOFF

At West Milton, Glowegee Creek drains an area of 26.0 square miles. However, the area of concern in this report is that extending from site 1 to site 3. Within this reach, the flow of the creek can be either sluggish or rather fast; several small tributaries as well as the waste water from the ditch contribute to the flow in the creek.

Because of the contribution from the ditch, the discharge pattern will vary from that under natural conditions. On many days during the summer months of 1959, waste water entering Glowegee Creek was more than 50 percent of the total flow at site 1. On July 27, for example, when the measured discharge at site 1 was 1.1 cfs, the discharge from the ditch was 0.8 cfs, and the mean daily discharge of the ditch for that day was 1.12 cfs.

The duration of flow curve for Glowegee Creek at site 3 also illustrates this effect (fig. 11). The observed duration of flow for the period 1949–54 is plotted in this figure. This relationship has been adjusted to the longer period 1928–54 on the basis of the long period of

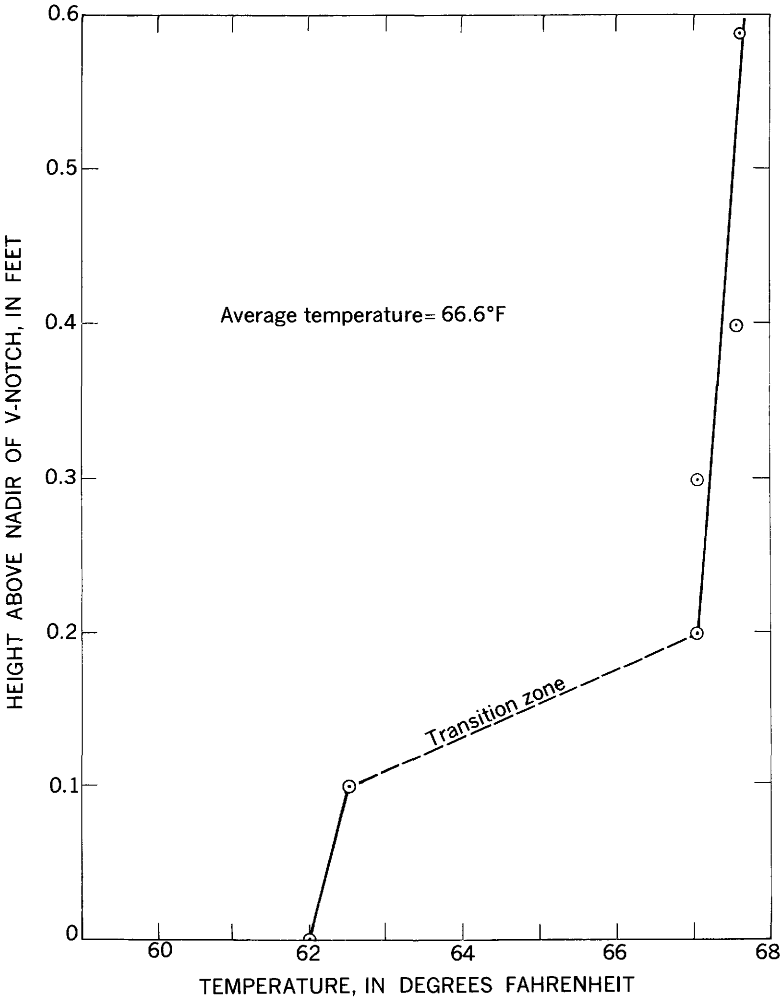

FIGURE 8.—A vertical-temperature profile of water at site 2.

streamflow records for Kayaderosseras Creek. To show the effect of the ditch inflow, the duration of flow curve for 1959–61 has been plotted in the figure. For discharges lower than that at the 90-percent point, the discharge during 1959–61 was observed to be higher than would be expected on the basis of past records at this site. To further study the low-flow characteristics of Glowegee Creek for this period, curve B has been plotted. This curve represents the duration of daily discharges for 1959–61 at site 3 adjusted by subtracting the mean daily inflow from the ditch. In effect, this is the discharge that would have occurred without the ditch being in use. Evidently, below about the 98-percent point the 1959–61 discharge is higher than that of past records, but the difference is much less significant than it was before the subtraction of the ditch discharge.

To determine if the period 1959–61 differed hydrologically from the long-term record, the duration of flow for Kayaderosseras Creek was plotted for the same periods as for Glowegee Creek. The curves in figure 12 show virtually the same pattern as was observed for Glowegee Creek. The discharge for the period 1959–61 was generally lower than that indicated by the long-term records, but the creek had a better than usual sustained flow below the 98-percent point. Thus, overall, the discharge for 1959–61 was somewhat lower than usual, but it was not drastically low.

