ACID MINE DRAINAGE TREATMENT IN GREENS RUN
BY AN ANOXIC LIMESTONE DRAIN

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Introduction

From its headwaters in Pocahontas, Randolph and Tucker Counties, the Cheat River flows 157 miles north through West Virginia to the Pennsylvania state line (Figure 1). It is one of the longest free-flowing rivers in the eastern U.S. Its headwaters spring from the Allegheny Highlands (being drained by Shavers Fork and Dry Fork), and from Canaan Valley (being drained by the Blackwater River). It is an area of high-relief, and contains more land over 4,000 feet in elevation than any other drainage in West Virginia. Streams in the Cheat River Basin are characterized by steep gradients, rock channels, and high water flow velocities. It flows through spectacular mountain scenery and steep canyons, and serves a multi-million dollar per year commercial whitewater industry.

Industrial activities in the upper, middle, and lower Cheat consist of logging operations, underground and surface coal mines, and numerous abandoned coal mines. Water quality ranges from excellent to very poor. In the river's lower 20 miles, it becomes so severely polluted by acid mine drainage (AMD) from historic surface and underground coal mines that it is effectively dead. AMD continues to be the largest environmental water quality problem in this region of West Virginia, and this continuing problem results in loss of fish and wildlife, aesthetic damage due to unsightly orange stains on river sediments, degraded drinking water, and limited opportunities for recreation. Several significant recreational spots occur in the watershed: Blackwater Falls State Park, Canaan Valley State Park, Coopers Rock State Forest, Dolly Sods, Seneca Rocks, Spruce Knob, and a portion of the Monongahela National Forest.

The upper portion of the Cheat River includes the Blackwater River and its tributaries, Dry Fork and its tributaries, and Shavers Fork (Figure 1). The Blackwater River and Dry Fork form the Black Fork above Parsons, WV. The Black Fork River has recently been turned into a net alkaline stream due to the application of limestone powder from a limestone drum station facility near Davis, WV. Shavers Fork is a low-buffered stream, naturally low in pH due to the organic acids from forest cover in the area. Although some abandoned underground mines exist in the area drained by Shavers Fork, the stream is not impacted significantly by mine drainage as compared to the Blackwater River and other tributaries in the lower Cheat.

The middle portion of the Cheat River extends from Parsons to Rowlesburg, AN. The streams entering the Cheat in this portion are generally classed as having very good to fair water quality. Therefore, the impact of AMD on this section of the river is negligible.

The lower Cheat begins at Rowlesburg and proceeds to the state line north of Morgantown, WV (Figure 2). The greatest and most degrading AMD problems exist in this stretch of Cheat River. It is estimated that 86% of the acid load that enters the Cheat River enters in this lower section. Of the 25 major tributaries that enter the lower Cheat, seven tributaries contribute nearly 95% of the acid load to the Cheat (Table 1).

Table 1. Percent contribution of acid load to the lower Cheat River from seven AMD-impacted tributaries (Figure 2).

Tributary	Area	Flow	Acid Concentration	Acid Load	Percent of Total
	(mi^2)	(cfs)	(mg/l)	(tons/yr)	(%)
Pringle Run	9.80	24.42	52	1,254	5.6
Lick Run	4.70	27.71	189	5,173	22.9
Heather Run	2.12	6.93	126	863	3.8
Morgan Run	8.90	32.90	163	5,297	23.5
Greens Run	11.70	13.40	72	953	4.2
Muddy Creek	34.00	96.09	85	8,068	35.8
Bull Run	11.60	12.80	75	948	4.2
Total	**82.82**	**214.25**	---	**22,556**	**100**

The Cheat River has the potential to be a major resource for West Virginia, and full realization of this tourism and recreational potential requires a solution to the AMD problem. The Cheat was nationally recognized as one of the ten most threatened and endangered rivers in North America by the American Rivers Association. In recognition of this potential, several organizations have joined together to form the River of Promise. The partners in this organization share a commitment to restore the Cheat River to provide diverse recreational opportunities and to sustain viable local economies. The initial partners are listed in Table 2.

Table 2. Initial signatories in the River of Promise.

