CHAPTER 5. COAL ASH BENEFICIAL USE ON BITUMINOUS MINE SITES

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5.1 INTRODUCTION

Beneficial use of coal ash on bituminous coal mine sites in Pennsylvania is not a new concept and has been practiced for at least 15 years. In 2002 approximately 6,390,000 tons of coal ash were beneficially used on 42 bituminous and anthracite surface mine sites and 5 refuse disposal sites (Dalberto et al., Chapter 1). Several considerations make the recycling of coal ash for use in bituminous mine reclamation a natural fit:

- Coal ash is material that originated on mine sites, although it has been physically and chemically altered through combustion and sometimes through the addition of other materials, such as limestone.
- Some coal ash has chemical and physical characteristics that enhance mine site reclamation.
- Recycling suitable coal ash through mine site beneficial use preserves valuable space at waste disposal sites.
- Coal ash often can be hauled to mine sites by trucks on return trips from power plants, making it an economical form of recycling.

Much of the coal ash currently beneficially used on Pennsylvania surface mine sites is from waste coal power plants using fluidized bed combustion (FBC) technology in which limestone is injected into the boiler with the fuel stream. In 2002 approximately 79 per cent or 5,054,000 tons of the coal ash beneficially used on Pennsylvania coal mine sites was FBC ash (Dalberto et al.,Chapter 1). FBC ash is typically highly alkaline giving it chemical and physical properties, described in Chapter 3, that make it particularly useful in mine reclamation.

Pennsylvania currently defines the following uses of coal ash on active mine sites as beneficial uses: alkaline addition; low permeability material; soil substitute or additive; placement.

Alkaline addition takes advantage of the potential for some coal ashes to generate alkaline leachate and is used to offset the potential for on-site materials to generate acid mine drainage. Brady and Hornberger, (1990), Perry and Brady (1995) and Skousen et al., (2002) have shown in empirical studies of completed mine sites that post mining water quality correlates more strongly with the amount of alkaline material on a mine site than with the amount of sulfur in the rocks. According to Pennsylvania's current guidelines, to qualify for use as an alkaline addition agent the ash should have a neutralization potential (NP) of at least 100 parts per thousand and a pH of between 7.0 and 12.5. (NP and its determination will be discussed in more detail in section 5.2.2.1.) The amount of coal ash needed to offset potential acid production can be calculated using the methods described by Smith and Brady (1998).

Using ash as a low permeability material usually entails sealing or encapsulating materials on site that have the potential to produce acid mine drainage. Potential uses for ash as a low permeability material on a mine site include paving the pit floor, capping material segregated from the rest of the mine spoil due to its potential to generate acid mine drainage (AMD), encapsulating reject material on coal refuse reprocessing operations, and in some cases capping entire sites or significant parts of sites. For use as a low permeability material on a mine site an ash should have significant pozzolanic characteristics and should be capable of achieving a permeability equal to or less than 1.0×10^{-6} cm/sec under laboratory conditions.

As a soil supplement alkaline coal ash can be used as a liming agent and also to improve the physical characteristics of the soil or soil substitute being used as site cover. In some re-mining settings soil is not readily available, especially on coal refuse reprocessing operations, and coal ash can be used to enhance the characteristics of other on-site material to produce an acceptable growth medium.

The term “placement” covers uses of coal ash on a mine site that do not clearly fit into one of the above categories, such as using ash to re-contour pits or refuse piles on re-mining sites. In practice, coal ash use on a bituminous mine site typically fulfills more than one of the above beneficial use criteria. For example, coal ash being returned to a refuse reprocessing site may serve as an alkaline addition agent, an encapsulating agent (capping), and as a soil additive.

An application for use of coal ash on bituminous mine sites must include chemical analyses of the ash proposed for use showing that the ash is not likely to cause water quality degradation. Appendix 5.A includes a copy of the detailed quality analyses required. Analyses performed on a dry-weight basis are required for pH and sixteen metals. An SPLP leachate analyses is required for pH, sulfate, chloride, plus seventeen metals. In addition, results of a neutralization potential test must be provided if the proposed use is for alkaline addition, and a hydraulic conductivity test must be provided when the proposed use is as a low conductivity material.

5.2 CASE STUDIES

The following sites were chosen as examples of various types of applications of coal ash that have been performed on bituminous coal mine sites. They are intended to illustrate some types of situations where coal ash has been used on bituminous mine sites in Pennsylvania. The results from not one of these sites can be applied to the general class of coal ash usage that they represent. These are site-specific results. One of the primary criteria for choosing the sites was that operations had been completed or had at least progressed enough so that monitoring results could be meaningfully interpreted.

5.2.1 Refuse Pile Reclamation—Ebensburg Power Company Revloc Site

Abandoned coal refuse piles, large and small, dot the landscape of Pennsylvania’s bituminous coal region. Coal refuse (also known as gob) is the nonmarketable material that was removed from mines along with the coal. Many of the piles occur near old mine mouths or cleaning plants; most, but not all, are associated with deep mines, but surface mined coal that was cleaned prior to being marketed also contributed to some piles. In addition to the above ground piles, some coal refuse was also historically buried in abandoned surface mine pits. The aboveground piles typically are toxic to any colonizing vegetation and are highly erosive. Often the refuse was deposited in the lowland areas, below mine entries or cleaning facilities, frequently on stream banks, and sometimes directly in the stream channel. Even decades after refuse placement, each significant precipitation event washes fresh refuse onto adjacent properties and into streams. Most coal refuse contains relatively high percentages of sulfur and, therefore, leaches severe quality AMD. Because the oxidation of pyrite is exothermic, some refuse piles catch fire and burn for decades, adding air pollution to the list of problems they create for the small mining communities that often exist next to them. Under today's regulations, refuse disposal sites must be carefully engineered. They usually are constructed with an under drain system so that leachate can be collected and treated; the piles are also carefully compacted to limit infiltration and prevent combustion and are covered with soil, and planted so that they do not erode.

Abandoned coal refuse piles are especially challenging from the abandoned mine land reclamation (AML) standpoint. To put out the fires, the entire pile sometimes has to be reworked. They can be graded, covered with soil and capped, and while that may solve the erosion problems, it typically does not address the acidic leachate problem. Treating the discharges from abandoned refuse piles is especially challenging for two reasons: First, the discharges usually occur at the interface of the pile with original ground, and because the piles often were placed in stream valleys, those discharges often occur at the stream bank, leaving no room for treatment facilities. Second, the leachate from refuse piles often is extremely poor, very expensive to treat with conventional chemical treatment and beyond the effective capability of present passive treatment technology. Even if the discharges can be treated, that does not address polluted groundwater that leaves the site as diffuse flow.

It was the advent of the use of fluidized bed combustion technology to burn bituminous waste coal as a fuel to generate electricity that provided the first hope for full remediation of coal refuse piles, and their associated environmental impacts on a large scale. Coal waste burning plants can burn low-grade fuel of varying sulfur content and relatively low BTU content. Because ground limestone is injected into the boilers to capture air pollutants, the resulting ash is typically very alkaline (pH 11-12) and contains significant $CaCO_3$ equivalency, most in the form of CaO and $Ca(OH)_2$. So, not only are many waste coal piles now a potential fuel source, the ash generated by burning the piles is a material that can be useful in remediating the sites from which the refuse is extracted.

