STATUS REPORT: Long Term Effects of Alkaline Trenches and Funnels at the Mercer Site - An Update

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Introduction

The Mercer site is a small (approximately eight hectare (20 acre)) reclaimed, but acid producing, inactive coal mine located in Upshur County, West Virginia. The mine is horseshoe shaped and hydrologically isolated. All of the drainage from the site is naturally channeled to one area, where the flow emanates through four seeps, affording excellent control and facilitating drainage sampling. Mined in the early 19701s, the initial drainages at the toe of the backfill in 1982, had acidities on the order of 400-600 mg/l (acidity as $CaCO_3$).

Alkaline Trench Study

In preparation for selective material handling during proposed site recontouring, samples of the overburden were to be collected in conjunction with identification of the existing water table. With a nine meter (30 foot) backhoe, 16 large diameter holes were dug to pavement (estimated to be six to nine meters (20 to 30 feet) below the existing surface) to collect rock samples for analysis and to determine the configuration of the water table in the backfill. The overburden consisted primarily of sandstones and shales, and significantly, water table elevations, with which a water table map could be constructed, were absent. In other words, only three of the 16 holes encountered water. We further discovered that the zones below surface depressions (which we presumed to be areas of recharge) were generally dry. Thus, areas initially identified as recharge sites, were areas with perched water tables.

In addition, during the construction of Hole 13 the hole was dry and remained so until the backhoe had dug seven meters (23 feet) into the reclaimed backfill, at which time water was encountered. Within an hour, the water level in the hole rose to within 2.4 meters (8 feet) of the mine surface. This suggests that the mine contains highly permeable channels that are randomly oriented and interconnected within the backfill to create a "pseudo-Karst" hydrologic setting. It was also during this time that we recognized that reclamation efforts had to be formulated with due consideration given to the "pseudo-Karst" hydrologic nature of the backfill. Given this hydrologic regime, the recontouring effort was reconsidered and an alternative plan, incorporating this hydrologic setting, was implemented.

As part of a field experiment to improve water quality, fifteen alkaline trenches were installed on the mine surface in the summer of 1983 (Caruccio, et al, 1984; 1985). These installations were designed to divert surface runoff into groundwater recharge, while at the same time elevating the alkalinity. The trenches averaged 3 meters (10 feet) wide, 0.9 meters (3 feet) deep and 23 to 221 meters (75 to 725 feet) long, and were constructed with a small bulldozer (Figure 1). The exposed trench floor was capped with sodium carbonate briquettes (2.4 kgs $/m^2$ or 0.5 pounds/ ft^2) and covered with two feet of limestone reject. Halogen tracers (KI and KBr), introduced to the groundwater at the time the trenches were installed, served to identify flow paths which had flowed through the treatment and which could be identified at the seep location.

Following the installation of the trenches, monitoring of the four seeps began on a regular basis. About eight months later, following the completion of the trenches, the halogen tracers which were included within the limestone fills, appeared at the seep collection points, indicating that recharge had taken place within the backfill. Concurrent with the emergence of the tracer, a dramatic improvement in drainage quality took place; where now the acidities were on the order of 75-125 mg/l.

In 1984, in an attempt to generate additional alkalinity, limestone reject was broadcast over the entire site at a rate of 100 tons per acre. In spite of both treatments, the acidities continued to hover around 100 mg/l.

Alkaline Funnel Study

In February, 1994, to compliment the acid abatement efforts, eight "funnels" were installed adjacent to or within the trenches, in areas clearly identified as zones of ground water recharge. Each existing trench in the western half of the site was surveyed to evaluate the success of the trench in providing an avenue for enhanced infiltration of surface water. The evaluation included a survey of the vegetation as well as the physical characteristics of each trench. Due to the time of year (late winter), the dead grasses and vegetation served as a useful tool to determine the direction of flow within each trench and on the mine surface. Certain areas within the trenches showed considerable draining of surface water into the backfill during periods of high intensity, short duration rainfalls.

