WATER QUALITY DATA FOR PRECIPITATION AND STORM RUNOFF IN PENNYPACK CREEK BASIN, PHILADELPHIA, PENNSYLVANIA

By Deloris W. Speight

U.S. GEOLOGICAL SURVEY

Open-File Report 86-140

Prepared in cooperation with

PHILADELPHIA WATER DEPARTMENT

Harrisburg, Pennsylvania

1989

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
4th Floor, Federal Building
P.O. Box 1107
Harrisburg, Pennsylvania 17108-1107

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who prefer metric (International System) units rather than the inch-pound units used in this report, the following conversion factors may be used:

Multiply Inch-Pound Unit	By	To Obtain Metric Unit
	Length	
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.6093	kilometer (km)
foot per mile (ft/mi)	0.18943	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
acre	0.4047	square hectometer (hm^2)
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	0.001233	cubic hectometer (hm^3)
	Flow	
cubic foot per second (ft^3/s)	28.32	liter per second (L/s)
	0.02832	cubic meter per second (m^3/s)
	Mass	
ton	0.9072	megagram (Mg)

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ABSTRACT

This report presents data on the chemistry of precipitation and storm runoff that were collected during 29 storms from July 1979 through November 1980, in an urban environment in the Pennypack Creek basin, Philadelphia, Pennsylvania. Daily mean and instantaneous stream discharge data were collected at two U.S. Geological Survey gaging stations. Water-quality data collected from these sites and from one storm-sewer sampling site included nutrients, chemical and biochemical oxygen demands, solids, metals, major anions, other constituents, and pH. Instantaneous loads of selected constituents were computed.

Chemical oxygen demand, biochemical oxygen demand, sulfate, alkalinity, chloride, and dissolved solids generally were low in precipitation and runoff. During the November 5, 1980 storm at Pine Road, dissolved nitrate concentrations equaled or exceeded 10 milligrams per liter in 17 percent of the samples analyzed and dissolved ammonia nitrogen concentrations exceeded 2.5 milligrams per liter. Generally, a comparison of median concentration of copper, lead, and zinc in precipitation and runoff at the Tustin Street storm-sewer site showed that median concentrations in precipitation were greater than those in runoff.

INTRODUCTION

Chemistry of precipitation and its impact on runoff quality is largely unknown in the Philadelphia, Pennsylvania urban area (fig. 1). The chemical composition of precipitation varies from place to place, as well as from shower to shower and season to season at the same place. Precipitation contains many constituents of local origin and some that have been transported by winds from distant places. Because dry fallout and contaminants deposited on the ground may have a significant effect on runoff quality, runoff and precipitation data collected concurrently are needed to determine their effect on runoff quality in the urban area. Water-quality management may be needed because contaminated runoff from urbanized areas in Pennypack Park (fig. 1) may adversely alter the ecological balance of the receiving water.

The Pennypack Creek basin was selected for study because Pennypack Creek flows entirely within Pennypack Park in Philadelphia. Four other major creeks, that also flow through parks, traverse Philadelphia. Information collected for this study can be used to assess the impact of precipitation quality on Pennypack Creek and other streams in similar areas. This study was done in cooperation with the Philadelphia Water Department.

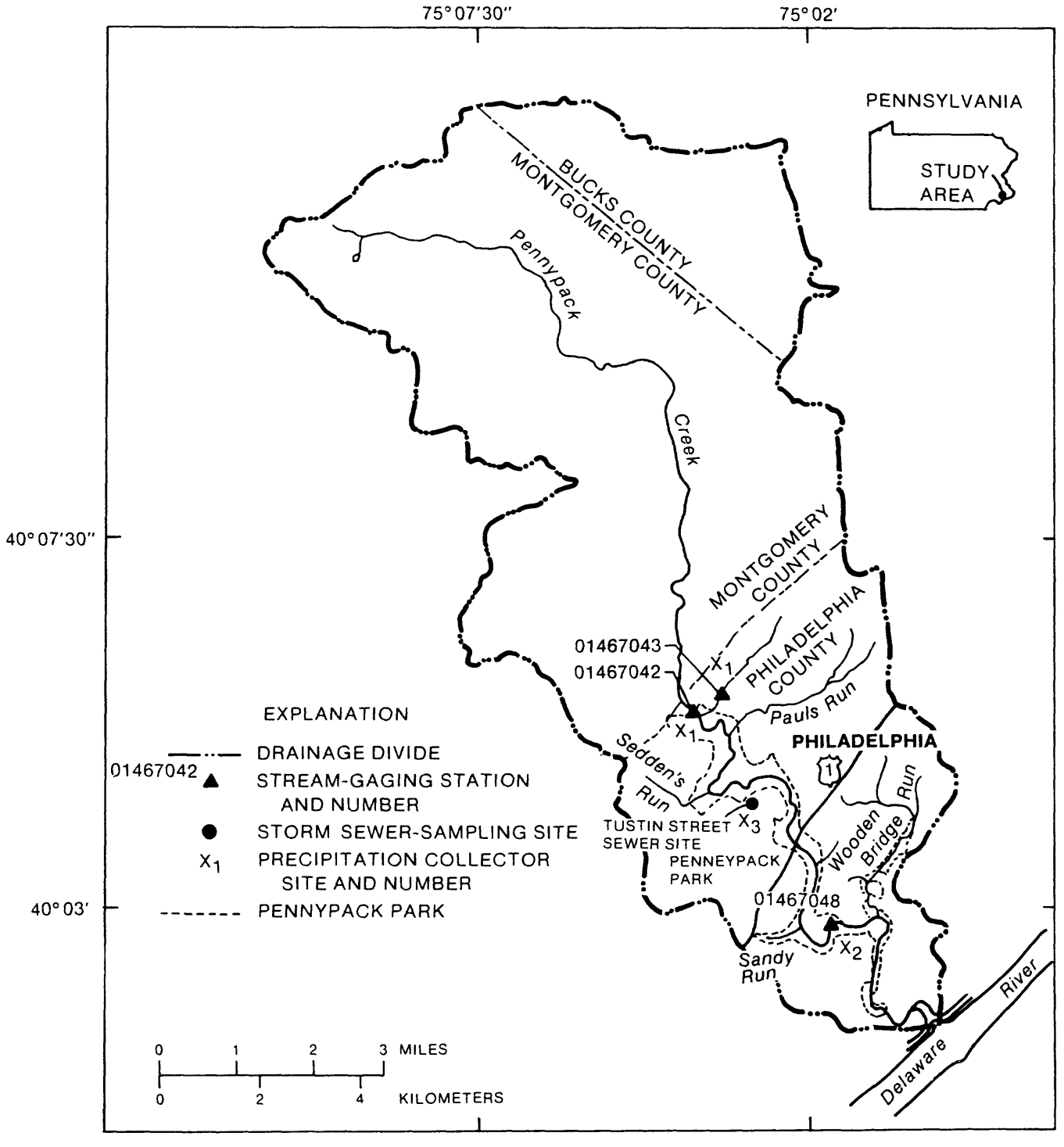

Figure 1.-- Location of data-collection sites.

Purpose and Scope

This report presents the results of a study to determine the quality of precipitation and runoff from the urbanized part of Pennypack Creek basin. The report presents: (1) data on the quality of precipitation and runoff collected from July 1979 through November 1980, and analyzed by the City of Philadelphia; (2) statistical summaries of water-quality data; and (3) comparisons of selected chemical constituents and physical properties of precipitation and runoff.

Description of Study Area

The Pennypack Creek basin has a nontidal drainage area of 55 mi^2 (square miles). The study area (fig. 1) encompasses 22 percent of the Pennypack Creek basin (11.9 mi^2) and is entirely within the city of Philadelphia (Philadelphia County is entirely coincident with the city). Pennypack Creek above Philadelphia's city limit has an average slope of 40 ft/mi (feet per mile). From the city limits to the confluence with the Delaware River, the average slope of the creek is 30 ft/mi.

Acknowledgments

The assistance provided by the City of Philadelphia Water Department, W.J. Marrazzo, Water Commissioner, is gratefully acknowledged. Special thanks to the personnel of the laboratories who analyzed and furnished the water-quality data.

DATA-COLLECTION SITES

Precipitation

Precipitation collectors were installed at three sites (fig. 1) in the Pennypack Creek basin in Philadelphia. One precipitation sample per storm was collected in open plastic buckets located on the roofs of two buildings and in a tree. Precipitation was not sampled for all storms. Personnel arrived onsite as soon as possible after the storm to collect and deliver samples to the two City of Philadelphia laboratories for chemical analysis.

Runoff

Gage height was recorded continuously at the two sites on Pennypack Creek (table 1) and converted to discharge. Daily mean discharge for sampled storms is given in table 2.

Daily mean discharge for the sampled storms exceeded the peak discharge above base of 1,000 ft^3/s (cubic feet per second) at Pine Road (01467042) once and 1,250 ft^3/s at Lower Rhawn Street (01467048) twice. Generally, the flow during the sampled storms did not exceed these discharges. Daily mean discharge ranged from 15 to 1,040 ft^3/s and averaged 208 ft^3/s at Pine Road; at Lower Rhawn Street it ranged from 30 to 1,330 ft^3/s and averaged 325 ft^3/s. The average discharge was 67.3 ft^3/s at Pine Road for 1964-81 and 93.7 ft^3/s at Lower Rhawn Street for 1965-81.

Table 1.--Description of discharge data-collection sites

SITE 1 - Station Number:	01467042
Station Name:	Pennypack Creek at Pine Road, Philadelphia, Pa.
Location:	Latitude 40°05'23", Longitude 75°04'10" Philadelphia County. On right bank 20 feet below Pine Road, 300 feet upstream from Stream "A" at north city limits of Philadelphia.
Drainage Area:	37.9 square miles.
Gage:	Water-stage recorder.
SITE 2 - Station Number:	01467048
Station Name:	Pennypack Creek at Lower Rhawn Street Bridge, Philadelphia, Pa.
Location:	Latitude 40°03'00", Longitude 75°01'59" Philadelphia County. On left bank at downstream side of footbridge pier, 400 feet downstream from Lower Rhawn Street Bridge, upstream from Wooden Bridge Run in Philadelphia.
Drainage Area:	49.8 square miles.
Gage:	Water-stage recorder.

