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ACID-MINE-DRAINAGE PROBLEMS

ANTHRACITE REGION OF PENNSYLVANIA

By S. H. Ash, E. W. Felegy, D. O. Kennedy, and P. S. Miller

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CONTENTS

ILLUSTRATIONS

TABLES

ACID-MINE-DRAINAGE PROBLEMS
ANTHRACITE REGION OF PENNSYLVANIA[1]

By
S. H. Ash,[2] E. W. Felegy,[3] D. O. Kennedy,[4] and P. S. Miller[5]

Summary

NO MORE important question has come before the coal-mining industry in many places, especially in the anthracite region of Pennsylvania, than prevention of stream pollution by mine drainage.

Available information on acid mine drainage in the anthracite region of Pennsylvania indicates that a pollution problem must be solved in any program of anthracite mine drainage. The major problem concerns satisfactory disposal of the daily average mine-water discharge of 327,000 gallons per minute (g. p. m.), or 472 million gallons per day (g. p. d.), containing a free-acid load of 431 tons or a total acid load of 934 tons a day as H_2SO_4. This report indicates the scope of the problem and gives some suggestions concerning its solution.

Diversion of individual mine drainage in the anthracite region from receiving streams and purification of mine drainage before entering streams are alternative remedial measures to combat pollution of surface streams by acid mine drainage. The approximate 327,000 g. p. m. (730 second-feet) drainage from the mines of the anthracite region represents a not inconsiderable quantity of water, and the effect of its removal from the surface streams coursing through and beyond the anthracite region is one of the phases that must be considered in any solution of the mine-drainage problem. When collected and made available at one point, such as the portal of a drainage tunnel, it also is a potentially valuable source of water supply for industrial or other utilization if its chemical quality can be improved to make it suitable for use. This appears possible with a tunnel system.

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INTRODUCTION

Stream pollution by mine drainage has been the subject of considerable study both by the mining industry and Government agencies (*4, 7, 9, 22, 26, 40, 70*).[6]

Samples of water from mines in the anthracite region have been collected, analyzed, and studied and reports made thereon (*4, 22*). Factual data regarding water impounded in underground pools and in abandoned strippings have been obtained and constitute an important part of information being gathered by the Bureau of Mines pertinent to the collection and ultimate disposal of mine drainage in the anthracite region. Recent studies and reports on pumping (*5, 40, 41*) and field work concerning drainage tunnels have extended materially the information available on the mine-water problem and emphasize the importance of presenting salient factors concerning acid mine drainage in the region.

The subject of industrial waste and its disposal, either with or without treatment, has reached a place of high importance in engineering (*6, 21, 22, 33, 34, 52, 57, 64, 65, 74, 75, 78*). Acid mine water from anthracite mines, though classed as an industrial waste, is not to be construed as being an economic loss to the industry. The factor of economic damage by pollution of the receiving bodies of water confronts the industry in developing the pollution-abatement program of the Commonwealth of Pennsylvania (*32, 59, 61, 64, 79*).

Much of the water from anthracite mines is utilized for controlling dust in underground mines, for hydraulic backfilling (*3*), combatting mine fires, aiding transportation of anthracite in gently dipping mine workings, and preparing anthracite (*3, 36, 53*). (*See* table 2.)

The question is often asked: What is "industrial waste"? Industrial waste has been defined as a waste produced as a result of some industrial, processing, or servicing operation (*6*). It is usually, though not always, liquid. Whether or not it is a liquid, a chemical, or some particulate matter, water or sewage is the carrying medium for its disposal.

The purpose of this report is not to develop a practicable or feasible method or process of treating acid mine water but rather to present available factual and deduced data that may be useful in showing the *p*H range over which the treatment is to take place and the sludge products most likely to be handled.

[6] Italicized numbers in parentheses in both text and tables refer to items in the bibliography at the end of this report.

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TRENDS IN POLICIES AND MINING AS AFFECTING STREAM POLLUTION

The responsibility of the Federal Government to develop an engineering method that will keep the anthracite mines of Pennsylvania in operation has long been recognized. The whole economy of the northeastern section of the United States depends to a large extent on the mining of anthracite in the Pennsylvania anthracite region. The anthracite from this region is shipped to New Jersey, New York, and New England and is a principal source of energy and heat for that entire section of the Nation (*15*).

NATIONAL POLICY

The National Water Pollution Control Act of 1948 reflects the national interest in the subject of water pollution. Hollis (*33*) discusses water-pollution abatement in the United States and explains the national policy embodied in the National Water Pollution Control Act of 1948. On national policy, Hollis (*33*) states:

> The national interest is reflected in the action of the Congress in passing the Water Pollution Control Act. Clearly stated in Section I of this act is the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the states in controlling water pollution. Congress also recognized, however, that water pollution was not solely a state problem, but often interstate in character. The act, in recognizing the primary rights of the states, sets up the means whereby the federal government can give the states financial and technical aid, and strengthen the over-all program through enforcement measures applying to interstate waters.
>
> The Public Health Service believes that the policy established by Congress will work. The success of cooperative action depends largely, however, upon strong state programs. Historically, the policy of the Public Health Service has been to aid the states to that end. Much progress has been made in building up a friendly and cooperative relationship, for which a large share of credit is due the Conference of State and Territorial Health Officers, the Conference of State Sanitary Engineers, and other national organizations.
>
> The present law limits federal enforcement to interstate problems with the consent of the state in which the problem originates. The burden of making this cooperative procedure work rests upon the states and the Public Health Service. The legislative history of the Water Pollution Control Act makes it clear that failure to accomplish adequate progress in pollution abatement through the cooperative efforts of the federal and state agencies will undoubtedly call for much stronger and more direct federal enforcement measures at some subsequent session of the Congress.
>
> Three points for strengthening state action are:
> 1. State legislation.
> 2. State organization for pollution abatement.
> 3. Intergovernmental cooperation.
>
> *National Defense.* All are aware of what the nation can do to improve the living standards of its citizens in peacetime. The signs indicate, however, that it may not be given to this generation to work in an environment of complete peace. Members of the Federation bear a heavy responsibility for maintaining the high standards of health that have been achieved in the nation. In addition, as the quality of the water resources diminishes, as it undoubtedly has since 1940, added responsibilities must be borne to support and safeguard the operation of the industrial machine. Industry can be reduced in capacity, prevented from expanding, or even wiped out for lack of water of sufficient volume and quality. Many know that in some river basins in this country there has been an approach to critical conditions between water quality and the uses to which the waters must be put.
>
> It does not take a great deal of foresight to see that in many areas the surface waters of the nation will become a most precious natural resource, to be guarded and husbanded against waste and destruction. It is hoped that more positive action to save this resource will not be further delayed. Many of the needs are known; specific needs in critical areas are now being investigated. For the immediate future it is probable that pollution abatement projects should be pointed to critical areas. Economic reports indicate that unless significantly greater defense demands are made upon nation, it may be possible to meet most of the demands for construction in this field. However, it will be wise to plan for a re-evaluation of program, rather than for business as usual.
>
> Pollution of surface streams is the resultant by-product of Twentieth-Century development. At no time during this century has the upward trend in pollution been checked. Decade by decade, stream conditions have grown progressively worse. By comparison, over the past decade, including the war years, the rate of increase has been alarming. Simple mathematics will show that over wide areas stream conditions are reaching the critical stage.
>
> As action programs for the predictable future are blueprinted, aggressive remedial measures in critical areas should be subordinated only to the most urgent national defense needs.

POLICY OF NATIONAL RESOURCES WATER POLICY PANEL

The domestic and industrial aspects of water supply and pollution have been discussed by the National Resources Water Policy Panel, Engineers' Joint Council; this discussion is important to future mining in the anthracite region, as it reflects public opinion (*21, 34, 74, 75*).

Use of the Nation's water resources for public supply constitutes the highest and best use. The aggregate volume of water used for public water supplies is relatively small. The total domestic and industrial use of water from public supplies is one-fifth of that used by irrigation. Public water supplies use 15,000 million gallons per day (m. g. d.), of which one-third is used by industry. In addition, industries use 5,000 m. g. d., which they individually develop, plus still larger quantities of recirculated and sea water. Although comparatively small in amount, as compared with the total water resources, public water supplies are the most basic requirement for urban development. Almost two-thirds of the United States population now enjoys and depends on public water supplies (*21*, *34*).

There are four sources of water on which industry must depend to meet its present and future requirements:

1. Surface water.
2. Underground water.
3. Sea water.
4. Water reclaimed from industrial and domestic sewage.

A water-conservation program, either local or national in scope, designed to accommodate the increasing industrial requirements, will prove inadequate unless all these sources are evaluated (*21*, *34*).

Requirements with regard to the quantity and quality of water for miscellaneous industries vary widely, and each industry has requirements that must be satisfied. However, most industrial uses of water fall within one or more of the following classifications:

1. Cooling.
2. Processing (entering into or contacting products manufactured).
3. Power generation.
4. Sanitary services.
5. Fire protection.
6. Miscellaneous (air conditioning, washing, etc.).

A complete catalog of water consumption by the many units in each industry would be a hopelessly long and difficult task, but statistics are available from which good estimates can be made (*21*, *33*, *34*, *61*).

Although Nation-wide in development, water supply for domestic and industrial uses essentially is a local problem. Of the 13,000 public-water-supply systems serving 85 million people in the United States with 15,000 m. g. d. of water, nearly all are intrastate problems. Only a few are interstate problems, and a limited number are concerned with more than two States (*21*, *34*).

Because the anthracite acid-mine-water problem is region-wide and concerns a densely populated area, the statements of policy regarding acid mine water are important, and excerpts of pertinent statements by the National Resources Water Policy Panel, Engineers' Joint Council (*34*), are as follows:

Stream pollution from coal production falls into two general categories—that due to the acid formed following the opening up of the coal measures and that resulting from the preparation of the coal itself.

A source of pollution is the acid drainage formed when the sulfur bodies in the coal, and particularly in the associated strata, break down in the presence of moisture and air to form free sulfuric acid and iron sulfates, which later hydrolize to form additional free sulfuric acid and ferrous and ferric hydroxides, at times also associated with aluminum sulfate. The processes by which the pyrite, marcasite, or "sulfur balls" oxidize to their final forms of free sulfuric acid and the ferric hydroxides of various forms, are subject to some question and there are different schools of thought as to the role which bacteria play in these processes. The Sanitary Water Board of Pennsylvania has had a fellowship at Mellon Institute for four years in an effort to solve not only the mechanism of acid formation but also to devise means for minimizing, controlling, or preventing its formation.

The problem of acid mine drainage is so large and the need for a solution to it is so urgent that all agencies capable of cooperating in the work should do so in close cooperation. The role which the federal government can most effectively take in the matter is an active study, both by research in the laboratory and by experimentation with actual mines, in close coordination with the work of the states and all other agencies now engaged in this work and which can be effectively enlisted.

It is believed that, without assuming any attitude of direction, the federal government, through its Bureau of Mines and through the U. S. Public Health Service, if the latter can contribute to the work, could and probably should engage in an active attack on the problem in close coordination with the other agencies, as previously indicated. When satisfactory answers are found, there will probably be little need to be unduly concerned as to the method of enforcement, because the importance of removal measures will lead to reasonable enforcement through the self-interest of each state involved.

Recognizing that rivers do not respect state lines, it is believed that studies, investigation, and research of pollution due to urban and industrial wastes and the production of oil, coal, and other mineral resources can be facilitated by legislation at the federal level. Such federal legislation should use to the greatest possible extent the existing state and interstate river-basin compacts, local authorities, and industries and their facilities for the abatement of stream and ground-water pollution. Federal participation should be through guidance rather than control of procedures.

COMMENT ON NATIONAL POLICY

Few national questions have so consistently received congressional interest as has the pollution of the Nation's watercourses. During the past 50 years, more than 100 bills have been introduced into the Congress relating to Federal regulation and control of stream pollution. No informed person can fail to recognize the need for correcting the present gross contamination of rivers, lakes, and tidal waters, but so far groups fostering regulatory measures have been unable to agree on the nature and extent of Federal control. Industry generally is recognizing its responsibilities in the matter of industrial wastes, although it has not yet fully recognized that disposal of waste is just as much a manufacturing cost as sweeping scraps from around a machine (*47*).

A number of problems of industrial-waste disposal have been magnified with industrial growth and development, and sporadic efforts have been put forth during the last 25 or 30 years by groups attempting to solve the difficulties. Despite these activities, it is well known that, except in isolated areas, no broad corrective program has been forthcoming. Existent conditions cannot be indefinitely continued without injustice to groups holding different opinions on the form that stream-pollution control should take (*52*).

Progress has been made in some areas in minimizing pollution and assuring future control over these matters. In other areas, little or no control has been effected. It must be conceded that the problem has not been corrected on a national basis and that gross pollution by sanitary and industrial wastes has outstripped the effort to maintain the national waterways in a reasonable state of purity. Dark as this picture appears, many industries recognize their responsibilities and have spent and are spending large sums of money on both research and the installation of treatment facilities. During recent years, many leaders of industry have recognized their obligations and are cooperating with the authorities in an effort to improve conditions on surface watercourses (*52*).

Scott (*57*) points out that benefit to public health is the most important consideration in the eye of the public and is a dominant factor in selling stream-pollution abatement; however, economic considerations are also of great importance. Municipalities must assume heavy financial burdens in many instances to provide sewage treatment, and treatment of some industrial wastes is a serious problem because of the cost. Research still has to show the way to practical methods of treating certain wastes.

Stream-pollution control in some instances is handled by individual States acting alone, but there is increasing interest in interstate negotiations leading to interstate informal agreements or formal compacts to control the pollution of waters common to two or more States. Approach to pollution problems on a regional basis by the cooperating States is believed far preferable to Federal control, even though a receptive attitude is maintained toward Federal advice or stimulation in connection with a national stream-pollution-abatement program. It is believed that the States are in much more intimate contact with the water-use potentialities and the economic aspects of their region than the Federal Government.

As far back as 1936, the United States Congress debated the merits of a considerable number of pollution-abatement bills. In 1938 a Federal bill was passed by the Congress and vetoed by the President. Some later bills included provisions that were both impracticable and unwarranted, such as provision for immediate drastic action to clean up all sources of pollution, whether because of effect on health or on fish or bird life. Later bills presented a nearer approach to agreement among groups interested in and affected by stream-pollution legislation and placed a great deal of emphasis on machinery for State and interstate action rather than Federal legal action.

The pollution problem has grown beyond State borders, and discharge of sewage and industrial wastes in one State may and frequently does affect the water use in a neighboring State. That fact does not make Federal pollution control necessary, but the slowness of some States to accept their responsibilities in water-pollution control will hasten Federal legislation.

Existing concentrations of municipal-sewage pollution and industrial-wastes pollution have grown to their present proportions over a span of many years. Industries and heavily populated communities are a part of modern civilization. We cannot hope to restore all streams to pristine purity, as some enthusiasts have advocated, unless we wish to "turn the country back to the Indians." Nevertheless, reckless and unwarranted pollution of water resources must be controlled, and waters must be improved to the extent justified by their present and planned future uses, whether for water supply, bathing, commercial or recreational fishing, boating, industrial purposes, or navigation (*57*).

STATE ACTION ON STREAM POLLUTION

Stream-pollution legislation in the major coal-producing States is causing considerable activity in the construction of water-clarification systems and of slurry-deposit systems. Wet plants built in the future must provide facilities to prevent pollution of receiving streams (*12, 27, 33, 45, 46, 48, 49, 50, 59, 64, 78, 79*).

All cities, most large boroughs, and many township communities in Pennsylvania have sewer systems through which millions of gallons of sewage, much of it untreated, is discharged daily into State waters. As late as 1944 less than 300 sewage-treatment works had been built in Pennsylvania, and a large proportion of these are in small communities. The great centers of population, with their satellite communities, are the chief offenders in the matter of stream pollution of the kind offensive to people that depend on or live along the banks of the streams (*64*).

In addition to the sewage discharged into Pennsylvania waters, a great variety of industrial wastes harmful to the streams is discharged into them (*11, 39, 64, 72*). Among these wastes is the acid mine water discharged from the coal mines in the State (*11, 22, 32, 45, 53, 59, 64*).

Efforts to control stream pollution obtained backing in 1905, when the Purity of Waters Act was passed. Crighton (*16*) and Stewart (*64*) have discussed the history of stream-pollution control relating to coal-mine wastes (*11*).

The Pennsylvania Stream-Pollution Law of 1937 definitely granted an exception from the general provisions of the act for acid mine drainage and silt until the Sanitary Water Board decided that practical means for removing the polluting properties of such drainage had become known. After a careful and intensive study, the board took official action, declaring that practical means were known for removing silt from coal-mine wastes, but at that time the board knew of no practical method of general applicability for removing the acid properties of mine drainage (*59, 61, 64*).

The act of 1945 completed action on the removal of silt from streams in Pennsylvania by coal-mining processes, and at present a widespread action program is in effect (*12, 32, 45, 46, 49, 50, 61, 78, 79*).

The pollution problem in the Schuylkill River Basin has increased progressively (*59, 79*). Two acts of the legislature (the Brunner Act and the Desilting Act, No. 441, June 4, 1945) state:

> The accumulation of wastes from mining operations, industrial processes, and municipal sanitation in the Schuylkill River and its tributaries has reached the point where it constitutes a menace to the health, safety, and welfare of the public; has endangered and contaminated the supply of pure waters; and is primarily responsible for the frequent floods resulting in the spreading of disease and great loss of life and property.
>
> It is imperative for government to exercise due diligence and reasonable control and to provide appropriate services in the matter of the development and conservation of human and natural resources.
>
> It is necessary to continue the proper relationships and divisions of responsibilities among the Federal, State, and local levels of government under which this nation has operated so successfully.
>
> It is a fundamental public right to require streams to be reasonably free of pollution and other objectionable forms of contamination.

As a result of the above-mentioned legislation, the Schuylkill River Restoration Project was undertaken (*79*).

Investigations of water resources in Pennsylvania have been conducted for many years (*61, 79*). The principal objectives of the Commonwealth from these investigations covering the Schuylkill River Basin are:

1. To have a running account of the accomplishments of the clean-up program and to show that the processes set up by industries and mining companies are effective.
2. To have data on the progress of the project in order to show that the Commonwealth is completing its part of the agreement since the work to be done by the Federal Government is contingent upon demonstrable progress by the Commonwealth in the river above Norristown.
3. To have information relating to the design of the desilting basins to be built in the headwaters of the Schuylkill River, and to measure their effectiveness after completion.
4. To collect data on sediment resulting from erosion from sources other than coal-mining operations in order that the Commonwealth may energize soil-conservation activities if these are necessary to supplement the corrective measures now being instituted in the coal fields. The data collected on sediment from soil or bank erosion will be valuable in any reforestation or other future projects relating to soil conservation or flood control.
5. To provide data on acid waters in the basin and changes in quality that may result from the corrective measures of the current program. These studies may aid in finding an economic solution for the treatment of water from the mines.
6. To encourage new industries to locate in the Schuylkill Valley as a supplement to possible declining employment in anthracite mining, by providing information as to quality of water available, since this is of vital concern to an industrialist considering plant location.

Particular attention has been given to the discharge of sediment into the receiving streams (*59, 61, 79*). White and Lindholm have described the water-resources investigation relating to the Schuylkill River Restoration Project, particularly the problem relating to the sediment discharged from anthracite mines (*59, 79*). Consideration of pollution from untreated municipal and other industrial wastes entering the Schuylkill River Basin is not part of their report (*79*). After all municipal and industrial wastes, except acid mine water, have been effectively controlled, the acid mine waters will still be running in the Schuylkill until extensive investigations determine and yield a practical method for treating them, means are taken to keep the mine wastes out of the streams, or a combination of these means is adopted.

The main streams in the anthracite region transcend the State's boundaries. Where water pollution spreads and passes State boundaries, a general agreement has grown in some quarters that the problem must be attacked by cooperative action of the affected States (*1, 21, 33, 34, 35, 58, 61, 74, 75*).

FUTURE POLLUTION-CONTROL MEASURES REGARDING ACID MINE WATER

Because water pollution by acid mine drainage in the anthracite region is similar in character to that in the region affected by the bituminous-coal mines (*45*), the deleterious effects of this drainage have been accepted as a necessary and unavoidable evil connected with the essential work of producing a fuel that is requisite and indispensable not only to the State but also the Nation.

The success or failure of the coal-mining industry affects the economy of the Nation, particularly anything that influences the cost or manner of operating this industry. The relationship, therefore, between stream pollution and the industry cannot be underestimated (*32*, *50*, *58*). The question resolves itself into the manner, methods, and cost of controlling acid mine drainage in each affected area. Whether acid mine drainage will or can be controlled depends largely on how it is done and who is going to pay for it, so that the industry can continue to operate economically. It must be borne in mind that abandoned and not active mines are the principal offenders as regards uncontrolled mine drainage.

What is a reasonable and logical use of a stream for the disposal of wastes is a debatable question; however, a municipality or an industry, because of its mere existence, does not have the right to discharge its wastes into the waters of the State without assuming moral and legal responsibility to prevent, control, or treat efficiently undue pollution of such waters.

NATURE AND EXTENT OF STREAM POLLUTION IN ANTHRACITE REGION

Collection and analyses of samples of the receiving streams have shown that the acid in the mine water entering the Lehigh, Schuylkill, and Susquehanna Rivers disappears because of dilution and the neutralizing action of the waters of the receiving streams and the limestone areas through which they flow (*11*, *22*, *61*, *71*, *79*). The investigation covered by the present anthracite flood-prevention project points out that the main streams, except the Lackawanna and Schuylkill Rivers, that flow through the anthracite region are nearly always alkaline at all points within the region itself. Moreover, a short distance below the coal measures, the rivers are permanently alkaline (*22*).

The Lackawanna and Schuylkill Rivers are not offensive within the anthracite region because of their acid character. However, on becoming alkaline farther downstream, the Schuylkill River presents a problem to those communities along its banks below the region (*11*). The acid water of the Lackawanna is neutralized at its confluence with the Susquehanna River a short distance below Duryea. Streams are polluted not only by the anthracite mining industry but also by other industries and communities that utilize the streams for their own purposes (*11*, *22*). (*See* table 9.)

Because the water of the North Branch of the Susquehanna River is alkaline throughout its entire length in the anthracite region (*22*, *61*), the diluting and neutralizing effect is sufficient to produce the least acid mine water handled in the anthracite region. Moreover, its alkalinity on entering the region and through its course is sufficient to neutralize the acid of the Lackawanna River, Solomon's Creek, Nescopeck Creek, Shamokin Creek, and some smaller streams that are highly acid. This is accomplished a short distance from the confluence of these streams and the main stream (*22*, *61*). (*See* tables 9 and 11.)

Much of the Susquehanna River is utilized for run-of-river hydroelectric plants that generate power from water impounded behind four dams. The slack water of one of them (York Haven Dam) constructed at Conewago Falls reaches Three-Mile Island, a short distance below Harrisburg. Another, the Holtwood Dam, was completed in 1910 and at that time was America's largest hydroelectric development (*24*). From Columbia, which is midway between York Haven Dam and Holtwood Dam, there are only 8 miles of current to tidewater, a mile in the tailrace below Safe Harbor Dam, 2 miles below Holtwood Dam, and 5 miles below Conowingo Dam (*24*, *71*).

In its lower reaches, where the Susquehanna River has cut its way through a range of tableland, the river channel has an average grade of 6 feet per mile. The above-mentioned dams and their respective run-of-river hydroelectric plants are constructed in this stretch of river. Turner (*71*) gives the following data for these plants:

TABLE 1.—*Hydroelectric plants on lower Susquehanna River*

Plant	Distance from tidewater, miles	Year of initial operation	Number of units	Head, feet	Maximum discharge, cubic feet per second	Effective capacity, kilowatts	Pondage [1]
Conowingo, Md	4	1928	7	89	45, 000	252, 000	4, 200
Holtwood, Pa	19	1910	10	51	32, 000	104, 000	1, 100
Safe Harbor, Pa	27	1931	7	55	65, 000	230, 000	3, 300
York Haven, Pa	50	1904	20	20	18, 000	20, 000	----------

[1] Approximate pondage (in cubic feet per second), days per foot for normal regulation.

Swatara Creek is the lowest-situated stream downstream that contains mine water (*22*). It discharges into the Susquehanna River at Middletown, Pa., and is alkaline at this point, which is above York Haven Dam. The Susquehanna River water has been sampled and analyzed many times at Marietta midway between York Haven Dam and Holtwood Dam (*61*). This water is therefore typical of the water that is utilized to develop hydroelectric power at the power plants of York Haven Dam, Safe Harbor Dam, Holtwood Dam, and Conowingo Dam.

(*See* table 9.) The fact that this water has been utilized for hydroelectric power for more than 40 years is evidence that the acid mine water discharged into the Susquehanna River has not prevented its utilization for this purpose without treatment to prevent undue corrosion of power equipment. The Conowingo plant has been in continuous operation since 1928 with no major replacements, although the turbine runners are constructed of cast steel and shafts are of forged steel. Turner (*71*) has described plant operation at Conowingo Dam. A pollutant (fine coal) from anthracite mines has been and still is a source of fuel for steam-power plants at these dams. Millions of dollars have been derived from this source. In the not too distant future, this fuel will no longer be available (*59, 61, 64, 79*).

The Schuylkill River is acid from Tuscarora (headwaters) in the Southern field to the city limits of Reading (*11, 22, 61, 79*). Chubb and Merkel (*11*) have shown that after Maiden Creek (a large, alkaline stream draining a limestone region) joins the Schuylkill River, which has a *p*H of 4.5, at a point 7 miles above Reading, the river in 6½ hours becomes neutral (*p*H, 7) at Shepp's Dam, at the upper city limits of Reading. The river remains generally on the alkaline side until it joins the Delaware (*11, 22, 61, 79*). (*See* table 9.)

Because industry can be reduced in capacity, prevented from expanding, or even wiped out for lack of enough suitable water, and because the health of communities depends on an ample supply of unpolluted water, the problem of stream pollution is becoming acute in many places (*33*). Furthermore, the water-pollution problem assumes added importance in view of the defense-related problems now facing the Nation (*33, 61, 64*).

Morgan has briefly discussed stream pollution from acid mine drainage from bituminous-coal mines, in southwestern Pennsylvania (*45*). His data are derived from a report of the United States Public Health Service that covers a survey of the pollution of the Ohio River by acid mine drainage (*72*).

EXTENT OF DRAINAGE PROBLEM

The average annual rainfall in the United States as a whole far exceeds any reasonable predicted demand for municipal and industrial water. The United States Weather Bureau estimates that an average of 30 inches of precipitation occurs annually over the United States. Federal Geological Survey records show that 21.5 inches of rainfall returns to the atmosphere owing to evapotranspiration and 8.5 inches runs off directly through streams or through the ground and eventually reaches the oceans. The Federal Geological Survey estimates that approximately 0.75 inch is intercepted by water users throughout the country. The total consumption ranges from 100,000 to 150,000 m. g. d., of which industry uses 10,000 m. g. d. Approximately 25,000 m. g. d. is taken from the ground through wells, and the remainder is supplied by surface water. This consumption does not include usage of salt water from the ocean or from underground sources (*21*, *34*).

RAINFALL IN ANTHRACITE REGION

A tremendous quantity of water falls on Pennsylvania each year as rain, snow, and hail; this has been estimated to be 138 billion tons in an average year, or 5,000 tons per acre (*61*, *79*). The mean annual precipitation over the Susquehanna River drainage area is almost 40 inches, and the mean annual run-off averages 47 percent of the precipitation (*71*). However, a great quantity of water from rivers and streams outside the coal measures traverses the anthracite region, most important of which is the North Branch of the Susquehanna River in its course through the Wyoming Basin (*2*, *22*, *61*). Because a vast network of mine workings underlies the Buried Valley of the Susquehanna River, seepage of an unknown large quantity of normally alkaline water of the river finds its way into the mine workings (*2*).

The Susquehanna River has a total drainage area of more than 27,000 square miles, which includes 47 percent of the total area of Pennsylvania and 13 percent of the total area of New York, besides a small area in Maryland (*71*).

Although the mean annual runoff in the Susquehanna River drainage area averages approximately 47 percent of the precipitation, the runoff ranges widely from day to day, week to week, and season to season; the recorded minimum, about 2,000 second-feet average for a week, occurred during late summer of 1930, and the maximum recorded flood runoff, about 875,000 second-feet, in March 1936. Runoff is at its minimum during August, September, and October and at its maximum during March, April, and May (*71*).

From its source at Otsego Lake, altitude 1,194 feet, in central New York, the North Branch of the Susquehanna River flows for 444 miles and empties into the Chesapeake Bay in Maryland. Before the river reaches Owego, N. Y., which is 120 miles upstream from Wilkes-Barre, Pa., the river waters have been polluted by industrial wastes, among which is that from the large tanneries that produce leather for shoemaking in the Triple Cities (Endicott, Johnson City, and Binghamton), N. Y. (*24*). It is apparent that stream pollution of the North Branch of the Susquehanna River is an interstate problem, and the water as it enters the anthracite region has received numerous pollutants. These, however, have not altered its chemical composition to a degree to make it acid at Falls, Pa., just before it enters the anthracite region and crosses the coal measures. (*See* table 9.)

The Northern field of the anthracite region is a part of a very large watershed (*24*) that has an area of 9,960 square miles and is tributary to the North Branch of the Susquehanna (*71*). Although the area comprising the coal measures in that portion of the watershed in the Northern field is relatively small (176 square miles), almost all the rainfall as runoff that reaches the Lackawanna River and the North Branch of the Susquehanna River flows over mine workings for 62 miles (*2*, *4*, *5*, *22*). (*See* fig. 1.)

Because the Buried Valley of the Susquehanna and a vast network of mine workings underlie the above-mentioned portion of the Susquehanna River drainage basin, the anthracite industry in this area is exposed constantly to a possible catastrophe, which is controlled partly by a system of dikes and partly by mine-working supports (barrier pillars). This situation has been described by Ash and others (*2*, *3*, *4*, *5*). The enormous volume of water seeping into mine workings accounts for an unknown percentage of the water pumped from mine workings (*5*, *25*). (*See* tables 4 and 8 and figs. 1 to 7.)

It is well-known that breaks of the strata between mine workings and the surface have occurred in the above-mentioned area several times in the past when the surface has been covered with flood waters (*2*).

Numerous floods have occurred in this area. In March 1914 the flood waters of the North Branch of the Susquehanna River inundated the surface overlying some old mine workings in the Henry colliery area, at which time a break also occurred that was connected to the adjoining Enterprise workings. A disaster was fortunately averted. In 1936 a flood stage of 33.32 feet was reached—the highest stage of record since 1875.

The flood of the North Branch of the Susquehanna River on May 28 to 30, 1946, demonstrates again the absolute necessity for a control system over the mine workings of the Wyoming portion of the Northern field, which can be affected by seepage through the Buried Valley and breaks in the strata into mine workings. Because of floods, dikes have been constructed that can, unless they fail, confine flood waters to the channel of the Susquehanna River. However, dikes cannot and do not prevent seepage over a large area.

Despite the dikes that have been constructed the flood waters in 1946 covered a large area. For the 3-day period, May 26 to 28, 1946, the rainfall at Wilkes-Barre was 4.1 inches. A 32.01-foot flood crest was reached at Wilkes-Barre on May 29, 1946.

Figure 1 shows the place and direction from where the photographs, figures 2 to 7, inclusive, were taken during the period when the flood waters of the river were at flood crest, and after the flood waters had receded. It also shows the relative position of the flooded surface, the Buried Valley of the Susquehanna River, and underlying coal measures and mine workings.

It is obvious that seepage of the normally alkaline river water of the Susquehanna River enters the valley fill of the Buried Valley and passes through pervious strata into mine workings (old and active) and contributes much to the enormous underground pools of water that are confined by barrier pillars (*2*, *4*).

The effect of the flood waters and ordinary seepage from the North Branch of the Susquehanna River on the mine-water discharges must be considered with means for handling the water between flood stages as well as during floods, over which there is no control upstream by dams or reservoirs. At the present stage of the study of the anthracite-mine-water problem, it appears that a tunnel system and auxiliary central pumping plants should constitute an effective long-range drainage scheme for underground workings as more and more mines are abandoned for whatever cause.

The Schuylkill River drains an area of approximately 1,900 square miles in southeastern Pennsylvania. The upper-river branches rise in the mountains of Schuylkill County and receive acid mine water from mines in the Southern field. After flowing for 60 miles, the river leaves the mountains at Port Clinton Gap and flows through farm country and a highly industrialized region for 90 miles to its confluence with the Delaware River at Philadelphia. Pottstown, 20 miles below Reading, and most of the communities from there on downstream to and including Philadelphia take domestic water supplies from the Schuylkill River (*11*, *22*).

WATER HANDLED BY ANTHRACITE MINES

Mine water from underground workings is pumped, drained, and stored in huge quantities. The mine-drainage systems in the anthracite region handle more than 200 billion gallons of water annually, of which more than 150 billion gallons is pumped to the surface. Over 91 billion gallons of water is impounded in underground pools (*4*, *5*). Much of this water is employed for breaker use, dust-control installations, hydraulic backfilling, combatting mine fires, and aiding in the transportation of anthracite in gently dipping places where sheet iron is used. Roos (*53*) estimates that 1,100 gallons of mine water is utilized in preparing each ton of anthracite mined. Table 2 shows the volume of mine water utilized in the preparation plants, in gallons per minute, as of March 1951.

Table 3 shows the maximum, minimum, and mean flow (cubic feet per second) during 1944 to 1948, inclusive, of the Susquehanna River at Wilkes-Barre, the Lackawanna River at Old Forge, the Schuylkill River at Pottsville, and the Little Schuylkill River at Tamaqua.

RELATIONSHIP BETWEEN PRECIPITATION AND VOLUME OF WATER PUMPED

The volume of water pumped to the surface from the anthracite mines depends on so many factors that it is impossible to ascertain definite relationship between precipitation and volume of water pumped. Tables 4 to 7 give the precipitation in inches and corresponding million gallons of rainfall in the four anthracite fields, the volume (million gallons) of water pumped to the surface, and the relationship, expressed in percent, between the volume of water pumped and the volume of precipitation for 1944 to 1948, inclusive. Table 8 gives the precipitation, expressed in million gallons of rainfall in the anthracite region, the volume (million gallons) of water pumped to the surface, and the rela-

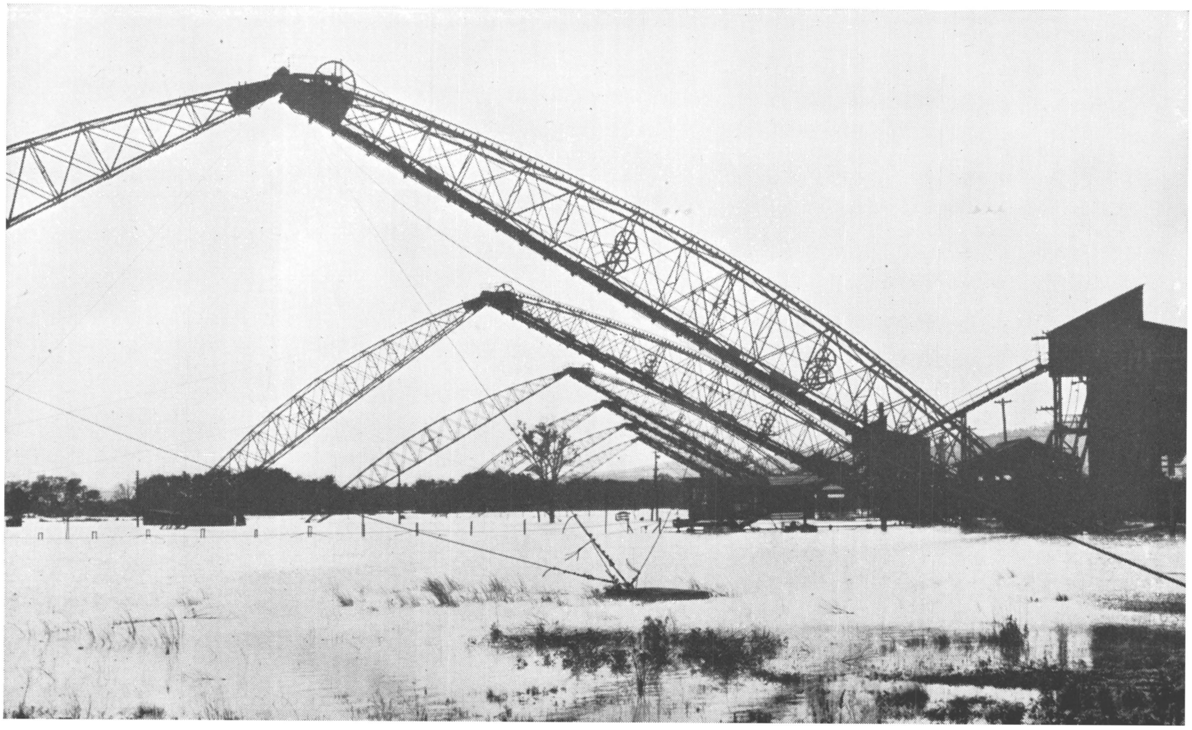

FIGURE 2.—D. L. & W. COAL CO. STORAGE PLANT ON MAY 29, 1946.

FIGURE 3.—FARM LANDS FLOODED ALONG MAIN LINE OF LEHIGH VALLEY RAILROAD ON EAST SIDE OF SUSQUEHANNA RIVER, AT PLAINSVILLE, PA., ON MAY 29, 1946.

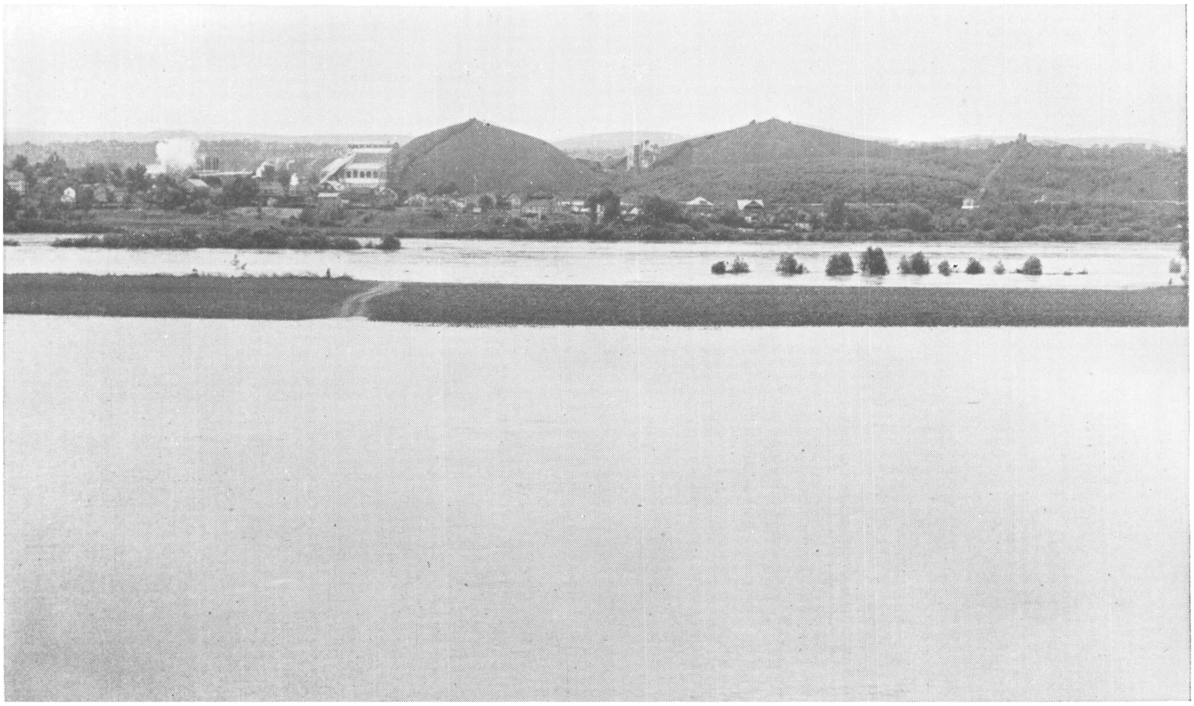

FIGURE 4.—FARM LANDS OVER SCHOOLEY MINE FLOODED ON WEST SIDE OF SUSQUEHANNA RIVER, AT WYOMING, PA., ON MAY 28, 1946.

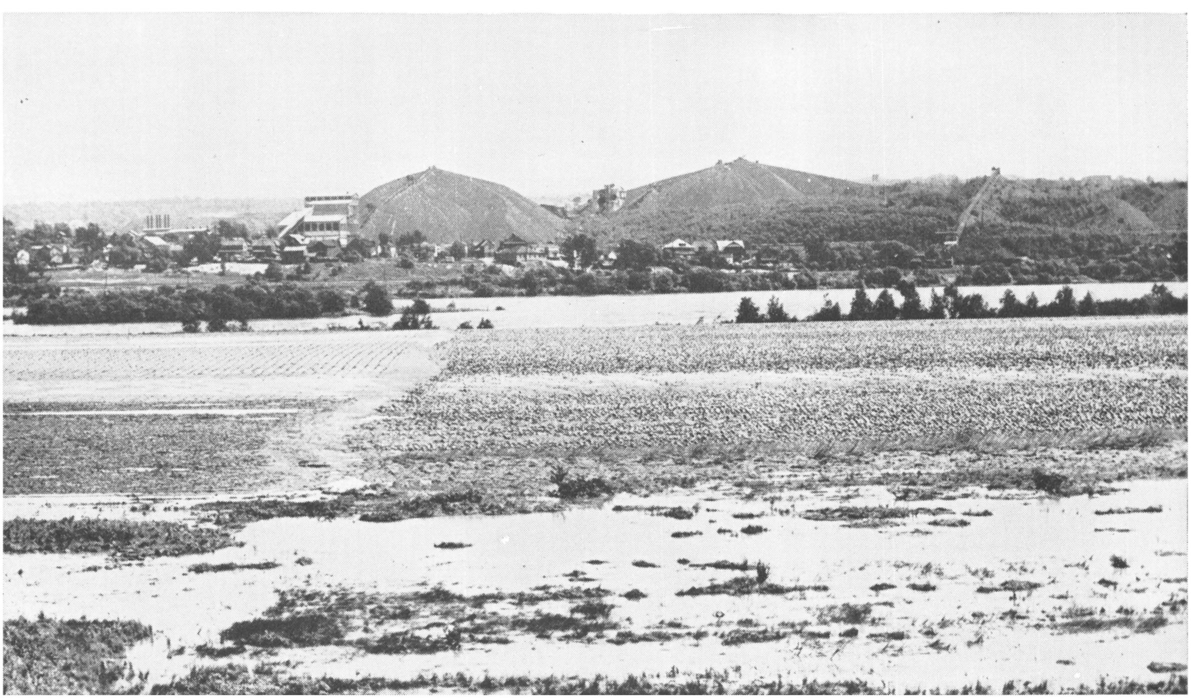

FIGURE 5.—FARM LANDS OVER SCHOOLEY MINE AFTER FLOOD WATERS HAD RECEDED, MAY 31, 1946.

FIGURE 6.—FORTY FORT AIRPORT (NEAR WILKES-BARRE, PA.) OVER MALTBY MINE, MAY 29, 1946.

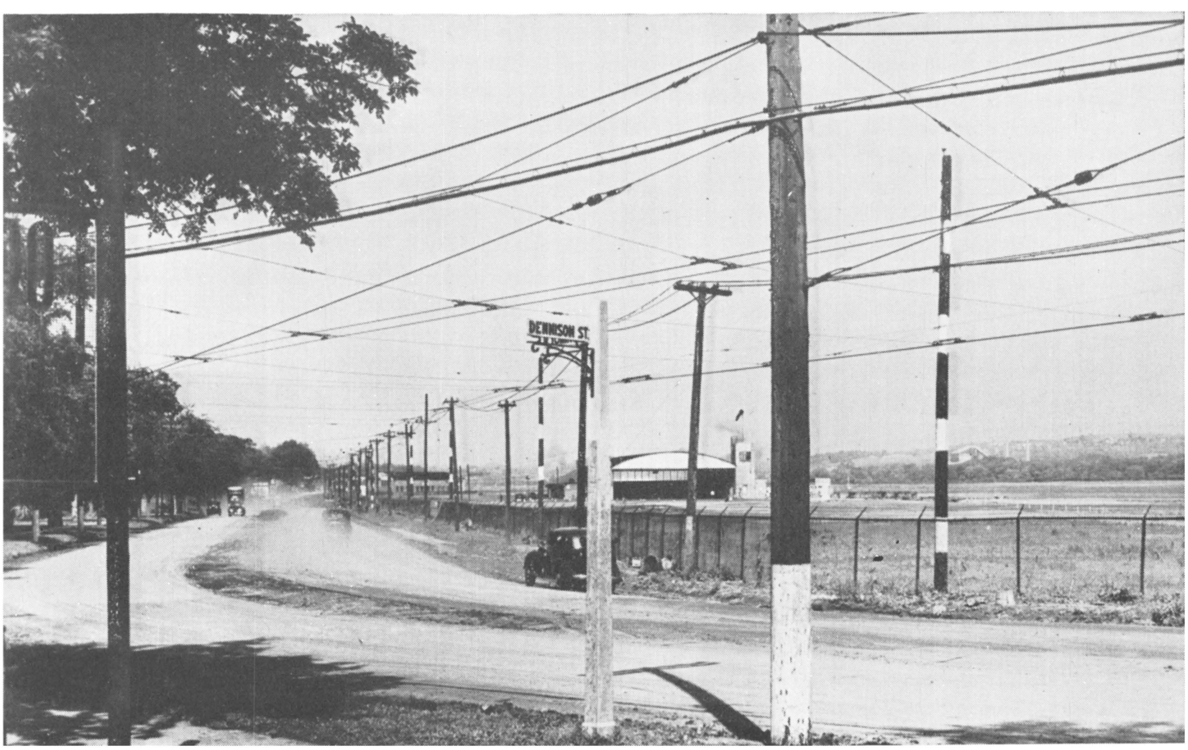

FIGURE 7.—FORTY FORT AIRPORT OVER MALTBY MINE, MAY 31, 1946.

