# Chemical Quality of Surface Water in the West Branch Susquehanna River Basin Pennsylvania

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1779-C

*Prepared in cooperation with the Commonwealth of Pennsylvania Department of Forests and Waters*

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By E. F. McCARREN

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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# CHEMICAL QUALITY OF SURFACE WATER IN THE WEST BRANCH SUSQUEHANNA RIVER BASIN, PENNSYLVANNIA

By E. F. McCarren


## ABSTRACT

The West Branch Susquehanna River is 228 miles long and drains 6,913 square miles of mountainous area in central Pennsylvania. Much of this area is forest-covered wilderness, part of which is reserved as State game land. Wild animals, such as deer, bear, turkey and grouse, are sheltered there, and many streams contain trout and other game fish. This helps to make the region one of the best hunting and fishing areas in Pennsylvania.

The Congress has approved Federal funds for the construction of several reservoirs to prevent flooding of the main river and several of its tributaries. Water stored behind the dams will not be withdrawn below a minimum level designated as conservation pools. These pools will be available for recreation.

Several headwater streams, such as Clearfield, Moshannon, and at times Sinnemahoning Creek, that carry drainage from coal mines are acid and contain high concentrations of dissolved solids, especially sulfates. These streams acidify the West Branch Susquehanna River downstream as far as Jersey Shore.

One of the most influential tributaries affecting the quality of the West Branch Susquehanna River after they merge is Bald Eagle Creek. Bald Eagle Creek enters the main river downstream from Lock Haven which is approximately 100 river miles from the river's source. Because of its alkaline properties, water of Bald Eagle Creek can neutralize acidic water. Many streams draining small areas and several draining large areas such as Pine Creek, Lycoming Creek, and Loyalsock Creek are clear nearly neutral water low in dissolved solids whose pH is about 7.0 most of the time. These streams have a diluting and neutralizing effect on the quality of the West Branch Susquehanna River, so that from Williamsport downstream the river water is rarely acid, and for most of the time it is of good chemical quality.


## INTRODUCTION

This report describes the chemical quality of surface streams in the West Branch Susquehanna River basin above Lewisburg, Pa., which is 7 miles from the river mouth. The drainage area of the river at Lewisburg is 6,847 square miles. Quality studies were made of the river at selected locations along its length and of those tributaries that drained areas of 200 square miles or more. The quality of several tributaries draining areas less than 200 square miles was evaluated also because these tributaries affect the quality of the river significantly when stream and river mix. These tributaries were the principal acidic streams that drained the bituminous coal fields of Clearfield and Cambria Counties.

The chemical quality of streams described is mostly based on data obtained by analyzing daily samples taken from the river near Curwensville from August 1960 to April 1961, at Lock Haven from October 1958 to September 1959, and at Lewisburg from October 1957 to September 1958. Other data based on chemical-quality records of the river and its tributaries obtained as early as 1944 were also used. At many places samples were taken only at high or low streamflow. All samples were analyzed by the U.S. Geological Survey for the most common ionic constituents of water and their individual concentrations. Dissolved solids, specific conductance, pH and color were also determined.

The Commonwealth of Pennsylvania proposes to construct reservoirs in the West Branch Susquehanna River basin on the main river near Curwensville, and on Bald Eagle Creek approximately 1 mile upstream from Blanchard. The Alvin R. Bush Reservoir on Kettle Creek was completed in 1962. It is located approximately 8.5 miles above Westport.

These reservoirs will prevent flooding of streams and will provide areas for storing water of good quality essential for the economical management and distribution of water throughout the river basin. How efficiently the water resources of a river basin are handled by management depends largely on the availability of water-quality information. Such information on acidic water in the basin is useful to engineers designing reservoirs because satellite structures, such as dams and their control gates, spillways and bridges, when made of ordinary materials, are strongly unresistant to acidic-water weathering. The degree and rapidity of deterioration of most structural materials are related directly to the quality of water to which they are exposed.

In the West Branch Susquehanna River basin intangible damages can be expected if streams bearing acidic coal-mine wastes are impounded for recreational use or for controlled distribution to augment streamflow or to improve or stabilize quality in downstream areas. For example, some forms of plankton and certain strains of bacteria may thrive abundantly in impounded acidic water that contains coal-mine wastes because most mine effluents contain heavy concentrations of iron and manganese which nurture their growth. If their growth is unchecked, colonies form to consume oxygen and increase the carbon dioxide content of the water, which may create an unfavorable environment for aquatic life. Water impounded in reservoirs is an unnatural innovation which can cause water temperature changes in a river system. These water-temperature variations endanger fish life, not only in the impounded water areas but in the stream below. This is an important reason why continuous water temperatures are desirable quality data.

Documenting the changes in the water chemistry of streams that are directly related to reservoirs constructed in the West Branch Susquehanna River basin and where they occur will help to locate economically the facilities needed for storing, treating, and distributing water for public, industrial, and recreational uses.

The acidic character of the West Branch Susquehanna River in its upper part seldom extends into segments of the river below Jersey Shore. Below Jersey Shore the quality of the river supports aquatic life and is more suitable for industrial and domestic uses. However, wastes from some mines may extend into this part of the river occasionally, because of increased mining or because local storms wash more of the waste into receiving streams. The effects of these wastes may be far reaching if the river is at low flow and, therefore, inadequate to dilute them. This stream status, caused by streamflow and waste discharge, is a recognizable but preventable pollution hazard that can cause serious destruction of fish and degrade the West Branch Susquehanna River water generally for domestic, industrial, and recreational uses.

This study and similar investigations are carried out jointly by the Pennsylvania Department of Forests and Waters and the U.S. Geological Survey. The study fulfills part of the objectives of a cooperative program between State and Federal agencies that was begun in 1944.

## LOCATION AND ENVIRONMENT OF THE WEST BRANCH SUSQUEHANNA RIVER BASIN

The West Branch Susquehanna River originates in Carrol Township of northwestern Cambria County at an elevation of 1,990 feet. From its source the river flows northward toward Gleasonton; then at North Bend it takes a southward course toward Lock Haven. The river resumes a northeastward course toward Muncy, changing again to flow southward to Northumberland where it combines with the North Branch to form the Susquehanna River. From its source to its mouth the river falls 578 feet, averaging 3.9 feet of fall per mile. The river from Lock Haven to its mouth falls 110 feet, at an average rate of 1.6 feet per mile.

The river drainage area of 6,913 square miles includes all or parts of Bradford, Cambria, Cameron, Centre, Clearfield, Clinton, Columbia, Elk, Indiana, Lycoming, McKean, Montour, Northumberland, Potter, Sullivan, Tioga and Union Counties (pl. 1). The total population of these counties is nearly 1,000,000, according to the 1960 census, and the population of the largest city, Williamsport, is approximately 42,000.

The mean annual air temperature in the basin is 50° F, and the mean annual precipitation is 40 inches.

The West Branch Susquehanna River Basin drains the Allegheny Plateau. The basin is underlain by shale and sandstone containing coal, oil, iron ore, and in some areas, limestone. Acidic wastes from coal mining and associated operations in the upper basin drain into nearby streams. Because of this environment the river is acidic for more than half its length.

In the lower half of the basin, streams draining sandstone and limestone areas acquire alkaline characteristics. The alkaline properties of these tributaries neutralize some of the acid in the main river, but neutralization is not complete above Lock Haven. Not until the river receives the diluting water of Pine Creek and the neutralizing water of Bald Eagle Creek does its acidic character change.

## WATER QUALITY IN THE WEST BRANCH SUSQUEHANNA RIVER BASIN

### WEST BRANCH SUSQUEHANNA RIVER NEAR CURWENSVILLE

The results of the water-quality study of streams in the river basin are presented in downstream sequence from Curwensville to Lewisburg.

At Curwensville the river drains parts of Clearfield, Cambria, and Indiana Counties where coal deposits are recovered by deep-mining and strip-mining methods. Rocks adjacent to coal seams contain compounds of sulfur, and when strip mining exposes them to air and water, sulfuric acid is formed. Much of the water pumped to the surface from deep mines has been exposed to sulfur-bearing rocks underground for long periods of time, and therefore may be highly acidic and concentrated with solutes (McCarren, Wark, and George, 1961). Mining activities in the vicinity of Curwensville cause acidic wastes to be discharged to nearby streams.

The West Branch Susquehanna River drains an area of 315 square miles at Bower, which is approximately 18 miles upstream from Curwensville (pl. 1). At this location the average discharge for 47 years (1913–60) was 553 cfs (cubic feet per second) (table 1), which is approximately 360 mgd (million gallons per day).

In April 1960, field tests for specific conductance and pH of the river and its tributaries near Curwensville were made and samples taken for chemical analyses. From August 1, 1960, through May 9, 1961, samples were collected daily to determine specific conductance, pH and temperature of the river. The first 10 samples collected

TABLE 1.—*Drainage areas and discharge of streams in West Branch Susquehanna River basin*

| Stream | Stream length (mi) | Drainage basin area (sq mi) | Gaging station and drainage area (sq mi) | | Discharge at gage (cfs) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Average | Maximum | Minimum |
| West Branch Susquehanna River at Bower | | 315 | At Bower | | 553<br>47 yrs<br>(1913–60) | 31,500<br>3–18–36 | 14<br>8–29–39 |
| Clearfield Creek | 62 | 396 | At Dimeling | 371 | 576<br>47 yrs<br>(1913–60) | 30,600<br>3–18–36 | 6<br>10–1, 9–25 |
| Moshannon Creek | 46 | 290 | At Osceola Mills | 68.8 | 114<br>20 yrs<br>(1914–60) | 2,760<br>3–1–54 | 6.9<br>12–5–57 |
| West Branch Susquehanna River at Karthaus | | 1,462 | At Karthaus | | 2,499<br>20 yrs<br>(1940–60) | 50,900<br>4–1–40 | 109<br>9–30–43 |
| Sinnemahoning Creek at Sinnemahoning | 45 | 685 | At Sinnemahoning | | 1,150<br>22 yrs<br>(1938–60) | 59,800<br>7–18–42 | 1.2<br>9–4–39 |
| Kettle Creek | 41 | 240 | Near Westport | 233 | 381<br>6 yrs<br>(1954–60) | 7,970<br>3–8–56 | 8.9<br>9–9, 10–57 |
| West Branch Susquehanna River at Renovo | | 2,975 | At Renovo | | 4,875<br>47 yrs<br>(1908–15, 1919–59) | 236,000<br>3–18–36 | 80<br>12–6–08 |
| Bald Eagle Creek | 51 | 780 | At Blanchard | 339 | 469<br>6 yrs<br>(1954–60) | 5,130<br>10–15–55 | 117<br>8–10–55 |
| Pine Creek | 72 | 973 | At Cedar Run | 604 | 826<br>42 yrs<br>(1918–60) | 52,000<br>5–28–46 | 5.1<br>9–6–29 |
| Lycoming Creek | 23 | 276 | Near Trout Run | 173 | 280<br>46 yrs<br>(1914–60) | 21,800<br>5–27–46 | 3.2<br>9–27–36 |
| West Branch Susquehanna River at Williamsport | | 5,682 | At Williamsport | | 8,887<br>65 yrs<br>(1895–1960) | 264,000<br>3–18–36 | 162<br>9–17–43 |
| Loyalsock Creek | 59 | 493 | At Loyalsock | 443 | 762<br>35 yrs<br>(1925–60) | 51,200<br>11–16–26 | 12<br>9–26–39 |
| Muncy Creek | 33 | 216 | Near Sonestown | 23.8 | 48.8<br>20 yrs<br>(1940–60) | 7,310<br>3–11–52 | .8<br>8–31–53<br>9–1–53 |
| West Branch Susquehanna River at Lewisburg | | 6,847 | At Lewisburg | | 10,880<br>21 yrs<br>(1939–60) | 262,000<br>5–29–46 | |

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each month were composited and analyzed to determine quantities of silica, aluminum, iron, manganese, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, nitrate, dissolved solids, color, hardness, and acidity. Concentrations of acidity were used to estimate the quantities of sulfuric acid transported by the river.

Near Curwensville the river contains calcium sulfate water. An average of the analyses completed showed that calcium, magnesium, and sulfate represented approximately 75 percent of the dissolved solids. Calcium and magnesium occurring in rocks and soils in the area are dissolved in water by weathering processes. Although calcium and magnesium cause most of the hardness of the river water, aluminum, iron, and manganese from these rocks and hydrogen ions of the acid mine water also contribute to the hardness. Hardness ranged from 67 to 409 ppm (parts per million) table 2.

Sulfate, which results mostly from oxidation of coal mining wastes, ranged from 74 to 707 ppm from September 1957 to April 1961. Sulfuric acid discharge by the river was approximately 23 tons per day—a value obtained by multiplying the concentration of sulfuric acid (in parts per million) in the river by the discharge at time of sampling, using 0.0027 as a factor for converting to tons per day

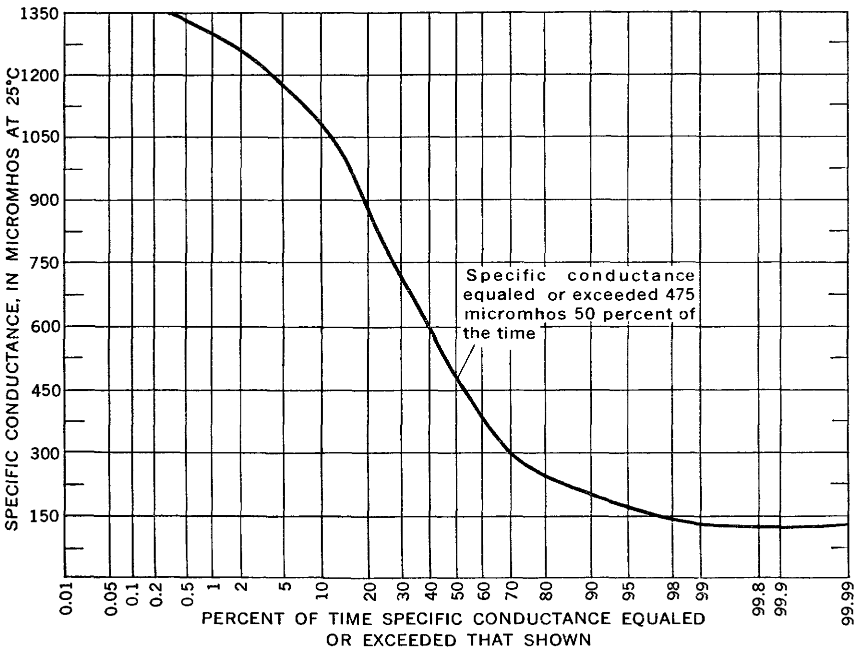


FIGURE 1.—Cumulative frequency curve of specific conductance, West Branch Susquehanna River near Curwensville, Pa., August 1960 to May 1961.

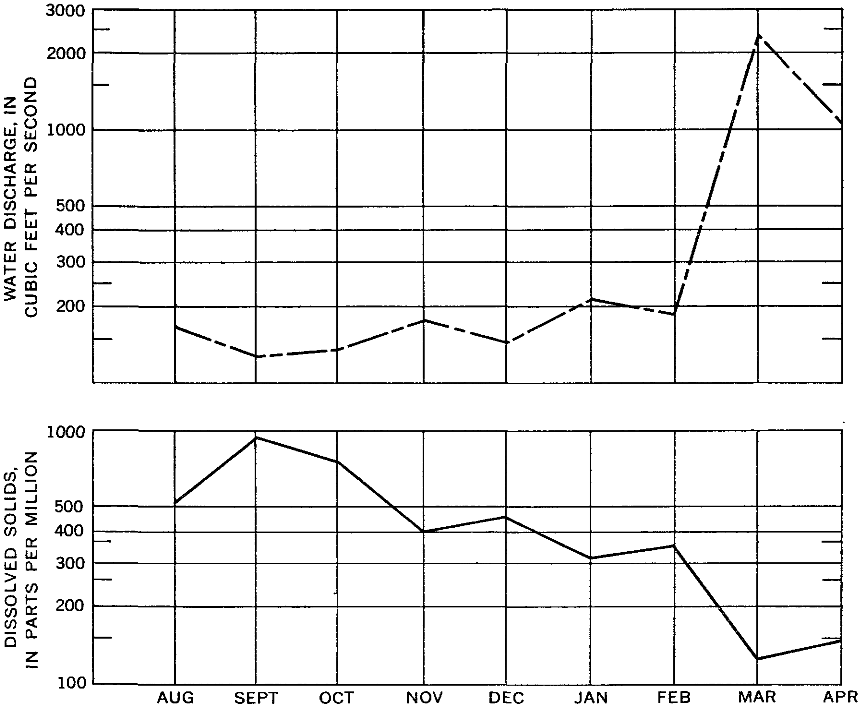


FIGURE 2.—Variations in dissolved-solids content and water discharge, West Branch Susquehanna River near Curwensville, Pa., monthly means, August 1960 to April 1961.

(table 3). The acidity of the river at Curwensville affects the chemical quality of the river downstream as far as Lock Haven where the river flows acidic most of the time (Pennsylvania State Planning Board, 1953).

Specific conductance is a useful characteristic of natural water to indicate the concentration of dissolved minerals. As mineral concentrations increase, the specific conductance also increases. (For the analyses of the river near Curwensville shown in table 2, the Dissolved-solids content (in parts per million) ranges from 61 to 75 percent of the specific conductance in micromhos).