CHEMICAL QUALITY

The dissolved-solids content of water from Glowegee Creek at site 3 was less than 167 ppm (based on specific conductance) 99 percent of the time during 1958–61. Although the dissolved-solids concentrations were higher in several samples, they did not exceed 180 ppm. The average dissolved-solids content was about 142 ppm with a standard deviation of about 17 ppm.

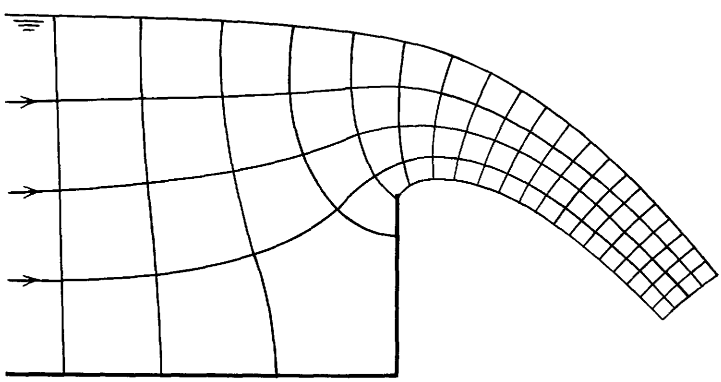

FIGURE 9.—Two-dimensional flow net for the weir at site 2.

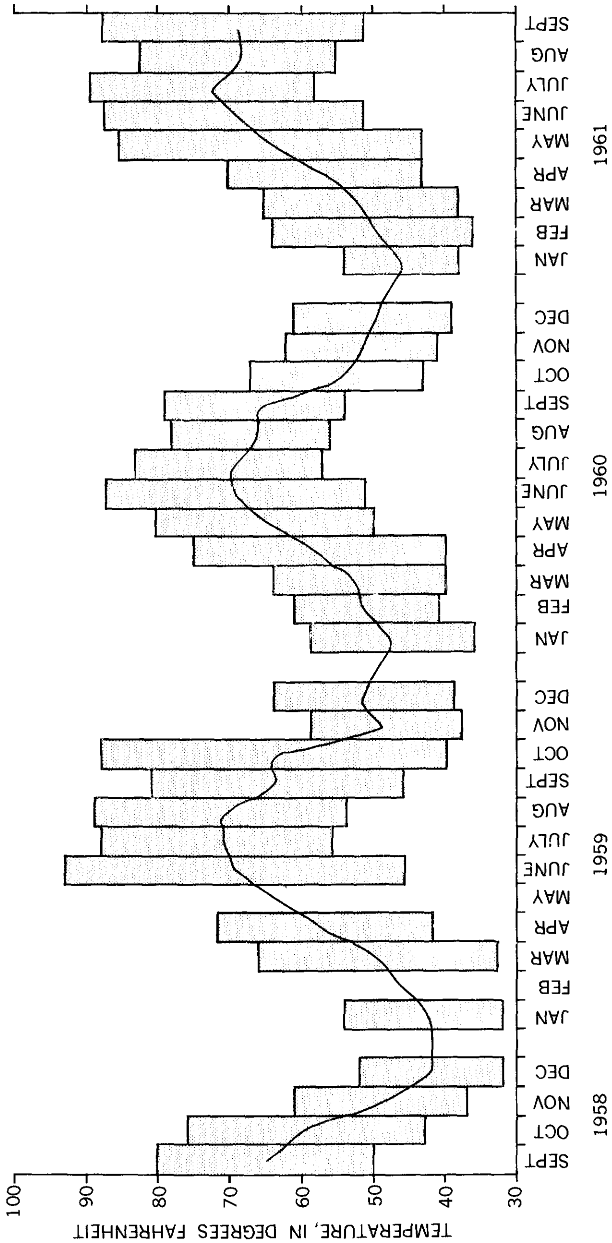

FIGURE 10.—Monthly ranges of water temperatures of waste water in ditch at site 2, 1958–61.