5.2.1.1 Site characterization/ setting

The Ebensburg Power Company Revloc site is located directly east of the village of Revloc and south of highway US 422 in Cambria County, Pennsylvania. The South Branch of Blacklick Creek (South Branch), a tributary of the Conemaugh River, bisects the pile. The South Branch supports a native brook trout population directly upstream of the Revloc pile, but has been virtually devoid of aquatic life below the pile for decades. Refuse in the pile is from the Bethlehem Mines Corporation Mine 32 Lower Kittanning deep mine that operated during the middle decades of the twentieth century. The refuse was placed in a lowland area where an unnamed tributary entered the South Branch; the refuse actually dammed the South Branch, producing a pond on the upstream side of the pile.

The depth to the deep mine varies from about 350 to nearly 400 feet beneath the Revloc site. Bedrock of the original land surface beneath the pile is of the Glenshaw Formation, Conemaugh Group. None of the coal seams that occur between the base of the pile and the Lower Kittanning coal has been deep mined. The northwest-southeast trending Johnstown syncline lies just to the southeast of the site, so rock strata beneath the site dip gently to the southeast, at about 2 percent. The shallow monitoring wells drilled for this site show that bedrock immediately beneath the site consists of interbedded shales and sandstones. Ebensburg Power Company reported that no groundwater was encountered when the pile itself was drilled during the exploration. (Ebensburg Power Company, 1988). However, the occurrence of persistent seeps at the refuse pile/soil interface indicates at least a thin saturated zone existed at the base of the pile, prior to present operations. The shallow groundwater flow immediately beneath the pile is likely topographically controlled, with fracture flow dominating over diffuse flow, as is usually the case in these strata. Because the pile in its original configuration is porous, has a complex topography, is visibly heterogeneous (fine compacted refuse, lenses of porous-looking red dog and coarse rock, massive, welded red dog bodies) groundwater flow within the pile, both saturated and unsaturated, is likely to be highly complex. The nature of the pile materials and their effects on water flow through them is an important consideration in attempting to interpret monitoring results from sites such as this. One should expect that once a site is disturbed by a reclamation effort, either through re-mining or otherwise, water quality at down-gradient monitoring will likely fluctuate until a substantial part of the reclamation is completed.

Ebensburg Power Company obtained separate mining permits on the northern and southern sections of the Revloc pile, which are separated by the South Branch. The company permitted the larger northern pile under Surface Mining Permit # 11880201 (Revloc 1), which DEP issued in 1989. Revloc 1 contained approximately 3.8 million tons of coal refuse spread over approximately 56 acres. In 1997, the company obtained Surface Mining Permit # 11960202 (Revloc 2), which included 0.7 million tons of coal refuse (Ebensburg Power Company, 1996).

The Revloc 2 site contained primarily reject material from an earlier, unsuccessful reprocessing attempt by another company on the Revloc 1 area; that previous operation had placed its reject on the Revloc 2 area, covered it with a thin soil layer, and planted it. The planting largely failed, the reject caught fire, and the pile developed two small, but extremely poor quality seeps. So, despite its relatively small size, the Revloc 2 site presented some significant environmental liabilities.

Ebensburg Power Company began removing refuse from the Revloc 1 site at the end of 1990 and began bringing ash back to the site in very early 1991, when its 50-megawatt fluidized bed cogeneration facility, located in Ebensburg, PA, went online. Mining began on the northern end of the site adjacent to Route 422 and has advanced toward the southwest on multiple working faces. The company activated the Revloc 2 site in the fall of 1997; excavation on Revloc 2 began on the eastern side of the pile, in the area known to be burning. Thus, the fire was extinguished early in the operations to end that source of air pollution and to preserve the useable fuel in the pile. The company operates the two piles concurrently as fuel needs warrant.

5.2.1.2 Mine operations

The mining plan for both Revloc sites is similar. The refuse is screened to remove oversized material. The oversized material and already burned material (red dog) is set aside. While only the Revloc 2 site was actively burning when permitted, sections of the Revloc 1 pile had burned in the past. The fine refuse is sent to the power plant for fuel, and ash is trucked back to the site. The ash is mixed, layered and compacted with the oversized reject and the red dog in an area behind the working face. On the Revloc sites, the operator has been removing the refuse material down to original ground, even in areas where the pile has been extensively burned. This practice, which results in virtually all potentially acid-forming material being encapsulated in alkaline ash, insures that there are no coarse–grained pathways for water or air within the reclaimed site. In some areas, soil buried beneath the pile is recovered for use in final site reclamation.

Once an area has been re-graded to its permitted configuration with the ash/reject mixture, a layer of soil typically one foot thick is spread and then seeded. Because of its large size, obtaining enough soil to reclaim the site is a challenge. Soil used to date has come from beneath the pile, from areas adjacent to the Revloc 2 refuse area, and, in the early stages of the operations was purchased from off site. Once the soil is spread, the area is seeded with a grass/legume mixture. A portion of the Revloc 2 site has also been planted in black locust.

Mining operations on the Revloc 1 site are nearing completion, with about one to two years of mining and reclamation to be completed. The Revloc 2 site is about ½ completed as of this writing, but because of its small size, and because it is being mined concurrently with Revloc 1, it too will likely be completed in the next 1 to 2 years.

Figure 5.1 is a photograph of the Revloc 1 site taken from the Revloc 2 site looking toward the village of Revloc to the northwest. The lighter green area in the center of the photo is recently planted area, while the darker green area on the right side of the photo is area that has been planted for at least two years. The dark area on the left of the photo is an area awaiting soil and vegetation. The refuse in the foreground is a yet-to-be-reclaimed area on the Revloc 2 site, and the small tree line at the base of the reclaimed pile marks the location of the South Branch.

5.2.1.3 Monitoring results to date at the Revloc 1 site

Because the Revloc 1 site has been active for ten years, there is a large body of data available from the site. When DEP permitted the Revloc 1 site, the emphasis on ash site monitoring was on monitoring wells, rather than downgradient discharges, so most of the ash monitoring data available for the Revloc 1 site is from three monitoring wells. (The approximate locations of the monitoring points discussed herein are shown on Figure 5.2.) Well MW-1 is a downgradient well, located just off the south-central edge of pile and between the pile and the South Branch. MW-2 is located along the western side of the pile, between the pile and the village of Revloc, and is located upgradient of the site. Well 3 is located along the north central edge of the pile, between, the pile and US Route 422, and MW-3 is located transverse to the direction of groundwater flow. The shallow groundwater flow direction at the site is from the northwest toward the southeast, from an upland recharge area in and to the north of the village of Revloc toward the discharge area at the South Branch.

Figure 5.1. Photograph of the reclaimed portions of the Revloc 1 refuse site. Note the contrast with Figure 5.2.

The three monitoring wells on the Revloc 1 site were similarly constructed. Each is a 7-7/8-inch hole drilled approximately 60 feet deep, and is cased to the bottom with 4-inch slotted PVC surrounded by clean sand to within 5 feet of the surface. A 1.5-foot bentonite plug sits atop the sand, with a short section of 6-inch steel casing set in concrete finishing off the top of the hole. The steel casing is fitted with a locking cap. The wells are designed to measure water quality in the shallow groundwater system surrounding the site.