Organization	Signature
Anker Energy Corporation	John Faltis
U.S. Office of Surface Mining	Robert Uram
WV Division of Environmental Protection	Laidley E. McCoy
WV Division of Natural Resources	Charles B. Felton
Friends of the Cheat	Dave Bassage
WV River's Coalition	Roger Harrison
Environmental Protection Agency, Region III	W. Michael McCabe
U.S. Bureau of Mines	Rhea Graham

Greens Run

Greens Run, a stream degraded by past mining activities, is a tributary of the Cheat River, located in Preston County, WV (Figure 3). The area drains an area of about 7,500 acres north of Kingwood, WV. It flows eastward into the Cheat River opposite of Muddy Creek. Greens Run has three major sections: the main stem of Greens Run (the North Fork), the Middle Fork, and the South Fork. The North Fork of Greens Run is not severely impacted by AMD and contributes little acidity to the total acid load in Greens Run. The Middle Fork has several point sources of AMD. The South Fork is also damaged by AMD, and it has been selected for a limestone fines dumping project by the West Virginia Division of Natural Resources. The limestone fines project will dump finely ground limestone directly into the stream for acid neutralization. Limestone continues to dissolve over time as it washes down the stream and decomposes. This type of acid neutralization of streams has been successful in the Middle Fork of the Tygart Valley River of West Virginia (Zurbuch 1996, this proceedings).

This paper describes a project that attempts to neutralization some of the AMD in the Middle Fork of Greens Run. The Greens Run project resulted from discussions between the President of Anker Energy Corporation, John Faltis, and representatives of a local watershed organization, Friends of the Cheat. Anker presented a conceptual plan for abatement of AMD in the Middle Fork of Greens Run to the West Virginia Division of Environmental Protection (WVDEP) and the Office of Surface Mining (OSM). The plan resulted in a memorandum of agreement between WVDEP and Anker Energy, where WVDEP is the project sponsor with Anker Energy being a no-cost contractor to WVDEP. Anker Energy obligated financial, engineering and construction resources for the project. It is anticipated that this project will act as a catalyst for future AMD abatement projects in Greens Run and other tributaries of the Cheat River.

Three point sources of AMD were located in this creek and water samples were taken from these three sources and analyzed. One source flows from the base of an abandoned highwall and is the result of past surface and deep mining in the 1960s. The flow from this seep varies from 40 to 120 gpm depending on the season (Table 3). The second source of AMD drainage is a 400 M2 pond. The third source is a seep from another highwall on the site which discharges between 50 to 250 gpm.

Table 3. Point source discharges of AMD in the Middle Fork of Greens Run.

Point Source	Flow	Acid Concentration	Tons of Acid
	(gpm)	(mg/l)	(tons/yr)
#1 base of highwall	77	1,335	226
#2 pond	188	674	279
#3 base of highwall	152	841	281

The AMD abatement project on the Middle Fork of Greens Run is divided into three phases. The first phase consists of constructing an anoxic limestone drain (ALD) to treat the drainage from the #3 seep. Phase 2 will involve removing the pond by filling it will alkaline fly ash and reclaiming the area around the pond. Phase 3 will include treating the 91 seep by the use of an ALD or the placement of limestone in the stream to act as an open limestone channel (Ziemkiewicz et al. 1996, this proceedings).

Materials and Methods

During initial site visits between the authors, Ben Faulkner, and other Anker personnel, it was determined that the AMD from seep #3 could be treated with the use of an ALD. The water had <1 mg/l dissolved oxygen and the iron was predominantly in the ferrous form (Table 4), although the aluminum contents were high (50 mg/1) . An adequate amount of space was available for excavation, and access to the area was good. The road leading to the site was upgraded for hauling materials and equipment. The data used for the design of the passive treatment system were gathered over the course of six months (Table 4) and this information was inserted into the equations for sizing an ALD (Skousen 1991).

Table 4. Water quantity and quality for seep #3 in the Middle Fork of Greens Run.

Characteristic	Low	High	Average
Flow (gpm)	50	250	152
pH	2.4	3.0	
Acidity (mg/l)	780	981	841
Total Fe	227	284	250
Fe^{+3}	9	17	12
Fe^{+2}	218	267	238
Total Mn	3	7	4
Total Al	33	61	49
Dissolved Oxygen	< 1	< 1	< 1

Calculations (Skousen 1991)

Flow	152 gpm
Acidity	841 mg/l
Acid Load	281 tons/yr (152 x 841 x 0.0022 = 281 tons/yr)
Longevity	20 yrs
Total Tons of Acid/20 yrs	5620 tons
Limestone Quality	85 % (5620/.85 = 6612 tons)
Limestone Dissolution	75 % (6612/.75 = 8816 tons)
Total Tons of Limestone	8816 tons.

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Based on this information and materials available, an ALD was designed with the following characteristics and dimensions (Figures 4-6):

1. Size: 330 ft long, 54 ft, wide, and 10 ft deep.
2. Liner: The excavation was lined with I ft of Morgantown Energy Associates co-generation fly ash.
3. Limestone:

    a. 0.5 ft of limestone sand was placed in the bottom for initial acid neutralization.
    b. 2 ft of 4- to 6-inch limestone were placed next (1,200 tons).
    c. 7 ft of 3/4- to 11/2-inch limestone were placed on top of the large limestone

(7,800 tons).