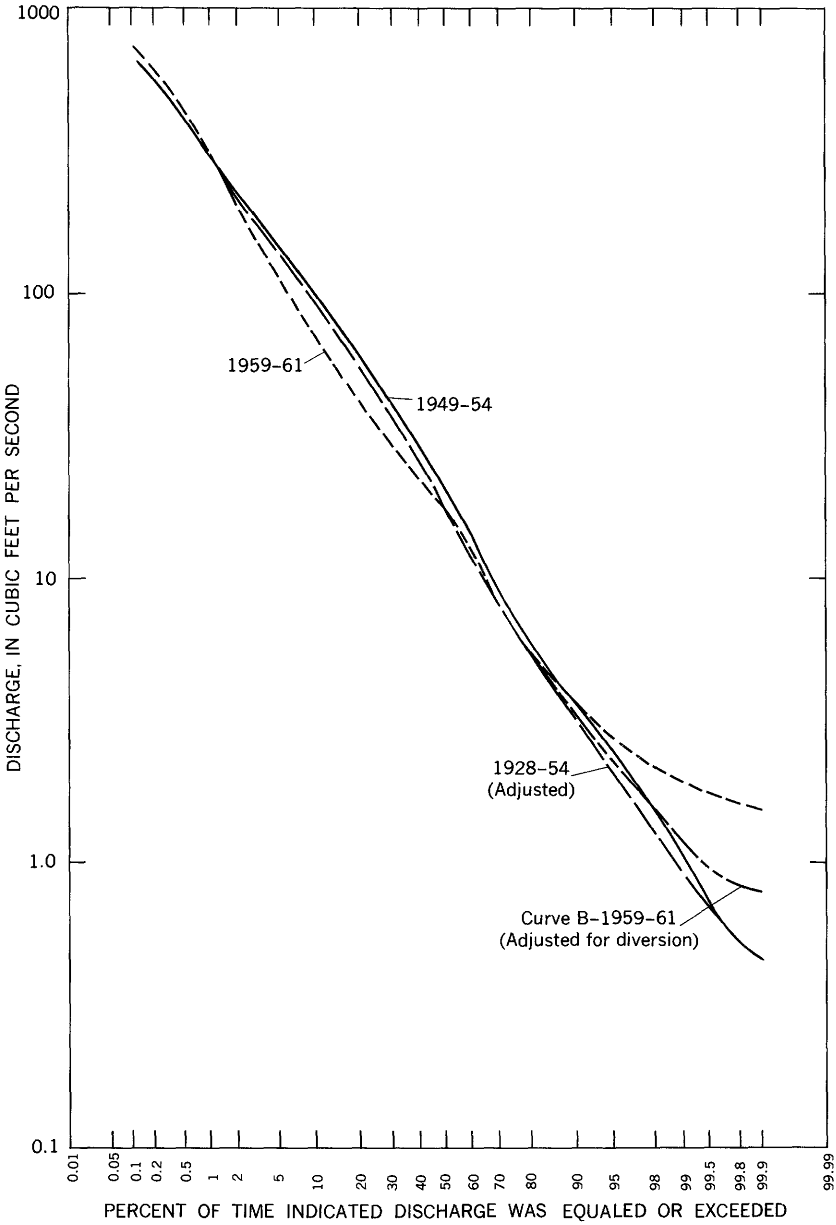

FIGURE 11.—Duration of flow of Glowegee Creek at site 3, water years 1928–54, 1949–54, and 1959–61.

Table 5 shows the percentage distribution pattern of specific conductance for 11 ranges of discharge. When streamflow was less than 25 cfs, the specific conductance ranged from 181 to 300 micromhos; this range would be equivalent to a dissolved-solids content of about 109 to 180 ppm. Even at a discharge of about 35 cfs, the specific conductance ranged from 181 to 280 micromhos. The effect of dilution is apparent. However, at the higher discharges in the range of 86 to 155 cfs; about 89 percent of the measurements were less than 181 micromhos. Throughout the several ranges of discharge, fluctuations in the quality of waste water flowing into Glowegee Creek account for the wide scatter of dissolved-solids concentrations.

TABLE 5—*Percentage of days that specific conductance occurred in range shown for a given discharge range, Glowegee Creek at West Milton (site 3), 1958–61*

Discharge (cfs)	Percent of days in which specific conductance occurred in the range of micromhos indicated										
	<100	101–120	121–140	141–160	161–180	181–200	201–220	221–240	241–260	261–280	281–300
0 - 5.0	------	--------	--------	--------	--------	9	13	17	41	18	2
5.1- 15	------	--------	--------	--------	--------	2	8	43	38	8	1
16 - 25	------	--------	--------	--------	--------	9	43	30	14	2	2
26 - 35	------	--------	--------	1	--------	35	31	21	11	1	--------
36 - 45	------	--------	--------	--------	14	36	29	13	8	--------	--------
46 - 55	------	--------	--------	10	13	54	20	3	--------	--------	--------
56 - 65	3	--------	--------	6	31	45	6	9	--------	--------	--------
66 - 85	3	3	--------	10	31	25	25	3	--------	--------	--------
86 -155	3	5	23	35	23	8	3	--------	--------	--------	--------
156 -240	------	--------	45	45	10	--------	--------	--------	--------	--------	--------
241 -360	------	67	33	--------	--------	--------	--------	--------	--------	--------	--------
361 -425	------	67	33	--------	--------	--------	--------	--------	--------	--------	--------
426 -599	------	100	--------	--------	--------	--------	--------	--------	--------	--------	--------
600	100	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