In addition, based on field observations during rainstorms, large (approximately 6 inch) diameter holes developed in several trenches that served as drainage conduits for surface runoff and groundwater recharge. The combination of ascertainable holes coupled with vegetation oriented in a direction consistent with flow towards a hole, was the criterion used to delineate the location of a funnel. Surface water infiltration conduits were not readily apparent in all of the previously constructed trenches. When no evidence supported a finding that a trench provided any greater infiltration rate than that of the surrounding soil, that trench site was excluded as a funnel site. Additionally, only locations within the western half of the site were selected based on previous information regarding the hydrology of the mine.

The funnels were dug with a backhoe to depths averaging 6 to 10 feet and width of 3 to 6 feet and packed with limestone (to increase water recharge directly to the backfill). There was some concern that the backfill material excavated from the hole and brought to the surface, may be acid producing. Accordingly, as a precautionary measure to prevent acid from being formed on the mine surface, the backfill material that was brought to the surface was encapsulated with 20 mil PVC plastic, buried with spare limestone and utilized as diversion dams to further enhance surface water runoff into groundwater recharge.

Eight funnel locations were selected. Each location was flagged, marked and photographed. The funnel identification scheme relates back to the trench numbering system. Each funnel site number begins with an "F" (for funnel), followed by the prior trench number, and the funnel's relative location within the trench; north, south, east or west (denoted as N, S, E, or W). Figure 2 shows the locations of the previous trenches and the new funnel locations.

On February 21, 1994, the funnels were constructed using a Caterpillar 215 track excavator and a rubber tire loader. The first two funnels were installed in trench 14; F 14 W and F 14 E. Funnel F 14 W excavation was approximately four feet (1.2 m) by six feet (1.8 m) in area and eight feet (2.4 m) deep. The initial plan was to construct funnels two feet by three feet (0.6 m by 0.9 m) and deeper than eight feet (2.4 m). The loose, rubbly nature of the backfill material, however, precluded the excavation of a hole the width of the excavator bucket. The deeper the hole was dug, the larger the diameter of the hole became. Therefore, based on the field conditions, the size of each of the holes was modified to address field conditions. Table 1 provides the dimensions of each funnel.

The backfill material withdrawn from hole F 14 W, and from each of the successive holes, was placed on a sheet of either 20 mil or 40 mil PVC liner and encapsulated by folding the plastic over the backfill material and tucking the ends under the pile. In two holes, two sheets of plastic were used; one for the base and one to cover the pile. The resulting enclosed pod of material was covered with limestone to prevent the weakening of the PVC due to ultra violet rays. The excavated hole was filled with coarse grained limestone from the Century Limestone Corp., in Elkins, West Virginia.

Table 1. Mercer Funnel Construction; February 21, 1994

FUNNEL NUMBER	HOLE DIMENSIONS (ft.)			HOLE VOLUME	
	width	length	depth	(cu. feet)	(cu. m)
F 14 W	4	6	8	192	5.4
F 14 E	4	7	8	224	6.3
F 15 N	4	8	7	224	6.3
F 4 N	4	5	5	100	2.8
F 5 W	4	5	8	160	4.5
F 8 E	3	6	10	180	5.1
F 9 W	4	6	8	192	5.4
F 1 N	4	8	7	224	6.3
			Total	1496	42.2

A total of approximately 130 tons (118 metric tons) of coarse grained, crushed limestone was used both in the installation of the funnels and the covering of the PVC with limestone. Based on the volume of the holes, between 60 and 80 tons (54 and 73 metric tons) of limestone were used in the funnel construction and between 50 and 70 tons (45 and 64 metric tons) was applied on the PVC liner.[1]

[1] Given the hole volume in cubic feet (c.f.); then Tons of limestone = (c.f.)(62.5 #/c.f.)(2.7 [specific density of limestone])(porosity of the limestone) / (2000 #/ton).

Assuming a porosity of the limestone within the holes varying between 0.6 and 0.7, and the hole volume varying between 1496 and 1044 c.f., then the range of the weight of limestone used to fill the excavations will vary between 52.9 and 88.4 tons. Assuming a porosity closer to 0.7 and a hole volume less than 1496 based on the rounded nature of the bottom of the hole, then a value between 60 and 80 tons is a best approximation.