Some of the results from the earliest background data at the Revloc 1 site (primarily the data up through mid-1988) are erratic, and the data include sampling dates for which the analyses for individual parameters are not in agreement with one another. For example, acidity/sulfate ratios are not what one would expect, and there is not good agreement between specific conductance and TDS levels; DEP identified the issue during review of the permit application. After split sampling between DEP and Ebensburg Power Company, the company changed its sampling procedures and the laboratory doing the analysis. For that reason the data collected for the Revloc 1 site prior to June of 1988 are not considered valid, were not relied upon during review of the permit application, and are not included in this discussion. However, inclusion of that data would not substantially change the conclusions regarding the site.

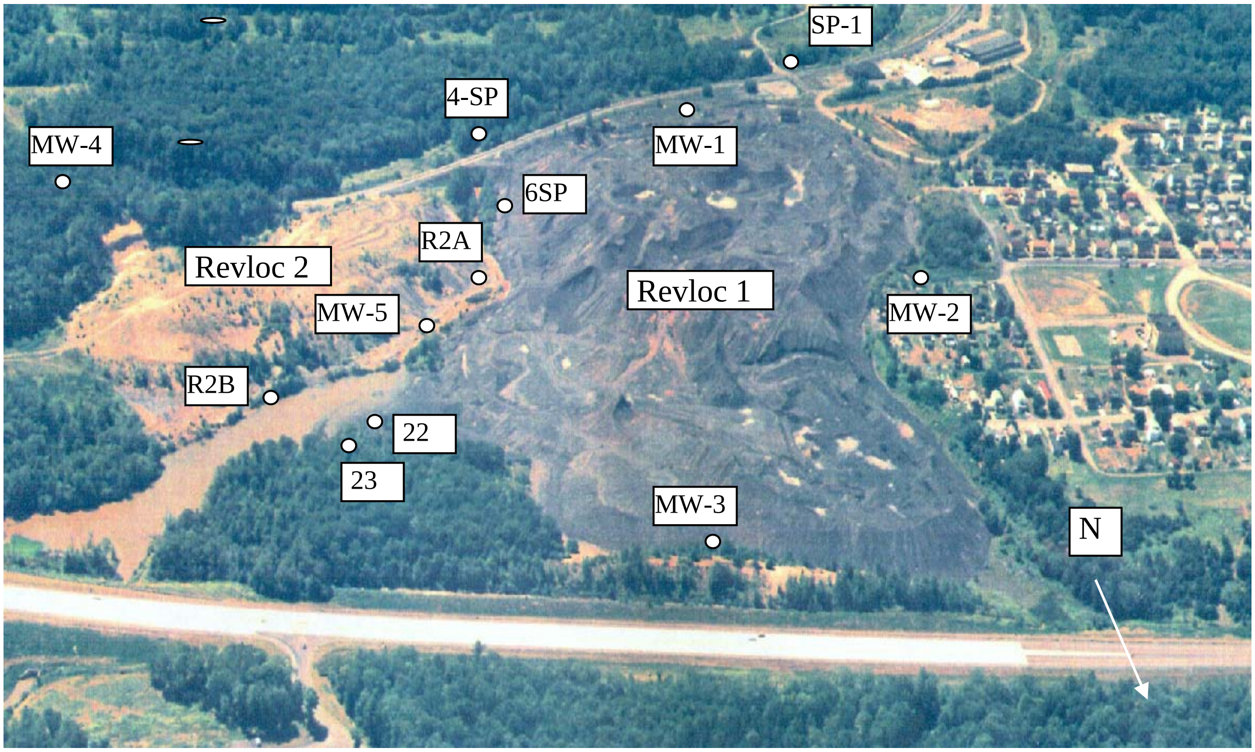

Figure 5.2. Aerial photo circa 1988 showing the Revloc sites and key associated monitoring reports. The photo was obtained from the permit application for Revloc 1.

Water quality results presented in this chapter will sometimes be compared to the maximum contaminant levels (MCL's) for drinking water supplies. This is done because the MCL's are a common benchmark with which many people are familiar. MCL's tend to be conservative to protect human health. Results that exceed an MCL must be considered in terms of cause/effect relationships, the use(s) or lack thereof of the water being tested, the volume of the water if it is a discharge, background conditions that existed prior to the condition being studied, and the overall setting of the project and sample point(s).

Where metals data are discussed in this chapter, they are in terms of total metals; some dissolved metals determinations are available for some parameters, but there are more totals metals data available for review. Where acidity is referred to in this chapter, it is hot acidity.

Data from MW-1, and other monitoring points from the Revloc site discussed herein, are presented in Appendix 5.B. Figure 5.3 displays the historical results for acidity, iron and sulfate, three of the parameters most commonly elevated in mine drainage. The data show that groundwater downgradient of the pile was, not surprisingly, severely degraded by acid mine drainage prior to the Ebensburg Power Company operation. The data show a steady trend of declining concentrations for acidity, iron and sulfate throughout the monitoring period. The decline appears to have begun prior to initiation of Ebensburg Power Company's operations in early 1991. The site had been disturbed by another operation approximately 10 years before Ebensburg Power Company permitted the site; it is possible that some of the earlier declines in concentrations are due to the natural attenuation of the results of that earlier disturbance of the pile.

Table 5.1 compares the median background values (N=9) for the parameters displayed in Figure 5.3 to the median values nine most recent samples, as of this writing. While water quality in MW-1 continues to show an influence from mine drainage, groundwater quality at the well has markedly improved.

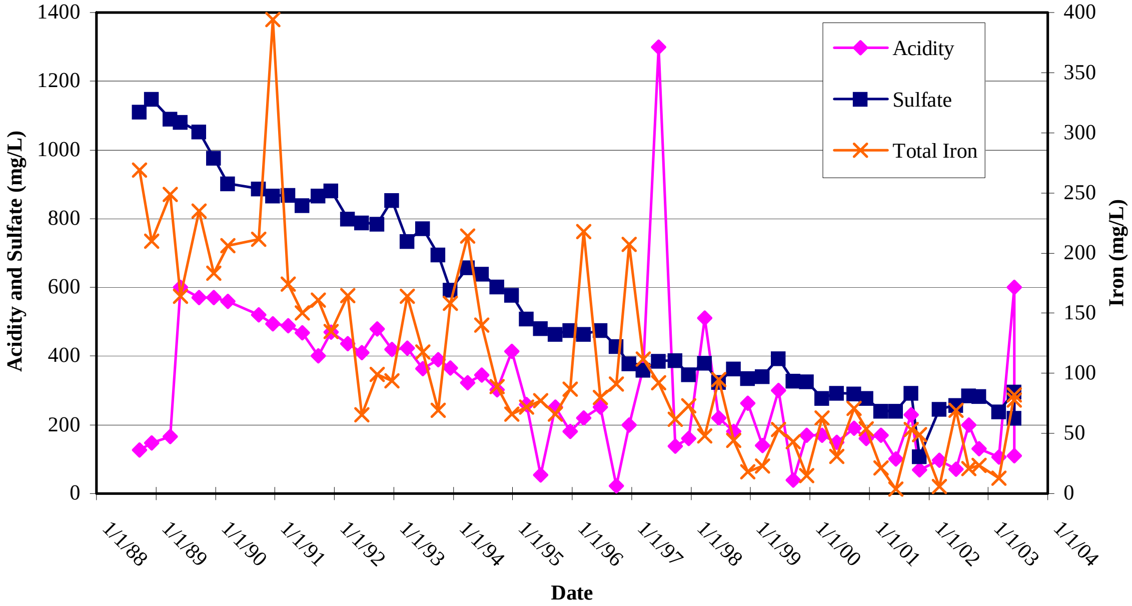

Figure 5.3. Graph of acidity, sulfate and iron at MW-1.