The curve of the mean monthly values of specific conductance shows the seasonal fluctuations during 1958–61 (fig. 13). It reflects periods of low and high flows in the Creek. Although for the period 1958–61 there is no apparent trend, a comparison with the curve for 1953–56 shows that the mean monthly values of specific conductance for 1958–61 are somewhat higher.

Because of the large concentrations of calcium and magnesium in solution, water from Glowegee Creek was moderately hard; 91 percent of the time hardness in water from Glowegee Creek equaled or exceeded 100 ppm. As stream discharge increased, dilution was effective in reducing the concentrations of calcium and magnesium and computed hardness, based on these concentrations, was also reduced. For example, the hardness of one water sample was 75 ppm; at the time of sample collection the mean daily discharge was 131 cfs (table 6). For the period 1958–61, the average hardness was 119 ppm with a standard deviation of 13 ppm. Table 7 shows the distribution of hardness concentrations at site 3.

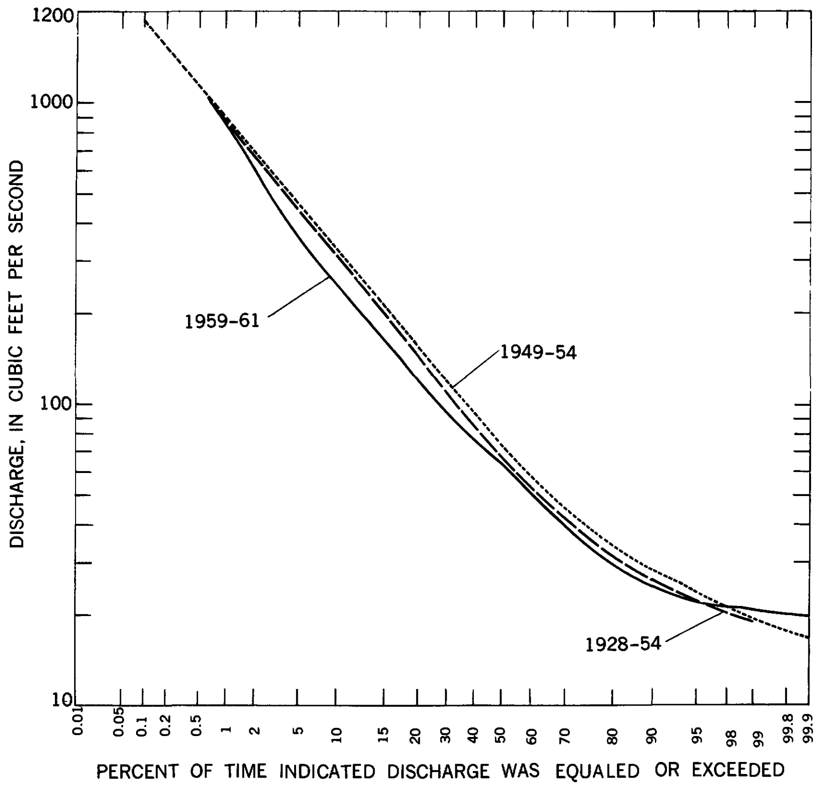

FIGURE 12.—Duration of flow of Kayaderosseras Creek near West Milton, water years 1928–54, 1949–54, 1959–61.

