FLOOD ON BUFFALO CREEK FROM SAUNDERS TO MAN, WEST VIRGINIA

On February 26, 1972, at approximately 8 a.m., a coal mine refuse dam collapsed on Middle Fork, a tributary to Buffalo Creek. The resulting failure released some 17.6 million cubic feet (132 million gallons) of impounded water and sediment into the Buffalo Creek valley. As a consequence, West Virginia experienced the most devastating flood in its history, with at least 118 lives lost and property damage exceeding $50 million (U.S. Geol. Survey Circ. 667, 1972).

Immediately after the flood, scientists of the U.S. Geological Survey began to collect hydrologic information necessary to document the disaster.

Throughout the Appalachian coal mining areas, those agencies concerned with the regulation and safety of coal mining refuse banks and impoundments are now planning remedial measures to reduce potential flood hazards from similar dams and impoundments. This atlas report documents the hydrologic events associated with the Buffalo Creek disaster as an aid in this planning.

Buffalo Creek Basin: The basin is located in the southwestern part of West Virginia, 40 miles south of Charleston. Altitudes range from 700 feet at Man, to more than 2,600 feet at the head of the basin. The flood plain is generally less than 400 feet wide and was occupied by the 16 closely spaced coal mining communities along Buffalo Creek.

Precipitation: The average annual precipitation in southern West Virginia is 44 inches, and the average monthly precipitation for February is 3.50 inches. February 23–26, 1972, 1.5 inches of snow was reported to have fallen at Logan on February 19–20. Further east, snowfall had reached 11 to 12 inches at Beckley by February 22. In the Buffalo Creek area, a few drifts on the higher altitudes as late as Wednesday, February 23. According to most valley residents, it rained occasionally from Wednesday through early Saturday morning, with some reporting that it rained hard throughout Friday night.

The National Weather Service reported that during the 72-hour period ending at 7 a.m. on February 26, the general area of Logan County and Buffalo Creek had 3.7 inches of rainfall. (See fig. 1.) Precipitation of that intensity occurs about once every 2 years; that is, southwestern West Virginia can expect precipitation equal to or exceeding 3.7 inches in a 72-hour period on the average of once every 2 years. A "bucket" survey in the Buffalo Creek Valley made during the week after the February 26 flood revealed no catchment of precipitation in open cans or other containers that exceeded the 3.72 inches recorded at Logan.

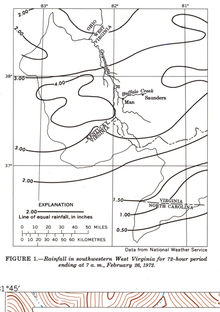


FIGURE 1.—*Rainfall in southwestern West Virginia for 72-hour period ending at 7 a. m., February 26, 1972.*

Middle Fork Dam and Reservoir: Middle Fork drains an area of 1.2 square miles, of which 1.1 square miles is above mine refuse dam No. 3; 2,500 feet upstream from the mouth. Refuse dam No. 3 was approximately 500 feet wide, 420 feet thick, and stood 44 to 60 feet above the level of sludge in dam No. 2. The impoundment behind No. 3 rose to a maximum elevation of 1,753.1 feet above mean sea level, with a surface area of 14.2 acres, at the time of failure. (See fig. 2.)

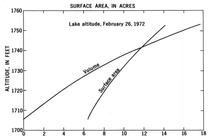


FIGURE 2.—*Relationship of elevation versus volume, and elevation versus surface area, for the impoundment at dam No. 3.*

The elevation of the sludge pond that remained after failure was 1,705.6 feet, which gives a depth of 47.5 feet of water and sludge at dam No. 3. A plan view of dam No. 3 and its impoundment and an aerial photograph are shown in figure 3. It was established that about 4 p.m. Thursday, February 24, a local mining-company employee placed a measuring stick on the lowest point of the back (upstream) side of the coal-waste dam No. 3, so that the top of the stick was approximately 1 foot below the compacted part of the dam. The employee visited the dam frequently between 4 p.m. Thursday and 4:30 a.m. Saturday, observing the rate of rise in the pool. Peak inflow during the storm period was estimated from these observations, interviews with mine-company personnel, and from indirect measurements on other small drainage areas in the Buffalo Creek basin near Middle Fork. The estimated inflow hydrograph into the impoundment during February 25–26 is shown in figure 4.