The actual weight of the limestone used is not critical, in as much as the alkalinity produced is limited by equilibrium concentrations to 65 mg/l alkalinity as CaC03 equivalents based on atmospheric partial pressures of carbon dioxide. Accordingly, the size of the funnels is based on the projected volume of rainwater and surface water that will be diverted into the funnels.

Samples of the limestone were collected and analyzed for neutralization potential and leachate quality. The specification sheet from the quarry indicated a calcium carbonate equivalent percentage between 60 and 75, magnesium carbonate percentage between 1.0 and 3.25 and silica dioxide (quartz) percentage between 14 and 23. For a more detailed analysis see Appendix A. The results of previous laboratory studies by Neuhaus indicate that given adequate time for equilibrium conditions to occur (greater than 150 hours), the alkalinity generated by limestones of varying qualities is relatively similar. (Neuhaus, C.F, 1982). Therefore, the exact specifications of the limestone are not critical to alkalinity generation and should not significantly effect the results of the funnel study.

Discharge Monitoring

Since 1982, four primary seeps emanating from the north toe of the backfill have been monitored at various frequencies. The seeps occur in an east-west trend and are sequentially labeled 1, 2, 3, and 4 from west to east as shown on Figure 2. Seep 1 is typically a low flow, diffuse seep with a broad discharge pattern. Seeps 2 and 3, on the other hand, are well defined and have higher flow rates. Seep 4 is sampled at the toe of the backfill, at approximately the same topographic elevation as seeps 1 through 3. Seep 4, however, represents several coalescing seeps which intermittently surface at a higher elevation, reenter the backfill, and are discharged in the proximity of the Seep 4 collection point.

Since February 19, 1994, in conjunction with the current study, the seeps have been monitored on a weekly basis. Samples are collected with the cooperation of the West Virginia Department of Environmental Protection (WV DEP) personnel and shipped to the University of South Carolina for analysis in prepackaged, postage paid cartons. The samples are analyzed for pH, specific conductance, acidity, alkalinity, sulfate, and the tracer ions bromide and iodide. In addition, weekly precipitation data is collected from the site.

Figures 3 through 5 represent the leachate quality of seeps 1 through 3 since *monitoring began* in the 1980's and more recently in our study from February, 1994. The bromide tracer had not appeared as of late 1994, however, the iodide tracer appeared in the late spring and early summer of 1994 with apparently no reduction in acidity. At the time of this writing, the acidities of the seeps are averaging about 25-75 mg/l.

It may appear that the limestone additions, including all of the alkaline trenches, the blanket broadcast of limestone reject and the limestone funnels, are not having an impact on the drainage quality. However, it must be recognized that the alkaline additions amended through alkaline trenches, were limed with sodium carbonate briquettes and afforded very high levels of alkalinity and at these levels, would significantly alter the seep chemistry. The alkaline trenches were constructed to provide a double blast of alkalinity; one coming from the sodium carbonate briquettes, short time response, and one coming from the limestone additions, long term response. This design was intended to elevate the pH generating inhospitable conditions for the iron bacteria and thereafter, maintaining alkaline conditions. The seeps that were impacted by the limestone trenches received two dosages of alkaline additions; one highly concentrated short term effect from the briquettes and one long term moderately alkaline from the limestone. The latter was designed to maintain alkaline *conditions* for decades.

Accordingly, in response to the induced moderate levels of alkalinity afforded by the *funnels, it* is quite probable that the alkalinity is at equilibrium and generating no more than 60 mg/l alkalinity. It is envisioned that an alkaline *concentration* gradient exists between the recharge locations and discharge locations, such that along any given groundwater flow path the acidity is being mitigated through time following every flushing, precipitation event. In other words, the mine drainage quality may have been impacted near the environs of the recharge areas within the backfill, where low levels of alkalinity are slowly, but *consistently neutralizing* the acidity along the flow path. These suggested interpretations will be corroborated in the near future.