4. Covering:

    a. 1-2 inches of hay prevented overlying materials from sifting into the limestone.
    b. 1 ft of MEA fly ash was placed on top as a oxygen barrier.
    c. 2 to 3 ft of earth covered the entire surface.

Excavation began on 18 September 1995, and all materials were in place by 10 November 1995. AMD was introduced into the drain on 14 November 1995. Final seeding and revegetation are being conducted in March/April 1996.

Results

Water began coming out of the ALD in December 1995. The first water sample was taken on 13 December 1995, and subsequent water samples have been taken and water quality analyses performed (Table 5).

Table 5. Water sampling dates and water quality from the #3 seep in the Middle Fork of Greens Run prior to construction of the ALD, and after construction and treatment by the ALD.

Date	pH	Flow	Acid	Alkal	Fe	Mn	Al	Conductivity
		(gpm)	------------------ (mg/l)				----------------	(mmho/cm)
Ave before	2.7	100	841	0	250	4.0	49.0	3,740
13 Dec 95	6.2	45	----	52	171	4.7	48.2	1,720
10 Jan 96	6.1	65	----	31	142	4.6	39.7	1,810
22 Jan 96	5.4	90	----	50	101	4.2	1.0	1,870

Based on the few samples we have collected from the ALD discharge, the ALD is adding alkalinity to the water and raising pH. The total iron averaged 250 mg/l in the raw water, and the amount coming out of the ALD varied from 101 to 171 mg/l, an average decrease of 54%. Manganese was about 4 mg/l in the original raw water, and is about 4.0 mg/l in the water exiting the ALD. The aluminum content of the raw water averaged 49 mg/l, and the aluminum in water exiting the drain on 13 December 1995 was nearly identical to this before-construction average value. However, the 10 Jan 1996 water sample had only 40 mg/l of aluminum, and the latest sample had 1 mg/l.

From the data available at this time, about one-half of the iron may be precipitating in the drain, and nearly all the aluminum may be precipitating in the ALD if the current trend of aluminum and iron contents in the ALD effluent water remain constant. The precipitating iron and aluminum hydroxides will certainly have an impact on the treatment efficiency and longevity of the limestone in the ALD to treat the AMD in Greens Run. Continued sampling of the water emanating from the ALD will confirm whether the iron and aluminum is precipitating in the drain.

References

Skousen, J. 1991. Anoxic limestone drains for acid mine drainage treatment. Green Lands 21:30-35.

Ziemkiewicz, P.F., D.L. Brant, and J.G. Skousen. 1996. Acid mine drainage treatment with open limestone channels. In. Proceedings of the Sixteenth Annual Surface Mine Drainage Task Force Symposium, Morgantown, WV.

Zurbuch, P. 1996. Calcium carbonate neutralization of two West Virginia rivers acidified by AMD. In Proceedings of the Sixteenth Annual Surface Mine Drainage Task Force Symposium, Morgantown, WV.