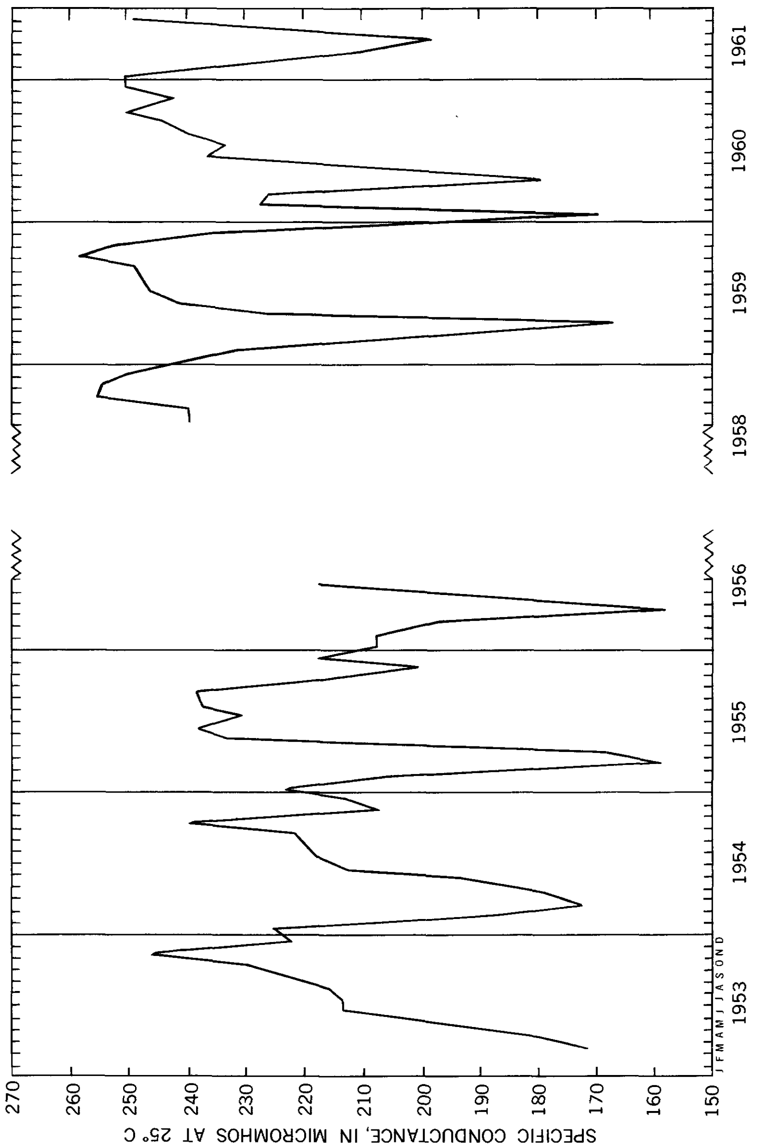

FIGURE 13.—Mean monthly values of specific conductance, Glowegee Creek at West Milton, 1953–56, 1958–61.

TABLE 6.—*Chemical analyses of water in Glowegee Creek at West Milton (site 3)*

[Chemical constituents in parts per million]

Date of collection	Mean discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
June 24, 1952	13	5.7	0.00	28	10	2.4	0.8	126	11	2.4	0.1	0.5	130	111	8	216	7.8	5
Aug. 20, 1957	1.8	5.3	.09	28	9.9	2.8	.8	128	10	3.5	.2	.8	128	111	6	230	7.3	4
Dec. 17, 1957	14	7.4	.17	30	9.5	3.5	.7	98	34	5.9	.0	.8	149	114	34	248	7.2	4
Mar. 30, 1958	131	5.2	.01	19	6.7	2.4	.8	67	16	5.3	.0	.9	92	75	20	153	7.5	10
June 30, 1958	4.0	6.3	.11	28	10	2.4	.7	122	11	4.5	.1	.7	130	111	11	229	7.4	5
Sept. 30, 1958	6.3	7.7	.14	30	12	4.5	1.0	121	25	6.0	.2	.2	153	125	26	245	8.1	15
Dec. 30, 1958	9.3	7.9	.09	30	12	3.6	.7	123	18	7.0	.1	.9	146	125	24	242	7.3	5
Mar. 30, 1959	62	6.1	.06	22	8.4	3.6	.8	94	15	6.0	.1	1.0	112	90	13	196	7.2	10
July 1, 1959	2.6	6.9	.19	30	11	4.1	1.1	136	12	5.0	.2	1.1	139	120	9	260	7.2	6

TABLE 7.—*Distribution of hardness in water from Glowegee Creek at site 3, 1958–61*

Range (ppm as $CaCO_3$*)*	*Number of samples*	*Percent*	*Range (ppm as* $CaCO_3$*)*	*Number of samples*	*Percent*
65– 74.9	2	0.9	125–134.9	68	29.8
75– 84.9	2	.9	135–144.9	13	5.7
85– 94.9	8	3.5	145–154.9	2	.9
95–104.9	21	9.2			
105–114.9	38	16.7		228	100.0
115–124.9	74	32.4			

In water samples collected at site 3, 98.6 percent of the samples had phosphate concentrations that ranged from 0.00 to 0.23 ppm; concentrations in three samples were higher (table 8).