Acknowledgements

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REFERENCES

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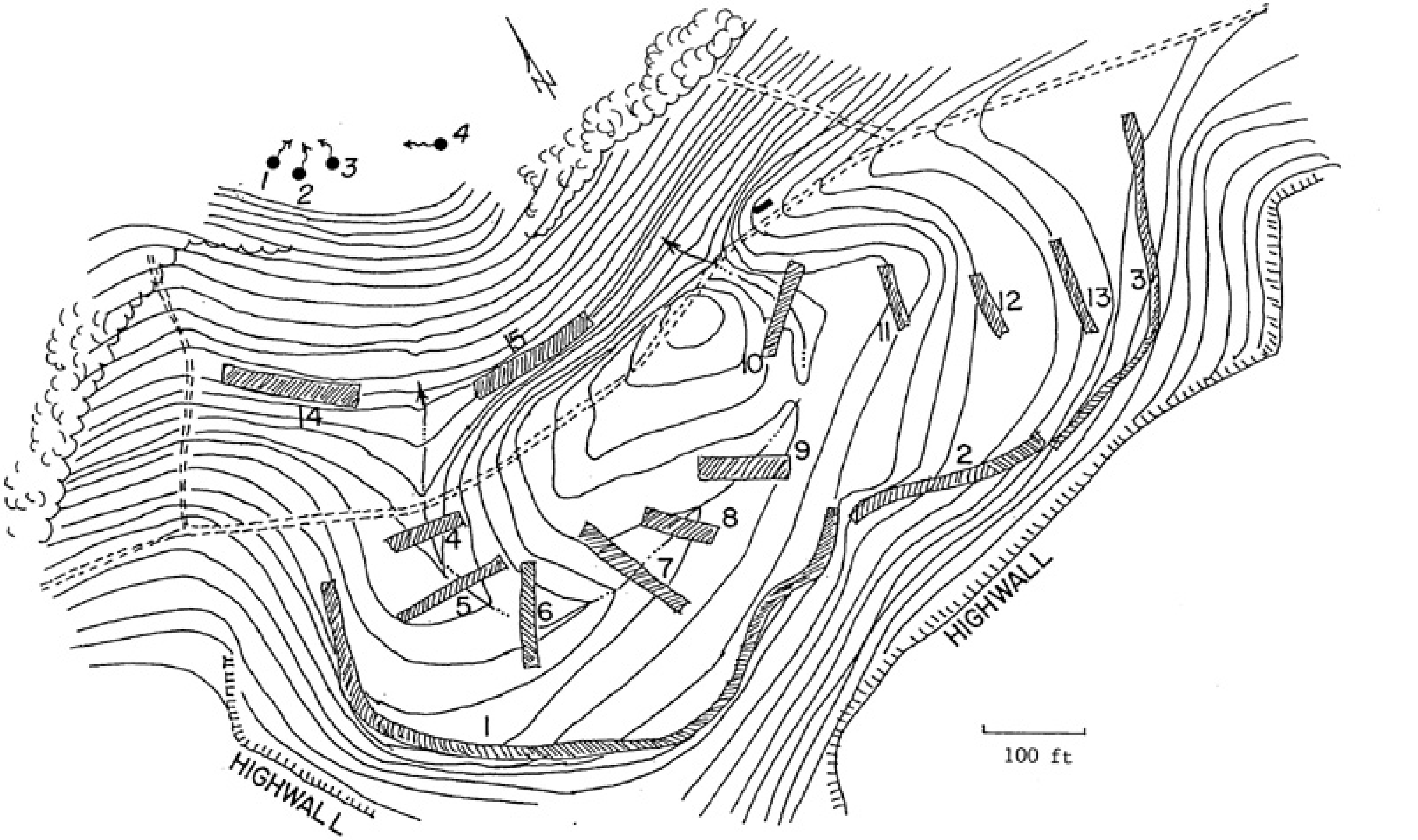