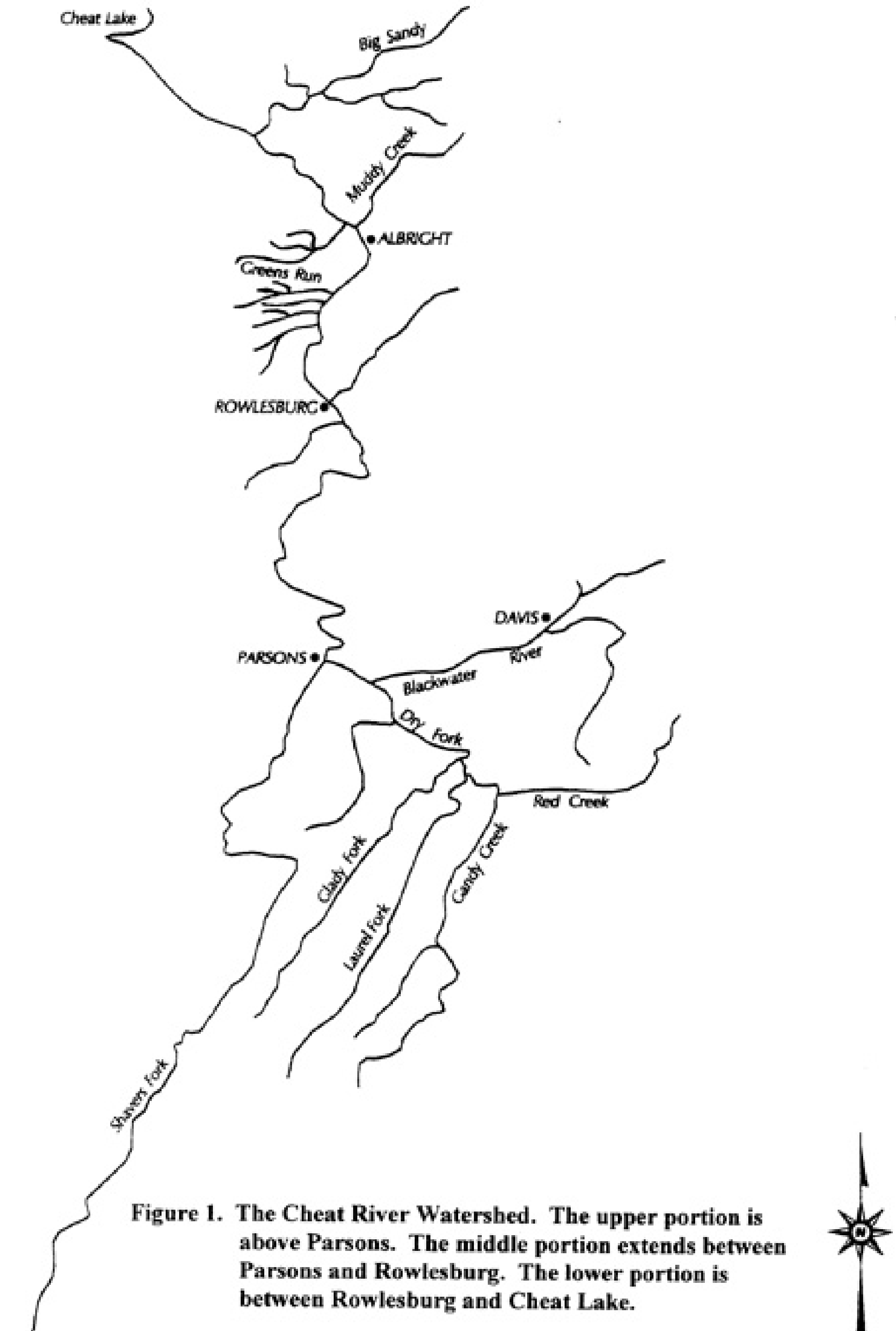
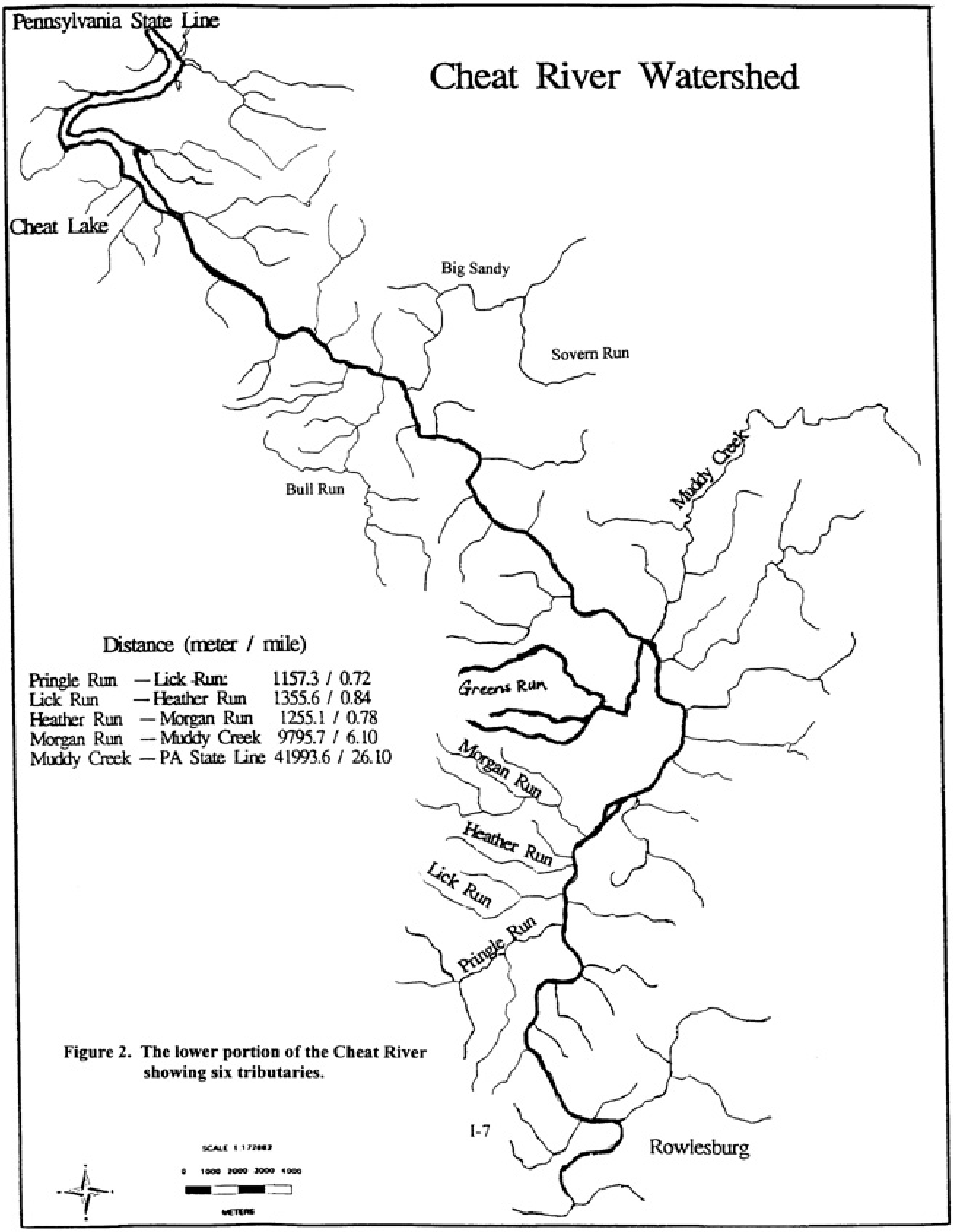


