REPORT OF INVESTIGATIONS

FLOOD-PREVENTION PROJECTS AT PENNSYLVANIA ANTHRACITE MINES

A PRELIMINARY STUDY

BY

S. H. ASH AND JAMES WESTFIELD
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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

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2/ Chief, Safety Division (supervising engineer), Bureau of Mines, Washington, D. C.

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INTRODUCTION

Because of the increasing shortage of fuel in the United States, especially of residential fuel in the Eastern and New England States, it was essential that the maximum production of anthracite be obtained to help win the war and to prevent human distress. The nine railroads that depend on the anthracite region for a substantial portion of their business were not congested unduly with other traffic, because the region was not participating in industrial activities to the same degree as in many other sections of the United States; consequently, transportation of anthracite to the New England States, New York, New Jersey, and eastern Pennsylvania over a shorter rail haul than for any other fuel was desirable.

The prevention of floods that would cause a loss of anthracite production was important to the war program. Every shut-down deprives the northeastern section of the United States of anthracite that is needed badly. Failure to prevent inundation of anthracite mines halts production, endangers the lives of workmen, damages, sometimes beyond repair, vital underground equipment, and threatens the permanent loss of a large portion of the Nation's anthracite reserves.

Funds were made available to the Department of the Interior, Bureau of Mines, for the fiscal year ended June 30, 1945, through a supplemental appropriation for anthracite investigations, one of which was to conduct inquiries and scientific and technologic investigations that have a bearing on the anthracite mine-flood problem. As part of the investigation the Bureau proposed to obtain the cooperation of the anthracite-mining companies and the State in effecting a program to prevent the inundation of mines in the anthracite region.

No large engineering projects were undertaken by the Bureau during the fiscal year ended June 30, 1945, on the anthracite mine-flood problem. Small projects were chosen that could be completed within 1 year to prevent loss of anthracite production at a critical time. It was believed that such projects would lessen the chance that flood water would inundate active mine workings.

Purpose of Report

The data contained in this report were collected during the course of an investigation of the anthracite mine-flood problem (3,4,7,9,14)\textsuperscript{4} undertaken by the Department of the Interior through the Bureau of Mines; the report describes investigative work conducted during the period July 1, 1944, to June 30, 1945. The investigation included construction work on four mine flood-prevention projects that offered a field for scientific and technologic investigations of the mine-flood problem. Each of the four flood-prevention projects was undertaken in cooperation with anthracite-mining companies that agreed to collaborate with the Government.

\textsuperscript{4} Numbers in parentheses refer to items in the bibliography at the end of this report.
THE ANTHRACITE MINE-FLOOD PROBLEM

During the years, the rainfall in the anthracite region has altered relatively little, but the quantity of water that enters the mine through fissures in the strata between the surface and the mine workings has increased materially, as indicated by the ratio of tons of water pumped to tons of coal produced underground. The ratio has increased from 8 to 1 in 1920 to 30 to 1 in 1942 at some collieries producing a large tonnage. For the region as a whole, the ratio of tons of water pumped to tons of coal produced underground is 13 to 1 (9).

It is recognized that the chief factor that threatens to cut short the life of the anthracite industry and to curtail the present production of anthracite is the encroachment of mine water (4, 9, 14). The anthracite mine-flood problem is complex. Mining practices have created conditions that allow surface water to enter into active and abandoned mine workings through fissures in the coal beds or in the rock strata, through cave-ins, through stripings, and through mine openings.

The basin-and-range structure of the coal measures in the anthracite region facilitates the accumulation of water either in the strata or in abandoned mines or active mine workings. The mountains surrounding the anthracite fields are steep, and the coal beds dip from the sides of the hills to the valleys below. Strippings and mining operations near surface bodies of water or water-laden strata have created conditions that permit an excessive quantity of water to enter mine workings. Illegal (bootleg) mining of barrier pillars and outcrops has played an important part in the water problem.

As a consequence of the above conditions, rainfall is quickly noticeable in anthracite mine workings. A sudden inflow of water after heavy precipitation often overtaxes the capacity of underground pumping plants, and floods parts of active mines, and causes loss of production.

Heavy precipitation increases the quantity of water that accumulates in abandoned mines, and unless drainage facilities are adequate to handle this excess water the hydrostatic pressure against the barrier pillars is increased. Many of the barrier pillars between underground pools of water and active mine workings are not strong enough to withstand additional hydrostatic pressure beyond a definite figure; consequently, either costly stand-by pumping facilities are installed to handle the excess water or the active mines affected are forced to close when the lives of the workmen are jeopardized.

The hydrostatic pressure against barrier pillars in abandoned mines is maintained, where possible, at a definite figure either by draining the water through boreholes in barrier pillars or by pumping the water direct.

The following examples give an idea how water in abandoned mines, lacking barrier-pillar protection, affects the economy of the anthracite industry and imperils the safety of mining operations:
1. In order to work a large active mine in the Western Middle Field during the period 1940-44, more than $19 \frac{1}{2}$ billion gallons of water was pumped to the surface against a head of 790 feet. Over $7 \frac{1}{2}$ billion gallons (38 percent) was drained into the active mine through boreholes in a barrier pillar to maintain safely the hydrostatic pressure against the barrier pillar between the abandoned mine and the active mine. The cost to pump the additional water during the 5-year period was $358,000.

2. In the Northern Field, in order to work safely three large active mines, the hydrostatic pressure against the barrier pillars between an abandoned mine and other mine workings must be maintained at a safe figure. The water in the abandoned mine is allowed to drain through pipes in a dam in a barrier pillar into old workings of one of the three active mines. A passageway has to be maintained to conduct the water through the old workings to the mine sump, from whence the water is pumped to the surface against a head of 700 feet. The cost to pump the water coming from the abandoned mine is paid on a percentage basis by the three companies operating the mines that are affected by the water in the abandoned mine. Since February 1941, when the water impounded in the abandoned mine was first admitted into the adjacent active mine, to June 30, 1945, more than $2 \frac{1}{2}$ billion gallons of water has been drained into the active mine and pumped to the surface at a cost of $109,000.

Infiltration of Surface Water Into Mines

Surface water that infiltrates into underground workings can be attributed to the following:

1. Main- and side-stream leakage.
2. General surface leakage.

Main- and Side-Stream Leakage

Stream leakage is the most important source of surface water in several anthracite mining districts. Potential danger zones in the anthracite region are the areas where rivers and creeks overlie the coal measures.

In the Wyoming Region, from the Lackawanna and Luzerne County line, to the city of Nanticoke, is present the so-called "buried valley" or ancient channels of the Susquehanna River, which has carved for itself a new channel after having filled an old one with sand and gravel deposits that are water-bearing and very irregular in course and depth (6). (See fig. 3.) The present river channel is above the level of the old waterways. In places, the depth of the sediment filling the old channels is over 300 feet (generally it is 100 to 150 feet) and the river wash is 2 miles wide. The companies that operate mines under or adjacent to this "buried valley" must spend large sums of money to drill numerous boreholes in order to establish definitely and accurately the course and extent of the water-soaked river wash, so that a safe rock cover between the mine workings and the river wash can be maintained.
The anthracite region contains many miles of streams as well as the Lackawanna, Susquehanna, Lehigh; and Schuylkill Rivers. The coal measures in Lackawanna County alone are crossed by 70 miles of surface streams. Stream beds throughout the region allow water to infiltrate into underground workings. Preventive methods to exclude water from mine workings are a major problem.