Table 5.1. Comparison of background and recent pollutant concentrations in MW-1.

Revloc 1, MW-1	Acidity (mg/L)	Fe (mg/L)	Mn (mg/L)	Sulfate (mg/L)
Background Median	520	211	18.6	1052
Recent Median	106	23	6.3	257
% Change in Median	-80	-89	-66	-76

The data for MW-1 (Appendix 5.B) show that specific conductance, aluminum, zinc and TDS have declined at MW-1 during the monitoring period, which is consistent with the decline in mine drainage parameters. pH has remained largely unchanged, despite the decrease in acidity and AMD metals. Both calcium and magnesium remain similar to background levels and are relatively low for mine drainage contaminated water; recent samples show Ca concentrations in the 30 to 40 mg/L range, with Mg concentrations in the 10 to 20 mg/L range. Chloride concentrations may have increased during the monitoring period, but remain below 25 mg/L. Most other metal concentrations remained unchanged during the monitoring period. Chromium, copper, and barium, with an occasional exception, have remained below detection limits, and below the maximum contaminant level (MCL) for drinking water supplies. Cadmium has consistently been below the detection limit, but the limit reported by the laboratory in this case (0.05mg/Ll) is in excess of the MCL. The available data show no trends in lead concentrations; the lab reporting the data has used a relatively high detection limit of 0.1 mg/L.

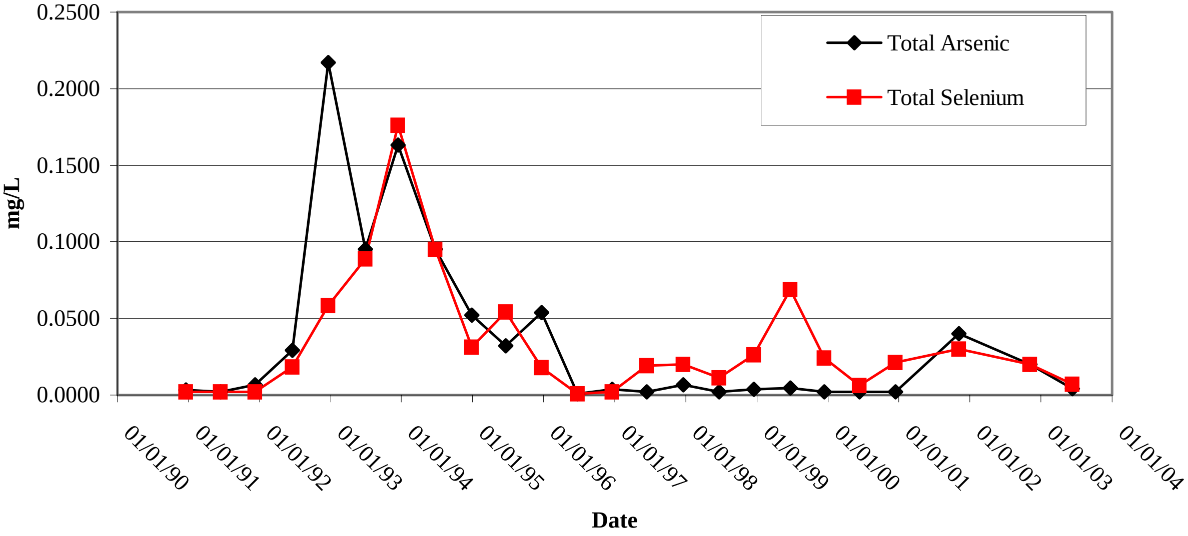

Figure 5.4. Graph of selenium and arsenic concentrations at MW-1.

Arsenic and selenium concentrations in MW-1 increased, beginning in 1992, peaking in 1992 for arsenic and in 1993 for selenium, then returned to background levels by mid-1996 (See Fig. 5.4.) Since 1996, both arsenic and selenium have remained below the MCLs, with the exception of one spike in selenium in 1999. The coal refuse ash is an unlikely source for the elevated arsenic and selenium during the early 1990's for the following reasons: 1) When the increase began, ash had been placed only on the northern end of the site, most distant from MW-1; 2) during the time when selenium and arsenic concentrations were declining from their peak values, then stabilizing, large volumes of ash were being placed directly upgradient of MW-1; 3) the selenium and arsenic data from both MW-2 (clearly upgradient of the site) and MW-3 show similar spikes, although of a lesser magnitude during the same time period as MW-1, suggesting that sampling or laboratory procedures may also have been a factor.

Monitoring well MW-2 is an upgradient well for the Revloc 1 site. The data from it show low TDS water with no mine drainage influence, confirming its upgradient position. The data are generally unchanged with time. The data for MW-2 are provided in Appendix 5.B, but will not be discussed in detail here.

Monitoring well MW-3 is located immediately adjacent to the north-central part of the Revloc 1 site. The available data for MW-3 are included in Appendix 5.B. The permittee reports that MW-3 is a low-volume well from which it is difficult to obtain a clean sample. Water quality in MW-3 has been variable throughout the monitoring period. The initial background samples show some influence from mine drainage, indicating that groundwater at the well was receiving some contamination from the refuse pile. However, for much of the monitoring period the mine drainage influence in the well was slight (sulfate values typically less than 100 mg/L), and at times the well produced very low TDS water (TDS <100 mg/L). Then, beginning in 1998, the acid mine drainage influence in the well increased significantly, only to decline to background levels again during 2003. Even though the location of MW-3 is toward the upgradient end of the pile, because it is located directly adjacent to the pile, it is still at times influenced by contaminated groundwater associated with the pile. The heavy metal concentrations in MW-3 do not show any noticeable trends, with the possible exception of selenium, which may have increased in the 1999 through 2002-time period. Selenium concentrations, however, have remained below the MCL of 0.050 mg/L, and the latest available analysis from a sample collected in June 2003 was below the detection limit of 0.007 mg/L.

The Revloc1 abandoned refuse site was producing six discharges of very poor acid mine drainage leachate, when the site was permitted by Ebensburg Power Company. Data for each of these points, designated 4SP, 4SPA, 4SPB, 6SP, 22SP, and 23SP, are included in Appendix 5.B. The discharges all emanate from the pile in proximity to the South Branch. The most significant of these discharges in terms of both flow volume and pollution load is 4SP, which flows directly into the South Branch from an abandoned railroad grade that forms the southern boundary of the pile. Six samples were collected from discharge 4SP prior to the site being activated by Ebensburg Power Company, however, during the first year of operations, disturbance of the site was limited to the northern end, most distant from 4SP. Therefore, the twelve samples collected from 1991 are included in Table 5.2, which compares the median concentration values of the first 18 samples collected to the most recent 18 samples collected for key acid mine drainage parameters.

Table 5.2. Reduction in flow and concentrations at discharge 4SP.