TABLE 2.—*Mine water utilized in preparation plants in Pennsylvania anthracite region*

Company	Colliery	Gallons per minute
Northern field.		
Consagra Coal Co	Consagra	1, 000
Duryea Anthracite Coal Co	Duryea Anthracite	1, 755
Glen Alden Coal Co	Baker	3, 000
	Huber	1, 500
	South Wilkes-Barre	700
	Wanamie	600
Heidelberg Coal Co	Heidelberg	2, 500
The Hudson Coal Co	Laflin	2, 100
	Pine Ridge	5, 500
Kehoe-Berge Coal Co	William "A"	100
Lehigh Valley Coal	Prospect	2, 500
Old Forge Coal Co	Morgan	2, 500
Pagnotti Coal Co	Harry "E"	3, 700
	No. 9	4, 000
Pennsylvania Coal Co	Underwood	2, 200
Pompey Coal Co	Pompey	2, 000
Susquehanna Collieries Co	Glen Lyon	1, 000
Total		36, 655
Eastern Middle field:		
Lehigh Valley Coal Co	Hazleton Shaft	6, 000
Jeddo-Highland Coal Co	Jeddo No. 7	1, 800
Sandy Run Miners & Producers	Sandy Run	1, 000
Payne Coal Co	Spring Mountain	2, 500
Middle Eastern Coal Co	Steele	1, 000
Broad Mt. Fuel Co	Coleraine	1, 000
Gowen Coal Co	Gowen	1, 000
Glen Alden Coal Co	Audenreid	1, 200
Total		15, 500
Western Middle field:		
Philadelphia & Reading Coal & Iron	Locust Summit	1, 327
	St. Nicholas	892
Stevens Coal Co	Trevorton	1, 328
Otto Collieries Co	Oakland	1, 423
Hammond Coal Co	Hammond	575
Locust Coal Co	Weston	1, 328
Hazle Brook Coal Co	Mid-Valley	1, 028
M. A. Hanna Coal Co	Glen Burn	1, 849
Gilberton Coal Co	Gilberton	1, 326
Delano Anthracite Collieries Co	Park No. 1	345
Total		11, 421
Southern field:		
Philadelphia & Reading Coal & Iron	Oak Hill	1, 052
Repplier Coal Co	New Castle	658
St. Clair Coal Co	St. Clair	1, 250
Total		2, 960
Grand total		66, 536

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TABLE 3.—*Rate of flow (cubic feet per second) of water in some main streams of Pennsylvania anthracite region, at points indicated, for 1944–48*

Year [1]	Susquehanna River at Wilkes-Barre			Lackawanna River at Old Forge			Schuylkill River at Pottsville			Little Schuylkill River at Tamaqua		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean
1944	81, 200	1, 010	10, 860	5, 300	73	401	2, 010	18	115	1, 900	4. 2	77. 5
1945	112, 000	1, 630	15, 590	5, 000	122	740	2, 660	18	123	1, 340	6. 2	106. 0
1946	206, 000	1, 850	16, 390	7, 380	188	689	1, 410	26	117	1, 460	10. 5	113. 0
1947	143, 000	2, 390	15, 990	7, 110	144	679	2, 380	22	131	1, 900	16. 0	123. 0
1948	180, 000	1, 160	13, 170	4, 180	115	550	470	24	103	614	9. 5	99. 2
Average	144, 440	1, 608	14, 400	5, 794	128	612	1, 786	22	118	1, 443	9. 0	104. 0

[1] Period year, Oct. 1–Sept. 30, taken from records of Hydrographic Service, Pennsylvania Department of Forests and Waters.

tionship, expressed in percent, between the volume of water pumped to the surface and the volume of precipitation for 1944 to 1948.

It is apparent from a study of tables 4 to 8 that, during the years of greatest precipitation, more water was pumped from the mines than during the years of less precipitation. It is also observed from comparisons between similar items in the four anthracite fields that the relationship between the volume of water pumped to the surface and the volume of precipitation may depend in magnitude on the

TABLE 4.—*Relationship between volume of water pumped to surface and volume of precipitation for 5-year period, 1944–48, in Northern field (176 square miles)*

Year	Precipitation		Pumped, million gallons	Relationship between volume of water pumped and volume of precipitation, percent
	Inches	Million gallons		
1944	31. 31	95, 762	92, 846	97. 0
1945	53. 77	164, 454	129, 616	78. 8
1946	35. 91	109, 824	116, 982	106. 5
1947	44. 02	134, 640	119, 572	88. 8
1948	43. 81	133, 989	110, 252	82. 3
Total		638, 669	569, 268	
Average	41. 76			89. 1

TABLE 5.—*Relationship between volume of water pumped to surface and volume of precipitation for 5-year period, 1944–48, in Eastern Middle field (33 square miles)*

Year	Precipitation		Pumped, million gallons	Relationship between volume of water pumped and volume of precipitation, percent
	Inches	Million gallons		
1944	38. 41	22, 027	7, 038	32. 0
1945	61. 17	35, 078	8, 333	23. 8
1946	46. 36	26, 586	7, 861	29. 6
1947	56. 66	32, 492	8, 443	26. 0
1948	55. 02	31, 552	9, 230	29. 3
Total		147, 735	40, 905	
Average	51. 52			27. 7

TABLE 6.—*Relationship between volume of water pumped to surface and volume of precipitation for 5-year period, 1944–48, in Western Middle field (120 square miles)*

Year	Precipitation		Pumped, million gallons	Relationship between volume of water pumped and volume of precipitation, percent
	Inches	Million gallons		
1944	37. 42	78, 032	26, 055	33. 4
1945	51. 67	107, 748	37, 979	35. 2
1946	41. 24	85, 998	32, 055	37. 3
1947	52. 15	108, 748	33, 997	31. 3
1948	48. 01	100, 115	32, 146	32. 1
Total		480, 641	162, 232	
Average	46. 10			33. 8

TABLE 7.—*Relationship between volume of water pumped to surface and volume of precipitation for 5-year period, 1944–48, in Southern field (200 square miles)*

Year	Precipitation		Pumped, million gallons	Relationship between volume of water pumped and volume of precipitation, percent
	Inches	Million gallons		
1944	42. 20	146, 667	15, 034	10. 3
1945	58. 19	202, 240	20, 454	10. 1
1946	40. 75	141, 627	17, 463	12. 3
1947	56. 31	195, 706	18, 246	9. 3
1948	48. 01	166, 859	17, 308	10. 4
Total		853, 099	88, 505	
Average	49. 09			10. 4

TABLE 8.—*Relationship between volume of water pumped to surface and volume of precipitation for 5-year period, 1944–48, in anthracite region*

Year	Precipitation, million gallons	Pumped, million gallons	Relationship between volume of water pumped and volume of precipitation, percent
1944	342,488	140,973	41.2
1945	509,520	196,382	38.5
1946	364,035	174,361	47.9
1947	471,586	180,258	38.2
1948	432,515	168,936	39.1
Total	2,120,144	860,910	
Average			40.6

physical characteristics of the individual field and ranges from 89.1 percent in the Northern field to 10.4 percent in the Southern field.

The volume (196,382 million gallons) of water pumped in 1945 from the mines in the anthracite region is equivalent to a mean flow of 373,632 gallons per minute, or 830 cubic feet per second, throughout the year; this flow of water corresponds almost exactly to the combined average mean flow (834 cubic feet per second) of the Lackawanna River at Old Forge, Pa., the Schuylkill River at Pottsville, and the Little Schuylkill River at Tamaqua for the 5-year period 1944 to 1948.

Because the Northern field is canoe-shaped, rainfall over this field drains to the lowest points in the broad single valley overlying the coal measures; this contributes to the infiltration of surface water into both active and abandoned mines. The anthracite beds in this field are continuous, which makes the infiltration of rainfall into most abandoned mines a pumping problem for the active mines. Clay, sand, and gravel deposits of glacial origin, as well as those in the Buried Valley of the Susquehanna River, overlie anthracite beds in a large part of the Northern field. The Susquehanna and Lackawanna Rivers flow over these deposits along the longitudinal axis of the canoe-shaped basin; this is undoubtedly responsible to no small degree for much of the water that infiltrates into the mines in the Northern field. A true comparison between the amount of water pumped and the precipitation could be made only if some method was available to determine how much river water seeps into the coal measures and subsequently into the mines.

Physical conditions of the coal measures in the Southern field differ somewhat from those in the Northern field. In the Southern field numerous isolated basins with no underground relationship or continuity and with independent surface-drainage systems prevent much of the rainfall from critically contributing to the pumping load of many active mines. Thus, a true comparison of rainfall with pumping load could be made only by reducing the volume of rainfall to that actually on surface areas overlying or draining into streams overlying active mines. In many parts of the Southern field infiltration of surface water into abandoned mines has no effect upon active mines in adjoining but isolated basins.

The data in tables 4 to 8 relating to the volume of water pumped to the surface and the volume of precipitation cannot be accepted as a criterion for possible future comparisons; however, they do show a relationship between the volume of water pumped and the volume of precipitation during the given period and emphasize the complexity of the mine-water problem.

Restriction on the discharge of sewage or industrial wastes must be reasonable and standards or codes adopted for particular streams both attainable and financially feasible. An expense that is out of proportion to the benefits sought cannot be imposed on the State's industrial and municipal economy or the program to prevent pollution will be doomed to failure (*1*, *10*).

CODES FOR DISPOSAL OF INDUSTRIAL WASTES

The Municipal Code of Los Angeles provides limits of *p*H 5.5 (for acidity) and *p*H 9.0 (for alkalinity) for any industrial waste discharged into a sewer or storm drain. By implication, this restriction also applies to water channels. This limitation is placed on industrial-waste effluent for protection against corrosion or other harmful chemical action on sewage and drainage conduits and structures. It also helps to insure delivery of a more nearly constant quality of effluent at treatment plants (*6*).

Rules and regulations have been formulated by Westchester County, N. Y., governing discharge of sewage, industrial wastes, and other wastes into the county sewers (*76*).

In Westchester County "industrial waste" means any gas, liquid, solid, or other waste substance or a combination thereof resulting from any process of industry, manufacturing, trade, or business or from the development or recovery of any natural resources.

The following standards have been adopted to control the quantity and quality of industrial waste that may be discharged through a connection into the county sewage system.

1. Industrial wastes shall contain no solids in solution which will precipitate greater than 1,000 p. p. m. upon acidification (*p*H below 5.5) or alkalization (*p*H above 8.5) or oxidation or reduction.
2. Viscosity of industrial wastes shall not exceed 1.10 upon discharge or after acidification or alkalization, etc., as outlined immediately above.
3. The temperature of industrial wastes upon discharge shall be within the limits of 32° and 150° F.
4. The color of industrial wastes shall not exceed an intensity of 500 p. p. m. Samples shall be diluted with distilled water to bring the range within 10 to 50 p. p. m. and judged on a basis of "intensity" or transmission of light rather than "true color" (Platinum-Cobalt Standard).
5. The limiting chemical characteristics of receivable industrial wastes shall be as follows:

B. O. D. 5-day, 20° C	400 p. p. m. (max.)
Chlorine demand (30 min., room temperature)	25 p. p. m. (max.)
Suspended solids	300 p. p. m. (max.)
Settleable solids (Imhoff cone test, 1 hour)	10 ml./liter (max.)
Hydrogen-ion concentration (*p*H)	4.5 to 9.5

Because the Potomac River and many of its tributaries are interstate in character, with no one State having complete jurisdiction, any information concerning the uses of land and water in the Potomac River Basin are of interest to other States. As the basin includes part of several States, the public control of water pollution has required the creation of an interstate agency (*35*).

The Interstate Commission on the Potomac River Basin was organized in 1941 under a compact between Maryland and West Virginia, the Commonwealths of Virginia and Pennsylvania, and the District of Columbia for the control and abatement of pollution. The commission is a part of the Government machinery of the United States and the States within the Potomac Basin. It is financed by appropriations from the signatory bodies and the United States (*35*).

The Interstate Commission on the Potomac River Basin, as of August 8, 1946, recommended to the States of the Basin for their use minimum water-quality criteria. Waters in class B are what may be expected of waters under discussion in this report. The commission in this jurisdiction defines such waters (class B) as suitable for bathing, fish life, and similar recreational purposes. This water is also satisfactory for domestic water supplies with complete treatment, for industrial-process water, and other similar uses. The results of sampling are required to meet the following minimum requirements:

Coliform Bacteria: The monthly average of all samples shall show the most probable number of coliform bacteria per 100 ml. shall vary between the limits of 50 to 500. Any one sample shall not contain more than 1,000 coliform bacteria as the most probable number per 100 ml.

Color: A color of not more than 20 p. p. m. is desirable.

Turbidity: A turbidity of not more than 40 p. p. m. is desirable.

pH: The acidity or alkalinity of the water shall vary between the limits of 6.0 to 8.5.

5-Day Biochemical Oxygen Demand: The 5-day 20°-C. B. O. D. of all samples during any 1 month shall not exceed 1.5 p. p. m. The maximum observed B. O. D. in any sample shall not be more than 3.0 p. p. m.

Dissolved Oxygen: The monthly average of all samples shall show a D. O. content of not less than 6.5 p. p. m. No one sample shall show a D. O. content of less than 5.0 p. p. m.

Other Conditions: The waters shall contain no toxic substances of any nature such as oils, tars, or free acid at any time. There shall be no floating solids or debris except from natural sources. No taste- or odor-producing substances will be permitted unless they are of natural origin. There shall be no sludge deposits of any nature.

The TVA is deeply interested in conditions affecting stream sanitation in the Tennessee Valley. However, it has no regulatory power over stream pollution except where pollutants are discharged across TVA-owned property. The number of potential industrial sites from which pollutants might be discharged across TVA-owned property is small (*68*).

In an effort to make possible the full utilization of water as a resource, TVA has conducted studies on stream sanitation for a number of years in collaboration with the States concerned. These States determine the extent of pollution in surface waters and in this manner assist industries in discovering means for reclaiming, reusing, or otherwise reducing losses in plant wastes. Industries have been greatly interested and frequently have utilized the data and obtained savings of definite financial value.

Control over stream pollution is exercised by each of the Tennessee Valley States in a varying degree. Their expressions on control of stream pollution, as summarized by TVA, are as follows (*68*):

Alabama: There are no water-control laws other than the State water laws governing public water supplies. Riparian owners are dependent upon the common law for damage to streams. A committee was established by the 1948 Alabama Legislature to make studies of stream pollution. The committee prepared a report for the 1950 session of the legislature on the sanitary conditions of water in Alabama streams.

Georgia: The State Department of Public Health has a staff of water-supply and waste-treatment engineers who are available to consult with industry toward selection of the most suitable location for the best utilization of water resources.

Kentucky: The basic health law requires that any industry constructing a plant must submit plans and specifications for treatment of any processed water or waste. Necessary information is required on composition of the wastes. Enforcement of the law is with the State Department of Health, which works closely with the Fish and Game Commission.

Mississippi: The State Game and Fish Commission enforces a law passed in 1946 for control of stream pollution. Each industry is inspected and when found in compliance with the law is given a Certificate of Compliance. The certificate can be revoked by the commission at any time the industry is found not complying with the rules and regulations.

North Carolina: There are no specific laws at present regarding industrial wastes or the protection of streams other than those used as public water supplies. The laws on public water supplies require that plans for new facilities be submitted to and approved by the State Board of Health and that sources of water supply to be used for public drinking water or other domestic purposes be approved by the State Board of Health. They further require that no sewage may be emptied into streams used as public water supplies unless the sewage is first treated in a manner meeting the approval of the State Board of Health. However, stream sanitation is being studied and policies established with respect thereto.

Tennessee: The Department of Public Health administers a law passed in 1945 for the regulation and control of pollution of the surface waters and streams. The regulations require an industry to submit plans for review and approval prior to the construction of any new works or major improvements to existing systems. The plans for the proposed system and works are reviewed by the engineers of the Health Department to assure the adequacy and suitability of proposed installations, taking into consideration the regional plan for stream-pollution control.

Virginia: Stream-pollution abatement is under the State Water Control Board, which derives its authority from the State Water Control Law of 1946. Other laws relating to stream pollution remain unchanged, but the 1946 law directs that the administration of any such laws pertaining to pollution shall be in accord with the State Water Control Law and the general policies adopted by the State Water Control Board. The Board invites industries to confer with its technical staff on specific problems and with itself on decisions concerning specific discharges.

Standards were promulgated by the United States Public Health Service, February 5, 1946, for drinking and culinary water supplied by carriers subject to the Federal Quarantine Regulations (*62*). Section 4, relating to the physical and chemical characteristics of such water, is pertinent to this report and is as follows:

4. As to the Physical and Chemical Characteristics

4.1. *Physical characteristics.*[a]—The turbidity of the water shall not exceed 10 p. p. m. (silica scale), nor shall the color exceed 20 (standard cobalt scale). The water shall have no objectionable taste or odor.

4.2. *Chemical characteristics.*—The water shall not contain an excessive amount of soluble mineral substance, nor excessive amounts of any chemicals employed in treatment. Under ordinary circumstances, the analytical evidence that the water satisfies the physical and chemical standards given in sections 4.1 and 4.21 and simple evidence that it is acceptable for taste and odor will be sufficient for certification with respect to physical and chemical characteristics.

4.21. The presence of lead (Pb) in excess of 0.1 p. p. m., of fluoride in excess of 1.5 p. p. m., of arsenic in excess of 0.05 p. p. m., of selenium in excess of 0.05 p. p. m., of hexavalent chromium

[a] The requirements in section 4.1 relating to turbidity and color shall be met by all filtered water supplies. Turbidity and color limits for unfiltered waters and the requirements of freedom from taste or odor for either filtered or unfiltered waters should be based on reasonable judgment and discretion, giving due consideration to all the local factors involved.

in excess of 0.05 p. p. m. shall constitute grounds for rejection of the supply.

These limits are given in parts per million by weight and a reference to the method of analysis recommended for each determination is given in section 4.31. Salts of barium, hexavalent chromium, heavy metal glucosides, or other substances with deleterious physiological effects shall not be added to the system for water treatment purposes.

Ordinarily analysis for these substances need be made only semiannually. If, however, there is some presumption of unfitness because of these elements, periodic determination for the element in question should be made more frequently.

Where experience, examination, and available evidence indicate that such substances are not present or likely to be present in the water supplies involved, semiannual examinations are not necessary, provided such omission is acceptable to the reporting agency and the certifying authority.

4.22. The following chemical substances which may be present in natural or treated waters should preferably not occur in excess of the following concentrations where other more suitable supplies are available in the judgment of the certifying authority. Recommended methods of analysis are given in section 4.3.

Copper (Cu) should not exceed 3.0 p. p. m.
Iron (Fe) and manganese (Mn) together should not exceed 0.3 p. p. m.
Magnesium (Mg) should not exceed 125 p. p. m.
Zinc (Zn) should not exceed 15 p. p. m.
Chloride (Cl) should not exceed 250 p. p. m.
Sulfate (SO_4) should not exceed 250 p. p. m.
Phenolic compounds should not exceed 0.001 p. p. m. in terms of phenol.
Total solids should not exceed 500 p. p. m. for a water of good chemical quality. However, if such water is not available, a total solids content of 1,000 p. p. m. may be permitted.

For chemically treated waters, i. e., lime softened, zeolite or other ion exchange treated waters, or any other chemical treatments, the following three requirements should be met:

(1) The phenolphthalein alkalinity (calculated as $CaCO_3$) should not be greater than 15 p. p. m. plus 0.4 times the total alkalinity. This requirement limits the permissible *p*H to about 10.6 at 25° C.

(2) The normal carbonate alkalinity should not exceed 120 p. p. m. Since the normal alkalinity is a function of the hydrogen-ion concentration and the total alkalinity, this requirement may be met by keeping the total alkalinity within the limits suggested below when the *p*H of the water is within the range given. These values apply to water at 25° C.

*p*H range	Limit for total alkalinity (p. p. m. as $CaCO_3$)
8.0 to 9.6	400
9.7	340
9.8	300
9.9	260
10.0	230
10.1	210
10.2	190
10.3	180
10.4	170
10.5 to 10.6	160

(3) If excess alkalinity is produced by chemical treatment, the total alkalinity should not exceed the hardness by more than 35 p. p. m. (calculated as $CaCO_3$).

Because a low or high *p*H is often an indication of the nature of an industrial-waste discharge, the *p*H range of 4.5 to 9.5 of the Westchester County code represents the widest acceptable limits for industrial wastes and meets conditions likely to be encountered in any highly industrialized area.

The designation of water quality depends on the presence or absence of those substances that determine whether the water will serve a particular purpose. It is quite possible to rate a given water as good for one use and poor for another. Water characteristics cannot be put under single groupings because the same substance may be harmful in one combination and not harmful in another. Certain conditions must be maintained for the purpose at hand. Ellis and others give a complete bibliography on the determination of water quality (*20*, *22*, *76*).

Wolman's comments on bacterial standards for waters are equally applicable to chemical standards designed to make waters utilizable (*80*). He raises the questions of whether quality is an area in which standardization either is indicated or desirable and of what the standards should be if they are worthy of formulation and application. He points out the absence of any sound basis for universal standardization of desirable or desired characteristics of stream quality and suggests that, as stated in the Ohio River Basin report (*48*), the public interest can be served only by adapting standards to conditions existing in individual stream reaches and by considering the most valuable stream use.

CHARACTER OF SURFACE WATERS

Chemical-quality investigations of surface waters have been conducted by the Commonwealth of Pennsylvania and by Federal agencies, and these investigations have yielded data that give essential facts concerning acid mine drainage in the anthracite region (*4, 20, 22, 36, 61, 78, 79*).

Extensive investigations have been and are being conducted to determine exactly how acid mine water is formed, in the belief that, if this is known, a practical method may be found for its treatment (*31, 61, 66, 79*).

Acidity in natural, unpolluted waters is usually due to the presence of carbon dioxide and several organic acids as tannic and humic (*20*). Mineral acids, such as sulfuric, and many hydrolizable salts, which include the sulfates, are often harmful in very small quantities due to the changes in *p*H that they may produce and to the specific toxicity of some individual compounds (*7, 20, 79*).

It is assumed quite often that the sulfate content of the surface waters in mining regions is principally a measure of the acid mine water (*79*) and as such is distinctly harmful. This is not strictly true. Sulfates are components of many industrial wastes and of waters draining natural formations, such as pyrite-bearing strata. As such, sulfates are good tracers, making possible evaluation of their significance in the waters under consideration. Sulfates are found in most natural fresh waters, except some mountain streams near their snow sources, a very few "soft" lakes, and some spring-fed streams. Sulfates, particularly magnesium, calcium, and sodium, can be listed as one of the expected groups of compounds tolerated by fish up to 300 parts per million or more without marked effects (*20*).

Evaluation of pollution hazards is not an easy task, and this report does not attempt to do so. Pooled samples (*20*) were not collected by the engineers of the Bureau of Mines and are not used in the data on mine discharges given in this report, although they do have value in some instances. The small streams containing mine discharges from the anthracite region that traverse mining areas and the individual pumping-plant discharges can be reasonably classed as "slugs" that are poured into the receiving stream. As such, their effect in the zone of the receiving stream below the entrance of the particular acid-mine-water waste is important.

Available chemical data are given in table 9 for some surface waters that are conveyed through concrete-lined aqueduct tunnels and are utilized for general purposes in widely separated localities; also of selected surface waters in the drainage basins tributary to and in the anthracite region of Pennsylvania.

The changes in the chemical quality of the receiving rivers that traverse the anthracite region, where affected by acid mine water from anthracite mines, are shown in table 9.

The Lackawanna River at Uniondale and at Forest City, where it enters the Lackawanna Basin of the Northern anthracite field, is alkaline (*p*H, 7+). Acid mine water (*p*H, 3.1) from anthracite mines is discharged into the river downstream from Forest City and rapidly acidifies the river, which has a *p*H of 4 at Jermyn, 10 miles from Forest City. From Jermyn downstream to Duryea, a short distance upstream from the confluence of the Lackawanna River and the North Branch of the Susquehanna River at Pittston, numerous mines discharge mine water into the Lackawanna River, which has a *p*H of 3.5 at Duryea. Under average conditions, one-third of the water in the river at Duryea comes from the mine discharges (pumping plants and drainage tunnels) in the Lackawanna Basin (*4, 5*). (*See* table 9.)

The North Branch of the Susquehanna River is alkaline (*p*H, 7.5) at Pittston where it enters the Wyoming Basin of the Northern field and receives the acid Lackawanna River water. The discharge of the Susquehanna River at this point is more than 10 times that of the Lackawanna River. Because of the volume and the alkalinity of the Susquehanna River, the acidity of the Lackawanna is completely neutralized where it discharges into the Susquehanna. At this confluence of the rivers, the alkalinity as $CaCO_3$ (methyl-red indicator) of the Susquehanna River is 58 parts per million, and the alkalinity as $CaCO_3$ (phenolphthalein indicator) is 55 parts per million. The free acidity as H_2SO_4 (methyl-red indicator) of the Lackawanna River is 81 parts per million, and the total acidity as H_2SO_4 (phenolphthalein indicator) is 240 parts per million. (*See* table 9.)

Although much additional acid mine water from mines in the Wyoming Basin and Eastern Middle field is discharged into the Susquehanna River between Pittston and Danville, a

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of*

Source of water	Date of collection	Mean discharge, second-feet	*p*H	Conductivity ($K\times10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Hetch Hetchy	Aug. 27, 1936		6.4	1.97	3.8	0.02	0.02	0.0	1.1	1.4	0.1	0.0	0.1	0.1
Colorado River aqueduct	1942		8.1	124.0	3.0		.1		92.0	32.0	129		.15	.4
	1949		8.3	110.0	8.5		Tr.		84.0	30.0	107		.1	.5
Delaware River (East Branch).	Aug. 16, 1949	145	7.2	6.06	1.7		.10	.01	10.1	1.7				.05
Delaware River (West Branch).	do	74	8.2	7.91	3.1		.35	.02	11.5	4.8				.05
Neversink River	do	84	8.2	6.73	2.5		.20	.02	9.1	3.2				.10
Lackawanna River (from headwaters toward confluence with Susquehanna River near Duryea)	July 11, 1941	(*)	7.6											
	Oct. 8, 1941	(*)	5.6											
	Dec. 2, 1941	(*)	6.9											
	Aug. 5, 1946	(*)	7.4											
	Aug. 16, 1946	(*)	7.2											
	Mar. 19, 1945	(*)	6.5	4.02										
	May 2, 1941	(*)	7.3											
	do	(*)	7.1											
	do	(*)	5.9											
Wilson Creek	do		7.1											
Lackawanna River (continued)	do	(*)	4.4											
	do	(*)	4.0											
	July 20, 1944	48.1	3.5	56.2	10.0	7.1	.08	3.0	34.0	21.0	7.2			.1
	Sept. 22, 1944		3.4	42.4										
	Mar. 19, 1945		4.5	15.7										
	Mar. 31, 1945	199.0	4.0	31.3	6.0	2.0	.04	1.1	21.0	14.0	2.6	1.4		.1
	Aug. 5, 1946	120.0	4.2											
	Aug. 16, 1946	56.0	3.7											
	May 2, 1941	(*)	4.0											
	do	(*)	4.0											
	do	(*)	3.9											
	do	(*)	4.9											
	do	(*)	3.9											
	do	(*)	3.5											
	Aug. 5, 1946	(*)	3.6											
	Aug. 16, 1946	(*)	3.6											
	May 2, 1946	(*)	3.4											
	do	(*)	3.0											
	do	(*)	3.7											
	May 13, 1941	(*)	3.2											
	do	(*)	3.8											
	May 14, 1941	(*)	5.7											
	do	(*)	4.8											
	May 21, 1941	(*)	3.7											
	do	(*)	3.7											
	July 11, 1941	265.0	2.6											
	Oct. 8, 1941	114.0	3.3											
	Dec. 2, 1941	120.0	3.5											
	Aug. 5, 1946	481.0	3.4											
	Aug. 16, 1946	336.0	3.2											
	Dec. 9, 1944	(*)	4.2	47.3										
	Mar. 19, 1945	(*)	3.75	40.1										
Susquehanna River, North Branch (proceeding downstream)	June 5, 1941	3,060	8.1											
	July 14, 1941	996	7.7											
	Oct. 2, 1941	468	7.5											
	Nov. 23, 1941	1,510	8.1											
	July 21. 1944	1,570	7.7	22.3	1.0				31.0	6.2	4.6			.1
	Mar. 28, 1945	26,000	6.6	13.0	3.4		.01	0	17.0	3.2	3.5			.1
	July 29, 1946	3,630	8.6											
	Aug. 12, 1946	4,700	7.8											
	Aug. 21, 1946	3,700	7.7											
	1944[3]													
	Oct. 1–10	1,712	7.7	21.3	1.3		.02		29.0	4.5	8.4	1.8		0
	Oct. 11–20	2,977	7.8	22.4	.6		.01	0	29.0	5.2	8.5	1.9		0
	Oct. 21–31	5,058	7.4	17.0	1.4		.02		23.0	4.2	5.4	1.8		.1
	Nov. 1–10	2,868	8.3	19.3	1.0		.02		26.0	4.7	7.1	1.7		.2
	Nov. 11–20	4,515	7.7	18.7	1.4		.03		25.0	4.7	6.1	1.8		.1
	Nov. 21–30	6,932	7.3	14.6	2.0		.02		19.0	3.3	4.5	1.1		.1
	Dec. 1–10	10,910	7.1	11.6	3.0		.03		15.0	2.9	3.6	1.3		.2
	Dec. 11–20	12,700	7.2	11.7	3.1		.02		15.0	2.9	3.2	1.3		.1
	Dec. 21–31	5,569	7.4	15.2	2.5		.02		20.0	3.6	4.2	1.2		.1

See footnotes at end of table.

streams in the anthracite-region drainage basins (parts per million except pH and conductivity)

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_2SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
0	7	1.6	1.0	0.1	15	9.0	--------	--------	6.0	--------	--------	Water supply, San Francisco. Water conveyed through concrete-lined aqueduct (*18*). Natural water is soft and suitable for industrial and domestic purposes.
0	129	380.0	100.0	.5	802	361.0	255	--------	--------	--------	--------	Water supply, Metropolitan Water District, Los Angeles, Calif. Conveyed through concrete-lined aqueduct tunnels. Natural water used for many years as such (*28*, *30*, *77*) contains 1 to 1.6 parts per million free CO_2.
2	140	314.0	85.0	.2	701	334.0	215	--------	--------			
0	18	7.2	2.0	--------	40	28.0	25	--------	18.0			
4	19	8.9	4.8	--------	49	30.0	32.4	--------	23.0	--------	--------	New York State Department of Health analyses of streams tapped by Delaware Aqueduct.
4	12	7.2	3.6	--------	32	26.0	24.0	--------	16.0			
--------	--------	--------	--------	--------	--------	--------	--------	16.0	18.0			
--------	--------	--------	--------	--------	--------	--------	--------	28.0	30.0			
--------	--------	--------	--------	--------	--------	--------	--------	17.0	17.0	--------	--------	At Uniondale (*22*, p. 11).
--------	--------	--------	--------	--------	--------	--------	--------	40.0	38.0			
--------	--------	--------	--------	--------	--------	--------	--------	15.0	20.0			
--------	9	8.0	1.0	.8	--------	16.0	--------	--------	--------	--------	--------	At Forest City (*61*, p. 160).
--------	--------	--------	--------	--------	--------	--------	--------	9.0	11.0	--------	--------	Above Clinton Colliery (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	6.0	4.0	--------	--------	Below Clinton Colliery (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	0.0	24.0	Above Wilson Creek (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	79.0	43.0	--------	--------	Above Wilson Creek tunnel (*22*, p. 43).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	0	25.0	Below Wilson Creek (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	24.0	80.0	At Jermyn (*22*, p. 42).
--------	0	231.0	4.0	.0	344	231.0	231	--------	--------	--------	69.0	At Archbald (*4*, p. 51).
--------	0	--------	2.0	--------	--------	--------	--------	--------	--------	--------	--------	At Archbald (*61*, p. 160).
--------	0	60.0	.5	--------	--------	--------	--------	--------	--------	--------	11.0	At Archbald (*56*, p. 160).
--------	0	126.0	1.4	.4	188	128.0	128	--------	--------	--------	28.0	At Archbald (*4*, p. 51).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	15.0	34.0	At Archbald (*22*, p. 11).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	44.0	78.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	28.0	74.0	Above Gravity Slope, Archbald (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	28.0	74.0	Above Dana drift below Gravity (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	25.0	82.0	At Winton, 500 feet below Dana drift (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	13.0	54.0	Above Grassy Island at Olyphant (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	31.0	122.0	Above Olyphant shaft (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	101.0	281.0	Below Olyphant shaft (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	59.0	118.0	At Dickson City (*6*, p. 11).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	59.0	128.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	80.0	241.0	Above Marvine pump discharge (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	294.0	307.0	600 feet below Marvine pump discharge (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	52.0	316.0	Below Pennsylvania Coal Co. tunnel (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	25.0	88.0	150 feet above Von Storch discharge (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	31.0	101.0	500 feet below Von Storch discharge (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	0	16.0	150 feet above No. 30 (Volpe) (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	3.0	13.0	300 feet below No. 28 (Volpe) (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	49.0	155.0	Above Baker (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	49.0	155.0	Below Baker (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	94.0	238.0	At Old Forge (*22*, p. 11).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	126.0	418.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	39.0	215.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	74.0	127.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	74.0	201.0	Do.
--------	0	217.0	4.0	--------	--------	--------	--------	--------	--------	--------	--------	At Duryea (*61*, p. 160).
--------	0	162.0	2.0	--------	--------	132.0	--------	--------	--------	--------	39.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	43.0	45.0	--------	--------	At Towanda (*22*, p. 11).
--------	--------	--------	--------	--------	--------	--------	--------	48.0	41.0	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	75.0	66.0	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	56.0	51.0	--------	--------	Do.
--------	100.0	19.0	7.0	1.2	129	103.0	21.0	--------	--------	--------	--------	At Towanda (*61*, p. 47).
--------	44.0	18.0	3.4	4.2	78	56.0	20.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	70.0	65.0	--------	--------	At Towanda (*22*, p. 11).
--------	--------	--------	--------	--------	--------	--------	--------	55.0	55.0	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	60.0	65.0	--------	--------	Do.
--------	84.0	23.0	10.0	.6	125	91.0	22.0	--------	--------	--------	--------	At Falls (*61*, p. 98).
--------	90.0	21.0	10.0	.8	125	94.0	20.0	--------	--------	--------	--------	Do.
--------	66.0	21.0	5.5	1.0	97	75.0	20.0	--------	--------	--------	--------	Do.
--------	76.0	21.0	9.0	1.0	110	84.0	22.0	--------	--------	--------	--------	Do.
--------	74.0	20.0	7.2	1.1	106	82.0	21.0	--------	--------	--------	--------	Do.
--------	54.0	18.0	4.6	1.4	83	61.0	17.0	--------	--------	--------	--------	Do.
--------	39.0	18.0	3.8	2.8	70	49.0	17.0	--------	--------	--------	--------	Do.
--------	40.0	18.0	3.8	3.2	71	49.0	17.0	--------	--------	--------	--------	Do.
--------	57.0	20.0	5.0	3.4	89	65.0	18.0	--------	--------	--------	--------	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge, second-feet	*p*H	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
	1945[3]													
Susquehanna River, North Branch (proceeding downstream)—Continued	Jan. 1-10	17,740	7.1	12.2	3.7		0.03		15.0	2.0	5.1	1.0		0.1
	Jan. 11-20	8,103	7.2	14.0	3.8		.03	0	20.0	3.7	3.9	1.1		.1
	Jan. 21-31	4,879	7.4	17.6	2.0		.02		24.0	4.2	4.7	1.2		0
	Feb. 1-10	4,579	7.3	18.2	2.2		.02		25.0	4.4	4.6	1.4		0
	Feb. 11-20	7,292	7.2	16.2	3.7		.03		21.0	3.7	5.3	1.1		.1
	Feb. 21-28	31,720	7.1	11.1	3.0		.03	0	14.0	3.1	3.3	1.1		.1
	Mar. 1-10	66,180	7.0	8.9	4.2		.07	0	11.0	2.2	2.2	1.0		.1
	Mar. 11-20	52,260	7.1	9.6	4.4		.10	0	13.0	2.5	1.9	.6		.2
	Mar. 21-31	50,060	7.1	10.3	4.8		.09	0	14.0	2.4	2.5	.9		.1
	Apr. 1-10	23,500	7.1	12.4	3.5		.01	0	16.0	2.8	3.0	1.0		.1
	Apr. 11-20	10,620	7.3	15.0	1.6		.01		21.0	3.8	3.7	1.1		.1
	Apr. 21-30	14,460	7.3	13.3	2.0		.01	0	18.0	3.1	3.7	.6		.1
	May 1-10	27,260	7.1	10.9	3.0		.02	0	14.0	2.9	3.3	.5		.1
	May 11-20	37,470	7.1	10.4	4.0		.15	0	14.0	2.3	2.9	1.0		.1
	May 21-31	18,820	7.2	14.1	2.6		.03		19.0	3.3	2.8	.9		.1
	June 1-10	13,760	7.3	14.3	1.8		.02		19.0	3.5	3.1	.9		.1
	June 11-20	15,490	7.2	13.6	2.1		.02	0	18.0	3.1	3.2	1.2		.1
	June 21-30	11,290	7.3	14.8	1.8		.01	0	20.0	3.5	4.6	1.2		.2
	July 1-10	6,028	7.3	17.1	1.0		.01	0	23.0	4.0	5.2	1.6		.1
	July 11-20	6,177	7.5	18.8	1.8		.01	0	25.0	4.3	5.8	1.3		.1
	July 21-31	10,880	7.2	16.2	3.8		.01	0	22.0	3.7	4.4	1.2		.1
	Aug. 1-10	8,719	7.4	14.6	3.8		.02	0	20.0	3.3	3.7	1.0		.1
	Aug. 11-20	4,375	7.8	18.5	1.3		.02	0	25.0	4.4	5.0	1.4		.1
	Aug. 21-31	3,400	7.2	20.2	2.2		.01	0	26.0	4.9	6.3	1.7		.1
	Sept. 1-10	4,252	7.4	21.7	2.1		.01	0	28.0	5.2	7.2	1.6		.1
	Sept. 11-20	8,872	6.9	16.7	3.5		.03	0	22.0	3.5	5.0	1.4		.1
	Sept. 21-30	15,400	7.2	13.0	4.8		.05	0	18.0	3.0	2.6	1.4		.1
	Oct. 1-10	21,740	7.2	13.0	5.5		.02		18.0	3.5	1.5			.1
	Oct. 11-20	18,110	7.1	13.5	4.6		.03		18.0	3.1	4.3			.1
	Oct. 21-31	11,810	7.5	15.7	3.5		.03		21.0	3.6	4.2			.1
	Nov. 1-10	19,940	7.0	12.7	3.5		.02		17.0	3.1	4.1			.1
	Nov. 11-20	21,110	7.3	12.3	3.1		.02		16.0	1.6	5.8			.1
	Nov. 21-30	31,000	6.9	10.8	3.9		.06		14.0	2.8	3.4			.1
	Dec. 1-10	25,070	7.0	12.2	3.9		.03		15.0	3.1	4.3			.1
	Dec. 11-20	13,170	7.3	15.1	3.8		.03		19.0	3.8	5.6			.1
	Dec. 21-31	9,035	7.4	17.2	3.1		.03		23.0	4.2	4.6			0
	1946[3]													
	Jan. 1-10	26,280	7.2	12.7	3.7		.09		16.0	3.1	3.7			.1
	Jan. 11-20	18,870	7.3	12.7	4.3		.04		16.0	2.9	4.7			.1
	Jan. 21-31	6,481	7.5	18.4	3.9		.04		24.0	4.2	7.0			.1
	Feb. 1-10	5,256	7.5	20.1	3.2		.04		26.0	4.8	7.1			.1
	Feb. 11-20	7,432	7.4	18.0	2.6		.04		24.0	4.2	6.7			.1
	Feb. 21-28	5,376	7.5	17.1	2.8		.02		22.0	3.6	6.2			.1
	Mar. 1-10	43,300	6.9	9.9	3.5		.02		12.0	2.2	3.1			.1
	Mar. 11-20	38,760	7.0	9.6	4.6		.10		13.0	2.1	2.7			.1
	Mar. 21-31	15,140	7.2	13.7	2.3		.04		18.0	3.1	4.0			.1
	Apr. 1-10	7,910	7.7	16.7			.03		22.0	3.8	5.2			.1
	Apr. 11-20	6,531	7.4	17.5	.1		.03		22.0	4.2	7.1			.1
	Apr. 21-30	5,273	7.4	17.7	.4		.02		23.0	4.0	6.1			.1
	May 1-10	5,794	7.7	17.3	.7		.03		23.0	3.9	6.1			.1
	May 11-20	10,380	7.2	14.4	.8		.01		18.0	3.3	6.1			.1
	May 21-31	70,500	7.0	9.0	3.8		.06		11.0	2.2	3.6			.1
	June 1-10	36,660	7.4	11.1	4.7		.08		15.0	2.9	3.2			.1
	June 11-20	16,480	7.3	14.1	3.6		.02		19.0	3.4	4.5			.1
	June 21-30	9,222	7.5	16.0	2.7		.02		22.0	3.7	7.2			.1
	July 1-10	10,710	7.5	15.1	1.8		.01		20.0	5.3	1.9			.1
	July 11-20	4,423	7.6	19.4	1.7		.01		26.0	4.6	5.5			.1
	July 21-31	6,524	7.4	17.9	2.8		.05		23.0	4.2	5.4			
	Aug. 1-10	10,030	7.4	15.9	5.5		.07		20.0	3.9	5.5			
	Aug. 11-20	6,126	7.4	16.4	3.0		.05		21.0	3.9	6.0			
	Aug. 21-31	3,722	7.6	18.8	1.8		.03		24.0	4.9	6.4			
	Sept. 1-10	2,136	7.6	22.9	1.1		.02		30.0	5.6	9.2			.1
	Sept. 11-20	2,125	7.5	24.0	1.1		.02		32.0	6.2	8.0			.1
	Sept. 21-30	4,346	7.5	20.9	3.2		.03		29.0	5.4	3.5			.1
	June 6, 1941	6,300	7.3											
	July 15, 1941	1,600	6.7											
	Oct. 3, 1941	693	6.8											
	Nov. 24, 1941	2,020	7.3											
	July 29, 1944	2,010	6.7	35.0	1.6		.03		41.0	14.0	2.9			.1
	Apr. 4, 1945	22,900	7.1	16.1	3.7		.01	0	20.0	5.1	3.0			.1
	July 29, 1946	5,770	7.4											
	Aug. 12, 1946	6,840	7.0											
	Aug. 21, 1946	6,300	6.9											
Toby Creek	Sept. 6, 1944	1.87	7.0	11.9	1.8		.01		13.0	2.3	5.8			.3
	Apr. 3, 1946	265	6.2	7.51	3.7		.01	0	8.4	1.7	3.0			.1
Solomon Creek	May 19, 1941		7.6											
	do		2.8											
	do		3.4											
	May 6, 1944	3.9	2.7	223.0	33.0	29.0	6.4	10.0	159.0	93.0	39.0			
	Apr. 3, 1946	20.3	3.0	123.0	19.0	18.0	2.8	3.8	77.0	45.0	13.0	1.9		.2
Preston Creek	May 19, 1941		3.6											
	do		3.0											
Nescopeck Creek	Sept. 8, 1945	75-100	3.0	126.0										
Catawissa Creek	do		3.4	52.2										

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_2SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
--------	38.0	18.0	3.1	2.4	72	46.0	14.0	--------	--------	--------	--------	At Falls (*61*, p. 98).
--------	50.0	20.0	4.5	3.7	84	65.0	24.0	--------	--------	--------	--------	Do.
--------	64.0	20.0	5.6	3.4	101	77.0	25.0	--------	--------	--------	--------	Do.
--------	70.0	20.0	6.0	2.9	105	80.0	23.0	--------	--------	--------	--------	Do.
--------	62.0	18.0	6.2	2.8	96	68.0	17.0	--------	--------	--------	--------	Do.
--------	35.0	17.0	3.1	3.4	68	48.0	19.0	--------	--------	--------	--------	Do.
--------	24.0	15.0	2.2	3.4	58	36.0	17.0	--------	--------	--------	--------	Do.
--------	31.0	14.0	2.2	2.1	60	43.0	17.0	--------	--------	--------	--------	Do.
--------	38.0	14.0	2.4	1.9	63	45.0	14.0	--------	--------	--------	--------	Do.
--------	46.0	17.0	3.1	2.4	75	51.0	14.0	--------	--------	--------	--------	Do.
--------	61.0	17.0	4.0	1.9	87	68.0	18.0	--------	--------	--------	--------	Do.
--------	54.0	16.0	3.5	1.3	77	58.0	13.0	--------	--------	--------	--------	Do.
--------	39.0	16.0	2.2	1.4	65	47.0	15.0	--------	--------	--------	--------	Do.
--------	40.0	15.0	1.8	1.0	65	44.0	12.0	--------	--------	--------	--------	Do.
--------	58.0	15.0	2.6	1.6	82	61.0	13.0	--------	--------	--------	--------	Do.
--------	59.0	16.0	3.2	1.0	82	62.0	13.0	--------	--------	--------	--------	Do.
--------	56.0	14.0	3.0	1.7	80	58.0	12.0	--------	--------	--------	--------	Do.
--------	62.0	15.0	3.5	1.9	86	64.0	14.0	--------	--------	--------	--------	Do.
--------	74.0	16.0	4.5	1.7	97	74.0	13.0	--------	--------	--------	--------	Do.
--------	80.0	18.0	6.1	1.6	107	80.0	15.0	--------	--------	--------	--------	Do.
--------	69.0	15.0	4.6	2.0	95	70.0	14.0	--------	--------	--------	--------	Do.
--------	62.0	14.0	3.5	.9	86	63.0	13.0	--------	--------	--------	--------	Do.
--------	82.0	17.0	5.2	.8	103	80.0	13.0	--------	--------	--------	--------	Do.
--------	90.0	16.0	6.5	.8	113	85.0	11.0	--------	--------	--------	--------	Do.
--------	94.0	18.0	7.8	1.0	122	91.0	14.0	--------	--------	--------	--------	Do.
--------	70.0	15.0	5.6	1.7	96	69.0	12.0	--------	--------	--------	--------	Do.
--------	52.0	14.0	3.0	1.8	73	57.0	15.0	--------	--------	--------	--------	Do.
--------	53.0	13.0	2.9	1.4	79	59.0	16.0	--------	--------	--------	--------	At Falls (*61*, p. 100).
--------	56.0	15.0	2.8	1.6	79	58.0	12.0	--------	--------	--------	--------	Do.
--------	64.0	16.0	3.8	2.0	89	67.0	15.0	--------	--------	--------	--------	Do.
--------	52.0	15.0	3.2	1.3	75	55.0	13.0	--------	--------	--------	--------	Do.
--------	46.0	15.0	3.0	1.6	70	46.0	9.0	--------	--------	--------	--------	Do.
--------	38.0	16.0	2.8	2.4	66	46.0	15.0	--------	--------	--------	--------	Do.
--------	43.0	17.0	3.1	2.5	72	50.0	15.0	--------	--------	--------	--------	Do.
--------	58.0	19.0	4.0	2.3	87	63.0	15.0	--------	--------	--------	--------	Do.
--------	67.0	19.0	4.9	3.8	100	75.0	20.0	--------	--------	--------	--------	Do.
--------	45.0	16.0	3.2	2.9	76	53.0	16.0	--------	--------	--------	--------	Do.
--------	45.0	16.0	3.8	3.7	74	52.0	15.0	--------	--------	--------	--------	Do.
--------	73.0	20.0	5.6	4.6	104	77.0	17.0	--------	--------	--------	--------	Do.
--------	84.0	19.0	5.8	3.7	113	85.0	16.0	--------	--------	--------	--------	Do.
--------	76.0	17.0	6.2	3.5	101	77.0	15.0	--------	--------	--------	--------	Do.
--------	66.0	17.0	5.5	4.2	95	70.0	16.0	--------	--------	--------	--------	Do.
--------	31.0	13.0	3.5	2.0	61	39.0	14.0	--------	--------	--------	--------	Do.
--------	34.0	13.0	2.5	2.2	60	41.0	13.0	--------	--------	--------	--------	Do.
--------	50.0	17.0	4.0	2.3	79	58.0	17.0	--------	--------	--------	--------	Do.
--------	66.0	17.0	6.0	1.5	93	70.0	16.0	--------	--------	--------	--------	Do.
--------	73.0	17.0	6.1	1.4	97	72.0	12.0	--------	--------	--------	--------	Do.
--------	72.0	18.0	6.1	.6	100	74.0	15.0	--------	--------	--------	--------	Do.
--------	69.0	19.0	6.6	1.0	97	73.0	17.0	--------	--------	--------	--------	Do.
--------	57.0	17.0	4.6	.8	86	58.0	12.0	--------	--------	--------	--------	Do.
--------	31.0	14.0	1.8	1.9	58	36.0	11.0	--------	--------	--------	--------	Do.
--------	42.0	16.0	2.6	1.7	75	49.0	15.0	--------	--------	--------	--------	Do.
--------	60.0	15.0	3.4	1.8	82	61.0	12.0	--------	--------	--------	--------	Do.
--------	76.0	16.0	4.1	1.0	91	70.0	8.0	--------	--------	--------	--------	Do.
--------	66.0	14.0	4.0	1.7	94	72.0	18.0	--------	--------	--------	--------	Do.
--------	84.0	18.0	4.9	1.2	107	84.0	15.0	--------	--------	--------	--------	Do.
--------	72.0	18.0	5.0	2.0	104	75.0	16.0	--------	--------	--------	--------	Do.
--------	62.0	18.0	4.4	2.6	95	66.0	15.0	--------	--------	--------	--------	Do.
--------	68.0	18.0	4.2	1.4	95	68.0	13.0	--------	--------	--------	--------	Do.
--------	79.0	19.0	6.0	1.1	107	80.0	15.0	--------	--------	--------	--------	Do.
--------	96.0	25.0	8.5	1.2	127	98.0	19.0	--------	--------	--------	--------	Do.
--------	102.0	23.0	9.8	1.4	136	105.0	22.0	--------	--------	--------	--------	Do.
--------	82.0	21.0	8.1	1.8	120	95.0	27.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	30.0	34.0	--------	--------	At Wilkes-Barre (*22*, p. 12).
--------	--------	--------	--------	--------	--------	--------	--------	19.0	17.0	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	15.0	19.0	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	36.0	41.0	--------	--------	Do.
--------	64.0	94.0	10.0	1.9	218	160.0	107.0	--------	--------	--------	--------	At Wilkes-Barre (*61*, p. 47).
--------	40.0	37.0	2.6	2.8	94	71.0	38.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	40.0	40.0	--------	--------	At Wilkes-Barre (*22*, p. 12).
--------	--------	--------	--------	--------	--------	--------	--------	30.0	25.0	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	25.0	30.0	--------	--------	Do.
--------	35.0	16.0	5.5	.8	69	42.0	13.0	--------	--------	--------	--------	At Luzerne (*61*, p. 51).
--------	14.0	16.0	2.1	3.9	51	28.0	16.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	Neutral	2.0	Above No. 4 slope (*22*, p. 43).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	266.0	521.0	Below No. 4 slope (*22*, p. 43).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	95.0	271.0	Below creek junction with Preston (*22*, p. 43).
--------	0	1,100.0	10.0	.6	1,550	1,070.0	1,070.0	--------	--------	--------	365.0	At Wilkes-Barre (*61*, p. 51).
--------	0	542.0	6.5	.4	760	548.0	548.0	--------	--------	--------	188.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	26.0	206.0	Huber discharge (*22*, p. 42).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	390.0	624.0	Askam discharge (*22*, p. 42).
--------	0	611.0	1.0	.1	--------	435.0	--------	--------	--------	--------	312.0	At Nescopeck (*61*, p. 160).
--------	0	231.0	2.0	.8	--------	120.0	--------	--------	--------	--------	136.0	At Catawissa (*61*, p. 160).