Figure 1. The Cheat River Watershed. The upper portion is above Parsons. The middle portion extends between Parsons and Rowlesburg. The lower portion is between Rowlesburg and Cheat Lake.

CHEAT RIVER DRAINAGE

SCALE: 1 = 1,000,000



Pringle Run	— Lick Run:	1157.3 / 0.72
Lick Run	— Heather Run	1355.6 / 0.84
Heather Run	— Morgan Run	1255.1 / 0.78
Morgan Run	— Muddy Creek	9795.7 / 6.10
Muddy Creek	— PA State Line	41993.6 / 26.10

Figure 2. The lower portion of the Cheat River showing six tributaries.

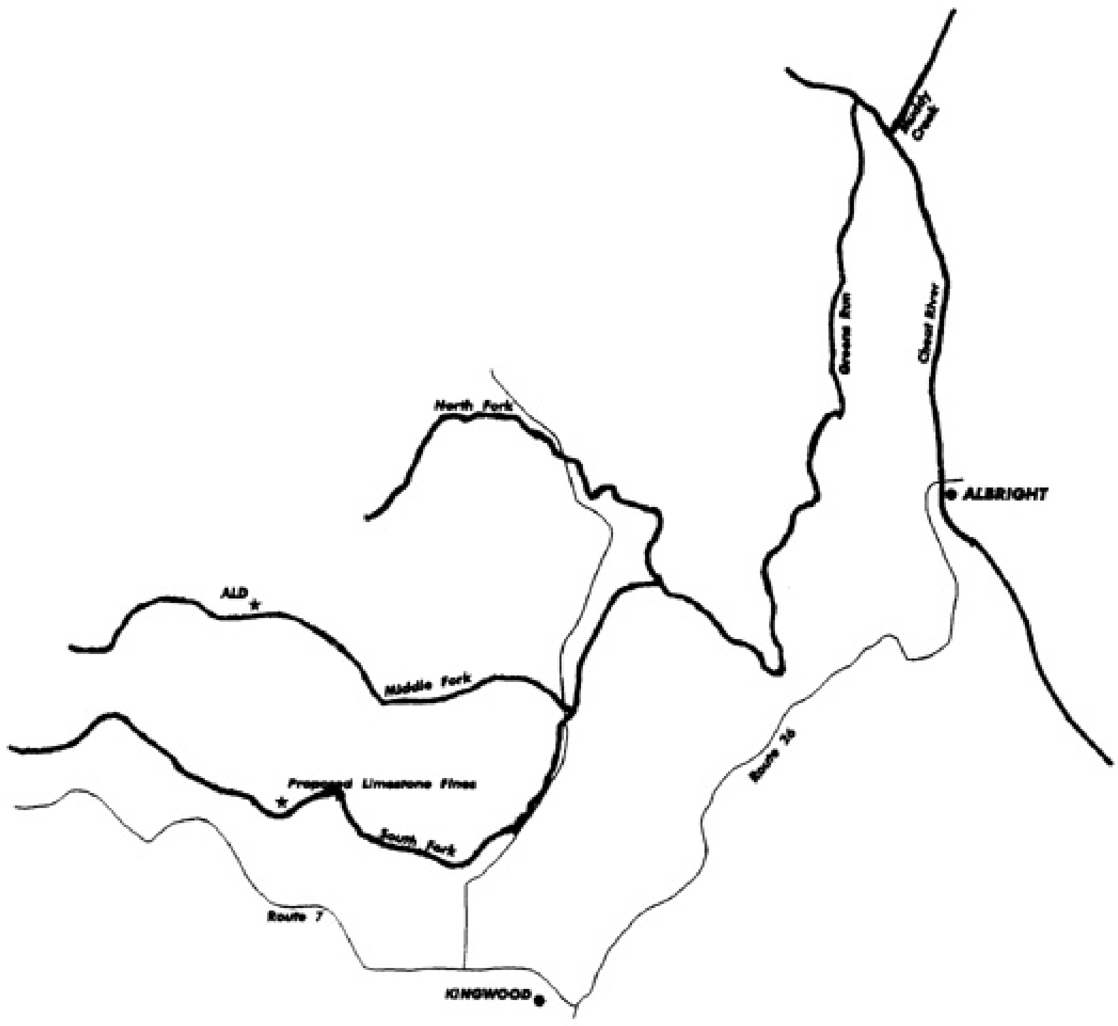


Figure 3. The Greens Run Watershed showing the location of the anoxic limestone drain on the Middle Fork of Greens Run and the proposed limestone fines project on the South Fork of Greens Run.