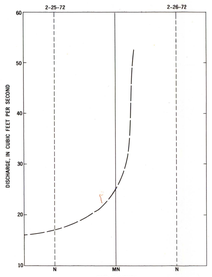


FIGURE 4.—*Estimated inflow to impoundment at mine refuse dam No. 3, from 8 a. m., Friday February 25, 1972, to 8 a. m., Saturday February 26, 1972.*

The Flood: Floodflow on Buffalo Creek was abnormally high on February 26. Streams other than Buffalo Creek in southern West Virginia had peak flows having recurrence intervals of from 2 to 20 years (see table 1), as a result of the 3-day rainfall during the latter part of February. Streams in the Buffalo Creek basin not influenced by the failure of the dam on Middle Fork experienced peak flows having recurrence intervals less than 10 years, while the peak flow in Buffalo Creek below Saunders indicates a discharge greater than 40 times the 50-year flood (table 2). The difference in the recurrence intervals reflects the difference between the natural flood that probably would have occurred and the flood that resulted from the rainfall and the failure of the mine refuse dam.

Table 1.--Floods in southwestern West Virginia, February 25-27, 1972, excluding Buffalo Creek basin.

Station number	Station name and location	Drainage area (sq mi)	Highest previous flood: Date (mo-yr)	Gage height (ft)	Discharge (cfs)	Recurrence interval (years)	Flood of February 26, 1972: Gage height (ft)	Discharge (cfs)	Recurrence interval (years)
03198450	Drawdy Creek near Peytona	7.75	7-71	10.54	850	9	8.57	491	3
03198500	Big Coal River at Ashford	393	8-16	36.3	35,800	a1.3	23.28	20,600	18
03199000	Little Coal River at Danville	270	2-39	30.2	40,800	a2.1	21.45	14,300	9
03202400	Guyandotte River near Baileysville	308	12-69	16.22	16,300	10	17.26	18,500	19
03202480	Briar Creek at Panrock	7.20	12-69	5.46	485	3	5.21	422	3
03203000	Guyandotte River at Man	762	3-63	34.78	49,000	a1.1	19.34	31,600	10
03203600	Guyandotte River at Logan	836	3-63	34.98	55,000	a1.2	27.28	36,100	13
03204000	Guyandotte River at Branchland	1,226	3-63	43.83	44,500	27	41.63	40,800	20
03206600	East Fork Twelvepole Creek near Dunlow	38.2	12-69	12.64	2,280	5	12.99	2,490	6
03207020	Twelvepole Creek below Wayne	300	2-39	31.03	22,000	a1.3	23.19	7,210	2
03213000	Tug Fork at Litwar	502	1-57	21.60	35,700	a1.1	8.89	11,000	2
03213500	Panther Creek near Panther	30.8	3-67	10.67	4,600	a1.1	6.14	810	2
03213700	Tug Fork at Williamson	932	12-69	31.54	22,600	2	29.75	23,000	3
03214000	Tug Fork near Kermit	1,185	3-63	45.65	69,600	a1.1	40.25	46,800	8

a Ratio to 50-year flood.

Table 2.--Floods in Buffalo Creek basin, February 25-27, 1972.

Name and location	Drainage area (sq mi)	Discharge (cfs)	Recurrence interval (years)
1. North Fork above Middle Fork, above Saunders, W. Va.	0.85	80	2
2. Buffalo Creek above Middle Fork, above Saunders, W. Va.	3.16	200	2
3. Buffalo Creek below Saunders, W. Va.	6.05	50,000	a40
4. Tinney Fork at Pardee, W. Va.	4.07	500	b
5. Buffalo Creek below Stowe, W. Va.	21.0	13,000	a4
6. Buffalo Creek above Accoville, W. Va.	30.8	8,800	a2
7. Right Fork at Accoville, W. Va.	9.49	500	2

a Ratio to 50-year flood.

The flood profile was determined on the basis of a field survey of high-water marks left by the flood of February 26, 1972, and is shown on the maps (fig. 5 A–H). The area inundated by the Buffalo Creek flood are also shown on the maps. Floodmarks were identified along the 15-mile reach of the creek, and their elevations were determined by leveling to bench marks. Flood boundaries were delineated on topographic maps. The attenuation of the flood peak (due to valley storage) as the floodwater moved downstream is shown by the estimated hydrographs on the maps (fig. 6 A–D). The estimated natural flow of Buffalo Creek, used to prepare the flood hydrographs, was 60 cfsm (cubic feet per second per square mile). The time base on the hydrograph is the estimated time of overbank flow at the selected sites. The surge of the flood wave as it entered the Guyandotte River is shown on the trace of the gaging station record for Guyandotte River at Man in figure 7.