Specific conductance of the river near Curwensville from August 1960 to May 1961 ranged from 132 to 1,390 micromhos (table 4); 50 percent of the time it equaled or exceeded 475 micromhos (fig. 1). The maximum specific conductance for the period of record was 1,400 micromhos on September 11, 1957.

Dissolved-solids content of the river water from 1960 to 1961 ranged from 125 to 934 ppm. As shown in figure 2, the dissolved-solids content was less concentrated during high flow than during low flow.

TABLE 2.—*Chemical analyses, in parts per million, of streams in West Branch Susquehanna River basin, Pa., 1945–61*

[On dates marked by an asterisk (*) calcium and magnesium were not determined separately]

| Date of collection | Mean discharge (cfs) | Temperature (° F) | Silica ($SiO_2$) | Aluminum (Al) | Iron (Fe) | Manganese (Mn) | 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 | Total acidity as $H_2SO_4$ | Specific conductance (micromhos at 25° C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **West Branch Susquehanna River at McGees Mills** | | | | | | | | | | | | | | | | | | | | | | |
| Sept. 11, 1945* | -------- | 72 | 9.5 | 6.9 | 1.0 | 1.6 | 108 | 33 | 47 | | 0 | 544 | 4.5 | ------ | 0.9 | 780 | 471 | 471 | 82 | 1,100 | 3.40 | 2 |
| Apr. 26, 1960 | 164 | 69 | ------ | ------ | ------ | ------ | ------ | ------ | 85 | | 0 | 493 | 1.0 | ------ | .7 | -------- | 320 | 320 | 78 | 993 | 3.70 | 1 |
| **Chest Creek at Patton** | | | | | | | | | | | | | | | | | | | | | | |
| Apr. 26, 1960 | -------- | 66 | ------ | ------ | ------ | ------ | ------ | ------ | -------- | | 24 | 34 | 1.5 | ------ | 5.0 | -------- | 54 | 33 | ------ | 133 | 6.9 | 1 |
| **Chest Creek at Westover** | | | | | | | | | | | | | | | | | | | | | | |
| Apr. 24, 1960 | -------- | 67 | ------ | ------ | ------ | ------ | ------ | ------ | -------- | | 18 | 94 | 2.0 | ------ | 3.6 | -------- | 112 | 97 | ------ | 256 | 6.6 | 1 |
| **Chest Creek at Mahaffey** | | | | | | | | | | | | | | | | | | | | | | |
| Sept. 11, 1945* | -------- | 70 | 5.4 | ------ | 0.06 | ------ | 35 | 10 | 5.8 | | 25 | 101 | 10 | 0.1 | 1.3 | 192 | 128 | 108 | ------ | 302 | 6.8 | 12 |
| Apr. 26, 1960 | -------- | 69 | ------ | ------ | ------ | ------ | ------ | ------ | 3.9 | | 16 | 105 | 2.5 | ------ | 2.8 | -------- | 120 | 107 | ------ | 280 | 6.7 | 1 |
| **West Branch Susquehanna River at Bower** | | | | | | | | | | | | | | | | | | | | | | |
| Aug. 7, 1944* | 98.2 | 74 | 9.2 | 5.7 | 0.14 | 1.1 | 54 | 16 | 21 | | 0 | 283 | 5.9 | ------ | 1.6 | 410 | 258 | 258 | 68 | 722 | 3.30 | 4 |
| Apr. 16, 1945* | 454 | 54 | 7.6 | 2.6 | .03 | .40 | 33 | 11 | 9.0 | 1.2 | 0 | 153 | 2.0 | .1 | 1.4 | 233 | 146 | 146 | 22 | 364 | 4.20 | 1 |
| Sept. 11* | -------- | 73 | 6.0 | 3.7 | .45 | .80 | 48 | 16 | 12 | | 0 | 228 | 6.0 | ------ | 1.0 | 353 | 220 | 220 | 45 | 573 | 3.65 | 2 |
| Apr. 24, 1959 | 2 | 48 | 6.8 | 1.9 | .08 | .38 | 29 | 9.9 | 9.8 | 1.3 | 0 | 136 | 3.8 | .1 | .9 | 210 | 113 | 113 | 29 | 311 | 4.30 | 2 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bell Run at Bells Landing** | | | | | | | | | | | | | | | | | | | | | |
| Apr. 26, 1960 | | 65 | | | | | | | | | 3 | 66 | | | | | | | | 158 | 6.7 | |
| **Anderson Creek at Curwensville** | | | | | | | | | | | | | | | | | | | | | |
| Sept. 11, 1945* | | 70 | 4.6 | 2.1 | 0.24 | .80 | 88 | 3.1 | | | 0 | 53 | 1.0 | | 0.6 | 84 | 56 | 56 | 25 | 170 | 3.85 | 4 |
| Oct. 7, 1957 | 8.0 | 56 | | | .38 | .88 | | | | | 0 | 81 | 3.0 | | .2 | | 38 | 38 | 39 | 245 | 3.60 | 2 |
| Apr. 26, 1960 | | | | | | | | | | | | 57 | | | | | | | 20 | 177 | 3.90 | 1 |
| **West Branch Susquehanna River near Curwensville** | | | | | | | | | | | | | | | | | | | | | |
| Sept. 11, 1957 | | 65 | | | | | | | | | 0 | 707 | | | | | | | 142 | 1,400 | 3.20 | |
| Jan. 11, 1958 | | 32 | | | | | | | | | | 196 | | | | | | | 29 | 442 | 4.20 | |
| Apr. 22, 1960 | 342 | 62 | | | | | | | 25 | | 0 | 196 | 2.0 | | 1.4 | 296 | | | 20 | 443 | 4.40 | |
| Apr. 26 | 313 | 71 | 8.6 | 3.7 | 0.50 | 0.94 | 46 | 14 | 22 | 2.5 | 0 | 222 | 5.0 | 0.3 | 1.2 | 335 | 173 | 173 | 24 | 501 | 4.20 | |
| June 10 | 241 | 67 | 8.6 | 3.7 | .04 | .93 | 41 | 13 | 20 | 1.3 | 0 | 213 | 4.0 | .2 | .8 | 340 | 156 | 156 | 24 | 457 | 4.40 | 5 |
| July 28 | 241 | 78 | 9.8 | 7.0 | .10 | 1.5 | 70 | 19 | 40 | 1.4 | 0 | 380 | 7.0 | .1 | .8 | 562 | 253 | 253 | 59 | 812 | 3.70 | 5 |
| Aug. 1-10 | 130 | | 13 | 7.4 | .08 | 1.6 | 63 | 20 | 38 | 4.4 | 0 | 342 | 4.0 | .2 | 1.5 | 514 | 239 | 239 | 54 | 746 | 3.75 | 3 |
| Sept. 1-10 | 55 | | 15 | 14 | .66 | 2.7 | 106 | 35 | 76 | 3.9 | 0 | 650 | 6.0 | .2 | 1.2 | 934 | 409 | 409 | 108 | 1,300 | 3.35 | 3 |
| Oct. 1-10 | 72 | | 12 | 11 | .24 | 3.6 | 86 | 32 | 60 | 3.0 | 0 | 512 | 4.0 | .2 | .5 | 730 | 346 | 346 | 83 | 1,080 | 3.35 | 1 |
| Nov. 1-10 | 158 | | 9.4 | 4.5 | .02 | 1.2 | 49 | 16 | 30 | 2.4 | 0 | 276 | 3.0 | .1 | 1.4 | 392 | 189 | 189 | 29 | 582 | 4.20 | 0 |
| Nov. 16 | 147 | 49 | 8.4 | 3.5 | .03 | .89 | 42 | 13 | 23 | 1.8 | 0 | 208 | 2.5 | .1 | .6 | 314 | 159 | 159 | 24 | 478 | 4.25 | 1 |
| Dec. 4-10 | 88 | | | | | | | | | | | 305 | 6.0 | .1 | .5 | 453 | 210 | 210 | 39 | 678 | 4.00 | |
| Jan. 1-10, 1961 | 214 | | 9.9 | 2.0 | .03 | 1.2 | 36 | 13 | 25 | 1.9 | 0 | 206 | 4.5 | .2 | 2.6 | 314 | 144 | 144 | 29 | 490 | 4.35 | 3 |
| Feb. 1-10 | 178 | | 11 | 3.9 | .06 | 1.0 | 41 | 13 | 29 | 1.8 | 0 | 231 | 5.0 | .1 | 1.9 | 351 | 156 | 156 | 39 | 538 | 3.60 | 3 |
| Mar. 1-10 | 2,400 | | 6.7 | 1.2 | .03 | .55 | 19 | 4.6 | 4.2 | 1.0 | 0 | 74 | 3.0 | .1 | 2.3 | 125 | 67 | 67 | 10 | 199 | 4.40 | 2 |
| Apr. 1-10 | 1,050 | | 9.9 | 1.1 | .02 | .52 | 21 | 7.5 | 7.3 | 1.5 | 0 | 95 | 2.0 | .1 | 1.1 | 147 | 84 | 84 | 10 | 243 | 4.50 | 3 |
| May 1-9 | | | 7.9 | 1.2 | .02 | .57 | 24 | 8.5 | 4.3 | 1.8 | 0 | 109 | 1.5 | .0 | .60 | 162 | 95 | 95 | 10 | 266 | 4.50 | 3 |
| **Clearfield Creek at Dimeling** | | | | | | | | | | | | | | | | | | | | | |
| Aug. 8, 1944* | 110 | 80 | 8.4 | 5.8 | 0.35 | 1.6 | 37 | 14 | | | 0 | 212 | 1.8 | 0.2 | 0.0 | 331 | 224 | 224 | 78 | 653 | 3.10 | 8 |
| Apr. 16, 1945* | 568 | 55 | 7.5 | 3.0 | .18 | .6 | 19 | 7.1 | 2.6 | 1.1 | 0 | 113 | 2.0 | .2 | .8 | 162 | 111 | 111 | 74 | 147 | 3.50 | 3 |
| Apr. 24, 1959 | 610 | | 8.6 | 1.5 | .03 | .7 | 23 | 11 | 2.7 | 1.3 | 0 | 124 | 2.2 | .1 | .9 | 210 | 113 | 113 | 29 | 330 | 3.50 | 3 |
| **Clearfield Creek near Clearfield** | | | | | | | | | | | | | | | | | | | | | |
| Sept. 11, 1945* | | 75 | 6.4 | 2.3 | .44 | 1.0 | 24 | 8.6 | 1.9 | | 0 | 123 | 1.8 | | 1.2 | 183 | 127 | 127 | 40 | 363 | 3.50 | 2 |
| Oct. 7, 1957 | 49 | 58 | | | 5.3 | 2.5 | | | | | 0 | 522 | 17 | | .8 | | 280 | 280 | 2.5 | 1,130 | 2.70 | 5 |

TABLE 2.—*Chemical analyses, in parts per million, of streams in West Branch Susquehanna River Basin, Pa., 1945–61*—Continued

[On dates marked by an asterisk (*) calcium and magnesium were not determined separately]

| Date of collection | Mean discharge (cfs) | Temperature (° F) | Silica ($SiO_2$) | Aluminum (Al) | Iron (Fe) | Manganese (Mn) | 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 | Total acidity as $H_2SO_4$ | Specific conductance (micromhos at 25° C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **West Branch Susquehanna River at Clearfield** | | | | | | | | | | | | | | | | | | | | | | |
| Oct. 7, 1957 | 54 | 57 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 513 | 18 | ------ | 1.1 | -------- | 280 | 280 | 2.0 | 1,070 | 3.20 | 2 |
| **Moshannon Creek at Osceola Mills** | | | | | | | | | | | | | | | | | | | | | | |
| Aug. 7, 1944* | 65.9 | 76 | 12 | 18 | 2.9 | 2.8 | 49 | 21 | 6.2 | | 0 | 393 | 2.2 | 0.2 | 0.1 | 636 | 399 | 399 | 227 | 1,210 | 2.80 | 5 |
| Aug. 10,* | 18.0 | 71 | 20 | 23 | 11 | 3.4 | 71 | 29 | 18 | | 0 | 593 | 3.1 | ------ | 1.0 | 797 | 584 | 584 | 342 | 1,700 | 2.60 | 5 |
| Apr. 16, 1945* | 116 | 50 | 9.8 | 7.9 | 2.3 | 1.6 | 30 | 13 | 1.7 | 1.4 | 0 | 236 | 1.4 | .2 | .4 | 349 | 245 | 245 | 62 | 788 | 2.95 | 4 |
| Apr. 24, 1959 | 129 | ------ | 9.4 | 2.4 | .16 | 1.5 | 27 | 15 | 2.7 | 1.5 | 0 | 188 | 2.0 | .1 | .2 | 270 | 129 | 129 | 64 | 505 | 3.20 | 3 |
| **Moshannon Creek at Phillipsburg** | | | | | | | | | | | | | | | | | | | | | | |
| Oct. 7, 1957 | 25 | 54 | ------ | ------ | 11 | 2.6 | ------ | ------ | ------ | ------ | 0 | 515 | 5.0 | ------ | 1.3 | -------- | 310 | 310 | 3.2 | 1,210 | 2.55 | 3 |
| **West Branch Susquehanna River at Karthaus** | | | | | | | | | | | | | | | | | | | | | | |
| Aug. 8, 1944* | 850 | 75 | 9.0 | 6.9 | 0.26 | 1.6 | 49 | 15 | 15 | | 0 | 266 | 7.9 | ------ | 0.6 | 384 | 256 | 256 | 88 | 750 | 3.20 | 5 |
| Apr. 17, 1945 | 2,490 | 56 | 6.8 | 2.8 | .07 | .4 | 22 | 7.6 | 4.8 | 1.0 | 0 | 114 | 1.4 | 0.1 | 1.0 | 167 | 116 | 116 | 35 | 333 | 3.60 | 2 |
| Oct. 10, 1957 | 190 | 57 | ------ | ------ | 5.7 | 2.0 | ------ | ------ | ------ | ------ | 0 | 417 | 10 | ------ | .5 | -------- | 264 | 264 | 2.2 | 1,020 | 2.90 | 8 |
| **Sinnemahoning Creek at Cameron** | | | | | | | | | | | | | | | | | | | | | | |
| July 19, 1957 | ---------- | 77 | ------ | ------ | ------ | ------ | ------ | ------ | 8.0 | | 24 | 19 | 6.0 | ------ | 0.5 | 80 | 34 | 15 | ------ | 120 | 7.5 | 2 |

**Bennett Branch Sinnemahoning Creek near Driftwood**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 10, 1957 | 14.1 | 58 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 228 | 22 | ------ | 0.2 | -------- | 116 | 116 | 3.3 | 571 | 3.35 | 4 |

**Sinnemahoning Creek at Sinnemahoning**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 10, 1944* | 398 | 77 | 11 | 6.1 | 0.14 | 0.9 | 22 | 9.2 | 6.6 | | 0 | 126 | 12 | 0.2 | 1.0 | 205 | 135 | 135 | 59 | 335 | 3.80 | 5 |
| May 23, 1945* | 1,490 | 58 | 3.4 | ------ | .05 | .00 | 5.8 | 1.8 | 2.3 | | 6 | 18 | 1.8 | .1 | .4 | 35 | 22 | 17 | ------ | 59 | 7.3 | 5 |
| Sept. 12,* | ------ | ------ | 10 | 7.1 | .30 | 1.2 | 26 | 10 | ------ | ------ | 0 | 141 | 8.0 | ------ | 1.0 | 223 | 159 | 159 | 64 | 380 | 3.70 | 5 |
| Oct. 10, 1957 | 29 | 61 | ------ | ------ | .22 | .89 | ------ | ------ | ------ | ------ | 0 | 138 | 18 | ------ | .2 | -------- | 105 | 105 | .7 | 347 | 4.00 | 4 |
| Oct. 30, 1958 | 327 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 10 | 32 | 4.0 | ------ | .9 | -------- | 41 | 33 | ------ | 102 | 6.5 | 3 |
| Dec. 10 | 630 | ------ | 6.1 | ------ | .01 | .33 | 8.4 | 3.2 | 2.0 | .9 | 3 | 34 | 1.0 | .1 | .2 | 69 | 34 | 32 | ------ | 101 | 5.2 | 2 |
| Apr. 16, 1959 | 980 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 14 | | 1 | 55 | 2.8 | ------ | .4 | 99 | 32 | 31 | ------ | 104 | 4.8 | 3 |
| Apr. 23 | 820 | ------ | 5.2 | .0 | .0 | .05 | 6.5 | 2.3 | 3.0 | .7 | 0 | 30 | 4.0 | .1 | .2 | 50 | 26 | 26 | 20 | 72 | 4.10 | 2 |
| May 27 | 455 | ------ | 5.6 | 1.8 | .04 | .31 | 8.2 | 5.7 | 3.0 | 1.3 | 0 | 60 | 5.0 | .3 | .4 | 136 | 44 | 44 | 24 | 201 | 3.80 | 3 |
| July 14 | 116 | ------ | 6.2 | 2.6 | .03 | .72 | 16 | 4.5 | 5.5 | 1.7 | 0 | 78 | 9.0 | .2 | 1.4 | 158 | 59 | 59 | 24 | 268 | 3.70 | 3 |
| Aug. 17 | 34 | ------ | 11 | 2.4 | .16 | 1.9 | 20 | 10 | 12 | 1.8 | 0 | 141 | 9.0 | ------ | .4 | -------- | 91 | 91 | 59 | 396 | 3.70 | 4 |
| Oct. 22 | ------ | 48 | 6.8 | 5.0 | .04 | 1.9 | 21 | 8.5 | 14 | 1.8 | 0 | 115 | 2.2 | .2 | 1.3 | 195 | 88 | 88 | 39 | 458 | 3.90 | 2 |
| Dec. 17 | ------ | ------ | 5.6 | ------ | .07 | .25 | 9.0 | 2.8 | 4.0 | 1.5 | 5 | 31 | 3.5 | .1 | .6 | 64 | 34 | 30 | ------ | 93 | 5.5 | 3 |
| Jan. 26, 1960 | ------ | ------ | 8.1 | 1.1 | .03 | .54 | 10 | 4.7 | 3.0 | 1.4 | 0 | 59 | 3.5 | .1 | 1.2 | 112 | 45 | 45 | 20 | 180 | 3.90 | 1 |
| Mar. 10 | ------ | ------ | 6.9 | 2.3 | .04 | .65 | 11 | 4.7 | 4.2 | 1.0 | 0 | 66 | 4.5 | ------ | .4 | -------- | 47 | 47 | 20 | 207 | 3.95 | 3 |
| Apr. 20 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 7.8 | | 2 | 43 | 6.8 | ------ | .2 | -------- | 39 | 38 | ------ | 123 | 4.8 | 1 |
| Aug. 31 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 145 | 16 | ------ | .2 | 231 | 98 | 98 | 54 | 397 | 3.70 | 1 |
| Oct. 12 | ------ | 54 | 6.9 | 8.8 | .07 | 2.4 | 26 | 14 | 13 | 4.5 | 0 | 189 | 16 | .1 | .0 | -------- | 123 | 123 | 78 | 484 | 3.75 | 1 |
| Nov. 15 | ------ | 46 | 6.2 | 2.2 | .03 | 1.2 | 17 | 8.2 | 8.2 | 1.4 | 0 | 94 | 9.5 | .1 | .4 | 152 | 76 | 76 | 29 | 291 | 4.10 | 3 |
| Jan. 6, 1961 | ------ | 32 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 106 | 14 | ------ | .5 | 196 | 86 | 86 | 39 | 324 | 3.80 | 3 |
| Feb. 9 | ------ | 32 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 90 | 12 | ------ | 1.4 | 161 | 76 | 76 | 20 | 273 | 4.30 | 3 |
| Mar. 22 | ------ | 38 | 6.8 | .1 | .00 | .17 | 9.0 | 3.5 | 4.2 | 1.3 | 1 | 42 | 3.0 | ------ | .2 | 75 | 37 | 36 | 9.8 | 120 | 4.7 | 3 |