General Surface Leakage

Rock fissures, cave-ins, fissures in outcrops, and strippings, either on the flood plains of streams or on drainage areas, provide easy ingress to much of the surface water and create a serious mine-water problem in the anthracite region. Many of the fissures and cave-ins are not visible on the surface because they are hidden under refuse banks or are partly filled with dirt; nevertheless these openings contribute much to water seepage.

Barrier-Pillar Seepage

Often, active mine workings are connected to abandoned mine workings or have barrier pillars that permit water to seep through them. Over 69 billion gallons of water is impounded in underground pools in anthracite mines (8). (See figs. 1 and 2.)

Very little has been written about barrier-pillar seepage under different adjoining hydrostatic heads. Little or no information has been developed on this question in the anthracite region. Data from England, where water pools similar to the underground pools in the Pennsylvania anthracite region have been under observation for many years, indicate 500 g.p.m. occur at hydrostatic heads over 300 feet where the barrier pillar is capable of withstanding calculated water pressure (10, 14). It has been observed in one instance in the Pennsylvania anthracite region that seepage up to 365 g.p.m. occurs under a hydrostatic head of 570 feet against an ample barrier pillar that is intact.

Control of Surface Drainage

It cannot be said that anthracite companies have done nothing to prevent the infiltration of water into underground workings, but because of the magnitude of the anthracite mine-water problem, the solution of it by the anthracite industry unaided is beyond the financial ability of the industry. Much interest has been manifested in the solution of the problem, as indicated by the number of papers that have been written on the subject in recent years (1 to 14, inclusive).

In the anthracite region during 1944, 200 billion gallons of water was handled at a cost of 10 million dollars (14); 150 billion gallons of this water was pumped to the surface or to drainage tunnels at a cost of 9 million dollars, and 50 billion gallons was handled by water-level drainage tunnels and ditches and flumes on the surface at a cost of 1 million dollars.
In view of the high cost to pump water from mines, sometimes against heads of 1,200 feet, considerable effort is made (and much more should be made) to prevent the infiltration of surface water into underground workings. Large sums of money have been spent in the construction and maintenance of flumes and ditches to conduct water to watercourses, thereby circumventing, at least to some extent, outcrops, rock fissures, strippings, mine openings, and cave-ins. These flumes and ditches must carry immense quantities of water during flash floods. (See figs. 4 to 9, inclusive). Some of these flumes and ditches are paved or lined where they cross broken ground. One large anthracite company maintains over 40,000 feet of wooden flume ranging in width from 36 to 36 inches. The flumes are either semicircular, square-box, or "V" types. Where there is danger of spillage, wood-stave pipe of the same diameter is used.

In spite of the many protective flumes and ditches that are in use to prevent the inundation of mine workings, a large quantity of water still infiltrates into abandoned or active mine workings. Many abandoned properties do not maintain protective ditches and flumes to exclude surface water. To maintain ditches and flumes on these abandoned properties is beyond the financial ability of the anthracite industry (9).

Large sums of money have been spent by the anthracite industry, the State, and the Federal Government on projects to divert rivers and streams to new and safer channels and for the erection and maintenance of levees to prevent the inundation of flood plains; the levees were constructed to prevent inundation of residential areas rather than to prevent inundation of mines; however, a few levees have been constructed by mining companies.

In 1936 the Lackawanna River overflowed its banks in Duryea, Luzerne County, Pa.; the water inundated the Halletsdale mine of the Kehoe-Berge Coal Co. and several contiguous mines operated by other companies. Although no lives were lost, 6,000 mine workers were made idle for a considerable period; all pumping equipment was lost, and 16 billion gallons of water had to be pumped to the surface. At the time of the flood, unemployment of miners in the anthracite region was a serious social problem. In consideration of the cost to the coal companies to recondition the mines, and in order that the affected workmen could be employed, the Commonwealth of Pennsylvania furnished the pumps, equipment, and power that were necessary to unwater the mines at a cost of $500,000 to the State alone.

Following rehabilitation of the mines, it was recognized that something had to be done to prevent a similar experience. A Federal Works Progress Administration project, under the sponsorship of the Department of Health of the Commonwealth of Pennsylvania, was authorized, under which a levee was constructed on the west bank of the Lackawanna River in Duryea, Pa. The project was completed at a cost of more than $40,000 to the State. The Federal Government contributed a much larger sum (4).
Levees erected along the Susquehanna River and streams in the area of the "buried valley" in the Wyoming region prevent inundation of parts of flood plains but do not prevent the infiltration of water into the sand and gravel of the "buried valley." The erection of additional levees along the streams in this area does not obviate the need for boreholes to establish the extent of the "river wash."

As part of the investigation of the anthracite mine-water problem, information has been collected relative to underground pools in the various fields. This information shows that in the Northern Anthracite Field there are 26 underground pools containing an estimated 12 billion gallons of water; in the Southern Field 31 pools with an estimated water content of 32 billion gallons; and in the Western Middle Field 25 pools having an estimated water content of 20 to 25 billion gallons.

Maps and cross sections have been made and other data assembled that give the following information: Relative position in area, size, head of water, altitude of overflow point, and quantity of water. (See figs. 1 and 2.)

**Flooding Mines Unwatered**

It is common practice to unwater mines in the anthracite region flooded by drown-outs or to remove water from abandoned mines in order to work the mines with safety or to recover coal reserves (14).

**DRAINAGE TUNNELS**

Drainage tunnels constitute an important link in anthracite-mine drainage, and without them many such mines could not operate. Drainage tunnels are used only where the coal basins lie for the most part above the natural drainage horizon of the nearby surface area. Drainage tunnels are used extensively in the Eastern Middle Field and in the Western Middle Field where most of the coal measures lie at an altitude slightly higher than that of nearby valleys.

In the anthracite region there are 22 drainage tunnels, with a combined length of 138,000 feet, that handle water from active and abandoned mines (4). Of these, only two, having a total length of 14,960 feet, are in the Northern Field, and only one, which is 19,890 feet long, is in the Southern Field.

**REASONS FOR PROJECTS ON PREVENTION OF INUNDATION OF ANTHRACITE MINES**

To conduct inquiries and scientific and technologic investigations bearing on the anthracite mine-water problem, projects were chosen and completed by the Federal Government, through the Bureau of Mines, in cooperation with anthracite mining companies, during the fiscal year ended June 30, 1945. The four projects offered a field for investigation.
because of the threat of inundation of active mine workings, and they are
typical of the mine-flood problems encountered in the anthracite region as
a whole. At each project the mining company that collaborated with the
Government either owned the property or operated an adjacent property that
would be protected or benefited. Two of the projects were in the Northern
Field, one in the Western Middle Field, and one in the Southern Field.

A preliminary survey was made on each of the four projects; much
of the information was contributed by the mining companies that collabo-
rated with the Government in the performance of the work. The history
and details pertaining to the flood problem are as follows:

Project No. 1

In the spring of 1942 an active mine in the Western Middle Field was
closed on orders of the Pennsylvania Department of Mines when the pressure
of the water in an abandoned mine reached 55 pounds a square inch against
a barrier pillar that was believed to be too weak to withstand that
pressure.