The most destructive flood in West Virginia's history swept through 15.3 miles of the Buffalo Creek valley at an average speed of 7 feet per second (5 miles per hour) and reached the town of Man at the mouth of Buffalo Creek around 11 a.m. The travel time for the 15.3 miles was about 3 hours. During the 3-hour cascade down the valley at least 118 lives were lost, 500 homes were destroyed, 4,000 people were left homeless, property damage exceeded $50 million and highway damage alone exceeded $15 million (U.S. Geol. Survey Circ. 667, 1972).

Photographs: Photographs after the flood along Buffalo Creek are shown on sheets 1 and 2 (figs. 8–13). Photographs were taken by West Virginia Department of Highways and the Charleston Daily Mail.

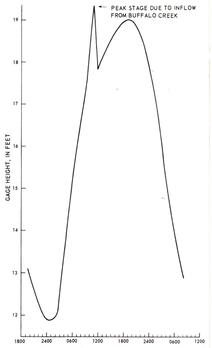


FIGURE 7.—*Flood hydrograph of Guyandotte River at Man, W. Va., February 25-27, 1972. Inflow from Buffalo Creek produced a sudden sharp peak of 19.2a feet at 11 a.m., February 26, at gaging station on Guyandotte River at Man.*

WATER QUALITY ASPECTS OF THE BUFFALO CREEK FLOOD

A few days after the flood a sample of the floodwater from No. 3 impoundment was recovered from the freezer unit of a refrigerator found at Saunders. Chemical quality samples were also taken from the water in No. 5 mine (site No. 1) and from the water of Middle Fork and Buffalo Creek (site Nos. 2–6). Nine samples were analyzed for 35 chemical and physical properties, including major ions and 12 minor elements. Metals were determined on both filtered and unfiltered samples of the floodwater. The results of these analyses are shown in table 3. Field measurements of pH and conductance were made of small rivulets (sites MF 1–6) draining into Middle Fork in the vicinity of No. 5 mine. pH is measured on a scale from zero to fourteen. A pH value of less than seven is acid, and that greater than seven is alkaline. A pH value of seven is neutral. The results of the field measurements are shown in the following table.

Specific conductance and pH of runoff rivulets draining into Middle Fork

Site No.	Specific conductance (micromhos/cm at 25°C)	pH
MF 1	760	3.8
MF 2	410	5.7
MF 3	850	5.8
MF 4	1,200	3.8
MF 5	840	4.1
MF 6	620	3.9

Coal fines and other fine rock wastes made up about 50 percent, by weight, of the floodwater sample collected at Saunders. High quantities of various trace metals, such as lead, zinc, copper, nickel, and chromium associated with the sediments, are shown in table 4.

Evaluation of the data points out the contrast between the quality of wet-weather runoff from the Middle Fork basin and that of the floodwater. The wet-weather runoff from the Middle Fork basin is characteristically acid and of a relatively dilute calcium magnesium sulfate composition. The floodwater sample contained more than 2,500 mg/l dissolved solids, and 930 mg/l bicarbonate alkalinity and had a pH of 7.0 (neutral). The floodwater consisted not only of surface runoff but also of significant quantities of ground-water discharge. Ground water discharging from rocks of the Middle Fork basin is moderately concentrated and alkaline. Previous samplings in similar geohydrologic settings in this part of West Virginia have shown that during periods of low flow, when the ground-water increment is dominant, the discharge is alkaline.

Two major sources of alkalinity responsible for neutralizing the acid runoff that entered No. 3 impoundment are:

(1) Alkaline materials in the coal-mining refuse making up the bed and dam of No. 3 impoundment. According to Hennen (1914) the Kanawha formation in this area of the Buffalo Creek basin is more than 1,500 feet thick and consists of coal, shale, sandstone, clay, and at least three irregular limestone beds. Two of the limestone units above the coal seam contain marine fossils. Large quantities of waste rock of varying size was dumped into No. 3 impoundment at several different points. The fineness of these alkaline materials provided a large surface area where neutralization could take place at the liquid-solid interface.

(2) Alkaline ground water discharging from the calcareous strata of the basin. Samples collected from small streams in the coal fields of southern West Virginia during times of low surface runoff contain more than 200 mg/l bicarbonate alkalinity and have pH values greater than 8.2. A sample collected in October 1972 from a nearby coal mine had a pH of 7.2 and contained 207 mg/l bicarbonate alkalinity.