Table 2.--Streamflow for sampled storms

Date	Daily mean discharge for Pennypack Creek at Pine Road (cubic feet per second)	Daily mean discharge for Pennypack Creek at Lower Rhawn Street Bridge (cubic feet per second)
July 17, 1979	143	248
July 18, 1979	88	99
July 25, 1979	39	51
July 30, 1979	1,040	1,330
Aug. 2, 1979	64	72
Aug. 3, 1979	79	173
Aug. 4, 1979	73	102
Aug. 6, 1979	42	45
Aug. 12, 1979	313	400
Aug. 18, 1979	46	52
Aug. 30, 1979	35	45
Sept. 6, 1979	884	1,300
Sept. 24, 1979	51	49
Oct. 1, 1979	489	718
Oct. 10, 1979	578	830
Oct. 11, 1979	167	285
Nov. 5, 1979	51	54
May 22, 1980	48	53
July 17, 1980	22	42
July 24, 1980	15	30
July 29, 1980	600	850
July 30, 1980	50	125
Aug. 6, 1980	600	1,010
Aug. 12, 1980	117	181
Sept. 15, 1980	48	70
Sept. 18, 1980	254	508
Sept. 26, 1980	23	507
Oct. 3, 1980	58	114
Nov. 5, 1980	16	74

Runoff was sampled at predetermined intervals for selected storms at the two streamflow sites on Pennypack Creek and at one storm-sewer site (fig. 1) that drains into the creek. Runoff from each storm was sampled by an ISCO[1] automatic sampler and analyzed by the City of Philadelphia laboratories. The samplers were set to activate at various stages and generally collected one bottle every 15 minutes. Sampling continued until all bottles were used. Samples were composited.

STATISTICAL SUMMARIES OF WATER-QUALITY OF PRECIPITATION AND RUNOFF

Table 3 gives the water-quality constituents, range of the values, and the number of samples collected. Instantaneous loads for three storms were computed (table 4). The following procedure, described by Anderson and Faust (1973, p. 40), was used to compute the loads.

Table 3.--Range in concentration of selected constituents in precipitation and runoff

[mg/L, milligrams per liter; µg/L, micrograms per liter; a double dash indicates no data]

Station name	NUTRIENTS							OXYGEN DEMANDS	
	Nitrogen, nitrate dissolved (mg/L as N)	Nitrogen, nitrite dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, organic total (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Phosphorus, total (mg/L as P)	Carbon, organic total (mg/L as C)	Chemical oxygen demand (mg/L)	Biochemical oxygen demand 5 day (mg/L)
	Number of precipitation samples								
Pine Road	16	16	8	7	9	16	2	3	0
Lower Rhawn	11	10	3	0	0	11	0	5	0
Tustin Street	13	12	8	8	9	16	5	7	0
	Concentration range								
Pine Road	0.09-2.9	0.00-0.13	0.04-1.0	<0.1-1.6	<0.1-2.6	0.01-0.21	5.1-11	5- 7	--
Lower Rhawn	.11-2.7	.00- .02	.07- .45	--	--	.01- .17	--	5-24	--
Tustin Street	.10-7.6	.00- .03	.08-1.3	< .1-1.4	< .1-2.2	.01- .18	.5- 9.3	12-31	--
	Number of runoff samples								
Pine Road	120	120	81	0	0	132	0	93	11
Lower Rhawn	129	129	133	0	0	133	0	28	0
Tustin Street	24	24	24	11	11	24	11	24	0
	Concentration range								
Pine Road	0.02-26	0.00-0.96	0.01-2.9	--	--	0.40-34	--	8-460	14-46
Lower Rhawn	.03- 2.6	.01- .13	.02- .84	--	--	.24-11	--	12- 52	--
Tustin Street	.13- 3.4	.00- .02	.01-2.1	<0.1- 2.3	.5-3.3	.02- .26	5.7-16	4- 40	--

[1] Use of firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Water-quality constituents can be expressed in load units. A convenient unit is tons per day, which is derived from the following relation between concentration and water discharge:

$$L = kCQ$$

where L is load, in tons per day;
C is concentration, in milligrams per liter;
Q is water discharge, in cubic feet per second; and
k is a conversion factor equal to 0.0027 tons per day per milligram per liter-cubic foot per second.

The calculated instantaneous loads may be used to assess the impact of the runoff on the quality of the receiving stream. Table 5 (at back of report) gives precipitation chemistry data for selected storms. For seven of these storms, concurrent runoff chemistry data is available (table 6, at end of report).

Table 3.--Range in concentration of selected constituents in precipitation and runoff--(Continued)

SOLIDS		MAJOR ANIONS AND OTHER CONSTITUENTS				METALS					
Solids, dissolved (mg/L)	Solids, suspended (mg/L)	pH Lab (units)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Zinc, dissolved (µg/L as Zn)
				Number of precipitation samples							
8	15	16	16	15	16	9	9	9	7	9	9
0	10	11	11	11	11	0	0	0	0	0	0
8	16	14	14	17	15	9	9	9	4	9	9
				Concentration range							
6-166	0- 62	3.6-5.1	0-1	2-51	0-3	<10-20	<10-20	10- 70	80-470	<10-140	40-360
--	0-122	3.7-5.2	0-7	4-29	1-3	--	--	--	--	--	--
4- 76	0-204	3.4-5.0	0-2	3-59	1-4	<10-20	<10-50	10-340	180-460	10-280	80-490
				Number of runoff samples							
0	131	107	107	117	121	0	0	0	0	0	0
0	133	133	133	132	133	0	0	0	0	0	0
11	24	24	24	24	24	11	11	11	0	11	11
				Concentration range							
--	14- 3,990	4.5-7.7	0-78	19-270	4-41	--	--	--	--	--	--
--	50-46,900	4.7-7.7	2-50	6- 96	4-19	--	--	--	--	--	--
28-126	1- 157	5.0-8.0	1-64	1- 14	1- 6	10-20	<10-90	10- 40	--	10-290	60-220

Water-quality data statistics for precipitation and storm runoff are given in tables 7 and 8 (at back of report); the data include means, medians, minimums, maximums, and numbers of measurements of properties and constituents for six types of chemical data: nutrients, chemical and biochemical oxygen demands, solids, metals, major anions, and other constituents. Statistical summaries are not included when less than three values are reported for a constituent. Two kinds of statistics are computed in tables 7 and 8--the arithmetic mean and the median. The arithmetic mean cannot be computed from a value with open-ended class intervals; that is, when the items are grouped in < (less than) class intervals. Therefore, the calculations made in these tables containing open-ended groups are based on closing the ends (dropping the < condition) and are greater than the actual value. That is, by dropping the < condition, a higher-than-normal concentration bias is created. The median is a better measure of central tendency of small data sets than the mean. Tables 9 to 19 (at back of report) list runoff water-quality data by constituent for sampled storms.

Table 4.--Constituent values and instantaneous loads for runoff from three storms

[ft^3/s, cubic foot per second; µS/cm, microsiemens per centimeter at 25° Celsius; Deg C, degree Celsius; mg/L, milligrams per liter; Colonies/100 mL, Colonies per 100 milliliters; tons/d, tons per day; a double dash indicates no data]

Station name	Time	Streamflow-instantaneous (ft^3/s)	Specific conductance (µS/cm)	Temperature, water (Deg C)	Oxygen, dissolved (mg/L)	Biochemical oxygen demand 5 day (mg/L)	Fecal coliform (Colonies /100 mL)	Dissolved nitrate Concentration (mg/L as N)	Dissolved nitrate Load (tons /d)	Dissolved nitrite Concentration (mg/L as N)	Dissolved nitrite Load (tons/ /d)	Dissolved ammonia Concentration (mg/L as N)	Dissolved ammonia Load (tons /d)	Total phosphorus Concentration (mg/L as P)	Total phosphorus Load (tons /d)
							August 6, 1979								
Pine Road	0730	36	317	23.0	6.4	2.9	1,300	2.6	0.26	0.06	0.01	0.16	0.02	3.4	0.33
Lower Rhawn	0815	49	285	24.0	7.6	2.3	1,500	2.5	.33	.06	.01	.04	.01	1.6	.21
							October 1, 1979								
Pine Road	0700	99	209	17.5	7.8	3.9	900	2.1	.56	.11	.03	--	--	1.3	.35
Lower Rhawn	0900	109	170	17.5	8.6	3.9	500	1.9	.56	.06	.02	--	--	.93	.27
							November 5, 1979								
Pine Road	0640	45	281	7.0	9.6	1.3	700	3.4	.41	.11	.01	.30	.04	2.3	.28
Lower Rhawn	0715	61	240	7.0	10.9	1.7	600	2.7	.44	.07	.01	.09	.01	1.7	.28

Nutrients

Leaching of fertilizers from lawns and gardens, leaves, and garden trimmings are likely sources of nitrogen in urban runoff. Another source of nitrogen is excrement, primarily from dogs, cats, and birds. Precipitation also may account for a large fraction of the total nitrogen concentration in runoff.

Dissolved Nitrate

Nitrate in water may be caused by the decay of organic matter or from sewage or nitrogen-bearing fertilizers washed from soils. The maximum contaminant level in drinking water, established by the USEPA (U.S. Environmental Protection Agency, 1975) is 10 mg/L (milligrams per liter) nitrate as nitrogen. Nitrate is essential for algal growth, and concentrations seldom exceed 10 mg/L in nonpolluted water. Nitrate and chloride are major components of human and animal wastes, and elevated concentrations of both suggest pollution. Nitrate in the precipitation samples at all three sites ranged from 0.09 to 7.6 mg/L (table 7). Nitrate concentrations in runoff at Lower Rhawn Street and Tustin Street storm-sewer sites were less than 3.5 mg/L (table 8). At Pine Road, concentrations equaled or exceeded 10 mg/L in 17 percent of the samples analyzed and reached a maximum of 26 mg/L for the November 5, 1980, storm (table 9).