To decrease the hydrostatic pressure against the barrier pillar so
that the mine could resume operations, as well as to control the water im-
pounded in the abandoned mine, thus obviating the necessity for closing
the active mine, officials of the company decided to enlarge two of the
seven boreholes in the barrier pillar from 4 inches in diameter to 8
inches. The owners of the abandoned mine, however, had obtained an
injunction from the District Court of the United States restraining the
operators of the active mine from enlarging the boreholes. With the aid
of the Pennsylvania Department of Mines and the moral support of the
Bureau of Mines, a plan was approved and adopted whereby the company
operating the active mine was permitted to enlarge the bore-holes in the
barrier pillar.

Previous to the shut-down, the hydrostatic pressure was controlled
by draining the water into the adjacent active mine through seven 4-inch
boreholes in the barrier pillar. Owing to excessive rainfall in the area
during May 1942 (11.9 inches was recorded, 10.3 inches of which fell during
one week), the hydrostatic pressure against the barrier pillar increased
to a critical figure, and the mine was closed for a long time, with
resultant loss of 97,000 net tons of anthracite and $350,000 in wages to
1,680 employees.

The surface water that infiltrates into the above-mentioned abandoned
mine comes from a drainage area comprising a hillside above an abandoned
stripping. The water enters into the abandoned mine through surface breaks
and abandoned strippings. To prevent the entrance of water (from the drain-
age area) into the abandoned strippings, diversion ditches and flumes had
been constructed (as a W.P.A. project in 1936) on the hillside above the
strippings. The ditches and flumes were not maintained and were eventually
destroyed by surface breaks caused by "bootleg" mining and by freshets,
so that water entered the abandoned mine workings.
As nothing was done to prevent it, large quantities of surface water (more than 1 billion gallons each year) have seeped into the abandoned mine. This water must be drained into the active mine and pumped to the surface to maintain a safe hydrostatic pressure against the barrier pillar. In addition, there was the threat that during a period of heavy rainfall the hydrostatic pressure against the barrier pillar might increase so much that it would be unsafe to work the active mine. For these reasons and to prevent the entrance of flood water into stripings and cave-ins, a project was completed to reduce, in part, the quantity of water entering the active mine.

A preliminary survey was made by engineers of the company that agreed to cooperate on the project (No. 1), and plans, specifications, and an estimate of the cost were submitted to the Bureau for approval.

**Project No. 2**

In the Southern Field a large active mine and two abandoned mines, which are partly filled with water, are interconnected by mine workings. The water in the abandoned mines is impounded in old workings by dams of unknown strength, as well as by falls or 'spills.' Information obtained from maps of the abandoned mine workings and from records on boreholes shows that mining has been conducted in the abandoned mines under the Little Schuylkill River, so that insufficient rock cover has been left between the river bed and the mine workings (fig. 16). The active mine workings are below those of the above-mentioned abandoned workings. There is a definite threat (by inundation) to the lower workings of the active mine by the Little Schuylkill River in the event of sudden subsidence of the strata between the river and the adjacent abandoned mines, or from the sudden release of large bodies of water impounded in the abandoned mines.

In 1910, the company operating the active mine started a project to establish a dependable barrier pillar between the active workings and the abandoned mine workings. Considerable work was done on the project during the periods 1910 to 1920 and 1928 to 1931, after which the work was discontinued because of the depression. During these periods slopes and tunnels were driven in rock, abandoned workings were reopened and explored, and one dam and part of another were constructed.

In 1944, the company resumed work on the aforementioned project, and, as part of the work necessary to reopen the abandoned mine workings, a drainage tunnel, 8 by 10 feet in cross section was driven in rock, slightly upgrade across the coal measures, a distance of 587 feet from the face of a gangway on the third level of the active mine.

To prevent loss of production of anthracite and possible loss of life, a project (No. 2) was authorized on which the Bureau of Mines and the mining company collaborated and drove a drainage chute (in rock) from the face of the drainage tunnel to the abandoned mine workings, so that possible sites could be inspected and studied for the installation of mine dams that would prevent inundation of the active mine by water from the Little Schuylkill River and adjacent abandoned mines.
Project No. 3

A group of active mines in the Northern Field having a combined daily production of 6,000 tons of coal and employing 2,500 men was confronted with a flood menace so long as flood water of a river and one of its tributaries (a creek) could enter a shaft of an abandoned mine and a slope of another abandoned mine.

In 1942 the river and creek overflowed their banks, and the flood water inundated the area in which the shaft collar and slope portal of the abandoned mines are situated. The surface of the water was less than a foot below the collar of the shaft and but a few feet below the portal of the slope.

The abandoned mines adjoin a group of active mines lower in altitude and either are connected by mine workings to the abandoned mines or have unreliable barrier pillars.

In the event flood water from the river or creek enters either the shaft or the slope of the abandoned mines, the mine workings of the active mines may be inundated.

A concrete wall 6 feet high was constructed on the top of the shaft, and three dams were built in passageways near the bottom of the abandoned slope (figs. 17 and 20).

Project No. 4

Three large active mines in the Northern Field of the anthracite region are menaced by the water in an abandoned mine unless the hydrostatic pressure against the barrier pillars of the abandoned mine is maintained at a safe figure. Because the barrier pillars are unreliable, the hydrostatic pressure is controlled by draining the water (through pipes and valves installed in a dam in the barrier pillar) into one of the active mines. The water then flows by gravity through a watercourse in "old" mine workings and eventually into the sump, from which it is pumped to the surface against a head of 713 feet.

One of the three companies operating an active mine adjacent to the abandoned mine has spent a large sum of money in order to strengthen the barrier pillar between the abandoned mine and their mine.

It was noted in May 1944 that part of the watercourse was blocked by falls and mine timber, and that the water was backing towards the dam in the barrier pillar. It was feared that the valves in the dam would be submerged, thereby preventing control of the water impounded in the abandoned mine. In order to assure free flow of water in the watercourse, it was decided to reopen and retimber part of the watercourse for a distance of 1,365 feet. The work done in this part of the watercourse is called project No. 4.
PLANS TO CONDUCT AND FINANCE PROJECTS

To achieve the purposes of the flood-prevention projects undertaken by the Bureau of Mines in cooperation with a mining company, it was decided that either one of two plans could be used to govern the procedure by which the workmen on construction work were hired, supervised, and paid.

Plan No. 1

Plan 1 provides that the Federal Government hire, supervise, and pay the men to do part of the construction work on a temporary and "when actually employed" basis. Under this plan, the Government agrees to contribute a definite sum of money to be spent for labor, and the mining company cooperating with the Government on the project agrees to furnish all supplies and materials for the project as well as to perform engineering work and other labor that may cost more than the Government's allocation.

Plan No. 2

Plan 2 provides that the Bureau of Mines and the mining company wishing to cooperate with the Federal Government enter into a cooperative agreement whereby the mining company shall perform the work of the project, using its own crews and labor, under its sole supervision and control but subject to general direction of the Government's engineers. The mining company shall furnish all the necessary tools, equipment, and materials. The Government shall contribute to the expense of the work a sum determined by the number of man-hours actually worked by miners, timbermen, and laborers assigned by the mining company, up to but not exceeding an agreed sum, and at a set rate per man-hour, whether the work is that of miners, timbermen, or laborers.