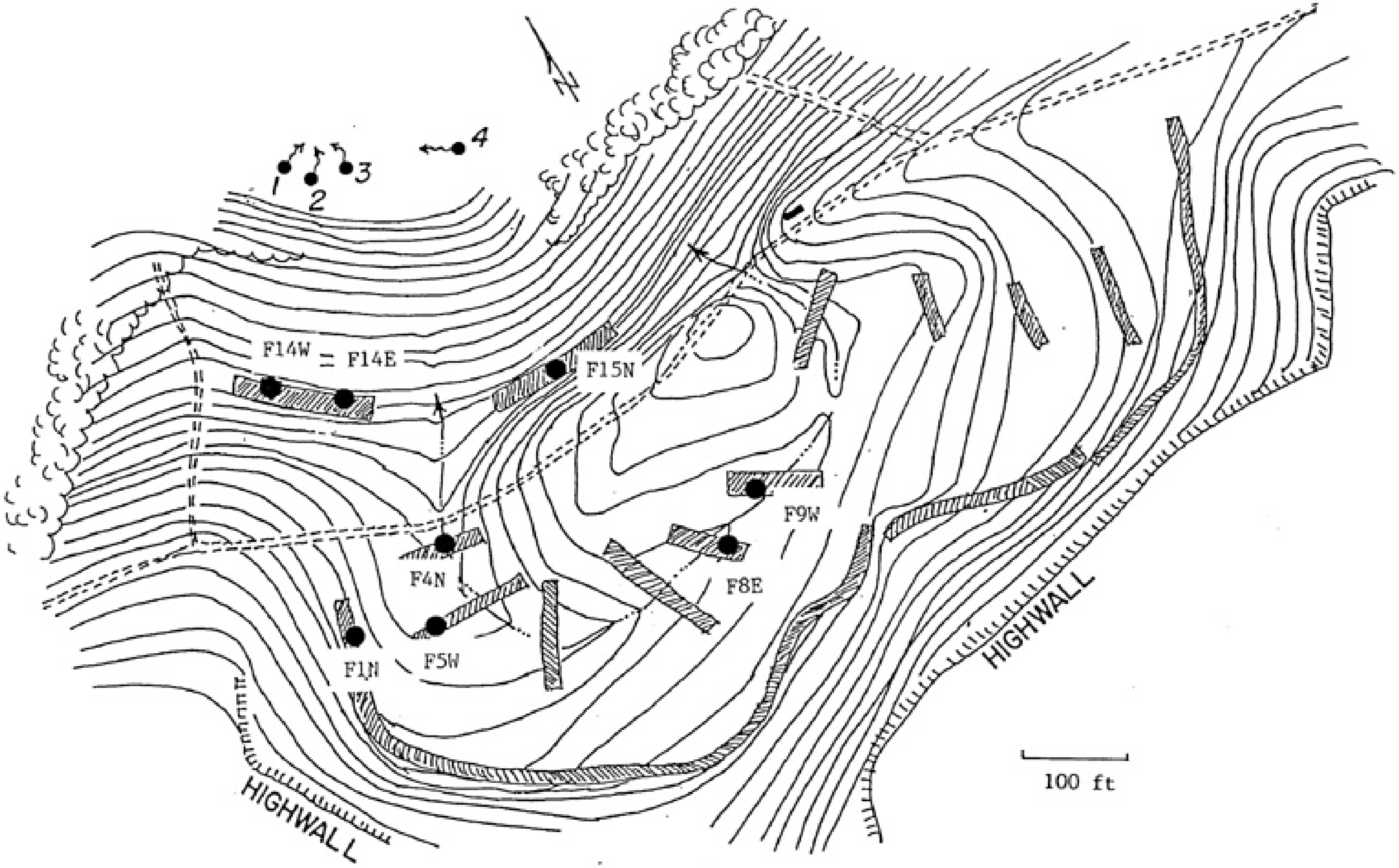


Figure 1. Map of the Mercer Site Showing the Locations of the Trenches and Seeps



c.i. = 3'

Figure 2. Map of the Mercer Site Showing the Locations of the Funnels

Figure 3.