Dissolved Nitrite

Nitrite may be found in waters receiving municipal and industrial wastes. Nitrite in surface water is quickly oxidized to nitrate, which is then used in photosynthesis (Chow, 1964). Nitrite concentrations in precipitation and runoff samples from all three sites were less than 1 mg/L (tables 5 and 10).

Dissolved Ammonia Nitrogen

Dissolved ammonia nitrogen--a component of the nitrogen cycle--is a common minor component of water. A concentration of more than 0.1 mg/L usually indicates organic pollution. The toxicity to fish can be directly related to the amount of ammonia in solution and is dependent on the pH of the water. Although the tolerances of fish differ, 2.5 mg/L of ammonia nitrogen is considered harmful in the 7.4 to 8.5 pH range. Ammonia concentrations were a small fraction of the total nitrogen and exceeded 2.5 mg/L only in the runoff samples collected on November 5, 1980, for Pine Road (table 11).

Total Organic and Total Kjeldahl Nitrogen

The concentrations of total organic nitrogen for precipitation and runoff samples at the Tustin Street storm-sewer site were essentially the same. The minimums for both precipitation and runoff at this site were less than 0.1 mg/L and the maximums were 1.4 mg/L for precipitation and 2.3 mg/L for runoff (tables 7 and 8). Total kjeldahl nitrogen (reported as total ammonia plus organic nitrogen) generally accounted for a little more than one-half of the total nitrogen present in both runoff and precipitation.

Total Organic Carbon

The range of total organic carbon concentrations at the Tustin Street storm-sewer site differed substantially for precipitation (0.5 to 9.3 mg/L) and runoff (5.7 to 16 mg/L); however, median total organic carbon values for the precipitation and runoff were 7.0 and 7.4 mg/L, respectively (tables 7 and 8).

Total Phosphorus

In concentrations found in water, phosphorus is not reported to be toxic to man, animal, or fish. However, the element does stimulate the growth of algae, which is a nuisance to public-water supplies and open-water bodies. Mean total phosphorus concentration for precipitation and runoff from all stations were 0.05 and 2.4 mg/L, respectively (tables 7 and 8).

Oxygen Demands

Chemical oxygen demand (COD) is an indicator of the pollutant load imposed upon a water system by oxygen-demanding material dissolved or suspended in the water. Probable sources of COD are automobile oil and gasoline residue on the streets, and particulate organic debris, such as leaves and bits of paper. The COD concentration of rainfall at all sites did not exceed 31 mg/L (table 7). The mean COD of runoff at all sites was 76 mg/L (table 8). At these levels the COD of the water is probably insufficient to cause oxygen depletion.

Biochemical oxygen demand (BOD), an indirect measure of organic matter in a stream, was determined in only 11 runoff samples from the Pine Road site for the August 18, 1979, storm. The maximum BOD, 46 mg/L, was found in the first sample collected (table 19).

Solids

Dissolved Solids

The dissolved-solids concentration of water denotes the amount of chemicals in solution. Dissolved solids in excess of 1,000 mg/L in water may have adverse physiological effects when ingested, and such water is not recommended for many purposes. Drinking-water standards of the USEPA (1975) and most State agencies recommend a limit of 500 mg/L. Low concentrations of sulfate and dissolved solids characterized the quality of both precipitation and runoff waters and are of little significance when considering the impact of precipitation on runoff. Sulfate concentrations in runoff at all sites ranged from 1 to 270 mg/L, with a median of 33 mg/L (table 8). The dissolved-solids concentrations in precipitation at all sites ranged from 4 to 166 mg/L, with a mean of 58 mg/L for all sites.

Suspended Solids

Suspended solids in stream water are due to the erosion of stream channels and land. The quantity, characteristics, and cause of sediment in streams are influenced by environmental factors. Some major factors are

degree of slope, length of slope, soil characteristics, land use, and quantity and intensity of precipitation. Suspended solids in precipitation and in runoff ranged from 0 to 204 mg/L (table 7) and from 1 to 46,900 mg/L (table 8), respectively.

Metals

Elevated concentrations of dissolved metals--principally cadmium, chromium, copper, iron, lead, and zinc--can adversely affect organisms in aquatic environments. Cadmium, chromium, and lead are toxic to humans. Precipitation samples collected at Pine Road and at the Tustin Street storm-sewer site and runoff samples collected at the Tustin Street storm-sewer site were analyzed for metals. Except for iron, the highest concentration of the metals in precipitation samples was found at the Tustin Street storm-sewer site (table 7).

Cadmium is a common component of industrial waste, inasmuch as it is used in metallurgy, electroplating, ceramics, and photography. The USEPA (1975) has established a criterion of 10 µg/L (micrograms per liter) of cadmium for marine aquatic environments and public-health standards. Concentrations in runoff at the Tustin Street sewer site on August 4, 1979, equaled or exceeded this criterion in every sample (table 19).

Chromium from natural sources generally is not found in measurable concentrations in water. Some runoff samples exceeded the recommended limit (USEPA, 1976) of 50 µg/L, but the precipitation samples did not exceed this limit (table 7).

In water supplies, iron causes no adverse health effects. Iron concentrations ranged from 80 to 470 µg/L in the precipitation samples from all sites. The recommended limit (USEPA, 1976) of 300 µg/L for domestic-water supplies was exceeded in 27 percent of the samples.

Generally, a comparison of median concentration of copper, lead, and zinc in precipitation and runoff at the Tustin Street storm-sewer site showed that median concentrations in precipitation were greater than those in runoff (tables 7 and 8). Lead concentrations exceeded the drinking-water recommended limit (USEPA, 1975) of 50 µg/L in 78 percent of the precipitation samples and in 55 percent of runoff samples at the Tustin Street storm-sewer site.

pH and Major Anions

pH

Hydrogen-ion concentration (pH) is one of the primary determinations used to characterize the quality of precipitation and urban runoff. A pH below 7.0 indicates acidic conditions and above 7.0 indicates basic or alkaline conditions. In natural waters, pH generally ranges from 6.0 to 8.5. The main factors usually controlling the pH of water are the geochemistry of the drainage basin and external influences such as pollution.

Very acidic water or very alkaline water can corrode metals and concrete and may indicate the presence of contaminants. The frequency distribution of all the pH data at the three sites is summarized in figure 2.

The pH of rainfall in equilibrium with atmospheric carbon dioxide at 25°C is 5.7 (Carroll, 1962). The pH of precipitation in all of the samples (fig. 2) ranged from 3.4 to 5.2. The most common value of pH in precipitation and in runoff was 3.9 and 7.0, respectively. pH of precipitation was consistently acidic, but pH of runoff ranged from acid to alkaline; 93 percent of pH values for runoff ranged from 5.6 to 8.0.

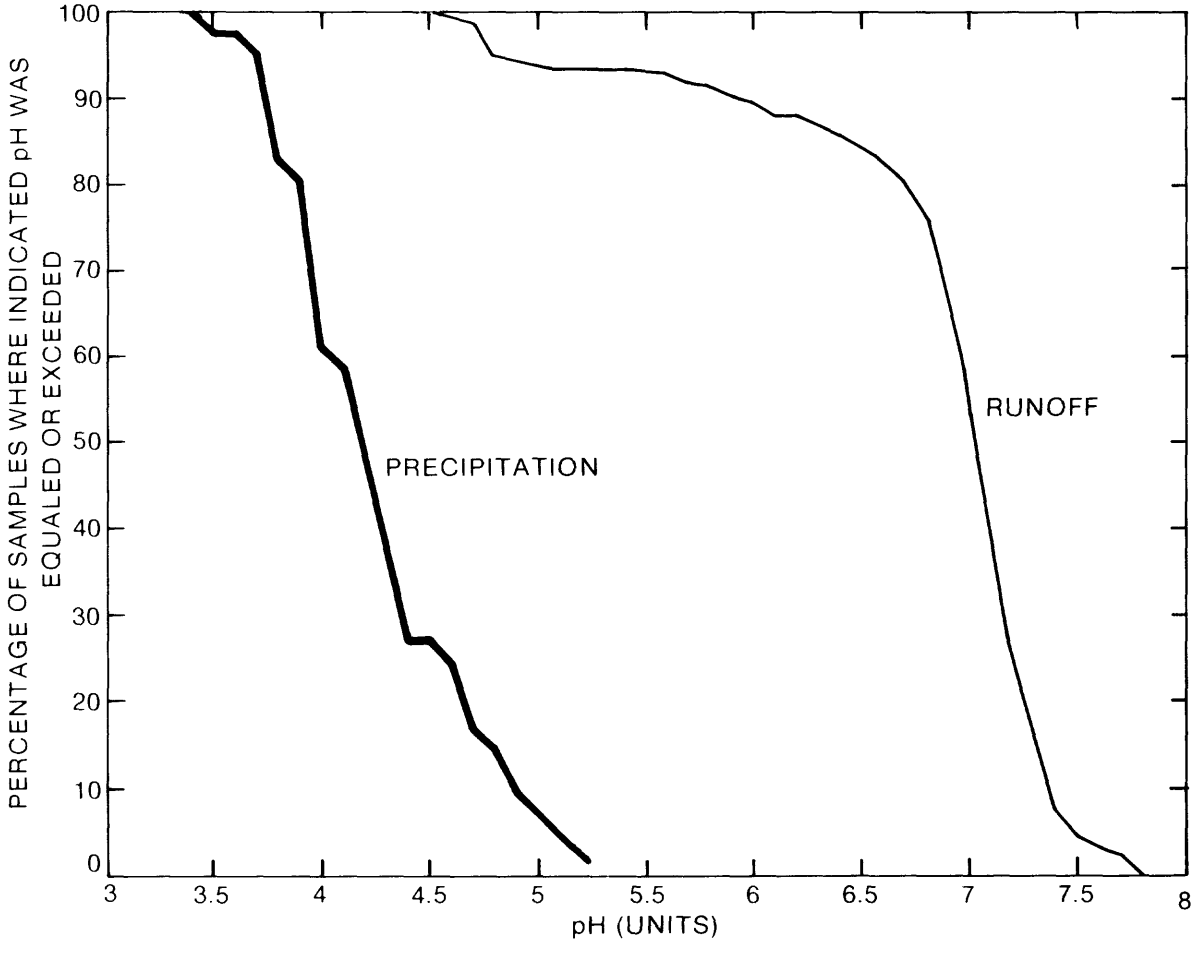

Figure 2.-- Frequency distribution of pH in precipitation and runoff.