Discharge 4SP	**Flow (gpm)**	**Acidity (mg/L)**	**Iron (mg/L)**	**Manganese (mg/L)**	**Aluminum (mg/L)**	**Sulfate (mg/L)**
1990-91 Data	31.6	2860	2.23	11.1	435	3820
2002-03 Data	19.2	600	0.80	5.7	17	1221
% Change	-39	-79	-64	-49	-96	-68

Flow and mine drainage pollutant concentrations are both reduced when the earliest data are compared to the most recent data at 4SP. The mine drainage emanating from the Revloc 1 site is characterized by very high acidity and sulfate values, moderate iron concentrations, and very high aluminum concentrations. Some refuse piles leach higher manganese and iron concentrations than does the Revloc 1 site, and the aluminum concentrations at the Revloc 1 site are at the high end of what is typically seen. Figure 5.5 is a graph showing the change in flow and pollution load from 4SP with time. Acid and aluminum loads both have been reduced substantially during the monitoring period. The decline in pollution load is the result of both improved water quality and a decrease in the discharge flow.

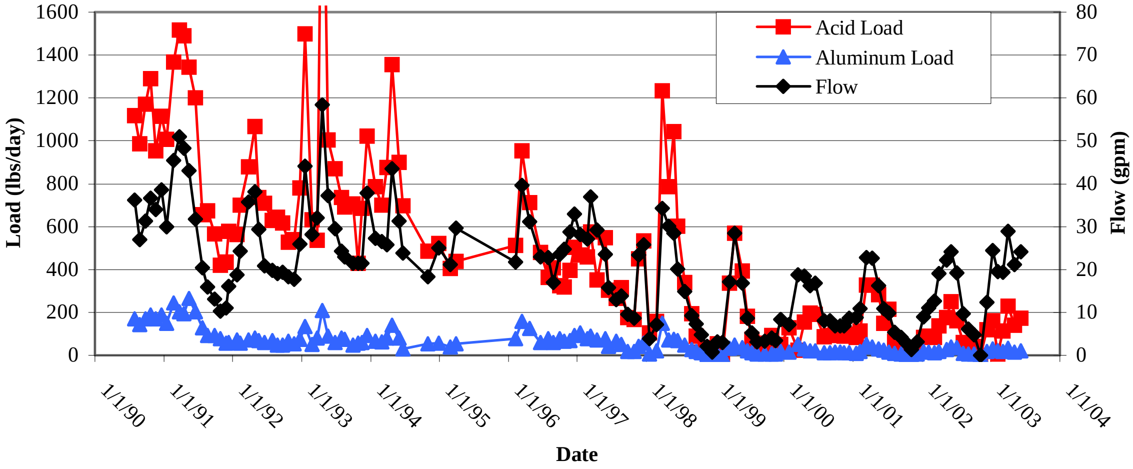

Figure 5.5. Flow, acid load and aluminum load at discharge 4SP.

The monitoring data for discharges 4SPA and 4SPB show similar reductions in both flow and pollutant concentrations and load to those observed at 4SP. In the case of 4SPB, the reductions are due more to a reduction in concentrations than flow. 4SPA and 4SPB are located in the same general area of the site as 4SP.

Discharge 6SP was located along the southeastern portion of the pile; it was eliminated by the operation in 1998, removing its pollution load from the site.

Seeps 22SP and 23SP were the smallest of the discharges emanating from the Revloc 1 site and they occur along the east-central edge of the pile. Water monitoring data for these two points are shown in Appendix 5.B. While concentrations for some parameters have increased at 22SP, pollution loading has decreased due to a reduction in flow. At 23SP both concentrations and loading have increased for some parameters, but the increases are dwarfed by the decreases seen at the larger discharge points. Table 5.3 summarizes the flow and pollution load data for the seeps at the Revloc 1 refuse pile.

When the median values of the first two years of monitoring data are compared to the median values of the last two years of data (Table 5.3), the pollutant load reductions to the South Branch Blacklick Creek from the discharges downgradient of the Revloc site are: 1935 lbs/day of acidity; 283 lbs/day of aluminum; 3675 lbs/day sulfate; lesser amounts of other pollutants. These values show only the decrease in pollutant load in terms of the measurable discharges from the site; additional reductions in pollutant loads in terms of direct groundwater baseflow to the stream are also likely occurring.

Table 5.3. Summary of flow and AMD pollutant load data for the discharges from the Revloc 1 site. Background data were collected in 1990-1991 and recent data were collected in 2002 to mid 2003. N=18 for most of the background and recent data sets. Flows are in gpm and loads are in lbs/day.

	Totals	**4SP**	**4SPA**	**4SPB**	**6SP**	**22SP**	**23SP**
Background Flow	67.8	31.6	13	17	2.7	2.9	0.6
Recent Flow	38.4	19.2	2.6	15.3	0	0.4	0.9
Background Acid Load	2137.7	1060	578	430.9	62.2	6.4	0.2
Recent Acid Load	203.4	116	28	58.3	0	0.7	0.4
Background AL Load	312.5	168.8	83.9	51.9	7.2	0.7	0.01
Recent AL Load	29.9	17.1	5	7.7	0	0.1	0.06
Background Fe Load	3.4	0.89	0.4	2	0.1	0	0.01
Recent Fe Load	0.45	0.15	0	0.3	0	0	0
Background Mn Load	8.61	4.1	2	2	0.3	0.2	0.01
Recent Mn Load	2.24	0.99	0.2	0.9	0	0.1	0.05
Background SO4 Load	5084	1406	724	2854	87	12.4	0.4
Recent SO4 Load	1409	260	51	1091	0	4.1	3.1

5.2.1.4 Monitoring results to date at the Revloc 2 site

The Revloc 2 site, located directly across the South Branch from the Revloc 1 site, has four ash monitoring points associated with it. They are: MW-4, an upgradient well; MW-5 a downgradient well; R2A, a down-gradient discharge; R2B, a downgradient discharge. Monitoring data for all four of these points are included in Appendix 5.B.

The upgradient well is located on the hilltop to the south of the site, and the water quality shows it to be unaffected by mine drainage. The data also show that the water quality at MW-4 has not been affected by the Ebensburg Power operation. MW-4 does show chloride concentrations higher than what may be expected, as high as 175 mg/L. MW-4 is located within 500 feet of an interchange for US Route 219, and road salt may explain the relatively high chloride concentrations in the well.

MW-5 is located between the Revloc 2 site and the South Branch along the north-central edge of the pile. Background data on MW-5 show that it was affected by mine drainage from the pile prior to Ebensburg Power Company’s operation. The data also show that water quality in MW-5 has improved, since the well was established to the point where it is now uncontaminated. The change in water quality at MW-5 began before Ebensburg Power Company had substantially affected the Revloc 2 site, so factors other than the re-mining and reclamation, possibly site preparation work and well construction and purging techniques, apparently have contributed to the improvement in the water quality at MW-5. The data for MW-5 show no trends in terms of any toxic metals, while Ca and Mg have decreased.