**Kettle Creek at Cross Fork**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sept. 12, 1945* | ------ | 70 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 24 | ------ | 1.0 | ------ | 0.2 | -------- | ------ | ------ | ------ | 52 | 6.9 | 5 |
| Oct. 10, 1957 | 9.0 | 61 | ------ | ------ | ------ | ------ | ------ | ------ | 7.8 | | 22 | 7.9 | 3.2 | ------ | .5 | -------- | ------ | ------ | ------ | 64 | 6.4 | 8 |

**Kettle Creek near Cross Fork**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 11, 1944* | 7.32 | 73 | 3.1 | ------ | 0.01 | ------ | 6.5 | 1.2 | 1.7 | | 20 | 7.9 | 1.8 | 0.0 | 0.2 | 32 | ------ | 14 | ------ | 60 | 6.8 | 10 |
| Apr. 18, 1945* | 142 | 47 | 2.8 | ------ | .03 | ------ | 4.6 | 1.3 | 1.9 | | 14 | 7.1 | .8 | .1 | 1.0 | 25 | ------ | 6 | ------ | 41 | 6.6 | 9 |
| Sept. 12 | ------ | 71 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 24 | 7.0 | 1.0 | ------ | .4 | -------- | ------ | ------ | ------ | 52 | 6.8 | 5 |

**Kettle Creek at Dam Site near Westport**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sept. 12, 1957 | 10.3 | 68 | 2.8 | .1 | 0.03 | 0.02 | 8.3 | 1.8 | 3.2 | 1.2 | 20 | 12 | 6.2 | 0.1 | 0.4 | 58 | ------ | 12 | ------ | 84 | 6.6 | 2 |
| Oct. 9, 1957 | 16.5 | 65 | 2.6 | .1 | .01 | .01 | 7.5 | 1.4 | 2.9 | 1.2 | 18 | 9.2 | 7.0 | .1 | .9 | 53 | 25 | 10 | ------ | 78 | 6.0 | 5 |
| Nov. 20 | 103 | 42 | 2.7 | .1 | .01 | .00 | 7.1 | 1.2 | 1.7 | .9 | 16 | 10 | 3.1 | .1 | .2 | -------- | 23 | 10 | ------ | 61 | 6.4 | 2 |

TABLE 2.—*Chemical analyses, in parts per million, of streams in West Branch Susquehanna River Basin, Pa., 1945–61*—Continued

[On dates marked by an asterisk (*) calcium and magnesium were not determined separately]

| Date of collection | Mean discharge (cfs) | Temperature (° F) | Silica ($SiO_2$) | Aluminum (Al) | Iron (Fe) | Manganese (Mn) | 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 | Total acidity as $H_2SO_4$ | Specific conductance (micromhos at 25° C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kettle Creek at Westport** | | | | | | | | | | | | | | | | | | | | | | |
| July 13, 1945* | | 77 | | | | | | | | | 6 | 18 | 1.0 | | 0.1 | | | 19 | | 61 | 6.6 | 4 |
| Sept. 12* | 30 (est) | 73 | | | | | | | | | 10 | | | | | | | | | 80 | 6.5 | 3 |
| July 19, 1957 | | 83 | | | | | | | 5.1 | | 6 | 37 | 2.0 | | .7 | | | 31 | | 107 | 5.9 | 2 |
| Oct. 9 | 17.0 | 66 | | | | | | | | | 0 | 58 | 6.5 | | .0 | | | 42 | | 173 | 4.25 | 3 |
| **Bald Eagle Creek at Blanchard** | | | | | | | | | | | | | | | | | | | | | | |
| Oct. 11, 1956 | 246 | 54 | 6.1 | | 0.02 | | 42 | 13 | 3.6 | 1.8 | [1]167 | 19 | 5.0 | 0.1 | 6.1 | 184 | 158 | 22 | | 325 | 8.5 | 3 |
| Jan. 2, 1957 | 425 | 35 | 7.6 | | .02 | | 37 | 11 | 2.5 | 1.5 | [2]144 | 19 | 3.8 | .1 | 7.0 | 164 | 137 | 20 | | 281 | 8.4 | 3 |
| Oct. 28, 1958 | 191 | | 5.4 | | .00 | | 38 | 15 | 4.7 | 1.6 | 165 | 19 | 6.5 | .2 | 7.5 | 185 | 157 | 22 | | 321 | 7.4 | 3 |
| Dec. 14, | 185 | | | | | | | | 4.6 | | 132 | 20 | 6.2 | | 5.7 | | 132 | 24 | | 272 | 7.8 | 3 |
| Apr. 14, 1959 | 837 | | 5.6 | | .00 | | 20 | 6.3 | 3.5 | 1.5 | 132 | 20 | 6.2 | | 3.0 | 116 | 76 | 16 | | 170 | 7.7 | 3 |
| July 16, | 154 | | 10 | | .00 | | 41 | 14 | 5.5 | 1.7 | 170 | 21 | 8.0 | .0 | 4.8 | 238 | 160 | 21 | | 330 | 8.1 | 3 |
| Aug. 20, | 127 | | | | | | | | 3.2 | | 172 | 19 | 8.5 | | 5.2 | | 170 | 29 | | 343 | 7.7 | 3 |
| Oct. 2, | | 67 | | | | | | | | | 158 | 21 | 9.0 | | 7.5 | 208 | 158 | 29 | | 322 | 7.9 | 5 |
| Nov. 18, | | 38 | 5.6 | | .00 | | 36 | 10 | 6.0 | 1.8 | 132 | 22 | 6.0 | .1 | 7.6 | 159 | 131 | 23 | | 275 | 7.6 | 3 |
| Dec. 16, | | | | | | | | | | | 88 | 25 | 3.8 | | 4.6 | 123 | 96 | 24 | | 202 | 7.8 | 1 |
| Jan. 28, 1960 | | | 16 | | .01 | 0.03 | 37 | 12 | 6.8 | 1.4 | 133 | 25 | 8.0 | .1 | 7.8 | 180 | 142 | 33 | | 298 | 8.2 | 3 |
| Mar. 7, | | | 7.1 | | .01 | .01 | 37 | 12 | 5.0 | 1.2 | 135 | 24 | 6.0 | .1 | 4.4 | 166 | 142 | 32 | | 288 | 7.9 | 2 |
| Apr. 18, | | | 6.4 | | .01 | .03 | 38 | 12 | 4.0 | 1.4 | 138 | 23 | 8.5 | .0 | 8.5 | 183 | 145 | 32 | | 291 | 7.7 | 3 |
| June 6, | | | 6.6 | | | .02 | 33 | 10 | 2.8 | 1.3 | 128 | 20 | 5.2 | .2 | 4.8 | 174 | 124 | 19 | | 256 | 7.8 | 3 |
| July 11, | | | | | | | | | | | 184 | 20 | 6.5 | | 5.8 | 190 | 172 | 21 | | 330 | 8.0 | 3 |
| Nov. 16, | | 49 | 5.9 | | .00 | | 42 | 16 | 6.8 | 1.7 | 178 | 18 | 7.4 | .0 | 7.4 | 198 | 171 | 25 | | 341 | 7.9 | 3 |
| Dec. 29, | | | | | | | | | | | 174 | 23 | 9.0 | | 5.6 | 236 | 154 | 12 | | 350 | 8.0 | 3 |
| Feb. 17, 1961 | | 38 | 13 | | .02 | .00 | 36 | 8.4 | 6.0 | 2.0 | 112 | 26 | 10 | .1 | 6.1 | 168 | 125 | 33 | | 281 | 6.7 | 3 |
| Mar. 20, | | 42 | 17 | | .00 | .00 | 27 | 8.0 | 6.3 | 1.8 | 100 | 19 | 4.5 | | 4.5 | 140 | 101 | 19 | | 222 | 7.4 | 3 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bald Eagle Creek at Beech Creek Station** | | | | | | | | | | | | | | | | | | | | | |
| Aug. 12, 1944* | 167 | 70 | 2.7 | ------ | 0.02 | ------ | 40 | 16 | 2.0 | | 176 | 14 | 5.0 | 0.0 | 5.0 | 188 | 166 | 21 | ------ | 328 | 7.8 | 9 |
| Apr. 18, 1945* | 903 | 55 | 4.5 | ------ | .03 | 0.00 | 26 | 8.2 | 2.3 | | 96 | 17 | 2.8 | .0 | 4.1 | 112 | 99 | 20 | ------ | 199 | 7.6 | 8 |
| Oct. 9, 1957 | 188 | 67 | ------ | ------ | .43 | .00 | ------ | ------ | 17 | | 166 | 22 | 6.6 | ------ | 8.5 | ------ | 140 | 4 | ------ | 325 | 7.7 | 8 |
| **Pine Creek at Cedar Run** | | | | | | | | | | | | | | | | | | | | | |
| Aug. 30, 1944* | 53.1 | 68 | 2.4 | ------ | 0.02 | ------ | 14 | 3.3 | 6.1 | | 25 | 26 | 7.5 | 1.2 | 0.6 | 75 | 48 | 28 | ------ | 136 | 7.2 | 4 |
| **Pine Creek at Waterville** | | | | | | | | | | | | | | | | | | | | | |
| July 14, 1945* | ------ | 73 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | | 23 | 15 | 4.5 | ------ | 0.1 | ------ | 33 | 14 | ------ | 87 | 7.2 | 8 |
| **Pine Creek near Jersey Shore** | | | | | | | | | | | | | | | | | | | | | |
| Oct. 13, 1950 | ------ | 54 | 4.6 | ------ | 0.04 | ------ | 7.1 | 1.7 | 1.1 | 1.0 | 14 | 13 | 1.5 | 0.2 | 0.7 | 42 | 25 | 13 | ------ | 64 | 7.4 | 7 |
| Nov. 15, | ------ | ------ | 3.3 | ------ | .07 | ------ | 6.3 | 1.7 | 1.0 | .7 | 12 | 13 | 1.4 | .3 | .5 | 37 | 23 | 13 | ------ | 57 | 7.4 | 4 |
| Dec. 13, | 2,840 | ------ | 4.0 | ------ | .02 | ------ | 6.2 | 1.5 | .9 | .9 | 5 | 17 | 1.2 | .2 | .4 | 38 | 22 | 18 | ------ | 57 | 6.8 | 2 |
| Mar. 27, 1951 | 2,160 | 40 | 4.9 | ------ | .03 | ------ | 6.3 | 1.6 | 3.3 | .9 | 14 | 14 | 2.9 | .1 | 1.2 | 42 | 22 | 18 | ------ | 62 | 6.8 | 6 |
| May 4, | 1,160 | ------ | 3.8 | ------ | .05 | ------ | 6.4 | 1.6 | 1.4 | 1.4 | 15 | 12 | 1.4 | .1 | .5 | 44 | 23 | 10 | ------ | 58 | 7.3 | 3 |
| June 5, | 328 | 74 | 2.2 | ------ | .05 | ------ | 7.9 | 2.0 | 2.6 | 1.5 | 22 | 13 | 2.2 | .1 | .4 | 49 | 28 | 10 | ------ | 74 | 7.3 | 4 |
| July 11, | 745 | 75 | 3.6 | ------ | .08 | ------ | 7.8 | 1.6 | 2.8 | 1.0 | 20 | 14 | 1.8 | .1 | .3 | 46 | 26 | 10 | ------ | 70 | 7.0 | 5 |
| Aug. 15, | 308 | 72 | 1.9 | ------ | .05 | ------ | 10 | 2.8 | 3.7 | | 30 | 13 | 3.8 | .1 | .9 | 52 | 36 | 12 | ------ | 88 | 7.1 | 5 |
| Oct. 9, 1957 | 73 | 60 | ------ | ------ | ------ | ------ | ------ | ------ | 8.7 | | 28 | 18 | 5.0 | ------ | .5 | ------ | 32 | 9 | ------ | 105 | 6.7 | 5 |
| **Lycoming Creek near Trout Run** | | | | | | | | | | | | | | | | | | | | | |
| Nov. 10, 1952 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 1.1 | | 14 | 13 | 2.6 | ------ | 0.8 | ------ | 27 | 16 | ------ | 66 | 7.2 | 3 |
| Dec. 18, | ------ | 37 | ------ | ------ | ------ | ------ | ------ | ------ | 1.7 | | 7.0 | 11 | 2.1 | ------ | 1.8 | ------ | 18 | 12 | ------ | 48 | 7.2 | 3 |
| Jan. 21, 1953 | ------ | 38 | ------ | ------ | ------ | ------ | ------ | ------ | 2.3 | | 8.0 | 11 | 3.5 | ------ | 1.3 | ------ | 19 | 12 | ------ | 48 | 7.1 | 4 |
| Feb. 28, | ------ | 38 | ------ | ------ | ------ | ------ | ------ | ------ | 3.0 | | 8.0 | 11 | 2.5 | ------ | 1.2 | ------ | 16 | 9 | ------ | 47 | 7.1 | 4 |
| Mar. 31, | ------ | 45 | ------ | ------ | ------ | ------ | ------ | ------ | 1.6 | | 5.0 | 10 | 2.7 | ------ | 1.4 | ------ | 16 | 12 | ------ | 44 | 6.9 | 4 |
| May 5, | ------ | 54 | ------ | ------ | ------ | ------ | ------ | ------ | 1.3 | | 8.0 | 11 | 1.4 | ------ | 1.0 | ------ | 18 | 11 | ------ | 47 | 7.0 | 3 |
| July 2, | ------ | 70 | ------ | ------ | ------ | ------ | ------ | ------ | .7 | | 13 | 14 | 1.6 | ------ | 1.3 | ------ | 27 | 16 | ------ | 67 | 7.2 | 3 |
| July 14 | ------ | 63 | ------ | ------ | ------ | ------ | ------ | ------ | 1.6 | | 9.0 | 10 | 1.8 | ------ | 2.7 | ------ | 19 | 12 | ------ | 54 | 7.2 | 7 |
| Aug. 18, | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 2.1 | | 13 | 14 | 3.2 | ------ | 1.2 | ------ | 26 | 15 | ------ | 70 | 7.4 | 3 |
| Oct. 9, 1957 | 72 | 59 | ------ | ------ | ------ | ------ | ------ | ------ | 7.6 | | 19 | 15 | 2.9 | ------ | 1.7 | ------ | 20 | 4 | ------ | 77 | 6.6 | 4 |

[1] Includes equivalents of 2 ppm of carbonate ($CO_3$).

[2] Includes equivalents of 4 ppm of carbonate ($CO_3$).