Mercer Site Seep #1

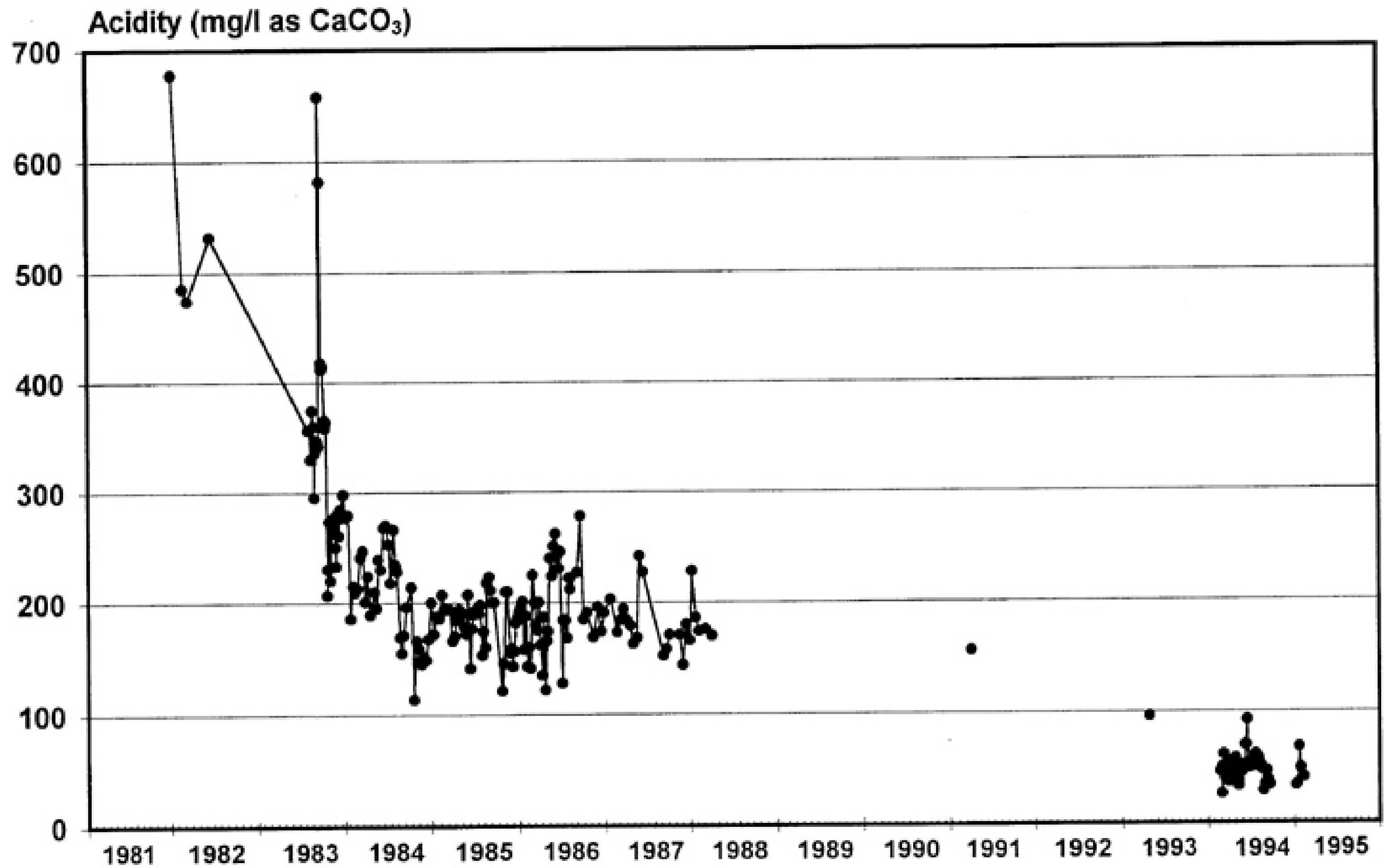


Figure 4.