Plans Used on Projects

Officials of the mining company that cooperated with the Bureau of Mines on project 1 did not consider it advisable for the mining company to furnish the workmen, who would perform labor on this project, because of the shortage of manpower at their mines and because of possible complications that might arise in making an agreement with the labor union having jurisdiction in the area where the project is situated; therefore, plan 1 was used, and the Bureau of Mines employed the laborers on a "when actually employed" basis and supervised the work of these men.

The work on projects 2 and 4 was conducted from the workings of mines operated by the companies that agreed to cooperate with the Government on these projects; as a consequence, plan 2 was followed, whereas the work was supervised and conducted by employees of the mining companies. Plan 2 was also followed to perform the work on project 3, although the construction work was done on an abandoned property not owned by the mining company that cooperated with the Government.
Before work commenced on projects 2, 3, and 4, a cooperative agreement was made and approved by the Department of the Interior and by officials of the mining companies cooperating with the Government on the projects. The cooperative agreement that applied to project 2 is shown as exhibit A at the end of this report.

CONSTRUCTION

Project No. 1

Twelve men were employed by the Bureau of Mines on a "when actually employed" basis, and work was commenced October 26, 1944, on project 1. One of the employees acted as foreman.

Construction work was started on the discharge end of the system of flumes and ditches, so that water would be collected by the flumes or ditches as they were constructed, thus diverting water that previously entered nearby abandoned strappings. The work on project 1 consisted of:

1. The dismantlement and salvage of 190 feet of 42-inch-diameter, semicircular, steel flume that was lying in a breach in a fill across the strappings. A washed-out portion of a fill across the strappings was refilled with 700 cubic yards of materials. The flume thus recovered was installed on the fill across the strappings, and retaining walls of riprap were constructed at the intake end of the flume to divert flood water into it (fig. 10).

2. The construction of 1,600 feet of earthen ditch having an average cross section 34 feet deep, 4 feet wide at the bottom, and 12 feet wide at the top. This ditch was made on the hillside above the abandoned strappings by excavating a new ditch and cleaning and repairing an old one that had been constructed as a W.P.A. project during the depression but which had been destroyed by surface breaks and flash floods (figs. 11 to 15, inclusive).

3. The construction of a steel flume 818 feet long, consisting of 221 feet of 48-inch-diameter semicircular steel-flume sections and 597 feet of 36-inch-diameter semicircular steel-flume sections. The purpose of the flume is to divert flood water that, unless diverted, enters the underground workings through surface breaks. A portion of the old W.P.A. ditch had been destroyed completely by surface breaks caused by the removal of the beds underlying the Mammoth bed. The 48-inch-diameter steel flume was installed at the discharge end of the flume. The steel-flume sections were bolted together and supported at the top by tie rods placed at 10-foot intervals. The flume was also supported by a dirt fill along both sides of the flume.

A bulldozer was used to level the side hill and to move filling materials. The bulldozer was also used to drag 300 feet of the steel sections into place. Because of deep snow and ice on the hillside, the remainder 518 feet had to be dragged by manpower from an unloading point on the highway.
4. The construction of 159 feet of flume designed to divert water from a community on the hillside above the abandoned stripinggs. This water was entering the stripinggs. The flume was made of 48-inch-diameter semicircular steel sections bolted together and reinforced with tie rods, which were placed at 10-foot intervals across the top of the flume.

The construction work on project 1 was done during the winter; the ground was frozen much of the time and at times was covered with 18 inches of snow, which made the work slow and hard. It could have been done in less time and with better results in the late spring, summer, or fall. However, the project was started as soon as possible after it was selected so that it could be completed in time to handle flood water during the spring and summer.

The project was inspected frequently by an engineer of the Bureau of Mines during the progress of the work. It was observed that sewage from the hillside community was entering abandoned mines through breaks in the surface between the community and the diversion ditch being excavated. This sewage is estimated to average 200 gallons a minute.

The sewerage system leading from the hillside community apparently had been blocked, which caused the sewage to come to the surface through a manhole. The sewage flowed into abandoned mines through an old mine shaft and other surface breaks and eventually reaches active mine workings, from which it must be pumped to the surface against a head of 790 feet.

These facts were brought to the attention of the chief engineer of the company cooperating on this project, and he requested the Pennsylvania State Board of Health to correct this condition. An engineer of the State Board of Health visited the project with the chief engineer of the mining company and an engineer of the Bureau of Mines. The Bureau's engineer made the following recommendation to the chief engineer: "If the sewerage system is not repaired, the sewage should be conducted into the diversion ditch by a flume or a pipe installed across the surface breaks." At the time of writing this report nothing had been done to repair the system or divert the sewage.

One thousand feet of the old W.P.A. ditch that forms an extension of the portion of the W.P.A. ditch repaired on project 1 is intact, with the exception of the 60 feet that have been washed out. After each flash flood in this area the water collected by the intact portion of the ditch escapes through the gap and flows onto a highway and then into abandoned stripinggs. The State Highway Department spends considerable time and money to clean and repair the highway at this point. The chief engineer of the mining company requested the State Highway Department to fill the washed-out portion of the ditch. At the time this report was written, this had not been done.

The Bureau's share of construction on project 1 was completed February 28, 1945.
Project No. 2

The Federal Government and a mining company entered into a cooperative agreement on October 27, 1944, to do the work contemplated by project 2, which comprised construction of a chute, which was driven in the strata between the workings of an active mine and those of adjacent abandoned mines.

Work on the drainage chute commenced November 15, 1944, and was completed March 31, 1945. The chute starts at the face of the drainage tunnel off the third level of the active mine and was driven in rock to the rise at an angle of 35° from the horizontal. It crosses transversely the coal measures and is 6 by 3 feet in cross section, timbered with standard chute sets, and divided into two parts—a rock-compartment and a manway compartment.

When the drainage chute had been driven a distance of 138 feet it intersected an old chute that served as a watercourse between the abandoned mines and the fourth level of the active mine. After the connection had been made, the water, which had to be pumped previously from the fourth level to the surface, was directed down the drainage chute being driven as part of the work on project 2. The water is now collected on the third level and is pumped to the surface against a head that is 250 feet less than formerly.

It is estimated that the quantity of water that was diverted by the drainage chute averages 500 gallons a minute. From information available it is estimated that the average cost to pump water in this mine is 9 cents a million foot-gallons.

By the diversion of the mine water into the drainage chute and the third level, a saving of $6,000 a year in pumping cost will accrue to the company operating the active mine, and the way has been cleared for an investigation to devise means to complete dams and take other protective measures.

It was found difficult to cope with the water in the drainage chute. First, a false bottom of planks was constructed 6 inches above the bottom of the chute to form a ditch to carry the water under the manway compartment of the drainage chute. This ditch proved unsatisfactory, as it became clogged, and the water, which is cold, flowed into the manway compartment. All materials used to construct the drainage chute, such as timber, lagging, and sheet iron, were carried to the face by manpower. This necessitated several trips up and down the chute each shift. Because of water (500 g.p.m.) in the manway compartment, the men could not keep dry even when water-repellent clothing was worn, and the progress of the work was slow and laborious.