TABLE 2.—*Chemical analyses, in parts per million, of streams in West Branch Susquehanna River Basin, Pa., 1945–61*—Continued

[On dates marked by an asterisk (*) calcium and magnesium were not determined separately]

| Date of collection | Mean discharge (cfs) | Temperature (° F) | Silica ($SiO_2$) | Aluminum (Al) | Iron (Fe) | Manganese (Mn) | 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 | Total acidity as $H_2SO_4$ | Specific conductance (micromhos at 25° C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lycoming Creek at Williamsport** | | | | | | | | | | | | | | | | | | | | | | |
| Sept. 13, 1945* | ---- | 71 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | | 22 | 10 | 2.0 | ---- | 1.5 | ---- | 33 | 15 | ---- | ---- | ---- | ---- |
| **West Branch Susquehana River at Williamsport** | | | | | | | | | | | | | | | | | | | | | | |
| July 19, 1944* | 1,550 | 76 | 4.0 | ---- | ---- | ---- | 21 | 7.0 | 5.6 | | 14 | 71 | 5.1 | 0.0 | .9 | 130 | 81 | 70 | ---- | 204 | 6.8 | 3 |
| Mar. 22, 1945* | 55,000 | 44 | 4.6 | ---- | 0.04 | 0.0 | 5.8 | 1.8 | 2.2 | | 7 | 17 | 1.1 | .1 | 1.6 | 39 | 22 | 16 | ---- | 58 | 6.1 | 5 |
| Sept. 13* | ---- | 75 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | | 32 | 89 | 10 | ---- | 1.6 | ---- | 108 | 82 | ---- | 283 | 6.6 | 5 |
| Oct. 9, 1957 | 708 | 61 | ---- | ---- | .40 | .19 | ---- | ---- | 28 | | 25 | 137 | 18 | ---- | 3.4 | ---- | 130 | 110 | ---- | 385 | 6.5 | 8 |
| **Loyalsock Creek at Loyalsock** | | | | | | | | | | | | | | | | | | | | | | |
| July 20, 1944* | 103 | 68 | 3.0 | ---- | ---- | ---- | 6.0 | 1.4 | 1.1 | | 13 | 10 | 1.2 | .0 | .5 | 31 | 21 | 10 | ---- | 51 | 7.0 | 4 |
| Mar. 26, 1945* | 1,360 | 49 | 3.2 | ---- | 0.01 | 0.0 | 4.5 | 1.0 | 1.4 | | 7 | 10 | 1.0 | .0 | .9 | 28 | 15 | 10 | ---- | 41 | 6.7 | 5 |
| Nov. 10, 1952 | 51 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 1.4 | | 12 | 9.4 | 2.0 | ---- | .8 | ---- | 20 | 10 | ---- | 54 | 7.0 | 3 |
| Dec. 18 | 769 | 36 | ---- | ---- | ---- | ---- | ---- | ---- | 1.3 | | 7.0 | 11 | 1.7 | ---- | 1.6 | ---- | 18 | 12 | ---- | 47 | 7.1 | 3 |
| Jan. 21, 1953 | 1,240 | 38 | ---- | ---- | ---- | ---- | ---- | ---- | .3 | | 7.0 | 10 | 1.3 | ---- | .8 | ---- | 18 | 12 | ---- | 43 | 7.0 | 3 |
| Feb. 28 | 750 | 39 | ---- | ---- | ---- | ---- | ---- | ---- | .4 | | 14 | 13 | 1.5 | ---- | .9 | ---- | 33 | 22 | ---- | 73 | 6.4 | 7 |
| Mar. 30 | 1,760 | 44 | ---- | ---- | ---- | ---- | ---- | ---- | .9 | | 7.0 | 9.9 | 1.4 | ---- | 1.1 | ---- | 17 | 11 | ---- | 42 | 6.9 | 7 |
| May 5 | 901 | 61 | ---- | ---- | ---- | ---- | ---- | ---- | 1.3 | | 7.0 | 9.6 | 1.6 | ---- | 1.0 | ---- | 16 | 10 | ---- | 43 | 7.1 | 4 |
| June 8 | 751 | 53 | ---- | ---- | ---- | ---- | ---- | ---- | 1.0 | | 10 | 9.0 | 1.2 | ---- | 1.1 | ---- | 18 | 10 | ---- | 46 | 7.1 | 7 |
| July 13 | 63 | 73 | ---- | ---- | ---- | ---- | ---- | ---- | 1.5 | | 13 | 9.1 | 1.8 | ---- | .7 | ---- | 20 | 9 | ---- | 53 | 7.1 | 3 |
| Aug. 18 | 46 | 68 | ---- | ---- | ---- | ---- | ---- | ---- | 1.0 | | 15 | 8.4 | 1.9 | ---- | .5 | ---- | 22 | 10 | ---- | 57 | 6.9 | 8 |
| Oct. 9, 1957 | 313 | 55 | ---- | ---- | ---- | ---- | ---- | ---- | 5.5 | | 17 | 9.4 | 2.6 | ---- | .7 | ---- | 16 | 2 | ---- | 61 | 6.6 | 4 |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Muncy Creek at Sonestown** | | | | | | | | | | | | | | | | | | | | | |
| Aug. 31, 1944* | 2.21 | 66 | 3.0 | ------ | 0.02 | ------ | 5.6 | 1.0 | 1.6 | 13 | 7.6 | 1.8 | 0.1 | 0.2 | 28 | 18 | 7 | ------ | 45 | 7.1 | 7 |
| Mar. 28, 1945* | 67.8 | 50 | 3.8 | ------ | .01 | 0.0 | 4.0 | .8 | 1.7 | 7 | 8.4 | .8 | .1 | 1.4 | 24 | 13 | 8 | ------ | 35 | 6.4 | 8 |
| **Muncy Creek at Muncy** | | | | | | | | | | | | | | | | | | | | | |
| Oct. 9, 1957 | 17 | 56 | ------ | ------ | ------ | ------ | ------ | ------ | 11 | 43 | 21 | 6.4 | ------ | 6.8 | ------ | 47 | 12 | ------ | 149 | 7.1 | 4 |
| **White Deer Creek at White Deer** | | | | | | | | | | | | | | | | | | | | | |
| Sept. 14, 1945* | 26.5 | 64 | 3.7 | ------ | 0.02 | ------ | 4.5 | 1.5 | ------ | 17 | 3.3 | .9 | 0.1 | .4 | 26 | 17 | 3 | ------ | 38 | 6.7 | 18 |
| **Buffalo Creek at Lewisburg** | | | | | | | | | | | | | | | | | | | | | |
| July 14, 1945* | ------ | 70 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 101 | 13 | 1.5 | ------ | 4.3 | ------ | 98 | 15 | ------ | 203 | 7.5 | 7 |

TABLE 3.—*Sulfuric acid discharge, West Branch Susquehanna River near Curwensville, Pa., April 1960 to April 1961*

| Sample-collection period | Mean discharge (cfs) | Sulfuric acid (ppm) | Sulfuric acid (tons per day) | Number of days | Sulfuric acid (tons per interval) |
|---|---|---|---|---|---|
| *1960* | | | | | |
| Apr. 22 | 342 | 20 | 18 | 1 | 18 |
| Apr. 26 | 313 | 24 | 20 | 1 | 20 |
| June 10 | 241 | 24 | 16 | 1 | 16 |
| July 28 | 241 | 59 | 38 | 1 | 38 |
| Aug. 1–10 | 130 | 54 | 19 | 10 | 190 |
| Sept. 1–10 | 55 | 108 | 16 | 10 | 160 |
| Oct. 1–10 | 72 | 83 | 16.1 | 10 | 161 |
| Nov. 1–10 | 158 | 29 | 12.4 | 10 | 124 |
| Nov. 16 | 147 | 24 | 10 | 1 | 10 |
| Dec. 4–10 | 88 | 39 | 9 | 7 | 63 |
| *1961* | | | | | |
| Jan. 1–10 | 214 | 29 | 16.8 | 10 | 168 |
| Feb. 1–10 | 178 | 39 | 18.8 | 10 | 188 |
| Mar. 1–10 | 2,400 | 10 | 64.8 | 10 | 648 |
| Apr. 1–10 | 1,050 | 10 | 28.4 | 10 | 284 |
| Total | | | | 92 | 2,088 |

Aluminum, iron, manganese, and hydrogen ions in equivalents per million (table 5) made up 10 percent of the constituents analyzed; calcium and magnesium 26 percent, sodium and potassium 14 percent, sulfate 48 percent, and chloride, fluoride, and nitrate 2 percent (fig. 3).

From August 1, 1960, to May 9, 1961, the river was acidic. The pH ranged from 3.25 to 4.8 (table 6). Water temperature during the same period ranged from freezing for many days to 81° F in August (table 7).

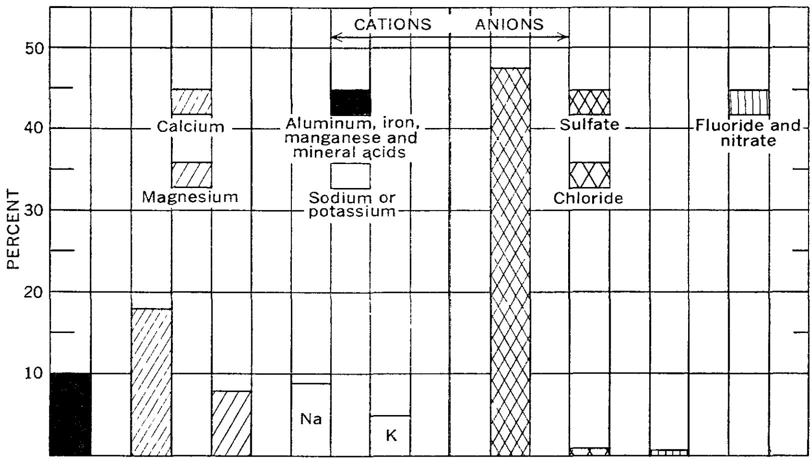


FIGURE 3.—Average percentage composition, based on equivalents per million, West Branch Susquehanna River near Curwensville, Pa., 1960–61.

TABLE 4.—*Specific conductance, in micromhos at 25° C, West Branch Susquehanna River near Curwensville, Pa., August 1, 1960 to May 9, 1961*

| Day | August | September | October | November | December | January | February | March | April | May |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 658 | 1,250 | 967 | 915 | --------- | 496 | 505 | 198 | 257 | 230 |
| 2 | 733 | 1,250 | 1,000 | 738 | --------- | 520 | 504 | 198 | 256 | 252 |
| 3 | 733 | 1,260 | 1,020 | 580 | --------- | --------- | 522 | 218 | 223 | 252 |
| 4 | 665 | 1,250 | 1,030 | 466 | 579 | 481 | 520 | 217 | 234 | 278 |
| 5 | 760 | 1,220 | 1,060 | 540 | 566 | 481 | 521 | 228 | 238 | 303 |
| 6 | 723 | 1,230 | 1,220 | 541 | 692 | 476 | 550 | 229 | 237 | 328 |
| 7 | 818 | 1,300 | 1,190 | 344 | 690 | 504 | 557 | 132 | 237 | 250 |
| 8 | 741 | 1,330 | 1,150 | 641 | 706 | 506 | 575 | 178 | 229 | 250 |
| 9 | 771 | 1,390 | 1,150 | 511 | 679 | 386 | 563 | 184 | 247 | 242 |
| 10 | 850 | 1,290 | 1,110 | 529 | 723 | 382 | --------- | 197 | 246 | --------- |
| 11 | 887 | 1,010 | 1,110 | 534 | 696 | 348 | 567 | 214 | 210 | --------- |
| 12 | 829 | 380 | 1,070 | 504 | 736 | 313 | 570 | 213 | 193 | --------- |
| 13 | 792 | 301 | 1,080 | 432 | --------- | 316 | --------- | 226 | 195 | --------- |
| 14 | 842 | 337 | 1,120 | 443 | 756 | 331 | 517 | 232 | 197 | --------- |
| 15 | 861 | 373 | 1,120 | 460 | 867 | 332 | --------- | 204 | 172 | --------- |
| 16 | 933 | 510 | 1,130 | 497 | 797 | 358 | 509 | 201 | 153 | --------- |
| 17 | 978 | 471 | 1,190 | 334 | 738 | 412 | 322 | 214 | 153 | --------- |
| 18 | 1,040 | 521 | 1,180 | 532 | --------- | 413 | 385 | 232 | 189 | --------- |
| 19 | 996 | 604 | 1,150 | 564 | 808 | 379 | 385 | 253 | 190 | --------- |
| 20 | 1,030 | 690 | 1,140 | 516 | 797 | 380 | 250 | 255 | 200 | --------- |
| 21 | 1,010 | 721 | 1,090 | 585 | 650 | 380 | 147 | 229 | 222 | --------- |
| 22 | 1,030 | 633 | 1,010 | 586 | 731 | 385 | 147 | 244 | 242 | --------- |
| 23 | 1,010 | 660 | 996 | 653 | 747 | 380 | 193 | 236 | 196 | --------- |
| 24 | 1,030 | 660 | 989 | 664 | 649 | 382 | 193 | 239 | 166 | --------- |
| 25 | 1,090 | 660 | 813 | 701 | 680 | 395 | 132 | 229 | 189 | --------- |
| 26 | 1,120 | 738 | 800 | --------- | 708 | 397 | 132 | 226 | 194 | --------- |
| 27 | 1,080 | 785 | 975 | 689 | 704 | 420 | 154 | 246 | 168 | --------- |
| 28 | 1,080 | 848 | 1,020 | 623 | 776 | 446 | 154 | 246 | 195 | --------- |
| 29 | 1,100 | 908 | 914 | 659 | 751 | 446 | --------- | 253 | 210 | --------- |
| 30 | 1,130 | 943 | 911 | --------- | 659 | 501 | --------- | 211 | 230 | --------- |
| 31 | 1,200 | --------- | 962 | --------- | 540 | --------- | --------- | 242 | --------- | --------- |

TABLE 5.—*Conversion factors—Parts per million to equivalents per million*

| *Ion* | *Multiply By—* |
|---|---|
| Aluminum (Al) | 0.11119 |
| Bicarbonate ($HCO_3$) | .01639 |
| Calcium (Ca) | .04990 |
| Carbonate ($CO_3$) | .03333 |
| Chloride (Cl) | .02820 |
| Fluoride (F) | .05263 |
| Hydrogen (H) | .99206 |
| Hydroxide (OH) | .05880 |
| Iron ($Fe^{+2}$) | .03581 |
| Iron ($Fe^{+3}$) | .05372 |
| Magnesium (Mg) | .08224 |
| Manganese ($Mn^{+2}$) | .03640 |
| Manganese ($Mn^{+4}$) | .07281 |
| Nitrate ($NO_3$) | .01613 |
| Potassium (K) | .02558 |
| Sodium (Na) | .04350 |
| Sulfate ($SO_4$) | .02082 |

Chest Creek and Bell Run flow into the river between McGees Mills and Curwensville and usually have a lower dissolved-solids content than the West Branch Susquehanna River. Although there is some strip mining in the Chest Creek drainage basin, neither the water of Chest Creek nor that of Bell Run was acidic at the time of sampling. These tributaries, therefore, dilute and partly neutralize acid water of the main stream. Anderson Creek, which flows into the West Branch Susquehanna River at Curwensville, also drains a strip-mining area and was acidic when sampled (table 2).

The Curwensville dam will create a conservation pool that will be available for recreation, although impounded water in this region is likely to contain acidic coal-mine wastes. If and when water stored in the reservoir has a quality inferior to that of the river below the dam, flow from storage can be withheld until its quality has been improved or it can be released in harmless increments. Furthermore, releases of stored water from above the Curwensville dam can be delayed until discharge and quality of the receiving stream can help to counteract the effects of inferior or acidic water by dilution or neutralization.