Concentrations of bicarbonate increased more with an increase in dissolved solids than any other constituent in water from Glowegee Creek. Because of the large concentrations of bicarbonate, water from the creek was alkaline—above pH 7.0. The usual range was 7.4 to 8.2, but a pH as high as 8.8 was determined also in one water sample (table 9).

TABLE 8.—*Distribution of phosphate concentrations in water samples from Glowegee Creek at site 3, 1958–61*

Range (ppm)	*Number of analyses*	*Percent*	*Range (ppm)*	*Number of analyses*	*Percent*
0.00–0.03	63	29.2	0.20–0.23	10	4.6
.04– .07	64	29.6	.24– .27	2	.9
.08– .11	27	12.5	.28– .31	1	.5
.12– .15	28	13.0			
.16– .19	21	9.7		216	100.0

TABLE 9.—*pH in water from Glowegee Creek at site 3, 1958–61*

Range	*Number of samples*	*Percent*	*Range*	*Number of samples*	*Percent*
7.0–7.19	7	3.1	8.2–8.39	9	3.9
7.2–7.39	19	8.4	8.4–8.59	4	1.8
7.4–7.59	49	21.6	8.6–8.79	1	.4
7.6–7.79	40	17.6			
7.8–7.99	64	28.2		227	100.0
8.0–8.19	34	15.0			

CONCLUSIONS

Figure 11 clearly shows that waste water from the ditch materially increases the flow of Glowegee Creek when the discharge is less than that indicated for the 90-percent point. The amount of this increase will be about 10 percent at the 90-percent point and more than 100 percent at the 99.9-percent point.

To further illustrate the effects of the plant effluent on the discharge of Glowegee Creek, the mean monthly discharge for 1959 was plotted on the curves of maximum, minimum, and mean monthly discharge for the long-term period 1949–54. Even with the increased flow augmenting Glowegee Creek, the discharge during the months of June, July, and August was below or near the lowest of record. If there were no augmentation, the flow of Glowegee Creek would have been as shown in the curve for 1959 in figure 14.

Although, as previously shown, the duration of flow below the 90-percent point has been affected by the discharge from the ditch, a statistical analysis of the mean discharge for the period 1959–61 was also made to determine if the mean discharge was different from that