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	pH	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Susquehanna River, North Branch—Continued	June 6, 1941	5,850	7.2											
	July 15, 1941	2,100	6.3											
	Oct. 3, 1941	1,010	4.7											
	Nov. 24, 1941	2,380	7.5											
	1945 [3]													
	Oct. 1–10	25,110	6.8	18.2	5.8		0.04	0	22.0	6.0	2.9	1.8		0.1
	Oct. 11–20	22,170	6.8	18.1	5.2		.03	0	20.0	5.8	4.1	2.0		0
	Oct. 21–31	13,120	7.0	22.8	4.2		.07	0	26.0	7.9	5.0	2.1		0
	Nov. 1–10	22,090	7.0	18.0	3.4		.03	0	20.0	5.7	3.9	1.6		.1
	Nov. 11–20	23,750	7.0	16.9	3.0		.04	0	18.0	5.2	3.8	1.4		.1
	Nov. 21–30	36,790	7.0	14.4	3.6		.08	0	16.0	4.2	3.1	1.5		.1
	Dec. 1–10	30,010	7.0	16.0	3.5		.12	0	18.0	4.9	3.5	1.7		.1
	Dec. 11–20	16,150	6.9	16.7	3.8		.02	0	19.0	5.9	5.4	1.8		.1
	Dec. 21–31	11,300	6.9	24.8	3.6		.02	0	28.0	9.0	7.0	1.6		.1
	1946 [3]													
	Jan. 1–10	30,700	6.9	17.6	3.8		.06	0	19.0	6.1	5.2	1.3		.1
	Jan. 11–20	23,890	6.9	15.1	4.2		.04	0	17.0	5.0	4.4	1.2		.1
	Jan. 21–31	8,125	6.9	27.2	4.4		.03	.16	30.0	10.0	6.8	1.5		.1
	Feb. 1–10	6,173	7.0	30.2	4.3		.03	.40	34.0	11.0	8.2	1.6		.1
	Feb. 11–20	8,328	6.9	27.9	3.4		.05	0	31.0	9.8	7.4	1.4		.1
	Feb. 21–28	6,173	7.0	24.2	3.0		.09	.28	26.0	8.7	5.5	1.7		.1
	Mar. 1–10	47,110	6.8	12.0	3.4		.13	0	13.0	3.5	3.0	1.5		.1
	Mar. 11–20	50,080	6.9	11.4	4.8		.22	0	13.0	3.5	2.2	1.2		.1
	Mar. 21–31	19,100	6.9	17.1	3.8		.06	0	19.0	5.4	3.9	1.6		0
	Apr. 1–10	9,695	7.0	23.7	1.8		.13	.13	26.0	8.1	5.5	1.6		.1
	Apr. 11–20	7,399	7.1	26.1	1.2		.06		30.0	9.2	6.2	1.3		.1
	Apr. 21–30	5,899	7.0	27.3	1.6		.04	0	31.0	10.0	4.6	1.1		.1
	May 1–10	6,169	6.9	27.5	4.0		.04	0	30.0	9.9	7.1	1.5		.2
	May 11–20	11,930	6.9	20.8	1.2		.02	.03	23.0	6.8	5.2	.9		.1
	May 21–31	88,670	6.4	11.2	3.6		.09	.02	12.0	3.8	2.5	.8		.1
	June 1–10	46,800	7.0	14.2	5.1		.10	.03	16.0	4.4	2.8	.5		.1
	June 11–20	18,910	7.1	19.2	3.4		.06	.03	23.0	6.5	4.2	.4		.1
	June 21–30	11,040	6.8	23.3	2.3		.02	0	26.0	7.8	5.3	.9		.1
	July 1–10	12,000	7.0	23.6	2.8		.03	0	28.0	8.4	5.7	.9		.1
	July 11–20	5,131	6.9	31.4	2.8		.02	0	36.0	12.0	6.9	1.4		.1
	July 21–31	6,784	7.1	29.7	3.4		.16	0	32.0	11.0	6.7	2.9		.1
	July 29	7,140	7.1											
	Aug. 1–10	11,440	6.8	25.1	4.2		.01	0	26.0	9.8	5.4	1.6		.1
	Aug 11–20	7,242	6.7	28.7	4.9		.01	0	30.0	12.0	5.6	1.9		.1
	Aug. 12	8,740	7.1											
	Aug. 21	7,900	7.1											
	Aug. 21–31	4,576	6.8	34.1	3.5		.01	0	35.0	15.0	7.0	1.8		.1
	Sept. 1–10	2,460	6.6	47.9	3.7		.01	.53	48.0	23.0	9.8	1.8		.2
	Sept. 11–20	2,346	6.6	49.5	3.3		.01	.5	50.0	24.0	9.8	2.0		.1
	Sept. 21–30	4,463	6.8	41.4	3.7		.01	.4	41.0	18.0	9.9	2.0		.1
	Nov. 19, 1946	5,070	7.5											
Susquehanna River	Aug. 8, 1944	3,350	5.7	40.7	2.6		.35		44.0	17.0	6.3			.1
	Mar. 16, 1945	76,900	6.8	11.6	4.3		.03	0	13.0	3.6	2.8			.1
	Nov. 19, 1946	8,900	7.2											
Shamokin Creek	July 23, 1941		2.4											
	Aug. 8, 1944	69.2	3.0	178.0	21.0	29.0	15.0	10.0	119.0	68.0	17.0			.1
	Dec. 11, 1944		3.3	67.9										
	Mar. 16, 1945	141	2.75	210.0	20.0	19.0	8.3	10.0	148.0	82.0	8.6	2.1		.2
	Mar. 20, 1945		3.0	117.0										
	Sept. 8, 1945	50–60	2.9	170.0										
	Nov. 19, 1946	38	3.3											
Mahanoy Creek	Dec. 11, 1944		3.45	75.6										
	Mar. 20, 1945		3.4	100.0										
	Sept. 8, 1945	40–50	3.2	191.0										
	Nov. 19, 1946		3.5											
Wiconisco Creek	Dec. 11, 1944		6.1	14.2										
	Mar. 20, 1945		5.7	32.3										
	Sept. 8, 1945	30	5.9	49.2										
	Nov. 19, 1946		7.1											
	do		7.2											

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_4SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
--------	--------	--------	--------	--------	--------	--------	--------	9.0	11.0	--------	--------	At Danville (*22*, p. 12).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	Neutral	5.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	13.0	44.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	17.0	24.0	--------	--------	Do.
--------	36.0	50.0	2.9	1.8	111	80.0	50.0	--------	--------	--------	--------	At Danville (*61*, p. 102).
--------	38.0	45.0	3.2	1.7	110	74.0	43.0	--------	--------	--------	--------	Do.
--------	46.0	60.0	3.8	1.8	141	97.0	60.0	--------	--------	--------	--------	Do.
--------	39.0	43.0	3.0	1.4	104	73.0	41.0	--------	--------	--------	--------	Do.
--------	35.0	41.0	3.2	1.3	98	66.0	38.0	--------	--------	--------	--------	Do.
--------	32.0	34.0	2.6	1.5	84	57.0	31.0	--------	--------	--------	--------	Do.
--------	34.0	38.0	3.0	1.8	94	65.0	37.0	--------	--------	--------	--------	Do.
--------	35.0	46.0	2.8	2.3	101	72.0	43.0	--------	--------	--------	--------	Do.
--------	44.0	71.0	4.8	3.7	153	107.0	71.0	--------	--------	--------	--------	Do.
--------	34.0	45.0	3.2	3.0	104	73.0	45.0	--------	--------	--------	--------	Do.
--------	31.0	38.0	2.6	2.9	89	63.0	38.0	--------	--------	--------	--------	Do.
--------	42.0	80.0	5.0	4.0	170	116.0	82.0	--------	--------	--------	--------	Do.
--------	52.0	86.0	6.1	4.5	190	130.0	88.0	--------	--------	--------	--------	Do.
--------	54.0	74.0	6.4	4.5	172	118.0	73.0	--------	--------	--------	--------	Do.
--------	38.0	70.0	5.0	3.8	147	101.0	70.0	--------	--------	--------	--------	Do.
--------	25.0	25.0	3.4	2.8	74	47.0	26.0	--------	--------	--------	--------	Do.
--------	24.0	26.0	2.2	2.4	72	47.0	27.0	--------	--------	--------	--------	Do.
--------	36.0	43.0	3.4	2.6	103	70.0	40.0	--------	--------	--------	--------	Do.
--------	43.0	66.0	4.6	1.9	145	98.0	63.0	--------	--------	--------	--------	Do.
--------	45.0	76.0	5.4	1.4	159	113.0	76.0	--------	--------	--------	--------	Do.
--------	45.0	80.0	6.0	2.3	176	118.0	82.0	--------	--------	--------	--------	Do.
--------	49.0	78.0	6.5	1.9	176	116.0	75.0	--------	--------	--------	--------	Do.
--------	40.0	56.0	4.5	1.6	127	85.0	53.0	--------	--------	--------	--------	Do.
--------	22.0	28.0	1.8	1.8	68	46.0	28.0	--------	--------	--------	--------	Do.
--------	31.0	39.0	2.4	2.2	86	56.0	33.0	--------	--------	--------	--------	Do.
--------	42.0	50.0	3.1	2.2	116	84.0	50.0	--------	--------	--------	--------	Do.
--------	46.0	65.0	3.5	1.3	142	97.0	59.0	--------	--------	--------	--------	Do.
--------	42.0	66.0	3.9	2.1	144	104.0	70.0	--------	--------	--------	--------	Do.
--------	42.0	103.0	5.0	2.0	201	139.0	105.0	--------	--------	--------	--------	Do.
--------	43.0	96.0	5.5	3.0	191	125.0	90.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	15.0	5.0	--------	--------	At Danville (*22*, p. 12).
--------	30.0	86.0	4.5	1.8	157	105.0	81.0	--------	--------	--------	--------	At Danville (*61* p. 102).
--------	30.0	103.0	4.0	2.2	181	124.0	100.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	10.0	10.0	--------	--------	At Danville (*22*, p. 12).
--------	--------	--------	--------	--------	--------	--------	--------	15.0	15.0	--------	--------	Do.
--------	27.0	129.0	5.5	2.3	220	149.0	127.0	--------	--------	--------	--------	At Danville (*61*, p. 102).
--------	14.0	204.0	6.2	2.2	327	214.0	203.0	--------	--------	--------	--------	Do.
--------	20.0	208.0	8.0	2.8	334	223.0	207.0	--------	--------	--------	--------	Do.
--------	33.0	158.0	8.0	2.8	270	176.0	149.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	35.0	40.0	--------	--------	At Danville (*22*, p. 12).
--------	4.0	162 0	8.8	11.0	275	180.0	176.0	--------	--------	--------	--------	At Sunbury (*61*, p. 47).
--------	16.0	33.0	2.5	2.6	69	47.0	34.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	40.0	35.0	--------	--------	At Sunbury (*22*, p. 12).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	269.0	462.0	At bridge route 14 (*22*, p. 42).
--------	0	817.0	22.0	.1	1,260	845.0	845.0	--------	--------	--------	342.0	At weight scale (*61*, p. 58).
--------	0	278.0	5.0	--------	--------	--------	--------	--------	--------	--------	--------	At Sunbury (*61*, p. 160).
--------	0	994.0	3.2	.3	1,430	957.0	276.0	--------	--------	--------	276.0	At weight scale (*61*, p. 58).
--------	0	467.0	9.5	--------	--------	352.0	--------	--------	--------	--------	174.0	At Sunbury (*61*, p. 160).
--------	0	770.0	17.0	.1	--------	660.0	--------	--------	--------	--------	230.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	95.0	215.0	At weight scale (*22*, p. 43).
--------	0	375.0	2.0	--------	--------	--------	--------	--------	--------	--------	--------	At Herndon (*61*, p. 160).
--------	0	502.0	1.0	--------	--------	--------	--------	--------	--------	--------	--------	Do.
--------	0	1,160.0	2.0	--------	--------	--------	--------	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	160.0	295.0	At Highway No. 14 (*22*, p. 43).
--------	10.0	60.0	3.0	--------	--------	54.0	--------	--------	--------	--------	--------	At Millersburg (*61*. p. 160).
--------	4.0	138.0	3.0	3.0	--------	--------	--------	--------	--------	--------	--------	Do.
--------	14.0	236.0	2.0	4.0	--------	255.0	--------	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	20.0	10.0	--------	--------	At Millersburg (*22*, p. 43).
--------	--------	--------	--------	--------	--------	--------	--------	20.0	10.0	--------	--------	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	*p*H	Conductivity ($K\times10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Susquehanna River—Continued	July 22, 1941	6, 480	6. 5											
	Oct. 5, 1941	2, 580	6. 3											
	Nov. 25, 1941	6, 350	7. 7											
	1944 [3]													
	Oct. 1-10	4, 546	7. 0	32. 6	2. 6		0. 01		36. 0	11. 0	10. 0	2. 4		0. 1
	Oct. 11-20	6, 366	7. 0	29. 3	2. 6		. 02	0	31. 0	9. 6	9. 7	2. 7		. 1
	Oct. 21-31	14, 650	6. 7	22. 9	3. 8		. 02	0	24. 0	7. 1	6. 8	2. 6		. 1
	Nov. 1-10	7, 207	7. 0	19. 9	4. 0		. 02	0	21. 0	6. 3	6. 1	2. 3		. 1
	Nov. 11-20	7, 200	7. 2	23. 9	2. 4		. 05	0	26. 0	7. 0	7. 2	1. 9		. 1
	Nov. 21-30	12, 700	7. 2	21. 8	3. 4		. 04	0	25. 0	6. 8	7. 5	2. 1		. 1
	Dec. 1-10	20, 110	7. 1	17. 3	4. 0		. 04	0	20. 0	5. 4	5. 4	1. 4		. 1
	Dec. 11-20	30, 630	7. 0	13. 9	4. 7		. 08	0	16. 0	4. 2	3. 9	1. 3		. 1
	Dec. 21-31	14, 860	6. 9	20. 1	4. 5		. 04	0	22. 0	7. 2	4. 7	1. 4		. 1
	1945 [3]													
	Jan. 1-10	42, 070	6. 7	18. 6	4. 4		. 02		19. 0	6. 9	6. 0	1. 2		. 1
	Jan. 11-20	19, 040	6. 8	22. 9	4. 1		. 02		23. 0	9. 3	4. 1	1. 5		0
	Jan. 21-31	12, 700	7. 1	20. 4	3. 6		. 04		22. 0	6. 3	6. 3	1. 4		. 0
	Feb. 1-10	12, 120	7. 1	22. 0	4. 4		. 06	. 10	24. 0	7. 1	9. 7	1. 0		. 1
	Feb. 11-20	23, 550	6. 9	19. 4	5. 4		. 16		22. 0	5. 5	7. 5	1. 0		. 2
	Feb. 21-28	81, 120	6. 8	14. 2	5. 2		. 03		15. 0	4. 1	4. 4	1. 1		. 1
	Mar. 1-10	186, 000	6. 3	8. 97	4. 2		. 10	0	10. 0	2. 7	2. 0	. 5		. 2
	Mar. 11-20	116, 200	6. 6	9. 77	4. 7		. 05	0	11. 0	3. 1	2. 7	. 5		. 1
	Mar. 21-31	123, 200	6. 7	9. 58	4. 4		. 08	0	11. 0	2. 9	2. 2	. 6		. 1
	Apr. 1-10	67, 350	6. 7	11. 6	4. 8		. 04	0	13. 0	3. 4	3. 0	. 9		. 1
	Apr. 11-20	36, 060	6. 8	11. 7	3. 4		. 01	0	12. 0	3. 6	2. 6	1. 1		. 1
	Apr. 21-30	43, 540	6. 6	12. 2	4. 4		. 03	. 10	13. 0	4. 1	2. 4	. 8		. 1
	May 1-10	75, 930	6. 8	9. 42	4. 6		. 04	0	10. 0	2. 9	2. 3	. 9		. 1
	May 11-20	101, 000	6. 8	9. 4	4. 2		. 07	0	10. 0	2. 9	2. 2	. 7		. 1
	May 21-31	60, 410	6. 8	10. 6	4. 5		. 05		12. 0	3. 4	2. 1	. 8		. 1
	June 1-10	43, 690	6. 7	10. 3	4. 3		. 04		11. 0	3. 1	1. 9	. 8		. 1
	June 11-20	29, 120	7. 0	14. 4	3. 1		. 01	0	16. 0	4. 5	3. 2	1. 0		. 1
	June 21-30	25, 410	7. 1	16. 6	4. 0		. 03	0	19. 0	5. 2	3. 7	1. 4		. 1
	July 1-10	14, 570	6. 9	18. 6	4. 6		. 03	0	21. 0	6. 2	5.4			. 1
	July 11-20	13, 240	7. 0	21. 7	3. 8		. 03	0	23. 0	7. 7	6.0			. 1
	July 21-31	24, 280	6. 8	25. 3	3. 6		. 02	. 3	25. 0	9. 6	6. 1	1. 6		. 1
	Aug. 1-10	24, 070	6. 9	18. 2	5. 4		. 02	0	18. 0	5. 9	4. 4	1. 2		. 1
	Aug. 11-20	10, 790	6. 8	21. 3	4. 0		. 02	0	22. 0	7. 8	4. 7	1. 4		. 1
	Aug. 21-31	10, 880	7. 0	23. 1	2. 4		. 03	0	24. 0	9. 0	5. 4	2. 1		. 1
	Sept. 1-10	9, 279	6. 7	27. 1	3. 8		. 01	0	26. 0	12. 0	6. 4	1. 9		. 1
	Sept. 11-20	22, 980	6. 7	26. 3	4. 8		. 02	0	27. 0	9. 7	6. 7	1. 7		. 1
	Sept. 21-30	44, 570	6. 8	14. 5	5. 2		. 03	0	16. 0	4. 4	3. 2	1. 5		. 1
	Oct. 1-10	47, 020	6. 7	12. 9	5. 0		. 06		15. 0	4. 3	1.7			. 1
	Oct. 10-21	38, 980	6. 9	15. 0	4. 8		. 02		17. 0	4. 9	3.9			. 1
	Oct. 21-31	22, 530	7. 0	19. 1	4. 2		. 01		21. 0	6. 4	4.6			. 1
	Nov. 1-10	36, 680	7. 0	15. 9	4. 1		. 05		17. 0	5. 0	5.3			0
	Nov. 11-20	48, 110	6. 9	12. 4	4. 7		. 03		13. 0	3. 6	3.1			. 1
	Nov. 21-30	99, 120	6. 6	9. 91	4. 5		. 05		11. 0	3. 0	3.1			. 1
	Dec. 1-10	83, 940	6. 8	10. 2	4. 8		. 03		11. 0	3. 2	2.2			. 1
	Dec. 11-20	38, 900	7. 2	13. 1	4. 8		. 01		14. 0	4. 2	3.5			. 1
	Dec. 21-31	25, 450	7. 3	22. 5	3. 8		. 03		24. 0	8. 3	5.0			0
	1946 [3]													
	Jan. 1-10	69, 260	7. 1	18. 0	3. 9		. 03		19. 0	6. 0	5.2			. 1
	Jan. 11-20	66, 870	6. 8	9. 37	4. 5		. 02		9. 5	2. 8	3.0			. 1
	Jan. 21-31	20, 360	7. 2	23. 0	5. 2		. 06		25. 0	8. 1	6.9			. 1
	Feb. 1-10	16, 650	6. 9	35. 7	5. 4		. 03		36. 0	16. 0	8.4			. 1
	Feb. 11-20	18, 450	7. 0	33. 9	3. 8		. 03		34. 0	14. 0	8.7			. 1
	Feb. 21-28	19, 000	7. 2	18. 6	3. 2		. 05		20. 0	6. 0	5.5			. 1
	Mar. 1-10	98, 320	6. 7	11. 3	4. 3		. 04		12. 0	3. 3	2.6			. 1
	Mar. 11-20	114, 400	6. 8	8. 96	4, 1		. 08		9. 6	2. 8	2.8			. 1
	Mar. 21-31	56, 630	6. 8	10. 2	4. 2		. 07		11. 0	3. 3	2.2			. 1
	Apr. 1-10	28, 910	7. 2	12. 1	4. 0		. 05		12. 0	3. 8	4.2			. 1
	Apr. 11-20	18, 130	7. 0	15. 6	3. 8		. 04		16. 0	5. 0	5.1			. 1
	Apr. 21-30	14, 110	7. 2	17. 8	3. 2		. 03		19. 0	5. 6	5.8			. 1
	May 1-10	13, 040	7. 2	19. 0	1. 9		. 03		20. 0	6. 0	6.6			. 1
	May 11-20	30, 900	6. 8	13. 4	2. 5		. 02		14. 0	4. 0	4.6			. 1
	May 21-31	184, 700	6. 8	8. 95	4. 8		. 40		10. 0	2. 6	4.1			. 1
	June 1-10	114, 000	6. 9	10. 7	5. 1		. 11		11. 0	3. 2	4.3			. 1
	June 11-20	56, 940	6. 8	11. 7	5. 4		. 03		12. 0	3. 5	4.9			. 1
	June 21-30	34, 380	6. 8	13. 7	4. 9		. 02		14. 0	4. 4	4.3			. 1
	July 1-10	26, 980	6. 8	16. 0	4. 0		. 01		17. 0	3. 6	6.9			. 1
	July 11-20	12, 670	7. 1	18. 8	4. 1		. 01		20. 0	6. 2	4.5			. 1
	July 21-31	14, 170	7. 0	23. 3	3. 6		. 04		25. 0	7. 8	7.7			
	July 31	10, 100	6. 7											
	Aug. 1-10	21, 980	6. 9	20. 2	4. 0		. 04		22. 0	6. 6	5.8			
	Aug. 11-20	14, 790	7. 0	19. 4	4. 6		. 04		20. 0	6. 3	6.2			
	Aug. 14	14, 400	7. 2											
	Aug. 27	8, 680	6. 9											
	Aug. 21-31	11, 200	7. 2	21. 6	4. 4		. 04		22. 0	7. 1	7.1			
	Sept. 1-10	5, 772	7. 3	24. 2	1. 8		. 02		24. 0	8. 8	8.3			
	Sept. 11-20	5, 431	7. 4	29. 7	1. 4		. 02		31. 0	11. 0	9.8			
	Sept. 21-30	9, 701	7. 5	26. 9	1. 6		. 03		29. 0	9. 6	9.7			
Swatara Creek	Aug. 23, 1944	39. 8	7. 7	28. 6	6. 4		. 02		27. 0	10. 0	10.0			. 1
	Mar. 21, 1945	930	6. 5	11. 1	6. 3		. 06	0	11. 0	3. 7	4.0			0
	Nov. 19, 1945		4. 6											
	do	102	7. 8											

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_2SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
										Neutral	5.0	At Harrisburg (22, p. 12).
								41.0	47.0			Do.
								32.0	36.0			Do.
	29.0	112.0	10.0	1.5	224	135.0	111.0					At Harrisburg (61, p. 104).
	26.0	101.0	7.8	1.6	185	117.0	96.0					Do.
	20.0	75.0	6.1	2.1	141	89.0	73.0					Do.
	22.0	61.0	5.2	1.8	119	78.0	60.0					Do.
	33.0	68.0	6.5	1.3	143	94.0	67.0					Do.
	35.0	63.0	5.8	2.2	130	90.0	62.0					Do.
	28.0	48.0	4.1	2.6	104	72.0	49.0					Do.
	22.0	38.0	3.5	2.8	85	57.0	39.0					Do.
	26.0	62.0	4.8	3.5	128	84.0	63.0					Do.
	19.0	60.0	3.4	3.1	117	76.0	60.0					Do.
	17.0	79.0	4.2	2.7	146	96.0	82.0					Do.
	34.0	54.0	5.2	3.4	126	81.0	53.0					Do.
	44.0	60.0	5.6	3.4	134	89.0	53.0					Do.
	43.0	47.0	5.0	4.3	122	78.0	42.0					Do.
	20.0	38.0	3.2	3.7	89	54.0	38.0					Do.
	8.0	26.0	1.8	2.6	58	36.0	30.0					Do.
	12.0	28.0	2.1	2.0	62	40.0	30.0					Do.
	18.0	24.0	1.9	1.9	61	39.0	25.0					Do.
	19.0	32.0	2.1	1.6	70	46.0	31.0					Do.
	11.0	36.0	2.5	1.9	70	45.0	31.0					Do.
	10.0	40.0	2.2	.8	76	49.0	41.0					Do.
	16.0	25.0	1.5	1.4	57	37.0	24.0					Do.
	16.0	25.0	2.1	1.2	58	37.0	24.0					Do.
	17.0	29.0	1.8	1.6	66	44.0	30.0					Do.
	14.0	29.0	2.0	1.3	63	40.0	29.0					Do.
	26.0	39.0	3.0	1.1	88	58.0	37.0					Do.
	32.0	44.0	3.0	1.8	104	69.0	43.0					Do.
	28.0	53.0	4.0	2.1	113	78.0	55.0					Do.
	28.0	68.0	4.5	1.6	134	89.0	66.0					Do.
	12.0	91.0	4.5	2.0	162	102.0	92.0					Do.
	17.0	59.0	3.5	1.9	113	69.0	55.0					Do.
	22.0	72.0	4.1	1.5	134	87.0	69.0					Do.
	25.0	77.0	4.5	1.7	143	97.0	76.0					Do.
	20.0	98.0	5.0	1.9	178	114.0	98.0					Do.
	22.0	89.0	5.5	2.9	164	107.0	89.0					Do.
	16.0	45.0	2.8	2.0	89	58.0	45.0					Do.
	22.0	34.0	2.6	1.8	78	55.0	37.0					Do.
	33.0	37.0	2.9	1.5	90	63.0	36.0					Do.
	35.0	51.0	3.8	1.6	115	79.0	50.0					Do.
	34.0	39.0	3.2	2.0	91	63.0	35.0					Do.
	20.0	31.0	2.6	1.7	73	47.0	31.0					Do.
	18.0	26.0	2.2	1.8	61	40.0	25.0					Do.
	14.0	28.0	2.2	1.8	62	41.0	29.0					Do.
	22.0	34.0	3.0	2.4	77	52.0	34.0					Do.
	32.0	67.0	4.1	3.9	143	94.0	68.0					Do.
	28.0	51.0	3.4	2.8	109	72.0	49.0					Do.
	12.0	26.0	2.2	1.9	56	35.0	25.0					Do.
	50.0	57.0	4.5	4.7	138	96.0	55.0					Do.
	22.0	138.0	5.9	4.4	241	156.0	138.0					Do.
	26.0	122.0	6.8	4.0	219	142.0	121.0					Do.
	34.0	47.0	4.8	3.2	111	75.0	47.0					Do.
	14.0	31.0	2.8	1.7	68	43.0	32.0					Do.
	15.0	22.0	3.0	2.2	54	35.0	23.0					Do.
	14.0	28.0	2.5	1.7	60	41.0	30.0					Do.
	14.0	36.0	3.0	1.5	74	46.0	34.0					Do.
	24.0	43.0	4.0	1.6	93	60.0	41.0					Do.
	27.0	52.0	4.0	1.1	109	70.0	48.0					Do.
	28.0	55.0	5.5	.9	115	75.0	52.0					Do.
	16.0	41.0	3.5	.6	84	51.0	38.0					Do.
	19.0	24.0	1.8	1.4	66	36.0	20.0					Do.
	19.0	28.0	2.4	1.9	66	41.0	25.0					Do.
	17.0	35.0	2.2	1.6	73	44.0	30.0					Do.
	12.0	45.0	3.0	1.4	84	53.0	43.0					Do.
	16.0	51.0	3.0	1.9	114	57.0	44.0					Do.
	22.0	58.0	3.6	1.8	114	75.0	57.0					Do.
	31.0	74.0	5.0	2.0	147	94.0	69.0					Do.
								15.0	5.0			At Harrisburg (22, p. 12).
	26.0	63.0	4.2	2.3	128	82.0	61.0					At Harrisburg (61, p. 104).
	24.0	60.0	3.9	1.9	121	76.0	56.0					Do.
								15.0	10.0			At Harrisburg (22, p. 12).
								10.0	10.0			Do.
	24.0	70.0	4.2	1.4	133	84.0	64.0					At Harrisburg (61, p. 104).
	33.0	75.0	5.5	1.4	150	96.0	69.0					Do.
	42.0	94.0	7.2	1.9	185	123.3	88.0					Do.
	50.0	77.0	7.5	1.5	168	112.0	71.0					Do.
	36.0	83.0	8.5	3.2	176	108.0	79.0					At Harpers Tavern (61, p. 64).
	23.0	24.0	3.0	4.0	70	43.0	24.0					Do.
										Neutral	15.0	At Highway No. 125 (22, p. 43).
								85.0	85.0			At Middletown (22, p. 43).

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	*p*H	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Susquehanna River—Continued	Aug. 24, 1944	3,790	6.9	38.7	2.4		0.01		40.0	16.0	11.00			0.2
	May 31, 1945	53,500	7.1	22.1	4.4		.02	0	24.0	7.7	5.4			.2
	Nov. 21, 1946	12,300	7.4											
Lehigh River (proceeding downstream)	July 29, 1944	43.5	6.2	3.92	2.4		.02		4.3	1.1	1.7			.1
	Apr. 2, 1945	237	5.8	3.44	2.1		.03	0	3.5	.9	1.0			.2
	Oct. 31, 1945	120	6.0	3.21	2.9		.01	0	3.5	1.0	1.2	.3		.1
	July 16, 1941	342	5.0											
	Oct. 22, 1941	119	7.3											
	Nov. 26, 1941	201	6.7											
	July 29, 1944	158	6.6	2.97	1.2		.01		3.3	1.1	.9			0
	Apr. 2, 1945	770	5.9	2.86	1.7		.01		2.9	.8	1.5			.2
	Oct. 31, 1945	403	6.5	3.05	2.1		.01	0	3.2	1.0	.9			.1
	Aug. 6, 1946	148	7.0											
	Aug. 19, 1946	420	6.9											
	Nov. 1, 1945	525	6.0	3.85										
Hunter Run	do	10.0	3.1	59.9	10.0	16.0	.7	.82	8.0	8.4				.1
Black Creek	Oct. 31, 1945	46.4	3.7	41.6	12.0	12.0	.13	2.2	17.0	14.0	3.0	1.8		0
	Nov. 1, 1945	15.0	3.9	56.5	14.0	11.0	.20	4.5	52.0	18.0				.1
Nesquehoning Creek	Oct. 31, 1945	15.0	3.8	67.9	12.0	15.0	.06	4.0	64.0	25.0	4.6	1.1		.1
	Nov. 1, 1945	16.3	3.7	58.2	11.0	12.0	.02	2.8	55.0	16.0	2.8	1.6		.1
Lehigh River—Continued	Oct. 31-Nov. 1, 1945.	735	4.5	10.2	4.2	1.2	.03	.35	6.4	3.6	1.8	.9		0
Pohapoco Creek	July 20, 1944	69.9	6.7	3.13	4.9		.01		2.8	1.2	3.2			.1
	Apr. 4, 1945	238	6.3	3.33	5.1		.02	0	3.2	1.3	2.2			.1
	Oct. 31, 1945			2.90	4.0		.02	0	2.7	1.2	1.2			.1
	Nov. 1, 1945	71.0	6.5	3.15										
Lehigh River—Continued	1944[3] Oct. 11-20	426	7.1	25.2	5.0		.03	.7	26.0	9.5	7.1	3.2		.1
	1945[3] Mar. 21-31	2,680	5.9	8.51	4.3		.04	.2	7.5	2.8	2.4	.6		.1
	Oct. 21-31	1,371	6.2	12.7	5.1		.01	.32	11.0	4.3	5.9			.1
	Oct. 31, 1945	1,190	6.7	13.3										
	July 16, 1941	1,270	6.8											
	Oct 22, 1941	476	7.0											
	Nov. 26, 1941	685	7.6											
	Aug. 6, 1946	1,040	7.4											
	Aug. 19, 1946	2,850	7.2											
	Oct. 30-Nov. 1, 1945.	1,550	6.6	19.7	6.0		.04	.20	20.0	8.0	5.4	1.2		.1
Little Schuylkill River (proceeding downstream). Pine Creek	Sept. 19, 1949	[4] 3.06	6.3	7.33	4.6		.02	0	7.0	1.7	3.2			0
Panther Creek	May 7, 1941		3.5											
	do		4.6											
	do		5.8											
	Apr. 13, 1948	[4] 7.32	3.6	143.0										
	Apr. 20, 1948	[4] 59.3	3.3	143.0	17.0	37.0	.57	7.2	117.0	74.0	13.0			.1
	May 4, 1948	[4] 54.2	3.7	169.0										.1
	July 13, 1948	[4] 25.1	3.3	167.0										.4
	July 20, 1948	[4] 29.2	3.25	134.0	13.0	37.0	1.20	7.2	100.0	67.0	3.0			.2
	July 27, 1948	[4] 41.7	3.2	187.0	15.0									.1
	Sept. 14, 1948	[4] 32.4	2.6	193.0	21.0									0
	Sept. 21, 1948	[4] 43.6	3.5	147.0	14.0	34.0	.85	5.7	144.0	86.0	6.5			0
	Sept. 28, 1948	[4] 30.4	3.3	159.0	14.0									0
	Sept. 19, 1949	[4] 22.3	3.15	194.0	25.0	64.0	1.60	8.2	167.0	107.0	1.2			2.0
	Oct. 4, 1949	[4] 21.0	3.05	209.0	26.0	50.0	6.00	17.0	156.0	103.0	3.0			0
	Oct. 18, 1949	[4] 39.0	3.45	181.0	20.0									0
	Oct. 25, 1949	[4] 28.0	3.15	206.0	20.0									0
Little Schuylkill River	July 28, 1944	9.77	4.2	28.3	8.6	5.0	.02	1.3	25.0	8.9	5.3			0
	Aug. 22, 1944	2	4.2	35.9										
	Apr. 2, 1945	70.2	3.8	33.0	9.2	5.7	.05	1.0	24.0	11.0	2.6	.4		.6
	Apr. 13, 1948	235	4.9	9.02	5.0									
	Apr. 20, 1948	179	4.45	9.01	3.2	.2	.28	.25	5.4	2.1	4.5			0
	May 4, 1948	76	4.35	13.5	7.0									
	July 13, 1948	27.4	4.0	24.9	4.0									0
	July 20, 1948	23.3	3.9	23.5	8.6	5.8	.17	.85	11.0	6.3				.1
	July 27, 1948	33.8	4.5	18.1	6.0									0
	Sept. 14, 1948	9.8	3.9	24.8	9.0									0
	Sept. 21, 1948	9.2	4.2	25.3	7.9	3.3	.40	.92	13.0	7.9	8.5			0
	Sept. 28, 1948	6.8	4.25	20.2	6.6									0
	Sept. 19, 1949	18.2	4.1	16.6	7.0	3.0	.08	.25	10.0	4.8	1.8			.1
	Oct. 4, 1949	16	4.2	21.8	7.0	5.7	.16	.9	14.0	5.6	4.3			0
	Oct. 18, 1949	12	4.3	25.3	9.2									0
	Oct. 25, 1949	10	4.1	26.4	9.4									0
	Apr. 13, 1948	304	3.9	50.5										
	Apr. 20, 1948	286	3.7	53.3	10.0	10.0	.16	2.7	32.0	22.0	7.3			0
	July 13, 1948	63.6	4.0	102.0										.1
	July 20, 1948	67.3	3.25	172.0	14.0	47.0	1.4	10.0	154.0	97.0	10.0			.2