In order to remove the objectionable working conditions, an 8-inch-diameter sheet-metal pipe was installed in the manway compartment of the drainage chute to handle the water. This pipe was serviceable for a short time, but before the chute was completed the acid mine water destroyed the
pipe at a number of places, thereby allowing 50 percent of the water to enter the manway compartment. Finally, a 10-inch-diameter wooden pipe was installed to handle the water; this proved adequate and satisfactory.

The drainage chute intersected other abandoned workings when driven distance of 221 feet, and the final connection with such workings was made at a distance of 294 feet. Progress on the construction of the drainage chute was slow because the chute and workings had to be timbered extensively.

Project No. 3

Construction work on project 3 commenced February 10, 1945, and was completed April 30, 1945.

A concrete collar for an abandoned shaft and three concrete dams that sealed off three passageways driven from an abandoned slope, were constructed in order to prevent the inundation of a group of mines by flood water of a river and a surface stream.

The abandoned shaft is 100 feet deep and 11 by 15 $\frac{3}{4}$ feet in cross section. It is divided into two compartments and is concreted from the surface for an estimated distance of 45 feet.

The altitude of the collar of the abandoned shaft was increased 6 feet by the construction of a concrete wall (fig. 18). Figure 19 shows the details of construction. The concrete wall is reinforced by horizontal and vertical steel rods. Angle-iron fence posts are set in the concrete and extend 2 feet above the concrete wall in order to support four strands of barbed wire. The upper foot of each post is bent outward at a 45-degree angle. The concrete used on the project was purchased from a central mixing plant and delivered and poured by an agitating truck.

The abandoned slope dips 30° from the horizontal, is in gravel, and intersects the top split of the Red Ash bed 150 feet from the surface. Two parallel entries are driven in the bottom split of the Red Ash bed as a continuation of the slope. Both splits have been removed in the haulage entry and the air course for a distance of 100 feet from the bottom of the slope. The mine workings are developed in the bottom split of the Red Ash bed.

Three dams were constructed at the following places to prevent inundation of abandoned workings off the slope by flood water:

No. 1 dam in the haulage entry at a point 300 feet inbye the portal of the slope.
No. 2 dam in a crosscut driven off the haulage entry at a point 250 feet inbye the portal of the slope. The crosscut connects the haulage entry to a breast.
No. 3 dam in the air course at a point 300 feet inbye the portal of the slope.
Construction of the three dams commenced February 11 and was completed February 26, 1945. The details of construction are shown in figure 21. A chute made of steel shaker-conveyor pans was used to convey the concrete from the surface to the bottom of the slope. The concrete was delivered from the discharge end of the chute to the site of the dams by wheelbarrow and buggy.

The concrete in the dams was reinforced by 25-pound steel rails placed horizontally and vertically. The ends of the rails were placed in hitches 4 to 6 inches deep in the floor, rib, and roof.

Dams 1 and 3, which were erected in the haulage entry and the air course, are 15 feet high on the water-storage side of the dam. The upper 6 to 7 feet of the other side of the dam is built against the top coal and cap rock, which were not removed by mining operations inby the two dams. The water-storage side of dams 1 and 3 is T-shaped. The lower 8 feet of dam 1 is 10 feet wide and 30 inches to 5 feet thick; the upper 6 feet 10 inches is 15 feet wide and 30 inches thick. The lower 8 feet 9 inches of dam 3 is 10 feet wide and 30 inches to 5 feet thick; the upper 6 feet is 16 feet wide and 30 inches thick.

No. 2 dam is 5 feet high, 15 feet 4 inches wide, and 30 inches thick. This dam is anchored in hitches cut in the coal ribs. The hitches in the ribs and the dam are constructed so that the dam has the shape of a cork. The hitch on the water-storage side of the dam is $2\frac{1}{2}$ feet deep, tapering to 1 foot on the other side of the dam. The vertical reinforcing rods are 25-pound steel rails and are placed in hitches 6 inches in the bottom and in the top rock.

The maximum head of water that the three dams will have to withstand is 70 feet.

The following summary shows the number of cubic yards of concrete poured and the footage of steel rails used in the construction of the three dams:

<table>
<thead>
<tr>
<th>Dam</th>
<th>Concrete, cu. yd.</th>
<th>25-lb. steel rails, ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>14</td>
<td>160</td>
</tr>
<tr>
<td>2.</td>
<td>9</td>
<td>115</td>
</tr>
<tr>
<td>3.</td>
<td>$22\frac{1}{2}$</td>
<td>275</td>
</tr>
</tbody>
</table>

After the three dams were constructed, the abandoned slope was filled with dirt and gravel taken from a nearby stripping.

**Project No. 4**

Project 4 consisted of work necessary to reopen 1,365 feet of watercourse in an active mine, whereby the free flow of water in the watercourse is assured and the hydrostatic pressure against the barrier pillars in an adjacent abandoned mine can be controlled.
Work on the project commenced April 1, 1945. On June 30, 1945, the expiration date of the cooperative agreement, the watercourse had been reopened and retimbered for a distance of 190 feet. The main restriction in the watercourse had been removed, and the water confined in by this restriction had been released, which lowered the level of the water so that the valve used to control the hydrostatic pressure against the barrier pillar of the abandoned mine was accessible. Lowering the level of the water in the watercourse also permitted the use of a weir to determine the flow of water.

A large body of water that was confined in the watercourse was released suddenly when a blast was made to break some large rocks in the watercourse. The sudden rush of water destroyed the ditch and the mine track in the portion of the watercourse that had been reopened. Considerable time was required to repair the water ditch and track. Progress of the work on the project was slow and laborious owing to the quantity of water (1,600 to 1,800 g.p.m.) that was flowing in the watercourse.

The work required to reopen the entire watercourse is being continued by the three mining companies that operate the active mines.

Cost of Construction

The total expenditure on project 1 was $4,912.76, of which $3,536.68 was contributed by the Federal Government for labor and $1,376.08 was paid by the mining company for supplies and labor.

The total cost of project 2 is but a small percentage of the expenditure that has been made previously and will have to be made to complete the program of which this project is a part. A total of $7,600 was expended on the construction of the drainage chute; of this sum, $3,000 was contributed by the Federal Government for labor and $4,600 by the mining company for supplies and labor.

The total cost of project 3 was $7,254.82, of which $2,999.70 was contributed by the Federal Government. The mining company paid $4,255.12 for supplies and labor.

The company that collaborated with the Federal Government on project 3 entered into a separate agreement with two other mining companies receiving benefits from the project, whereby each company would share the expense of supplies and labor above the amount contributed by the Federal Government.

The three mining companies receiving benefits from project 4 shared the expenses above the amount contributed by the Federal Government on a percentage basis, calculated on the basis of benefits derived.