Alkalinity

Alkalinity is a measure of the capacity of water to neutralize acid. Excessive alkalinity is undesirable in water for some uses, mainly because of its association with waters having excessive hardness or elevated concentrations of sodium (Chow, 1964). The criterion for alkalinity (USEPA, 1976) is 20 mg/L or more as $CaCO_3$ for freshwater aquatic life except where natural concentrations are less. The alkalinity of runoff at all the sites was 20 mg/L or more in 58 percent of the samples. The maximum alkalinity concentration in precipitation at all sites was only 7.0 mg/L (table 7); the maximum concentration in runoff at all the sites was 78 mg/L (table 8).

Sulfate

Sulfate is a component of the dissolved-solids content of water. Federal drinking-water recommended limit (USEPA, 1975) is that the concentration not exceed 250 mg/L. Sulfate concentrations ranged from 1 to 270 mg/L in precipitation and runoff at all sites (table 7 and 8), but 250 mg/L was only exceeded in one out of the 316 samples analyzed.

Chloride

Chloride is present in almost all stream waters and also may be present in sewage, waste brines, and industrial discharges. Human and animal excreta contain elevated concentrations of chloride. Chloride adds to the dissolved-solids concentration and increases the corrosive character of water. The USEPA (1977) recommends that the chloride concentration not exceed 250 mg/L. Chloride concentrations were less than or equal to 4 mg/L in precipitation and were less than or equal to 41 mg/L in runoff at all sites.

SUMMARY

Samples of precipitation and runoff were collected at three sites in the Pennypack Creek basin, Philadelphia, Pennsylvania to determine the water quality of precipitation and runoff in an urban area. Twenty-six constituents were analyzed in samples collected during 29 storms from July 1979 through November 1980.

Six types of chemical data were tabulated: nutrients, chemical and biochemical oxygen demands, solids, dissolved metals, major anions, and other constituents. Nitrite concentration of precipitation and runoff at all three sites did not exceed 1 mg/L, whereas the nitrate reached a maximum of 26 mg/L for the November 5, 1980, storm at the Pine Road site. Chemical oxygen demand, biochemical oxygen demand, sulfate, alkalinity, chloride, and dissolved solids generally were low in precipitation and runoff. The highest dissolved-metal concentrations (except iron) in precipitation was found at the Tustin Street storm-sewer site. The pH of precipitation was always acidic, and pH of runoff varied from acidic to alkaline. Ninety-three percent of runoff pH values ranged from 5.6 to 8.0.

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(p. 16 follows)

Table 5.--Quality of precipitation for selected storms

[mg/L, milligrams per liter; µg/L, micrograms per liter; a double dash indicates no data]

Date of collection	NUTRIENTS							OXYGEN DEMAND
	Nitrogen, nitrate dissolved (mg/L as N)	Nitrogen, nitrite dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, organic total (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Phosphorus, total (mg/L as P)	Carbon, organic total (mg/L as C)	Chemical oxygen demand (mg/L)
01467042 Pennypack Creek at Pine Road								
Aug. 3, 1979	--	--	--	1.6	2.6	--	11	--
Aug. 4, 1979	--	--	--	1.4	1.8	--	5.1	--
Aug. 12, 1979	0.48	0.01	0.20	<.1	<.1	0.02	--	--
Aug. 18, 1979	1.3	.01	1.0	.1	1.5	.05	--	--
Aug. 30, 1979	.72	.01	.59	.8	1.4	.05	--	--
Sept. 6, 1979	2.9	.13	.11	.5	.7	.01	--	--
Oct. 1, 1979	.49	.01	.23	.5	.8	.07	--	--
Oct. 10, 1979	.33	.01	.20	--	1.5	.02	--	--
Oct. 11, 1979	.09	.01	.04	--	1.3	.03	--	--
May 22, 1980	.69	.01	--	--	--	.05	--	--
July 29, 1980	.11	.00	.09	--	--	.05	--	--
July 30, 1980	.37	.01	--	--	--	.03	--	5
Aug. 6, 1980	.95	.01	--	--	--	.02	--	5
Aug. 12, 1980	.50	.01	--	--	--	.02	--	--
Sept. 15, 1980	1.5	.01	--	--	--	.21	--	7
Sept. 18, 1980	.23	.01	--	--	--	.02	--	--
Sept. 26, 1980	.53	.01	--	--	--	.04	--	--
Oct. 3, 1980	.62	.01	--	--	--	.02	--	--
01467048 Pennypack Creek at Lower Rhawn Street Bridge								
Oct. 10, 1979	0.31	0.01	0.18	--	--	0.02	--	--
July 24, 1980	.71	--	--	--	--	.06	--	24
July 29, 1980	.11	.00	.07	--	--	.03	--	8
July 30, 1980	.42	.01	--	--	--	.01	--	5
Aug. 6, 1980	.78	.01	--	--	--	.02	--	--
Aug. 12, 1980	.57	.01	--	--	--	.02	--	14
Sept. 15, 1980	2.7	.02	--	--	--	.17	--	--
Sept. 18, 1980	.22	.01	--	--	--	.01	--	--
Sept. 26, 1980	.68	.02	--	--	--	.07	--	--
Oct. 3, 1980	.67	.01	--	--	--	.03	--	--
Nov. 5, 1980	.40	.02	.45	--	--	.02	--	6
Tustin Street								
July 17, 1979	--	--	--	0.3	0.8	0.18	9.3	23
July 18, 1979	--	--	0.46	.5	1.5	.08	5.5	31
July 25, 1979	--	--	.95	.4	1.4	.05	7.0	24
July 30, 1979	--	--	--	.5	1.0	--	0.5	--
Aug. 2, 1979	0.98	0.01	.51	1.4	2.0	.07	7.3	29
Aug. 4, 1979	--	--	--	--	--	--	--	--
Aug. 12, 1979	.53	.01	.30	<.1	<.1	.03	--	--
Aug. 18, 1979	1.5	.01	1.3	.4	2.2	.06	--	--
Sept. 6, 1979	7.6	.01	.08	.2	.3	.01	--	--
Oct. 10, 1979	.31	.01	.18	--	1.8	.02	--	--
July 17, 1980	.72	.02	--	--	--	.18	--	12
July 24, 1980	.90	--	--	--	--	.05	--	21
July 29, 1980	.10	.00	.09	--	--	.03	--	--
Aug. 6, 1980	.60	.01	--	--	--	.02	--	--
Aug. 12, 1980	.57	.01	--	--	--	.03	--	12
Sept. 15, 1980	4.0	.02	--	--	--	.15	--	--
Sept. 26, 1980	.80	.03	--	--	--	.07	--	--
Oct. 3, 1980	.79	.01	--	--	--	.04	--	--

SOLIDS		MAJOR ANIONS AND OTHER CONSTITUENTS				METALS					
Solids, dissolved (mg/L)	Solids, suspended (mg/L)	pH Lab (units)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Zinc, dissolved (µg/L as Zn)
					01467042 Pennypack Creek at Pine Road						
104	—	—	—	—	—	20	20	70	—	100	360
86	—	—	—	—	—	10	20	10	—	70	220
—	1	3.9	0	13	3	<10	<10	10	80	10	40
14	0	3.7	0	51	2	<10	<10	10	470	140	90
34	5	3.9	0	4	3	10	20	30	220	140	90
22	9	5.1	1	2	3	<10	<10	10	190	<10	60
166	5	4.3	0	6	2	<10	<10	20	160	30	80
6	0	4.3	0	6	2	<10	<10	30	380	30	110
16	6	4.6	1	8	1	<10	10	20	230	20	60
—	15	4.1	0	—	0	—	—	—	—	—	—
—	1	4.7	1	12	1	—	—	—	—	—	—
—	3	4.3	0	8	2	—	—	—	—	—	—
—	2	3.6	0	10	1	—	—	—	—	—	—
—	48	3.9	0	5	1	—	—	—	—	—	—
—	62	3.9	0	19	1	—	—	—	—	—	—
—	0	4.1	0	4	1	—	—	—	—	—	—
—	—	4.6	1	17	2	—	—	—	—	—	—
—	7	4.3	0	6	1	—	—	—	—	—	—
					01467048 Pennypack Creek at Lower Rhawn Street Bridge						
—	0	4.2	0	6	2	—	—	—	—	—	—
—	9	4.1	0	6	1	—	—	—	—	—	—
—	1	5.2	7	4	2	—	—	—	—	—	—
—	4	4.2	0	4	1	—	—	—	—	—	—
—	5	3.7	0	8	1	—	—	—	—	—	—
—	122	3.9	0	5	1	—	—	—	—	—	—
—	9	3.9	0	24	3	—	—	—	—	—	—
—	4	4.2	0	4	1	—	—	—	—	—	—
—	—	4.8	1	29	2	—	—	—	—	—	—
—	13	4.3	0	6	1	—	—	—	—	—	—
—	1	4.5	0	8	1	—	—	—	—	—	—
					Tustin Street						
16	20	3.4	0	5	1	10	50	100	—	220	490
44	21	3.7	0	6	1	<10	<10	60	—	240	430
22	3	—	—	8	—	<10	<10	340	—	280	450
8	—	—	—	—	—	<10	20	70	—	170	370
76	12	3.9	0	8	2	20	40	30	—	90	320
—	1	—	—	10	—	—	—	—	—	—	—
—	0	3.7	0	14	2	<10	<10	10	200	10	80
8	4	3.7	0	59	3	<10	<10	20	460	200	160
32	10	4.9	1	3	4	<10	<10	10	180	70	90
4	0	4.2	0	6	2	<10	<10	20	270	50	310
—	0	—	—	15	2	—	—	—	—	—	—
—	17	4.1	0	5	1	—	—	—	—	—	—
—	1	4.8	2	3	1	—	—	—	—	—	—
—	8	3.8	0	7	1	—	—	—	—	—	—
—	204	3.9	0	5	1	—	—	—	—	—	—
—	9	4.0	0	23	3	—	—	—	—	—	—
—	—	5.0	1	26	2	—	—	—	—	—	—
—	10	4.6	1	5	1	—	—	—	—	—	—