TABLE 6.—*pH values, West Branch Susquehanna River near Curwensville, Pa., October 1, 1960 to May 9, 1961*

| Day | October | November | December | January | February | March | April | May |
|---|---|---|---|---|---|---|---|---|
| 1 | 3.60 | 3.35 | --------- | 4.35 | 3.85 | 4.45 | 4.30 | 4.55 |
| 2 | 3.60 | 3.55 | --------- | 4.35 | 3.75 | 4.45 | 4.40 | 4.60 |
| 3 | 3.55 | 3.70 | --------- | --------- | 3.80 | 4.40 | 4.30 | 4.40 |
| 4 | 3.65 | 3.80 | 3.90 | 4.50 | 3.90 | 4.45 | 4.50 | 4.50 |
| 5 | 3.55 | 4.00 | 3.90 | 4.20 | 4.05 | 4.50 | 4.60 | 4.50 |
| 6 | 3.30 | 4.00 | 3.80 | 4.15 | 3.85 | 4.45 | 4.60 | 4.55 |
| 7 | 3.30 | 4.10 | 3.75 | 4.00 | 3.60 | 4.60 | 4.50 | 4.60 |
| 8 | 3.30 | 3.85 | 3.75 | 3.95 | 3.40 | 4.50 | 4.55 | 4.70 |
| 9 | 3.30 | 3.85 | 3.75 | 4.20 | 3.30 | 4.50 | 4.40 | 4.60 |
| 10 | 3.40 | 3.85 | 3.75 | 4.25 | --------- | 4.55 | 4.45 | --------- |
| 11 | 3.35 | 3.80 | 3.95 | 4.00 | 3.75 | 4.60 | 4.55 | --------- |
| 12 | 3.35 | 3.85 | 3.70 | 4.30 | 3.60 | 4.60 | 4.60 | --------- |
| 13 | 3.35 | 3.85 | --------- | 4.35 | --------- | 4.70 | 4.45 | --------- |
| 14 | 3.35 | 3.80 | 3.60 | 4.40 | 3.60 | 4.60 | 4.55 | --------- |
| 15 | 3.40 | 4.00 | 3.55 | 4.40 | --------- | 4.55 | 4.65 | --------- |
| 16 | 3.35 | 3.90 | 3.70 | 4.35 | 3.40 | 4.60 | 4.45 | --------- |
| 17 | 3.30 | 4.00 | 3.90 | 4.10 | 3.60 | 4.60 | 4.55 | --------- |
| 18 | 3.35 | 3.75 | --------- | 4.05 | 3.95 | 4.60 | 4.50 | --------- |
| 19 | 3.45 | 3.55 | 3.90 | 4.25 | 3.95 | 4.65 | 4.60 | --------- |
| 20 | 3.55 | 3.65 | 3.90 | 4.20 | 3.95 | 4.65 | 4.60 | --------- |
| 21 | 3.60 | 3.65 | 4.10 | 4.10 | 4.45 | 4.70 | 4.55 | --------- |
| 22 | 3.55 | 3.55 | 4.05 | 4.00 | 4.50 | 4.70 | 4.50 | --------- |
| 23 | 3.50 | 3.35 | 4.15 | 4.15 | 4.40 | 4.40 | 4.65 | --------- |
| 24 | 3.35 | 3.25 | 4.20 | 4.15 | 4.35 | 4.45 | 4.75 | --------- |
| 25 | 3.55 | 3.50 | 4.15 | 4.30 | 4.50 | 4.50 | 4.60 | --------- |
| 26 | 3.55 | --------- | 4.10 | 4.10 | 4.60 | 4.60 | 4.65 | --------- |
| 27 | 3.35 | 3.70 | 4.10 | 4.05 | 4.45 | 4.60 | 4.70 | --------- |
| 28 | 3.40 | 3.90 | 4.00 | 4.00 | 4.50 | 4.60 | 4.50 | --------- |
| 29 | 3.75 | 3.80 | 4.15 | 3.90 | --------- | 4.60 | 4.55 | --------- |
| 30 | 3.75 | --------- | 4.20 | 3.80 | --------- | 4.70 | 4.60 | --------- |
| 31 | 3.50 | --------- | 4.15 | --------- | --------- | 4.80 | --------- | --------- |

TABLE 7.—*Water temperatures (°F), West Branch Susquehanna River near Curwensville, Pa., August 1, 1960 to May 9, 1961*

[Measured at approximately 1:30 p.m. daily]

| Day | August | September | October | November | December | January | February | March | April | May |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 80 | 80 | 62 | 53 | --------- | 32 | 32 | 41 | 40 | 50 |
| 2 | 79 | 78 | 61 | 51 | --------- | 32 | 32 | 41 | 40 | 50 |
| 3 | 79 | 76 | 62 | 46 | --------- | 32 | 32 | 42 | 41 | 47 |
| 4 | 76 | 74 | 61 | 48 | 41 | 32 | 32 | 42 | 40 | 50 |
| 5 | 78 | 76 | 61 | 45 | 41 | 32 | 32 | 44 | 43 | 53 |
| 6 | 79 | 73 | 60 | 43 | 39 | 33 | 32 | 44 | 45 | 52 |
| 7 | 78 | 76 | 57 | 39 | 40 | 34 | 32 | 46 | 45 | 57 |
| 8 | 80 | 73 | 59 | 43 | 38 | 34 | 32 | 41 | 43 | 57 |
| 9 | 81 | 73 | 59 | 51 | 32 | 32 | 32 | 40 | 41 | 61 |
| 10 | 79 | 77 | 61 | 41 | 32 | 33 | 34 | 38 | 41 | --------- |
| 11 | 79 | 63 | 63 | 41 | 32 | 33 | 34 | 36 | 41 | --------- |
| 12 | 75 | 63 | 61 | 40 | 32 | 32 | 34 | 36 | 43 | --------- |
| 13 | 75 | 62 | 61 | 45 | --------- | 34 | 34 | 40 | 41 | --------- |
| 14 | 78 | 62 | 63 | 47 | 33 | 32 | 36 | 40 | 44 | --------- |
| 15 | 76 | 64 | 65 | 49 | 34 | 32 | 36 | 43 | 49 | --------- |
| 16 | 79 | 67 | 64 | 50 | 32 | 32 | 36 | 40 | 45 | --------- |
| 17 | 77 | 66 | 61 | 45 | 32 | 32 | 36 | 37 | 45 | --------- |
| 18 | 79 | 67 | 58 | 44 | --------- | 32 | 33 | 39 | 44 | --------- |
| 19 | 79 | 66 | 55 | 47 | 32 | 32 | 37 | 39 | 44 | --------- |
| 20 | 78 | 68 | 54 | 47 | 32 | 32 | 37 | 41 | 46 | --------- |
| 21 | 75 | 67 | 52 | 43 | 32 | 32 | 35 | 43 | 44 | --------- |
| 22 | 76 | 68 | 51 | 44 | 32 | 32 | 35 | 40 | 50 | --------- |
| 23 | 74 | 70 | 50 | 42 | 32 | 32 | 41 | 40 | 55 | --------- |
| 24 | 75 | 71 | 50 | 42 | 32 | 32 | 41 | 40 | 58 | --------- |
| 25 | 73 | 72 | 47 | 44 | 34 | 32 | 44 | 45 | 57 | --------- |
| 26 | 76 | 69 | 59 | --------- | 33 | 32 | 44 | 45 | 54 | --------- |
| 27 | 74 | 67 | 50 | 45 | 33 | 32 | 42 | 50 | 51 | --------- |
| 28 | 75 | 68 | 52 | 49 | 32 | 32 | 43 | 50 | 51 | --------- |
| 29 | 80 | 66 | 51 | 50 | 32 | 33 | --------- | 49 | 49 | --------- |
| 30 | 80 | 67 | 50 | --------- | 32 | 32 | --------- | 46 | 50 | --------- |
| 31 | 79 | --------- | 50 | --------- | 32 | 32 | --------- | 43 | --------- | --------- |

The acidic water of the West Branch Susquehanna River near Curwensville will attack ordinary concrete and metals if they are used in the construction of the Curwensville dam. An example of damage done by acidic water to lock and dam structures was illustrated at the Loyalhanna Reservoir in western Pennsylvania. After 1 year of service, the control gates had to be replaced because of the corrosive damage done by the impounded water (U.S. Congress, House Committee on Public Works, 1962). Usually streams that are acidic because of mining wastes contain relatively high concentrations of sulfate, which will disintegrate concrete, as shown in the following table (U.S. Bureau of Reclamation, 1949).

| *Degree* | *Sulfate in water samples (ppm)* |
|---|---|
| Negligible | <150 |
| Positive | 150–1, 000 |
| Considerable | 1, 000–2, 000 |
| Severe | >2, 000 |

The sulfate content of samples removed from the river near Curwensville in March to May, 1961 was 74, 95, and 109 ppm. However, the sulfate content of other samples taken since 1957 ranged from

196 to 707 ppm (table 2). Thus, the foregoing table indicates that the water of the West Branch Susquehanna River would attack concrete.

Furthermore, acidic water is not recommended for use in mixing concrete, although some tests in which acid mine water was used in mixing portland-cement concrete indicated an increase in tensile strength or an acceleration in setting time (California Water Pollution Control Board, 1952). Therefore, it may be advisable not to use the water from some surface streams for mixing concrete until samples are tested.

Compared with natural water the West Branch Susquehanna River at Curwensville contains high concentrations of aluminum, iron, and manganese, as do most streams that drain coal mining regions. Manganese concentrations ranged from 0.55 to 3.6 ppm in the 11 samples analyzed (table 2). These concentrations are considered high for most industrial uses (American Society for Testing Materials, 1959). Although the river is acidic, manganese remains in solution; but it precipitates if oxygen is available, and the pH is increased. Neutralization by seepage of alkaline ground water is one way the river pH may be increased.

Iron and manganese impart strong staining characteristics to water when they precipitate as insoluble hydrates. In water, iron and manganese also nurture the growth of some micro-organisms, such as *Crenothrix*, which colonize in reservoirs (American Water Works Association, 1951). When a *Crenothrix* colony forms, it often attaches to the sides of reservoirs, aqueducts, or spillways and appears as a brown or black slimy mass. Unsightly, *Crenothrix* is an alkali-producing colony and, therefore, may promote the precipitation of iron and manganese from water to cause localized staining. Once iron or manganese is precipitated and formed on the reservoir, further precipitation of these ions may continue by catalysis in the area affected.

## CLEARFIELD CREEK

Approximately 9 miles east of Curwensville, Clearfield Creek flows into the West Branch Susquehanna River near Clearfield. The Creek is so named because of the clearings along its banks. It is 62 miles long and drains 396 square miles of parts of Cambria and Clearfield Counties. The average discharge of the Creek at Dimeling for 47 years of record (1913–60) was 576 cfs (table 1).

This subbasin is underlain by shale, sandstone, and rich deposits of bituminous coal. As a stream receiving coal mine wastes, Clearfield Creek contains high concentrations of solutes and is acidic most of the time. Little Clearfield Creek, less concentrated with dissolved solids (Pennsylvania State Planning Board, 1947), flows into

Clearfield Creek above Clearfield, diluting somewhat the main creek before it reaches the West Branch Susquehanna River.

Clearfield Creek, which contains a calcium sulfate water (table 2), discharges sulfuric acid into the West Branch Susquehanna River.

### MOSHANNON CREEK

Downstream from the confluence of Clearfield Creek with the West Branch Susquehanna River, Moshannon Creek enters the main branch from the south near Karthaus. Moshannon is a corruption of a Delaware Indian word meaning "elk creek." The creek is 46 miles long and drains an area of 290 square miles of parts of Cambria, Blair, Clearfield, and Centre Counties. Discharge records of Moshannon Creek at Osceola Mills appear in table 1.

Underlying this subbasin are sedimentary rocks of shale and sandstone that contain coal deposits. Moshannon Creek also transports wastes from coal mines to the West Branch Susquehanna River. At Osceola Mills Moshannon Creek contains an acidic heavily concentrated calcium and magnesium sulfate water. Calcium, magnesium, and sulfate constitute about 86 percent of the dissolved solids. At times of analysis, the dissolved-solids content ranged from 270 to 800 ppm. The stream contains high concentrations of aluminum, iron, and manganese. For the four samples collected, noncarbonate hardness averaged approximately 350 ppm (table 2).

### WEST BRANCH SUSQUEHANNA RIVER AT KARTHAUS

Approximately 42 river miles separate Curwensville from Karthaus. The Drainage area of the West Branch Susquehanna River at Karthaus is 1,462 square miles, including the area drained by Mosquito Creek. The discharge of the river at Karthaus averaged 2,499 cfs, or approximately 1,610 mgd, for the 20-year period (1940–60).

The principal ions in the river at Karthaus are calcium and sulfate. As with most streams, the solute concentration is greater at times of low discharge than at high discharge. Note in table 2 the two samples of August 1944 and April 1945; each was taken at a time of active mining in the headwater area. The April sample was taken when the discharge was average; the August sample was taken when the discharge was approximately one-third as great. In the August sample many solute concentrations are twice as great as in the April sample. The third sample (October 1957) was taken some years after most mining operations had ceased. At that time the discharge was about one-thirteenth of the average. Most concentrations are even greater than in the August 1944 sample, although the concentration of free sulfuric acid is considerably less. Approximately 200 tons of sulfuric acid flowed past Karthaus on August 8, 1944, and 235 tons on April 17, 1945, but only 55 tons on October 10, 1957, which was approximately one-fourth as much as when coal mining was more active in the headwater area.

### SINNEMAHONING CREEK

Sinnemahoning Creek drains the largest tributary area in the West Branch Susquehanna River basin. Sinnemahoning is a Delaware Indian word meaning "stony lick." Its basin is underlain by shale and sandstone containing some bituminous coal. The Creek enters the river at Keating, near Karthaus. This stream is approximately 45 miles long and drains an area of 1,030 square miles of parts of Clearfield, Elk, McKean, Cameron, Potter, and Clinton Counties. The average discharge of the stream at Sinnemahoning for a 22-year period (1938–60) was 1,150 cfs (table 1), or approximately 743 mgd.

Sinnemahoning Creek contains a calcium sulfate water, and water in many segments of the stream is usable for industrial, domestic, and recreational purposes. At Costello the stream is used, after treatment, as an industrial supply. However, the stream carries some mining wastes and, therefore, is acidic at times. Waste from paper mills also reaches the stream. For one sample collected during low flow on October 10, 1944, at Sinnemahoning the pH was 3.80, specific conductance 335 micromhos, dissolved-solids content 205 ppm, and hardness 135 ppm. When the flow was a little greater than average on May 23, 1945, the pH was 7.3, specific conductance 59 micromhos, dissolved-solids content 35 ppm, hardness 22 ppm, and bicarbonate concentration 6 ppm (table 2).

### KETTLE CREEK

Kettle Creek flows through 41 miles of a picturesque valley of hemlocks and natural wilderness of the Pennsylvania State game land in Clinton County. It is an excellent fishing stream that contains trout, muskellunge, sucker, and fallfish (Pennsylvania Fish Commission, 1961).

The Creek drains an area of 240 square miles of parts of Tioga, Potter, Cameron, and Clinton Counties and flows into the West Branch Susquehanna River at Westport. Underlying the basin are shale and sandstone containing some coal deposits in the upper basin. For a 6-year record near Westport (1954–60) the average discharge was 381 cfs (table 1).

Part of the time Kettle Creek contains a calcium bicarbonate water and part of the time a calcium sulfate water. The bicarbonate and sulfate ion concentrations are predominant at alternate times. Although the stream is acidic on occasion because of coal mine waste (pH 4.25, table 2), its chemical quality is generally good. Most of the time the pH is less than 7.0, and dissolved-solids content is less than 65 ppm.

Completed in 1962 the Alvin R. Bush Dam on Kettle Creek is part of a flood-control project controlling a drainage area of 226 square miles. The dam is located approximately 8.5 miles from the mouth of the Creek. During periods of water surplus the reservoir and recreation areas can be used for storage. Releases of good-quality water from storage could augment flow in the Creek and the West Branch Susquehanna River during dry periods and improve the quality downstream by diluting the concentration of dissolved solids. In addition, the releases of good water from the Kettle Creek Reservoir to the West Branch Susquehanna River could help counteract the deleterious effects of accidental spillages of pollutants into the river.

### WEST BRANCH SUSQUEHANNA RIVER AT LOCK HAVEN

There are approximately 100 river miles between Curwensville and Lock Haven. Based on streamflow records of the river at Renovo (table 1), the estimated average discharge at Lock Haven for a 47-year record was 5,460 cfs, or approximately 3,530 mgd.

Although the West Branch Susquehanna River improves in quality between Curwensville and Lock Haven, its water is still acidic at Lock Haven. The improved quality is largely attributable to the river's many small tributaries above Lock Haven that contain bicarbonates and have a lower concentration of dissolved solids than is in the river. Tributary water having these characteristics helps to dilute concentrations of solutes and to neutralize part of the acidity in the main river.

The bicarbonate furnished by some tributaries and that which enters the main stream directly from underground seepage is insufficient, however, to neutralize the river at Lock Haven, where the pH of 4.5 is exceeded only 10 percent of the time (table 8). From October 1, 1958, to September 30, 1959, the estimated discharge of

TABLE 8.—*Given values of physical and chemical properties that were equaled or exceeded for indicated percent of days, West Branch Susquehanna River at Lock Haven, Pa., October 1945 to September 1951*

| | Values equaled or exceeded for indicated percent of days | | | | |
|---|---|---|---|---|---|
| | 1 | 10 | 50 | 90 | 99 |
| Specific conductance micromhos at 25°C | 685 | 530 | 225 | 135 | 105 |
| pH | 4.8 | 4.5 | 4.05 | 3.60 | 3.30 |
| Calcium (Ca) ppm | 45 | 36 | 15 | 9.8 | 7.7 |
| Magnesium (Mg) ppm | | 14 | 5.9 | 3.5 | 2.7 |
| Sodium (Na) and Potassium (K) ppm | 9.8 | 7.8 | 3.4 | 2.1 | 1.6 |
| Sulfate ($SO_4$) ppm | 247 | 191 | 80 | 46 | 35 |
| Chloride (Cl) ppm | 8.3 | 6.4 | 2.7 | 1.7 | 1.3 |
| Dissolved solids ppm | | 288 | 123 | 74 | 58 |
| Hardness as $CaCO_3$ ppm | 222 | 172 | 74 | 45 | 36 |

TABLE 9.—*Sulfuric acid discharge, West Branch Susquehanna River at Lock Haven, Pa., October 1958 to September 1959*

| Collection period | Mean discharge (cfs) | Sulfuric acid discharge (tons per day) | Number of days | Sulfuric acid discharge (tons per interval) |
|---|---|---|---|---|
| *1958* | | | | |
| Oct. 1–10 | 2,960 | 192 | 10 | 1,920 |
| Oct. 11–18 | 1,480 | 116 | 8 | 928 |
| Oct. 19–31, Nov. 1–9 | 1,680 | 132 | 22 | 2,904 |
| Nov. 10–30 | 3,620 | 147 | 11 | 1,617 |
| Nov. 21–30, Dec. 1–6 | 4,120 | 111 | 16 | 1,776 |
| Dec. 7–8 | 5,230 | 212 | 2 | 424 |
| Dec. 9–10, 12–21 | 2,860 | 77 | 12 | 924 |
| Dec. 22–31 | ---------- | ---------- | ---------- | ---------- |
| *1959* | | | | |
| Jan. 1–4 | 2,080 | 85 | 14 | 1,190 |
| Jan. 5 | 2,700 | 146 | 1 | 146 |
| Jan. 6–17 | 2,060 | 56 | 12 | 672 |
| Jan. 18–21 | 4,610 | 124 | 4 | 496 |
| Jan. 22–26 | 34,800 | 940 | 5 | 4,700 |
| Jan. 27–31, Feb. 1–10 | 6,320 | 256 | 15 | 3,840 |
| Feb. 11–14 | 2,140 | 87 | 4 | 348 |
| Feb. 15–24 | 9,090 | 245 | 10 | 2,450 |
| Feb. 25–28, Mar. 1–6 | 5,550 | 150 | 10 | 1,500 |
| Mar. 7–24 | 10,500 | 425 | 18 | 7,650 |
| Mar. 25–31, Apr. 1–2 | 12,100 | 327 | 10 | 3,270 |
| Apr. 3–8 | 21,900 | 296 | 6 | 1,776 |
| Apr. 9–17 | 9,660 | 261 | 9 | 2,349 |
| Apr. 18–22, 24–27 | 6,630 | 269 | 9 | 2,421 |
| Apr. 23 | 7,020 | 550 | 1 | 550 |
| Apr. 28–30, May 1–3 | 25,100 | 678 | 6 | 4,068 |
| May 4–11 | 9,970 | 404 | 8 | 3,232 |
| May 12–27 | 4,760 | 257 | 16 | 4,112 |
| May 28–31, June 1–6 | 2,350 | 127 | 10 | 1,270 |
| June 7–26 | 1,510 | 118 | 20 | 2,360 |
| June 27–30, July 1–2 | 2,010 | 81 | 6 | 486 |
| July 3–10 | 1,330 | 86 | 8 | 688 |
| July 11–26 | 806 | 74 | 16 | 1,184 |
| July 27–31, Aug. 1 | 716 | 75 | 6 | 450 |
| Aug. 2–6 | 597 | 87 | 5 | 435 |
| Aug. 8–17 | 511 | 61 | 10 | 610 |
| Aug. 18–24 | 626 | 100 | 7 | 700 |
| Aug. 25–28 | 909 | 83 | 4 | 332 |
| Aug. 29–31, Sept. 1–18 | 601 | 71 | 21 | 1,491 |
| Sept. 19–30 | 248 | 36 | 12 | 432 |
| Total | ---------- | ---------- | 364 | 65,701 |

sulfuric acid in the river flowing past Lock Haven was 180 tons per day (table 9).