Discharge R2B is located directly downgradient of an area of the Revloc 2 site that has been mined and partially reclaimed. R2B was low-flow, with extremely poor acid mine drainage quality prior to Ebensburg Power Company's operations. As re-mining and reclamation of the area upgradient of R2B has progressed, the water quality at the point has improved. Acidity values have fallen from several hundred mg/L, and higher, to 0 in recent samples, while concentrations of metals typically found in mine drainage have also declined. pH has risen, while sulfate values have declined. Calcium, potassium, sodium, and chloride levels have increased. Among the toxic metals, copper, lead, and zinc concentrations appear to have declined, while selenium concentrations appear to have increased. For the years 1998 through 2002, selenium concentrations were elevated when compared to background data.

Discharge R2A is located along the northern edge of the Revloc 2 site, downgradient of an area where re-mining and reclamation are, as of this writing, in progress. The background data from this point show it to be of very poor acid mine drainage quality. While the discharge remains contaminated with mine drainage, the quality has improved in terms of acid mine drainage contamination over the past two years and flows have decreased. For example, the median acidity concentration of the first 12 samples collected was 2600 mg/L while the median acidity concentration of the last 12 samples was 1900 mg/L; the flows also appear to have declined with the median value for the first 12 samples being 12.4 gpm and the median flow of the last 12 samples being 6.1 gpm. Calcium and pH levels may have increased in R2A during the past two years. Magnesium concentrations have been as high as 580 mg/L at R2A. The quality at R2A is representative of very concentrated AMD leachate from the Revloc 2 pile. The concentrations of some heavy metals in R2A are relatively high. For example, arsenic concentrations exceeded the MCL during every sampling event, except for June 10, 2003, and have been as high as 0.67 mg/L. Lead concentrations have typically exceeded the MCL, and chromium, copper, and cadmium have also done so on occasion; the results for each of these heavy metals is variable without any clear trends. The elevated toxic metal concentration in R2A existed prior to Ebensburg Power Company's operation and illustrates that severe bituminous coal AMD, especially from coal refuse piles, can include significant toxic metal concentrations. Zinc concentrations at R2A have increased during the sampling period. Selenium concentrations at R2A have been highly variable, were less than detection limits during the background-sampling period, exceeded the MCL of 0.050 mg/L during much of the monitoring period, but returned to less than the MCL during 2002 and 2003. Table 5.4 presents a summary of the monitoring data on R2A and R2B for AMD parameters.

Sampling Point SP-1 is located on the South Branch below the Revloc 1 and Revloc 2 sites. This point is influenced by the direct discharges and groundwater baseflow from the piles into the stream. Monitoring data for SP-1 are available in Appendix 5.2. Table 5.5 compares the data in terms of median values collected from SP-1 prior to 1992 (N=14) to the 14 most recent samples at the time of this writing.

Table 5.4. Summary of flow and AMD pollutant load data from the Revloc 2 site discharges. Background data were collected from April 1996 through March 1997 (N = 12), and recent data were collected from June 2002 through June 2003 (N = 12). Flows are in gpm and loads are in lbs/day.

Parameter	**Total**	**R2A**	**R2B**
Background Flow	14.6	12.4	2.2
Recent Flow	6.14	6.1	0.04
Background Acid Load	298.2	281	17.2
Recent Acid Load	106	106	0
Background Iron Load	5.3	5	0.3
Recent Iron Load	0.05	0.05	0
Background Mn Load	7.2	6.5	0.7
Recent Mn Load	2.4	2.4	0
Background Al Load	47.7	45.9	1.8
Recent Al Load	16.6	16.6	0
Background SO4 Load	839	777	62
Recent SO4 Load	206	204	2.4

Table 5.5. Comparison of background median flow and mine drainage pollutant concentrations at SP-1, the monitoring point on the South Branch directly down stream of the Revloc 1 and 2 sites.

	Flow (gpm)	**pH (su)**	**Acidity (mg/L)**	**Iron (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**	**Sulfate (mg/L)**
1988-91 Data	3261	4.30	134	1.61	1.03	21.0	191
2000-03 Data	2427	5.55	16	0.50	0.55	1.50	73

Figure 5.6 shows graphically the reductions in aluminum, acidity and sulfate at SP-1, when the background data medians are compared to the most recent data medians.

The data from SP-1 show the improvement to date in terms of mine drainage pollution in the South Branch that has resulted directly from the Ebensburg Power Company operations at the two Revloc sites. Note especially the reduction in aluminum and acidity concentrations along with the increase in pH. During times of low flow, the stream still experiences spikes in pollutant concentrations, but that condition should only improve as re-mining and reclamation continues.

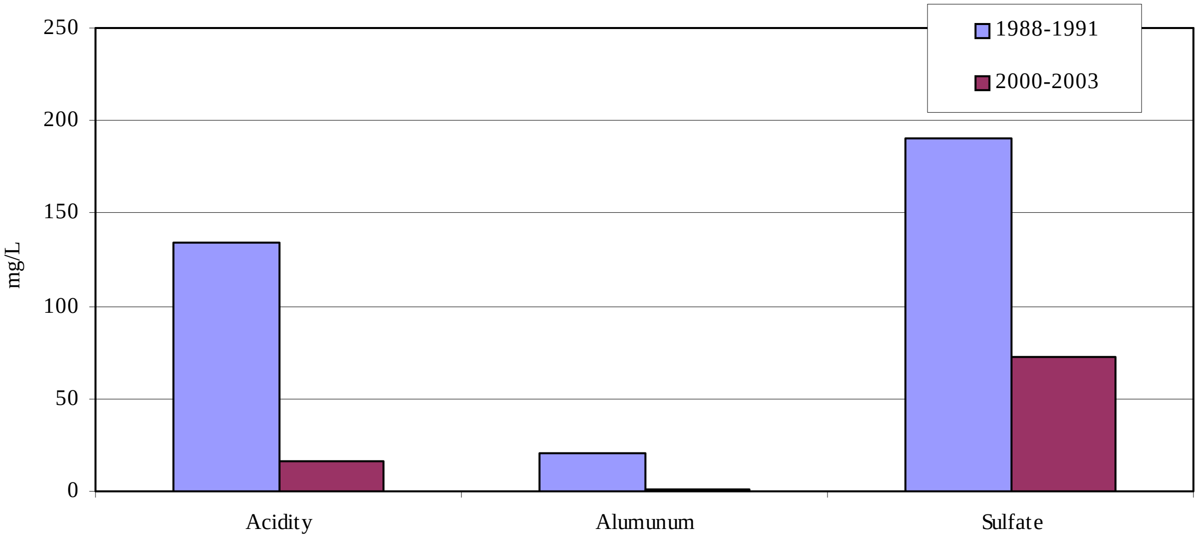

Figure 5.6. Comparison of background and recent median acidity, aluminum and sulfate concentrations at monitoring point SP-1, downstream of the Revloc sites.

While most toxic metal concentrations at the Revloc sites show no change or some decrease, selenium concentrations have increased at some points. Figure 5.7 shows the available selenium concentrations for downgradient ash monitoring points at the Revloc sites. Selenium concentrations at the upgradient points, MW-2 and MW-4 (not included in Fig. 5.7) show no increase during the monitoring period and have been consistently low.