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_4SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
	45.0	131.0	10.0	1.9	251	166.0	129.0					At Marietta (*61*, p. 50).
	32.0	67.0	3.2	2.8	131	92.0	65.0					Do.
								35.0	45.0			At Columbia (*22*, p. 12).
	9.0	8 0	2.0	.2	29	15.0	8.0					At Stoddardsville (*61*, p. 43).
	5.0	8.0	1.0	.3	27	12.0	8.0					Do.
	6.0	6.8	1.2	.1	27	13.0	8.0					At Stoddardsville (*61*, p. 156).
										Neutral	5.0	At Lehigh Tannery (*22*, p. 12).
								2.0	2.0			Do.
								2.0	2.0			Do.
	7.0	6.5	1.0	1.0	23	13.0	7.0					At Lehigh Tannery (*61*, p. 43).
	5.0	7.4	.8	.4	23	11.0	6.0					Do.
	5.0	7.0	1.4	.5	23	12.0	8.0					At Lehigh Tannery (*61*, p. 156).
								5.0			5.0	At Lehigh Tannery (*22*, p. 12).
								5.0			2.0	Do.
	6.0	13.0	1.5	.2		14.0	9.0					At Rockfort (*61*, p. 156).
	0	175.0	2.8	1.0	223	192.0	192.0				152.0	Do.
	0	172.0	6.2	0	255	181.0	181.0				90.0	At Weatherly (*61*, p. 156).
	0	263.0	4.2	.2	396	280.0	280.0				88.0	Do.
	0	338.0	4.8	.2	495	362.0	362.0				91.0	At Mauch Chunk (*61*, p. 156).
	0	270.0	4.2	.2	392	285.0	285.0				88.0	Do.
	0	36.0	1.2	.2	58	38.0	38.0				16.0	At Lehighton (*61*, p. 156).
	9.0	8.4	1.0	1.4	23	12.0	5.0					At Parryville (*61*, p. 43).
	8.0	6.6	1.4	3.1	25	13.0	7.0					Do.
	8.0	4.0	1.5	1.4	21	12.0	5.0					At Parryville (*61*, p. 156).
	12.0		1.4	1.7		12.0	2.0					Do.
	35	78.0	3.8	4.8	157	104.0	75.0					At Catasauqua (*61*, p. 43).
	5.0	29.0	1.5	1.1	53	30.0	26.0					Do.
	11.0	42.0	2.5	1.8	78	45.0	38.0					At Catasauqua (*61*, p. 156).
	14	43.0	1.8	1.5								Do.
								2.0	4.0			At Bethlehem (*22*, p. 12).
								36.0	43.0			Do.
								15.0	35.0			Do.
								30.0	20.0			Do.
								25.0	20.0			Do.
	40	44.0	5.9	8.6	116	83.0	50.0					At Glendon (*61*, p. 156).
	14.0	14.0	3.8	.1	45	24.0	13.0					At Barnesville (*79*, p. 120).
										32.0	66.0	At Edwardsville (*22*, p. 42).
										3.0	63.0	At No. 6 (*22*, p. 42).
								2.0	2.0			At Lansford (*22*, p. 42).
	0	798.0				660.0	660.0				322.0	At Tamaqua (*79*, p. 120).
	0	829.0	7.0	.2	1,230	844.0	844.0				308.0	Do.
	0	980.0				900.0	900.0				384.0	Do.
	0	996.0				716.0	716.0				536.0	Do.
	0	744.0	7.0	.4	1,120	779.0	779.0				312.0	Do.
	0	1,140.0	8.0			1,010.0	1,010.0					Do.
	0	1,300.0	12.0	.5		587.0	587.0				690.0	Do.
	0	899.0	6.0	.1	1,430	931.0	931.0				248.0	Do.
	0	1,090	4.0	3.5		650.0	650.0				496.0	Do.
	0	1,190	21.0	1.1	1,690	1,270.0	1,270.0				436.0	Do.
	0	1,170	6.0	1.8	1,870	1,140.0	1,140.0				488.0	Do.
	0	1,140	6.0	.6		988.0					324.0	Do.
	0	1,290	6.0	.6		1,040.0					592.0	Do.
	0	123.0	10.0	.1	192	131.0	131.0				31.0	At Tamaqua (*61*, p. 45).
												At Tamaqua (*61*, p. 160).
	0	139.0	1.5	2.1	200	147.0	147.0				51.0	At Tamaqua (*61*, p. 45).
	1.0	25.0				26.0					9.0	At Tamaqua (*79*, p. 117).
	0	28.0	3.0	2.7	51	25.0	25.0				15.0	Do.
	0	42.0				34.0	34.0				23.0	Do.
	0	90.0				141.0	141.0				60.0	Do.
	0	89.0	3.0	2.1	146	94.0	94.0				50.0	Do.
	0	54.0	9.0			380.0	380.0					Do.
	0	91.0	4.0	.6		134.0	134.0				55.0	Do.
	0	95.0	6.0	1.0	181	97.0	97.0				58.0	Do.
	0	93.0	4.0	.2		270.0	270.0				51.0	Do.
	0	59.0	5.0	1.8	91	66.0	66.0				36.0	Do.
	0	91.0	2.0	1.2	142	93.0	93.0				56.0	Do.
	0	110.0	2.0	1.3		108.0					68.0	Do.
	0	113.0	2.0	1.3		72.0					68.0	Do.
	0	203.0				126.0	126.0				81.0	At South Tamaqua (*79*, p. 117).
	0	240.0	5.0	1.0	362	241.0	241.0				115.0	Do.
	0	536.0				343.0	343.0				193.0	Do.
	0	1,070.0	4.0	.2	1,610	110.0	110.0				352.0	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	*p*H	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Little Schuylkill River—Continued	July 27, 1948	82.2	3.4	117.0	17.0	--------	------	--------	------	--------	------	--------	--------	0.1
	Sept. 14, 1948	54.7	2.6	146.0	18.0	--------	------	--------	------	--------	------	--------	--------	0
	Sept. 21, 1948	59.8	3.6	149.0	16.0	39.0	.32	8.0	138.0	79.0	8.0		--------	0
	Sept. 28, 1948	49.5	3.45	121.0	14.0	--------	------	--------	------	--------	------	--------	--------	0
	Oct. 4, 1949	54.0	3.55	119.0	17.0	29.0	1.2	7.7	102.0	49.0	16.0	--------	--------	0
	Oct. 18, 1949	57.0	3.6	127.0	19.0	--------	------	--------	------	--------	------	--------	--------	0
	Oct. 25, 1949	48.0	3.65	117.0	16.0	--------	------	--------	------	--------	------	--------	--------	0
	Dec. 5, 1947	215	4.1	53.3	9.2	--------	.18	--------	36.0	24.0	------	--------	--------	0
	Dec. 9, 1947	191	4.1	52.9	14.0	--------	.21	--------	39.0	19.0	------	--------	--------	0
	Dec. 15, 1947	141	3.9	63.7	12.0	--------	.16	--------	41.0	29.0	------	--------	--------	0
	Dec. 24, 1947	185	4.1	54.1	12.0	--------	.30	--------	40.0	17.0	------	--------	--------	0
	Dec. 30, 1947	144	4.0	59.3	12.0	--------	.21	--------	42.0	25.0	------	--------	--------	0
	Jan. 9, 1948	194	4.1	50.8	9.2	--------	.18	--------	32.0	20.0	------	--------	--------	0
	Jan. 14, 1948	169	4.05	61.7	12.0	--------	.66	--------	45.0	26.0	------	--------	--------	0
	Jan 22, 1948	145	3.9	60.7	14.0	--------	.36	--------	44.0	25.0	------	--------	--------	0
	Feb. 15, 1948	250	4.1	53.5	11.0	--------	.35	--------	39.0	21.0	------	--------	--------	0
	Feb. 26, 1948	385	4.0	31.1	9.2	--------	.18	--------	20.0	14.0	------	--------	--------	0
	Mar. 3, 1948	447	4.05	30.6	10.0	.6	.56	1.1	20.0	11.0	11.0		--------	0
	Mar. 9, 1948	326	4.05	32.6	10.0	1.3	.36	1.3	24.0	15.0	9.8		--------	0
	Mar. 16, 1948	710	4.3	24.2	7.5	2.0	1.2	.9	18.0	9.7	4.3		--------	.1
	Mar. 22, 1948	682	4.15	24.6	9.5	4.2	.43	.6	17.0	10.0	1.6		--------	0
	Mar. 30, 1948	300	3.9	37.9	6.0	4.6	.17	1.6	28.0	19.0	2.8		--------	.1
	Apr. 5, 1948	498	4.0	29.6	9.5	3.0	.24	.5	19.0	11.0	5.3		--------	0
	Apr. 13, 1948	474	4.0	30.9	4.0	4.1	.18	1.1	26.0	16.0	5.4		--------	------
	Apr. 15, 1948	1,240	4.25	19.3	4.8	3.0	.22	.4	19.0	10.0	2.1		--------	0
	Apr. 22, 1948	399	3.85	42.7	4.5	5.3	.26	1.6	36.0	21.0	1.5		--------	------
	Apr. 28, 1948	267	3.9	46.7	6.5	4.9	.17	2.1	35.0	22.0	5.7		--------	------
	May 3, 1948	247	4.05	44.8	5.0	9.1	.20	1.8	37.0	17.0	11.0		--------	0
	May 14, 1948	918	4.05	27.3	3.5	4.1	.19	1.1	20.0	8.6	2.2		--------	0
	May 24, 1948	334	4.0	38.8	10.0	7.3	.15	1.0	26.0	16.0	4.9		--------	0
	June 4, 1948	176	3.80	57.6	12.0	13.0	.06	2.8	40.0	27.0	4.7		--------	0
	June 9, 1948	191	4.0	53.9	11.0	11.0	.10	2.9	41.0	23.0	6.1		--------	0
	June 15, 1948	147	4.1	56.2	15.0	10.0	.09	2.5	52.0	30.0	12.0		--------	0
	June 22, 1948	153	4.0	65.5	6.4	13.0	.13	3.5	52.0	33.0	3.6		--------	0
	June 28, 1948	153	3.9	63.1	9.6	16.0	.22	3.4	40.0	26.0	2.8		--------	0
	July 8, 1948	86	3.65	84.9	11.0	19.0	.14	5.2	62.0	43.0	3.3		--------	0
	July 15, 1948	78	3.65	81.3	10.0	18.0	.21	3.7	61.0	35.0	3.5		--------	0
	July 21, 1948	94	3.65	90.8	12.0	19.0	.28	5.1	62.0	45.0	2.5		--------	1
	July 28, 1948	88	3.65	85.2	12.0	20.0	.45	4.9	66.0	41.0	------	--------	--------	0
	Aug 4, 1948	74	3.5	89.8	12.0	19.0	.14	4.3	69.0	35.0	7.1		--------	0
	Aug. 12, 1948	99	3.45	88.0	8.5	19.0	.21	4.4	70.0	38.0	3.0		--------	0
	Aug. 19, 1948	107	3.55	83.7	9.0	17.0	4.30	4.1	66.0	36.0	4.2		--------	0
	Aug. 27, 1948	64	3.65	95.8	10.0	23.0	.26	5.8	78.0	46.0	7.5		--------	0
	Aug. 31, 1948	61	3.75	96.8	10.0	21.0	.41	5.7	84.0	52.0	8.2		--------	0
	Sept. 9, 1948	78	3.70	99.4	8.5	18.0	.44	6.4	88.0	49.0	11.0		--------	0
	Sept. 16, 1948	57	3.7	99.7	10.0	22.0	.14	5.0	90.0	45.0	11.0		--------	0
	Sept. 24, 1948	50	3.7	98.6	15.0	29.0	.70	7.6	90.0	43.0	2.7		--------	0
	Oct. 1, 1948	59	3.7	92.1	4.5	17.0	.39	5.4	88.0	44.0	8.0		--------	0
	Oct. 5, 1948	50	3.8	93.6	7.5	21.0	2.90	5.7	82.0	45.0	7.3		--------	0
	Oct. 14, 1948	50	3.75	101.0	8.0	25.0	.11	6.9	93.0	48.0	3.1		--------	0
	Oct. 21, 1948	52	3.85	85.1	7.5	19.0	.26	4.8	76.0	40.0	11.0		--------	0
	Oct. 27, 1948	52	3.7	104.0	8.0	19.0	.26	6.4	98.0	51.0	13.0		--------	0
	Nov. 4, 1948	104	3.5	91.4	5.5	17.0	5.40	5.2	68.0	38.0	3.3		--------	0
	Nov. 9, 1948	115	3.95	60.6	9.0	14.0	.28	3.3	46.0	28.0	------	--------	--------	0
	Nov. 17, 1948	86	3.7	76.5	5.0	14.0	.12	4.0	68.0	34.0	3.4		--------	0
	Nov. 23, 1948	283	4.25	28.5	7.0	3.0	.12	1.5	23.0	13.0	2.0		--------	0
	Nov. 30, 1948	198	3.90	44.0	5.5	6.2	.15	1.9	32.0	18.0	5.4		--------	0
	Dec. 8, 1948	169	3.9	50.0	6.5	12.0	.11	2.0	33.0	17.0	4.7		--------	0
	Dec. 14, 1948	150	3.85	57.8	6.5	11.0	.15	2.8	42.0	18.0	15.0		--------	0
	Dec. 20, 1948	162	3.65	51.7	5.5	10.0	.16	2.3	33.0	18.0	3.1		--------	0
	Dec. 28, 1948	132	3.9	56.3	5.5	15.0	.21	3.0	46.0	26.0	8.1		--------	0
	Jan. 6, 1949	1,770	3.8	24.6	8.5	1.1	.66	.6	13.0	7.4	1.2		--------	0
	Jan. 11, 1949	464	3.75	41.8	6.5	9.6	.25	1.9	28.0	17.0	2.9		--------	0
	Jan. 18, 1949	255	3.7	57.7	12.0	10.0	.38	2.7	38.0	24.0	5.5		--------	0
	Jan. 26, 1949	380	3.8	40.2	8.8	6.8	.19	2.0	25.0	15.0	2.2		--------	0
	Feb. 2, 1949	375	3.9	37.1	7.0	7.2	.23	1.7	24.0	13.0	2.7		--------	0
	Feb. 10, 1949	279	3.85	49.4	9.0	8.0	.29	2.3	33.0	20.0	4.1		--------	0
	Feb. 16, 1949	370	3.95	36.9	8.8	7.3	.12	1.7	24.0	14.0	1.7		--------	0
	Feb. 22, 1949	410	4.0	32.8	6.5	5.4	.14	1.5	22.0	12.0	2.3		--------	0
	Mar. 4, 1949	271	4.0	44.7	9.0	5.9	.21	2.3	32.0	18.0	6.6		--------	0
	Mar. 9, 1949	218	3.95	46.3	11.0	6.4	.16	2.1	33.0	20.0	4.7		--------	0
	Mar. 15, 1949	191	3.8	52.2	10.0	9.0	.16	2.9	35.0	23.0	2.6		--------	0
	Mar. 22, 1949	138	3.85	51.7	10.0	10.0	.15	2.5	34.0	22.0	2.8		--------	0
	Mar. 28, 1949	156	3.80	56.6	11.0	13.0	.15	3.0	37.0	24.0	------	--------	--------	0
	Apr. 7, 1949	326	4.0	36.4	6.4	7.1	.10	1.8	24.0	12.0	4.0		--------	0
	Apr. 11, 1949	271	4.0	35.1	3.8	6.8	.11	1.7	20.0	13.0	3.1		--------	0
	Apr. 19, 1949	782	4.15	19.5	6.4	3.4	.07	.6	11.0	5.9	------	--------	--------	0
	Apr. 27, 1949	452	3.95	34.0	7.2	5.2	.14	1.6	21.0	12.0	4.4		--------	0
	May 3, 1949	334	4.15	35.9	8.6	5.7	.07	1.7	24.0	14.0	3.3		--------	0
	May 11, 1949	255	3.80	45.8	8.8	6.6	.11	2.3	31.0	17.0	3.7		--------	0
	May 19, 1949	162	3.85	59.9	10.0	13.0	.15	3.0	42.0	25.0	2.4		--------	.1
	May 25, 1949	375	4.05	31.3	7.6	5.0	.18	1.5	20.0	11.0	4.5		--------	0
	June 1, 1949	201	3.8	51.1	8.4	7.9	.51	2.6	35.0	20.0	7.3		--------	0
	June 8, 1949	130	3.75	66.1	12.0	15.0	.84	3.4	45.0	26.0	6.3		--------	0
	June 17, 1949	99	4.2	82.2	12.0	18.0	.49	4.1	56.0	34.0	13.0		--------	0
	June 23, 1949	91	4.2	87.7	13.0	19.0	.69	4.5	61.0	36.0	10.0		--------	0
	June 29, 1949	66	3.55	83.1	14.0	20.0	.34	4.8	54.0	31.0	4.6		--------	0

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_2SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
--------	0	553.0	7.0	--------	--------	460.0	460.0	--------	--------	--------	--------	At South Tamaqua (*79*, p. 117).
--------	0	775.0	6.0	0.5	--------	468.0	468.0	--------	--------	--------	398.0	Do.
--------	0	885.0	4.0	.5	1,410	914.0	914.0	--------	--------	--------	300.0	Do.
--------	0	758.0	4.0	.7	--------	570.0	570.0	--------	--------	--------	425.0	Do.
--------	0	640.0	5.0	.7	950	637.0	637.0	--------	--------	--------	218.0	Do.
--------	0	740.0	11.0	.6	--------	584.0	--------	--------	--------	--------	300.0	Do.
--------	0	657.0	2.0	.3	--------	520.0	--------	--------	--------	--------	224.0	Do.
--------	0	242.0	2.0	1.0	404	--------	--------	--------	--------	--------	96.0	At Drehersville (*79*, p. 118).
--------	0	236.0	6.0	1.2	388	--------	--------	--------	--------	--------	85.0	Do.
--------	0	289.0	5.0	2.0	468	--------	--------	--------	--------	--------	104.0	Do.
--------	0	236.0	4.0	1.3	390	--------	--------	--------	--------	--------	68.0	Do.
--------	0	252.0	4.0	.8	441	--------	--------	--------	--------	--------	81.0	Do.
--------	0	215.0	4.0	1.2	349	--------	--------	--------	--------	--------	76.0	Do.
--------	0	246.0	7.0	1.8	432	--------	--------	--------	--------	--------	79.0	Do.
--------	0	238.0	11.0	1.2	423	--------	--------	--------	--------	--------	79.0	Do.
--------	0	200.0	18.0	2.0	359	--------	--------	--------	--------	--------	61.0	Do.
--------	0	130.0	4.0	.8	200	--------	--------	--------	--------	--------	43.0	Do.
--------	0	120.0	4.0	.3	195	106.0	106.0	--------	--------	--------	54.0	Do.
--------	0	144.0	5.0	.7	229	136.0	136.0	--------	--------	--------	64.0	Do.
--------	0	102.0	4.0	.0	172	102.0	102.0	--------	--------	--------	40.0	Do.
--------	0	105.0	4.0	.9	170	112.0	112.0	--------	--------	--------	52.0	Do.
--------	0	174.0	4.0	2.5	272	183.0	183.0	--------	--------	--------	80.0	Do.
--------	0	114.0	4.0	4.0	192	116.0	116.0	--------	--------	--------	58.0	Do.
--------	0	156.0	7.0	.6	205	161.0	161.0	--------	--------	--------	70.0	Do.
--------	0	99.0	7.0	.2	122	108.0	108.0	--------	--------	--------	46.0	Do.
--------	0	201.0	7.0	.8	314	216.0	216.0	--------	--------	--------	110.0	Do.
--------	0	209.0	7.0	.4	344	215.0	215.0	--------	--------	--------	110.0	Do.
--------	0	226.0	5.0	2.0	328	221.0	221.0	--------	--------	--------	95.0	Do.
--------	0	106.0	6.0	.7	178	115.0	115.0	--------	--------	--------	54.0	Do.
--------	0	171.0	7.0	1.8	281	179.0	179.0	--------	--------	--------	89.0	Do.
--------	0	273.0	7.0	3.0	389	288.0	288.0	--------	--------	--------	155.0	Do.
--------	0	260.0	7.0	1.9	422	269.0	269.0	--------	--------	--------	133.0	Do.
--------	0	272.0	7.0	1.8	450	263.0	263.0	--------	--------	--------	128.0	Do.
--------	0	335.0	6.0	.3	508	350.0	350.0	--------	--------	--------	118.0	Do.
--------	0	294.0	6.0	.1	486	309.0	309.0	--------	--------	--------	120.0	Do.
--------	0	440.0	5.0	.5	664	458.0	458.0	--------	--------	--------	180.0	Do.
--------	0	397.0	6.0	.8	594	415.0	415.0	--------	--------	--------	169.0	Do.
--------	0	444.0	6.0	1.5	694	466.0	466.0	--------	--------	--------	215.0	Do.
--------	0	426.0	4.0	1.1	656	416.0	416.0	--------	--------	--------	212.0	Do.
--------	0	433.0	5.0	4.9	627	446.0	446.0	--------	--------	--------	166.0	Do.
--------	0	440.0	8.0	1.0	654	463.0	463.0	--------	--------	--------	242.0	Do.
--------	0	424.0	5.0	2.8	670	442.0	442.0	--------	--------	--------	175.0	Do.
--------	0	518.0	7.0	1.5	792	534.0	534.0	--------	--------	--------	216.0	Do.
--------	0	547.0	6.0	1.0	828	561.0	561.0	--------	--------	--------	192.0	Do.
--------	0	534.0	8.0	.8	819	544.0	544.0	--------	--------	--------	262.0	Do.
--------	0	543.0	8.0	.9	824	554.0	554.0	--------	--------	--------	278.0	Do.
--------	0	562.0	6.0	1.3	831	589.0	589.0	--------	--------	--------	218.0	Do.
--------	0	504.0	6.0	.6	748	516.0	516.0	--------	--------	--------	223.0	At Drehersville (*79*, p. 119).
--------	0	516.0	8.0	.4	828	533.0	533.0	--------	--------	--------	150.0	Do.
--------	0	567.0	4.0	1.7	864	590.0	590.0	--------	--------	--------	225.0	Do.
--------	0	468.0	9.0	.3	724	476.0	476.0	--------	--------	--------	170.0	Do.
--------	0	578,0	6.0	1.2	884	582,0	582,0	--------	--------	--------	228,0	Do.
--------	0	433.0	12.0	.3	692	461.0	461.0	--------	--------	--------	116.0	Do.
--------	0	297.0	5.0	.5	470	320.0	320.0	--------	--------	--------	128.0	Do.
--------	0	388.0	6.0	.2	599	405.0	405.0	--------	--------	--------	150.0	Do.
--------	0	127.0	3.0	.6	203	133.0	133.0	--------	--------	--------	48.0	Do.
--------	0	192.0	7.0	.6	302	198.0	198.0	--------	--------	--------	96.0	Do.
--------	0	218.0	6.0	4.9	302	229.0	229.0	--------	--------	--------	94.0	Do.
--------	0	263.0	5.0	4.3	374	253.0	253.0	--------	--------	--------	106.0	Do.
--------	0	215.0	5.0	4.5	304	228.0	228.0	--------	--------	--------	92.0	Do.
--------	0	315.0	8.0	.2	501	317.0	317.0	--------	--------	--------	106.0	Do.
--------	0	76.0	2.0	.9	125	80.0	80.0	--------	--------	--------	40.0	Do.
--------	0	198.0	3.0	3.0	254	206.0	206.0	--------	--------	--------	76.0	Do.
--------	0	253.0	6.5	5.6	383	266.0	266.0	--------	--------	--------	99.0	Do.
--------	0	164.0	3.0	4.9	242	174.0	174.0	--------	--------	--------	65.0	Do.
--------	0	153.0	4.0	5.2	231	163.0	163.0	--------	--------	--------	67.0	Do.
--------	0	206.0	9.0	3.8	332	221.0	221.0	--------	--------	--------	74.0	Do.
--------	0	156.0	4.0	2.8	220	167.0	167.0	--------	--------	--------	68.0	Do.
--------	0	133.0	4.0	4.2	200	143.0	143.0	--------	--------	--------	55.0	Do.
--------	0	194.0	5.0	2.2	304	196.0	196.0	--------	--------	--------	71.0	Do.
--------	0	203.0	5.0	1.8	295	210.0	210.0	--------	--------	--------	82.0	Do.
--------	0	235.0	3.5	2.2	352	246.0	246.0	--------	--------	--------	92.0	Do.
--------	0	233.0	3.5	2.0	342	243.0	243.0	--------	--------	--------	100.0	Do.
--------	0	258.0	5.0	2.7	375	277.0	277.0	--------	--------	--------	96.0	Do.
--------	0	153.0	3.0	3.2	288	157.0	157.0	--------	--------	--------	62.0	Do.
--------	0	145.0	2.5	2.4	256	150.0	150.0	--------	--------	--------	58.0	Do.
--------	0	75.0	3.5	3.2	123	75.0	75.0	--------	--------	--------	36.0	Do.
--------	0	138.0	2.0	2.7	220	139.0	139.0	--------	--------	--------	52.0	Do.
--------	0	152.0	2.0	2.1	242	156.0	156.0	--------	--------	--------	48.0	Do.
--------	0	189.0	4.0	2.7	326	197.0	197.0	--------	--------	--------	78.0	Do.
--------	0	280.0	3.5	1.8	437	293.0	293.0	--------	--------	--------	95.0	Do.
--------	0	129.0	3.0	1.8	198	130.0	130.0	--------	--------	--------	50.0	Do.
--------	0	229.0	2.5	2.2	364	228.0	228.0	--------	--------	--------	88.0	Do.
--------	0	313.0	4.0	3.0	486	320.0	320.0	--------	--------	--------	112.0	Do.
--------	0	390.0	6.5	4.5	599	391.0	391.0	--------	--------	--------	158.0	Do.
--------	0	413.0	6.0	3.2	639	419.0	419.0	--------	--------	--------	138.0	Do.
--------	0	381.0	5.0	4.5	594	397.0	397.0	--------	--------	--------	148.0	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	pH	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Little Schuylkill River—Continued	July 7, 1949	66	3.6	91.3	15.0	18.0	0.84	5.2	70.0	35.0	4.9			0
	July 13, 1949	88	3.4	94.3	14.0	18.0	.35	4.9	69.0	35.0	12.0			0
	July 19, 1949	94	3.6	73.5	11.0	11.0	.23	4.1	55.0	28.0	11.0			0
	July 28, 1949	68	4.05	105.0	16.0	26.0	.39	7.0	77.0	44.0	17.0			0
	Aug. 3, 1949	59	4.05	110.0	16.0	19.0	.58	6.2	84.0	50.0	12.0			0
	Aug. 10, 1949	50	3.90	112.0	16.0	25.0	1.00	6.1	82.0	49.0	13.0			0
	Aug. 17, 1949	59	4.2	97.3	16.0	17.0	.50	5.7	75.0	45.0	14.0			0
	Aug. 26, 1949	48	3.9	113.0	16.0	24.0	.96	6.3	90.0	51.0	12.0			0
	Sept. 1, 1949	61	4.05	102.0	16.0	23.0	.85	5.9	84.0	44.0	15.0			0
	Sept. 7, 1949	68	3.5	96.9	15.0	21.0	.31	5.3	78.0	34.0	13.0			0
	Sept. 14, 1949	78	3.6	85.7	12.0	17.0	.19		71.0					
	Sept. 20, 1949	59	3.7	92.6	16.0	24.0	.24	5.8	66.0	41.0	14.0			0
	Sept. 27, 1949	45	3.4	115.0	12.0	23.0	.48	7.0	81.0	51.0	25.0			0
	Aug. 22, 1944	150	4.1	116.0										
	July 24, 1941	(*)	3.3											
	Oct. 21, 1941	(*)	4.4											
	Dec. 1, 1941	(*)	4.3											
	July 31, 1946	(*)	4.0											
	Aug. 14, 1946	(*)	4.1											
	Aug. 27, 1946	(*)	4.1											
	Apr. 12, 1948	[4]725	4.25	28.9										
	Apr. 20, 1948	[4]420	4.0	30.9	8.0	.7	.14	1.5	20.0	12.0	14.0			0
	May 4, 1948	[4]200	4.35	44.3										.1
	July 13, 1948	[4]95.5	3.60	92.3										0
	July 20, 1948	[4]70	3.45	95.8	11.0	24.0	.50	5.2	66.0	47.0	2.3			.2
	July 27, 1948	[4]90.2	3.6	88.6	20.0									.1
	Sept. 14, 1948	[4]58	2.9	114.0	17.0									0
	Sept. 21, 1948	[4]69.8	3.6	119.0	16.0	37.0	.72	8.0	92.0	59.0	10.0			0
	Sept. 28, 1948	[4]47.7	3.7	98.8	13.0									0
	Sept. 19, 1949	[4]73.1	3.65	71.7	12.0	16.0	.12	2.3	52.0	28.0	9.6			.1
	Oct. 4, 1949	[4]83	3.65	89.3	14.0	25.0	.84	6.0	64.0	32.0	12.0			0
	Oct. 18, 1949	[4]64	3.85	104.0	16.0									0
	Oct. 25, 1949	[4]66	3.65	110.0	16.0									0
Schuylkill River (proceeding downstream).	July 31, 1946		3.7											
	Aug. 27, 1946		3.8											
	Apr. 6, 1949	[4]83	4.25	46.5	9.4	6.0	.33	2.0	29.0	16.0	8.6			0
	Apr. 14, 1949	[4]81	3.7	43.8	9.0	6.4	.10	2.0	27.0	11.0	9.7			0
	June 27, 1949	[4]19	3.4	87.7	13.0	5.8	.34	4.8	59.0	38.0	13.0			0
	Aug. 9, 1949	[4]11	3.4	96.9	14.0	13.0	.38	5.5	71.0	34.0	15.0			0
	Sept. 21, 1949	[4]7.9	3.2	101.0	17.0	15.0	.46	3.4	74.0	40.0	7.9			0
Mill Creek	Apr. 20, 1948	[4]36.9	4.2	52.9										
Schuylkill River—Continued	July 30, 1944	40.3	3.6	103.0	17.0	19.0	.06	8.8	92.0	52.0	7.6			.1
	Apr. 2, 1945	134	3.45	87.2	16.0	21.0	.28	4.4	60.0	41.0	7.2	2.0		.6
	Apr. 12, 1948	[4]570	3.85	56.4										
	Apr. 20, 1948	[4]560	3.95	56.1	11.0	6.9	.15	3.1	42.0	29.0	1.7			.1
	May 2, 1948	[4]369	4.0	68.5										.1
	July 13, 1948	[4]48.8	3.65	121.0										.1
	July 20, 1948	[4]36.9	3.4	126.0	13.0	17.0	.52	8.0	108.0	72.0	9.2			.2
	July 27, 1948	[4]57.0	3.6	98.8	12.0									.1
	Sept. 14, 1948	[4]27.8	3.2	107.0	16.0									0
	Sept. 21, 1948	[4]20.6	4.0	106.0	14.0	15.0	.51	6.9	96.0	59.0	4.7			0
	Sept. 28, 1948	[4]24.5	3.65	107.0	14.0									0
	Oct. 4, 1949	[4]27	4.6	102.0	14.0	7.3	.17	7.9	92.0	52.0	26.0			0
	Oct. 18, 1949	[4]25	4.6	105.0	14.0									0
	Oct. 25, 1949	[4]24	4.25	111.0	14.0									0
	Apr. 12, 1948	[4]608	4.4	54.6										
	Apr. 20, 1948	[4]597	4.1	54.4	11.0	4.8	.12	3.2	44.0	29.0	3.5			0
	May 4, 1948	[4]394	4.35	66.9										.1
	July 13, 1948	[4]52	3.95	104.0										0
	July 20, 1948	[4]39.4	3.55	110.0	13.0	14.0	1.30	7.0	95.0	63.0	3.6			.2
	July 27, 1948	[4]60.8	4.1	90.5	20.0									.1
	Sept. 14, 1948	[4]29.7	4.0	87.4	14.0									.0
	Sept. 21, 1948	[4]22	4.1	90.3	13.0	8.5	2.10	5.5	77.0	49.0	16.0			0
	Sept. 28, 1948	[4]26.4	4.45	98.0	13.0									0
	Oct. 4, 1948	[4]31	4.8	85.6	12.0	4.3	4.10	6.1	81.0	40.0	25.0			0
	Oct. 18, 1948	[4]28	6.5	94.8	14.0									0
	Oct. 25, 1948	[4]27	4.8	91.6	12.0									0
West Branch	Apr. 12, 1948		5.0	52.3	7.0									
	Apr. 20, 1948	[4]187	4.3	59.9	9.2	2.4	.12	2.8	47.0	35.0	9.7			0
	May 4, 1948	[4]98.6	4.6	65.8	9.0									.1
	July 13, 1948	[4]51.9	5.5	98.3	4.0									0
	July 20, 1948	[4]40.5	4.15	119.0	9.0	3.0	.23	5.6	115.0	77.0	18.0			.3
	July 27, 1948	[4]36.7	4.30	108.0	20.0									.1
	Sept. 14, 1948	[4]18.6	3.85	120.0	13.0									0
	Sept. 21, 1948	[4]24.8	3.2	158.0	12.0	10.0	1.50	5.5	137.0	78.0	39.0			0
	Sept. 28, 1948	[4]14.9	4.5	117.0	9.5									0
	Oct. 4, 1949	[4]24.0	5.0	121.0	9.5	3.3	.14	5.2	115.0	59.0	63.0			0
	Oct. 18, 1949	[4]13.0	6.5	136.0	8.8									0
	Oct. 25, 1949	[4]13.0	6.2	125.0	9.6									0

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_4SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
--------	0	426.0	6.0	1.8	696	443.0	443.0	--------	--------	--------	150.0	At Drehersville (*79*, p. 119).
--------	0	444.0	7.0	9.6	680	447.0	447.0	--------	--------	--------	162.0	Do.
--------	0	337.0	5.0	5.0	542	334.0	334.0	--------	--------	--------	114.0	Do.
--------	0	557.0	6.0	1.8	854	536.0	536.0	--------	--------	--------	200.0	Do.
--------	0	568.0	6.0	.2	870	538.0	538.0	--------	--------	--------	159.0	Do.
--------	0	574.0	7.0	.2	859	565.0	565.0	--------	--------	--------	218.0	Do.
--------	0	513.0	8.0	.2	806	482.0	482.0	--------	--------	--------	165.0	Do.
--------	0	581.0	5.0	5.4	888	588.0	588.0	--------	--------	--------	218.0	Do.
--------	0	545.0	5.0	1.8	832	536.0	536.0	--------	--------	--------	184.0	Do.
--------	0	471.0	7.0	7.9	760	478.0	478.0	--------	--------	--------	158.0	Do.
--------	0	417.0	--------	--------	--------	--------	--------	--------	--------	--------	--------	Do.
--------	0	491.0	7.0	3.4	756	488.0	488.0	--------	--------	--------	190.0	Do.
--------	0	584	9.0	6.4	914	575.0	575.0	--------	--------	--------	222.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------		--------	--------	--------	At Molino (*61*, p. 160).
--------	--------	--------	--------	--------	--------	--------	--------		--------	74.0	142.0	At Port Clinton (*22*, p. 13).
--------	--------	--------	--------	--------	--------	--------	--------		--------	67.0	163.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------		--------	96.0	183.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------		--------	69.0	103.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------		--------	78.0	147.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------		--------	93.0	157.0	Do.
--------	0	110.0	--------	--------	--------	76.0	76.0	--------	--------	--------	39.0	At Port Clinton (*79*, p. 120).
--------	0	129.0	4.0	2.1	200	111.0	111.0	--------	--------	--------	49.0	Do.
--------	0	184.0	--------	--------	--------	141.0	141.0	--------	--------	--------	70.0	Do.
--------	0	438.0	--------	--------	--------	509.0	509.0	--------	--------	--------	212.0	Do.
--------	0	495.0	4.5	4.1	733	521.0	521.0	--------	--------	--------	184.0	Do.
--------	0	269.0	8.0	--------	--------	343.0	343.0	--------	--------	--------	--------	Do.
--------	0	637.0	10.0	.8	--------	437.0	437.0	--------	--------	--------	271.0	Do.
--------	0	679.0	4.0	2.0	1,060	707.0	707.0	--------	--------	--------	244.0	Do.
--------	0	627.0	6.0	.8	--------	476.0	476.0	--------	--------	--------	329.0	Do.
--------	0	343.0	8.0	2.1	498	350.0	350.0	--------	--------	--------	153.0	Do.
--------	0	443.0	6.0	4.0	676	445.0	445.0	--------	--------	--------	168.0	Do.
--------	0	575.0	9.0	1.4	--------	416.0	--------	--------	--------	--------	246.0	Do.
--------	0	625.0	7.0	1.4	--------	508.0	--------	--------	--------	--------	224.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	54.0	79.0	At Tuscarora (*22*, p. 12).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	103.0	167.0	Do.
--------	0	183.0	3.0	2,4	301	178.0	178.0	--------	--------	--------	52.0	At Port Carbon (*79*, p. 82).
--------	0	173.0	2.0	.7	279	162.0	162.0	--------	--------	--------	62.0	Do.
--------	0	375.0	5.0	1.2	568	369.0	369.0	--------	--------	--------	138.0	Do.
--------	0	434.0	9.0	.6	642	422.0	422.0	--------	--------	--------	128.0	Do.
--------	0	460.0	6.0	.6	710	465.0	465.0	--------	--------	--------	136.0	Do.
--------	0	259.0	3.0	--------	--------	--------	--------	--------	--------	--------	94.0	At Port Carbon (*79*, p. 11)
--------	0	565.0	3.0	.0	843	576.0	576.0	--------	--------	--------	176.0	At Pottsville (*61*, p. 45).
--------	0	450.0	1.5	.1	637	463.0	463.0	--------	--------	--------	184.0	Do.
--------	0	256.0	--------	--------	--------	210.0	210.0	--------	--------	--------	68.0	At Pottsville (*79*, p. 82).
--------	0	262.0	3.0	.4	401	274.0	274.0	--------	--------	--------	71.0	Do.
--------	0	327.0	--------	--------	--------	315.0	315.0	--------	--------	--------	97.0	Do.
--------	0	647.0	--------	--------	--------	613.0	613.0	--------	--------	--------	164.0	Do.
--------	0	683.0	4.0	.1	1,030	697.0	697.0	--------	--------	--------	152.0	Do.
--------	0	509.0	4.0	--------	--------	410.0	410.0	--------	--------	--------	--------	Do.
--------	0	602.0	2.0	.2	--------	364.0	364.0	--------	--------	--------	216.0	Do.
--------	0	566.0	4.0	.3	871	585.0	585.0	--------	--------	--------	168.0	Do.
--------	0	648.0	2.0	.5	--------	675.0	675.0	--------	--------	--------	213.0	Do.
--------	2	533.0	6.0	.8	871	491.0	491.0	--------	--------	--------	96.0	Do.
--------	4	577.0	6.0	.4	--------	498.0	--------	--------	--------	--------	--------	Do.
--------	0	615.0	6.0	.3	--------	552.0	--------	--------	--------	--------	110.0	Do.
--------	0	250.0	--------	--------	--------	210.0	210.0	--------	--------	--------	56.0	At Mount Carbon (*79*, p. 82).
--------	0	257.0	4.0	.4	392	266.0	266.0	--------	--------	--------	63.0	Do.
--------	0	316.0	--------	--------	--------	300.0	300.0	--------	--------	--------	89.0	Do.
--------	0	540.0	--------	--------	--------	605.0	605.0	--------	--------	--------	132.0	Do.
--------	0	581.0	5.0	.3	872	605.0	605.0	--------	--------	--------	124.0	Do.
--------	0	431.0	3.0	--------	--------	345.0	345.0	--------	--------	--------	--------	Do.
--------	0	455.0	6.0	.7	--------	407.0	407.0	--------	--------	--------	122.0	Do.
--------	0	464.0	4.0	.8	729	461.0	461.0	--------	--------	--------	102.0	Do.
--------	0	472.0	2.0	.6	--------	501.0	501.0	--------	--------	--------	115.0	Do.
--------	3	461.0	7.0	1.5	682	413.0	413.0	--------	--------	--------	56.0	Do.
--------	8	484.0	5.0	2.0	--------	436.0	--------	--------	--------	--------	--------	Do.
--------	5	466.0	7.0	.4	--------	444.0	--------	--------	--------	--------	38.0	Do.
--------	1	233.0	--------	--------	--------	207.0	--------	--------	--------	--------	8.0	At Cressona (*79*, p. 117).
--------	0	287.0	3.0	.4	436	282.0	282.0	--------	--------	--------	30.0	Do.
--------	0	306.0	--------	--------	--------	300.0	300.0	--------	--------	--------	32.0	Do.
--------	8	507.0	--------	--------	--------	570.0	--------	--------	--------	--------	--------	Do.
--------	0	644.0	2.0	.1	965	634.0	634.0	--------	--------	--------	38.0	Do.
--------	0	362.0	10.0	--------	--------	372.0	372.0	--------	--------	--------	--------	Do.
--------	0	679.0	10.0	.3	--------	484.0	484.0	--------	--------	--------	91.0	Do.
--------	0	813.0	2.0	.3	1,200	768.0	768.0	--------	--------	--------	190.0	Do.
--------	0	541.0	4.0	.3	--------	623.0	623.0	--------	--------	--------	53.0	Do.
--------	5	665.0	4.0	.7	1,020	558.0	554.0	--------	--------	--------	26.0	Do.
--------	14	754.0	4.0	5.8	--------	684.0	--------	--------	--------	--------	--------	Do.
--------	16	677.0	5.0	.7	--------	584.0	--------	--------	--------	--------	--------	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	pH	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Schuylkill River—Continued	Dec. 10, 1947	176	3.85	78.9	20.0	5.7	0.22	5.9	72.0	45.0	12.0		--------	0
	Dec. 17, 1947	198	3.9	69.6	20.0	7.8	.18	5.2	68.0	39.0	--------	--------	--------	0
	Dec. 29, 1947	135	4.05	73.6	8.8	3.0	.16	5.8	64.0	43.0	22.0		--------	0
	Jan. 5, 1948	203	4.1	57.2	4.8	4.1	.80	3.8	49.0	32.0	5.2		--------	0
	Jan. 17, 1948	169	4.15	64.6	8.0	4.1	.44	2.5	58.0	36.0	9.5		--------	0
	Feb. 19, 1948	320	5.0	42.9	.8	1.8	1.20	1.6	38.0	22.0	7.1		--------	0
	Feb. 20, 1948	501	4.2	36.9	4.8	3.3	2.40	1.5	29.0	17.0	--------	--------	--------	0
	Feb. 26, 1948	426	4.4	38.4	5.6	1.9	1.10	1.9	33.0	20.0	7.2		--------	0
	Mar. 4, 1948	426	4.0	49.1	9.5	3.1	.74	2.5	38.0	23.0	5.8		--------	0
	Mar. 11, 1948	335	4.2	55.6	11.0	3.6	.11	2.5	46.0	28.0	7.6		--------	0
	Mar. 17, 1948	900	4.4	30.3	8.5	2.1	.07	1.5	24.0	14.0	2.6		--------	0
	Mar. 23, 1948	648	4.4	42.6	8.0	1.2	.52	1.9	36.0	23.0	6.0		--------	.2
	Apr. 2, 1948	910	4.3	36.9	8.0	3.1	.16	1.5	29.0	18.0	4.1		--------	0
	Apr. 8, 1948	426	4.3	56.9	9.0	4.0	.25	2.9	46.0	30.0	11.0		--------	.1
	Apr. 12, 1948	539	4.6	47.3	6.0	--------	--------	--------	--------	--------	--------	--------	--------	--------
	Apr. 20, 1948	523	4.25	54.1	10.0	2.9	.10	2.5	43.0	29.0	10.0		--------	0
	Apr. 23, 1948	354	4.3	47.9	10.0	3.6	.13	2.4	51.0	32.0	5.0		--------	0
	Apr. 30, 1948	244	4.3	68.1	10.0	5.1	.31	3.2	60.0	37.0	8.5		--------	.1
	May 4, 1948	306	4.5	58.7	10.0	--------	--------	--------	--------	--------	--------	--------	--------	--------
	May 7, 1948	895	4.6	33.4	7.4	2.5	.22	1.3	29.0	16.0	--------	--------	--------	0
	May 14, 1948	1,270	4.2	35.7	8.5	2.3	.52	1.8	28.0	16.0	2.7		--------	.1
	May 19, 1948	542	4.5	47.5	9.0	3.5	.38	2.1	48.0	28.0	2.4		--------	0
	May 25, 1948	347	4.35	58.3	6.5	1.9	.30	2.5	54.0	32.0	5.4		--------	0
	June 2, 1948	273	4.1	77.8	11.0	3.3	.21	2.9	74.0	46.0	8.9		--------	0
	June 9, 1948	227	4.45	64.4	6.0	5.2	.14	3.4	63.0	34.0	4.6		--------	0
	June 16, 1948	164	4.25	85.5	5.0	6.4	.26	5.2	84.0	50.0	9.2		--------	.1
	June 23, 1948	157	4.35	83.8	8.0	3.7	.40	4.2	88.0	49.0	11.0		--------	.1
	June 29, 1948	131	4.4	77.3	12.0	4.6	.17	4.0	74.0	45.0	12.0		--------	0
	July 7, 1948	91	4.4	89.8	12.0	3.9	1.30	5.2	93.0	61.0	4.9		--------	0
	July 13, 1948	144	4.4	105.0	--------	--------	--------	--------	--------	--------	--------	--------	--------	.1
	July 20, 1948	110	4.2	105.0	10.0	9.8	.28	6.6	100.0	63.0	10.0		--------	.2
	July 23, 1948	258	5.0	61.5	7.0	5.5	4.20	3.6	58.0	32.0	--------	--------	--------	0
	July 27, 1948	144	4.3	93.4	--------	--------	--------	--------	--------	--------	--------	--------	--------	0
	July 29, 1948	110	4.0	97.7	16.0	6.7	.53	6.5	92.0	57.0	13.0		--------	0
	Aug. 5, 1948	225	4.6	67.7	7.5	1.2	4.20	4.2	60.0	37.0	4.5		--------	.1
	Aug. 8, 1948	120	4.0	109.0	9.5	11.0	.38	6.4	110.0	65.0	7.0		--------	0
	Aug. 13, 1948	110	4.3	99.1	9.5	4.1	.16	5.8	106.0	60.0	8.2		--------	0
	Aug. 19, 1948	131	4.4	77.8	8.0	1.1	.30	4.2	82.0	42.0	12.0		--------	.1
	Sept. 2, 1948	105	3.95	116.0	14.0	15.0	.37	7.1	117.0	71.0	1.7		--------	.1
	Sept. 14, 1948	58	3.9	107.0	13.0	--------	--------	--------	--------	--------	--------	--------	--------	0
	Sept. 17, 1948	61	4.1	118.0	10.0	12.0	.14	6.6	118.0	73.0	4.8		--------	0
	Sept. 21, 1948	58	4.0	108.0	14.0	10.0	.42	6.0	97.0	59.0	26.0		--------	0
	Sept. 23, 1948	57	4.5	113.0	9.5	11.0	1.60	6.4	109.0	65.0	15.0		--------	0
	Sept. 28, 1948	50	4.4	92.4	12.0	--------	--------	--------	--------	--------	--------	--------	--------	0
	Sept. 29, 1948	48	4.2	116.0	5.0	8.0	.55	7.3	122.0	71.0	--------	--------	--------	0
	Oct. 8, 1948	73	4.35	115.0	14.0	7.1	.74	6.6	120.0	68.0	12.0		--------	0
	Oct. 15, 1948	54	4.70	116.0	8.3	5.6	.34	4.6	111.0	67.0	21.0		--------	0
	Oct. 20, 1948	66	4.2	109.0	14.0	8.0	1.00	5.1	104.0	59.0	21.0		--------	0
	Oct. 25, 1948	54	4.25	93.5	12.0	7.8	.15	6.6	98.0	58.0	--------	--------	--------	0
	Nov. 4, 1948	138	6.3	71.3	8.5	.8	4.30	3.3	68.0	37.0	17.0		--------	0
	Nov. 17, 1948	118	4.7	68.8	5.0	3.1	2.20	3.9	63.0	38.0	9.7		--------	0
	Nov. 22, 1948	406	4.35	44.9	10.0	2.0	.15	2.5	38.0	26.0	6.6		--------	0
	Dec. 1, 1948	241	4.3	61.7	6.5	7.3	.14	3.6	56.0	37.0	--------	--------	--------	0
	Dec. 9, 1948	203	4.3	64.4	10.0	9.7	.14	4.0	56.0	39.0	4.3		--------	0
	Dec. 17, 1948	248	4.4	64.5	12.0	8.9	.13	3.5	58.0	38.0	--------	--------	--------	0
	Dec. 22, 1948	189	4.4	69.4	12.0	8.9	.13	3.6	62.0	39.0	2.2		--------	0
	Dec. 30, 1948	1,960	5.0	24.4	6.5	1.8	.11	1.3	24.0	14.0	4.2		--------	0
	Jan. 7, 1949	1,330	4.1	38.8	7.0	2.5	.47	1.7	30.0	18.0	1.7		--------	0
	Jan. 11, 1949	598	4.05	57.6	12.0	7.9	.18	2.9	44.0	28.0	1.2		--------	0
	Jan. 19, 1949	301	4.4	67.4	6.0	9.7	.07	3.4	55.0	40.0	--------	--------	--------	0
	Jan. 28, 1949	618	4.6	41.7	5.5	3.9	.06	2.0	36.0	23.0	3.2		--------	0
	Feb. 3, 1949	350	4.1	60.0	8.0	4.6	.10	3.2	48.0	30.0	9.1		--------	0
	Feb. 11, 1949	270	4.2	65.9	7.6	3.9	.10	3.5	54.0	33.0	13.0		--------	0
	Feb. 15, 1949	301	4.35	59.4	7.6	4.6	.10	3.2	47.0	30.0	13.0		--------	0
	Feb. 23, 1949	485	4.35	42.8	7.2	2.9	.07	2.1	30.0	20.0	9.6		--------	0
	Mar. 2, 1949	309	4.35	52.1	6.5	4.1	.15	2.7	44.0	27.0	5.2		--------	0
	Mar. 10, 1949	239	4.3	60.1	6.5	5.6	.37	3.3	50.0	33.0	4.5		--------	0
	Mar. 16, 1949	180	4.35	59.1	12.0	6.7	.09	3.7	50.0	30.0	4.2		--------	0
	Mar. 22, 1949	157	4.3	65.0	7.0	4.4	.19	3.5	59.0	34.0	7.1		--------	0
	Mar. 30, 1949	135	4.6	65.8	12.0	5.0	.10	3.5	59.0	33.0	10.0		--------	0
	Apr. 7, 1949	315	4.1	43.6	8.0	2.3	.12	2.6	34.0	19.0	4.9	--------	--------	0
	Apr. 15, 1949	504	4.2	34.5	4.6	2.8	.08	1.8	25.0	15.0	3.5		--------	0
	Apr. 20, 1949	467	4.4	42.8	9.2	4.8	.12	2.2	28.0	21.0	7.9		--------	0
	Apr. 26, 1949	456	4.5	42.4	8.8	4.3	.12	2.1	31.0	22.0	2.7		--------	0
	May 6, 1949	239	4.4	58.2	9.6	5.4	.09	2.4	49.0	28.0	12.0		--------	0
	May 11, 1949	210	4.7	68.2	11.0	5.5	.15	3.5	61.0	36.0	6.9		--------	0
	May 18, 1949	144	4.6	70.3	9.6	3.4	.35	3.7	62.0	37.0	14.0		--------	.1
	May 24, 1949	280	4.4	47.6	9.4	4.7	.08	2.5	38.0	23.0	6.0		--------	0
	June 2, 1949	173	4.50	58.6	9.2	3.9	.08	3.5	51.0	31.0	9.5		--------	0
	June 7, 1949	138	4.4	71.1	8.2	3.6	.11	4.2	63.0	37.0	10.0		--------	.1
	June 16, 1949	127	4.6	76.8	13.0	5.4	.22	3.8	70.0	42.0	8.0		--------	0
	June 23, 1949	86	5.0	85.1	12.0	2.4	.18	4.1	77.0	46.0	12.0		--------	0
	June 27, 1949	86	4.35	75.4	11.0	7.6	.14	4.4	67.0	35.0	13.0		--------	0
	July 8, 1949	70	4.6	89.1	9.6	1.3	.19	4.9	86.0	48.0	10.0		--------	0
	July 14, 1949	68	4.4	94.9	10.0	4.4	.19	5.3	86.0	48.0	24.0	--------	--------	0
	July 21, 1949	78	4.4	84.5	9.5	2.3	.15	3.9	76.0	41.0	30.0	--------	--------	0
	July 27, 1949	110	4.1	72.6	11.0	2.5	.14	3.7	68.0	35.0	16.0	--------	--------	0
	Aug. 2, 1949	60	4.5	83.4	12.0	2.2	.20	4.7	82.0	49.0	23.0	--------	--------	0