During the 1959 water year the river at Lock Haven contained calcium sulfate water. The specific conductance of the water was less than 230 micromhos 50 percent of the time (fig. 4); the weighted-average noncarbonate hardness was 85 ppm (table 10); and the temperature of the river equaled or exceeded 75°F 26 percent of the time (fig. 5).

## BALD EAGLE CREEK

Bald Eagle Creek flows into the West Branch Susquehanna River below Lock Haven. The stream was named after the North American eagle, which frequented the basin area in Colonial days. It is 51 miles long and drains an area of 780 square miles of parts of Centre and Clinton Counties (table 1). Its principal tributaries are Fishing,

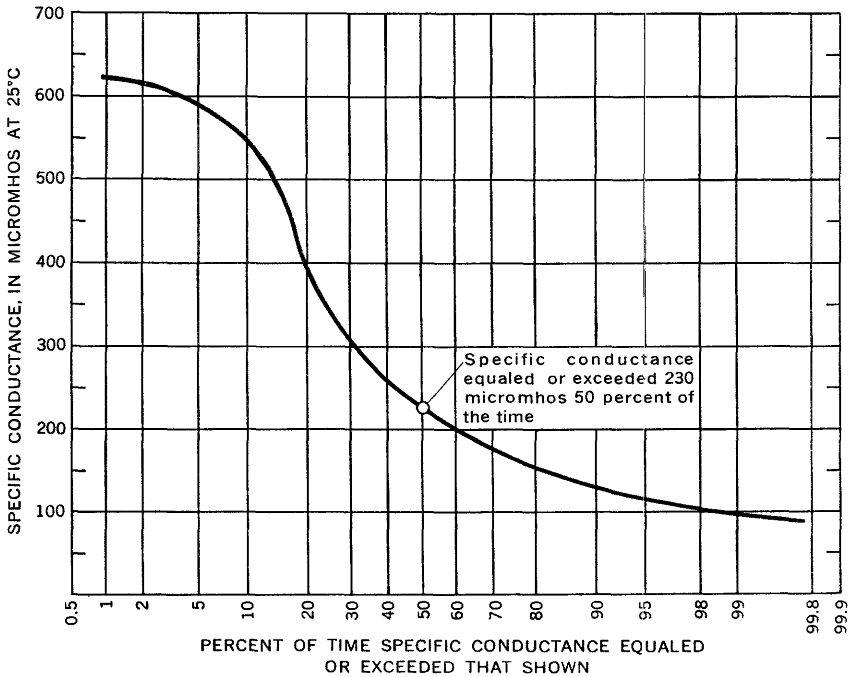


FIGURE 4.—Cumulative frequency curve of specific conductance, West Branch Susquehanna River at Lock Haven, Pa., October 1958 to September 1959.

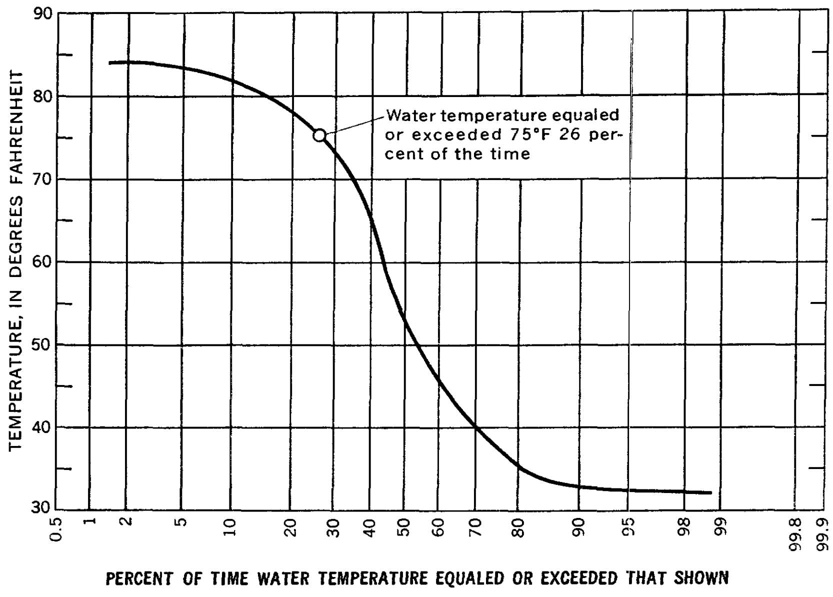


FIGURE 5.—Cumulative frequency curve of water temperature, West Branch Susquehanna River at Lock Haven, Pa., October 1958 to September 1959.

TABLE 10.—*Chemical analyses, in parts per million, West Branch Susquehanna River at Lock Haven, Pa., water year October 1958 to September 1959*

LOCATION.—Center of Lockport Bridge which is situated at the termination of North Jay Street, Lock Haven, Clinton County, and 30.1 miles downstream from gaging station at Renovo, Pa.

DRAINAGE AREA.—3,337 square miles.

RECORDS AVAILABLE.—Chemical analyses: October 1945 to September 1951, October 1958 to September 1959. Water temperatures: October 1945 to September 1951, October 1958 to September 1959.

EXTREMES 1958–59.—Dissolved solids: Maximum 380 ppm, August 18–24; minimum, 68 ppm, January 22–26, March 25–31, April 1–2. Hardness: Maximum, 189 ppm, September 19–30; minimum, 33 ppm, January 22–26. Specific conductance: Maximum daily, 781 micromhos, August 4; minimum daily, 98 micromhos, April 3. Water temperatures: Maximum, 84° F, July 30–31, August 16; minimum, freezing point on several days during winter months.

EXTREMES 1945–51, 1958–59.—Dissolved solids (1945–47, 1958–59): Maximum, 380 ppm, August 18–24, 1959; minimum, 51 ppm, March 1–10, 1946. Hardness (1945–47, 1949–51, 1958–59): Maximum, 206 ppm, September 11–20, 1958; minimum, 28 ppm, April 1–10, 1950. Specific conductance: Maximum daily, 785 micromhos, September 18, 1951; minimum daily, 79 micromhos, April 2, 1951. Water temperatures: Maximum 84° F, July 30–31, August 16, 1959; minimum, freezing point on many days during winter months.

REMARKS.—Records of specific conductance and pH of daily samples available in district office at Philadelphia, Pa. Records of discharge for water year October 1958 to September 1959 based on records for West Branch Susquehanna River at Renovo, Pa, which are given in Water-Supply Paper 1622.

| Date of collection | Mean discharge (cfs) | Temperature (° F) | Silica ($SiO_2$) | Aluminum (Al) | Iron (Fe) | Manganese (Mn) | 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 | Total acidity as ($H^{+1}$) | Specific conductance (micromhos at 25° C) | pH | Color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 1–10, 1958 | 2,960 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 88 | 3.2 | ------ | 0.0 | ------ | 69 | 69 | 0.5 | 265 | 3.85 | 2 |
| Oct. 11–18 | 1,480 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 106 | 3.9 | ------ | .1 | ------ | 84 | 84 | .6 | 275 | 4.15 | 3 |
| Oct. 19–31, Nov. 1–9 | 1,680 | ------ | 6.7 | 2.3 | 0.08 | 1.3 | 23 | 10 | 6.0 | 1.3 | 0 | 121 | 4.3 | 0.1 | .0 | 180 | 99 | 99 | .6 | 301 | 4.20 | 2 |
| Nov. 10–20 | 3,620 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 72 | 3.6 | ------ | .2 | ------ | 68 | 68 | .3 | 220 | 4.30 | 2 |
| Nov. 21–30, Dec. 1–6 | 4,120 | ------ | 7.5 | 1.0 | .00 | .31 | 12 | 5.4 | 2.2 | 1.4 | 0 | 61 | 2.6 | .1 | .2 | 90 | 52 | 52 | .2 | 164 | 4.5 | 3 |
| Dec. 7–8 | 5,230 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 78 | ------ | ------ | ------ | ------ | ------ | ------ | .3 | 213 | 4.30 | ------ |
| Dec. 9–10, 12–21 | 2,860 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 7.6 | | 0 | 64 | 3.4 | ------ | .2 | ------ | 55 | 55 | .2 | 175 | 4.5 | 2 |
| Dec. 22–31, Jan. 1–4, 1959 | 2,090 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 98 | 3.5 | ------ | 4.7 | ------ | 72 | 72 | .3 | 221 | 4.25 | 3 |
| Jan. 5 | 2,700 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 115 | ------ | ------ | ------ | ------ | ------ | ------ | .4 | 286 | 4.15 | ------ |
| Jan. 6–17 | 2,060 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 74 | 2.8 | ------ | 1.3 | 120 | 64 | 64 | .2 | 198 | 4.40 | 3 |
| Jan. 18–21 | 4,610 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 77 | ------ | ------ | ------ | ------ | ------ | ------ | .2 | 211 | 4.30 | ------ |
| Jan. 22–26 | 34,800 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 38 | 1.0 | ------ | 1.6 | 68 | 33 | 33 | .2 | 116 | 4.45 | 3 |
| Jan. 27–31, Feb. 1–10 | 6,320 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 67 | 1.9 | ------ | 1.8 | 106 | 54 | 54 | .3 | 184 | 4.10 | 2 |
| Feb. 11–14 | 2,140 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 43 | ------ | ------ | ------ | ------ | ------ | ------ | .3 | 136 | 4.35 | ------ |
| Feb. 15–24 | 9,090 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 61 | 2.2 | ------ | 1.2 | 110 | 52 | 52 | .2 | 177 | 4.30 | 3 |
| Feb. 25–28, Mar. 1–6 | 5,550 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 74 | 2.8 | ------ | 1.7 | 122 | 60 | 60 | .2 | 201 | 4.20 | 3 |
| Mar. 7–24 | 10,500 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 58 | 2.2 | ------ | .8 | 93 | 48 | 48 | .3 | 161 | 4.10 | 5 |
| Mar. 25–31, Apr. 1–2 | 12,100 | ------ | 6.8 | ------ | .00 | .41 | 9.6 | 3.9 | 2.5 | 1.0 | 0 | 43 | 2.0 | .1 | .4 | 68 | 40 | 40 | .2 | 135 | 4.5 | 3 |
| Apr. 3–8 | 21,900 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 42 | 1.6 | ------ | 1.3 | 71 | 37 | 37 | .1 | 121 | 4.30 | 2 |
| Apr. 9–17 | 9,660 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 59 | 2.2 | ------ | 1.1 | 94 | 50 | 50 | .2 | 169 | 4.15 | 2 |
| Apr. 18–22, 24–27 | 6,630 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 67 | 2.2 | ------ | 1.5 | 107 | 56 | 56 | .3 | 193 | 4.05 | 2 |
| Apr. 23 | 7,020 | ------ | 7.1 | 1.2 | .00 | .55 | 12 | 5.7 | 2.8 | 1.3 | 0 | 67 | 3.4 | .1 | .4 | 100 | 54 | 54 | .6 | 182 | 4.00 | 3 |
| Apr. 28–30, May 1–3 | 25,100 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 46 | 2.0 | ------ | 1.3 | 80 | 41 | 41 | .2 | 142 | 4.30 | 2 |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 4-11 | 9,970 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 70 | 2.0 | ------ | .9 | 111 | 57 | 57 | .3 | 199 | 4.00 | 2 |
| May 12-27 | 4,760 | ------ | 7.1 | ------ | .02 | .89 | 15 | 6.9 | 4.8 | .5 | 0 | 82 | 2.4 | .0 | .7 | 136 | 66 | 66 | .4 | 235 | 3.75 | 3 |
| May 28-31, June 1-6 | 2,350 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 99 | 2.8 | ------ | .5 | 159 | 76 | 76 | .4 | 279 | 3.80 | 0 |
| June 7-26 | 1,510 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 129 | 3.6 | ------ | 2.4 | 200 | 102 | 102 | .6 | 344 | 3.70 | 1 |
| June 27-30, July 1-2 | 2,010 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 80 | 1.5 | ------ | .8 | 150 | 68 | 68 | .3 | 222 | 4.00 | 1 |
| July 3-10 | 1,330 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 115 | 3.2 | ------ | .9 | 180 | 46 | 46 | .5 | 314 | 3.85 | 2 |
| July 11-26 | 806 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 161 | 5.0 | ------ | .6 | 229 | 117 | 117 | .7 | 410 | 3.65 | 3 |
| July 27-31, Aug 1 | 716 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 211 | 7.0 | ------ | .9 | 289 | 142 | 142 | .8 | 503 | 3.70 | 2 |
| Aug. 2-6 | 597 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 236 | 7.0 | ------ | .7 | 340 | 170 | 170 | 1.1 | 603 | 3.45 | 3 |
| Aug. 8-17 | 511 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 202 | 6.5 | ------ | 1.0 | 295 | 152 | 152 | .9 | 521 | 3.50 | 5 |
| Aug. 18-24 | 626 | ------ | 12 | 4.0 | .33 | 2.6 | 41 | 19 | 11 | 2.2 | 0 | 236 | 7.8 | .3 | .2 | 380 | 181 | 181 | 1.2 | 604 | 3.30 | 2 |
| Aug. 25-28 | 909 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 141 | 6.0 | ------ | .8 | 214 | 107 | 107 | .7 | 378 | 3.60 | 3 |
| Aug. 29-31, Sept. 1-18 | 601 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0 | 206 | 6.4 | ------ | .9 | 299 | 158 | 158 | .9 | 533 | 3.60 | 2 |
| Sept. 19-30 | 248 | ------ | 11 | 8.4 | .33 | 3.0 | 46 | 18 | 11 | 2.5 | 0 | 250 | 7.5 | .2 | .5 | 371 | 189 | 189 | 1.1 | 622 | 3.45 | 2 |
| Time-weighted average | 5,010 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 105 | 3.6 | ------ | .9 | 169 | 85 | 85 | .5 | 285 | ------ | 2 |

Beech and Spring Creeks. This subbasin is underlain by sandstone and limestone.

Bald Eagle Creek contains an alkaline calcium bicarbonate water (table 2). Bicarbonate is the dominant ion. The creek helps to neutralize and to dilute much of the acidity of the West Branch Susquehanna River when the creek and river mix.

Upstream at Blanchard, 14 miles from the mouth of Bald Eagle Creek, the average flow for a 6-year period (1954–60) was 469 cfs. However, the average discharge of this stream into the West Branch Susquehanna River probably is greater because other streams contribute water to Bald Eagle Creek below Blanchard. The first appearance of bicarbonate is in segments of the West Branch Susquehanna River below the mouth of Bald Eagle Creek. Limestone springs that underlie this subbasin give Bald Eagle Creek a dependable dry-season flow. One of these springs at Bellefonte gushes approximately 11,500,000 gallons of pure drinking water daily.

Because all the available supply from the limestone springs is not needed by Bellefonte and surrounding communities. approximately 8,000 gpd are directed to Spring Creek, tributary to Bald Eagle Creek at Milesburg. This spring water is reported to have a year-round temperature of 50° F.