Selenium concentrations at wells MW-1 and MW-3 at the Revloc 1 site have generally been higher than background, and on occasion have exceeded the MCL of 0.05 mg/L, although not since 1999. MW-2 is not shown in Figure 5.7, since selenium concentrations are of a lesser magnitude, but the MW-2 data do show a spike in selenium in 1993-1994 that suggests the elevated selenium shown in MW-1 and MW-3 in that time period may be, in part, related to sampling/laboratory considerations. This conclusion is based on MW-2 being clearly up gradient of the Revloc site and showing no other signs of influence from the pile. The highest selenium values are at R2A and R2B, seeps downgradient of the Revloc 2 site. Both of these points are low volume, and at times intermittent, with the median flow of the last 12 samples from R2B being 0.04 gpm and the median flow of the last 12 samples from R2A being 6.1gpm. Areas upgradient of R2A and R2B were disturbed early in the mining on the Revloc 2 site, in part to accommodate extinguishing the on-site fire. Some areas where ash and refuse reject have been placed above those points remain exposed and unvegetated. It seems likely the elevated selenium in these points is related to the exposed ash/refuse mixture on the surface, which is flushed with each runoff event. Once reclamation of this area is completed, it is reasonable to expect that water quality at the two points will further improve, including a reduction in selenium concentrations. MW-5 is located between R2A and R2B and also appears to be influenced, but to a lesser degree. While selenium concentrations are clearly elevated at R2B and R2A, it is important to view these data in light of the low flows from these points; while concentrations are relatively high, the amounts of selenium discharging at these points are low. Samples collected by DEP on December 1, 2003 and on February 18, 2004 at SP-1, directly down stream from the Revloc sites, showed a selenium concentration below the detection limit of 0.007 mg/L; copper, chromium, arsenic, mercury, lead, and nickel also were all below detection limits at SP-1 on those dates.

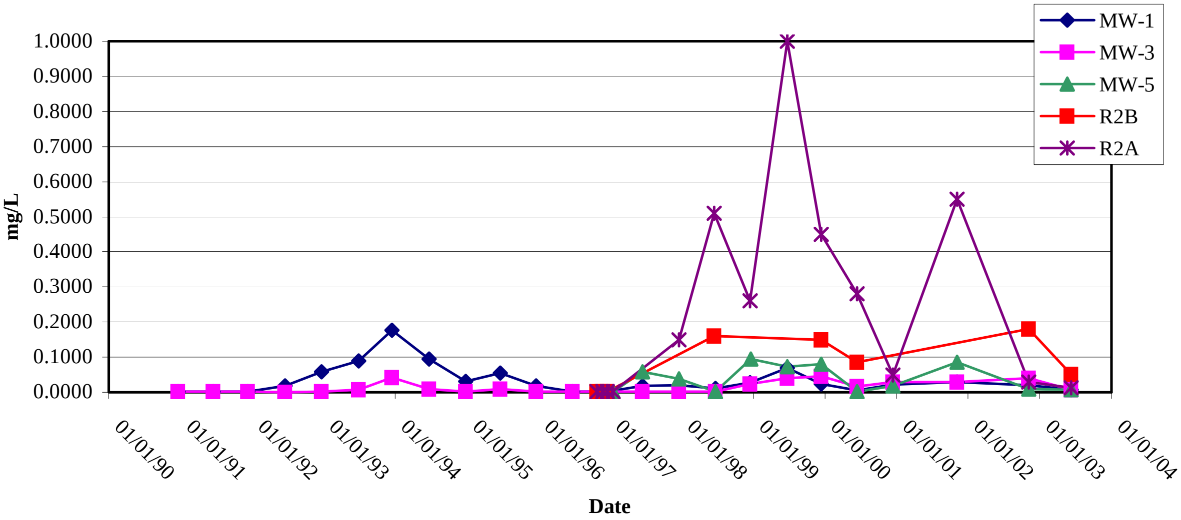

Figure 5.7. Selenium concentrations at downgradient ash monitoring points at the Revloc sites.

5.2.1.5 Conclusions regarding the Revloc site

- Pollution loads have decreased at the 4 largest seeps from the Revloc 1 site (4SP, 4SPA, 4SPB, and 6SP); loading has increased somewhat at the smallest seep (site 23), but the net change has been a clear decrease in pollution loading from the site discharges.

- Groundwater quality at the downgradient well, MW-1, for the Revloc 1 site has improved; water quality at the upgradient well MW-2 remains unchanged; quality at MW-3 also upgradient, but located at the base of the pile has been variable, and presently shows an influence from acid mine drainage.

- Groundwater at the downgradient monitoring well, MW-5, at the Revloc 2 site has improved, but the timing of the changes suggest factors other than re-mining and reclamation are responsible. Quality at the upgradient well, MW-4, remains unchanged.

- Data collected from the two seeps from Revloc 2, R2A and R2B, show that the abandoned coal refuse at the Revloc site leaches worst-case acid mine drainage that also includes metals such as arsenic, lead, and sometimes chromium, cadmium, and copper in excess of the respective MCL's for those parameters. This condition, including the occurrence of some heavy metals well in excess of their respective MCL's, existed prior to the Ebensburg Power Company operation, and the abandoned coal refuse is the source for those metals.

- Seep R2B has improved substantially in quality and declined in flow as a result of re-mining and reclamation on the Revloc 2 pile. Seep R2A has improved to a lesser degree, but has also decreased in flow as a result of re-mining and reclamation conducted upgradient of it. Reclamation is not completed upgradient of either of these two points. Most heavy metal concentrations appear to have declined at R2B, and remain relatively unchanged to this point at R2A.

- Taken collectively, the Revloc data indicate that selenium is one parameter for which concentrations may have increased as a result of the re-mining and reclamation with ash. Selenium at downgradient wells MW-1 and MW-5 is slightly elevated relative to background concentrations, although selenium has been below the MCL at MW-1 for the past three years and at MW-5 for the past two years. Selenium concentrations at R2B have been elevated relative to background and have consistently exceeded the MCL. Selenium concentrations at R2A have been highly variable, and for the past two years have been less than the MCL. R2A and R2B are both low volume seeps. Two recent downstream samples at SP1 show a selenium concentration of <0.007 mg/l. Selenium concentrations at R2A and R2B will likely decline with final reclamation of the upgradient areas, and monitoring of these points will continue.

- The major mechanism for decrease of mine drainage at Revloc 1 appears to be the removal of the marketable coal refuse and encapsulation of the remaining reject in the compacted FBC ash rather than the neutralization of mine drainage by alkaline leachate from the ash. This conclusion is supported by: 1) pH has remained low, while acidity and sulfate, as well as other mine drainage parameters, have declined at MW-1 and the larger of the pile discharges; 2) the flows of the primary discharge points at both the Revloc 1 and 2 sites have decreased, indicating that, as expected, the permeability of the areas reclaimed is less than that of the abandoned coal refuse.

- At point R2B at Revloc 2, pH, calcium and potassium have increased, while acid mine drainage parameters and manganese have decreased, indicating that alkaline leachate from the ash is having some influence on that point. Some of the same influence, although less pronounced, can be seen at R2A. R2A and R2B are subject to direct runoff from partially reclaimed areas where the ash/refuse mixture is exposed at the surface. Reclamation of areas directly upgradient of these seepages is not yet completed, so the final effects of reclamation and ash placement cannot be judged, although the results thus far are encouraging.