GREENS RUN DRAINAGE
SCALE: 1″ = 1000′

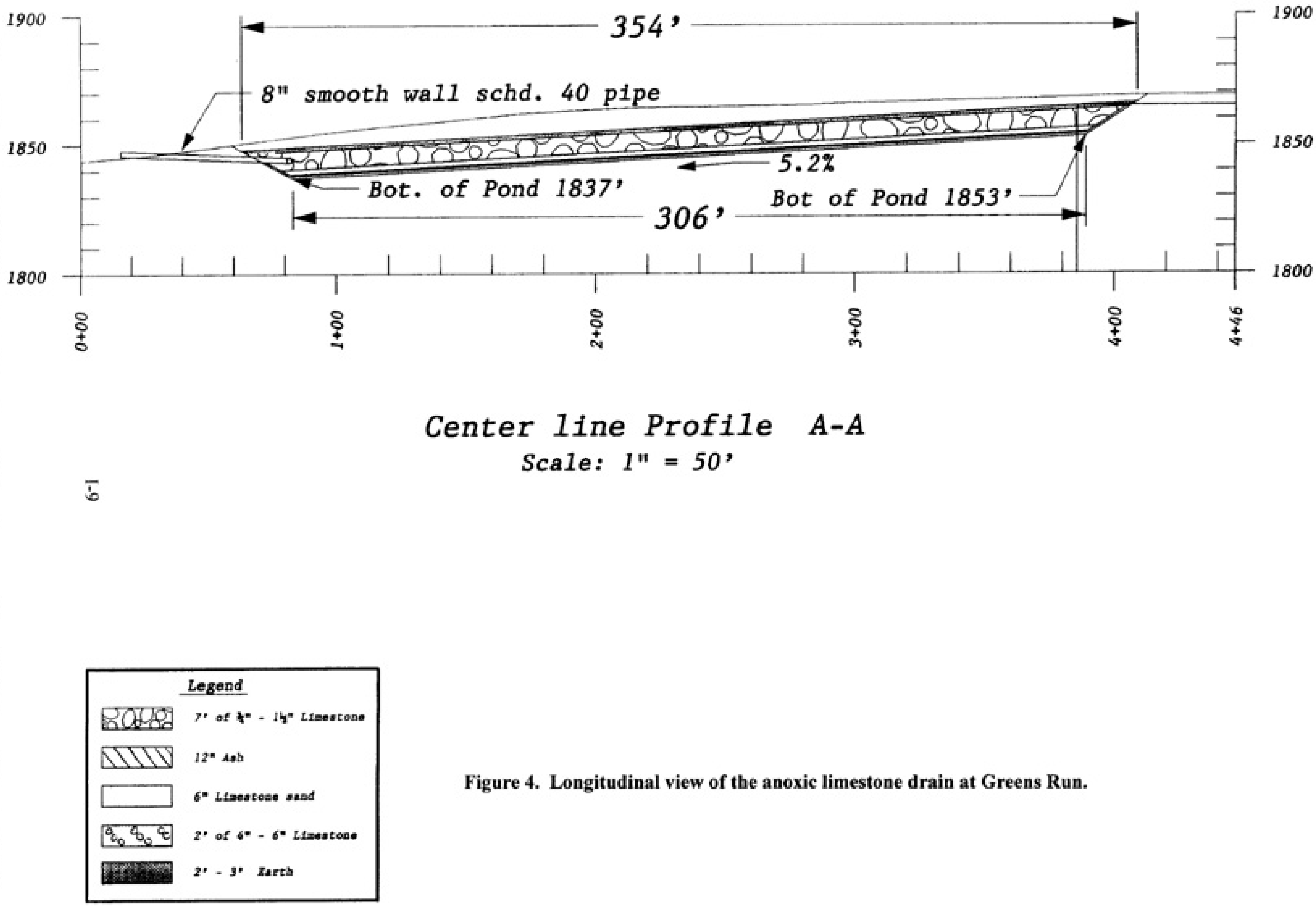