Several small tributaries in the basin are used for domestic supply. Spring Creek and Bald Eagle Creek, downstream as far as Blanchard, are stocked with brook, brown, and rainbow trout. Other species in the stream are smallmouth bass and pickerel. Sportsmen call areas along Spring Creek "fisherman's paradise."

A flood-control reservoir will be constructed on Bald Eagle Creek, approximately 1 mile upstream from Blanchard and 15 miles from the stream mouth. An area of 339 square miles will be drained above the dam site. A conservation pool of about 370 acres will be available for recreation. Because of the year-round availability of water from the many prolific springs in the area, storage of large quantities of good quality water is possible in the impoundment areas. Regulated releases of impounded water could be used to help maintain flow and quality of Bald Eagle Creek and the West Branch Susquehanna River downstream from its confluence with Bald Eagle Creek.

## PINE CREEK

Pine Creek, a major tributary of the West Branch Susquehanna River, enters the river near Jersey Shore. The creek lies within a glacial area in its headwaters and flows through Pine Creek Gorge, often referred to as the "Grand Canyon of Pennsylvania". The gorge extends from Mount Tom to Jersey Shore. The stream is 72 miles long and drains 973 square miles of parts of Tioga, Potter, and

Lycoming Counties (table 1). Its main tributaries are Marsh, Babb, and Little Pine Creeks. The subbasin is underlain with shale and sandstone, containing coal and oil deposits.

Pine Creek contains a mixed-type calcium bicarbonate sulfate water that is low in dissolved solids. For the times the stream was analyzed near Jersey Shore the dissolved solids did not exceed 52 ppm, pH ranged from 6.7 to 7.4, and specific conductance did not exceed 105 micromhos (table 2). When the waters of Pine Creek mix with the West Branch Susquehanna River, they help to dilute the concentration of solutes in the main river.

Based on 42 years of record (1918–60), the average discharge of Pine Creek at Cedar Run was 826 cfs, or approximately 520 mgd.

At Waterville the recorded average discharge for 12 years (1908–20) was 1,144 cfs (U.S. Geological Survey, 1960), or approximately 740 mgd. However, at Waterville the discharge does not include the discharge of Little Pine Creek, which drains 172 square miles of Tioga and Lycoming Counties. Therefore, the average discharge of Pine Creek into the West Branch Susquehanna River near Jersey Shore is considerably more than the reported average discharge of Pine Creek at Waterville.

Pine Creek is used as a source of supply to the Galeton-Eldred Water Co. It is also open to fishermen who may catch brown and rainbow trout, small-mouth bass, walleyes, suckers, and bullheads.

### LYCOMING CREEK

Lycoming Creek flows into the West Branch Susquehanna River at Williamsport. Lycoming is a Delaware Indian word meaning "sandy stream." The creek is approximately 23 miles long and drains 276 square miles of parts of Bradford, Lycoming, Sullivan, and Tioga Counties (table 1). The subbasin is underlain by shale and sandstone in which are coal deposits.

Lycoming Creek contains a calcium bicarbonate and calcium sulfate water of good quality. The maximum of 10 specific conductances measured on the stream from 1952 to 1957 was 77 micromhos. The range of pH was 6.6 to 7.4 (table 2).

For most of its length, Lycoming Creek provides the environment for the propagation of aquatic life. This stream contains trout, small-mouth bass, suckers, and fallfish.

### WEST BRANCH SUSQUEHANNA RIVER AT WILLIAMSPORT

The West Branch Susquehanna River at Williamsport contains a calcium magnesium sulfate water, and commonly has a pH between 6.0 and 7.0. Sulfate is the dominant constituent (table 2).

The acidic characteristic of the river in upstream segments has been changed noticeably in the reach of the river between Lock

Haven and Williamsport. Evidently several tributaries of good-quality water and ground-water seepages from limestone and sandstone aquifers underlying this part of the basin have produced the more diluted and neutral water that flows past Williamsport.

Concentration of dissolved solids decreases as water discharge increases, and conversely the concentration increases when water discharge is low. Low flow usually occurs during the summer; consequently, the concentrations of most solutes are at their highest level at this time.

The average discharge of the river at Williamsport for 65 years (1895–1960) was 8,887 cfs (table 1), or approximately 5,730 mgd.

The Pennsylvania State Health Department has established an automatic monitoring station at Williamsport for detecting acidity and changes in the quality of the West Branch Susquehanna River. Acidity, or other harmful properties of water, can sometimes be counteracted by dilution with good water released from upstream impoundments once they become available. This would tend to lessen the influence of harmful properties of water downstream.

### LOYALSOCK CREEK

A short distance to the east of Williamsport, Loyalsock Creek flows into the West Branch Susquehanna River at Montoursville. Loyalsock is a corruption of the Indian Lawi-saquik meaning "middle creek." The stream is 59 miles long and drains an area of 493 square miles of parts of Bradford, Lycoming, Sullivan, and Wyoming Counties. Most of the subbasin lies within the glacial area and is underlain by shale and sandstone containing deposits of soft anthracite.

At Loyalsock, 7 miles upstream from the mouth of the creek, the average discharge for 35 years (1925–60) was 762 cfs (table 1). Loyalsock Creek has good-quality calcium bicarbonate sulfate water, low in dissolved solids (table 2). The stream contains trout, smallmouth bass, walleyes, suckers, and bullheads.

### MUNCY CREEK

Muncy Creek joins the West Branch Susquehanna River near Muncy, approximately 20 miles upstream from Lewisburg. Muncy is a corruption of the Indian tribal name Minsi, meaning "wolf." The creek is 33 miles long and drains 216 square miles of parts of Columbia, Lycoming, Montour, and Sullivan Counties. Shale, sandstone, and limestone underlie this subbasin.

The average discharge of the stream near Sonestown for 20 years of record (1940–60) was 48.8 cfs (table 1).

Muncy Creek contains good-quality calcium bicarbonate sulfate water, low in dissolved solids (table 2). The species of fish available in the stream are trout, smallmouth bass, bullheads, suckers, and fallfish.

### WEST BRANCH SUSQUEHANNA RIVER AT LEWISBURG

Lewisburg, on the West Branch Susquehanna River, is approximately 7 miles upstream from the river mouth at Northumberland.

During early phases of the cooperative program between the Geological Survey and the Pennsylvania Department of Forests and Waters, the West Branch Susquehanna River at Lewisburg was selected as a site for daily sampling and chemical analyses. Sampling was continuous from 1944 to 1953 and, after a lapse of 3 years, was resumed in 1956. For most of the period of record, daily samples were composited into groups consisting of samples taken in sequence and composited at intervals of 10 days.

The average discharge of the river at Lewisburg for the 21-year period (1939–60) was 10,880 cfs (table 1), or approximately 7,020 mgd. The average discharge of 11,390 cfs for the 1958 water year (table 11) was approximately 4 percent greater than the average discharge for the period of record. Runoff during the 1958 water year was greater during the winter and spring than during the summer and autumn. This pattern of runoff at Lewisburg is characteristic of the entire river basin and causes seasonal variations in dissolved solids and specific conductance. Figure 6 shows variations in specific conductance and water discharge at Lewisburg for the period October 1944 to September 1950.

The specific conductance of the river at Lewisburg from October 1957 to September 1958 was less than 285 micromhos 90 percent of the time and exceeded 205 micromhos only 30 percent of the time (fig. 7). The average for the year was 184 micromhos; a maximum of 406 micromhos occurred October 7 during a period of low flow, and a minimum of 68 micromhos occurred April 8 during a period of high flow.

At Lewisburg the West Branch Susquehanna River contains a calcium sulfate water. Natural water usually contains calcium as a major constituent because compounds of calcium are widespread in soils and sedimentary rock and many of them are readily soluble, both underground and at the surface, through processes of weathering.

Calcium represents approximately 16 percent of the dissolved material in the river at Lewisburg and, combined with magnesium, also common in soils, represents more than 20 percent of the materials in solution (fig. 8). The ratio of calcium to magnesium in the river at Lewisburg, based on parts per million, is usually about 3 to 1. When computed from equivalents per million, the ratio is about 1.8 to 1.

Although the river at Lewisburg is nonacidic most of the time, the acidic character of the upper river accounts for the concentration of

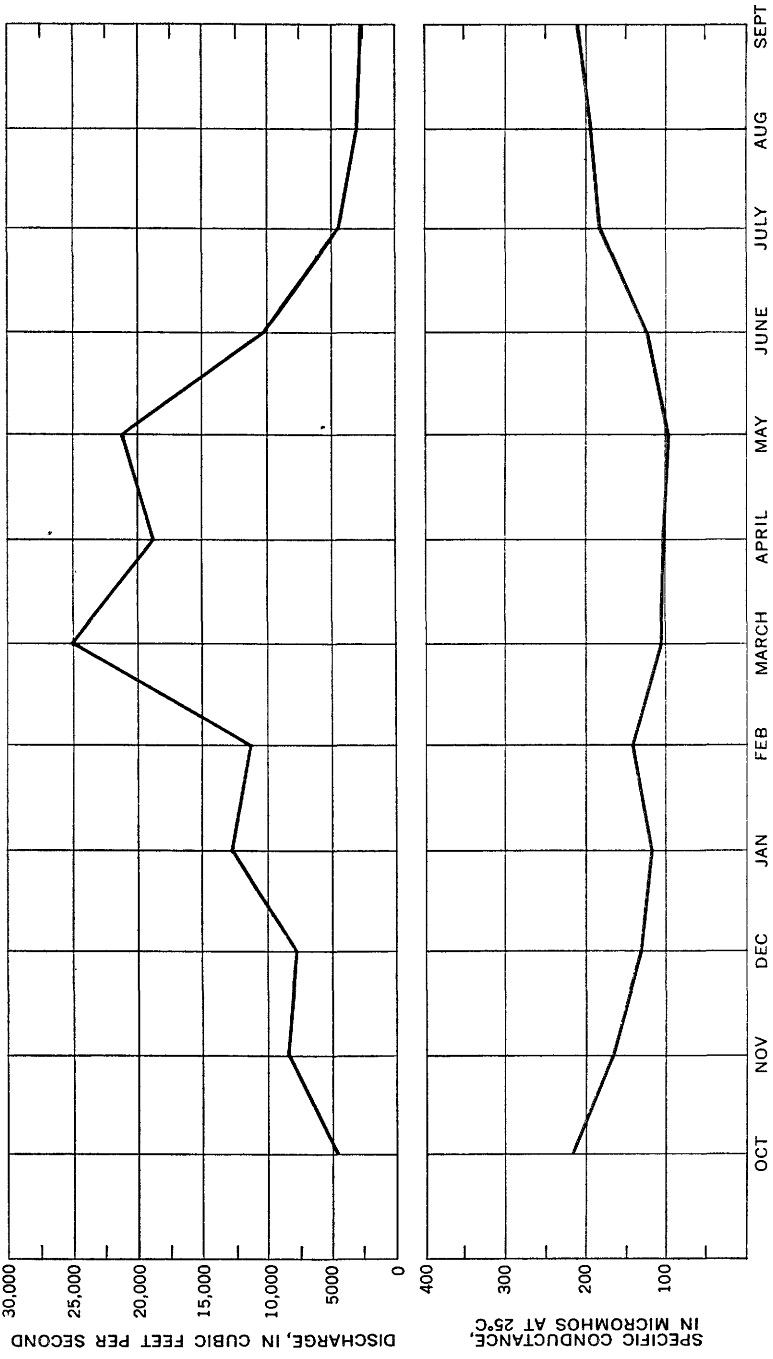


FIGURE 6.—Monthly discharge and specific conductance, West Branch Susquehanna River at Lewisburg, Pa., October 1944 to September 1950.

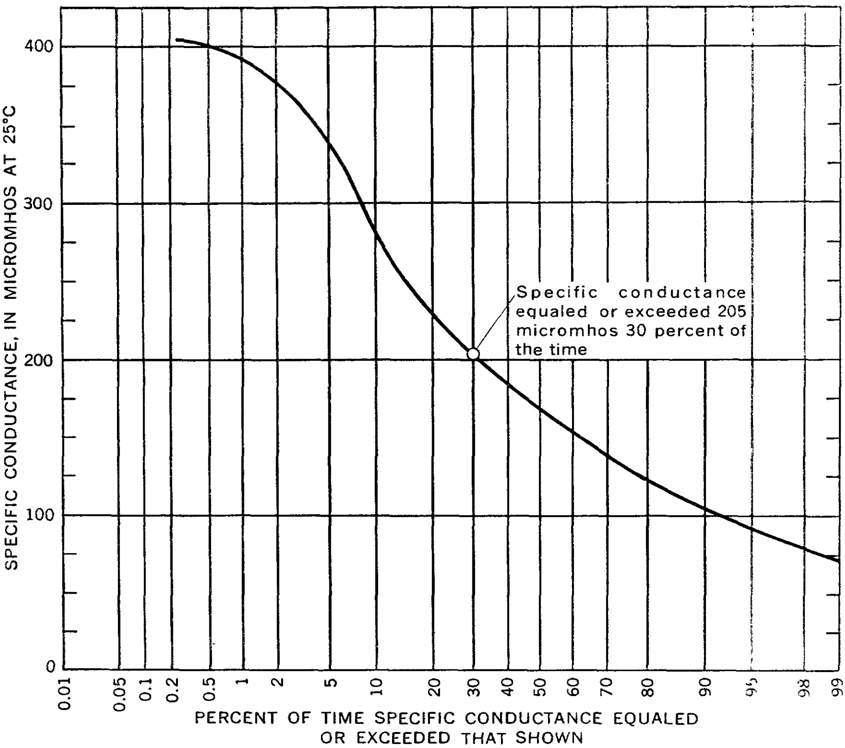


FIGURE 7.—Cumulative frequency curve of specific conductance, West Branch Susquehanna River at Lewisburg, Pa., October 1957 to September 1958.

noncarbonate hardness at Lewisburg. Noncarbonate hardness makes up about 80 percent of the hardness calculated as $CaCO_3$. The average hardness (as $CaCO_3$) for the 1958 water year was 71 ppm (table 11), which was higher than the average reported for other water years. The minimum hardness of water occurred during periods of high flow, commonly during winter and spring. However, much of the time hardness-causing constituents were within tolerance limits prescribed by many industries and other users (Fair and Geyer, 1954).

Approximately 55 percent of the dissolved solids in the river at Lewisburg is sulfate (fig. 9). Waste sulfuric acid draining from coal mines into streams of the headwaters account for the high sulfate. Sulfate does not form insoluble compounds with the concentrations of cations that ordinarily may be dissolved in the river water. Sulfate transported by the river past Lewisburg during the 1958 water year averaged 1,250 tons per day (table 12).

The minimum pH daily samples of the river at Lewisburg during the 1958 water year was 6.2. For a period of 4 years (1944–48) pH of similar samples was 5.0 or more about 97 percent of the time.

TABLE 11.—*Chemical analyses, in parts per million, West Branch Susquehanna River at Lewisburg, Pa., water year October 1957 to September 1958*

LOCATION.—At gaging station at Market Street Bridge at Lewisburg, Union County, 560 feet from east bank of river, 0.2 mile downstream from Buffalo Creek, and 7.4 miles upstream from mouth.
DRAINAGE AREA.—6,847 square miles.
RECORDS AVAILABLE.—Chemical analyses: October 1944 to June 1953, October 1956 to September 1958.
Water temperatures.—October 1944 to June 1953, October 1956 to September 1958.
EXTREMES, 1957–58.—Hardness: Maximum, 150 ppm October 1–11; minimum, 31 ppm April 7–24.
Specific conductance: Maximum daily, 406 micromhos October 7; minimum daily, 68 micromhos April 8.
Water temperatures: Maximum, 79°F July 6, 12; minimum, freezing point on many days during the winter months.
EXTREMES (1944–53, 1956–58).—Dissolved solids: Maximum, 240 ppm October 1–11, 1957; minimum, 46 ppm May 1–10, 1945.
Hardness: Maximum, 156 ppm October 1–10, 1951, August 26–September 6, 1957; minimum, 26 ppm May 21–31, 1946.
Specific conductance: Maximum daily, 423 micromhos August 26, 1957; minimum daily, 63 micromhos November 3, 1956.
Water temperatures: Maximum, 90°F July 28, August 10, 1949; minimum, freezing point on many days during the winter months.
REMARKS.—Records of specific conductance of daily samples available in district office in Philadelphia, Pa. Records of discharge for water year October 1957 to September 1958 given in Water-Supply Paper 1552.