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_2SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
--------	0	422.0	3.0	0.5	713	425.0	425.0	--------	--------	--------	85.0	At Landingville (*79*, p. 83).
--------	0	366.0	6.0	.1	663	390.0	390.0	--------	--------	--------	77.0	Do.
--------	0	394.0	4.0	.1	600	368.0	368.0	--------	--------	--------	72.0	Do.
--------	0	285 0	3.0	.2	436	290.0	290.0	--------	--------	--------	46.0	Do.
--------	0	326.0	4.0	.1	504	324.0	324.0	--------	--------	--------	46.0	Do.
--------	0	200.0	6.0	.1	315	201.0	201.0	--------	--------	--------	10 0	Do.
--------	0	165.0	6.0	.1	253	173.0	173.0	--------	--------	--------	18.0	Do.
--------	0	185.0	4.0	.1	288	183.0	183.0	--------	--------	--------	16.0	Do.
--------	0	221.0	3.0	0	343	222.0	222.0	--------	--------	--------	36.0	Do.
--------	0	260.0	4.0	0	415	258.0	258.0	--------	--------	--------	50.0	Do.
--------	0	126.0	5.0	.7	196	133.0	133.0	--------	--------	--------	30.0	Do.
--------	0	193.0	6.0	0	304	197.0	197.0	--------	--------	--------	35.0	Do.
--------	0	164.0	5.0	0	258	169.0	169.0	--------	--------	--------	33.0	Do.
--------	0	273.0	7.0	.1	420	268.0	268.0	--------	--------	--------	62.0	Do.
--------	0	210.0	--------	--------	--------	180.0	180.0	--------	--------	--------	30.0	Do.
--------	0	256.0	3.9	.4	400	250.0	250.0	--------	--------	--------	52.0	Do.
--------	0	278.0	5.0	0	432	579.0	579.0	--------	--------	--------	51.0	Do.
--------	0	335.0	6.0	0	520	339.0	339.0	--------	--------	--------	62.0	Do.
--------	0	277.0	--------	--------	--------	270.0	270.0	--------	--------	--------	49.0	Do.
--------	0	144.0	4.0	0	232	155.0	155.0	--------	--------	--------	33.0	Do.
--------	0	152.0	2.5	0	246	156.0	156.0	--------	--------	--------	33.0	Do.
--------	3	242.0	7.0	.1	365	259.0	257.0	--------	--------	--------	86.0	Do.
--------	0	270.0	7.0	1.1	438	283.0	283.0	--------	--------	--------	84.0	Do.
--------	0	395.0	7.0	.4	636	402.0	402.0	--------	--------	--------	144.0	Do.
--------	0	322.0	5.0	1.4	507	334.0	334.0	--------	--------	--------	55.0	Do.
--------	0	455.0	6.0	.8	710	463.0	463.0	--------	--------	--------	77.0	Do.
--------	0	451.0	4.0	.8	697	451.0	451.0	--------	--------	--------	74.0	Do.
--------	0	395.0	12.0	2.5	619	404.0	404.0	--------	--------	--------	82.0	Do.
--------	0	499.0	6.0	1.4	770	518.0	518.0	--------	--------	--------	86.0	Do.
--------	0	570.0	--------	--------	--------	596.0	596.0	--------	--------	--------	102.0	Do.
--------	0	572.0	3.0	.2	860	579.0	579.0	--------	--------	--------	72.0	Do.
--------	4	300.0	6.0	2.3	473	325.0	321.0	--------	--------	--------	46.0	Do.
--------	0	395.0	8.0	--------	--------	380.0	380.0	--------	--------	--------	--------	Do.
--------	0	520.0	3.5	.9	808	520.0	520.0	--------	--------	--------	126.0	Do.
--------	0	319.0	3.5	0	492	328.0	328.0	--------	--------	--------	42.0	Do.
--------	0	596.0	7.0	.8	916	616.0	616.0	--------	--------	--------	146.0	Do.
--------	0	534.0	6.0	.7	818	547.0	547.0	--------	--------	--------	140.0	Do.
--------	0	395.0	6.0	.1	606	393.0	393.0	--------	--------	--------	78.0	Do.
--------	0	649.0	4.0	.6	1,010	686.0	686.0	--------	--------	--------	179.0	Do.
--------	0	600.0	4.0	.7	--------	535.0	535.0	--------	--------	--------	137.0	Do.
--------	0	647.0	9.0	2.4	949	678.0	678.0	--------	--------	--------	152.0	Do.
--------	0	582.0	6.0	.1	904	557.0	557.0	--------	--------	--------	72.0	Do.
--------	0	570.0	12.0	.1	--------	517.0	517.0	--------	--------	--------	109.0	Do.
--------	0	611.0	9.0	.3	966	616.0	616.0	--------	--------	--------	146.0	Do.
--------	0	615.0	13.0	1.3	978	659.0	659.0	--------	--------	--------	178.0	Do.
--------	0	617.0	10.0	2.8	976	633.0	633.0	--------	--------	--------	162.0	At Landingville (*79*, p. 84).
--------	5	595.0	10.0	1.0	1,000	593.0	589.0	--------	--------	--------	45.0	Do.
--------	0	571.0	7.0	4.3	867	562.0	562.0	--------	--------	--------	72.0	Do.
--------	0	513.0	6.0	2.5	783	542.0	542.0	--------	--------	--------	94.0	Do.
--------	28	330.0	6.5	.3	534	344.0	321.0	--------	--------	--------	28.0	Do.
--------	0	345.0	4.0	0	558	344.0	344.0	--------	--------	--------	68.0	Do.
--------	0	220.0	3.0	0	336	219.0	219.0	--------	--------	--------	62.0	Do.
--------	0	317.0	4.0	0	497	341.0	341.0	--------	--------	--------	70.0	Do.
--------	0	352.0	4.5	.3	622	364.0	364.0	--------	--------	--------	100.0	Do.
--------	0	340 0	4.0	.1	506	358.0	358.0	--------	--------	--------	68.0	Do.
--------	0	357.0	4.0	0	696	373.0	373.0	--------	--------	--------	102.0	Do.
--------	2	127.0	3.5	.6	196	130.0	128.0	--------	--------	--------	22.0	Do.
--------	0	165.0	2.0	.5	251	171.0	171.0	--------	--------	--------	40.0	Do.
--------	0	267.0	2.0	.8	406	279.0	279.0	--------	--------	--------	60.0	Do.
--------	0	339.0	7.0	0	526	359.0	359.0	--------	--------	--------	96.0	Do.
--------	0	199.0	6.5	.8	302	210.0	210.0	--------	--------	--------	58.0	Do.
--------	0	283 0	2.0	1.5	423	279.0	279.0	--------	--------	--------	56.0	Do.
--------	0	307.0	6.0	2.0	464	299.0	299.0	--------	--------	--------	50.0	Do.
--------	0	284.0	4.0	1.3	426	271.0	271.0	--------	--------	--------	46.0	Do.
--------	0	186.0	3.0	1.6	274	178.0	178.0	--------	--------	--------	44.0	Do.
--------	0	247.0	2.5	.8	365	250.0	250.0	--------	--------	--------	50.0	Do.
--------	0	295.0	2.0	.7	442	301.0	301.0	--------	--------	--------	62.0	Do.
--------	0	286.0	3.0	.7	430	293.0	293.0	--------	--------	--------	57.0	Do.
--------	0	318.0	3.0	.6	477	320.0	320.0	--------	--------	--------	52.0	Do.
--------	3	319.0	3.0	.6	470	317.0	315.0	--------	--------	--------	43.0	Do.
--------	0	184.0	3.0	2.8	304	185.0	185.0	--------	--------	--------	38.0	Do.
--------	0	140.0	3.0	4.9	247	146.0	146.0	--------	--------	--------	32.0	Do.
--------	0	193.0	2.5	1.1	290	188.0	188.0	--------	--------	--------	38.0	Do.
--------	0	189.0	3.0	.9	288	196.0	196.0	--------	--------	--------	37.0	Do.
--------	0	281.0	3.5	1.1	487	273.0	273.0	--------	--------	--------	54.0	Do.
--------	2	330 0	4.5	1.3	520	338.0	336.0	--------	--------	--------	48.0	Do.
--------	1	342.0	5.0	.9	537	333.0	333.0	--------	--------	--------	41.0	Do.
--------	0	218.0	3.0	3.8	346	221.0	221.0	--------	--------	--------	45.0	Do.
--------	4	285.0	2.0	.9	477	283.0	280.0	--------	--------	--------	46.0	Do.
--------	0	338.0	5.0	.9	539	338.0	338.0	--------	--------	--------	51.0	Do.
--------	2	376.0	6.0	.9	593	385.0	383.0	--------	--------	--------	46.0	Do.
--------	3	400.0	7.0	.8	661	403.0	400.0	--------	--------	--------	32.0	Do.
--------	0	366.0	6.0	1.2	587	363.0	363.0	--------	--------	--------	60.0	Do.
--------	0	423.0	6.0	.8	681	429.0	427.0	--------	--------	--------	28.0	Do.
--------	0	466.0	7.5	7.8	734	448.0	448.0	--------	--------	--------	58.0	Do.
--------	0	411.0	8.0	9.0	640	380.0	380.0	--------	--------	--------	30.0	Do.
--------	0	339.0	5.0	6.6	548	339.0	339.0	--------	--------	--------	38.0	Do.
--------	0	451.0	8.0	.2	639	427.0	427.0	--------	--------	--------	34.0	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	pH	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Schuylkill River—Continued	Aug. 10, 1949	41	4.9	98.6	11.0	--------	0.20	4.8	92.0	55.0	32.0	--------	--------	0
	Aug. 18, 1949	84	6.1	87.0	9.0	--------	.51	4.6	84.0	50.0	21.0	--------	--------	0
	Aug. 23, 1949	42	5.1	97.8	9.5	--------	.31	5.2	95.0	55.0	32.0	--------	--------	0
	Sept. 2, 1949	66	4.4	116.0	12.0	6.7	.20	7.6	114.0	61.0	35.0	--------	--------	0
	Sept. 7, 1949	71	3.8	98.0	11.0	5.6	.25	5.7	86.0	47.0	23.0	--------	--------	0
	Sept. 16, 1949	48	4.05	109.0	11.0	2.8	.12	6.1	100.0	50.0	45.0	--------	--------	0
	Sept. 21, 1949	56	4.3	115.0	12.0	6.3	.08	6.5	105.0	59.0	50.0	--------	--------	0
	Sept. 27, 1949	46	3.95	116.0	12.0	6.8	.13	6.8	108.0	58.0	38.0	--------	--------	0
	Oct. 4, 1949	[4] 38	4.9	88.5	10.0	3.6	.11	5.9	86.0	42.0	30.0	--------	--------	0
	Oct. 18, 1949	[4] 53	6.1	94.6	10.0	--------	--------	--------	--------	--------	--------	--------	--------	0
	Oct. 25, 1949	[4] 44	5.3	89.2	11.0	--------	--------	--------	--------	--------	--------	--------	--------	0
	Aug. 22, 1944	100	4.2	115.0	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	Dec. 3, 1947	228	4.15	59.3	15.0	8.3	.18	3.8	54.0	31.0	--------	--------	--------	0
	Dec. 18, 1947	200	4.2	66.8	12.0	4.7	.12	2.7	62.0	37.0	10.0		--------	0
	Dec. 20, 1947	185	4.1	74.3	16.0	7.9	.10	3.2	78.0	42.0	13.0		--------	0
	Dec. 30, 1947	145	4.1	61.4	14.0	4.5	.30	2.5	54.0	32.0	12.0		--------	0
	Jan. 8, 1948	226	4.2	80.9	14.0	6.2	.20	2.6	80.0	45.0	6.0		--------	0
	Feb. 15, 1948	260	4.4	62.3	9.6	3.0	.15	1.5	53.0	28.0	28.0		--------	0
	Feb. 19, 1948	460	4.6	34.6	8.8	1.2	.26	1.7	32.0	20.0	--------	--------	--------	0
	Feb. 20, 1948	760	4.6	27.7	10.0	1.2	.41	2.0	32.0	14.0	--------	--------	--------	0
	Feb. 27, 1948	590	4.45	29.0	9.6	3.7	.04	1.2	33.0	18.0	--------	--------	--------	0
	Mar. 5, 1948	415	4.2	45.4	9.2	10.0	.25	1.6	39.0	23.0	--------	--------	--------	0
	Mar. 10, 1948	364	4.5	23.7	11.0	5.7	.18	1.1	30.0	10.0	--------	--------	--------	0
	do	364	4.4	45.2	15.0	6.2	.24	4.5	41.3	26.0	--------	--------	--------	0
	Mar. 17, 1948	1,250	4.3	47.5	18.0	8.7	.33	3.2	41.3	26.0	--------	--------	--------	0
	Mar. 26, 1948	483	4.3	50.7	24.0	8.8	.23	3.2	50.0	30.0	--------	--------	--------	0
	Mar. 31, 1948	328	4.35	39.8	17.0	14.0	.17	2.5	34.0	24.0	--------	--------	--------	0
	Apr. 6, 1948	518	4.2	56.7	16.0	15.0	.17	3.1	52.0	30.0	--------	--------	--------	0
	Apr. 23, 1948	447	4.15	64.8	17.0	9.9	.18	4.0	66.0	36.0	--------	--------	--------	0
	Apr. 30, 1948	272	4.40	62.1	5.5	3.9	.15	3.3	59.0	34.0	3.5		--------	0
	May 7, 1948	1,060	5.2	28.5	4.5	1.2	.14	1.3	26.0	13.0	3.4		--------	.1
	May 14, 1948	1,290	4.7	29.5	2.5	1.0	.10	1.5	26.0	13.0	2.2		--------	0
	May 21, 1948	650	4.4	47.7	6.0	5.7	.14	1.9	41.0	24.0	2.9		--------	0
	May 25, 1948	419	4.3	60.1	11.0	5.5	.05	3.1	51.0	30.0	13.0		--------	0
	June 3, 1948	263	4.25	69.8	17.0	6.0	.08	3.6	68.0	38.0	3.6		--------	0
	June 8, 1948	443	4.5	48.0	9.1	.4	.15	1.7	45.0	24.0	8.4		--------	0
	June 14, 1948	180	4.3	71.9	13.0	5.9	.22	3.8	66.0	43.0	7.9		--------	0
	June 16, 1948	171	4.3	85.2	14.0	4.8	.26	5.2	81.0	52.0	2.2		--------	0
	June 21, 1948	208	4.4	59.9	11.0	1.8	.15	3.5	53.0	37.0	1.1		--------	0
	July 2, 1948	178	4.35	76.7	15.0	6.3	.28	3.8	67.0	45.0	4.8		--------	0
	July 8, 1948	113	4.2	85.6	8.0	4.3	.32	2.0	82.0	51.0	3.1		--------	0
	July 15, 1948	145	4.3	89.6	11.0	8.5	.85	5.2	87.0	53.0	4.2		--------	0
	July 23, 1948	301	5.1	55.8	5.0	2.7	1.70	3.6	51.0	28.0	--------	--------	--------	0
	July 29, 1948	115	4.1	98.3	18.0	11.0	.31	6.0	90.0	54.0	7.7		--------	0
	Aug. 5, 1948	202	4.5	92.4	10.0	4.9	1.90	6.0	94.0	54.0	2.3		--------	0
	Aug. 10, 1948	90	4.05	96.9	20.0	12.0	.41	6.9	98.0	59.0	5.2		--------	0
	Aug. 17, 1948	80	4.5	98.3	9.0	5.9	.58	5.2	98.0	59.0	--------	--------	--------	.1
	Aug. 27, 1948	88	4.25	94.0	16.0	16.0	.45	5.4	92.0	52.0	4.5		--------	0
	Sept. 2, 1948	110	4.1	114.0	16.0	7.3	.12	7.6	120.0	73.0	1.8		--------	0
	Sept. 9, 1948	125	4.8	107.0	10.0	6.4	4.80	6.4	106.0	63.0	2.0		--------	0
	Sept. 15, 1948	62	4.0	108.0	16.0	16.0	.10	6.4	101.0	50.0	8.1		--------	0
	Sept. 24, 1948	62	4.6	105.0	8.0	11.0	2.30	6.8	106.0	61.0	6.2		--------	0
	Sept. 29, 1948	57	4.8	101.0	15.0	8.4	3.10	6.1	107.0	59.0	9.2		--------	0
	Oct. 8, 1948	80	4.9	94.4	13.0	1.6	1.70	5.7	96.0	55.0	24.0		--------	0
	Oct. 15, 1948	52	4.6	96.8	12.0	5.6	.28	5.0	104.0	55.0	15.0		--------	0
	Oct. 20, 1948	73	4.7	89.4	6.5	1.6	.72	6.0	82.0	48.0	37.0		--------	0
	Oct. 27, 1948	59	4.8	92.4	11.0	.8	.91	6.4	93.0	51.0	23.0		--------	0
	Nov. 5, 1948	123	4.9	76.1	7.0	2.8	.15	3.6	71.0	44.0	13.0		--------	0
	Nov. 16, 1948	148	4.1	74.2	6.5	9.0	.12	4.0	60.0	41.0	5.7		--------	0
	Nov. 22, 1948	439	4.35	41.9	5.0	3.1	.10	2.5	34.0	23.0	--------	--------	--------	.1
	Dec. 1, 1948	291	4.3	59.8	7.5	6.2	.20	3.4	48.0	34.0	--------	--------	--------	.1
	Dec. 8, 1948	254	4.1	60.1	12.0	4.7	.07	1.6	58.0	34.0	9.0		--------	0
	Dec. 10, 1948	223	4.4	61.6	5.0	2.5	.18	3.7	53.0	37.0	2.5		--------	.1
	Dec. 14, 1948	190	4.5	67.4	7.0	6.3	.09	2.1	60.0	39.0	3.0		--------	0
	Dec. 20, 1948	223	4.1	53.6	13.0	8.4	.18	2.8	38.0	27.0	3.3		--------	0
	Jan. 7, 1949	530	4.25	31.0	12.0	4.8	.15	1.3	21.0	14.0	2.2		--------	0
	Jan. 14, 1949	463	4.2	61.0	14.0	8.3	.25	3.4	48.0	32.0	1.6		--------	0
	Jan. 17, 1949	353	4.15	67.0	14.0	8.9	.22	3.5	51.0	35.0	7.3		--------	0
	Jan. 26, 1949	544	4.25	50.4	12.0	5.4	.13	2.5	40.0	26.0	3.5		--------	0
	Feb. 3, 1949	419	4.05	56.9	7.5	5.7	.17	3.0	44.0	29.0	5.8		--------	0
	Feb. 11, 1949	338	4.25	56.8	9.0	6.5	.17	2.9	43.0	28.0	9.2		--------	0
	Feb. 15, 1949	353	4.45	53.8	7.6	1.8	.09	2.7	44.0	26.0	14.0		--------	0
	Feb. 21, 1949	500	4.5	42.6	6.8	1.2	.12	2.2	33.0	21.0	11.0		--------	0
	Mar. 2, 1949	375	4.3	48.1	11.0	4.8	.62	2.5	37.0	24.0	3.2		--------	0
	Mar. 10, 1949	288	4.45	55.5	8.0	3.3	.10	3.0	44.0	28.0	13.0		--------	0
	Mar. 16, 1949	220	4.5	57.2	7.5	3.6	.14	3.0	49.0	31.0	8.3		--------	0
	Mar. 23, 1949	245	4.7	54.3	6.0	3.3	.17	2.6	50.0	26.0	8.0		--------	0
	Mar. 31, 1949	190	4.5	63.9	12.0	3.8	.10	3.4	55.0	33.0	11.0		--------	0
	Apr. 6, 1949	443	4.45	35.6	7.0	2.6	.04	2.0	29.0	16.0	16.0		--------	0
	Apr. 12, 1949	304	4.2	43.8	5.8	3.3	.10	2.4	34.0	21.0	21.0		--------	0
	Apr. 20, 1949	572	4.4	36.1	8.2	3.4	.05	1.8	28.0	16.0	16.0		--------	0
	Apr. 28, 1949	463	4.7	45.3	9.2	4.2	.17	2.1	37.0	21.0	21.0		--------	0
	May 6, 1949	260	4.5	54.5	9.2	4.0	.07	2.8	46.0	26.0	9.9		--------	.1
	May 13, 1949	192	4.45	64.8	9.0	5.3	.17	3.6	56.0	28.0	17.0		--------	0

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_2SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
--------	0	502.0	10.0	0.1	764	465.0	463.0	--------	--------	--------	18.0	At Landingville (*79*, p. 84).
--------	17	421.0	14.0	.4	663	425.0	411.0	--------	--------	--------	--------	Do.
--------	2	508.0	8.0	0	768	474.0	472.0	--------	--------	--------	--------	Do.
--------	0	622.0	10.0	1.2	980	588.0	588.0	--------	--------	--------	88.0	Do.
--------	0	464.0	10.0	12.0	748	458.0	458.0	--------	--------	--------	62.0	Do.
--------	0	536.0	8.0	11.0	882	486.0	486.0	--------	--------	--------	46.0	Do.
--------	0	613.0	9.0	3.4	1,040	554.0	554.0	--------	--------	--------	70.0	Do.
--------	0	606 0	9.0	6.0	1,000	564.0	564.0	--------	--------	--------	84.0	Do.
--------	2	464.0	8.0	.6	697	418.0	417.0	--------	--------	--------	32.0	At Landingville (*79*, p 87).
--------	12	477.0	9.0	.4	--------	468.0	--------	--------	--------	--------	--------	Do
--------	10	450.0	8.0	.3	--------	448.0	--------	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	At Auburn (*61*, p. 160).
--------	0	286.0	4.0	.7	502	324.0	324.0	--------	--------	--------	108.0	At Auburn (*79*, p. 85).
--------	0	346.0	2.0	.6	494	341.0	341.0	--------	--------	--------	52.0	Do.
--------	0	429.0	2.0	.6	--------	421.0	421.0	--------	--------	--------	61.0	Do.
--------	0	312.0	2.0	.5	513	301.0	301.0	--------	--------	--------	61.0	Do.
--------	0	428.0	3.0	.5	697	428.0	428.0	--------	--------	--------	74.0	Do.
--------	0	313.0	2.0	1.9	510	268.0	268.0	--------	--------	--------	34.0	Do.
--------	0	155.0	2.0	0	249	173.0	173.0	--------	--------	--------	23.0	Do.
--------	0	129.0	2.0	0	206	149.0	149.0	--------	--------	--------	25.0	Do.
--------	0	162.0	2.0	0	262	180.0	180.0	--------	--------	--------	26.0	Do.
--------	0	226.0	2.0	.1	358	254.0	254.0	--------	--------	--------	40.0	Do.
--------	0	103.0	4.0	.9	205	150.0	150.0	--------	--------	--------	24.0	Do.
--------	0	210.0	6.0	0	395	253.0	253.3	--------	--------	--------	34.0	Do.
--------	0	232.0	2.0	0	448	266.0	266.0	--------	--------	--------	89.0	Do·
--------	0	266.0	4.0	.1	484	305.0	305.0	--------	--------	--------	81.0	Do.
--------	0	193.0	2.0	.5	399	268.0	268.0	--------	--------	--------	76.0	Do.
--------	0	272.0	4.0	.5	481	346.0	346.0	--------	--------	--------	104.0	Do.
--------	0	343.0	4.0	.4	595	379.0	379.0	--------	--------	--------	98.0	Do.
--------	0	305.0	4.0	.7	489	316.0	316.0	--------	--------	--------	62.0	Do
--------	6	119.0	4 0	.5	202	128.0	123.0	--------	--------	--------	23.0	Do.
--------	0	122.0	3 0	.5	204	127.0	127.0	--------	--------	--------	34.0	Do.
--------	0	230.0	2.0	2.0	352	238.0	238.0	--------	--------	--------	61.0	Do.
--------	0	294 0	7.0	1.4	470	289.0	289.0	--------	--------	--------	80.0	Do.
--------	0	349.0	8.0	1.5	570	368.0	368.0	--------	--------	--------	84.0	Do.
--------	0	215 0	7.0	1.7	362	217.0	217.0	--------	--------	--------	35.0	Do.
--------	0	372.0	9.0	1.1	606	384.0	384.0	--------	--------	--------	96.0	Do.
--------	0	439.0	2.0	.3	672	455.0	455.0	--------	--------	--------	58.0	Do.
--------	0	289.0	6.0	.5	442	302.0	302.0	--------	--------	--------	40.0	Do.
--------	0	379.0	8.0	.7	591	396.0	396.0	--------	--------	--------	54.0	Do.
--------	0	426.0	6.0	.8	682	446.0	446.0	--------	--------	--------	62.0	Do.
--------	0	477.0	6.0	.4	731	496.0	496.0	--------	--------	--------	92.0	Do.
--------	0	257.0	2.0	.1	408	268.0	268.0	--------	--------	--------	50.0	Do.
--------	0	512.0	3.5	3.0	790	524.0	524.0	--------	--------	--------	88.0	Do.
--------	4	476.0	4.0	.5	922	500.0	497.0	--------	--------	--------	82.0	Do.
--------	0	553.0	4.5	1.0	1,010	572.0	572.0	--------	--------	--------	148.0	Do.
--------	0	500.0	4.0	0	790	531.0	531.0	--------	--------	--------	110.0	Do.
--------	0	530.0	5.5	.8	1,020	545.0	545.0	--------	--------	--------	116.0	Do.
--------	0	632.0	3.0	.1	992	658.0	658.0	--------	--------	--------	108.0	Do.
--------	0	559.0	3.0	2.2	882	584.0	584.0	--------	--------	--------	134.0	Do.
--------	0	547.0	7.0	2.4	892	564.0	564.0	--------	--------	--------	108.0	Do.
--------	0	575.0	7.0	0	912	595.0	595.0	--------	--------	--------	78.0	Do.
--------	0	564.0	6.0	.1	856	576.0	576.0	--------	--------	--------	52.0	Do.
--------	0	513.0	6.0	.1	785	490.0	490.0	--------	--------	--------	30.0	At Auburn (*79*, p. 86).
--------	0	524.0	8.0	2.0	808	527.0	527.0	--------	--------	--------	36.0	Do.
--------	4	466.0	10.0	1.0	726	424.0	420.0	--------	--------	--------	--------	Do.
--------	2	473.0	10.0	1.7	742	461.0	459.0	--------	--------	--------	--------	Do.
--------	3	379.0	8.0	.2	610	381.0	378.0	--------	--------	--------	56.0	Do.
--------	0	365.0	4.0	1.6	574	374.0	374.0	--------	--------	--------	130.0	Do.
--------	0	190.0	4.0	.8	292	202.0	202.0	--------	--------	--------	66.0	Do.
--------	0	280.0	4.0	.6	448	303.0	303.0	--------	--------	--------	105.0	Do.
--------	0	321.0	2.0	.7	513	318.0	318.0	--------	--------	--------	54.0	Do.
--------	0	294.0	4.0	0	466	307.0	307.0	--------	--------	--------	94.0	Do.
--------	0	336.0	4.0	.2	527	349.0	349.0	--------	--------	--------	92.0	Do.
--------	0	250.0	3.5	5.2	379	262.0	262.0	--------	--------	--------	58.0	Do.
--------	0	135	3.5	.8	201	141.0	141.0	--------	--------	--------	33.0	Do.
--------	0	294.0	2.5	1.6	444	307.0	307.0	--------	--------	--------	64.0	Do.
--------	0	328.0	2.0	2.7	501	331.0	331.0	--------	--------	--------	72.0	Do.
--------	0	234.0	3.5	3.5	348	244.0	244.0	--------	--------	--------	47.0	Do.
--------	0	266.0	3.5	2.0	402	271.0	271.0	--------	--------	--------	61.0	Do.
--------	0	269.0	4.0	.9	398	266.0	266.0	--------	--------	--------	54.0	Do.
--------	0	248.0	3.0	1.9	356	233.0	233.3	--------	--------	--------	38.0	Do.
--------	2	189.0	2.0	2.1	277	180.0	178.0	--------	--------	--------	30.0	Do.
--------	0	217.0	3.0	3.4	334	226.0	226.0	--------	--------	--------	39.0	Do.
--------	0	260.0	4.0	1.1	389	250.0	250.0	--------	--------	--------	45.0	Do.
--------	3	275.0	3.0	.6	401	276.0	273.0	--------	--------	--------	56.0	Do.
--------	4	252.0	4.5	.6	385	255.0	252.0	--------	--------	--------	29.0	Do.
--------	0	305.0	3.5	1.6	466	301.0	301.0	--------	--------	--------	41.0	Do.
--------	0	150.0	4.5	3.9	249	157.0	157.0	--------	--------	--------	28.0	Do.
--------	0	192.0	2.0	3.2	320	197.0	197.0	--------	--------	--------	36.0	Do.
--------	0	155.0	2.5	2.1	248	159.0	159.0	--------	--------	--------	30.0	Do.
--------	0	200.0	3.0	2.4	303	206.0	206.0	--------	--------	--------	40.0	Do.
--------	0	255.0	3.0	.9	387	249.0	249.0	--------	--------	--------	33.0	Do.
--------	0	310.0	3.5	.9	507	292.0	292.0	--------	--------	--------	44.0	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	*p*H	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Schuylkill River—Continued.	May 18, 1949	157	4.6	64.5	9.0	3.5	0.12	3.2	55.0	32.0	16.0		---	0
	May 25, 1949	383	4.6	42.5	7.6	2.9	.10	2.2	36.0	19.0	8.6		---	0
	May 31, 1949	248	4.4	55.5	8.8	4.4	.10	3.2	45.0	28.0	5.2		---	0
	June 7, 1949	141	4.4	65.8	11.0	4.4	.11	3.4	55.0	33.0	14.0		---	.1
	June 15, 1949	119	4.4	77.1	9.8	5.1	.23	4.5	67.0	39.0	15.0		---	0
	June 20, 1949	102	4.25	69.6	11.0	1.9	.15	5.1	61.0	36.0	7.1		---	0
	June 28, 1949	92	4.4	80.8	12.0	3.8	.25	5.2	72.0	41.0	13.0		---	0
	July 11, 1949	75	3.85	82.4	12.0	3.0	.19	5.0	76.0	40.0	20.0	---	---	0
	July 20, 1949	73	4.3	85.1	10.0	3.1	.16	4.3	76.0	42.0	26.0	---	---	0
	July 26, 1949	73	4.0	83.5	10.0	3.9	.15	4.5	75.0	39.0	20.0	---	---	0
	Aug. 3, 1949	60	4.5	79.1	10.0	2.8	.11	4.5	74.0	39.0	20.0	---	---	0
	Aug. 9, 1949	57	4.6	95.7	9.5	1.1	.24	4.5	87.0	49.0	32.0	---	---	0
	Aug. 18, 1949	92	4.9	84.7	9.5	2.8	.10	4.4	80.0	44.0	22.0	---	---	0
	Aug. 23, 1949	45	4.8	92.7	12.0	.8	.31	4.6	85.0	48.0	30.0	---	---	0
	Sept. 2, 1949	69	4.45	100.0	14.0	6.9	.31	5.8	92.0	52.0	27.0	---	---	0
	Sept. 9, 1949	62	3.95	96.7	12.0	5.5	.10	4.9	90.0	42.0	32.0	---	---	0
	Sept. 12, 1949	66	3.8	98.6	14.0	5.9	.18	5.4	88.0	42.0	30.0	---	---	0
	Sept. 20, 1949	66	4.05	101.0	12.0	5.2	.12	5.6	94.0	53.0	33.0	---	---	0
	July 24, 1941	(*)	3.7	---	---	---	---	---	---	---	---	---	---	---
	Oct. 21, 1941	(*)	4.6	---	---	---	---	---	---	---	---	---	---	---
	Dec. 1, 1941	(*)	4.3	---	---	---	---	---	---	---	---	---	---	---
	July 31, 1946	(*)	4.3	---	---	---	---	---	---	---	---	---	---	---
	Aug. 14, 1946	(*)	4.3	---	---	---	---	---	---	---	---	---	---	---
	Aug. 27, 1946	(*)	4.6	---	---	---	---	---	---	---	---	---	---	---
	Apr. 12, 1948	[4] 914	4.7	34.5	---	---	---	---	---	---	---	---	---	---
	Apr. 20, 1948	[4] 751	4.4	41.8	8.8	2.3	.10	2.2	34.0	21.0	6.4		---	0
	May 4, 1948	[4] 398	4.9	46.9	---	---	---	---	---	---	---	---	---	.2
	July 13, 1948	[4] 150	4.8	74.8	---	---	---	---	---	---	---	---	---	.1
	July 20, 1948	[4] 140	4.3	79.8	8.0	3.0	.25	4.4	71.0	45.0	15.0		---	.2
	July 27, 1948	[4] 155	4.6	72.6	15.0	---	---	---	---	---	---	---	---	.1
	Aug. 14, 1948	[4] 77	4.15	81.7	12 0	---	---	---	---	---	---	---	---	0
	Aug. 21, 1948	[4] 69.8	4.5	82.2	10.0	5.5	.45	4.2	71.0	47.0	12.0		---	0
	Aug. 28, 1948	[4] 66.7	4.5	74.3	8.6	---	---	---	---	---	---	---	---	0
	Oct. 4, 1949	[4] 65	4.8	68.3	11.0	2.8	.11	4.6	68.0	34.0	19.0	---	---	0
	Oct. 18, 1949	[4] 63	5.1	77.0	9.2	---	---	---	---	---	---	---	---	0
	Oct. 25, 1949	[4] 56	4.8	78.2	10.0	---	---	---	---	---	---	---	---	0
	Aug. 22, 1944	250	4.1	103.0	---	---	---	---	---	---	---	---	---	---
	Apr. 13, 1948	[4] 1,320	4.8	30.8	---	---	---	---	---	---	---	---	---	---
	Apr. 20, 1948	[4] 1,100	4 3	37.7	8.4	4.6	.10	2.0	30.0	16.0	2.8		---	.0
	May 4, 1948	[4] 825	4.5	43.4	---	---	---	---	---	---	---	---	---	.3
	July 13, 1948	[4] 222	4.0	77.0	---	---	---	---	---	---	---	---	---	0
	July 20, 1948	[4] 214	3.95	79.4	9.0	9.8	.34	4.4	65.0	44.0	7.7		---	.2
	July 27, 1948	[4] 298	4.2	73.8	8.0	---	---	---	---	---	---	---	---	.4
	Sept. 14, 1948	[4] 149	3.35	91.8	15.0	---	---	---	---	---	---	---	---	0
	Sept. 21, 1948	[4] 161	3.8	96.0	14.0	19.0	.35	6.0	72.0	51.0	6.0		---	0
	Sept. 28, 1948	[4] 155	4.05	85.7	11.0	---	---	---	---	---	---	---	---	0
	Oct. 4, 1949	[4] 200	4.8	77.1	12.0	14.0	.19	5.2	66.0	32.0	19.0	---	---	0
	Oct. 18, 1949	[4] 136	4.35	89.8	12.0	---	---	---	---	---	---	---	---	0
	Oct. 25, 1949	[4] 139	4.4	92.5	13.0	---	---	---	---	---	---	---	---	0
	Dec. 11, 1947	426	4.1	54.1	10.0	13.0	.84	---	42.0	23.0	---	---	---	0
	Dec. 16, 1947	748	4.4	49.5	20.0	5.4	6.00	---	38.0	20.0	---	---	---	0
	Dec. 22, 1947	444	4.0	53.3	20.0	11.0	1.20	---	40.0	25.0	---	---	---	0
	Dec. 3, 1947	402	4.0	61.9	15.0	10.0	.94	---	41.0	18.0	42.0		---	.1
	Jan. 7, 1948	502	4.2	48.7	12.0	9.1	.85	---	39.0	20.0	---	---	---	0
	Jan. 12, 1948	410	3.9	57.8	5.0	12.0	1.40	---	41.0	24.0	---	---	---	0
	Jan. 20, 1948	310	3.9	63.6	10.0	11.0	1.20	---	45.0	26.0	12.0		---	0
	1948 [3]													
	Feb. 13–17	509	4.0	57.5	8.4	4.8	.04	3.0	45.0	25.0	20.0	3.5	---	.1
	Feb. 18–20	1,600	4.3	27.1	6.8	1.0	.04	1.1	21.0	12.0	9.4	3.0	---	.1
	Feb. 21–29	1,360	4.3	31.4	8.6	3.1	.02	1.4	22.0	12.0	8.3	1.9	---	---
	Mar. 1–10	1,140	4.35	35.6	8.4	3.0	.02	1.6	26.0	15.0	8.5	1.8	---	.1
	Mar. 11–20	1,580	4.3	33.6	8.2	2.9	.02	1.7	24.0	14.0	7.4	1.8	---	.1
	Mar. 21–31	1,150	4.35	35.6	8.6	3.7	.02	1.7	25.0	16.0	7.9	1.9	---	.1
	Apr. 1–10	1,540	3.8	31.6	8.7	3.0	.03	1.4	22.0	14.0	6.2	1.6	---	.1
	Apr. 11–20	1,790	4.15	31.6	9.3	3.8	.03	1.4	21.0	14.0	5.9	1.5	---	.1
	Apr. 21–30	822	4.2	47.9	9.8	5.3	.03	2.5	37.0	23.0	10.0	2.1	---	.1
	May 1–4	658	4.25	51.9	9.6	5.6	.05	2.7	41.0	27.0	11.0	2.0	---	.1
	May 5–10	2,200	4.25	26.6	8.0	2.7	.05	1.1	17.0	11.0	5.6	1.8	---	.1
	May 11–20	2,050	4.25	33.2	9.4	3.9	.04	1.5	22.0	15.0	6.1	1.4	---	.1
	May 21–30	969	4.1	46.2	10.0	5.0	.78	4.2	35.0	21.0	6.0	1.1	---	.1
	June 1–10	592	4.0	54.0	5.2	5.2	.06	4.5	43.0	26.0	7.1	1.0	---	0
	June 11–17	437	4.0	61.6	11.0	9.7	.06	4.0	50.0	29.0	7.2	1.2	---	0
	June 18–27	471	4.30	52.2	9.6	8.2	.15	3.1	52.0	28.0	---	---	---	.1
	June 28–July 7	316	4.15	58.1	8.4	8.8	.17	3.2	50.0	30.0	3.2		---	0
	July 8–17	250	3.90	71.8	12.0	12.0	.27	4.2	64.0	39.0	7.0		---	.1
	July 18–31	327	3.90	72.5	11.0	7.8	.21	4.2	63.0	42.0	15.0		---	.1
	Aug. 1–10	264	4.0	73.6	12.0	8.3	.21	4.3	63.0	44.0	20.0		---	0
	Aug. 11–20	220	3.95	78.3	13.0	6.6	.22	4.6	73.0	45.0	16.0		---	.1
	Aug. 21–31	271	4.0	67.5	13.0	6.0	.19	3.8	61.0	38.0	6.2		---	0
	Sept. 1–10	193	4.2	83.6	9.2	9.5	.25	5.6	77.0	47.0	16.0		---	0
	Sept. 11–20	156	4.2	87.3	14.0	12.0	.40	2.7	88.0	50.0	8.0		---	0
	Sept. 21–30	138	4.0	85.1	18.0	13.0	.15	5.8	84.0	46.0	6.3		---	0

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Noncarbonate	Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_2SO_4	Total acidity[2] as H_2SO_4	Remarks
--------	8	302.0	5.0	0.9	485	294.0	288.0	--------	--------	--------	36.0	At Auburn (*79*, p. 86).
--------	3	190.0	4.0	1.5	298	188.0	186.0	--------	--------	--------	26.0	Do.
--------	0	255.0	3.0	.6	421	259.0	259.0	--------	--------	--------	44.0	Do.
--------	0	314.0	5.0	.9	492	305.0	305.0	--------	--------	--------	36.0	Do.
--------	0	374.0	6.0	1.2	612	366.0	366.0	--------	--------	--------	44.0	Do.
--------	0	319.0	4.0	.3	530	323.0	323.0	--------	--------	--------	52.0	Do.
--------	0	383.0	6.0	.7	635	380.0	380.0	--------	--------	--------	50.0	Do.
--------	0	405.0	6.0	8.2	628	388.0	388.0	--------	--------	--------	60.0	Do.
--------	0	417.0	7.5	8.6	626	390.0	390.0	--------	--------	--------	34.0	Do.
--------	0	402.0	8.0	5.2	632	383.0	383.0	--------	--------	--------	58.0	Do
--------	0	384.0	7.5	1.3	614	369.0	369.0	--------	--------	--------	40.0	Do.
--------	1	484.0	10.0	.3	738	434.0	433.0	--------	--------	--------	29.0	Do.
--------	3	421.0	9.5	1.1	664	404.0	402.0	--------	--------	--------	20.0	Do.
--------	2	464.0	9.0	.1	684	423.0	422.0	--------	--------	--------	26.0	Do.
--------	0	533.0	6.5	.1	822	494.0	494.0	--------	--------	--------	64.0	Do.
--------	0	475.0	6.0	13.0	762	442.0	442.0	--------	--------	--------	46.0	Do.
--------	0	476.0	8.0	10.0	759	444.0	444.0	--------	--------	--------	66.0	Do.
--------	0	520.0	11.0	7.4	834	496.0	496.0	--------	--------	--------	52.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	24.0	74.0	At Port Clinton (*22*, p. 12).
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	16.0	88.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	11.0	47.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	39.0	78.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	25.0	64.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	29.0	59.0	Do.
--------	0	139.0	--------	--------	--------	123.0	123.0	--------	--------	--------	21.0	At Port Clinton (*79*, p. 87).
--------	0	190.0	3.5	.5	295	189.0	189.0	--------	--------	--------	33.0	Do.
--------	0	207.0	--------	--------	--------	207.0	207.0	--------	--------	--------	18.0	Do.
--------	2	360.0	--------	--------	--------	350.0	--------	--------	--------	--------	--------	Do.
--------	0	399.0	4.5	.2	610	390.9	390.0	--------	--------	--------	52.0	Do.
--------	0	261.0	8.0	--------	--------	380.0	380.0	--------	--------	--------	--------	Dol
--------	0	405.0	6.0	3.8	--------	453.0	453.0	--------	--------	--------	94.0	Do.
--------	0	414.0	4.0	0	665	410.0	410.0	--------	--------	--------	70.0	Dol
--------	0	449.0	4.0	.2	--------	553.0	553.0	--------	--------	--------	85.0	Do.
--------	4	347.0	6.0	.8	514	334.0	330.0	--------	--------	--------	46.0	Do.
--------	6	382.0	7.0	.5	--------	332.0	--------	--------	--------	--------	--------	Do.
--------	7	397.0	7.0	.6	--------	352.0	--------	--------	--------	--------	38.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	At Hamburg (*61*, p. 160).
--------	1	132.0	--------	--------	--------	98.0	--------	--------	--------	--------	27.0	At Hamburg (*79*, p. 87).
--------	0	166.0	3.5	.6	258	172.0	172.0	--------	--------	--------	41.0	Do.
--------	[illegible]	197.0	--------	--------	--------	177.0	177.0	--------	--------	--------	38.0	Do.
--------	0	344.0	--------	--------	--------	407.0	407.0	--------	--------	--------	112.0	Do.
--------	0	402.0	6.0	1.0	618	412.0	412.0	--------	--------	--------	94.0	Do.
--------	0	376.0	6.0	--------	--------	380.0	380.0	--------	--------	--------	--------	Do.
--------	0	490.0	6.0	.9	--------	351.0	351.0	--------	--------	--------	162.0	Do.
--------	0	506.0	6.0	.5	820	515.0	515.0	--------	--------	--------	138.0	Do.
--------	0	488.0	2.0	.3	--------	378.0	378.0	--------	--------	--------	190.0	Do.
--------	2	399.0	6.0	1.6	601	384.0	382.0	--------	--------	--------	90.0	Do.
--------	0	474.0	6.0	1.0	--------	456.0	--------	--------	--------	--------	100.0	Do.
--------	0	500.0	6.0	1.0	--------	472.0	--------	--------	--------	--------	96.0	Do.
--------	0	245.0	6.0	--------	387	278.0	278.0	--------	--------	--------	63.0	At Berne (*79*, p. 88).
--------	0	223.0	4.0	--------	367	224.0	224.0	--------	--------	--------	39.0	Do.
--------	0	239.0	6.0	--------	378	268.0	268.0	--------	--------	--------	41.0	Do.
--------	0	307.0	8.0	--------	458	240.0	240.0	--------	--------	--------	79.0	Do.
--------	0	215.0	6.0	--------	341	236.0	236.0	--------	--------	--------	44.0	Do.
--------	0	264.0	6.0	--------	416.	282.0	282.0	--------	--------	--------	78.0	Do.
--------	0	296.0	6.0	--------	462	290.0	290.0	--------	--------	--------	103.0	Do.
--------	0	261.0	9.0	1.4	400	252.0	252.0	--------	--------	--------	50.0	Do.
--------	0	110.0	2.0	.3	172	111.0	111.0	--------	--------	--------	20.0	Do.
--------	0	131.0	1.5	.1	204	126.0	126.0	--------	--------	--------	36.0	Do.
--------	0	152.0	2.5	.2	237	147.0	147.0	--------	--------	--------	30.0	Do.
--------	0	142.0	1.5	.1	223	139.0	139.0	--------	--------	--------	34.0	Do.
--------	0	155.0	2.0	.1	237	153.0	153.0	--------	--------	--------	39.0	Do.
--------	0	133.0	1.0	.2	202	140.0	140.0	--------	--------	--------	36.0	Do.
--------	0	130.0	1.0	.2	199	137.0	137.0	--------	--------	--------	39.0	Do.
--------	0	218.0	2.5	.4	334	224.0	224.0	--------	--------	--------	50.0	Do.
--------	0	240.0	2.0	1.0	369	252.0	252.0	--------	--------	--------	57.0	Do.
--------	0	107.0	1.0	.2	164	107.0	107.0	--------	--------	--------	32.0	Do.
--------	0	140.0	1.0	.2	215	143.0	143.0	--------	--------	--------	38.0	Do.
--------	0	207.0	3.0	.6	321	215.0	215.0	--------	--------	--------	61.0	Do.
--------	0	251.0	3.5	1.5	394	256.0	256.0	--------	--------	--------	64.0	Do.
--------	0	293.0	2.8	1.5	449	310.0	310.0	--------	--------	--------	64.0	Do.
--------	0	272.0	4.0	1.2	413	298.0	298.0	--------	--------	--------	59.0	Do.
--------	0	299.0	3.1	3.1	456	315.0	315.0	--------	--------	--------	76.0	Do.
--------	0	386.0	8.5	3.4	578	400.0	400.0	--------	--------	--------	97.0	Do.
--------	0	392.0	6.0	3.6	584	388.0	388.0	--------	--------	--------	108.0	Do.
--------	0	415.0	4.5	2.9	608	398.0	398.0	--------	--------	--------	102.0	Do.
--------	0	425.0	5.5	2.6	658	418.0	418.0	--------	--------	--------	112.0	Do.
--------	0	345.0	5.0	1.7	542	354.0	354.0	--------	--------	--------	82.0	Do.
--------	0	460.0	6.0	.3	708	452.0	452.0	--------	--------	--------	--------	Do.
--------	0	487.0	7.0	1.5	755	501.0	501.0	--------	--------	--------	122.0	Do.
--------	0	466.0	6.0	2.9	730	485.0	485.0	--------	--------	--------	120.0	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of stream*