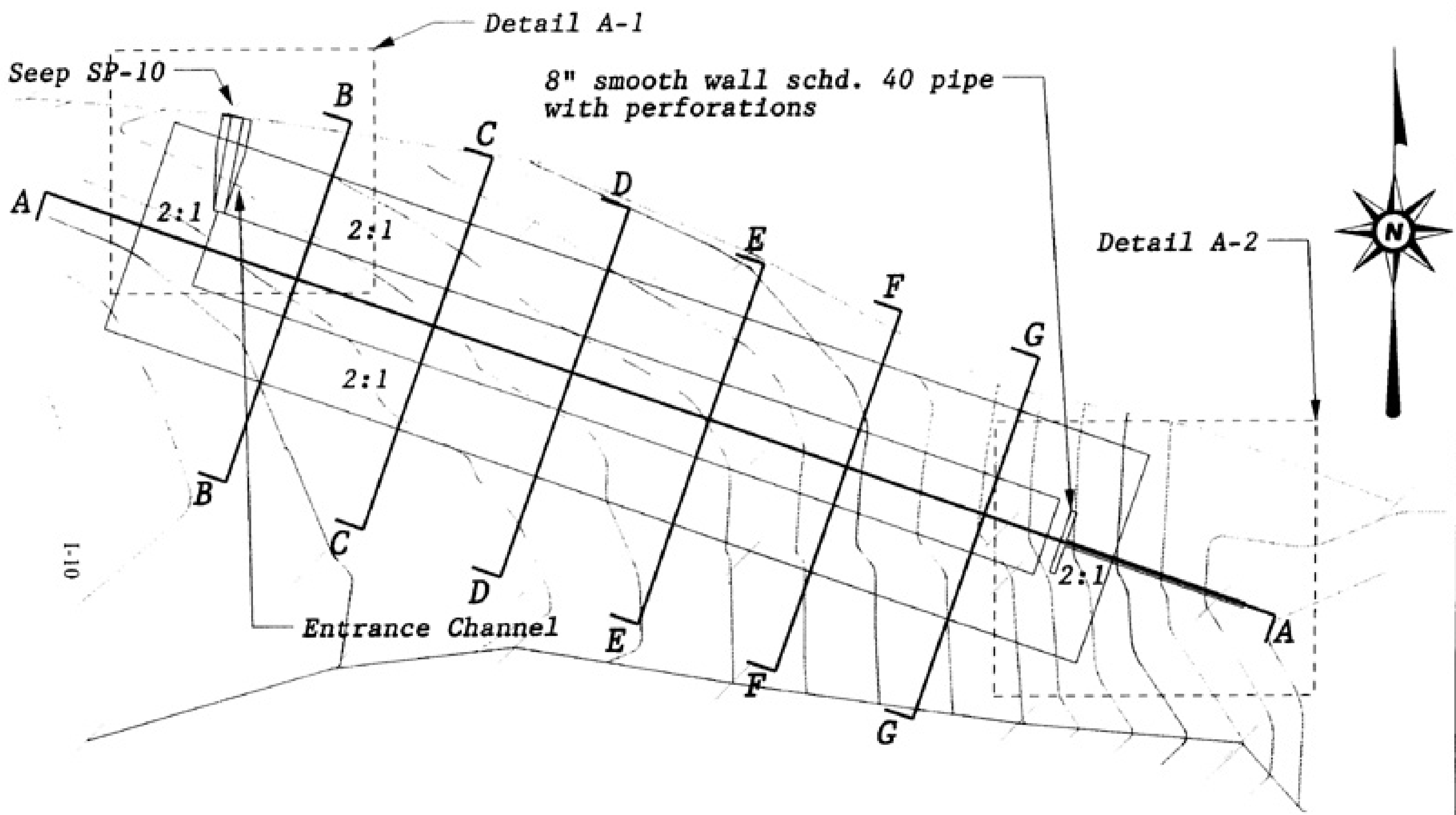


Figure 4. Longitudinal view of the anoxic limestone drain at Greens Run.