Table 6.--Chemical quality of precipitation and runoff for selected storms, 1979-80

[mg/L, milligrams per liter; a double dash indicates no data]

Storm date	Aug. 18, 1979	Sept. 06, 1979	July 29, 1980	July 30, 1980	Oct. 10, 1979	July 29, 1980	Aug. 04, 1979
	Pennypack Creek at Pine Road				Pennypack Creek at Lower Rhawn Street		Tustin Street
Dissolved nitrate nitrogen							
Precipitation	--	2.9	0.11	0.37	0.31	0.11	--
First runoff	--	.99	11	.77	2.2	1.6	--
Last runoff	--	1.3	9.1	.92	1.2	1.2	--
Dissolved nitrite nitrogen							
Precipitation	--	0.13	0	0.01	0.01	0	--
First runoff	--	.03	0.57	.17	.02	0.07	--
Last runoff	--	.01	.47	.96	.01	.07	--
Dissolved ammonia nitrogen							
Precipitation	--	0.11	0.09	--	0.18	0.07	--
First runoff	--	.08	.47	--	.05	.15	--
Last runoff	--	.07	.31	--	.03	.11	--
Total phosphorus							
Precipitation	0.05	0.01	0.05	0.03	0.02	0.03	--
First runoff	1.8	.40	2.9	5.9	.67	.92	--
Last runoff	.97	.38	1.9	2.5	.71	.98	--
Chemical oxygen demand							
Precipitation	--	--	--	5	--	8	--
First runoff	--	--	--	460	--	31	--
Last runoff	--	--	--	210	--	31	--
Suspended solids							
Precipitation	0	9	1	3	0	1	1
First runoff	684	140	638	3,990	244	288	6
Last runoff	444	28	103	2,310	404	425	2
pH [units]							
Precipitation	--	5.1	4.7	4.3	4.2	5.2	--
First runoff	--	7.1	6.8	6.9	7.2	6.8	--
Last runoff	--	7.2	7.0	6.8	7.2	7.1	--
Alkalinity							
Precipitation	--	1	1	0	0	7	--
First runoff	--	23	47	37	14	18	--
Last runoff	--	24	53	25	9	22	--
Dissolved sulfate							
Precipitation	--	2	12	8	6	4	10
First runoff	--	22	62	100	28	65	14
Last runoff	--	19	55	200	13	11	4
Dissolved chloride							
Precipitation	--	3	1	2	2	2	--
First runoff	--	8	37	6	14	11	--
Last runoff	--	10	38	7	9	12	--

Table 7.-Statistical summary of precipitation chemistry

[mg/L, milligrams per liter; µg/L, micrograms per liter; a double dash indicates no data]

	NUTRIENTS							OXYGEN DEMANDS	
	Nitrogen, nitrate dissolved (mg/L as N)	Nitrogen, nitrite dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, organic total (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Phosphorus, total (mg/L as P)	Carbon, organic total (mg/L as C)	Chemical oxygen demand (mg/L)	Biochemical oxygen demand 5 day (mg/L)
				01467042 Pennypack Creek at Pine Road					
Mean	0.74	0.02	0.31	0.7	1.3	0.04	--	6	--
Median	.52	.01	.20	.5	1.4	.03	--	5	--
Minimum	.09	.00	.04	<.1	<.1	.01	--	5	--
Maximum	2.9	.13	1.0	1.6	2.6	.21	--	7	--
Number of values	16	16	8	7	9	16	*	3	*
				01467048 Pennypack Creek at Lower Rhawn Street Bridge					
Mean	0.69	0.01	0.23	--	--	0.04	--	11	--
Median	.57	.01	.18	--	--	.02	--	8	--
Minimum	.11	.00	.07	--	--	.01	--	5	--
Maximum	2.7	.02	.45	--	--	.17	--	24	--
Number of values	11	10	3	*	*	11	*	5	*
				Tustin Street					
Mean	1.5	0.01	0.48	0.5	1.2	0.07	5.9	22	--
Median	.79	.01	.38	.4	1.4	.05	7.0	23	--
Minimum	.10	.00	.08	<.1	<.1	.01	.5	12	--
Maximum	7.6	.03	1.3	1.4	2.2	.18	9.3	31	--
Number of values	13	12	8	8	9	16	5	7	*
				Summary of all precipitation data					
Mean	0.97	0.01	0.37	0.6	1.3	0.05	6.5	15	--
Median	.61	.01	.20	.5	1.4	.03	7.0	12	--
Minimum	.09	.00	.04	<.1	<.1	.01	.5	5	--
Maximum	7.6	.13	1.3	1.6	2.6	.21	11	31	--
Number of values	40	38	19	15	18	43	7	15	*

* Less than 3 values are reported

SOLIDS		MAJOR ANIONS AND OTHER CONSTITUENTS				METALS					
Solids, dis-solved (mg/L)	Solids, sus-pended (mg/L)	pH Lab (units)	Alka-linity (mg/L as $CaCO_3$)	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Cadmium, dis-solved (µg/L as Cd)	Chro-mium, dis-solved (µg/L as Cr)	Copper, dis-solved (µg/L as Cu)	Iron, dis-solved (µg/L as Fe)	Lead, dis-solved (µg/L as Pb)	Zinc, dis-solved (µg/L as Zn)
				01467042 Pennypack Creek at Pine Road							
56	11	4.4	0	11	2	11	10	23	250	61	120
28	5	4.2	0	8	2	<10	<10	20	220	30	90
6	0	3.6	0	2	0	<10	<10	10	80	<10	40
166	62	5.1	1	51	3	20	20	70	470	140	360
8	15	16	16	15	16	9	9	9	7	9	9
				01467048 Pennypack Creek at Lower Rhawn Street Bridge							
--	17	4.5	1	9	1	--	--	--	--	--	--
--	5	4.2	0	6	1	--	--	--	--	--	--
--	0	3.7	0	4	1	--	--	--	--	--	--
--	122	5.2	7	29	3	--	--	--	--	--	--
*	10	11	11	11	11	*	*	*	*	*	*
				Tustin Street							
26	20	4.4	0	12	2	11	20	73	280	150	300
19	9	4.0	0	7	2	<10	<10	30	240	170	320
4	0	3.4	0	3	1	<10	<10	10	180	10	80
76	204	5.0	2	59	4	20	50	340	460	280	490
8	16	14	14	17	15	9	9	9	4	9	9
				Summary of all precipitation data							
41	16	4.4	0	11	2	11	16	48	260	100	210
22	5	4.1	0	6	1	<10	<10	20	220	80	140
4	0	3.4	0	2	0	<10	<10	10	80	<10	40
166	204	5.2	7	59	4	20	50	340	470	280	490
16	41	41	41	43	42	18	18	18	11	18	18

Table 8.-Statistical summary of runoff chemistry

[mg/L, milligrams per liter;
µg/L, micrograms per liter]

	NUTRIENTS							OXYGEN DEMANDS	
	Nitrogen, nitrate dissolved (mg/L as N)	Nitrogen, nitrite dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Nitrogen, organic total (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Phosphorus, total (mg/L as P)	Carbon, organic total (mg/L as C)	Chemical oxygen demand (mg/L)	Biochemical oxygen demand 5 day (mg/L)
				01467042 Pennypack Creek at Pine Road					
Mean	6.3	0.20	0.67	--	--	4.3	--	100	21
Median	3.2	.07	.34	--	--	1.8	--	57	19
Minimum	.02	.00	.01	--	--	.40	--	8	14
Maximum	26	.96	2.9	--	--	34	--	460	46
Number of values	120	120	81	*	*	132	*	93	11
				01467048 Pennypack Creek at Lower Rhawn Street Bridge					
Mean	1.2	0.04	0.12	--	--	0.89	--	33	--
Median	1.2	.03	.08	--	--	.74	--	33	--
Minimum	.03	.01	.02	--	--	.24	--	12	--
Maximum	2.6	.13	.84	--	--	11	--	52	--
Number of values	129	129	133	*	*	133	*	28	*
				Tustin Street					
Mean	1.5	0.01	0.54	1.1	1.5	0.08	8.6	16	--
Median	1.5	.01	.10	1.1	1.3	.06	7.4	13	--
Minimum	.13	.00	.01	<.1	.5	.02	5.7	4	--
Maximum	3.4	.02	2.1	2.3	3.3	.26	16	40	--
Number of values	24	24	24	11	11	24	11	24	*
				Summary of all runoff data					
Mean	3.5	0.11	0.35	--	--	2.4	--	76	--
Median	1.4	.04	.12	--	--	.88	--	32	--
Minimum	.02	.00	.01	--	--	.02	--	4	--
Maximum	26	.96	2.9	--	--	34	--	460	--
Number of values	273	273	238	**	**	289	**	145	**