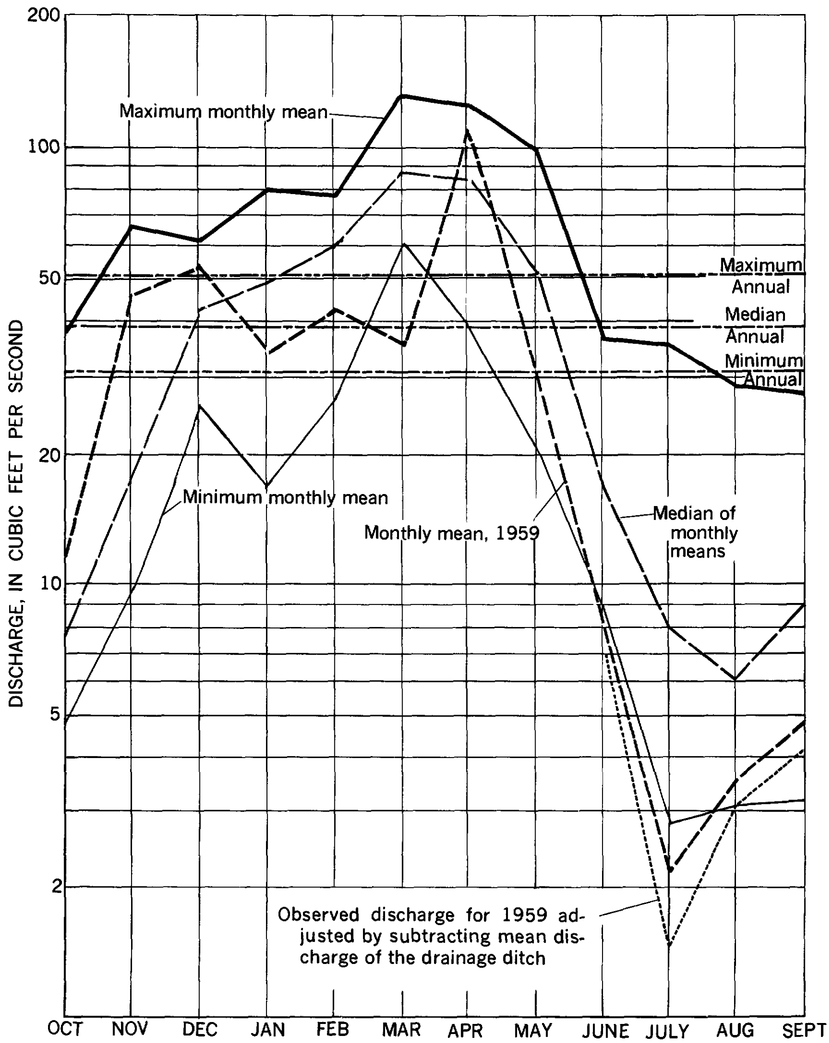

FIGURE 14.—Maximum, minimum, and median monthly discharges at Glowegee Creek at site 3, water years 1949–54, and 1959.

for the period 1949–58. There is no significant evidence that the mean discharges for the two periods are different.

From the duration-curve data and the analysis of means, it is concluded that on a day-to-day basis the streamflow of Glowegee Creek was materially altered but that the yearly mean discharge was not significantly affected.

Did release of the waste water into Glowegee Creek affect the chemical quality of water downstream at site 3? To answer this question, the ratio of specific conductance at West Milton (site 3) to that at site 1 was taken as a measure of the extent of the effect of waste water. Generally, if the ratio was 1.00 or less, the chemical quality was assumed to be the same at both locations; and the introduction of waste water had no significant effect on the chemical quality of Glowegee Creek at site 3. The converse assumption also is believed to be valid.

Sixty-one percent of the time the specific conductance at site 3 equaled or exceeded that at site 1. Most of the ratio values ranged from 0.95 to 1.15; the average ratio was 1.03 with a standard deviation of 0.08. This information indicated that the waste water did affect the chemical quality of Glowegee Creek water. During the period of record, however, the dissolved solids at site 3 never increased by more than 20 percent over those at site 1. In other words, if specific conductance were 200 micromhos at site 1, it would be about 240 micromhos at site 3. The dissolved-solids concentrations would be about 120 ppm and 144 ppm at sites 1 and 3, respectively. The actual dissolved-solids content (based on specific conductance) did not exceed about 180 ppm. The average dissolved-solids content was about 142 ppm with a standard deviation of about 17 ppm.

Similarly, the ratio of hardness of water from Glowegee Creek at site 3 to that at site 1 indicates that the hardness of water at site 3 was affected by inflow of waste water into the creek. The percentage frequency was about the same as that for specific conductance. Sixty percent of the time, the ratio was greater than one; and 40 percent of the time (the ratio was less than one), waste water had no affect on the hardness. During the period of record, the hardness at site 3 ranged from 67 to 154 ppm and averaged 119 ppm.

Initially, the water temperature of Glowegee Creek rose with inflow of warm waste water from the ditch. Within a short distance, however, dilution and thermal exchange with the air lowered the water temperature of the creek. As would be expected, the lowering took place more rapidly during high flow than during low flow, as well as during periods of cold weather (table 10).

At West Milton no significant departure from the normal temperature was determined. For this purpose, the temperature data obtained

TABLE 10.—*Temperatures, in degrees Fahrenheit, of water from drainage ditch and Glowegee Creek (upstream and downstream from ditch)*

Site	Date				
	10-25-61	11-16-61	1-4-62	4-4-62	4-26-62
Glowegee Creek, 20 yards above ditch (site 1)	44	38	32	34	61
Ditch, at weir (site 2)	67	58	49	59	83
Ditch, 55 feet from weir to point of entry into creek	66	56	49	59	83
Glowegee Creek, 5 yards downstream from ditch	53	45	32	35	65
Glowegee Creek, 20 yards downstream from ditch	50	43	32	34	61
At West Milton (site 3)	47	37	32	37	61
Air-temperature range °F	25-63	18-51	5-38	15-50	37-82
Discharge, Glowegee Creek at West Milton (site 3) cfs	3.0	6.2	9.3	90	23

for Kayaderosseras Creek near West Milton was used as a base for comparison. Both creeks are subject to the same climatic conditions but differ in the size of their drainage area: 26 square miles for Glowegee Creek at West Milton and 90 square miles for Kayaderosseras Creek near West Milton. The agreement of water temperatures for these two streams for the period 1953–57 was excellent, and no significant departures were evident for the period 1958–61 (fig. 15).