The total expenditure on project 4 was $6,139.23 during the period April 1, 1945, to June 30, 1945. Of this sum, $3,492.47 was contributed by the Federal Government for labor and $2,646.76 was paid by the three mining companies. The total cost of the project covers but a relatively small portion of the expenditure that will have to be made to reopen and retimber the remainder 1,175 feet of watercourse.
TABLE 1. - Cost of supplies and labor expended by the mining companies and the Federal Government on each project

<table>
<thead>
<tr>
<th>Project</th>
<th>Man-hours (labor and supervision) paid for by the Government</th>
<th>Rate per man-hour under provisions of cooperative agreement</th>
<th>Amount contributed by Government for labor</th>
<th>Amount paid by mining company for labor</th>
<th>Cost for labor</th>
<th>Cost of supplies paid by mining company</th>
<th>Total paid by mining company for supplies and labor</th>
<th>Total cost of project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 .......</td>
<td>4,124</td>
<td>-</td>
<td>$3,536.68</td>
<td>$139.03</td>
<td>$3,675.71</td>
<td>$1,237.05</td>
<td>$1,376.08</td>
<td>$4,912.76</td>
</tr>
<tr>
<td>2 .......</td>
<td>3,750</td>
<td>$0.80</td>
<td>3,000.00</td>
<td>2,915.02</td>
<td>5,915.02</td>
<td>1,684.98</td>
<td>4,600.00</td>
<td>7,600.00</td>
</tr>
<tr>
<td>3 .......</td>
<td>2,727</td>
<td>1.10</td>
<td>2,999.70</td>
<td>2,574.33</td>
<td>5,574.03</td>
<td>1,680.79</td>
<td>4,255.12</td>
<td>7,254.82</td>
</tr>
<tr>
<td>4 .......</td>
<td>3,010.75</td>
<td>1.16</td>
<td>3,492.47</td>
<td>1,982.18</td>
<td>5,474.65</td>
<td>664.58</td>
<td>2,646.76</td>
<td>6,139.23</td>
</tr>
<tr>
<td></td>
<td>13,611.75</td>
<td>-</td>
<td>13,028.85</td>
<td>7,610.56</td>
<td>20,639.41</td>
<td>5,267.40</td>
<td>12,877.96</td>
<td>25,906.81</td>
</tr>
</tbody>
</table>
Table 1 shows the cost of supplies and labor on the four projects and the amounts expended by the Federal Government and the mining companies that collaborated with the Federal Government on each project.

Table 1 shows that $25,906.81 was spent. Of this amount, $12,877.96 was paid by the mining companies and $13,028.85 (slightly more than 50 percent of the total cost) was contributed by the Federal Government.

SAFETY

The construction work on the four projects described in this report was completed without injury to anyone, despite the fact that some of the work was hazardous.

Much of the work on project 1 was done in freezing weather, when the ground was deeply covered with snow, making transportation of the heavy steel flume sections along the hillside more hazardous than usual.

Construction work on projects 2 and 4 and a part on project 3 was done underground. The work on projects 2 and 4 consisted of the construction, in heavy ground, of mine openings through which a large quantity of water flowed, thereby making the work hazardous.

MAINTENANCE

The construction work on projects 2 and 4 was conducted in active mines, and the total cost is but a small portion of the expenditure that will have to be made to complete the objectives of the program of which projects 2 and 4 are a part. It is logical to believe that the construction works completed on those projects will be maintained to protect the large investment. However, projects such as Nos. 1 and 3 are situated on abandoned properties, and there is no assurance that either the mining companies that derive benefits from the projects, or the landowners, or the State or local governments will assume responsibility to maintain the construction works completed. This is substantiated by the fact that the drainage ditch that was constructed as a W.P.A. project at the site of project 1 was destroyed because it was not maintained.

Events that followed the completion of project 3 show that before any money is expended by the Federal Government on a flood-prevention project that is situated on abandoned property, the continued maintenance and protection of the construction works should be assured.

Soon after project 3 was completed, stripping was conducted to remove a portion of the Red Ash bed believed to underly a 2 20-acre tract of land that lies between the Lackawanna River and the abandoned slope and mine workings in which project 3 was situated. The stripping extends along the river bank and is only 25 feet from the abandoned mine workings and 40 feet from the river bank.
At the time this report was written, the stripping, approximately 70 feet deep, 200 feet long, and more than 100 feet wide, had been abandoned and allowed to fill with water. The materials removed consisted of gravel and clay, and no anthracite was encountered. A levee was constructed between the river bank and the stripping by placing materials (gravel and clay) taken from the stripping operation along the bank of the river.

The anthracite mining laws of Pennsylvania are so worded as to give protection to men working in mines adjacent to abandoned mines that are entirely or partly filled with water; the laws do not prevent mining operations that are conducive to the infiltration of water into abandoned mines or into active mines unless there is immediate danger to the lives of the workmen.

Article III, section 10, of the Anthracite Mining Laws of Pennsylvania, reads thus:

It shall be obligatory on the owners of adjoining coal properties to leave, or cause to be left, a pillar of coal in each seam or vein of coal worked by them, along the line of adjoining property, of such width that, taken in connection with the pillar to be left by the adjoining property owner, will be a sufficient barrier for safety of the employees of either mine in case the other should be abandoned and allowed to fill with water; such width of pillar to be determined by the engineers of the adjoining property owners together with the inspector of the district in which the mine is situated, and the surveys of the face of the workings along such pillar shall be made in duplicate and must practically agree. A copy of such duplicate surveys, certified to, must be filed with the owners of the adjoining properties and with the inspector of the district in which the mine or property is situated.

In some instances mining has been conducive to the infiltration of water into abandoned mines, threatening the loss of anthracite production and reserves and creating conditions that, if not controlled or corrected, imperil the lives of workmen in active mines.

In 1932, a Water Hazards Commission for Lackawanna County was established by the Pennsylvania Department of Mines to study the water problems relating to mining in the Lackawanna area. The commission consisted of three State mine inspectors who held more than 50 meetings with engineers and executives of anthracite companies concerned.

The Water Hazards Commission submitted a report by letter, dated April 18, 1934, to the Secretary of Mines of the Commonwealth of Pennsylvania, setting forth five conclusions, as follows:
First: A safety zone shall be established beneath and adjacent to the Lackawanna River, extending horizontally from the high-water mark of each bank thereon 250 feet and extending vertically downward to the limit of the workable beds beneath the river.

Second: This zone shall be considered as having two subdivisions:

(A) That area 250 feet horizontally from the high-water mark of each bank of the river and down to and including 35 feet of rock cover.

(B) That area within 250 feet on either side of the high-water mark of the river and below the 35-foot rock-cover line down to the limit of the workable beds.

Third: In the upper zone, that called "A", no mining whatsoever shall be permitted, except such exploratory work or narrow roads for special purposes as may be specifically authorized by the State Water Hazards Commission upon formal request thereof, and after the same shall have been submitted to all operators interested, for their consideration, and recommendations for the same having been obtained.