* Leas than 3 values are reported

** Only 1 site has data

SOLIDS		MAJOR ANIONS AND OTHER CONSTIUTENTS				METALS					
Solids, dis-solved (mg/L)	Solids, sus-pended (mg/L)	pH Lab (units)	Alka-linity (mg/L as $CaCO_3$)	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Cadmium, dis-solved (µg/L as Cd)	Chro-mium, dis-solved (µg/L as Cr)	Copper, dis-solved (µg/L as Cu)	Iron, dis-solved (µg/L as Fe)	Lead, dis-solved (µg/L as Pb)	Zinc, dis-solved (µg/L as Zn)
				01467042 Pennypack Creek at Pine Road							
--	571	7.0	32	96	20	--	--	--	--	--	--
--	406	6.9	24	58	20	--	--	--	--	--	--
--	14	2.2	0	19	4	--	--	--	--	--	--
--	3,990	7.7	78	270	41	--	--	--	--	--	--
*	131	108	108	117	121	*	*	*	*	*	*
				01467048 Pennypack Creek at Lower Rhawn Street Bridge							
--	866	7.1	20	28	10	--	--	--	--	--	--
--	364	7.1	20	21	9	--	--	--	--	--	--
--	50	4.7	2	6	4	--	--	--	--	--	--
--	46,900	7.7	50	96	19	--	--	--	--	--	--
*	133	133	133	132	133	*	*	*	*	*	*
				Tustin Street							
75	17	7.0	8	6	3	20	30	20	--	100	120
60	6	6.1	3	4	3	20	<10	20	--	60	100
28	1	5.0	1	1	1	10	<10	10	--	10	60
126	157	8.0	64	14	6	20	90	40	--	290	220
11	24	24	24	24	24	11	11	11	*	11	11
				Summary of all runoff data							
--	661	7.1	24	56	14	--	--	--	--	--	--
--	352	7.0	21	33	9	--	--	--	--	--	--
--	1	2.2	0	1	1	--	--	--	--	--	--
--	46,900	8.0	78	270	41	--	--	--	--	--	--
**	288	265	265	273	278	**	**	**	**	**	**

Table 9.—Dissolved nitrate nitrogen concentrations in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road						Pennypack Creek at Lower Rhawn Street Bridge						Tustin Street
	Sept. 06, 1979	Sept. 24, 1979	July 17, 1980	July 29, 1980	July 30, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	0.99	—	6.3	11	0.77	10	0.90	2.1	1.4	2.2	0.91	1.6	0.95
2	1.2	0.02	7.0	7.9	1.0	3.5	.97	—	1.5	2.4	.98	1.4	1.1
3	1.6	—	7.5	6.9	.76	2.9	.94	2.3	1.5	2.5	.88	2.1	.79
4	—	.02	9.9	6.9	.89	13	—	—	1.7	2.6	1.0	1.3	.69
5	.85	—	6.8	6.3	.79	1.9	.67	2.3	1.6	2.6	1.0	1.6	1.6
6	.85	.39	9.9	5.9	.87	9.6	.71	—	1.5	2.5	.84	1.3	.55
7	.84	—	6.7	6.2	1.1	7.0	.84	2.4	1.4	2.4	.97	1.4	.73
8	.83	.88	9.9	5.4	.89	2.0	.75	—	1.5	2.0	.85	1.8	.77
9	.89	—	10	6.4	.86	5.8	.85	1.8	1.2	1.6	.85	1.2	.88
10	.88	1.1	10	4.4	.90	20	.80	—	1.1	1.6	.92	1.2	.66
11	.95	—	9.8	5.6	.98	1.4	.87	1.1	0.92	1.4	.91	1.4	1.4
12	.93	1.4	—	4.6	.89	1.3	.83	—	.84	1.2	—	1.2	1.8
13	.94	—	—	7.5	1.2	20	.87	0.84	.78	1.4	—	1.2	2.0
14	1.0	1.7	—	7.0	.99	1.8	.79	—	.75	1.4	—	1.5	1.7
15	1.3	—	—	7.6	.96	25	.87	.68	.70	1.4	—	1.7	3.4
16	—	1.8	—	7.7	1.1	6.7	.82	—	.70	1.6	—	2.1	1.8
17	—	—	—	7.4	.91	26	.86	.77	.67	1.5	—	1.6	1.7
18	—	.04	—	7.1	.98	24	.85	—	.68	1.4	—	2.4	.13
19	—	—	—	8.1	1.0	24	.03	.77	.67	1.4	—	1.2	3.4
20	—	.02	—	8.3	1.1	25	.91	—	.66	1.5	—	1.3	3.2
21	—	—	—	9.0	.93	24	.27	.76	.65	1.5	—	1.3	.23
22	—	1.9	—	9.1	1.0	24	—	—	.65	1.6	—	1.3	2.8
23	—	—	—	9.9	1.4	25	—	.76	.65	1.5	—	1.4	1.7
24	—	1.9	—	9.4	.97	24	—	—	.65	1.6	—	1.3	3.0
25	—	—	—	9.7	.86	24	—	.77	.67	1.5	—	1.5	—
26	—	—	—	9.1	.90	20	—	—	.67	1.3	—	1.4	—
27	—	—	—	11	.94	19	—	.76	.66	1.2	—	1.6	—
28	—	—	—	9.1	.92	—	—	—	.71	1.2	—	1.2	—

Table 10.--Dissolved nitrite nitrogen concentrations in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road						Pennypack Creek at Lower Rhawn Street Bridge						Tustin Street
	Sept. 06, 1979	Sept. 24, 1979	July 17, 1980	July 29, 1980	July 30, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	0.03	--	0.01	0.57	0.17	0.09	0.04	0.04	0.04	0.02	0.02	0.07	0.01
2	.03	0.00	.01	.34	.11	.05	.03	--	.03	.01	.02	.06	.02
3	.02	--	.01	.27	.08	.07	.05	.08	.05	.03	.05	.06	.01
4	--	.00	.02	.34	.10	.07	--	--	.05	.03	.02	.06	.01
5	.02	--	.01	.28	.08	.03	.07	.09	.08	.02	.02	.06	.02
6	.02	.02	.02	.30	.09	.15	.03	--	.07	.01	.02	.06	.01
7	.03	--	.01	.39	.06	.14	.02	.12	.10	.01	.02	.06	.01
8	.02	.06	.02	.38	.07	.02	.06	--	.13	.02	.02	.06	.02
9	.03	--	.02	.31	.07	.11	.03	.08	.13	.02	.03	.06	.01
10	.03	.07	.02	.25	.06	.26	.06	--	.08	.01	.02	.06	.02
11	.04	--	.01	.42	.07	.02	.03	.04	.05	.02	.03	.07	.01
12	.03	.07	--	.25	.06	.02	.05	--	.04	.02	--	.07	.00
13	.04	--	--	.46	.06	.32	.02	.03	.03	.02	--	.07	.00
14	.04	.01	--	.46	.06	.02	.06	--	.03	.01	--	.07	.00
15	.01	--	--	.52	.06	.44	.04	.01	.03	.01	--	.07	.01
16	--	.06	--	.51	.05	.02	.06	--	.03	.01	--	.07	.00
17	--	--	--	.48	.05	.44	.04	.02	.03	.01	--	.07	.01
18	--	.00	--	.46	.45	.44	.04	--	.03	.01	--	.07	.01
19	--	--	--	.51	.06	.43	.03	.02	.03	.01	--	.07	.01
20	--	.00	--	.51	.54	.45	.04	--	.03	.01	--	.07	.01
21	--	--	--	.54	.06	.44	.03	.02	.03	.01	--	.08	.00
22	--	.06	--	.51	.06	.44	--	--	.03	.01	--	.07	.01
23	--	--	--	.62	.04	.45	--	.02	.03	.01	--	.07	.00
24	--	.05	--	.55	.05	.42	--	--	.03	.01	--	.07	.00
25	--	--	--	.58	.08	.40	--	.02	.03	.01	--	.07	--
26	--	--	--	.51	.06	.35	--	--	.03	.01	--	.07	--
27	--	--	--	.59	.11	.36	--	.02	.04	.01	--	.07	--
28	--	--	--	.47	.96	--	--	--	.04	.01	--	.07	--

Table 11.--Dissolved ammonia nitrogen concentrations in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road				Pennypack Creek at Lower Rhawn Street Bridge						Tustin Street
	Sept. 06, 1979	Sept. 24, 1979	July 29, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	0.08	--	0.47	0.63	0.09	0.06	0.05	0.05	0.09	0.15	0.03
2	.02	--	.38	.17	.08	--	.05	.05	.09	.12	.07
3	.02	--	.25	.42	.81	.24	.05	.05	.08	.13	.05
4	--	0.02	.26	1.1	--	--	.07	.04	.10	.14	.09
5	.04	--	.23	.11	.03	.84	.13	.03	.08	.12	.03
6	.05	.01	.25	.10	.02	--	.12	.03	.09	.13	.12
7	.04	--	.39	.56	.04	.34	.32	.03	.08	.18	.16
8	.06	.34	.41	.09	.02	--	.32	.04	.08	.13	.06
9	.04	--	.26	.45	.02	.25	.45	.04	.15	.12	.10
10	.03	.69	.17	1.3	.02	--	.19	.03	.09	.14	1.3
11	.03	--	.27	.11	.03	.15	.15	.03	.19	.13	.99
12	.03	1.0	.38	.10	.03	--	.09	.03	--	.12	1.2
13	.02	--	.35	1.6	.03	.10	.08	.03	--	.16	1.3
14	.03	1.1	.20	.14	.03	--	.06	.03	--	.13	1.5
15	.07	--	.29	2.1	.03	.61	.06	.03	--	.23	.08
16	--	1.1	.30	.52	.02	--	.06	.03	--	.39	1.4
17	--	--	.21	2.2	.02	.41	.26	.03	--	.14	2.1
18	--	.97	.19	2.3	.02	--	.05	.03	--	.13	2.1
19	--	--	.34	2.4	.02	.37	.06	.03	--	.21	.04
20	--	1.1	.34	2.1	.02	--	.06	.04	--	.13	.07
21	--	--	.39	2.1	.03	.39	.06	.03	--	.13	.01
22	--	1.2	.35	2.1	.02	--	.08	.03	--	.26	.04
23	--	--	.38	2.2	.03	.42	.07	.03	--	.12	.01
24	--	1.3	.44	2.3	.02	--	.07	.04	--	.12	.10
25	--	--	.32	2.3	.02	.47	.07	.03	--	.14	--
26	--	--	.29	1.8	--	--	.10	.03	--	.12	--
27	--	--	.49	1.7	--	.41	.10	.03	--	.14	--
28	--	--	.31	2.9	--	--	.07	.03	--	.11	--