Because of extensive fracturing of the rocks and rapid infiltration of runoff, the quality of the water impounded in local coal mines may be highly dependent upon time elapsed since the last rainfall. Even though the sample obtained from No. 5 mine (site No. 1, table 3) was collected at a time of very high runoff, it contained a small amount of bicarbonate alkalinity and had a pH of 6.5. As runoff diminishes, and particularly during times of very dry weather, this impoundment contains relatively larger quantities of alkaline ground waters.

The chemical alterations that took place in the water of No. 3 impoundment indicate that the lake functioned as a huge water-treatment basin. Over an extended period of time, storage in the lake resulted in the virtual elimination of runoff acidity and brought about a significant reduction in metal concentrations. Simultaneously, concentrations of major ions, such as calcium, magnesium, and sulfate, increased as much as threefold.

REFERENCES CITED

Davies, W. E., Bailey, J. F., and Kelly, D. B., 1972, West Virginia's Buffalo Creek flood——a study of the hydrology and engineering geology: U.S. Geol. Survey Circ. 667, 32 p.

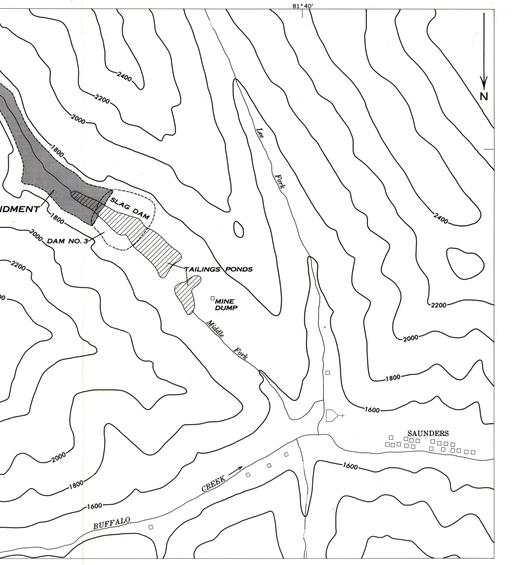
Hennen, R. V., Reger, D. B., and Price, W. A., 1914, Logan and Mingo Counties: West Virginia Geological Survey, 775 p.

Table 3.--Chemical analyses, in milligrams per liter, of water samples from Buffalo Creek basin
[All samples, except as indicated, were filtered].

Site No.	Description and location	Date of collection	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate as N
--	Floodwater sample found in freezer at Saunders.	3- 3-72	15	380	100	26	21	930	1,100	26	0.6	0.1
1	Mine water from impoundment in No. 5 Mine.	3-21-72	10	98	32	75	10	15	530	5.9	.4	1.0
2	Middle Fork above No. 5 Mine.	3-21-72	21	86	45	3.3	5.0	0	490	.8	.5	.4
3	Middle Fork at spillway of No. 4 Dam.	3- 3-72	17	82	46	4.5	3.7	0	460	1.7	.4	.6
4	Middle Fork at Saunders, 100 feet downstream from base of slag heap.	3- 3-72	14	88	45	8.4	4.9	0	450	2.6	.4	.4
4	.....do.....	3-21-72	15	100	45	22	6.0	0	510	2.7	.4	.3
5	Buffalo Creek at Latrobe, 100 feet downstream from highway bridge.	3- 1-72	8.6	73	34	32	6.3	26	360	8.6	.4	1.0
6	Buffalo Creek at Man, at mouth.	3-21-72	7.8	55	27	50	6.0	64	340	17	.3	1.0

Site No.	Description and location	Date of collection	Nitrite as N	Ammonia as N	Organic nitrogen as N	Total phosphate as P	Chemical oxygen demand	Acidity as HCO_3	Dissolved solids	Loss on ignition	Specific conductance (micromhos/cm at 25°C)	pH (units)
--	Floodwater sample found in freezer at Saunders.	3- 3-72	0.00	7.2	290	30	32,600	120	2,520	--	1,940	7.0
1	Mine water from impoundment in No. 5 Mine.	3-21-72	.00	.00	.00	.0	3	5	780	60	1,030	6.5
2	Middle Fork above No. 5 Mine.	3-21-72	.00	.30	.10	.0	.4	140	764	120	1,140	3.3
3	Middle Fork at spillway of No. 4 Dam.	3- 3-72	.00	.70	.00	.0	1	93	619	--	966	3.5
4	Middle Fork at Saunders, 100 feet downstream from base of slag heap.	3- 3-72	.00	1.6	21	.1	200	38	638	--	859	4.3
4	.....do.....	3-21-72	.00	.9	.00	.1	68	39	718	50	918	4.5
5	Buffalo Creek at Latrobe, 100 feet downstream from highway bridge.	3- 1-72	--	--	--	--	--	--	542	--	--	--
6	Buffalo Creek at Man, at mouth.	3-21-72	.1	1.4	16	3.0	2,430	15	508	40	719	7.2