Mercer Site Seep #2

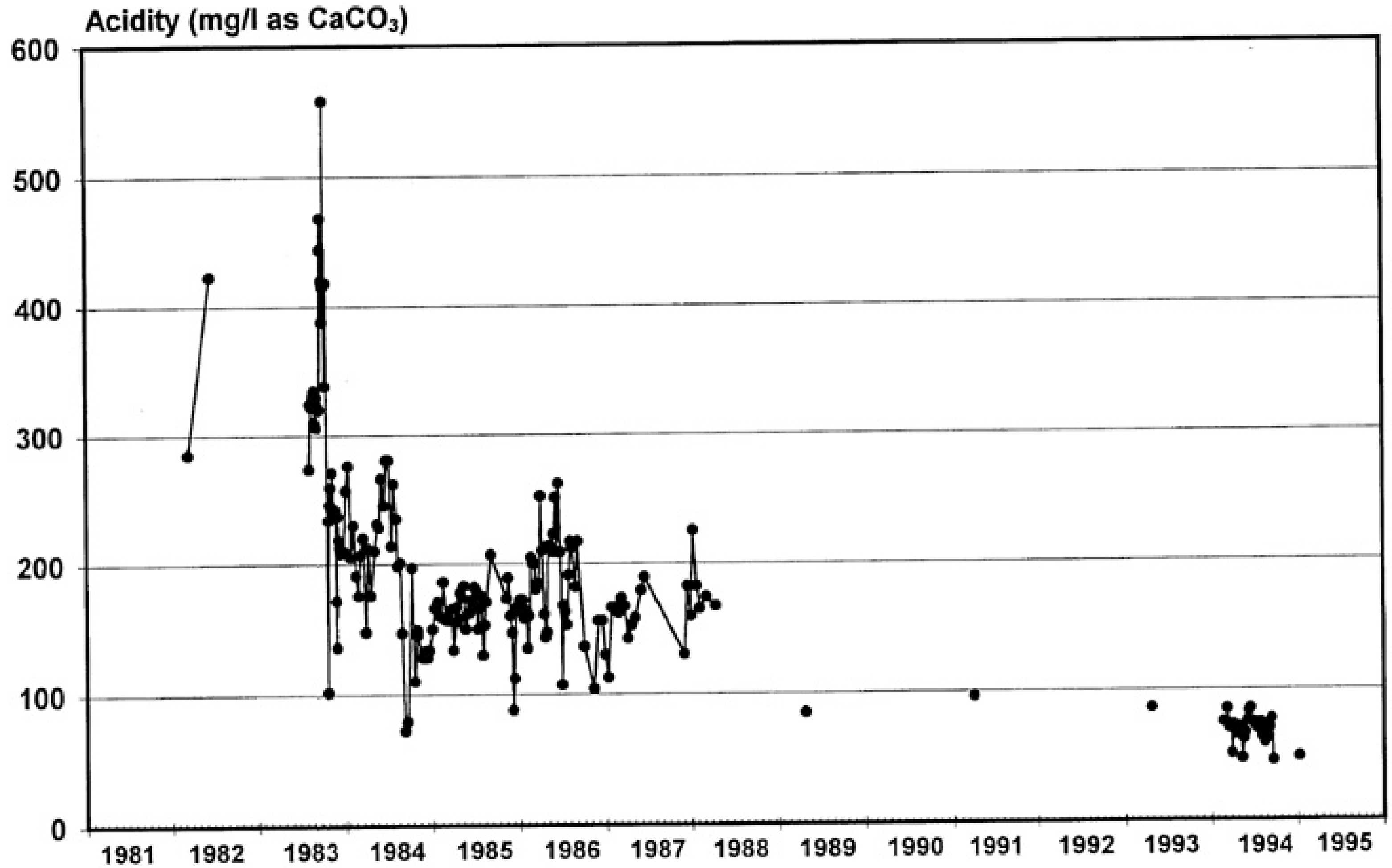


Figure 5.

Mercer Site Seep #3