Table 12.--Total phosphorus concentrations in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

	Pennypack Creek at Pine Road							Pennypack Creek at Lower Rhawn Street Bridge						Tustin Street
Sample number	Aug. 18, 1979	Sept. 06, 1979	Sept. 24, 1979	July 17, 1980	July 29, 1980	July 30, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	1.8	0.40	--	2.0	2.9	5.9	34	5.3	1.0	0.74	0.67	0.56	0.92	0.12
2	1.2	.45	0.54	2.1	3.8	2.5	26	2.9	--	.83	.62	.53	.99	.19
3	.94	.76	--	1.9	2.3	1.8	21	11	1.0	.78	.59	.35	.95	.26
4	--	--	.48	1.1	2.5	2.0	21	--	--	.86	.67	.40	1.0	.15
5	--	.65	--	2.3	2.2	1.6	14	1.4	1.2	.88	.66	.39	.93	.16
6	--	.62	5.9	.40	2.7	2.0	17	1.1	--	.87	.66	.31	.99	.09
7	--	.53	--	2.0	2.5	1.3	15	1.3	1.2	.98	.66	.53	1.0	.08
8	--	.56	.70	1.8	2.4	1.6	15	.84	--	1.0	.81	.30	1.0	.09
9	--	.50	--	.66	2.0	1.6	15	.90	1.1	1.1	.57	.34	.94	.08
10	--	.43	.70	.80	2.2	1.3	16	.87	--	.97	.52	.48	1.0	.05
11	--	.44	--	2.0	2.0	1.1	11	.88	.95	.98	.57	.43	1.1	.07
12	--	.42	.71	--	2.7	1.1	14	.82	--	.86	.47	--	1.0	.03
13	--	.40	--	--	2.0	.87	16	.79	.78	.78	.47	--	.97	.04
14	--	.38	.78	--	1.8	.91	10	.78	--	.75	.44	--	.94	.03
15	--	.38	--	--	1.7	.97	17	.70	.66	.73	.49	--	1.0	.04
16	--	--	.80	--	2.1	.90	9.8	.60	--	.73	.24	--	.78	.03
17	--	--	--	--	1.8	1.7	21	.63	.48	.70	.65	--	.98	.03
18	--	--	.88	--	1.9	1.4	16	.65	--	.68	.65	--	1.0	.02
19	--	--	--	--	1.8	1.8	16	.66	.38	.64	.65	--	.98	.06
20	--	--	.82	--	1.9	1.9	20	.63	--	.66	.70	--	.99	.06
21	1.1	--	--	--	1.7	1.7	13	.58	.53	.56	.71	--	1.0	.03
22	1.9	--	.84	--	1.8	1.4	14	.62	--	.59	.77	--	1.0	.06
23	1.4	--	--	--	1.6	1.8	5.8	.53	.62	.57	.75	--	1.0	.06
24	1.0	--	.73	--	1.7	1.8	6.4	.64	--	.60	.75	--	1.1	.07
25	.70	--	--	--	1.6	2.2	.40	.64	.69	.62	.75	--	.88	--
26	.87	--	--	--	1.7	2.1	13	--	--	.60	.67	--	.98	--
27	1.2	--	--	--	1.9	2.5	9.8	--	.42	.56	.65	--	1.0	--
28	.97	--	--	--	1.9	2.5	2.4	--	--	.55	.71	--	.98	--

Table 13.--Chemical oxygen demand in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road				Pennypack Creek at Lower Rhawn Street Bridge	Tustin Street
	July 17, 1980	July 29, 1980	July 30, 1980	Nov. 05, 1980	July 29, 1980	Aug. 04, 1979
1	15	10	460	250	31	34
2	30	10	190	240	31	12
3	12	8	140	180	12	16
4	39	12	180	290	33	40
5	24	10	120	200	33	32
6	15	10	160	210	18	18
7	9	10	57	--	33	18
8	48	10	120	210	31	25
9	30	27	85	210	31	25
10	51	10	72	210	31	18
11	24	10	38	170	31	15
12	--	12	42	170	31	4
13	--	18	12	220	33	8
14	--	21	36	150	33	9
15	--	21	52	190	36	9
16	--	18	27	150	52	10
17	--	16	210	210	36	10
18	--	14	160	220	31	8
19	--	16	140	190	36	11
20	--	23	210	210	36	13
21	--	16	140	230	36	11
22	--	14	140	190	40	11
23	--	16	160	150	33	16
24	--	14	180	--	31	13
25	--	16	180	140	40	--
26	--	8	180	230	33	--
27	--	18	53	170	31	--
28	--	29	210	190	31	--

Table 14.--Suspended solids concentrations in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road, Philadelphia, PA							Pennypack Creek at Lower Rhawn Street Bridge, Philadelphia, PA						Tustin Street
	Aug. 18, 1979	Sept. 06, 1979	Sept. 24, 1979	July 17, 1980	July 29, 1980	July 30, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	684	140	--	72	638	3,990	1,370	8,160	404	452	244	460	288	6
2	216	--	22	94	1,030	1,380	1,160	7,180	--	388	219	176	294	2
3	104	650	--	62	75	1,280	798	46,900	452	334	208	80	354	157
4	--	--	16	90	210	1,700	1,080	--	--	580	228	88	278	65
5	--	610	--	127	253	1,110	658	1,790	468	452	212	84	407	50
6	--	590	24	20	344	1,580	879	2,700	--	460	192	108	355	3
7	--	500	--	47	338	654	993	2,030	524	216	244	312	401	3
8	--	460	16	170	286	1,080	1190	730	--	612	344	76	370	1
9	--	392	--	43	169	876	1,260	580	552	596	252	50	321	4
10	--	370	18	73	422	828	819	610	--	652	224	180	344	7
11	--	300	--	55	262	450	882	630	600	556	248	56	459	12
12	--	390	14	--	376	524	713	570	--	442	224	--	397	12
13	--	300	--	--	119	427	903	560	944	482	212	--	447	3
14	--	310	16	--	81	468	662	690	--	520	196	--	340	3
15	--	160	--	--	87	523	772	460	440	412	212	--	326	4
16	--	--	30	--	99	406	574	150	--	396	220	--	326	14
17	--	--	--	--	83	1,610	801	440	256	426	312	--	348	5
18	--	--	44	--	55	1,130	658	370	--	364	328	--	368	7
19	--	--	--	--	70	1,630	716	410	312	420	360	--	420	17
20	--	--	32	--	88	2,820	949	364	--	324	332	--	334	15
21	416	--	--	--	60	1,210	515	332	176	352	344	--	351	4
22	956	--	34	--	41	1,100	597	364	--	332	344	--	385	5
23	480	--	--	--	60	1,640	137	530	356	312	360	--	309	9
24	252	--	28	--	77	1,980	130	450	--	312	376	--	429	2
25	156	--	--	--	61	1,370	66	410	460	320	416	--	389	--
26	336	--	--	--	58	1,450	426	--	--	298	404	--	440	--
27	548	--	--	--	97	1,850	302	--	208	316	360	--	427	--
28	444	--	--	--	103	2,310	896	--	--	292	404	--	425	--

Table 15.--pH in runoff for sampled storms

[Units, standard units; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road					Pennypack Creek at Lower Rhawn Street Bridge						Tustin Street
	Sept. 06, 1979	Sept. 24, 1979	July 29, 1980	July 30, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	7.1	--	6.8	6.9	6.6	6.9	7.2	6.9	7.2	7.0	6.8	6.2
2	--	7.2	7.0	6.8	6.9	6.9	--	7.2	7.3	7.3	7.0	5.7
3	6.9	--	7.1	6.8	6.7	7.0	7.7	7.1	7.3	7.5	7.0	5.8
4	--	7.0	7.0	6.8	6.0	--	--	7.2	7.3	7.4	7.0	5.6
5	6.9	--	7.0	6.8	6.7	6.8	6.4	7.2	7.3	7.4	7.0	7.7
6	6.9	7.2	7.1	6.9	5.9	6.7	--	6.8	7.3	7.5	7.0	5.9
7	7.0	--	7.0	7.0	6.4	6.3	7.2	7.0	7.3	7.4	6.7	6.0
8	7.0	7.3	6.9	6.8	6.6	6.9	--	6.8	7.2	7.4	6.9	6.0
9	7.1	--	6.9	6.9	6.0	6.9	7.2	7.2	7.3	7.5	7.0	6.2
10	7.1	7.4	7.0	6.9	4.6	7.0	--	7.2	7.3	7.5	6.8	6.6
11	7.1	--	7.0	6.9	6.6	6.9	7.2	7.1	7.3	7.6	6.8	6.2
12	7.1	7.4	7.0	6.9	6.4	6.8	--	7.1	7.2	--	7.0	5.8
13	7.1	--	6.9	7.0	4.7	6.8	7.1	7.1	7.2	--	7.0	5.8
14	7.2	7.4	7.0	7.0	6.5	7.0	--	7.1	7.3	--	6.8	5.6
15	--	--	7.1	7.0	4.5	6.8	4.7	7.1	7.3	--	7.0	6.7
16	--	7.7	7.1	7.0	4.8	6.9	--	7.1	7.3	--	6.9	5.4
17	--	--	7.1	6.7	4.6	7.0	6.7	6.4	7.3	--	6.9	5.6
18	--	7.6	7.2	6.9	4.7	7.1	--	7.1	7.3	--	6.9	7.2
19	--	--	7.2	6.8	4.7	6.9	6.6	7.0	7.3	--	6.7	6.9
20	--	7.7	7.1	6.7	4.7	7.1	--	7.1	7.4	--	7.0	6.5
21	--	--	7.0	6.8	4.7	7.2	6.6	7.1	7.3	--	7.1	7.1
22	--	7.7	7.1	6.8	4.7	7.2	--	7.1	7.3	--	6.7	8.0
23	--	--	7.0	6.8	4.7	7.1	6.5	7.1	7.3	--	7.1	5.0
24	--	7.7	7.1	6.8	4.7	7.0	--	7.1	7.3	--	7.1	6.3
25	--	--	7.0	6.8	4.7	6.9	6.3	7.1	7.3	--	6.9	--
26	--	--	7.0	6.7	4.9	--	--	7.1	7.3	--	7.1	--
27	--	--	6.9	6.8	4.9	--	6.5	7.0	7.2	--	7.0	--
28	--	--	7.0	6.8	--	--	--	7.2	7.2	--	7.1	--