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. 1–11, 1957 | 855 | 4.3 | 0.01 | 43 | 10 | 14 | 2.4 | 27 | 140 | 13 | 0.1 | 2.0 | 240 | 150 | 128 | 384 | 7.1 | 5 |
| Oct. 12–31–Nov. 1–11 | 1,280 | | | | | 15 | | 32 | 104 | 12 | | 2.5 | | 120 | 94 | 313 | 7.5 | 8 |
| Nov. 12–17, 20 | 2,620 | | | | | 19 | | 24 | 105 | 11 | | 2.0 | | 104 | 85 | 281 | 7.3 | 5 |
| Nov. 21, 22 | 4,500 | | | | | 9.0 | | 15 | 52 | 6.0 | | 2.9 | | 58 | 46 | 159 | 6.9 | 6 |
| Nov. 23–Dec. 11 | 2,640 | | | | | 12 | | 20 | 78 | 7.0 | | 2.3 | | 84 | 68 | 224 | 6.9 | 7 |
| Dec. 12–20 | 4,060 | | | | | 8.3 | | 8 | 80 | 6.4 | | 2.3 | | 83 | 77 | 218 | 6.5 | 5 |
| Dec. 21–31 | 29,370 | 6.4 | .01 | 9.1 | 2.8 | 1.3 | 1.1 | 6 | 28 | 2.6 | .0 | 2.1 | 64 | 34 | 29 | 94 | 6.8 | 3 |
| Jan. 6–7, 9, 22, 1958 | 7,650 | | | | | 5.1 | | 16 | 45 | 4.1 | | 2.5 | | 57 | 44 | 149 | 6.8 | 3 |
| Jan. 23–26, 29–30 | 10,130 | | | | | 5.5 | | 15 | 34 | 4.0 | | 2.8 | | 44 | 32 | 121 | 7.0 | 7 |
| Jan. 31–Feb. 1, 9, 11, 15 | 4,710 | | | | | 5.3 | | 19 | 48 | 5.0 | | 3.8 | | 64 | 49 | 166 | 7.1 | 5 |
| Feb. 16–17, 19–27 | 4,610 | | | | | 7.8 | | 20 | 57 | 6.6 | | 3.8 | | 72 | 56 | 191 | 7.0 | 3 |
| Feb. 28–Mar. 9 | 25,540 | | | | | 3.2 | | 10 | 33 | 2.8 | | 3.1 | | 42 | 34 | 112 | 6.7 | 5 |
| Mar. 11–30 | 14,490 | | | | | 4.4 | | 14 | 40 | 4.0 | | 2.3 | | 51 | 40 | 134 | 6.9 | 3 |
| Mar. 31–Apr. 6 | 36,940 | 4.9 | .05 | 8.9 | 2.7 | 1.6 | 1.1 | 6 | 27 | 2.2 | .1 | 1.3 | | 33 | 28 | 97 | 6.2 | 2 |
| Apr. 7–24 | 39,100 | | | | | 3.0 | | 6 | 27 | 2.0 | | 1.8 | | 31 | 26 | 84 | 6.3 | 3 |
| Apr. 25–May 14 | 30,320 | | | | | 3.7 | | 8 | 35 | 2.1 | | .3 | | 38 | 32 | 101 | 6.4 | 3 |
| May 16–26 | 9,140 | | | | | 5.8 | | 17 | 50 | 3.8 | | 2.3 | | 61 | 47 | 154 | 6.3 | 3 |
| May 27–June 11 | 5,590 | 13 | .01 | 21 | 6.9 | 5.7 | 1.6 | 20 | 63 | 5.2 | .1 | 2.7 | 134 | 81 | 65 | 203 | 6.7 | 3 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June 12-23 | 9,860 | | | | | | 5.8 | | 15 | 44 | 3.5 | | 1.4 | | 52 | 40 | 138 | 6.6 | 4 |
| June 24-29, July 1-6 | 3,900 | | | | | | 7.1 | | 24 | 66 | 5.0 | | 1.8 | | 81 | 62 | 203 | 6.6 | 3 |
| July 7-12, 14-18 | 8,140 | 9.0 | .02 | 18 | 5.8 | 4.0 | \| | 1.6 | 20 | 55 | 4.5 | | 3.0 | 112 | 69 | 53 | 174 | 6.7 | 2 |
| July 19-25 | 9,800 | | | | | | 4.8 | | 6 | 53 | 4.0 | | 1.3 | | 56 | 51 | 146 | 6.7 | 3 |
| July 29-Aug. 4 | 14,100 | | | | | | 5.8 | | 14 | 43 | 3.2 | | 1.8 | | 50 | 39 | 127 | 6.6 | 6 |
| Aug. 5-31 | 5,900 | | | | | | 7.8 | | 14 | 66 | 5.2 | | 1.8 | | 72 | 61 | 189 | 7.0 | 3 |
| Sept. 1-13, 15-27 | 4,130 | 7.9 | .02 | 21 | 6.3 | 4.5 | \| | 1.5 | 14 | 71 | 5.8 | .0 | 2.4 | 129 | 79 | 67 | 203 | 6.9 | 3 |
| Weighted average | 11,390 | | | | | | | | 16 | 61 | 5.6 | | 2.2 | | 71 | 57 | 184 | | 4 |

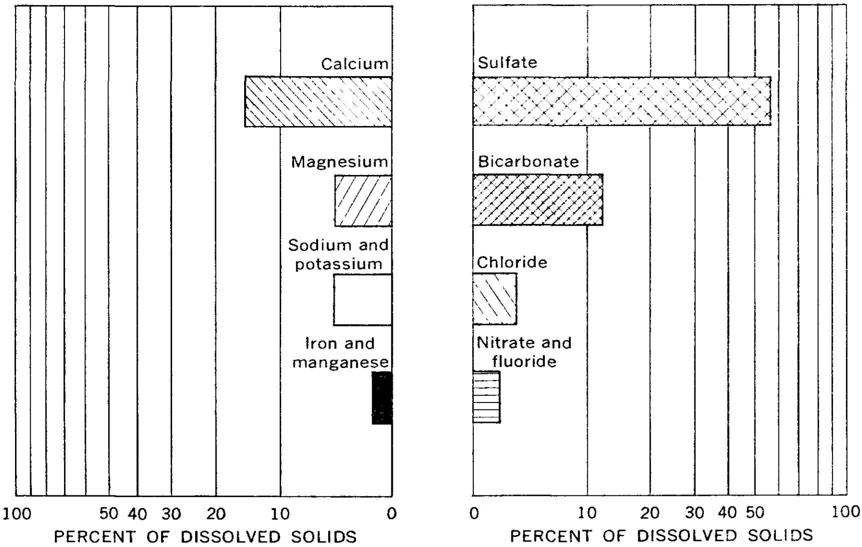


FIGURE 8.—Percentage composition, based on parts per million of average daily analyses, West Branch Susquehanna River at Lewisburg, Pa., 1944–47.

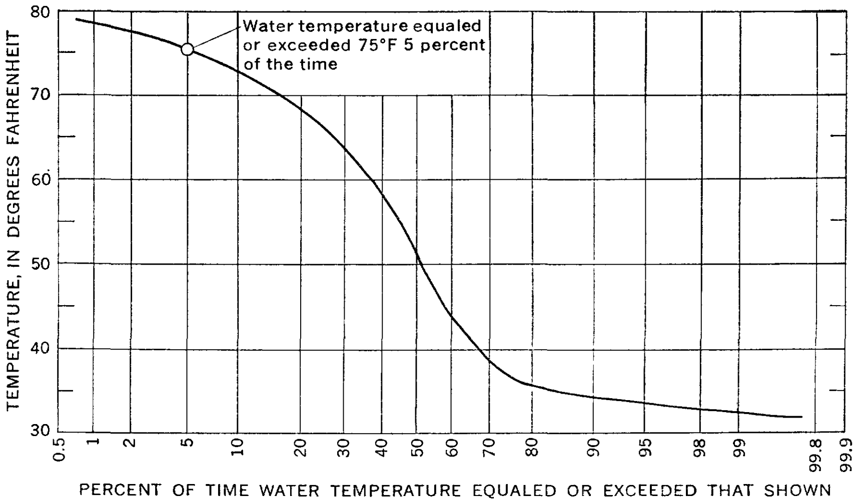


FIGURE 9.—Cumulative frequency curve of water temperature, West Branch Susquehanna River at Lewisburg, Pa., October 1957 to September 1958.

Most of the low values occurred during the war years, 1944–45, when coal mining in the upper basin was at near-peak production.

Temperature of the river during the 1958 water year exceeded 75°F only 5 percent of the time (fig. 9).

Nearly 60 river miles separate Lewisburg from Lock Haven, and this part of the river drains an area of approximately 3,000 square miles. The average discharge at Lewisburg is about twice the average

TABLE 12.—*Sulfate discharge, West Branch Susquehanna River at Lewisburg, Pa., October 1957 to September 1958*

| Collection period | Mean discharge (cfs) | Sulfate discharge (tons per day) | Number of days | Sulfate discharge (tons per interval) |
|---|---|---|---|---|
| *1957* | | | | |
| Oct. 1-11 | 855 | 323 | 11 | 3,553 |
| Oct. 12-31, Nov. 1-11 | 1,280 | 359 | 31 | 11,129 |
| Nov. 12-17, 20 | 2,620 | 743 | 7 | 5,201 |
| Nov. 21, 22 | 4,500 | 632 | 2 | 1,264 |
| Nov. 23-Dec. 11 | 2,640 | 556 | 19 | 10,554 |
| Dec. 12-20 | 4,060 | 877 | 9 | 7,893 |
| Dec. 21-31 | 29,370 | 2,220 | 11 | 24,420 |
| *1958* | | | | |
| Jan. 6, 7, 9, 22 | 7,650 | 929 | 4 | 3,716 |
| Jan. 23-26, 29-30 | 10,130 | 930 | 6 | 5,640 |
| Jan. 31, Feb. 1, 9, 11, 15 | 4,710 | 610 | 5 | 3,050 |
| Feb. 16-17, 19-27 | 4,610 | 709 | 11 | 7,799 |
| Feb. 28-Mar. 9 | 25,540 | 2,276 | 10 | 22,760 |
| Mar. 11-30 | 14,490 | 1,564 | 20 | 31,280 |
| Mar. 31-Apr. 6 | 36,940 | 2,693 | 7 | 18,851 |
| Apr. 7-24 | 39,100 | 2,850 | 18 | 51,300 |
| Apr. 25-May 14 | 30,320 | 2,865 | 20 | 57,300 |
| May 16-26 | 9,140 | 1,234 | 11 | 13,574 |
| May 27-June 11 | 5,590 | 951 | 16 | 15,216 |
| June 12-23 | 9,860 | 1,171 | 12 | 14,052 |
| June 24-29, July 1-6 | 3,900 | 795 | 12 | 8,340 |
| July 7-12, 14-18 | 8,140 | 1,210 | 11 | 13,300 |
| July 19-25 | 9,800 | 1,402 | 7 | 9,815 |
| July 29-Aug. 4 | 14,100 | 1,637 | 6 | 9,822 |
| Aug. 5-31 | 5,900 | 1,041 | 27 | 28,107 |
| Sept. 1-13, 15-27 | 4,130 | 792 | 26 | 20,592 |
| Total | | | 319 | 398,528 |

discharge at Lock Haven for the period of record. Because of this increased streamflow, the river has a lower concentration of solutes at Lewisburg than in upstream segments. At Lewisburg the water is softer, and most of the time the sulfate-ion concentration is less than half that at Lock Haven. However, the concentrations of calcium, magnesium, sodium, and potassium were about the same at both Lock Haven and Lewisburg, whereas the pH and concentration of bicarbonate, chloride, and nitrate were greater at Lewisburg than at Lock Haven (table 13).

A comparison of water quality of the respective branches of the Susquehanna River at Lewisburg and Danville before they merge at Northumberland is shown below:

| | *Average—1958 water year* | | |
|---|---|---|---|
| | *Specific conductance (micromhos at 25°C)* | *Hardness* | *Ratio sulfate to bicarbonate* |
| West Branch At Lewisburg | 184 | 71 | 4 to 1 |
| North Branch At Danville | 265 | 110 | 1.7 to 1 |

## SUMMARY

The principal features of the West Branch Susquehanna River basin affecting water quality are coal mining in the headwaters and limestone formations underlying major tributaries in other parts of the basin. The first of these features causes the river to flow acidic

TABLE 13.—*Chemical analyses, in parts per million, of West Branch Susquehanna River at Lock Haven and Lewisburg, Pa., 1945–59*

[Time-weighted averages]

| | Lock Haven | | | | | | Lewisburg | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1946 | 1947 | 1948 | 1949 | 1950 | 1959 | 1945 | 1946 | 1947 | 1948 | 1949 | 1950 | 1958 |
| Discharge (mean annual) cfs | 6,416 | 5,351 | 5,765 | 4,822 | 5,937 | 5,010 | 11,530 | | 10,520 | 11,029 | 9,436 | 11,230 | 11,390 |
| Silica | 5.1 | 5.2 | | | | | 4.5 | 4.3 | 4.6 | | | | |
| Iron | .08 | .04 | | | | | .02 | .03 | .01 | | | | |
| Aluminum | 1.7 | 1.5 | | | | | | | | | | | |
| Manganese | .31 | .39 | | | | | .2 | .11 | .09 | | | | |
| Calcium | 14 | 14 | | | | | 15 | 14 | 13 | | | | |
| Magnesium | 5.2 | 5.0 | | | | | 4.7 | 4.3 | 3.9 | | | | |
| Sodium + potassium | 4.4 | 3.3 | | | | | 5.4 | 4.1 | 4.4 | | | | |
| Bicarbonate | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 12 | 10 | 11 | 12 | 8 | 16 |
| Sulfate | 72 | 69 | 89 | 109 | 84 | 105 | 52 | 44 | 42 | 52 | 57 | 48 | 61 |
| Chloride | 2.3 | 2.4 | 3.4 | 4.1 | 3.0 | 3.6 | 3.6 | 3.2 | 3.0 | 4.0 | 5.0 | 3.0 | 5.6 |
| Fluoride | | | | | | | .1 | | | | | | |
| Nitrate | .9 | .9 | 1.0 | .9 | .9 | .9 | 1.4 | 1.4 | 1.4 | 1.5 | 1.5 | 1.3 | 2.2 |
| Dissolved solids | 111 | 109 | | | | 169 | 94 | 84 | 79 | | | | |
| Hardness, as $CaCO_3$ | 72 | 69 | | | 68 | 85 | 57 | 53 | 48 | | | 54 | 71 |
| Noncarbonate | 72 | 69 | | | | | 50 | 43 | 40 | | | 47 | 57 |
| Total acidity as sulfuric acid ($H_2SO_4$) | 25 | 22 | 31 | 44 | | 22 | | | | | | | |
| Specific conductance micromhos at 25° C | 214 | 200 | 243 | 311 | 263 | 285 | 150 | 136 | 130 | 158 | 173 | 144 | 184 |
| Color | 4 | 3 | 2 | 7 | 4 | 2 | 6 | 5 | 3 | 3 | 8 | 3 | 4 |

in the upper half of its length, west of Jersey Shore, whereas the second feature tends to neutralize the acidic water as it flows downstream. The change takes place noticeably in the lower half of the river after it mixes with water from Bald Eagle and Pine Creeks.

In the acidic part of the river, particularly the headwater segments and Clearfield, Moshannon, and Sinnemahoning Creeks, the concentrations of aluminum, iron, manganese, and sulfate in water are higher than in downstream segments of the river and in several of the larger tributaries. Concentrations of these and other ionic solutes exceed the tolerances specified by some industries and other water users. However, chemical treatment and(or) dilution can make the water suitable for many users.

The acidic quality of some surface streams whose sulfate concentration also exceeds 150 ppm indicates that ordinary metallic and concrete materials used in bridges and dams in acid-water regions will be subjected to corrosive attack and deterioration.

Aluminum, iron, and manganese in water stain concrete when conditions promote their precipitation from solution as insoluble hydrates. These ions in water also nurture the growth of micro-organisms that often colonize in unsightly masses on the sides of concrete spillways and reservoirs.

Most of the time the West Branch Susquehanna River downstream to Lock Haven contains a calcium sulfate water of an acid pH. However, east of Lock Haven, Bald Eagle Creek contributes calcium bicarbonate water to the river so that below confluence with Bald Eagle Creek the river contains bicarbonate ions for the first time. The high pH and the high alkalinity of Bald Eagle Creek as compared with the river are attributed to the geology of the subbasin which is underlain by limestone. Approximately 9 miles east of the confluence of the Susquehanna River and Bald Eagle Creek, Pine Creek enters the river at Jersey Shore. Pine Creek is a stream of good quality; it is low in dissolved solids and therefore dilutes the more concentrated river water where the creek and river mix. Both Bald Eagle and Pine Creeks contribute water whose quality completes the change of the West Branch Susquehanna River from an acidic to a nonacidic less concentrated river.

This change in quality of the river is noticeable at Williamsport and farther downstream at Lewisburg, although the river still contains a calcium sulfate water, and sulfate is the dominant constituent. At Lewisburg most of the time the pH ranges from 6.0 to 7.0. During the 1958 water year specific conductance was less than 285 micromhos for 90 percent of the time.

Several dams will be constructed on the river and on tributaries throughout the basin. Therefore, much of the basic data presented in this study will be useful for evaluating any changes in the chemistry of the West Branch Susquehanna River after construction of reservoirs near Curwensville, on Kettle Creek above Westport, and on Bald Eagle Creek above Blanchard. Although designed primarily to control floods, these dams will also provide storage space for surplus water, part of which will be used for recreation. Impounded water can be released in controlled allotments to supplement streamflow during dry periods and to improve the quality level of the West Branch Susquehanna River, especially the acidic part. At least 100 miles of the river in the upper part of the basin can be made more useful for recreation, domestic, and industrial uses by timely releases of stored water from impoundments when the quality of stored water is suitable for dilution or neutralization purposes.

The West Branch Susquehanna River is less concentrated with dissolved solids than the North Branch where the rivers merge at Northumberland. Despite the influence of coal mining on some tributaries, and on the main river in most of its upper half, many streams throughout the West Branch Susquehanna River basin are clear and relatively pure. A large part of the West Branch Susquehanna River basin is marked for recreational enjoyment, because fish are plentiful, and many wild animals drink from these streams. A man who hunts and fishes in this region may drink from these streams and be refreshed.

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