In the second zone, that called "B", first mining may be done, provided it does not exceed the maximum chamber widths and centers and minimum pillar widths given in the following table:

<table>
<thead>
<tr>
<th>Thickness of bed, ft.</th>
<th>Chamber centers, ft.</th>
<th>Maximum chamber widths, ft.</th>
<th>Minimum pillar widths, ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - 5........</td>
<td>50</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>5 - 8........</td>
<td>54</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>8 - 12........</td>
<td>54</td>
<td>26</td>
<td>28</td>
</tr>
<tr>
<td>12 plus</td>
<td>54</td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>

If in the judgment of the mine inspector the first mining undertaken in this zone is objectionable, the mine inspector will refer the mining plans to the Water Hazards Commission as provided under the immediate succeeding paragraph covering robbing in the same zone.
No pillar recovery shall be undertaken except under plans approved by the Water Hazards Commission, it being understood that their scrutiny of these plans shall be directed to the factors of depth, thickness of bed, percentage of pillars proposed to be extracted and to be left, to its effect on pillars remaining in the overlying beds, and any other special features that may be involved in each particular case.

**Fourth:** Proof of the existence of 35 feet of rock cover, where such is in doubt, shall be furnished the Water Hazards Commission by test holes drilled on intersecting lines forming rectangles or squares where the cover thickness is known to be less than 50 feet. These holes shall be drilled on spacing not more than 100-foot centers.

**Fifth:** When any mining operations are being conducted in the vicinity of the Lackawanna River within the restricted zone provided for in Rule No. 1 herein, no authorization shall be granted by the Water Hazards Commission for exceptional mining under these rules without first having consulted all of the operators who may be affected by such mining.

During 1942 the flood water of the Lackawanna River covered part of the present stripping area, and the level of the flood water was but a few feet below the portal of the abandoned slope situated on the site of project 3.

Notwithstanding the conclusions of the commission appointed in 1932 to report on water problems relating to mining in Lackawanna County and the serious nature of the flood in 1942, stripping operations were conducted along the river bank.

It is apparent that the area in which the stripping was conducted is an old watercourse, and the Red Ash bed has been washed out or eroded away in this area. The extent of the erosion is unknown, and the thickness of the coal pillar, if any, between the stripping and abandoned workings connected to the slope and the shaft that were sealed by project 3 also is unknown.

**CONCLUSIONS**

1. The ditches, flumes, drainage chute, dams, and underground watercourse constructed by the four flood-prevention projects discussed in this report have accomplished their purpose thus far and will continue to do so as long as the construction works are properly maintained.
2. Before any money is expended by the Federal Government on an anthracite flood-prevention project on abandoned mining property, the continued maintenance and protection of the construction works should be assured. In some instances, the construction works of a flood-prevention project may make it possible for speculative operators to obtain permission to conduct mining operations that create a new mine-flood menace that may be worse than the harmful condition that the project is designed to correct, thereby defeating the purpose of the project.

3. By actual participation in the construction work on the four anthracite flood-prevention projects, the Federal Government obtained factual information regarding some complexities of the anthracite mine-water problem and the solution of the problem.

4. Owing to the magnitude of the work required to solve the mine-water problem, and because of the financial inability of the anthracite industry to cope with the water problem on abandoned properties, and the lack of mining regulations to safeguard the construction works, the anthracite mine-water problem cannot be solved by small projects on abandoned properties.

5. By reason of the many complexities involved in the anthracite mine-water problem, and inasmuch as inundation of anthracite mines and anthracite reserves threatens both to cut short the life of the anthracite industry and to curtail production, it is concluded that an engineering study of the mine-water problem should be commenced as soon as possible, provided such study leads to the safe maintenance and the protection of construction works that may be built (9). Such a study would be a sound investment for the Federal Government, the State, and the mining companies (4).

ACKNOWLEDGMENTS

The authors acknowledge the assistance of the Anthracite State Mine Inspectors, numerous officials of anthracite mining companies, engineers of the Bureau of Mines, and others in obtaining material and discussing the subject matter upon which this report is based.
BIBLIOGRAPHY


EXHIBIT A

COOPERATIVE AGREEMENT

This agreement, made and entered into this ___ day of _______, 194_, by and between the United States of America, acting by and through the Department of the Interior and the Bureau of Mines, thereof, hereinafter called the "Government", and the ___(name of company)__________, hereinafter called the "Contractor", WITNESSETH:

WHEREAS, the flooding of anthracite coal mines in various regions of Pennsylvania is a constant threat to lives and property, as to which the Government desires to conduct certain inquiries and scientific and technologic investigations; and

WHEREAS, the ________ mine of the Contractor offers a field for such inquiries and investigations by reason of the threat of water from an adjacent flooded abandoned mine and from the ______ River; and

WHEREAS, the Contractor desires to cooperate and collaborate with the Government in making such inquiries and investigations;

NOW THEREFORE, it is agreed as follows:

The ________ mine of the Contractor shall be used as a site for the Government’s inquiries and investigations. To enable the Government to inspect and study a possible site for the installation of dams, the abandoned ________ slope workings in the Primrose and Orchard veins shall be repaired and retimbered by the Contractor. The Contractor shall perform this work by its own mine crews and labor, under its own sole supervision and control, but pursuant to plans that may be agreed upon before the work starts or as it progresses, and subject to the general direction of the Government’s engineers for the achievement of the purposes herein expressed. The Contractor shall furnish all necessary tools, equipment, and materials to accomplish the work.

The Government shall contribute to the expense of the work a sum measured by the number of man-hours of miners, timbermen, and laborers assigned by the Contractor to the work, during the time that they are actually engaged therein, up to but not in excess of a total of Three Thousand Dollars ($3,000), as follows: $0.50 per man-hour or fraction thereof in excess of one-half hour, whether the work is that of miners, timbermen, or laborers.

The Government shall be represented at the site of the work by such employees of the Bureau of Mines as may be appointed for the purpose, and the Government’s representatives shall have access to the site and to the work at all times. The Government may make such studies and experimental installations as it sees fit for the purposes of this agreement.
Neither the Government nor the Contractor assumes any liability or responsibility for damages to the persons or property of the other, of their officers, agents, or employees, arising out of this contract or work done thereunder. The Contractor shall perform the work in conformance with good mining practice for safeguarding life and property, and shall comply with all requirements of law in regard thereto including proper insurance.

This agreement shall be for a term beginning with the date hereof and continuing until the work is completed or the Government has expended or become liable, under the terms hereof, for the payment to the Contractor of a total sum of $3,000, as above provided, and as much longer as may be reasonably necessary for the Government to complete its studies and investigations: Provided, That in any event if not sooner terminated the contract shall terminate on June 30, 1945.

Officials Not to Benefit.—No Member of or Delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this contract or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

Covenant Against Contingent Fees.—The Contractor warrants that he has not employed any person to solicit or secure this contract upon any agreement for a commission, percentage, brokerage, or contingent fee. Breach of this warranty shall give the Government the right to terminate the contract, or, in its discretion, to deduct from the contract price or consideration the amount of such commission, percentage, brokerage, or contingent fees. This warranty shall not apply to commissions payable by contractors upon contracts or sales secured or made through bona fide established commercial or selling agencies maintained by the contractor for the purpose of securing business.