Table 16.--Alkalinity concentrations in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road					Pennypack Creek at Lower Rhawn Street Bridge						Tustin Street
	Sept. 06, 1979	Sept. 24, 1979	July 29, 1980	July 30, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	23	--	47	37	24	40	32	33	14	31	18	8
2	--	78	54	28	28	40	--	28	16	28	23	3
3	21	--	63	23	28	50	36	28	16	28	23	3
4	--	68	53	24	7	--	--	33	16	28	21	2
5	18	--	50	22	20	9	10	31	16	28	23	35
6	18	70	56	23	7	18	--	24	15	28	22	2
7	19	--	58	22	13	8	40	28	14	28	17	3
8	20	68	57	21	14	16	--	29	12	20	22	4
9	21	--	57	21	8	16	40	37	11	28	23	5
10	22	64	51	21	2	20	--	31	10	29	19	10
11	22	--	51	23	13	15	30	27	9	30	22	2
12	23	62	47	22	14	15	--	24	9	--	22	2
13	23	--	60	25	3	14	26	26	9	--	22	1
14	24	60	61	24	12	18	--	23	10	--	19	1
15	--	--	60	24	0	14	2	22	10	--	22	6
16	--	58	60	25	1	17	--	21	10	--	21	1
17	--	--	61	22	2	18	14	14	11	--	13	1
18	--	56	62	22	2	20	--	22	10	--	20	11
19	--	--	60	24	2	15	12	20	10	--	17	7
20	--	52	58	22	2	20	--	20	11	--	22	4
21	--	--	57	23	3	21	12	20	11	--	22	11
22	--	52	57	21	3	21	--	20	11	--	17	64
23	--	--	54	21	2	20	12	20	10	--	22	1
24	--	52	56	24	3	19	--	19	11	--	22	3
25	--	--	55	23	2	15	12	20	10	--	18	--
26	--	--	55	20	3	--	--	19	9	--	21	--
27	--	--	51	27	3	--	12	18	9	--	21	--
28	--	--	53	25	--	--	--	20	9	--	22	--

Table 17.--Dissolved sulfate concentrations in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road						Pennypack Creek at Lower Rhawn Street Bridge						Tustin Street
	Sept. 06, 1979	Sept. 24, 1979	July 17, 1980	July 29, 1980	July 30, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	22	--	44	62	100	160	18	38	10	28	25	65	14
2	22	--	49	100	180	140	18	--	10	33	25	39	12
3	28	--	44	58	150	140	35	58	9	36	25	44	12
4	--	--	44	48	170	200	--	--	--	32	24	40	10
5	21	--	52	45	150	140	28	86	10	33	25	45	7
6	20	--	40	57	180	170	23	--	16	30	25	42	8
7	19	--	38	49	120	150	40	34	16	32	28	42	9
8	20	--	48	49	170	200	21	--	19	18	28	45	10
9	21	--	36	42	130	160	19	33	10	18	26	48	12
10	21	94	45	41	150	210	18	--	10	19	26	51	9
11	20	--	50	50	35	160	22	34	8	16	25	22	4
12	21	32	--	50	130	150	23	--	8	16	--	44	1
13	20	--	--	44	90	190	25	43	8	18	--	28	2
14	22	31	--	45	98	160	18	--	8	18	--	44	2
15	19	--	--	41	35	200	25	92	8	20	--	45	2
16	--	30	--	49	110	180	17	--	6	18	--	45	2
17	--	--	--	40	130	220	18	56	15	18	--	50	2
18	--	30	--	35	150	200	20	--	10	19	--	50	2
19	--	--	--	39	230	160	24	55	9	21	--	96	4
20	--	28	--	40	270	190	21	--	8	18	--	52	2
21	--	--	--	40	180	160	21	54	8	20	--	55	2
22	--	32	--	40	160	160	20	--	7	24	--	56	3
23	--	--	--	39	200	110	21	58	10	21	--	55	2
24	--	73	--	48	190	110	20	--	10	26	--	56	4
25	--	--	--	45	190	87	24	69	11	25	--	60	--
26	--	--	--	52	180	140	--	--	12	19	--	11	--
27	--	--	--	55	190	110	--	54	13	10	--	11	--
28	--	--	--	55	200	170	--	--	13	13	--	11	--

Table 18.--Dissolved chloride concentrations in runoff for sampled storms

[mg/L, milligrams per liter; a double dash indicates no data]

Sample number	Pennypack Creek at Pine Road						Pennypack Creek at Lower Rhawn Street Bridge						Tustin Street
	Sept. 06, 1979	Sept. 24, 1979	July 17, 1980	July 29, 1980	July 30, 1980	Nov. 05, 1980	Sept. 06, 1979	Sept. 24, 1979	Oct. 01, 1979	Oct. 10, 1979	Oct. 11, 1979	July 29, 1980	Aug. 04, 1979
1	8	--	34	37	6	25	7	18	15	14	8	11	4
2	9	27	32	36	8	16	7	--	14	16	7	12	4
3	7	--	33	39	6	15	9	19	12	16	7	11	2
4	--	28	37	34	7	16	--	--	14	16	8	11	2
5	7	--	34	36	6	8	7	18	14	16	8	12	4
6	7	27	35	28	7	13	6	--	13	15	7	11	2
7	7	--	32	34	7	7	7	19	12	14	7	11	2
8	7	27	37	33	6	5	7	--	14	12	7	12	3
9	7	--	36	35	6	8	7	16	13	11	7	11	3
10	7	28	37	30	6	14	7	--	11	10	8	11	3
11	8	--	34	31	8	4	7	9	9	9	8	12	2
12	8	27	--	26	7	5	7	--	8	9	--	11	2
13	8	--	--	39	8	16	7	8	7	9	--	12	2
14	9	26	--	38	8	5	7	--	7	10	--	11	2
15	10	--	--	39	8	20	7	7	6	10	--	11	2
16	--	25	--	40	8	5	7	--	7	10	--	11	2
17	--	--	--	40	6	20	7	8	4	11	--	11	2
18	--	34	--	39	7	20	7	--	6	10	--	13	1
19	--	--	--	40	6	20	7	7	7	10	--	13	4
20	--	27	--	39	6	20	7	--	7	11	--	12	3
21	--	--	--	40	7	19	7	7	6	11	--	11	3
22	--	21	--	41	7	20	8	--	6	11	--	11	4
23	--	--	--	40	6	18	8	7	6	10	--	11	3
24	--	20	--	39	6	20	8	--	6	11	--	10	6
25	--	--	--	39	7	19	7	7	6	10	--	12	--
26	--	--	--	40	6	20	--	--	6	9	--	11	--
27	--	--	--	39	8	20	--	7	6	9	--	12	--
28	--	--	--	38	7	22	--	--	7	9	--	12	--

Table 19.--Runoff water-quality for sampled storms for indicated constituents at specified sites

[mg/L, milligrams per liter; µg/L, micrograms per liter; a double dash indicates no data]

Sample number	August 18, 1979 Pennypack Creek at Pine Road	August 4, 1979 Tustin Street								
		NUTRIENTS			SOLIDS	METALS				
	Biochemical oxygen demand 5 day (mg/L)	Nitrogen, organic total (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Carbon, organic total (mg/L as C)	Solids, dissolved (mg/L)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Zinc, dissolved (µg/L as Zn)
1	46	<0.1	0.5	9.7	126	20	30	30	60	150
2	22	.8	.9	9.0	94	20	40	40	290	220
3	14	.7	.8	16	60	20	80	30	290	210
4	--	.7	.9	6.4	60	20	90	30	140	160
5	--	1.2	1.3	15	102	20	<10	20	140	130
6	--	1.0	1.2	5.9	28	20	<10	10	40	70
7	--	1.1	1.3	5.7	32	10	<10	10	10	60
8	--	1.4	1.5	8.4	30	20	<10	30	20	70
9	--	1.4	1.6	6.3	58	20	<10	10	30	90
10	--	1.4	2.8	7.4	120	20	<10	10	10	60
11	--	2.3	3.3	5.7	118	20	<10	10	100	100
12-20	--	--	--	--	--	--	--	--	--	--
21	19	--	--	--	--	--	--	--	--	--
22	23	--	--	--	--	--	--	--	--	--
23	21	--	--	--	--	--	--	--	--	--
24	19	--	--	--	--	--	--	--	--	--
25	18	--	--	--	--	--	--	--	--	--
26	16	--	--	--	--	--	--	--	--	--
27	16	--	--	--	--	--	--	--	--	--
28	18	--	--	--	--	--	--	--	--	--