Source of water	Date of collection	Mean discharge (second-feet)	pH	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Schuylkill River—Continued	Oct. 1-10	176	4.25	83.1	12.0	12.0	0.12	5.0	85.0	45.0	1.3			0
	Oct. 11-20	158	4.35	79.3	13.0	8.8	.21	4.5	79.0	44.0	6.8			0
	Oct. 21-31	136	4.5	84.4	10.0	6.0	.16	3.8	86.0	47.0	7.5			0
	Nov. 1-10	375	4.35	67.2	6.0	2.1	1.40	3.6	62.0	35.0	14.0			0
	Nov. 11-20	392	4.1	61.0	5.0	8.4	.38	3.6	52.0	32.0	7.1			0
	Nov. 21-Dec. 1	678	4.35	43.4	5.5	7.6	.16	2.6	34.0	20.0	2.5			0
	Dec. 2-11	522	4.45	48.9	7.5	9.9	.13	2.6	43.0	28.0	4.3			0
	Dec. 12-20	528												
	Dec. 21-31	1,620	4.1	46.9	6.5	6.5	.10	2.2	34.0	20.0	6.1			0
	1949[3]													
	Jan. 1-10	2,590	4.15	30.5	6.0	4.1	.11	1.2	22.0	12.0	3.1			0
	Jan. 11-20	893	4.0	48.6	6.5	7.1	.08	2.0	36.0	21.0	6.6			0
	Jan. 21-31	1,260	4.0	40.3	7.5	5.2	.13	1.9	32.0	20.0	7.5			0
	Feb. 1-10	895	4.15	40.2	6.5	3.5	.18	1.9	29.0	19 0	4 3			0
	Feb. 11-20	880	4.25	40.3	6.4	3.1	.13	1.9	30.0	18.0	8.2			0
	Feb. 21-28	1,340	4.2	30.1	5.6	2.7	.10	1.3	20.0	12.0	7.5			0
	Mar. 1-10	748	4.25	39.4	8.0	3.0	.25	2.0	30.0	19.0	4.6			0
	Mar. 11-20	512	4.3	45.6	8.0	1.9	.27	2.5	36.0	23.0	2.6			0
	Mar. 21-31	455	4.3	46.2	9.6	8.4	.13	2.6	36.0	23.0	6.3			0
	Apr. 1-10	871	4.45	33.9	8.4	3.3	.13	1.7	26.0	16.0	1.4			0
	Apr. 11-20	1,110	4.25	29.6	6.4	2.3	.11	1.4	21.0	11.0	5.8			0
	Apr. 21-30	1,320	4.3	27.9	6.8	2.3	.08	1.2	20.0	11.0	5.4			0
	May 1-10	744	4.35	39.2	7.8	4.0	.13	2.0	29.0	17.0	6.5			3
	May 11-20	501	4.6	51.6	10.0	7.0	.12	2.6	37.0	21.0	13.0			0
	May 21-31	748	4.8	38.0	7.8	4.2	.10	2.0	27.0	16.0	8.6			0
	June 1-10	355	4.7	53.6	10.0	7.2	.12	2.7	41.0	24.0	9.3			0
	June 11-20	263	4.15	64.9	10.0	8.4	.19	3.8	51.0	29.0	11.0			0
	June 21-30	208	4.05	70.0	11.0	8.2	.18	4.0	57.0	31.0	11.0			0
	July 1-10	158	3.8	82.4	12.0	9.1	.19	4.5	62.0	38.0	21.0			9
	July 11-20	199	3.9	73.8	10.0	6.5	.19	4.0	60.0	34.0	20.0			0
	July 21-31	207	3.8	77.3	12.0	11.0	.22	4.0	66.0	27.0	22.0			0
	Aug. 1-10	139	3.8	89.7	13.0	12.0	.19	4.6	77.0	37.0	25.0			0
	Aug. 11-20	147	3.7	89.4	12.0	7.8	.18	4.9	74.0	41.0	28.0			0
	Aug. 21-31	144	3.7	90.7	12.0	9.9	.24	4.9	72.2	43.0	27.0			0
	Sept. 1-10	159	3.8	85.5	14.0	12.0	.16	4.8	72.0	36.0	18.0			0
	Sept. 11-20	166	3.8	90.6	14.0	14.0	.13	5.0	79.0	38.0	17.0			0
	Sept. 21-30	167	3.8	87.6	12.0	13.0	.21	4.9	70.0	36.0	20.0			0
	Apr. 13, 1948	[4]1,700	4.8	28.6										
	Apr. 20, 1948	[4]1,510	4.4	35.3	7.6	.6	.07	1.8	28.0	16.0	9.8			0
	May 4, 1948	[4]961	4.8	42.6										
	July 13, 1948	[4]241	4.3	67.6										0
	July 20, 1948	[4]240	4.15	71.3		2.9	.33	3.6	58.0	41.0	21.0			.1
	July 27, 1948	[4]296	4.3	64.1	10.0									.1
	Aug. 14, 1948	[4]158	4.0	76.0	13.0									0
	Aug. 21, 1948	[4]136	4.3	82.4	13.0	15.0	.37	5.2	72.0	46.0				0
	Aug. 28, 1948	[4]130	4.4	78.4	10.0									0
	Oct. 4, 1948	[4]163	4.6	70.0	12.0	6.5	.16	5.1	62.0	35.0	20.0			0
	Oct. 18, 1948	[4]132	4.7	82.6	12.0									0
	Oct. 25, 1948	[4]114	4.7	86.1	12.0									0
Maiden Creek	Apr. 13, 1948	[4]675	9.0	21.2	6.0									
	Apr. 20, 1948	[4]480	7.3	16.6	7.4		.10		19.0	5.9	3.8			0
	May 4, 1948	[4]333	7.3	18.8	7.0									.1
	July 13, 1948	[4]122	8.0	23.8	4.0									.3
	July 20, 1948	[4]118	7.6	24.3	5.0		.08		30.0	10.0	4.0			.1
	July 27, 1948	[4]128	7.1	25.3	7.0									.2
	Sept. 14, 1948	[4]135	7.9	23.7	6.8									0
	Sept. 21, 1948	[4]108	6.8	26.0	5.9		.20	.10	31.0	10.0				0
	Sept. 28, 1948	[4]69	7.5	20.2	4.2									0
	Oct. 4, 1949	[4]73	7.5	23.1	4.0		.09		28.0	9.3	4.0			0
	Oct. 18, 1949	[4]55	7.6	24.6	4.9									0
	Oct. 25, 1949	[4]39	7.7	26.7	6.9									0
Schuylkill River—Continued	Apr. 13, 1948	[4]2,410	6.9	23.4	7.0									
	Apr. 20, 1948	[4]2,010	5.9	27.0	7.8		.04		23.0	12.0	8.1			0
	May 4, 1948	[4]1,320	6.0	32.4	9.0									0
	July 13, 1948	[4]371	7.4	50.1	5.0									.1
	July 20, 1948	[4]360	6.1	52.5	9.6		.07		50.0	30.0	6.6			.2
	July 27, 1948	[4]426	6.7	48.0	8.0									.3
	Sept. 14, 1948	[4]294	6.9	49.4	7.5									0
	Sept. 21, 1948	[4]245	6.7	52.8	5.9		.23	2.3	58.0	29.0	6.4			0
	Sept. 28, 1948	[4]200	6.4	53.2	6.4									0
	Oct. 4, 1949	[4]238	6.8	46.4	13.0		.02		44.0	19.0	9.5			0
	Oct. 18, 1949	[4]189	7.0	59.7	9.9									0
	Oct. 25, 1949	[4]154	7.0	64.4	8.9									0

See footnotes at end of table.

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$ Total	Hardness as $CaCO_3$ Noncarbonate	Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_4SO_4	Total acidity[2] as H_2SO_4	Remarks
--------	0	451.0	6.0	0.2	721	475.0	475.0	--------	--------	--------	112.0	At Berne (*79*, p. 90).
--------	0	425.0	6.0	.6	676	437.0	437.0	--------	--------	--------	102.0	Do.
--------	0	436.0	7.0	1.2	690	448.0	448.0	--------	--------	--------	147.0	Do.
--------	0	328.0	7.0	.1	514	322.0	322.0	--------	--------	--------	92.0	Do.
--------	0	315.0	5.0	.2	577	320.0	320.0	--------	--------	--------	94.0	Do.
--------	0	208.0	3.0	.1	384	216.0	216.0	--------	--------	--------	72.0	Do.
--------	0	276.0	4.0	.1	464	284.0	284.0	--------	--------	--------	74.0	Do.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	Do.
--------	0	209.0	4.0	2.1	301	212.0	212.0	--------	--------	--------	--------	Do.
--------	0	130.0	2.0	1.5	182	133.0	133.0	--------	--------	--------	--------	Do.
--------	0	222.0	4.0	2.7	324	225.0	225.0	--------	--------	--------	64.0	Do.
--------	0	202.0	3.5	1.1	268	200.0	200.0	--------	--------	--------	54.0	Do.
--------	0	174.0	3.0	1.2	284	177.0	177.0	--------	--------	--------	52.0	Do.
--------	0	176.0	4.0	1.1	266	172.0	172.0	--------	--------	--------	42.0	Do.
--------	0	125.0	3.0	1.0	186	119.0	119.0	--------	--------	--------	28.0	Do.
--------	0	171.0	4.0	3.0	279	176.0	176.0	--------	--------	--------	49.0	Do.
--------	0	193.0	4.5	2.0	345	203.0	203.0	--------	--------	--------	59.0	Do.
--------	0	237.0	3.0	1.2	318	238.0	238.0	--------	--------	--------	64.0	Do.
--------	0	146.0	2.5	1.2	223	153.0	153.0	--------	--------	--------	42.0	Do.
--------	0	118.0	2.0	2.8	193	115.0	115.0	--------	--------	--------	36.0	Do.
--------	0	114.0	3.0	1.5	185	112.0	112.0	--------	--------	--------	28.0	Do.
--------	0	171.0	3.0	1.6	269	170.0	170.0	--------	--------	--------	50.0	Do.
--------	2	231.0	3.5	3.8	353	223.0	221.0	--------	--------	--------	62.0	Do.
--------	4	164.0	2.5	1.8	257	160.0	157.0	--------	--------	--------	44.0	Do.
--------	1	250.0	3.0	1.5	374	246.0	245.0	--------	--------	--------	68.0	Do.
--------	0	305.0	6.0	3.2	475	304.0	304.0	--------	--------	--------	76.0	Do.
--------	0	328.0	5.0	2.2	522	327.0	327.0	--------	--------	--------	74.0	Do.
--------	0	392.0	8.0	8.1	596	378.0	378.0	--------	--------	--------	93.0	Do.
--------	0	351.0	8.0	8.1	528	340.0	340.0	--------	--------	--------	72.0	Do.
--------	0	366.0	8.0	8.4	556	353.0	353.0	--------	--------	--------	85.0	Do.
--------	0	443.0	10.0	8.6	678	428.0	428.0	--------	--------	--------	97.0	Do.
--------	0	440.0	8.0	8.8	666	416.0	416.0	--------	--------	--------	100.0	Do.
--------	0	437.0	8.0	8.8	670	431.0	431.0	--------	--------	--------	118.0	Do.
--------	0	422.0	7.0	7.2	668	412.0	412.0	--------	--------	--------	114.0	Do.
--------	0	452.0	7.0	6.8	712	449.0	449.0	--------	--------	--------	106.0	Do.
--------	0	426.0	7.0	7.4	693	413.0	413.0	--------	--------	--------	104.0	Do.
--------	0	119.0	--------	--------	--------	94.0	94.0	--------	--------	--------	18.0	At Leesport (*79*, p. 93).
--------	0	151.0	4.5	1.5	238	144.0	144.0	--------	--------	--------	34.0	Do.
--------	0	177.0	--------	--------	--------	165.0	165.0	--------	--------	--------	40.0	Do.
--------	0	335.0	--------	--------	--------	371.0	371.0	--------	--------	--------	86.0	Do.
--------	0	362.0	5.5	1.0	559	340.0	340.0	--------	--------	--------	90.0	Do.
--------	0	282.0	4.0	--------	--------	254.0	254.0	--------	--------	--------	--------	Do.
--------	0	391.0	2.0	1.9	--------	378.0	378.0	--------	--------	--------	128.0	Do.
--------	0	432.0	6.0	.8	695	465.0	465.0	--------	--------	--------	88.0	Do.
--------	0	456.0	4.0	.7	--------	400.0	400.0	--------	--------	--------	147.0	Do.
--------	4	362.0	6.0	2.3	542	344.0	341.0	--------	--------	--------	--------	Do.
--------	8	428.0	6.0	1.6	--------	400.0	--------	--------	--------	--------	--------	Do.
--------	5	447.0	6.0	1.4	--------	384.0	--------	--------	--------	--------	72.0	Do.
--------	78	31.0	--------	--------	--------	40.0	--------	--------	--------	--------	--------	At Temple (*79*, p. 121).
--------	60	19.0	3.5	7.5	108	72.0	22.0	--------	--------	--------	--------	Do.
--------	75	18.0	--------	--------	--------	82.0	--------	--------	--------	--------	--------	Do.
--------	114	18.0	--------	--------	--------	81.0	--------	--------	--------	--------	--------	Do.
--------	116	18.0	4.0	5.9	141	116.0	21.0	--------	--------	--------	--------	Do.
--------	158	33.0	6.0	--------	--------	189.0	--------	--------	--------	--------	--------	Do.
--------	99	14.0	4.0	3.7	--------	232.0	--------	--------	--------	--------	--------	Do.
--------	110	16.0	4.0	--------	127	118.0	27.0	--------	--------	--------	--------	Do.
--------	113	16.0	4.0	6.3	--------	183.0	--------	--------	--------	--------	--------	Do.
--------	113	19.0	3.0	2.0	132	108.0	16.0	--------	--------	--------	--------	Do.
--------	122	18.0	3.0	3.6	--------	116.0	--------	--------	--------	--------	--------	Do.
--------	143	15.0	3.0	4.8	--------	125.0	--------	--------	--------	--------	--------	Do.
--------	12	87.0	--------	--------	--------	80.0	--------	--------	--------	--------	--------	At Muhlenberg, above Reading (*79*, p. 93).
--------	7	106.0	3.5	4.1	180	107.0	101.0	--------	--------	--------	--------	Do.
--------	4	128.0	--------	--------	--------	144.0	--------	--------	--------	--------	--------	Do.
--------	9	219.0	--------	--------	--------	234.0	--------	--------	--------	--------	--------	Do.
--------	6	238.0	5.0	2.5	386	248.0	243.0	--------	--------	--------	--------	Do.
--------	38	209.0	5.0	--------	--------	226.0	--------	--------	--------	--------	--------	Do.
--------	30	263.0	6.0	4.8	--------	244.0	--------	--------	--------	--------	--------	Do.
--------	26	236.0	6.0	3.0	391	264.0	243.0	--------	--------	--------	--------	Do.
--------	17	247.0	6.0	2.0	--------	310.0	--------	--------	--------	--------	--------	Do.
--------	21	192.0	4.0	1.3	311	188.0	171.0	--------	--------	--------	--------	Do.
--------	18	269.0	5.5	2.3	--------	268.0	--------	--------	--------	--------	--------	Do.
--------	25	299.0	4.5	2.7	--------	292.0	--------	--------	--------	--------	--------	Do.

TABLE 9.—*Chemical analyses of some selected surface waters in the United States and of streams*

Source of water	Date of collection	Mean discharge (second-feet)	pH	Conductivity ($K \times 10^5$ at 25° C.)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Boron (B)	Fluoride (F)
Schuylkill River—Continued	Apr. 14, 1948	[4]3,650	7.4	23.2	7.0	--------	--------	--------	--------	--------	--------	--------	--------	--------
	Apr. 21, 1948	[4]2,750	6.9	27.7	7.8	--------	0.06	--------	27.0	11.0	9.4		--------	0
	May 5, 1948	[4]2,640	6.9	26.2	8.0	--------	--------	--------	--------	--------	--------	--------	--------	0
	July 14, 1948	[4]1,150	6.5	40.9	8.8	--------	--------	--------	--------	--------	--------	--------	--------	.2
	July 20, 1948	[4]749	6.5	52.1	8.4	--------	.10	--------	52.0	24.0	17.0		--------	.2
	July 27, 1948	[4]627	6.7	47.5	12.0	--------	--------	--------	--------	--------	--------	--------	--------	.1
	Sept. 14, 1948	[4]586	6.6	48.6	8.9	--------	--------	--------	--------	--------	--------	--------	--------	0
	Sept. 21, 1948	[4]446	7.1	53.0	8.2	--------	.33	1.4	55.0	21.0	14.0		--------	0
	Sept. 28, 1948	[4]416	6.8	50.4	6.8	--------	--------	--------	--------	--------	--------	--------	--------	0
	Oct. 4, 1949	[4]337	6.7	44.9	6.5	--------	.04	--------	44.0	19.0	12.0	--------	--------	0
	Oct. 18, 1949	[4]262	6.9	55.1	9.5	--------	--------	--------	--------	--------	--------	--------	--------	.1
	Oct. 25, 1949	[4]284	6.9	59.1	8.8	--------	--------	--------	--------	--------	--------	--------	--------	0
	Apr. 14, 1948	[4]4,020	7.4	23.4	8.0	--------	--------	--------	--------	--------	--------	--------	--------	--------
	Apr. 21, 1948	[4]3,000	6.6	27.2	8.2	--------	.06	--------	27.0	11.0	7.6		--------	0
	May 5, 1948	[4]3,990	6.8	14.8	10.0	--------	--------	--------	--------	--------	--------	--------	--------	0
	July 14, 1948	[4]1,120	6.6	35.2	12.0	--------	--------	--------	--------	--------	--------	--------	--------	.2
	July 21, 1948	[4]639	6.9	46.9	9.6	--------	.05	--------	46.0	23.0	13.0		--------	.2
	July 28, 1948	[4]628	6.8	43.2	8.0	--------	--------	--------	--------	--------	--------	--------	--------	.1
	Aug. 15, 1948	[4]593	7.3	45.3	8.6	--------	--------	--------	--------	--------	--------	--------	--------	0
	Sept. 22, 1948	[4]485	7.4	47.3	8.9	--------	.25	.04	53.0	21.0	6.8		--------	0
	do	[4]360	7.0	42.2	4.5	--------	--------	--------	--------	--------	--------	--------	--------	0
	Oct. 5, 1949	[4]402	6.8	42.9	7.0	--------	.03	--------	42.0	18.0	15.0	--------	--------	0
	Oct. 19, 1949	[4]314	7.1	51.1	9.4	--------	--------	--------	--------	--------	--------	--------	--------	0
	Oct. 26, 1949	[4]306	7.0	51.8	9.4	--------	--------	--------	--------	--------	--------	--------	--------	0
	Apr. 14, 1948	[4]4,080	7.2	22.8	8.0	--------	--------	--------	--------	--------	--------	--------	--------	--------
	Apr. 21, 1948	[4]3,040	6.7	26.2	8.4	--------	.07	--------	26.0	11.0	7.2		--------	0
	May 5, 1948	4,050	6.7	19.9	11.0	--------	--------	--------	--------	--------	--------	--------	--------	.2
	July 14, 1948	1,140	6.6	33.0	8.0	--------	--------	--------	--------	--------	--------	--------	--------	.2
	July 21, 1948	[4]639	7.1	44.6	8.0	--------	.07	--------	45.0	19.0	14.0		--------	.2
	July 28, 1948	[4]638	7.0	44.1	8.0	--------	--------	--------	--------	--------	--------	--------	--------	.1
	Sept. 15, 1948	[4]602	7.2	42.8	8.9	--------	--------	--------	--------	--------	--------	--------	--------	0
	Sept. 22, 1948	[4]493	7.2	47.2	8.6	--------	.28	.05	50.0	17.0	22.0		--------	0
	Sept. 29, 1948	[4]489	7.1	43.0	5.6	--------	--------	--------	--------	--------	--------	--------	--------	0
	Oct. 5, 1949	[4]414	6.9	43.5	8.0	--------	.02	--------	42.0	18.0	17.0	--------	--------	0
	Oct. 19, 1949	[4]324	7.3	48.9	8.4	--------	--------	--------	--------	--------	--------	--------	--------	0
	Oct. 26, 1949	[4]315	7.1	50.1	7.6	--------	--------	--------	--------	--------	--------	--------	--------	0
	July 24, 1941	481	6.6	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	Oct. 21, 1941	272	7.1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	Dec. 1, 1941	321	7.5	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	1944 [3] Oct. 11–20	442	7.0	56.4	8.2	--------	.02	0	59.0	27.0	14.0	3.4	--------	.1
	1945 [3] Mar. 21–31	2,180	6.7	27.7	7.0	--------	.01	0	28.0	11.0	7.6	1.5	--------	.1
	Aug. 7, 1946	720	7.1	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
	Aug. 19, 1946	2,710	6.9	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

[1] Methyl-red indicator.
[2] Phenolphthalein indicator.
[3] Composites for complete analysis of samples collected for these years by the Division of Hydrography, Pennsylvania Department of Forests and Waters, were made up of equal quantities of each of the daily samples so that 3 composite analyses were available each month—1 for the 1–10 period, 1 for the 11–20 period, and 1 for the 21-to-end-of-month period. Specific conductivity and hydrogen-ion concentration were determined separately for

in the anthracite-region drainage basins (parts per million except pH and conductivity)—Continued

Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Alkalinity[1] as $CaCO_3$	Alkalinity[2] as $CaCO_3$	Free acidity[1] as H_2SO_4	Total acidity[2] as H_2SO_4	Remarks
						Total	Noncarbonate					
--------	31	64.0	--------	--------	--------	82.0	--------	--------	--------	--------	--------	Below Angelica, below Reading (*79*, p. 93).
--------	36	88.0	5.0	6.0	183	113.0	83.0	--------	--------	--------	--------	Do.
--------	41	72.0	--------	--------	--------	110.0	--------	--------	--------	--------	--------	Do.
--------	45	148.0	7.0	7.8	--------	174.0	--------	--------	--------	--------	--------	Do.
--------	95	164.0	12.0	.2	395	228.0	151.0	--------	--------	--------	--------	Do.
--------	86	148.0	11.0	--------	--------	178.0	--------	--------	--------	--------	--------	Do.
--------	91	134.0	12.0	.9	--------	323.0	--------	--------	--------	--------	--------	Do.
--------	102	144.0	14.0	2.2	361	224.0	140.0	--------	--------	--------	--------	Do.
--------	96	171.0	16.0	.9	--------	283.0	--------	--------	--------	--------	--------	Do.
--------	56	144.0	12.0	7.2	289	188.0	142.0	--------	--------	--------	--------	Do.
--------	66	179.0	20.0	4.4	--------	220.0	--------	--------	--------	--------	--------	Do.
--------	96	199.0	16.0	.7	--------	244.0	--------	--------	--------	--------	--------	Do.
--------	34	64.0	--------	--------	--------	81.0	--------	--------	--------	--------	--------	At Monocacy (*79*, p. 94).
--------	32	87.0	5.5	5.8	179	113.0	86.0	--------	--------	--------	--------	Do.
--------	26	35.0	--------	--------	--------	56.0	--------	--------	--------	--------	--------	Do.
--------	49	114.0	9.0	6.8	--------	147.0	--------	--------	--------	--------	--------	Do.
--------	60	145.0	18.0	7.1	321	209.0	160.0	--------	--------	--------	--------	Do.
--------	48	123.0	14.0	--------	--------	218.0	--------	--------	--------	--------	--------	Do.
--------	60	140.0	16.0	6.4	--------	183.0	--------	--------	--------	--------	--------	Do.
--------	80	135.0	16.0	6.0	300	219.0	153.0	--------	--------	--------	--------	Do.
--------	78	138.0	18.0	5.5	--------	146.0	--------	--------	--------	--------	--------	Do.
--------	56	138.0	14.0	6.0	276	179.0	133.0	--------	--------	--------	--------	Do.
--------	66	166.0	17.0	10.0	--------	212.0	--------	--------	--------	--------	--------	Do.
--------	72	176.0	12.0	9.6	--------	218.0	--------	--------	--------	--------	--------	Do.
--------	33	60.0	--------	--------	--------	80.0	--------	--------	--------	--------	--------	At Stowe (*79*, p. 94).
--------	32	84.0	5.0	6.0	170	110.0	84.0	--------	--------	--------	--------	Do.
--------	30	53.0	--------	--------	--------	76.0	--------	--------	--------	--------	--------	Do.
--------	50	102.0	10.0	5.0	--------	144.0	--------	--------	--------	--------	--------	Do.
--------	62	143.0	11.0	6.2	299	190.0	140.0	--------	--------	--------	--------	Do.
--------	52	132.0	14.0	--------	--------	204.0	--------	--------	--------	--------	--------	Do.
--------	66	132.0	12.0	5.2	--------	207.0	--------	--------	--------	--------	--------	Do.
--------	78	149.0	14.0	5.7	304	195.0	131.0	--------	--------	--------	--------	Do.
--------	81	150.0	14.0	7.4	--------	196.0	--------	--------	--------	--------	--------	Do.
--------	55	137.0	13.0	6.2	279	179.0	134.0	--------	--------	--------	--------	Do.
--------	64	168.0	10.0	8.1	--------	210.0	--------	--------	--------	--------	--------	Do.
--------	72	174.0	11.0	9.0	--------	214.0	--------	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	17.0	17.0	--------	--------	At Pottstown (*22*, p. 13).
--------	--------	--------	--------	--------	--------	--------	--------	44.0	54.0	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	39.0	26.0	--------	--------	Do.
--------	45	221.0	11.0	6.6	393	258.0	221.0	--------	--------	--------	--------	At Pottstown (*61*, p. 45).
--------	30	92.0	5.1	4.6	178	115.0	90.0	--------	--------	--------	--------	Do.
--------	--------	--------	--------	--------	--------	--------	--------	40.0	35.0	--------	--------	At Pottstown (*22*, p. 13).
--------	--------	--------	--------	--------	--------	--------	--------	20.0	10.0	--------	--------	Do.

each daily sample collected before admixing the daily samples to form the composite sample. The water analyses were made in the Geological Survey laboratory, Washington, D. C.

[4] Instantaneous discharge.

*No gaging station.

distance of 59 miles, the alkalinity of the Susquehanna River is enough to neutralize the acid. Moreover, extensive sampling of the Susquehanna River at Danville during a period of several years shows that river to have a *p*H of 6.9 to 7.0. The bicarbonate content of the Susquehanna River shows a decrease from 61 parts per million at Falls before entering the anthracite region to 37 parts per million at Danville. The sulfate content of the river shows an increase from 17 parts per million at Falls to 72 parts per million at Danville (*22*, *61*). (*See* table 9.)

Between Danville and Harrisburg four creeks carrying acid mine water from the Western Middle and Southern fields flow into the Susquehanna River but are neutralized by the alkaline water in the Susquehanna and its tributaries entering from the area west of the river. At Harrisburg the river samples over a period of several years show a *p*H between 6.8 and 7.2. The bicarbonate content of the river shows an increase to 53 parts per million and the sulfate content a decrease to 24 parts per million. (*See* table 9.) The change in sulfate content of the Susquehanna River cannot be directly related to any particular source because even the alkaline tributaries between Sunbury and Harrisburg contain much more sulfate (parts per million) than the main river (*61*).

The Lehigh River receives acid mine waters in creeks from the Eastern Middle and Southern fields between Rockfort and Mauch Chunk. The river at Rockfort has a *p*H of 6.0 to 7.3 but is slightly alkaline. (*See* table 9.) After receiving the inflow of three creeks containing acid mine water (*p*H, 3.1 to 3.9) the Lehigh River appears slightly acid (*p*H, 4.5) at Lehighton. This acid is neutralized by alkaline water from tributaries of the Lehigh River below Lehighton so that samples collected at Catasauqua and Bethlehem show slightly alkaline water having a *p*H of 6.6 to 7.6 (*22*). (*See* table 9.)

The Little Schuylkill River has its source in the Southern field, and all samples taken in the river show it to be acid from its source at Tamaqua to its confluence with the Schuylkill at Port Clinton (*22*, *79*). (*See* table 9.)

The Schuylkill River rises in the Southern field at Tuscarora and receives acid mine water from mine-pump discharges and creeks until it leaves the field at Cressona. Samples of the river show it to have a *p*H of 3.2 to 4.6 throughout this distance. It continues to be acid until Maiden Creek enters the river just below Leesport. This alkaline stream (*p*H, 7.0 to 8.0) neutralizes the acid in the river. From Leesport to Pottstown, the river water becomes more alkaline. The flow in the Schuylkill River at Leesport ranges from 114 to 1,700 second-feet, and the flow in Maiden Creek ranges from 39 to 675 second-feet (*22*, *79*). (*See* table 9.)

QUALITY AND CHARACTER OF ANTHRACITE MINE WATER

DEFINITION AND EXPLANATION OF *p*H

The exact significance of *p*H is still in dispute (*44*). It is commonly considered to be, as defined by Sørenson (*13, 60, 63*), the negative logarithm of the number of moles (gram-atoms) of ionized hydrogen per liter of water. Others interpret it as the negative logarithm of the "activity" of the hydrogen ions in a solution. Exactly, neither is correct (*38*), but the experimental determination of *p*H continues to offer valuable information as to the immediate acidity as contrasted with the total acidity of a solution, which may be titrated. The *p*H scale ranges from 0 to 14, *p*H 0.0 expressing the hydrogen-ion concentration of a 1.0 normal, completely dissociated acid and *p*H 14.0 expressing the hydrogen-ion concentration of a 1.0 normal, completely dissociated base (*51*).

Pure water is chemically neutral and theoretically has a *p*H of 7. Solutions having a *p*H ranging from 0 to 7 are acid, and those having a *p*H ranging from 7+ to 14 are alkaline. The *p*H of distilled water is 5.7; distilled water always is acid because it absorbs carbon dioxide from the air (*37*). Each unit of the *p*H scale (by whole numbers) represents a hydrogen-ion concentration 10 times greater than the *p*H unit below and one-tenth as great as the *p*H unit above. Hydrogen-ion concentrations that are uneven decimal fractions of mole per liter also can be expressed in *p*H units.

METHODS OF ANALYSIS

Free acidity or alkalinity of mine-water samples collected by the Bureau of Mines (*22*) was determined by titration at room temperature, utilizing methyl-red indicator. Total acidity or alkalinity was determined by titration at boiling temperatures, utilizing phenolphthalein indicator. Complete details of the analytical procedure are described in the original publication (*22*), from which tables 10 to 13 were derived.

A glass-electrode *p*H tester was used to determine *p*H values at room temperature (approximately 70° F.).

Mine-water discharges were collected at drainage-tunnel portals and at pump-discharge points by grab samples. The stream samples shown in table 9 were collected by the Bureau of Mines in 1941 by cross-section sampling; some stream samples collected in 1946 were obtained only in the middle of a stream (*22*). Analytical results, therefore, show the conditions of mine waters and streams on a particular day; the technique of pooled sampling (*20*) was never employed.

Studies of acid mine drainage in the anthracite region were conducted by the Bureau of Mines in 1941, 1942, 1946, and 1948. Some results of these investigations were published in 1948 and 1949 (*4, 22*).

Calculations for determining the average *p*H of all mine drainage in 1941 and a portion of the mine drainage in 1946 from the four anthracite fields are shown in tables 10 to 13, which also show the free acidity (methyl-red indicator) and total acidity (phenolphthalein indicator) or alkalinity (methyl-red indicator) and alkalinity (phenolphthalein indicator) of each mine and tunnel discharge sampled during that study. Tables 14 and 15 summarize the average *p*H and the acid loads of the mine-water discharges and drainage-tunnel discharges in each of the four anthracite fields and for the entire anthracite region. Numerical values of hydrogen-ion concentrations to the nearest whole number times 10^7, shown in tables 10 to 13 and used in computing the average *p*H, were derived mathematically from the expression of Sørenson's definition of $pH=\log\frac{1}{(H^+)}$.

The samples reported in tables 10 to 13 represent a daily total of 1,807,719 short tons or 301,400 gallons a minute of mine water discharged into the receiving streams in the anthracite region in 1941. Ash and others (*5*) report the average mine-water discharge as 327,000 g. p. m. for 1944 to 1948, inclusive. Tables 10 to 15 show a comparison of *p*H, free acidity, and total acidity determined in analyses of mine waters sampled in comparative mines in 1941 and again in 1946. It is apparent that the character of the waters remained essentially the same. Therefore, it may be assumed that the average chemical quality of the mine waters at present in the four different fields and in the entire anthracite region is well represented by the results obtained in the 1941 survey and summarized in table 14.

954704—51——4

TABLE 10.—*Compilation of information on volume, pH, free-acid loads, and total-acid loads of mine-water discharges, 1941* [1]

NORTHERN FIELD

Colliery	Discharge volume, gallons per minute	*p*H	$(H^+)\times10^7$	Product, gallons per minute × $(H^+)\times10^7$	Total weight of water per day, short tons	Load per day, short tons		Load per day, short tons	
						Alkalinity as $CaCo_3$[2]	Alkalinity as $CaCO_3$[3]	Free acidity as H_2SO_4[2]	Total acidity as H_2SO_4[3]
Lackawanna Basin:									
A3a	1, 983	3. 4	3, 981	7, 894, 323	11, 899	--------	--------	0. 73	1. 54
A5a	2, 376	3. 2	6, 310	14, 992, 560	14, 255	--------	--------	2. 10	4. 60
A7a	2, 651	2. 9	12, 589	33, 373, 439	15, 906	--------	--------	5. 65	8. 37
A13a	8, 552	3. 0	10, 000	85, 520, 000	51, 309	--------	--------	13. 12	26. 60
A15a	1, 675	2. 9	12, 589	21, 086, 575	10, 050	--------	--------	3. 12	4. 66
B1	50	3. 7	1, 995	99, 750	300	--------	--------	. 01	. 02
B2	900	6. 2	6	5, 400	5, 400	0. 02	--------	--------	. 07
B3a	3, 208	3. 0	10, 000	32, 080, 000	19, 250	--------	--------	2. 93	6. 57
B4a	6, 110	3. 1	7, 943	48, 531, 730	36, 660	--------	--------	6. 54	15. 12
B5a	7, 438	3. 9	1, 259	9, 364, 442	44, 628	--------	--------	2. 19	5. 64
B6a	8, 246	3. 3	5, 012	41, 328, 952	49, 476	--------	--------	13. 52	31. 52
B7a	9, 629	3. 3	5, 012	48, 260, 548	57, 774	--------	--------	16. 88	57. 98
B8abc	3, 308	2. 7	19, 953	62, 365, 724	19, 848	--------	--------	20. 66	53. 88
E1	603	4. 1	794	478, 782	3, 618	--------	--------	. 13	. 64
E2	2, 500	4. 2	631	1, 577, 500	15, 000	--------	--------	. 17	1. 59
H1f	1, 000	3. 5	3, 162	3, 162, 000	6, 000	--------	--------	. 08	. 20
H1g	1, 000	5. 2	63	63, 000	6, 000	--------	--------	0	. 16
Total basin	61, 229	--------	--------	410, 184, 725	367, 373	. 02	--------	87. 83	219. 16
Average	--------	3. 2	6, 699	--------	--------	--------	--------	--------	--------
Wyoming Basin:									
A1	105	7. 0	1	105	627	. 09	0. 03	--------	--------
A2a	1, 429	2. 8	15, 849	22, 648, 221	8, 576	--------	--------	1. 42	3. 45
A2b	747	6. 1	8	5, 976	4, 482	. 23	. 24	--------	--------
A2c	849	4. 3	501	425, 349	5, 096	--------	--------	. 67	2. 08
A4a	2, 072	6. 5	3	6, 216	12, 430	1. 09	1. 19	--------	--------
A4b	134	7. 4	0	0	804	. 11	. 08	--------	--------
A4c	26	7. 7	0	0	154	. 01	. 01	--------	--------
A6	308	3. 2	6, 310	1, 943, 480	1, 847	--------	--------	. 24	. 63
A8a	585	4. 4	398	232, 830	3, 511	--------	--------	. 41	1. 45
A8b	1, 539	3. 1	7, 943	12, 224, 277	9, 233	--------	--------	2. 03	3. 79
A9a	478	2. 9	12, 589	6, 017, 542	2, 868	--------	--------	. 71	1. 50
A9b	642	3. 6	2, 512	1, 612, 704	3, 850	--------	--------	. 10	. 77
A10a	1, 874	3. 3	5, 012	9, 392, 488	11, 243	--------	--------	3. 57	6. 79
A11a	266	4. 3	501	133, 266	1, 595	. 01	--------	--------	. 16
A11b	551	7. 3	1	551	3, 307	. 89	. 38	--------	--------
A12a	4, 757	2. 8	15, 849	75, 393, 693	28, 542	--------	--------	4. 65	10. 09
A14	749	2. 8	15, 849	11, 870, 901	4, 496	--------	--------	1. 84	3. 63
A16a	374	5. 1	79	29, 546	2, 245	. 09	. 10	--------	--------
A17	491	3. 0	10, 000	4, 910, 000	2, 948	--------	--------	1. 66	3. 19
A18a	333	3. 0	10, 000	3, 330, 000	1, 997	--------	--------	1. 24	2. 38
A18b	2, 084	3. 0	10, 000	20, 840, 000	12, 502	--------	--------	9. 16	15. 95
A18c	15	3. 1	7, 943	119, 145	90	--------	--------	. 01	. 02
A18d	192	3. 2	6, 310	1, 211, 520	1, 151	--------	--------	. 37	. 64
A19a	188	3. 0	10, 000	1, 880, 000	1, 126	--------	--------	. 81	1. 76
A19b	442	2. 8	15, 849	7, 005, 258	2, 653	--------	--------	2. 22	3. 33
A19c	766	2. 8	15, 849	12, 140, 334	4, 596	--------	--------	4. 42	6. 61
A19d	164	2. 9	12, 589	2, 064, 596	985	--------	--------	1. 12	1. 66
A20a	472	3. 6	2, 512	1, 185, 664	2, 831	--------	--------	. 20	. 29
A20b	922	3. 4	3, 981	3, 670, 482	5, 534	--------	--------	1. 49	3. 69
C1a	665	5. 8	16	10, 640	3, 988	. 02	--------	--------	. 46
C2a	1, 230	5. 6	25	30, 750	7, 377	--------	--------	0	. 18
C2b	3, 609	6. 0	10	36, 090	21, 657	. 04	. 17	--------	--------
C3a	2, 101	4. 4	398	836, 198	12, 609	--------	--------	. 46	1. 91
C4a	1, 193	5. 7	20	23, 860	7, 160	--------	--------	0	. 09
C4b	3, 015	5. 9	13	39, 195	18, 087	. 11	--------	--------	. 42

See footnotes at end of table.

TABLE 10.—*Compilation of information on volume, pH, free-acid loads, and total-acid loads of mine-water discharges, 1941* [1]—Continued

NORTHERN FIELD

Colliery	Discharge volume, gallons per minute	*p*H	$(H^+)\times10^7$	Product, gallons per minute × $(H^+)\times10^7$	Total weight of water per day, short tons	Load per day, short tons		Load per day, short tons	
						Alkalinity as $CaCo_3$[2]	Alkalinity as $CaCO_3$[3]	Free acidity as H_2SO_4[2]	Total acidity as H_2SO_4[3]
Wyoming Basin—Continued									
D1a	1, 720	3. 6	2, 512	4, 320, 640	10, 318	--------	--------	3. 30	6. 68
D3	5, 717	5. 7	20	114, 340	34, 304	0. 89	1. 03	--------	--------
D4a	2, 903	6. 5	3	8, 709	17, 419	. 03	. 37	--------	--------
D4b	1, 164	3. 0	10, 000	11, 640, 000	6, 983	--------	--------	2. 62	5. 95
D5	357	3. 7	1, 995	712, 215	2, 144	--------	--------	. 23	. 75
D6	22	6. 5	3	66	134	. 01	. 01	--------	--------
F1a	788	3. 0	10, 000	7, 880, 000	4, 732	--------	--------	1. 01	1. 95
F1b	1, 249	5. 0	100	124, 900	7, 497	. 03	--------	--------	. 12
F2	800	4. 9	126	100, 800	4, 800	--------	--------	. 02	. 30
F3	835	6. 7	2	1, 670	5, 009	. 18	. 21	--------	--------
G1a	1, 327	2. 9	12, 589	16, 705, 603	7, 960	--------	--------	7. 60	13. 73
G1b	680	2. 8	15, 849	10, 777, 320	4, 078	--------	--------	2. 46	4. 04
G1c	850	2. 9	12, 589	10, 700, 650	5, 102	--------	--------	1. 74	3. 49
G2a	1, 992	3. 2	6, 310	12, 569, 520	11, 954	--------	--------	4. 69	10. 19
G2b	3, 035	6. 7	2	6, 070	18, 209	1. 58	. 62	--------	--------
G2c	3, 220	5. 9	13	41, 860	19, 321	. 08	--------	--------	4. 55
G2d	112	6. 5	3	336	670	. 05	. 06	--------	--------
Total basin	62, 138	------	----------	276, 975, 576	372, 831	5. 54	4. 50	62. 47	128. 67
Average	--------	3. 4	4, 457	------------	----------	--------	--------	--------	--------
Total field	123, 367	------	----------	687, 160, 301	740, 204	5. 56	4. 50	150. 30	347. 83
Average	------	3. 2	5, 570	------------	----------	--------	--------	--------	--------

EASTERN MIDDLE FIELD

A1	18	3. 1	7, 943	142, 974	107	--------	--------	0. 04	0. 06
B1a	1, 135	2. 8	15, 849	17, 988, 615	6, 811	--------	--------	6. 29	8. 14
B1b	996	2. 9	12, 589	12, 538, 644	5, 977	--------	--------	4. 77	7. 45
C1	167	3. 6	2, 512	419, 504	1, 000	--------	--------	. 05	. 05
D1	91	4. 2	631	84, 721	549	--------	--------	. 02	. 04
E1	297	3. 5	3, 162	939, 114	1, 781	--------	--------	. 77	1. 23
F1a	1, 667	3. 2	6, 310	10, 518, 770	10, 001	--------	--------	5. 04	8. 00
F1b	394	2. 8	15, 849	6, 244, 506	2, 363	--------	--------	. 89	1. 23
F1c	400	3. 2	6, 310	2, 524, 000	2, 400	--------	--------	. 59	. 89
F1d	100	3. 2	6, 310	631, 000	600	--------	--------	. 07	. 10
G1a	1, 133	3. 0	10, 000	11, 330, 000	6, 800	--------	--------	3. 07	4. 51
G1b	1, 000	3. 4	3, 981	3, 981, 000	6, 000	--------	--------	. 57	. 88
I1	200	3. 6	2, 512	502, 400	1, 200	--------	--------	. 02	. 04
J1	1, 000	3. 1	7, 943	7, 943, 000	6, 000	--------	--------	2. 01	3. 67
K1	583	3. 2	6, 310	3, 678, 730	3, 500	--------	--------	. 60	1. 07
Total field	9, 181	------	----------	79, 466, 978	55, 089	--------	--------	24. 80	37. 36
Average	--------	3. 1	8, 656	------------	----------	--------	--------	--------	--------

WESTERN MIDDLE FIELD

B1	1, 000	3. 5	3, 162	3, 162, 000	6, 000	--------	--------	0. 82	2. 77
C1	3, 000	4. 1	794	2, 382, 000	18 000	--------	--------	1. 90	6. 42
D1a	1, 296	2. 4	39, 811	51, 595, 056	7 777	--------	--------	3. 52	5. 61
D1b	834	2. 5	31, 623	26, 373, 582	5, 004	--------	--------	1. 92	7. 44
D1c	549	2. 2	63. 096	34, 639, 704	3, 294	--------	--------	3. 17	5. 02
D2	150	6. 0	10	1. 500	900	0	0. 05	--------	--------
D3a	100	2. 1	79, 433	7, 943, 300	600	--------	--------	. 65	1. 09
D3b	3, 000	5. 5	32	96, 000	18, 000	0. 17	--------	--------	5. 66

See footnotes at end of table.