Eight-Hour-Law—Convict Labor.—(1) No laborer or mechanic doing any part of the work contemplated by this contract, in the employ of the Contractor or any subcontractor contracting for any part of said work contemplated, shall be required or permitted to work more than eight hours in any one calendar day upon such work at the site thereof, except upon the condition that compensation is paid to such laborer or mechanic in accordance with the provisions of this article. The wages of every laborer and mechanic employed by the Contractor or any subcontractor engaged in the performance of this contract shall be computed on a basic day rate of eight hours per day and work in excess of eight hours per day is permitted only upon the condition that every such laborer and mechanic shall be compensated for all hours worked in excess of eight hours per day at not less than one and one-half times the basic rate of pay. For each violation of the requirements of this article a penalty of five dollars shall be imposed upon the Contractor for each laborer or mechanic for every calendar day in which such employee is required or permitted to
labor more than eight hours upon said work without receiving compensation computed in accordance with this article, and all penalties thus imposed shall be withheld for the use and benefit of the Government: Provided, That this stipulation shall be subject in all respects to the exceptions and provisions of U. S. Code, title 40, sections 321, 324, 325, 325a, and 326, relating to hours of labor and compensation for overtime. (2) The Contractor shall not employ any person undergoing sentence of imprison-
ment at hard labor.

Discrimination in Employment.--In the performance of this contract the Contractor shall not discriminate against any employee or applicant for employment because of race, creed, color, or national origin, and shall require an identical provision to be included in all subcontracts.

IN WITNESS WHEREOF, the parties hereto have made, executed, and delivered this contract as of the day and year first above written.

Approved: ____________ ____________

THE UNITED STATES OF AMERICA

________________________

Director, U. S. Bureau of Mines

________________________

Contracting Officer

Approved: ____________ ____________

(NAME OF COMPANY)

________________________

Assistant Secretary of the Interior

________________________

(title of official)

Two witnesses to Contractor's signature:

________________________

________________________
I, ____________________________, certify that I am the secretary of the corporation named as contractor herein; that ____________________________ who signed this contract on behalf of the contractor, was then __________ (title) of said corporation; that said contract was duly signed for and in behalf of said corporation by authority of its governing body, and is within the scope of its corporate powers.

__________________________ /Corporate Seal/

I hereby certify that, to the best of my knowledge and belief, based upon observation and inquiry, ____________________________, who signed this contract for the __________ (company), had authority to execute the same, and is the individual who signs similar contracts on behalf of this corporation with the public generally.

__________________________
Contracting Officer.
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<tr>
<th>Map designation</th>
<th>Name of pool</th>
<th>Content Estimated gallons at present elev.</th>
<th>Present</th>
<th>If not held in present elevation will overflow to elev.</th>
<th>Control boreholes at elevations</th>
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</tr>
<tr>
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</tr>
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<td>Maltby</td>
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<tr>
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<tr>
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<td>Hollenback</td>
<td>+ 60</td>
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<tr>
<td>Y</td>
<td>Grand Tunnel</td>
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<td>+ 180</td>
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</tr>
<tr>
<td>Z</td>
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<td>237,270,000</td>
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<td>Surface</td>
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<td>6,395,532,000</td>
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<td>+ 390</td>
<td>No. 6</td>
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</tr>
<tr>
<td>R</td>
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<td>+ 72</td>
<td>Surface</td>
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<td>V</td>
<td>Kingston Coal Company</td>
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<td>+ 160</td>
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<tr>
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<td>(+ 60)(+340)</td>
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<td>+ 180</td>
<td>Surface</td>
<td>+510</td>
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<tr>
<td>Z</td>
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<td>Surface</td>
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<td>TOTAL - Wyoming Region</td>
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</tr>
</tbody>
</table>

Synclinal axis is of the lowest bed worked.

Scale of map: \( 1" = 2640^{1} \)

Longitudinal sections are along synclinal axis.

Scale of sections: \( 1" - \text{Vert} \cdot \frac{200^{1}}{2640^{1}} = \frac{1}{13^{2}} \)
Legend for Figure 2. - Map of underground pools impounded in the Southern Anthracite Field

<table>
<thead>
<tr>
<th>Pool No.</th>
<th>Pool</th>
<th>Elevation of surface of shaft</th>
<th>Elevation of top of shaft</th>
<th>Elevation of bottom of shaft</th>
<th>Elevation of lowest vein</th>
<th>Elevation of basin in Pottsville</th>
<th>Elevation of basin in workings</th>
<th>Number of gallons of water in workings</th>
<th>Location of overflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tamaqua Lands S.D.</td>
<td>951.0</td>
<td>951.0</td>
<td>951.0</td>
<td>-</td>
<td>-1150.0</td>
<td>-1150.0</td>
<td>600,000,000</td>
<td>No. 2 Drift, drainage holes, high mines drifts.</td>
</tr>
<tr>
<td>2</td>
<td>Tamaqua Lands N.D.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,774,000,000</td>
<td>Drill east of breaker.</td>
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<tr>
<td>3</td>
<td>Mary D</td>
<td>982.0</td>
<td>982.0</td>
<td>982.0</td>
<td>-1150.0</td>
<td>900,000,000</td>
<td>900,000,000</td>
<td>Water level drift east of Bell colly.</td>
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<tr>
<td>4</td>
<td>Kaolin</td>
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<tr>
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<td>915.5</td>
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<td>Water level drift.</td>
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<td>821.2</td>
<td>821.2</td>
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<td>949.0</td>
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<td>Water level drift.</td>
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<td>-</td>
<td>-</td>
<td>Overflows to Buck Run (old).</td>
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<tr>
<td>29</td>
<td>R.Cree &amp; Franklin</td>
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<td>897.0</td>
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<td>400,000,000</td>
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<td></td>
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</tbody>
</table>

**TOTAL:** 32,469,000,000
Figure 3. - Structural sections of the Buried Valley of the Susquehanna.
(Taken from Bureau of Mines Bull. 45. plate IV.)
Figure 4. - Funnel-shaped concrete intake of a 90-inch-diameter flume.
Figure 5. - General view of a 90-inch flume with 24-inch lateral discharging into same.
Figure 6. - View of a 90-inch semicircular creosoted wooden flume.
Figure 7. - Flash-flood water entering concrete intake of a 90-inch-diameter flume.
Figure 8. - View of V-shaped flume (during flash flood) entering Schaefer-lined tunnel under refuse bank.

Figure 9. - View of V-shaped flume (during flash flood) with sideboards to prevent overflow.
Figure 10. - Steel flume under construction on fill across strippings (Project No. 1).
Figure 11. - Section of diversion ditch being excavated (Project No. 1).

Figure 12. - Section of repaired WPA ditch (Project No. 1).
Figure 13. - Section of diversion ditch destroyed by a flash flood (Project No. 1).

Figure 14. - Section of diversion ditch after damage caused by flash flood had been repaired. (See fig. 13.)
Figure 15. - Section of a steel flume destroyed by a flash flood (Project No. 1).
Figure 16. - Part of Little Schuylkill River under which mining has been done (project No. 2).

Figure 17. - Abandoned shaft before project No. 3 was commenced.
Figure 18. - Concrete wall constructed to prevent flood water from entering abandoned shaft (project No. 3).

Figure 23. - Stripping excavation filled with water (project No. 3).
Figure 19. - Details of construction of concrete wall at top of abandoned shaft (project No. 3).
Figure 20. - Portal of abandoned slope (project No. 3).

Figure 22. - Stripping excavation between river and abandoned slope (project No. 3).
Figure 21. - Details of construction of three dams (project No. 3).