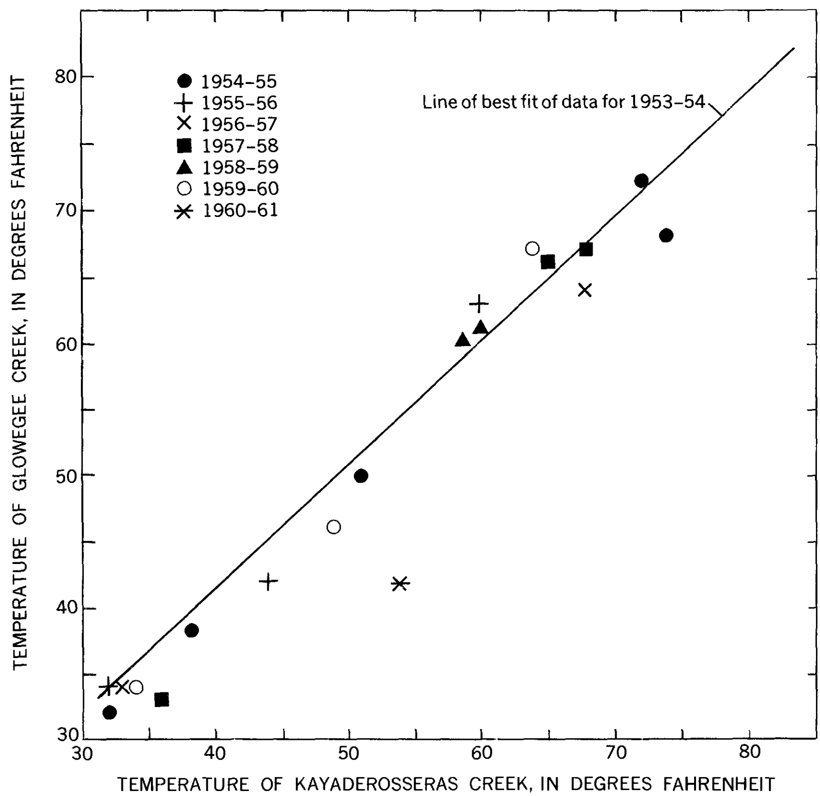

FIGURE 15.—Water temperature of Glowegee Creek at West Milton and Kayaderosseras Creek near West Milton, 1953–61.

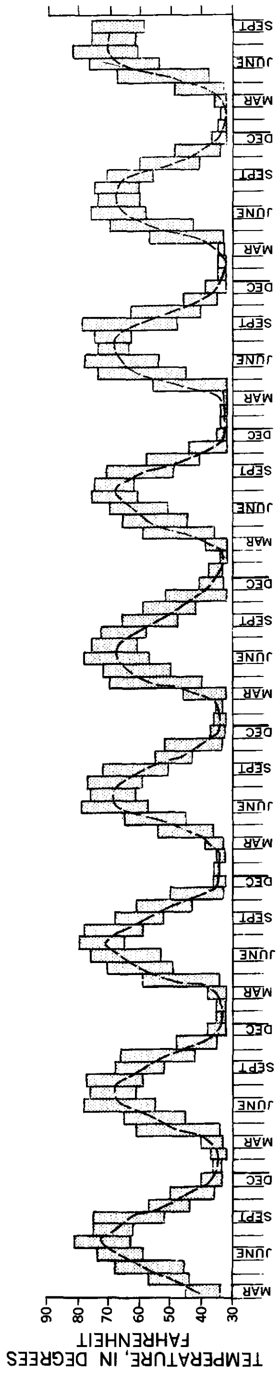

FIGURE 16.—Monthly maximum and minimum water temperatures, Glowegee Creek at West Milton, Mar. 1953–Sept. 1961.

Monthly maximum and minimum temperatures for Glowegee Creek at West Milton are shown in figure 16 for the period 1953–61. Each year a typical sine curve is reported, and no change in the trend is evident.

SELECTED REFERENCES

Mack, F. K., Pauszek, F. H., and Crippen, J. R., 1964, Geology and hydrology of the West Milton area, Saratoga County, New York: U.S. Geol. Survey Water-Supply Paper 1747, 110 p.

U.S. Geological Survey, 1960, Compilation of records of surface waters of the United States through September, 1950, part 1–B, North Atlantic slope basins, New York to York River: U.S. Geol. Survey Water-Supply Paper 1302, 679 p.

——— 1964. Compilation of records of surface waters of the United States, October 1950 to September 1960, part 1–B, North Atlantic slope basins, New York to York River: U.S. Geol. Survey Water-Supply Paper 1722, 578 p.

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