TABLE 10.—*Compilation of information on volume, pH, free-acid loads, and total-acid loads of mine-water discharges, 1941* [1]—Continued

NORTHERN FIELD

Colliery	Discharge volume, gallons per minute	*p*H	$(H^+) \times 10^7$	Product, gallons per minute $\times (H^+) \times 10^7$	Total weight of water per day, short tons	Load per day, short tons		Load per day, short tons	
						Alkalinity as $CaCo_3$[2]	Alkalinity as $CaCO_3$[3]	Free acidity as H_2SO_4[2]	Total acidity as H_2SO_4[3]
D4	20	2.5	31,623	632,460	120			0.03	0.05
D5	150	4.3	501	75,150	900			.02	.97
D6a	2,000	2.9	12,589	25,178,000	12,000			4.86	7.04
D6b	2,500	2.5	31,623	79,057,500	15,000			4.29	5.55
D7	318	2.7	19,953	6,345,054	1,908			.70	2.54
D8	500	3.3	5,012	2,506,000	3,000			.71	2.60
D9a	1,965	5.1	79	155,235	11,787			.09	4.60
D10	359	3.5	3,162	1,135,158	2,155			.25	1.10
D11	1,000	2.9	12,589	12,589,000	6,000			.66	1.18
D12	266	2.9	12,589	3,348,674	1,597			.57	1.52
D13	79	2.4	39,811	3,145,069	475			.20	.32
D14	2,100	4.2	631	1,325,100	12,600			1.63	12.24
D15a	2,959	2.6	25,119	74,327,121	17,754			7.79	24.19
D16a	1,334	3.1	7,943	10,595,962	8,000			2.91	6.73
D17	1,052	4.1	794	835,288	6,311			.08	1.55
D18	1,021	4.9	126	128,646	6,123	.13			1.91
D19a	1,272	6.4	4	5,088	7,633	1.23	.50		
D19b	202	6.4	4	808	1,214	.03	.04		
D20	500	5.2	63	31,500	3,000	.12			.35
D21a	1,638	2.7	19,953	32,683,014	9,827			1.29	3.12
D22	2,486	3.6	2,512	6,244,832	14,918			1.08	7.01
D23a	2,973	5.7	20	59,460	17,838	2.03	1.80		
D24	500	3.3	5,012	2,506,000	3,000			.27	.74
D25	1,883	3.6	2,512	4,730,096	11,300			1.25	7.41
E1a	3,035	3.1	7,943	24,107,005	18,209			4.43	13.11
Total field	42,041			417,940,362	252,244	3.71	2.39	45.09	139.84
Average		3.0	9,941						

SOUTHERN FIELD

Colliery	Discharge volume, gallons per minute	*p*H	$(H^+) \times 10^7$	Product, gallons per minute $\times (H^+) \times 10^7$	Total weight of water per day, short tons	Alkalinity as $CaCo_3$[2]	Alkalinity as $CaCO_3$[3]	Free acidity as H_2SO_4[2]	Total acidity as H_2SO_4[3]
A1	500	2.7	19,953	9,976,500	3,000			1.20	2.02
A3a	875	4.5	316	276,500	5,250			.08	1.59
A3b	2,500	2.3	50,119	125,297,500	15,000			5.08	9.06
A4	1,500	3.2	6,310	9,465,000	9,000			1.14	3.02
A5a	2,000	5.3	50	100,000	12,000	0.13			2.39
A5b	1,500	6.2	6	9,000	9,000			0	.05
A6	150	4.5	316	47,400	900			0	.01
A7a	1,000	6.1	8	8,000	6,000	.43	0.34		
A7b	1,500	5.9	13	19,500	9,000			.05	.07
A8	500	2.9	12,589	6,294,500	3,000			.10	.16
A9	150	4.4	398	59,700	900			0	.01
A10	1,731	6.9	1	1,731	10,385	1.65	1.03		
A11a	2,000	5.2	63	126,000	12,000	.05			.06
A11b	250	2.9	12,589	3,147,250	1,500			.08	.13
A11c	150	2.5	31,623	4,743,450	900			.23	.28
A11d	4,500	2.8	15,849	71,320,500	27,000			4.95	9.48
A12	1,340	6.3	5	6,700	8,040	.39	.31		
A13	150	3.5	3,162	474,300	900			.02	.04
A14	1,000	6.8	2	2,000	6,000	.05	.04		
A15	1,200	4.0	1,000	1,200,000	7,200			.47	4.07
A16	500	5.9	13	6,500	3,000	.51	.28		
A17a	300	2.9	12,589	3,776,700	1,800			.29	.36
A17b	300	2.8	15,849	4,754,700	1,800			.40	.58
B1a	504	3.9	1,259	634,536	3,022			.47	1.75
B2a	933	2.9	12,589	11,745,537	5,597			5.64	11.63
B3a	1,185	3.6	2,512	2,976,720	7,107			1.87	7.43

See footnotes at end of table.

TABLE 10.—*Compilation of information on volume, pH, free-acid loads, and total-acid loads of mine-water discharges, 1941* [1]—Continued

SOUTHERN FIELD—Continued

Colliery	Discharge volume, gallons per minute	*p*H	$(H^+)\times10^7$	Product, gallons per minute $\times$ $(H^+)\times10^7$	Total weight of water per day, short tons	Load per day, short tons		Load per day, short tons	
						Alkalinity as $CaCo_3$[2]	Alkalinity as $CaCO_3$[3]	Free acidity as H_2SO_4[2]	Total acidity as H_2SO_4[3]
B4a	147	5. 4	40	5, 880	885	0. 02			0. 22
B4b	147	4. 4	398	58, 506	885	. 02			. 31
B4c	147	5. 7	20	2, 940	885	. 02			. 23
B4d	147	5. 9	13	1, 911	885	. 02			. 26
B4e	147	3. 1	7, 943	1, 167, 621	885			0. 90	1. 77
B5a	700	3. 0	10, 000	7, 000, 000	4, 195			2. 28	4. 00
B5b	242	3. 2	6, 310	1, 527, 020	1, 451			. 75	1. 72
B7a	1, 560	4. 4	398	620, 880	9, 360			0	. 05
B8a	1, 934	2. 9	12, 589	24, 347, 126	11, 605			6. 53	11. 86
D1a	2, 492	2. 6	25, 119	62, 596, 548	14, 954			8. 94	16. 56
D1c	997	3. 4	3, 981	3, 969, 057	5, 982			1. 18	2. 98
D1d	300	2. 7	19, 953	5, 985, 900	1, 795			4. 13	6. 20
E1	1, 200	3. 4	3, 981	4, 777, 200	7, 200			3. 34	7. 62
F1	1, 000	6. 5	3	3, 000	6, 000	. 82	0. 59		
G1	500	3. 2	6, 310	3, 155, 000	3, 000			. 49	. 90
H1	150	2. 9	12, 589	1, 888, 350	900			. 18	. 25
I1a	4, 000	2. 3	50, 119	200, 476, 000	24, 000			10. 35	17. 40
I1b	1, 000	2. 3	50, 119	50, 119, 000	6, 000			3. 15	5. 23
I1c	700	2. 5	31, 623	22, 136, 100	4, 200			3. 14	4. 67
J1a	200	5. 5	32	6, 400	1, 200			. 02	. 24
J1b	2, 500	3. 8	1, 585	3, 962, 500	15, 000	. 06			. 05
K1	400	5. 1	79	31, 600	2, 400			. 15	. 44
L1a	150	3. 9	1, 259	188, 850	900			0	. 03
L1b	150	2. 6	25, 119	3, 767, 850	900			. 27	. 42
L1c	400	2. 6	25, 119	10, 047, 600	2, 400			. 74	1. 13
L1d	150	2. 8	15, 849	2, 377, 350	900			. 11	. 24
M1	100	5. 0	100	10, 000	600			0	. 03
N1a	218	4. 7	200	43, 600	1, 309	. 01			1. 19
O1a	1, 800	6. 9	1	1, 800	10, 800	. 67	. 55		
O1b	2, 991	6. 8	2	5, 982	17, 945	0	. 07		
Total field	54, 787			666, 751, 795	328, 722	4. 85	3. 21	68. 72	140. 19
Average		2. 9	12, 170						

ANTHRACITE REGION

Total region	229, 376			1, 851, 319, 436	1, 376, 259	14. 12	10. 10	288. 91	665. 22
Average		3. 1	8, 071						

NORTHERN, WESTERN MIDDLE, AND SOUTHERN FIELDS

Total	220, 195			1, 771, 852, 458	1, 321, 170	14. 12	10. 10	264. 11	627. 86
Average		3. 1	8, 047						

[1] Ref. *22*, table 8.
[2] Methyl-red indicator.
[3] Phenolphthalein indicator.

TABLE 11.—*Compilation of available information on volume, pH, free-acid loads, and total-acid loads of mine-water discharges, 1946* [1]

NORTHERN FIELD

Colliery	Discharge volume, gallons per minute	pH	$(H^+)\times 10^7$	Product, gallons per minute $\times (H^+)\times 10^7$	Total weight of water per day, short tons	Load per day, short tons		Load per day, short tons	
						Alkalinity as $CaCO_3$[2]	Alkalinity as $CaCO_3$[3]	Free acidity as H_2SO_4[2]	Total acidity as H_2SO_4[3]
Lackawanna Basin:									
A3A	4, 420	3. 3	5, 012	22, 153, 040	26, 521	------	------	2. 72	4. 42
A5a	2, 724	3. 3	5, 012	13, 652, 688	16, 342	------	------	1. 52	2. 24
A7a	5, 808	3. 1	7, 943	46, 132, 944	34, 853	------	------	7. 52	11. 96
A13a	10, 389	3. 0	10, 000	103, 890, 000	62, 332	------	------	14. 66	24. 74
A15a	2, 107	2. 9	12, 589	26, 525, 023	12, 643	------	------	2. 97	5. 15
A22	1, 322	3. 3	5, 012	6, 625, 864	7, 933	------	------	. 66	1. 01
B3a	9, 000	3. 3	5, 012	45, 108, 000	54, 000	------	------	7. 67	13. 76
B4a	4, 500	2. 9	12, 589	56, 650, 500	27, 000	------	------	3. 18	6. 62
B5a	7, 000	3. 8	1, 585	11, 095, 000	42, 000	------	------	1. 23	1. 65
B7a	24, 000	3. 1	7, 943	190, 632, 000	144, 000	------	------	22. 58	42. 34
B8d	3, 000	2. 8	15, 849	47, 547, 000	18, 000	------	------	7. 14	14. 20
Total basin	74, 270	------	----------	570, 012, 059	445, 624	------	------	71. 85	128. 11
Average	--------	3. 1	7, 675	----------	----------	------	------	------	------
Wyoming Basin:									
A2a	2, 745	4. 7	200	549, 000	16, 471	------	------	1. 05	1. 94
A4a	5, 537	7. 0	1	5, 537	33, 221	------	------	1. 14	2. 44
A10a	1, 625	3. 9	1, 259	2, 045, 875	9, 751	------	------	3. 97	6. 35
A12a	4, 514	4. 5	316	1, 426, 424	27, 083	------	------	1. 86	3. 71
A18b	3, 440	3. 0	10, 000	34, 400, 000	20, 639	------	------	12. 95	16. 89
A20b	681	3. 0	10, 000	6, 810, 000	4, 084	------	------	2. 22	4. 13
C1a	1, 675	3. 1	7, 943	13, 304, 525	10, 050	------	------	1. 58	7. 10
C2a	1, 184	3. 3	5, 012	5, 934, 208	7, 102	------	------	. 59	1. 08
C2b	1, 158	3. 3	5, 012	5, 803, 896	6, 950	------	------	. 65	. 99
C2c	1, 720	7. 2	1	1, 720	10, 318	0. 36	0. 36	------	------
C2d	3, 350	6. 6	3	10, 050	20, 100	. 90	. 90	------	------
C3a	2, 345	3. 9	1, 259	2, 952, 355	14, 070	------	------	1. 59	3. 11
C4a	737	3. 5	3, 162	2, 350, 394	4, 422	------	------	. 30	. 54
C4b	804	6. 3	5	4, 020	4, 824	. 36	. 27	------	------
C4c	2, 345	6. 1	8	18, 760	14, 070	. 77	. 63	------	------
G1ab	3, 178	2. 8	15, 849	50, 368, 122	19, 070	------	------	10. 18	18. 87
G1c	1, 049	3. 0	10, 000	10, 490, 000	6, 296	------	------	1. 23	2. 34
I1a	7, 145	3. 1	7, 943	56, 752, 735	42, 869	------	------	2. 94	5. 25
Total basin	45, 232	------	----------	193, 227, 621	271, 390	2. 39	2. 16	42. 25	74. 74
Average	--------	3. 4	4, 272	----------	----------	------	------	------	------
Total field	119, 502	------	----------	763, 239, 680	717, 014	2. 39	2. 16	114. 10	202. 85
Average	--------	3. 2	6, 387	----------	----------	------	------	------	------

See footnotes at end of table.

TABLE 11.—*Compilation of available information on volume, pH, free-acid loads, and total-acid loads of mine-water discharges, 1946* [1]—Continued

WESTERN MIDDLE FIELD

Colliery	Discharge volume, gallons per minute	pH	$(H^+)\times10^7$	Product, gallons per minute $\times$ $(H^+)\times10^7$	Total weight of water per day, short tons	Load per day, short tons		Load per day, short tons	
						Alkalinity as $CaCO_3$ [2]	Alkalinity as $CaCO_3$ [3]	Free acidity as H_2SO_4 [2]	Total acidity as H_2SO_4 [3]
D1a	1, 564	2. 8	15, 849	24, 787, 836	9, 383			2. 48	5. 98
D1b	1, 072	3. 2	6, 310	6, 764, 320	6, 434			63	1. 26
D3b	2, 250	6. 1	8	18, 000	13, 500	1. 69	0. 27		
D9a	2, 115	6. 0	10	21, 150	12, 690	. 38	. 63		
D15a	1, 842	3. 1	7, 943	14, 631, 006	11, 052			4. 39	7. 53
D16a	5, 237	3. 4	3, 981	20, 848, 497	31, 422			15. 55	25. 40
D21a	2, 310	4. 0	1, 000	2, 310, 000	13, 861			. 54	1. 70
D23a	1, 201	5. 3	50	60, 050	7, 206			. 22	1. 91
E1a	4, 146	3. 1	7, 943	32, 931, 678	24, 872			8. 16	14. 87
E1b	134	6. 9	1	134	804	. 06	. 04		
E1c	291	4. 1	794	231, 054	1, 746			. 05	. 08
Total field	22, 162			102, 603, 725	132, 970	2. 13	. 94	32. 02	58. 73
Average		3. 3	4, 630						

SOUTHERN FIELD

Colliery	Discharge volume, gallons per minute	pH	$(H^+)\times10^7$	Product, gallons per minute $\times$ $(H^+)\times10^7$	Total weight of water per day, short tons	Alkalinity as $CaCO_3$ [2]	Alkalinity as $CaCO_3$ [3]	Free acidity as H_2SO_4 [2]	Total acidity as H_2SO_4 [3]
A18	3, 900	3. 4	3, 981	15, 525, 900	23, 400			5. 62	8. 49
B1a	732	3. 9	1, 259	921, 588	4, 393			. 92	2. 45
B2a	905	2. 8	15, 849	14, 343, 345	5, 428			3. 88	7. 58
B3a	1, 261	3. 1	7, 943	10, 016, 123	7, 566			3. 08	5. 04
B4i	851	3. 0	10, 000	8, 510, 000	5, 104			6. 13	10. 48
B5a	442	2. 5	31, 623	13, 977, 366	2, 651			. 82	1. 52
B5b	201	3. 0	10, 000	2, 010, 000	1, 209			. 53	. 89
B7a	774	4. 1	794	614, 556	4, 644			. 50	1. 09
B8a	2, 219	3. 2	6, 310	14, 001, 890	13, 316			3. 59	5. 48
C1	500	6. 3	5	2, 500	3, 000	0. 36	0. 57		
Total field	11, 785			79, 923, 268	70, 711	. 36	. 57	25. 07	43. 02
Average		3. 2	6, 782						

NORTHERN, WESTERN MIDDLE, AND SOUTHERN FIELDS

Colliery	Discharge volume, gallons per minute	pH	$(H^+)\times10^7$	Product, gallons per minute $\times$ $(H^+)\times10^7$	Total weight of water per day, short tons	Alkalinity as $CaCO_3$ [2]	Alkalinity as $CaCO_3$ [3]	Free acidity as H_2SO_4 [2]	Total acidity as H_2SO_4 [3]
Total	153, 449			945, 766, 673	920, 695	4. 88	3. 67	171. 19	304. 60
Average		3. 2	6, 163						

[1] Ref. 22, table 8. [2] Methyl-red indicator. [3] Phenolphthalein indicator.

TABLE 12.—*Compilation of information on volume, pH, free-acid loads, and total-acid loads of mine water from drainage tunnels, 1941*

Colliery	Discharge volume, gallons per minute	pH	$(H^+)\times10^7$	Product, gallons per minute $\times (H^+)\times10^7$	Total weight of water per day, short tons	Load per day, short tons		Load per day, short tons	
						alkalinity as $CaCO_3$ [1]	alkalinity as $CaCO_3$ [2]	Free acidity as H_2SO_4 [1]	Total acidity as H_2SO_4 [2]
NORTHERN FIELD									
Lackawanna Basin:									
1	6, 500	3. 1	7, 943	51, 629, 500	39, 000			2. 64	10. 05
3	3, 000	4. 1	794	2, 382, 000	18, 000			. 60	2. 14
Total basin	9, 500			54, 011, 500	57, 000			3. 24	12. 19
Average		3. 3	5, 685						
Wyoming Basin	5, 000	2. 3	50, 119	250, 595, 000	30, 000			9. 14	18. 67
Total field	14, 500			304, 606, 500	87, 000			12. 38	30. 86
Average		2. 7	21, 007						
EASTERN MIDDLE FIELD									
1	3, 011	2. 9	12, 589	37, 904, 479	18, 070			11. 76	17. 25
2	1, 930	3. 1	7, 943	15, 329, 990	11, 578			3. 23	4. 72
3	7, 300	3. 0	10, 000	73, 000, 000	43, 800			20. 34	29. 83
4	11, 900	3. 1	7, 943	94, 521, 700	71, 400			42. 68	65. 70
5	3, 000	3. 2	6, 310	18, 930, 000	18, 000			3. 90	5. 43
6	2, 500	2. 9	12, 589	31, 472, 500	15, 000			7. 70	10. 79
7	5, 000	3. 1	7, 943	39, 715, 000	30, 000			7. 20	11. 71
8	1, 500	3. 1	7, 943	11, 914, 500	9, 000			2. 70	3. 78
9	500	2. 8	15, 849	7, 924, 500	3, 000			3. 31	3. 95
Total field	36, 641			330, 713, 669	219, 848			102. 82	153. 16
Average		3. 0	9, 026						
WESTERN MIDDLE FIELD									
1	3, 000	5. 5	32	96, 000	18, 000			2. 05	5. 66
2	5, 000	2. 6	25, 119	125, 595, 000	30, 000			16. 49	32. 31
3	1, 169	2. 2	63, 096	73, 759, 224	7, 012			4. 45	7. 25
4	3, 000	2. 4	39, 811	119, 433, 000	18, 000			15. 70	40. 71
Total field	12, 169			318, 883, 224	73, 012			38. 69	85. 93
Average		2. 6	26, 205						
SOUTHERN FIELD									
1	50	2. 8	15, 849	792, 450	300			0. 16	0. 23
2	200	5. 6	25	5, 000	1, 200			0	. 01
3	50	6. 3	5	250	300	0. 01	0. 01		
4	500	3. 1	7, 943	3, 971, 500	3, 000			1. 14	2. 01
5	100	6. 2	6	600	600	. 02	. 02		
6	700	4. 3	501	350, 700	4, 200			. 12	. 94
7	7, 000	4. 4	398	2, 786, 000	42, 000			1. 07	5. 64
Total field	8, 600			7, 906, 500	51, 600	. 03	. 03	2. 49	8. 83
Average		4. 0	919						
ANTHRACITE REGION									
Total	71, 910			962, 109, 893	431, 460	0. 03	0. 03	156. 38	278. 78
Average		2. 9	13, 379						
NORTHERN, WESTERN MIDDLE, AND SOUTHERN FIELDS									
Total	35, 269			631, 396, 224	211, 612	0. 03	0. 03	53. 56	125. 62
Average		2. 8	17, 902						

[1] Methyl-red indicator.
[2] Phenolphthalein indicator.

TABLE 13.—*Compilation of available information on volume, pH, free-acid loads, and total-acid loads of mine water from drainage tunnels, 1946*

Colliery	Discharge volume, gallons per minute	pH	$(H^+)\times10^7$	Product, gallons per minute $\times (H^+)\times10^7$	Total weight of water per day, short tons	Load per day, short tons		Load per day, short tons	
						alkalinity as $CaCO_3$ [1]	alkalinity as $CaCO_3$ [2]	Free acidity as H_2SO_4 [1]	Total acidity as H_2SO_4 [2]
NORTHERN FIELD									
Lackawanna Basin:									
1	300	3. 7	1, 995	598, 500	1, 800			0. 13	0. 23
3	5, 000	4. 4	398	1, 990, 000	30, 000			. 74	1. 03
Total basin	5, 300			2, 588, 500	31, 800			. 87	1. 26
Average		4. 3	488						
Wyoming Basin:									
2	5, 000	3. 2	6, 310	31, 550, 000	30, 000			5. 15	8. 82
Total field	10, 300			34, 138, 500	61, 800			6. 02	10. 08
Average		3. 5	3, 314						
EASTERN MIDDLE FIELD									
1	2, 992	2. 9	12, 589	37, 666, 288	17, 956			8. 45	12. 94
2	1, 930	3. 3	5, 012	9, 673, 160	11, 578			1. 71	2. 04
4	11, 400	2. 9	12, 589	143, 514, 600	68, 400			34. 53	56. 98
Total	16, 322			190, 854, 048	97, 934			44. 69	71. 96
Average		2. 9	11, 693						
WESTERN MIDDLE FIELD									
3	1, 802	2. 8	15, 849	28, 559, 898	10, 809			2. 07	8. 90
4	3, 632	2. 9	12, 589	45, 723, 248	21, 792			14. 63	27. 87
Total	5, 434			74, 283, 146	32, 601			16. 70	36. 77
Average		2. 9	13, 670						
SOUTHERN FIELD									
7	7, 000	4. 2	631	4, 417, 000	42, 000			2. 26	3. 09
Total	7, 000			4, 417, 000	42, 000			2. 26	3. 09
Average		4. 2	631						
ANTHRACITE REGION									
Total	39, 056			303, 692, 694	234, 335			69. 67	121. 90
Average		3. 1	7, 776						
NORTHERN, WESTERN MIDDLE, AND SOUTHERN FIELDS									
Total	22, 734			112, 838, 646	136, 401			24. 98	49. 94
Average		3. 3	4, 963						

[1] Methyl-red indicator.
[2] Phenolphthalein indicator.

TABLE 14.—*Summary of information on volume, pH, and acid loads of mine water discharged daily from anthracite region, 1941*

Field	Mine discharges							Drainage-tunnel discharges							Mine and drainage-tunnel discharges						
	Volume of water, gallons per minute	Average *p*H	Weight of water, short tons	Load per day (short tons)				Volume of water, gallons per minute	Average *p*H	Weight of water, short tons	Load per day (short tons)				Volume of water, gallons per minute	Average *p*H	Weight of water, short tons	Load per day (short tons)			
				Alkalinity as $CaCO_3$[1]	Alkalinity as $CaCO_3$[2]	Free acidity as H_2SO_4[1]	Total acidity as H_2SO_4[2]				Alkalinity as $CaCO_3$[1]	Alkalinity as $CaCO_3$[2]	Free acidity as H_2SO_4[1]	Total acidity as H_2SO_4[2]				Alkalinity as $CaCO_3$[1]	Alkalinity as $CaCO_3$[2]	Free acidity as H_2SO_4[1]	Total acidity as H_2SO_4[2]
Northern	123, 367	3. 2	740, 204	5. 56	4. 50	150. 30	347. 83	14, 500	2. 7	87, 000	-------	-------	12, 38	30. 86	137, 867	3. 1	827, 204	5. 56	4. 50	162. 68	378. 69
Eastern Middle	9, 181	3. 1	55, 089	-------	-------	24. 80	37. 36	36, 641	3. 0	219, 848	-------	-------	102. 82	153. 16	45, 822	3. 1	274, 937	-------	-------	127. 62	190. 52
Western Middle	42, 041	3. 0	252, 244	3. 71	2. 39	45. 09	139. 84	12, 169	2. 6	73, 012	-------	-------	38. 69	85. 93	54, 210	2. 9	325, 256	3. 71	2. 39	83. 78	225. 77
Southern	54, 787	2. 9	328, 722	4. 85	3. 21	68. 72	140. 19	8, 600	4. 0	51, 600	0. 03	0. 03	2. 49	8. 83	63, 387	3. 0	380, 322	4. 88	3. 24	71. 21	149. 02
All fields	229, 376	3. 1	1, 376, 259	14. 12	10. 10	288. 91	665. 22	71, 910	2. 9	431, 460	. 03	. 03	156. 38	278. 78	301, 286	3. 0	1, 807, 719	14. 15	10. 13	445. 29	944. 00
Northern, Western Middle, Southern.	220, 195	3. 1	1, 321, 170	14. 12	10. 10	264. 11	627. 86	35, 269	2. 8	211, 612	. 03	. 03	53. 56	125. 62	255, 464	3. 0	1, 532, 782	14. 15	10. 13	317, 67	753. 48

[1] Methyl-red indicator.
[2] Phenolphthalein indicator.

TABLE 15.—*Summary of information on volume, pH, and acid loads of mine water discharged daily from anthracite region, 1946*

Field	Mine discharges							Drainage tunnel discharges							Mine and drainage tunnel discharges						
	Volume of water, gallons per minute	Average *p*H	Weight of water, short tons	Load per day (short tons)				Volume of water, gallons per minute	Average *p*H	Weight of water, short tons	Load per day (short tons)				Volume of water, gallons per minute	Average *p*H	Weight of water, short tons	Load per day (short tons)			
				Alkalinity as $CaCO_3$[1]	Alkalinity as $CaCO_3$[2]	Free acidity as H_2SO_4[1]	Total acidity as H_2SO_4[2]				Alkalinity as $CaCO_3$[1]	Alkalinity as $CaCO_3$	Free acidity as H_2SO_4[1]	Total acidity as H_2SO_4[2]				Alkalinity as $CaCO_3$[1]	Alkalinity as $CaCO_3$[2]	Free acidity as H_2SO_4[1]	Total acidity as H_2SO_4[2]
Northern	119, 502	3. 2	717, 014	2. 39	2. 16	114. 10	202. 85	10, 300	3. 5	61, 800	-------	-------	6. 02	10. 08	129, 802	3. 2	778, 814	2. 39	2. 16	120. 12	212. 93
Eastern Middle	-------	-------	-------	-------	-------	-------	-------	16, 322	2. 9	97, 934	-------	-------	44. 69	71. 96	16, 322	2. 9	97, 934	-------	-------	44. 69	71. 96
Western Middle	22, 162	3. 3	132, 970	2. 13	. 94	32. 02	58. 73	5, 434	2. 9	32, 601	-------	-------	16. 70	36. 77	27, 596	3. 2	165, 571	2. 13	. 94	48. 72	95. 50
Southern	11, 785	3. 2	70, 711	. 36	. 57	25. 07	43. 02	7, 000	4. 2	42, 000	-------	-------	2. 26	3. 09	18, 785	3. 3	112, 711	. 36	. 57	27. 33	46. 11
All fields	153, 449	3. 2	920, 695	4. 88	3. 67	171. 19	304. 60	39, 056	3. 1	234, 335	-------	-------	69. 67	121. 90	192, 505	3. 2	1, 155, 030	4. 88	3. 67	240. 86	426. 50
Northern, Western Middle, Southern.	153, 449	3. 2	920, 695	4. 88	3. 67	171. 19	304. 60	22, 734	3. 3	136, 401	-------	-------	24. 98	49. 94	176, 183	3. 2	1, 057, 096	4. 88	3. 67	196. 17	354. 54

[1] Methyl-red indicator.
[2] Phenolphthalein indicator.

Table 16 shows complete analyses of two different anthracite mine-water samples, one fairly acid with a *p*H of 3.7 and one near the neutral point with a *p*H of 6.2 (*22*, pp. 4 and 5).

TABLE 16.—*Analytical report of samples of mine water in 2 typical anthracite mines*

Item		Mine A	Mine B
Discharge volume (gallons per minute)		2,500	900
*p*H		3.7	6.2
Free acid (parts per million)		124	[1] 4
Total acid (parts per million)		466	13
Silica (SiO_2)	Parts per million of filtered water	14	9.6
Aluminum (Al)	Parts per million of filtered water	17	1.9
Iron (Fe)	Parts per million of filtered water	22	.2
Manganese (Mn)	Parts per million of filtered water	10	4.6
Calcium (Ca)	Parts per million of filtered water	95	34
Magnesium (Mg)	Parts per million of filtered water	55	12
Sulfate (SO_4)	Parts per million of filtered water	746	172
Chloride (Cl)	Parts per million of filtered water	9	2.4
Dissolved residue dried at 103° C.		1,070	268
Suspended matter dried at 103° C.[2]		131	7.3

[1] Alkaline.
[2] Parts per million of unfiltered water.

Comparison of the analyses in table 16 indicates the range of concentrations of the mineral contents of anthracite mine waters having widely different *p*H's. The greatest difference appears in the iron content, and the next significant difference appears in the increase of the aluminum content in the more-acid sample. Total sulfate load in the water from mine A, which was distinctly acid (*p*H, 3.7), approaches *p*H 3.0 (the average) for all mine drainage in the region; this load was 4⅓ times as great as the total sulfate load in the water from mine B, which was almost neutral. No detailed conclusions can be drawn from the analyses of samples of water from only two mines, but the analyses of the samples of extreme *p*H range do serve as a general indication of the chemical quality of mine water in the anthracite region.

The sample from mine A is particularly interesting, inasmuch as it not only approaches the average water of the entire region in its *p*H value but also represents water standing in a pool in a long-abandoned mine and draining through the barrier pillar into an adjacent active mine.

Analyses of mine water often lead to a misconception of the source of iron compounds as being inherent in the strata or mineral deposit. Enormous quantities of iron materials are present in active mine workings that are constantly exposed to the action of the mine air and water. In a region as extensive as the anthracite mining area, thousands of tons of iron from rails, sheet iron, tools, and pipes utilized for carrying compressed air and water are a source of dissolved iron in the water and of rust on the metallic surfaces. When mines are abandoned, most of these materials are removed if worth salvaging. The main source of iron, therefore, cannot be assigned indiscriminately to iron sulfide minerals in the strata composing the coal measures. The quantity of dissolved iron derived from the iron materials and equipment utilized for mining purposes is unknown.

As part of the investigation of pools in stripping excavations, the acidity in these pools was determined (*4*).

Almost all the samples taken from stripping excavations may be characterized as slightly acid, the *p*H ranging from 3.7 to 7. Only two samples, both taken in the Southern field, show any trace of alkalinity; and only five, all taken in the Southern field, are markedly acid (*4*).

The relatively slight acidity of the water in abandoned stripping excavations (*4*), taken in conjunction with the relatively higher acidity of of the mine-water discharges (*22*), and the acidity or alkalinity of the rivers that drain the anthracite region, as shown in table 9, would indicate that the drainage from the stripping excavations has little effect upon the acidity of the surface drainage in the anthracite region (*4*).

TREATMENT OF ACID WASTES AND WATERS

The hydrogen-ion concentration of the inland streams of the United States, southern Canada, and northern New Mexico, excepting badly polluted portions of these waters, as seen in a review of some 10,000 readings made during the period 1932–37, lies, in general, between *p*H 6.7 and *p*H 8.6, with the extreme ranges of *p*H 6.3 and *p*H 9.0 in streams for which no specific pollution factor affecting the hydrogen-ion concentration was readily observable. The extreme *p*H range of flowing waters of inland streams of the United States, both polluted and unpolluted, was *p*H 3.9 to *p*H 9.5, although different effluents poured into these same waters were found to have a *p*H ranging from 1.0 to 11.0 at the point of entrance into the stream. These observations show that dilution and the buffer action of different substances in the river waters do change the *p*H's of the extremely acid and extremely alkaline waters rather rapidly to the range of the composite *p*H 6.3 to *p*H 9.0 (*19*).

In a study of survival of 700 goldfish in various concentrations of 11 acids found in industrial wastes, Ellis found that solutions of sulfuric acid in water at *p*H 4.5 were tolerated by the fish without apparent injury for several days but seemed definitely detrimental to goldfish in exposures longer than 2 weeks. He concluded that other aquatic organisms survived and that the fish escaped cumulative injuries in waters less acid than *p*H 5.5 (*19*).

PROBLEM OF CORROSION

The problem of corrosion is of paramount importance in any water system, particularly one with soft waters, and constant attention as to its effects and necessary preventive treatment will bring dividends in reduced maintenance, both in the system piping and in the consumer's premises. Water from the Hetch Hetchy water supply, San Francisco, Calif., is initially soft. Even though the *p*H ranges from 6.4 to slightly above this value (*see* table 9), the tendency of this water, which is excellent for domestic and industrial purposes, to be corrosive is noticeable (*55,56*). Investigations for nearly 16 years have yielded valuable data on the relationship between *p*H, alkalinity, and calcium, and corrosion of metallic substances (*55*).

Natural water with a *p*H of 6.4, but which has low calcium and low alkalinity, will be much undersaturated with calcium carbonate (*55*). Black-iron, steel, or cast-iron transmission lines or distribution mains conveying water are affected by such water. It tends to dissolve protective carbonate coatings of metal conduit and expose the metal to the action of the water.

Exhaustive tests were conducted by the water-purification division of the San Francisco water department (*55*). Cast-iron, black-iron, steel, galvanized-iron, and copper specimens were suspended in water; they were cleaned and weighed at monthly intervals to ascertain loss of weight due to corrosion. The results indicate that these metals, arranged in the order of most to least resistance to corrosion, are copper, galvanized iron, and black iron, steel, and cast iron about the same. In the order of their corrosive tendency, according to the *p*H of the water, tests showed that the natural water with the lowest *p*H had the greatest tendency to corrosion; furthermore, that the final *p*H, or saturation index, is not fixed but changes according to the general composition of the particular water (*55*). The optimum *p*H for a nearly noncorrosive water is when saturation with calcium carbonate is reached.

It appears that the following *p*H's, or saturation indices, must be attained with some selected but different waters to saturate them with calcium carbonate:

Water supply	*p*H, natural water	Saturated *p*H (saturation index)	*p*H change
A	6.5	9.6	+3.1
B	7.6	8.6	+1.0
C	7.8	8.2	+.4

It was found that a dosage of 25 pounds of lime (CaO) per million gallons of water B was required to raise the *p*H from 7.6 to 8.6 (1*p*H). With water A, 50 pounds of lime (CaO) or 125 to 170 pounds of limestone per million gallons was required to raise the *p*H from 6.5 to 9.6 (3.1*p*H).

A municipality (San Mateo, Calif.) was served with water having a *p*H of 7.3. Considerable dissolved iron was created. With the addition of 60 to 120 pounds of lime (CaO) per million gallons of water, the *p*H was raised from 7.3 to 8.8, or 1.5 *p*H. No complaints were received when the *p*H was maintained at 8.4, the saturation *p*H for this water (*55*).

The East Bay Municipal Utility District supplies water to Oakland, Berkeley, and other East Bay (Calif.) cities. The water supply is similar to Hetch Hetchy (water supply A, given above, and table 9). Many complaints of active corrosion and of red water were received. These conditions were corrected by lime treatment. The *p*H was raised from 7.1 to 9.0, or 1.9 *p*H, by the addition of 40 to 60 pounds of lime (CaO) per million gallons of water.

In softening plants, either all the water is treated or only a part of it, which is then admixed with the main supply, and this procedure is applicable to the particular purification problem at hand.

A high chromium-nickel steel containing silicon, molybdenum, copper, and a small amount of manganese looks like a promising material for acid pumps, although no plant operation has yet experimented with this (*14*).

Lesser (*40, 41*) recently has covered utilization of deep-well pumps, shaft pumps, and centrifugal pumps in the Pennsylvania anthracite mines.

A recent survey of pumping plants in the anthracite region of Pennsylvania showed that more than 90 percent of the pumps in use are the horizontal centrifugal types (*5*).

Although many types of water pumps are manufactured, the types generally used in the anthracite mines are:

Centrifugal pumps:	Displacement pumps:
Horizontal.	Plunger.
Vertical:	Piston.
Standard.	
Deep-well.	
Shaft.	

To reduce to a minimum the corrosive effect of acid mine water, pump casings and impellers should be made of anticorrosive metals.

Water pumped from anthracite mines is generally acid; therefore, pumps of cast iron are not satisfactory (*22, 36*). All parts of a pump in direct contact with acid mine water should be made of metal highly resistant to corrosion, such as bronze. Bronze containing 75 percent copper, 15 percent lead, and 10 percent tin will resist corrosion satisfactorily.

Pump parts, such as casings, shaft sleeves, shaft bushings, impeller rings, and casing rings, should be made of bronze or chrome iron. Where the *p*H of water from many anthracite mines is more than 4, pump casings made of bronze are considered suitable. If the *p*H is less than 4, pump casings of chrome iron should be considered.

To prevent electrolytic action, casing rings and casings should be made of the same metal. If chrome-iron impeller and bronze casing rings are specified, the bronze rings should be bored out and the chrome-iron rings pressed into them. A chrome-iron impeller ring may run in a bronze casing ring without danger of "seizing," but if both rings are made of chrome iron, seizing may occur. Under these conditions it is better that the impeller rings be made of zinc-free bronze. Shafts should be made of high-carbon steel.

Underground pools containing much water and extending over large areas (*4*), which may be reached through boreholes from the surface, present conditions favoring application of deep-well pumps. Deep-well pumps are being used in the anthracite-mining area for two general purposes: To maintain the surface of underground water pools so that water will not flow into adjacent active mining areas, and to keep the water level on one side of a barrier pillar such that the pillar will not be subjected to excessive pressure.

Inasmuch as pump parts may be exposed to the corrosive action of mine water, it is important to use parts made of metal that will resist corrosion from the particular water being pumped. The following metals have been found to be applicable at some Pennsylvania anthracite mines:

Casings	Zincless bronze, SAE 63, or a chrome-nickel alloy.
Impellers	Bronze, stainless steel, or a chrome-nickel alloy.
Shafts	High-carbon steel, with the exception of the lower section, which is preferably made of stainless steel.
Shaft tubing	Steel, outside bitumastic covered, or wrought iron, outside rubber-covered. Lower section is preferably made of stainless steel.
Discharge pipes	Steel, or wrought iron covered inside and outside with rubber or bitumastic paint.

Decisions pertaining to the selection of metals depend on the acidity of the water to be pumped. The *p*H of the water should be determined when a pumping project is contemplated.

Some of the effects of acid mine water on some elements of a deep-well pump were as follows: A deep-well pump was removed for inspection and repair in June 1949 after having been in continuous operation since July 1947. Five hundred feet of discharge pipe, pump-shaft tubing, and pump shaft (all in 10-foot lengths), and the motor, were removed in 48 hours, a total of 1,008 man-hours (*40*).

The pump casing, with its suction strainer and 10 stages of impellers, was replaced with an entire new unit. The used impellers and casing were returned to the manufacturer for inspection and reconditioning. The reconditioned unit will be held in reserve for an emergency.

Damaged portions of the rubber cover on the outside of the 16-inch-diameter discharge pipe, probably caused by mechanical abrasion during handling, were repaired by vulcanizing.

The inside of the discharge pipe was coated with yellow boy (sulfur mud) 3/64 to 1/16 inch thick, which dried quickly, became flaky, and was easily removed.

The stainless-steel bolts in the discharge pipe showed no signs of corrosion and were easily removed, whereas the bolts on the impeller casing, which contained a smaller percentage of chromium, were corroded and difficult to remove. All connections between the 10-foot sections of the discharge pipe, pump-shaft tubing, and pump shaft were easily removed except a few pump-shaft couplings, which required application of heat.

The acid-resisting bronze impellers and casing showed no signs of wear; however, a slight deposit of copper sulfate was present. Some of the rubber sealing rings between stages were worn or torn loose, which caused loss in capacity. The damage to the sealing rings was caused by improper adjustment of the pump shaft or elongation of the pump shaft while in operation. The actual condition of an impeller casing assembly can be determined only after it is disassembled and inspected at the manufacturing plant. The suction strainer was supposedly damaged at the time of the original installation, but this apparently had no adverse effect on the efficiency of the pump. This pump had operated 14,703 hours and had handled 4,136,310,000 gallons of water (2,068,155 million gallon-feet). After 2 years of service, the pump was considered to be in excellent condition.

A deep-well pumping plant maintains the surface of a large water pool below the overflow point of three adjoining mines. Its installation and operating costs are shared jointly by companies affected, and it therefore is an outstanding example of cooperative pumping of water.

The following features of design are worthy of note: A wrought-iron discharge pipe, rubber-covered inside and outside, with stainless-steel flanges and bolts; shaft oil tube of wrought iron, with the exception of the lower 50 feet, which is of stainless steel (the wrought-iron section is rubber-covered on the outside); a stainless-steel pump shaft for the lower 50 feet and high-carbon steel for the remainder; zincless-bronze pump casings, SAE 63; and impellers on chrome-nickel alloy.

When the pumps were installed in January 1948, they were equipped with an eight-stage pump rotor. During December 1948 one pump was hoisted for the purpose of replacing the eight-stage pump with one having nine stages. At that date, several minor defects were found and corrected, and now the operating performance of the pumps is considered to be very good.

A deposit of yellow boy 1/8 inch thick was found on the pump parts when they were inspected, which indicates the necessity of hoisting them at regular intervals for the removal of yellow boy.

Another pump was replaced for removing yellow boy. It had been in use from May 10, 1944, to March 25, 1948 (3 years, 10½ months). When the pump was tested, it was actually pumping 1,500 g. p. m., a loss of 1,000 g. p. m. under the rated capacity. Upon examination, the bronze strainer was coated with yellow boy 1½ to 2 inches thick. Only two openings remained open in the strainer through which the water could be pumped. The bronze impellers, shaft, bearings inside of the column line, and all other parts of the pump in contact with water were coated with yellow boy.

Where acid mine water having *p*H's ranging from 3 to 3.5 is to be pumped with five-stage, oil-lubricated, vertical-turbine, deep-well pumps, most recent practice based on experience to date (1951) advocates that column pipes and oil tubes be of stainless-steel construction, bowl assemblies be of zincless bronze, impellers be of chrome iron, and strainers be of stainless steel.

TREATMENT OF ACID WASTES

Johnson has discussed the treatment of acid mine water for breaker use in the anthracite region of Pennsylvania (*22*, *36*). Mine water with low acid content is used without treatment in breakers, but in many instances the mine water is highly acid and is treated to protect pipe, pumps, valves, tanks, screens, and the metallic lining of chutes from corrosion.

When only highly acid mine water was available for washery use at breakers, the replacement and labor costs required to maintain coal-preparation equipment at desired capacity were exorbitant. It was not unusual to replace pipe and other equipment after 3 weeks of service. Many companies utilized equipment made of extra-heavy metal. In recent years equipment made of acid-resistant alloys to obtain longer and more efficient wear has been used. During World War II, heavy metals and alloys were difficult to obtain.

To enable the industry to maintain peak production, the treatment of mine water for washery use with lime was begun in 1932; this provided a means by which lightweight materials could be utilized because of less corrosion. Lime is added to the acid mine water at anthracite breakers by four methods. All methods utilize a concentrated lime-water mixture or slurry that is fed into a storage reservoir or directly into the breaker pumping system.

Commercially, the term "lime" includes high-calcium lime that contains 90 percent or more calcium oxide (CaO); magnesium lime containing 5 to 25 percent of magnesia (MgO) and 75 to 95 percent of calcium oxide; and high-magnesium to dolomitic limes containing 25 to 45 percent magnesia and 55 to 75 percent calcium oxide. Chemically, pure lime is calcium oxide (CaO), but the commercial product contains impurities such as alumina, iron oxide, and silica.

Hydrated lime, $Ca(OH)_2$, is used in the anthracite region. This lime is purchased in 50-pound paper bags and shipped to the breakers by railroad or truck. In the early experimental stages of treatment, granular limestone and agricultural lime were used, but preliminary tests indicated that they were unsatisfactory. When water is added to quicklime, it slacks and forms lime hydrate, $Ca(OH)_2$. In this form lime reacts most effectively when used to treat acid mine water.

High-calcium hydrated lime is used at several lime-treating installations, but the total amount used is less than 25 percent of the lime used in the anthracite region.

The reaction rates of high-calcium hydrated lime and of dolomitic lime are very rapid, and it is difficult to distinguish between the two. However, because sulfuric acid tends to form insoluble calcium sulfate, this slightly retards the reaction rate of the high-calcium lime. The formation of calcium sulfate is less when dolomitic lime is present; the magnesium sulfate formed is soluble in water.

The desirable *p*H of the treated water varies with the opinions of those in charge of the lime-treating installations. The initial mine water may test from *p*H 2.7 to more than *p*H 7.0, but most treatments are on water having a *p*H that ranges from 2.7 to 4.0. The final *p*H ranges from 4.1 to 7.0. Some believe that when the *p*H ranges from 4.0 to 4.4 the free acid is neutralized, the "sting" or "bite" is removed, and additional treatment is not warranted. The majority believe that the water should be treated until a *p*H of at least 5.4 or preferably a *p*H that ranges from 5.8 to 6.0 is attained.

At *p*H 4.4 a leveling effect or buffer action is experienced. This is caused by dissolved iron salts, particularly ferrous sulfate. After all the iron salts have been precipitated, the *p*H will again rise at a uniform rate.