Site No.	Description and location	Date of collection	Boron (B)	Cadmium (Cd)	Chromium, hexavalent (Cr)	Copper (Cu)	Strontium (Sr)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)	Iron (Fe)	Manganese (Mn)	Mercury (Hg)
--	Floodwater sample found in freezer at Saunders.	3- 3-72	--	0.002	0.021	0.013	--	0.018	0.015	0.014	0.020	1.30	--
--	.....do (unfiltered).....	3- 3-72	0.280	.440	3.00	9.60	22	16	7.2	28	6,400	110	0.032
1	Mine water from impoundment in No. 5 Mine.	3-21-72	.090	.004	.000	.020	3.2	.030	.200	.140	.300	.320	<.0005
2	Middle Fork above No. 5 Mine.	3-21-72	.070	.002	.040	.140	2.0	.010	.400	.840	11	2.4	<.0005
3	Middle Fork at spillway of No. 4 Dam.	3- 3-72	.120	.002	.004	.150	2.6	.032	.380	.800	2.6	1.7	<.0005
4	Middle Fork at Saunders, 100 feet downstream from base of slag heap.	3- 3-72	.200	.000	<.020	1.2	2.4	.042	.500	.580	34	1.3	<.0005
4	.....do.....	3-21-72	.070	.002	.000	.140	1.8	.044	.300	.500	4.2	2.0	<.0005
5	Buffalo Creek at Latrobe, 100 feet downstream from highway bridge.	3- 1-72	--	--	--	--	--	--	--	--	1.4	--	--
6	Buffalo Creek at Man, at mouth.	3-21-72	.110	--	--	.300	1.8	.420	.240	.680	130	2.6	.0016



Plan view of mine refuse dam No. 3 and impoundment on Middle Fork.

Photograph by West Virginia Department of Highways

FIGURE 3.—*Aerial view of slag pile and reservoir area on Middle Fork at Buffalo Creek.*

Table 4.--Chemical analyses, in micrograms per gram (dry weight), of sediment samples collected March 1, 1972, from Buffalo Creek basin.

Site No.	Description	Cadmium (Cd)	Chromium, hexavalent (Cr)	Copper (Cu)	Cobalt (Co)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)	Iron (Fe)	Manganese (Mn)
1	Fines from section 100 feet from edge No. 3 Dam.	0.14	3.0	19	5.5	8.7	8.7	27	10,000	75
2	Composite at left bank of No. 2 Dam.	.14	3.0	20	5.0	8.5	9.0	23	8,000	37
4	Sludge near left bank of No. 3 Dam.	.13	4.8	19	6.9	12	13	37	8,500	53
5	Material, 600 feet from right bank of No. 2 Dam.	.09	6.0	32	7.5	16	11	35	15,000	110
6	Sludge from No. 2 Lake.	.11	3.2	17	3.5	7.5	7.5	16	5,600	27
7	Fines on flood plain, 12.5 miles downstream from Saunders.	.16	5.2	20	5.5	25	8.5	40	10,000	140
10	Material from right abutment of No. 3 Dam.	.19	3.5	16	3.7	11	7.2	17	13,000	250
11	Material from left abutment of No. 3 Dam (5 feet above base).	.25	3.2	21	6.0	12	9.5	27	6,700	300
12	Material from left abutment of No. 3 Dam (10 feet above base).	.19	2.1	15	4.5	8.7	7.0	24	6,700	120
13	Material from mound at "toe" of No. 3 Dam (200 feet from left abutment).	.19	4.0	22	6.7	11	12	32	11,000	750

Base by U.S. Geological Survey

FIGURE 5A–H.—*Profile of flood of February 26, 1972, on Buffalo Creek.*

Photograph by Charleston Daily Mail

FIGURE 8.—*Aerial view of Buffalo Creek between Lundale and Craneo.*

Photograph by West Virginia Department of Highways

FIGURE 9.—*Aerial view of Buffalo Creek looking upstream from Craneo to Lorado.*

Photograph by West Virginia Department of Highways

FIGURE 10.—*Aerial view of Buffalo Creek at Pardee.*

Photograph by West Virginia Department of Highways

FIGURE 11.—*Aerial view of Buffalo Creek looking toward Saunders and Middle Fork.*

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1974

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