Plan View

Scale 1" = 50'

Figure 5. Top view of the anoxic limestone drain.

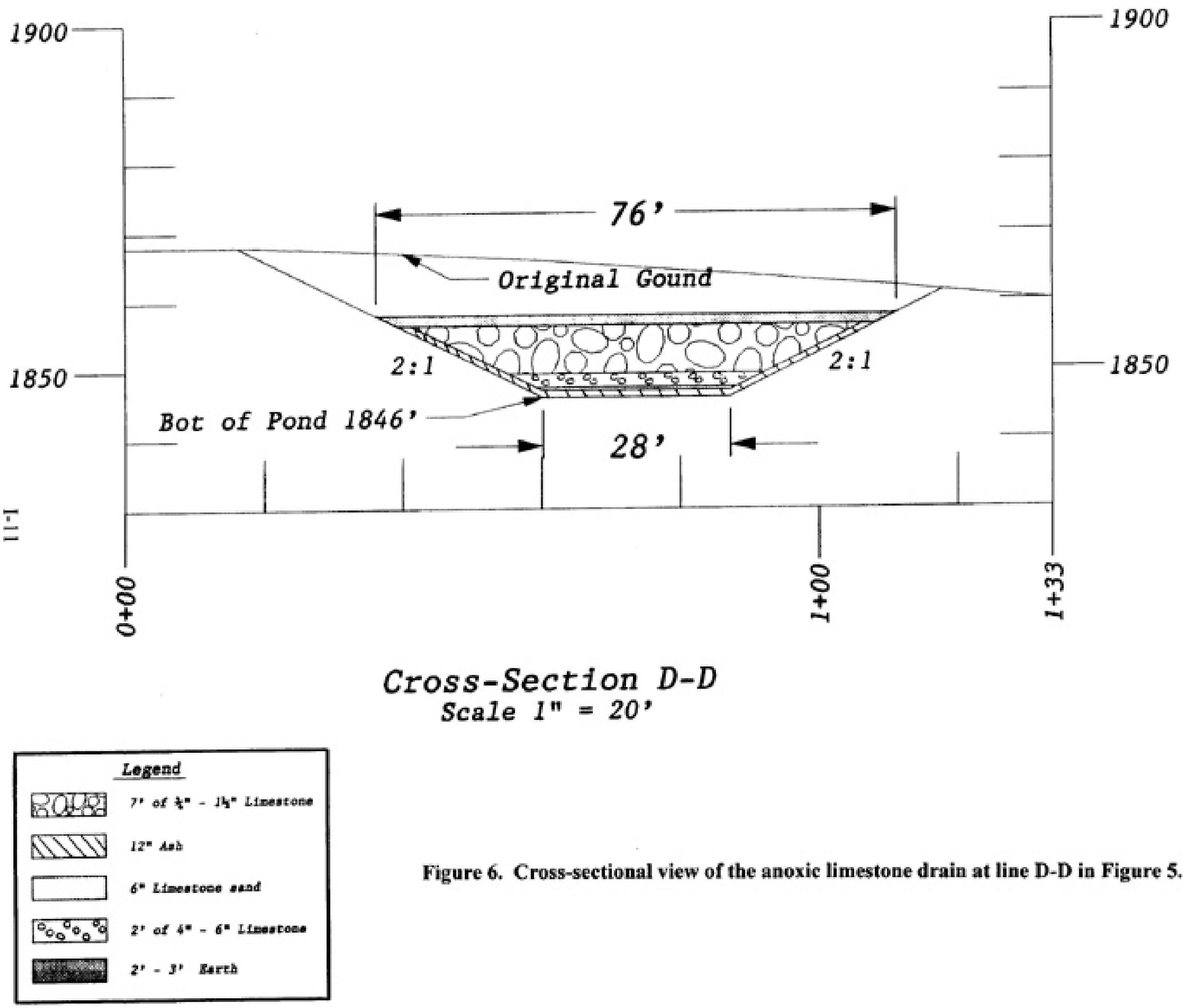


Figure 6. Cross-sectional view of the anoxic limestone drain at line D-D in Figure 5.