The *p*H of mine water differs from season to season because of change in the water table. During a rainy period, the *p*H may indicate more acid conditions for a few days because of water running through deposits of sulfur mud (yellow boy). Usually, during low-water periods, the *p*H of the mine water is low (highly acid), and more lime is required for treatment. A rough estimate used for lime requirements is that 100 pounds of hydrated lime will raise the *p*H value of 100,000 gallons of water 1 *p*H. This appears to be excessive but is justifiable where relatively small volumes of water are treated under conditions requiring a short reaction time.

Analytical results of water samples are sometimes shown as parts per million (p. p. m.) or as grains per gallon (gr./gal.). One p. p. m. equals 0.001 percent. It is a measure of proportion of weight and is equivalent to a unit weight per million unit weights of solution.

The older practice of reporting results in grains per gallon is gradually being superseded by the more convenient expression of parts per million. The results can be converted from one form to the other, because 17.1 p. p. m. is equivalent to 1 grain per United States gallon. A formula used to determine the lime required to neutralize acid mine water when expressed in grains per gallon is as follows:

> Grains of total sulfuric acid $\times$ 0.10804 = pounds of hydrated lime to neutralize 1,000 gallons of water.

It is difficult to refer to the lime treatment of acid mine water as a tangible asset, because appraisals on replacement parts, life of parts, labor costs, maintenance costs, and other related items are not usually kept in mine-cost-account records. Statements by individuals in charge of treatment processes infer that, before the mine water was treated to prevent corrosion, it was necessary either to replace pipe, chute linings, screens, and other metal equipment every few months or to use equipment of expensive acid-resistant alloys or extra-heavy metal.

Breaker equipment receives harsh treatment, primarily from the abrasive action of pulverized coal and rock, from silt in high-pressure water sprays, and from sand where used for preparation. However, equipment made of extra-heavy metals, alloys, rubber, and glass is used to prevent abrasion and corrosion. Where acid mine water is required for coal-preparation purposes, breaker officials have learned from the experience of many breakdowns, frequent and expensive replacements, and the cost of a large maintenance crew that the problem is greatly alleviated by installing a lime-treatment system.

Where the acid mine water is treated with lime, it has been possible to use steel pipe instead of cast-iron pipe, lightweight metal for chute linings in place of extra-heavy metal linings, and cast iron for parts in pumps, valves, and screens instead of parts made of acid-resistant alloys. Consequently, substantial savings are made by a reduction in the first cost of such mine equipment and the reduced costs resulting from longer and more satisfactory wear.

According to Dickerson and Brooks (*17*), one of the major waste-water problems of the Hercules Powder Co. at Parlin, N. J., is disposal of waste acids resulting from the production of nitrocellulose. These comprise a mixture principally of nitric and sulfuric acids having a maximum strength of 1.5 percent as sulfuric. The volume to be treated varies widely in rate of flow, averaging about 5,000 g. p. m. Minimums and maximums will range from 2 to 10,000 g. p. m., with no correlation to acidity. The effluent is discharged into the South River.

Initial treatment facilities comprised handling and storage facilities for burned dolomite lime and slacking equipment for producing a 10- to 20-percent slurry. The rate of feed was manual to provide for neutralization.

More stringent stream-pollution regulations required closer control of neutralization, and additional facilities were provided. These comprised lime-slurry storage tanks, slurry-circulating pumps and piping, a multiunit reaction chamber, and two *p*H controllers for automatically adjusting the rate of lime admission to provide a constant effluent *p*H.

The reaction chamber provides a reaction time of 7.5 minutes at average flow and contains five cells, each equipped with an agitator. The first two chambers are for equalization of *p*H in the untreated waste, the third receives the initial dosage of lime, and additional reaction is provided in the fourth unit. The fifth is for final *p*H adjustment, with the remaining lime requirements necessary. Ten-percent lime slurry is fed to the mixing compartments by butterfly valves actuated by air-operated *p*H controllers. Immersion electrodes have been used in place of the usual sampling pumps and electrode flow cells. Lime slurry is circulated past the butterfly valves in excess of the maximum demand, so there is always adequate lime slurry for proper control.

A *p*H of approximately 2.0 is maintained in the first neutralizing chamber and 3.0 in the second. There is a rise in *p*H from the treatment plant, so that the *p*H of the effluent leaving the plant property is approximately 5.0, providing complete neutralization (*17*).

Experience shows that acid waters prevent the self-purification capacity of the receiving bodies of water into which the acid waters are discharged (*11, 23, 31*).

An acid-water stream will carry organic matter in a pickled or preserved state as long as it remains acid (*11*). This is not considered offensive if the stream is not used for recreation or water supply. No undue offense is present where acid-water streams are not utilized for the foregoing purposes, and often advantage is taken of such streams for sewage disposal in mining communities; however, where such streams must be utilized for water supply or if they pass through communities along their banks and become alkaline from any cause, they present a problem of stream sanitation and become offensive (*11*).

Methods of neutralizing acid mine water have been known for many years (*16, 22, 26, 36*) and have been applied to some extent both where mine water is used for mining purposes and where it was offensive as a pollutant (*7, 36*).

Pretreatment of industrial wastes is still in its infancy. New and better methods are being constantly devised. Some methods of pretreatment are excessively costly. Some industrial wastes are not susceptible of successful chemical pretreatment.

Nearly all pretreatment of industrial wastes falls into one or more of the following patterns:

1. Clarification by sedimentation or flotation.
2. Chemical neutralization, coagulation, or precipitation.
3. Aeration, oxidation, or incineration.
4. Screening.
5. Deodorizing.
6. Decolorizing.
7. Bacterial sterilization.

Of the above-given patterns, chemical neutralization is the only method known or employed at present to prevent excessively acid or alkaline effluents from entering the receiving stream.

Low or high *p*H is often an indication of the deleterious nature of the waste discharge.

Dilution affects *p*H to some extent but cannot always be resorted to because of needed capacity in discharge lines or streams. Ordinary tap water is substantially neutral and therefore can have little effect on the *p*H, even in instances of enormous dilution (*6*).

If the acid in a stream is neutralized either by natural or artificial means, the organic load of the stream will be disposed of biochemically and be offensive during this process. The dilution factor is the important and reliable gage for determining the ability of a stream to dispose of its organic load only when the water, acting as diluent, creates an environment in the combined waters of the receiving stream and the stream discharging into it that is neutral or alkaline and favorable to the development of decay organisms (*6, 11*).

In discussing industrial-waste problems Van Horn (*73*) suggests that, where the natural waters in the afflicted areas are alkaline, it might be possible—by regulating the stream discharges by means of dams—to provide enough water in the stream to neutralize the acids to the extent that the aquatic environment would not be seriously affected. It is a fact that the main streams and rivers that flow through the anthracite region, except the Schuylkill River, are nearly always alkaline at all points within the anthracite region itself; moreover, short distances below the coal measures the rivers are permanently alkaline (*22*).

Lewis and Yost (*43*) have discussed utilization of lime in treating acidic industrial wastes. Lime applied in the form of a water slurry is reacted more quickly and completely than if applied in a dry form. However, within the last few years the procedure of dry liming has been given considerable study. Sludges from dry lime-acid systems have unusual dewatering and settling characteristics; the excellent filtering characteristics of the resulting sludge in dry liming can be an important factor in the final design of an acid-disposal system.

Two of the most common errors made in applying liming materials to waste acids are failure to establish the minimum acceptable effluent *p*H and failure to provide adequate reaction time between lime and acid to reach such minimum *p*H. Where large quantities of lime are utilized and reaction time is not thoroughly appreciated, the difference of one *p*H unit can result in costly waste of lime. Secondary undesirable effects in the treatment operation also result from excess lime dosage (*42, 43*).

Gehm (*23*) has reported the success of his experiments in neutralizing acid waste waters consisting mainly of a mixture of nitric and sulfuric acids and neutralizing hydrochloric, nitric, and sulfuric acids singly by upflow through limestone beds. Acids having an initial *p*H as low as 1.5 were raised to *p*H's well above 4, and by aeration to remove dissolved CO_2 the *p*H's were raised to 8.0.

The studies indicate that the upflow limestone bed shows promise of providing acid neutralization with little supervision and control at a very low initial equipment cost. The method employs pulverized limestone, one of the least-expensive neutralizing agents. Additional development of the method may prove it to be practicable in treating acid mine waters.

Lewis (*42*) discusses neutralization of acids by lime, considering primarily the *p*H range covered by the treatment and the minimum time available for the reaction between lime and acid. He points out that dolomitic lime might well be advantageous in treating sulfuric acid wastes because of the lesser sludge problem created by the formation of soluble magnesium sulfates in neutralizing the acid. Aeration of solutions containing ferrous iron salts results in change of ferrous iron to ferric iron and resultant precipitation, so that solutions can be freed of iron and mineral acid without ever passing the neutral point of *p*H 7. (*See* fig. 11.)

The two fundamentals of raising the *p*H and the time available for reaction are basic to the choice of a liming material for acid-waste treatment, but there are other factors. One very important factor is the disposal of sludge. The sludge problem may be so acute where cheap land area for lagooning is not available that the dewatering and disposal of sludge outweigh all other considerations; this is one of the reasons why acid-waste-treatment processes cannot be standardized but must be tailor-made to fit the occasion (*42*).

A method of lime treatment of mine water is utilization of pulverized (4- to 6-mesh) limestone. Laboratory tests on the neutralizing power of limestone have been conducted at the Missouri School of Mines and Metallurgy. A solution containing 200 p. p. m. of sulfuric acid was percolated through a bed of minus 4-mesh plus 6-mesh limestone assaying 98 percent calcium carbonate (*70*). The results are summarized in table 17.

TABLE 17.—*Neutralization of free acid by percolation through a bed of 4- to 6-mesh limestone*

Cumulative time of contract, seconds	*p*H	H_2SO_4, parts per million
0	3.0	200
11	5.5	Trace.
19	6.0	Do.
27	6.3	Do.
45	6.9	Do.
57	7.1	None.

The pulverized product can be placed in a proper trough so that the mine water will percolate upward through the limestone. Any precipitate of calcium sulfate will clear itself with upward percolation and not reduce the effectiveness of the limestone.

The treatment of acid mine water with lime for preparing anthracite in the anthracite region has been described (*22, 36*). Lime or limestone treatment of acid waste is often found to be a practicable means of complying with pollution-abatement requirements (*7, 23, 36, 42, 43, 70*). Furthermore, it is generally accepted that each treatment plant or process for the disposal of industrial wastes, which include acid mine water, must be made to fit the circumstances under each given set of conditions (*42*).

Every acid-disposal problem utilizing lime or limestone is concerned with three basic considerations: The *p*H range over which the treatment is to take place, the minimum time available for the reaction between the lime or limestone and acid, and the disposal of products formed, of which sludge is of primary imporance in the anthracite-mine-water problem. (*See* figs. 8 to 11.)

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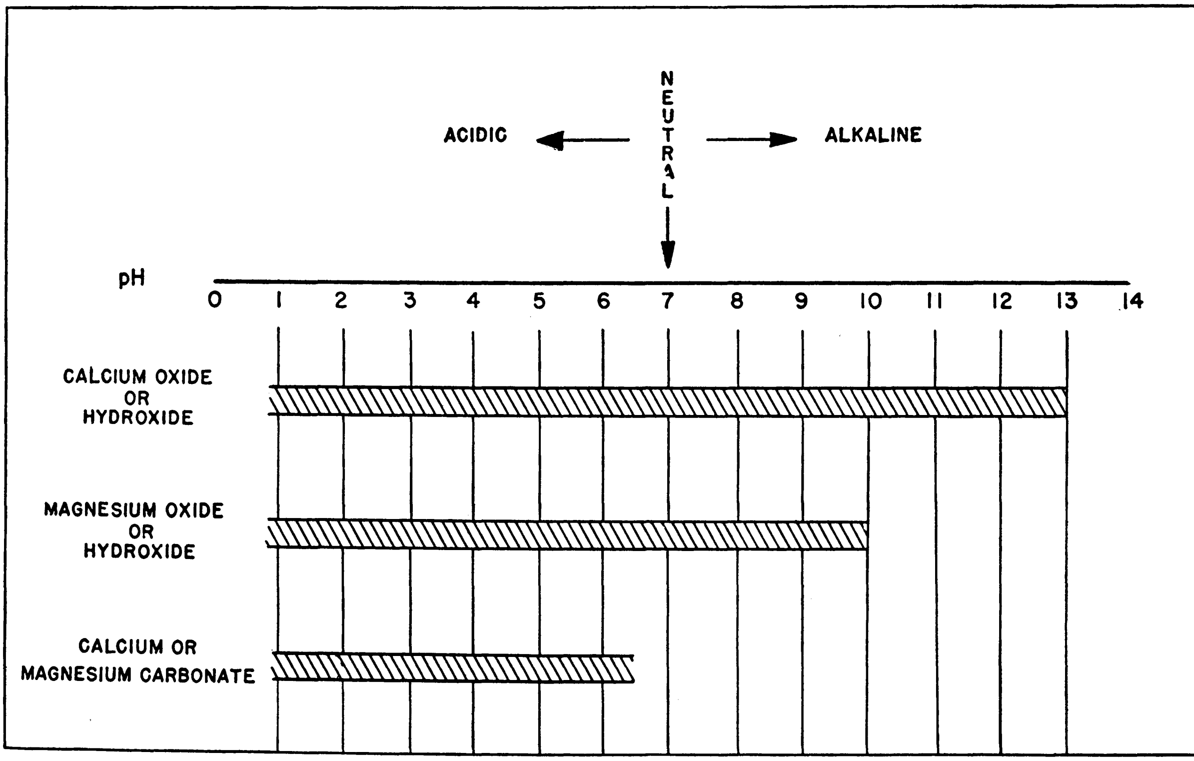

FIGURE 8.—GENERALIZED *p*H RANGES OBTAINABLE IN ALKALIZATION OF ACID SOLUTIONS BY CALCIUM AND MAGNESIUM PRODUCTS (AFTER LEWIS, REF. *42*).

In acid-waste treatment utilizing lime or limestone or both, it is necessary to know the final *p*H expected in the system after the addition of the lime or limestone. As little or nothing can be done under existent conditions in the anthracite region to change the initial *p*H of the acid mine water, it is sound to accept this circumstance as a fact and deal with the problem accordingly. The final *p*H of the mine-water discharges into the receiving streams under pollution-abatement regulations ultimately depends on State, local, and Federal abatement requirements.

Because calcium and magnesium products are utilized in the treatment of acid mine water, it is of interest to the anthracite industry to know what may be expected of calcium and magnesium products in the treatment of mine-water discharges. According to Lewis (*42*), calcium oxide or calcium hydroxide is effective over the entire *p*H range; magnesium oxide or magnesium hydroxide in active form is effective in the entire *p*H range below *p*H 10; and high-calcium limestone or high-magnesium limestone is effective in the entire *p*H range below *p*H 6. (*See* figs. 8 and 9.)

The time factor for the treatment of acid mine water must be considered in any mine-drainage scheme, which must be both practicable and economically feasible. According to Lewis (*42*), the reaction rates of calcium oxide or calcium hydroxide differ sharply from those of magnesium oxide or magnesium hydroxide. Moreover, the reaction rates of the oxides and the hydroxides differ sharply from those of the corresponding carbonates. (*See* fig. 9.)

Acid mine drainage is by no means restricted to coal mines. The mine water from metal mines is often more destructive to fish life and more offensive as an acid-mine-water producer, because of the greater number of minerals present, greater concentration of sulfide minerals in the metal-bearing formation, and toxic metals in solution in the mine water. Metal mines are less numerous than coal mines and spread over a vast area throughout the Nation. Because of their local character, wide distribution, and size, they are compelled to or do reduce or control acid-mine-water drainage in many instances (*7*, *9*, *39*).

Acid-mine-water drainage is a serious problem with many metal mines in the Tri-State zinc- and lead-mining district (*7*, *9*) and other mining districts (*70*). Particularly is this true where large volumes of water must be handled in unwatering old metal mines that have been flooded with water that in turn has become acid biologically (*66*) or chemically, either by

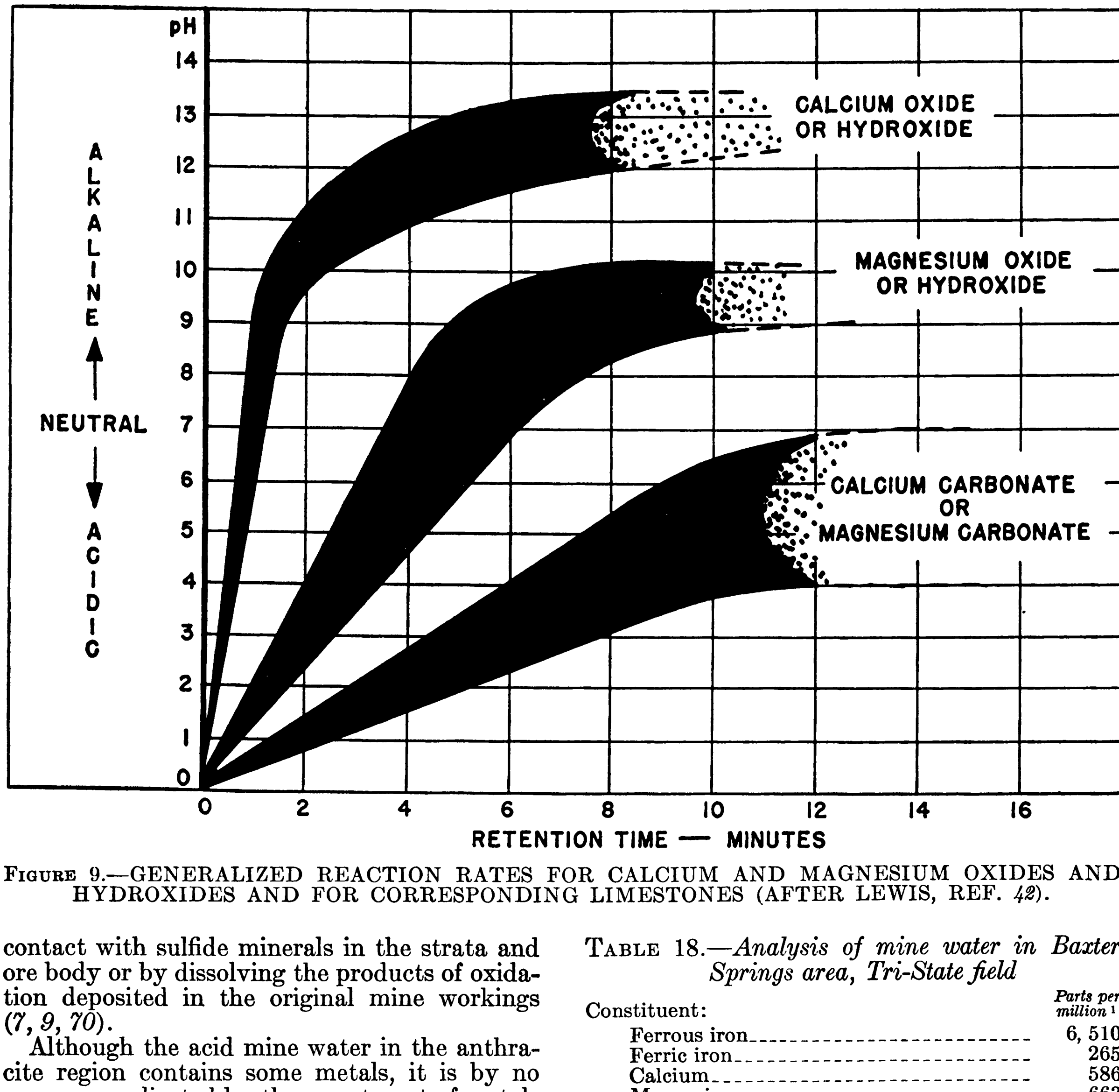

FIGURE 9.—GENERALIZED REACTION RATES FOR CALCIUM AND MAGNESIUM OXIDES AND HYDROXIDES AND FOR CORRESPONDING LIMESTONES (AFTER LEWIS, REF. *42*).

contact with sulfide minerals in the strata and ore body or by dissolving the products of oxidation deposited in the original mine workings (*7, 9, 70*).

Although the acid mine water in the anthracite region contains some metals, it is by no means complicated by the assortment of metals that are found in some metal-mine waters that, Bilharz states, have been treated successfully with lime (*7*). Analysis of mine water in the Baxter Springs area of the Tri-State metal-mining field is shown in table 18.

Bilharz reports experiences in unwatering mines in the Baxter Springs area of the Tri-State field where mine waters ranging as acid as *p*H 1.7 were treated and discharged into Spring River without injurious effect to fish life. Mine waters were treated with hydrated lime in a system of treatment plants and settling basins to raise the *p*H and to precipitate the iron salts in the water. Experiments showed that, when the approximate flow of Spring River was 44,000 g. p. m., 10 percent of that quantity—or 4,400 g. p. m. of mine water

TABLE 18.—*Analysis of mine water in Baxter Springs area, Tri-State field*

Constituent:	*Parts per million* [1]
Ferrous iron	6, 510
Ferric iron	265
Calcium	586
Magnesium	663
Sodium	526
Aluminum	1, 029
Zinc	2, 100
Cadmium	15
Copper	6
Lead	2
Manganese	12
Titanium	5
Phosphorus	3
Chlorine	15
Sulfates as (SO_4)	24, 649
CO_2 and bicarbonates as (HCO_3)	2, 637
Silica in solution	17
*p*H	2. 45

[1] Except *p*H.

having a *p*H not lower than 4.5 and containing not more than 500 p. p. m. ferrous iron—was diluted sufficiently to be noninjurious to fish life. The iron remaining was neutralized and

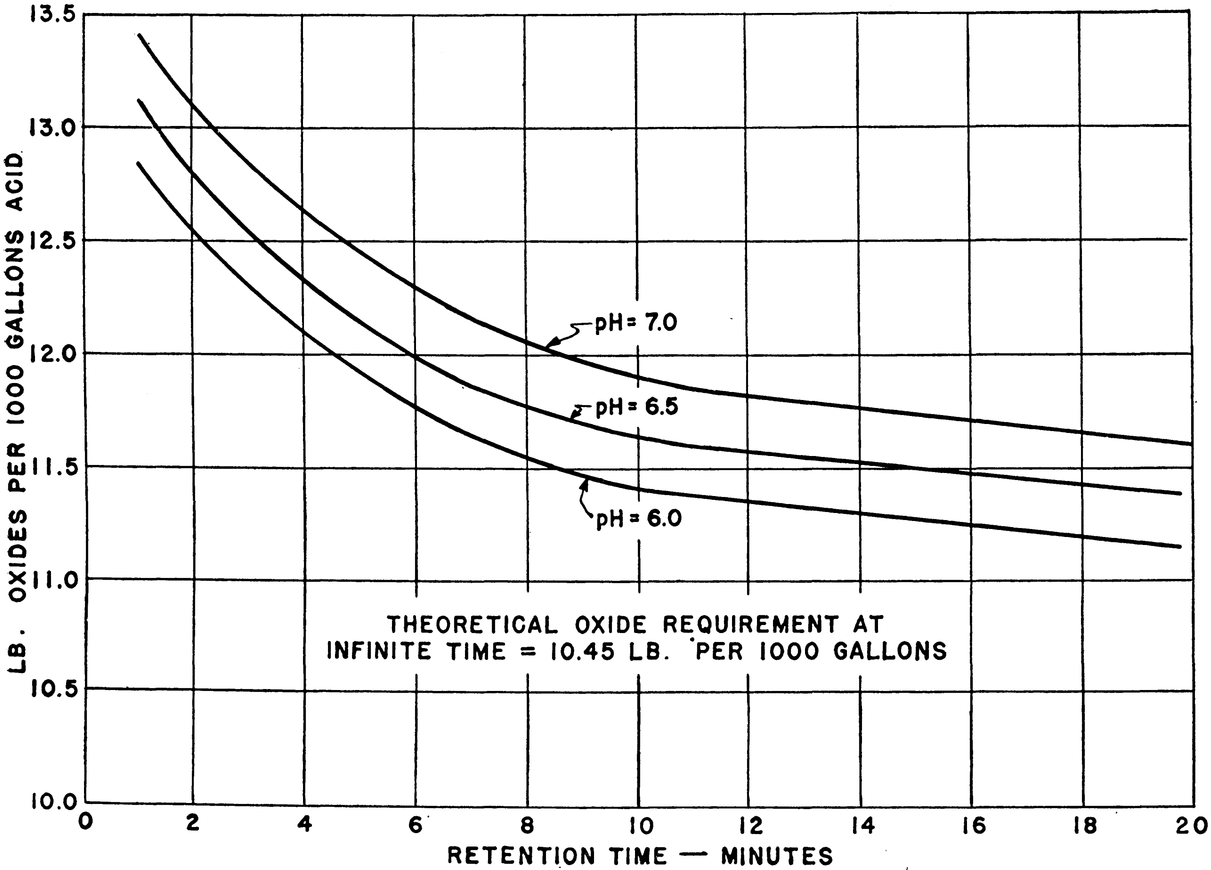

FIGURE 10.—LIME REQUIRED TO ALKALIZE ¼ PERCENT SULFURIC ACID SOLUTION USING SLAKED AND SLURRIED DOLOMITIC PEBBLE QUICKLIME (AFTER LEWIS, REF. *42*)

precipitated by the excess of alkalinity and dissolved oxygen in the river (*p*H 7.7 and 107 p. p. m. alkalinity as $CaCO_3$). The precipitates settled out within the first mile of flow (*7*) of the river.

With the trend toward more chemical processing and greater use of air conditioning in manufacturing plants, industrial water is becoming increasingly important. In the Tennessee Valley region, as elsewhere, water supply is a factor in the selection and establishment of industrial plants. Because many businessmen and engineers have sought and are seeking factual information on the economic feasibility of plant sites in the Tennessee Valley region, the Tennessee Valley Authority has collected a considerable amount of data on the volume and quality of water in the principal streams of Tennessee Valley, which has a watershed of 40,910 square miles (*68*).

A report (*68*) on the industrial-water supplies of the Tennessee Valley region states that, in the valley, there is only one stream (the Ocoee River) in which water causes damage to submerged structures.

The Ocoee River below Copperhill, Tenn., carries a large amount of silt from the eroded area and high concentrations of minerals and acids in discharges from mining- and mineral-processing plants in that area. The high acid concentration, together with the large amount of silt, appears to be responsible for abnormal deterioration of the runners of the turbines of hydroelectric plants on the Ocoee River (*67*, *68*, *69*). The metal utilized for parts of the turbine on the Ocoee 3 project are: Runner, 16-bucket, vertical, cast steel, 96.75-inch diameter; main shaft, forged steel; speed ring, cast steel; and scroll case, plate steel, riveted (*69*).

Copper sulfide is being mined and smelted in the Ocoee River Valley near Ducktown and Copperhill. Sulfuric acid is an important byproduct and is being produced extensively. This mining region also contains many other minerals, a few of which are being mined on a small scale (*67*).

Because the analyses of samples of the Ocoee River near Ducktown, Tenn., indicate effluents from the above-stated mining operations that show a *p*H (3.9 to 5.8) in the same range as

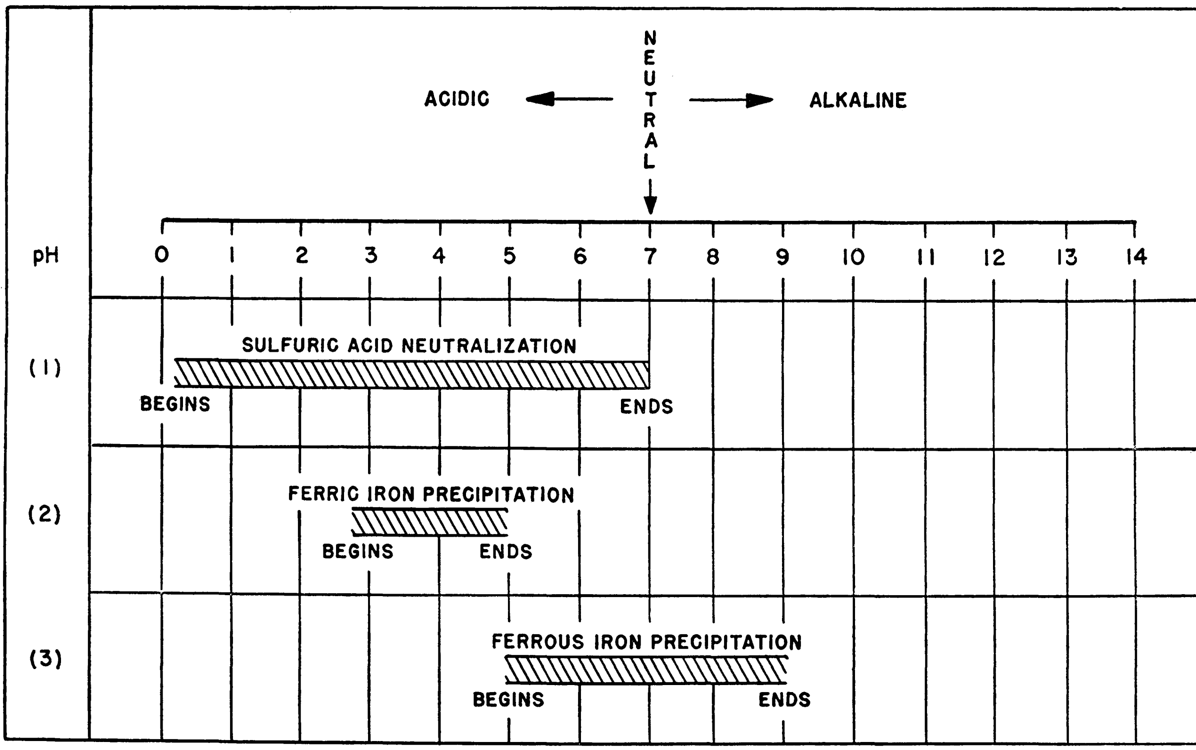

FIGURE 11.—*p*H RANGES FOR SULFURIC ACID NEUTRALIZATION AND FOR FERRIC AND FERROUS IRON PRECIPITATION (AFTER LEWIS, REF. *42*).

that of anthracite mine water that is treated and utilized for preparing anthracite, the analyses shown in table 19 are of interest (*22*, *36*, *68*).

It is important to note in table 19 that, when the *p*H range is 3.9 to 4.3, the "bite" probably is not removed; that is, the alkalinity with methyl-orange indicator is zero. However, the alkalinity with phenolphthalein indicator is also shown as zero in the *p*H range of 3.9 to 5.82. Johnson has shown (*22*, *36*) that lime-treated mine water for anthracite breakers has a satisfactory *p*H when it is within the foregoing *p*H range.

Waste water from the copper mines and the smelter at Copperhill flows into the Ocoee River a few miles upstream from the Ocoee 3 project dam, and, in addition, the river carries an unusually heavy silt load after each rainfall in the denuded area of the copper basin. To determine its suitability for concrete mixing, samples of the water were collected on different

TABLE 19.—*Ocoee River at river mile 29.2 near Ducktown, Tenn.*[1]

[Parts per million][2]

Mineral constituents	Oct. 27, 1944	Nov. 17, 1944	Dec. 22, 1944	Jan 19, 1945	Feb. 16, 1945	Mar. 13, 1945	Apr. 20, 1945	May 4, 1945	June 14, 1946	July 16, 1946	Aug. 23, 1946	Sept. 3, 1946
Turbidity	7	10	12	5	38	5	15	10	73	60	6	5
Color	13	8	4	2	5	3	2	3	7	2	0	7
Iron, unfiltered (Fe)	.74	.70	7.5	4.0	1.4	.90	1.60	1.41	14.3	3.10	.78	1.82
Silica (SiO_2)	5	5	5	5	3	6	7	5	5.5	4.5	5	5
Calcium (Ca)	11.62	11.56	18.94	29.94	12.44	14.20	19.20	15.04	8.81	11.06	9.58	13.33
Magnesium (Mg)	4.64	6.01	6.66	8.68	3.49	4.70	7.21	6.55	3.33	4.37	4.04	5.35
Sodium (Na)	4.62	5.26	5.70	5.31	2.66	10.03	9.54	5.80	17.11	4.72	4.52	9.05
Sulfate (SO_4)	49.24	51.71	88.51	122.64	49.04	53.76	82.55	63.74	23.13	47.90	41.22	55.61
Nitrate (NO_3)	1.42	1.42	3.01	1.46	1.59	2.39	1.42	1.24	.28	.30	.26	.40
Chloride (Cl)	1	1	2.0	1	1	2.2	1.9	1.9	2.0	1.1	2.3	2.1
Alkalinity, phenolphthalein	0	0	0	0	0	0	0	0	0	0	0	0
Alkalinity, methyl orange	3	0	0	0	3	3.1	1.4	3.4	3.0	0	4.3	2.5
Hardness as $CaCO_3$, noncarbonate	45	53.5	74.50	110	42	51.9	76.1	61.1	32.68	45.55	36.20	52.75
Hardness as $CaCO_3$, total	48	53.5	74.50	110	45	55.0	77.5	64.50	35.68	45.55	40.50	55.25
*p*H	5.5	4.3	4.0	3.9	4.8	5.40	4.40	4.69	5.82	4.81	5.20	4.7
Total solids	100	100	143	212	137	123	168	135	140	126	86	113

[1] Surface samples from Ocoee No. 3 Reservoir.
[2] Except *p*H.

occasions during low, high, and normal stages of the river and analyzed (*69*). These tests confirmed the suitability of the water for mixing concrete and are another example of satisfactory dilution and neutralization between the mining discharges and the receiving stream.

In 1951 Ash and Miller investigated the maintenance data of several concrete-lined tunnels, aggregating more than 300 linear miles in length, through which water is conveyed. The hydroelectric tunnel through which the water shown in table 19 is conveyed is the only one conveying water on the TVA project that has a *p*H in the acid range. Nevertheless, after 8 years of experience no deterioration or deleterious effects on the concrete have been observed with the water in the *p*H range of 3.9 to 5.82. Moreover, the Ocoee 3 project tunnel, which is 12,990 feet long, has a severe grade—1.1 percent for the first 3,000 feet downstream and 0.67 percent for the remaining 9,990 feet (*69*).

If tests indicate that it is feasible to treat a given acid mine water to attain the final *p*H required and the time factor is not prohibitive, the selection of a suitable alkaline agent will depend on the availability and cost of both the alkaline agent and the facilities necessary to provide satisfactory disposal of the sludge (*42*).

REMEDIAL MEASURES FOR COMBATTING STREAM POLLUTION BY ANTHRACITE-MINE WATERS

Although many anthracite-mine-drainage discharges flow directly into comparatively small streams, all the mine drainage in the region, except mine water remaining below sea level, eventually finds its way into the Susquehanna River, the Lehigh River, or the Schuylkill River. The major streams in the anthracite region also receive sewage and industrial wastes from large and small towns along their banks and in their drainage basins. As long as the anthracite mines continue to operate, the industry and the State will be confronted with the problems of mine drainage, whether the drainage continues to enter the streams at innumerable points as it does at present or whether the drainage is diverted intermediately to other channels and discharged into a receiving stream at a single or a few points.

In diverting the acid mine drainage from surface streams by means of a system of drainage tunnels and central pumping plants, consideration also must be given to the effect of the water on the tunnel lining and pump parts because of the chemical characteristics of the water. Table 14 shows that the average *p*H of all mine drainage from the anthracite region, as determined by analyses of samples collected in 1941, is 3.0 and that 1,807,719 tons of that water discharged daily from the mines in the anthracite region carry a load of 445.29 tons of free acid as H_2SO_4, and 14.15 tons of alkali (methyl-red indicator) as $CaCO_3$—a total-acid load of 944.00 tons as H_2SO_4, and an alkaline load of 10.13 tons (phenolphthalein indicator) as $CaCO_3$. Based on these figures, the average mine-water discharge of 327,000 g. p. m. (472 million g. p. d.) reported by Ash and others (*5*) from a study of pumping records over a 5-year period (1944–48) will carry a free-acid load of 431 tons as H_2SO_4 or a total-acid load of 934 tons a day as H_2SO_4. However, table 15 shows the average *p*H of samples collected in 1946 is 3.2; the *p*H, therefore, can be said reasonably to range from 3.0 to 3.2.

Some precipitation of yellow boy in the tunnels and possibly some reaction between the acid water and the tunnel lining may be expected, although such reaction may be expected to be so slight as to be entirely negligible. A solution of 1 percent sulfuric acid will corrode concrete substantially and noticeably within 1 to 2 months (*6*), but the acid load in the mine-water discharges from the anthracite mines corresponds to an acid solution of only 0.02 percent strength when based on free-acid load or 0.05 percent when based on total-acid load, as shown in table 14. Experience in some anthracite mines having concrete dams shows that early deposition of yellow boy and other material from the acid mine waters may be expected to form a thin protective coating on the tunnel lining that will prevent prolonged reaction of acid and concrete, however mild that reaction may be.

Sulfates of iron, aluminum, magnesium, sodium, potassium, and calcium are stated by some authorities to affect actively unprotected concrete. The stronger the concentration of these inorganic salts, the more active the corrosion. The relative degrees of attack on concrete by sulfates from soils, ground waters, or conveyed water are given in table 20 (*8*):

TABLE 20.—*Attack on concrete by soils and waters containing various sulfate concentrations*

Relative degree of sulfate attack	Water-soluble sulfate (as SO_4) in soil samples, percent	Sulfate (as SO_4) in water samples, parts per million
Negligible	0.00 to 0.10	0 to 150.
Positive	0.10 to 0.20	150 to 1,000.
Considerable	0.20 to 0.50	1,000 to 2,000.
Severe	Over 0.50	Over 2,000.

During 1951 Ash and Miller investigated the effects of natural waters on the concrete lining of tunnels and canals in the Hetch Hetchy aqueduct, San Francisco, Calif.; Mokelumne aqueduct, East Bay Municipal Utility District, East Bay Cities, Calif.; Colorado River aqueduct, Metropolitan Water District, Southern California; Delaware aqueduct, New York City; and the Tennessee Valley Authority, Knoxville, Tenn. The tunnels in these aqueduct systems total approximately 300 miles in length. As far as could be ascertained, no failures or noticeable deterioration of concrete lining has occurred in the tunnels or canals due to the chemical constituents of the waters. (*See* tables 9 and 19.)

Inspections in the Hetch Hetchy Coast Range tunnels, which are probably in the most troublesome formation encountered in the United States, have revealed no failures.

These tunnels have been in operation continuously since October 24, 1934 (*18*).

Although the pH of Hetch Hetchy natural water is 6.5 (*see* table 9), an interesting and serious problem arose in 1934 by the appearance of crenothrix, a type of iron bacteria (*54*, *56*). These bacteria have been found growing in the ground water that seeps into the Coast Range tunnels. This seepage water, having a high mineral content and containing the crenothrix organism, has seeded the Hetch Hetchy water flowing through the tunnels and carried the infection into several lines conveying the water. The bacteria are not harmful to health but form a slimy growth in an aqueduct, retard the flow of water, and impart an objectionable taste and otherwise affect the quality of the water. An intensive study of this organism and methods of controlling its growth have been made in the laboratory and in the field. As a result of the investigative work, it appears that a chlorine-ammonium treatment so far as known is the only satisfactory method of destroying this bacterial growth (*56*).

The 92 miles of concrete-lined tunnel of the Colorado River aqueduct have been in operation since July 1941. No evidence of concrete failure or noticeable corrosion has occurred traceable to the chemical constituents of the natural water conveyed by the aqueduct (*29*). This natural water is hard (pH, 8.1) and is softened after being conveyed through the aqueduct by pumping systems, tunnels, and canal.

Because some substances are considered aggressive and affect concrete structures by chemical action, it is interesting to note that the natural water conveyed by this aqueduct contains calcium (92 p. p. m.) and chloride (100 p. p. m.). Although the sulfate content of this water is higher than that of other natural waters conveyed by the tunnels investigated, no noticeable effect has occurred on the concrete lining in the tunnels.

The Colorado River aqueduct also utilizes 62 miles of concrete-lined canal subjected to desert conditions. No evidence of concrete destruction caused by chemical constituents of the water or otherwise is reported. Because of the desirability of utilizing as small a gradient as possible for tunnels that may be employed to handle anthracite mine water, it is interesting to note that this concrete-lined canal has the following hydraulic properties:

$A=360.57$ sq. ft.	$n=0.014$
$r=6.35$ ft.	$v=4.45$ ft. per sec.
$s=0.00015$	$Q=1{,}605$ c. f. s.

The slope of 0.00015 (0.792 foot per mile) is steeper than the theoretically economic gradient for this project but was considered necessary to provide ample velocity of flow (4.45 feet per second) to move sand that may blow into the stream to the sand traps. Lined canal has been found to be lowest in cost per linear foot to construct of any aqueduct section on this project. It requires least slope for its operation (*77*).

Diversion of individual mine drainage in the anthracite region from receiving streams or purification of mine drainages before entering streams are alternative remedial measures to combat pollution of surface streams by acid mine drainage. The approximate 327,000 g. p. m. (730 second-feet) drainage from the mines of the anthracite region represents a not inconsiderable quantity of water, and the effect of its removal from the surface streams coursing through and beyond the anthracite region is one of the phases that must be considered in any solution of the mine-drainage problem. When collected and made available at one point, such as the portal of a drainage tunnel, it also is a potentially valuable source of water supply for industrial or other utilization if its chemical quality can be improved to make it suitable for use, and this appears possible with a tunnel system.

CONCLUSIONS

The principal factor that threatens to curtail the life of the anthracite industry, reduce production, and affect the economic structure of the people and the businesses dependent on anthracite for their livelihood is inundation of anthracite mines.

Acid mine water from anthracite mines, although classed as an industrial waste, is not to be construed as being an economic loss to the industry. The factor of economic damage by pollution of the receiving bodies of water confronts the industry in developing the pollution-abatement program of the Commonwealth of Pennsylvania.

The facts indicate that a pollution problem must be solved in any program of anthracite mine drainage.

The average *p*H of all mine drainage from the anthracite region, as determined by analyses of samples collected in 1941, is 3.0. The average *p*H of samples collected in 1946 is 3.2; the *p*H, therefore, can be said reasonably to range from 3.0 to 3.2.

The average mine-water discharge of 472 million gallons a day, or 327,000 g. p. m., carries a free-acid load of 431 tons as H_2SO_4 (methyl-red indicator) or a total-acid load of 934 tons as H_2SO_4 (phenolphthalein indicator).

A solution of 1 percent H_2SO_4 will corrode concrete substantially and noticeably within 1 to 2 months, but the acid load in the mine-water discharges from the anthracite mines corresponds to an acid solution of only 0.02 percent strength when based on free-acid load or 0.05 percent when based on total-acid load. The experience in the anthracite region has shown that the damage caused by such weak solutions is negligible.

As long as the anthracite mines continue to operate, the industry and the State will be confronted with the problem of mine drainage, whether it continues to enter the streams at innumerable points as it does at present or whether it is directed intermediately to other channels and discharged into a receiving stream at a single or a few points.

The success or failure of the coal-mining industry, of which the anthracite industry is a major part, affects the economy of the Nation, particularly anything that concerns the cost or manner of operating that industry. The relation, therefore, between stream pollution and the industry cannot be underestimated. It must be borne in mind that abandoned and not active mines are the principal offenders for uncontrolled mine drainage.

Experience shows that acid waters counteract the self-purification capacity of the receiving bodies of water into which the acid waters are discharged.

Every acid-disposal problem is concerned with three basic considerations: The *p*H range over which the treatment is to take place, the minimum time available for the reaction between the treating reagent and the acid, and the disposal of products formed, of which sludge is of primary importance in the anthracite-mine-water problem.

As little or nothing can be done under existent conditions in the anthracite region to change the initial *p*H of the acid mine water, it is sound to accept this circumstance as a fact and deal with the problem accordingly. The final *p*H of the mine-water discharges into the receiving streams under pollution-abatement regulations depends ultimately on State, local, and Federal abatement requirements.

A low or a high *p*H often indicates the nature of an industrial waste. The *p*H range of 4.5 to 9.5 for an industrial waste, provided in the code regulating industrial wastes by Westchester County, N. Y., represents the widest acceptable limits for industrial wastes in effect at present. This code was designed to meet conditions likely to be encountered in any highly industrialized area.

Unless exceptional circumstances dictate, it is always better to develop a gravity or pressure system to handle large volumes of water than to employ pumping in drainage systems.

Large-capacity pumps at heads up to 500 feet can be successfully designed for single-stage operations. Such pumping plants are feasible but only practical in areas where power is available in large quantities and at very low cost.

Pumping should only be used as an auxiliary to the main drainage scheme in the capacity of central pumping plants to be utilized as emergency equipment to permit inspections or repairs of tunnels and to avoid large capital for developing tunnels that would have no use except for emergencies.

Natural water with a *p*H of 6.4, but with low calcium and low alkalinity, will be much undersaturated with calcium carbonate. Black-iron, steel, or cast-iron transmission lines or distribution mains conveying water are affected by such water. It tends to dissolve protective carbonate coatings of metal conduit and expose the metal to the action of the water.

Where acid mine water having *p*H's ranging from 3 to 3.5 is to be pumped with vertical-turbine, deep-well pumps, most recent practice based on experience to date (1951) advocates that column pipes and oil tubes be of stainless-steel construction, bowl assemblies be of zincless bronze, impellers be of chrome iron, and strainers be of stainless steel.

At the present stage of the study of the anthracite-mine-water problem, it appears that a tunnel system coupled with auxiliary central-pumping plants is the method by which a long-range drainage scheme for underground mine workings can be effective as more and more mines are abandoned for whatever cause. Such a scheme will obviate acid mine water, reduce drainage costs, save anthracite reserves, and materially extend the life of the industry and communities dependent thereon.

Concrete-lined tunnels, when properly designed and lined, are stable structures for conveying water without pretreatment over a wide range of *p*H's. They require no maintenance over many years of operation. The need for alternate or parallel tubes in general is unnecessary and usually unwarranted.

Diversion of individual mine drainage from receiving streams and purification of mine drainages before entering streams are alternative remedial measures to combat pollution of surface streams by acid mine drainage. The approximate 327,000 g. p. m. (730 second-feet) drainage from the mines of the anthracite region represents a not inconsiderable quantity of water, and the effect of its removal from the surface streams coursing through and beyond the anthracite region is one of the phases that must be considered in any solution of the mine-drainage problem. When collected and made available at one point such as the portal of a drainage tunnel, it also is a potentially valuable source of water supply for industrial or other utilization if its chemical quality can be improved to make it suitable for use, and this appears possible with a tunnel system.

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