- Re-mining and reclamation of the Revloc sites using coal refuse ash has substantially improved the quality of the South Branch Blacklick Creek by reducing the concentration of acid mine drainage parameters in the stream. There are no other sources AMD to the stream up stream of the Revloc sites, and no other mechanism that would account for the pollution reduction in the stream.

5.2.2 Alkaline Addition to Surface Mine Overburden--Laurel Land Development, Inc. McDermott Site

As mentioned in section 5.1, the amount of calcium carbonate in the overburden of a surface mine site has been shown to be the primary factor determining if the site produces acidic or alkaline drainage, more so than the amount of sulfur in the overburden. For this reason, importing alkaline material onto mine sites with alkaline deficient overburden has often been seen as a potential way to make otherwise unmineable sites permitable. However, Pennsylvania's experience with alkaline addition has yielded, at best, mixed results, with several alkaline addition sites having unexpectedly produced substandard water quality, especially during the early years of alkaline addition (Smith and Brady 1998; Brady and Hornberger, 1990). Some of the reasons include difficulty in determining how much alkaline addition is enough, determining the best application methods, and the reality that the cost of importing enough alkaline material frequently exceeds the profitability of the job. Pennsylvania's current approach to alkaline addition on surface mines is described in Technical Guidance Document 563-2112-217 available on DEP's website.

5.2.2.1 Site characterization /setting

The McDermott Mine is located in Jackson Township, Cambria County, PA, just to the north of US Route 22, and just east of the summit of Laurel Ridge. The site has previously been described by Kania (1998) and by Schueck et al., (2001), however, mining was on going during both of those investigations, which, thus were preliminary. In the initial submission and through subsequent permit amendments, mining was proposed on 26.5 acres of Lower Kittanning Coal (LK), 32.1 acres of Middle Kittanning Coal (MK) and 8.6 acres of Upper Kittanning (UK) Coal (Laurel Land Development, SMP# 11950102, 1995). The operator also proposed to remove shale and sandstone (Worthington) from the operation. Little shale was removed, but an unknown tonnage of sandstone was removed, processed, and marketed as aggregate.

In the area of this site, the LK and MK overburden rocks are generally brackish water deposits. Channel sandstone deposits frequently exist within a framework of finer grained sediments such as shales and mudstones. Usually the only significant zone rich in carbonates is the Johnstown limestone horizon (freshwater), which is located at or a few feet below the bottom of the UK coal. The shale units, especially those that directly overlie the LK and MK coals frequently include significant amounts of sulfide minerals. With the lack of carbonates in the overburden and the high-sulfur shales located around the coals, one would expect that LK and MK mining might produce poor quality water, although the role of the Johnstown limestone has to be considered in that conclusion.

Surface and deep mining on the LK and MK seams in the area of the McDermott Mine generally has resulted in acid mine drainage. Because of its persistence, thickness and quality, the LK seam has been extensively deep mined, so is generally available for surface mining under thinner overburden. The MK seam, while usually of good quality, is usually not thick enough for deep mining and often occurs in multiple benches. Surface mining on these seams, therefore, often cannot take place to a high enough overburden to encounter much, if any, of the Johnstown

Limestone. While the overburden quality for these seams can be problematic, the previous mining that has occurred and the resultant unreclaimed spoil, deep mines and discharges present re-mining opportunities at appropriate locations with appropriate mining plans.

The exploratory data on the McDermott site show that over most of the site, the LK coal is directly overlain by a shale unit of 0 to12 feet thick. Above that is sandstone, which in places cuts down to the top of the coal. There is a thin clay layer beneath the MK coal. The MK overburden over most of the site is shale with minor sandstone units in places. The Johnstown limestone is not present on the site, but at the horizon where it would be expected, there is a shale unit that contains significant amounts of carbonate. Unfortunately, the high-carbonate shale exists in an unweathered state only at the highest cover, and only a limited amount of it became part of the mine spoil on this site. The UK coal was encountered only incidentally to the MK mining. The McDermott site is located near the crest of the eastern flank of the Laurel Ridge Anticline, and strata on the site dip shallowly to the northeast.

The McDermott Mine included a proposal to daylight some of the abandoned deep mines, and to reclaim old spoil and an abandoned highwall on the site. The mining plan also proposed alkaline addition in the form of FBC ash from two power plants located in Cambria County, which burn coal refuse to generate electricity (Laurel Land Development, SMP# 11950102, 1995).

Mining previous to the McDermott operation had degraded the headwater areas of the receiving stream, Hinckston Run, a tributary of the Conemaugh River. However, Hinckston Run does improve enough approximately 4 to 5 miles downstream to allow for stocking of brook trout, and some limited trout reproduction.

The permittee performed an acid-base account overburden analysis as part of the pre-permit requirements. Researchers in West Virginia began applying acid-base accounting results to coal mine overburden during the 1970’s (Skousen et al., 1990). Interpretation of acid-base account data is complex, partially subjective, evolving, and dependant on the experience level of the interpreter. The approaches to interpreting acid-base account data currently used by Pennsylvania DEP permit reviewers are described in Brady et al., (1994), Perry and Brady (1995), and Perry (1998).

Acid-base accounting is intended to measure the potential of the disturbed rock to generate both acidity and alkalinity. The maximum potential acidity (MPA) is determined stoichiometrically from percent sulfur in the rock. The rock’s ability to neutralize acid is measured in the laboratory and is termed neutralization potential (NP). NP and MPA are reported in terms of tons $CaCO_3$ per 1000 tons of material (or parts per thousand, ppt). Sites are frequently characterized in terms of net NP (NNP=NP-MPA). Site-wide NNP is one of the more effective ways to evaluate acid-base account data (Perry and Brady, 1995; Skousen et al., 2002). These terms can be used to characterize a single rock horizon, a drill hole, an entire mine site, or parts thereof. Pennsylvania experience has shown that strata with NPs < 30 ppt $CaCO_3$, or NPs without a fizz (does not effervesce with 25% HCl) are typically not significant alkalinity producers. Likewise, strata with percent sulfur less than 0.5 are not generally significant producers of acidity. An approach sometimes taken is to evaluate the ABA data by including only those strata greater than these “thresholds” in the calculations (Brady and Hornberger, 1990). This is the approach that was taken here. Overburden data summaries referenced in this chapter were derived using a computer spreadsheet program (Smith and Brady, 1990).

Based on the mining plan submitted in the permit application, DEP interpreted the data to show an average site-wide $CaCO_3$ deficiency (i.e., a prevalence of potential acid producing material over potential alkaline producing material) of approximately –320 tons/acre and a net neutralization potential (NNP) of -3.07 tons calcium carbonate equivalence per 1000 tons of overburden. Sites with an NNP of less than zero have a high probability of producing acid water. (There are exceptions, such as low-cover sites in settings otherwise unlikely to create AMD (Perry and Brady, 1995).) For this study, the overburden data for the site were re-evaluated in light of how the site was actually mined; for example, more LK coal was mined, and thus more LK overburden was disturbed on the site than proposed. The recalculation shows a site-wide deficiency of –418 tons/acre and a NNP of –2.98 tons/1000 tons. The NNP (tons/1000 tons) is essentially unchanged by the recalculation, despite the increase in the tons per acre deficiency, because the total tons of overburden disturbed also increased with the recalculation. The recalculated site overburden data are summarized in the first row of Table 5.6.

Initially, the proposed ash (from the Interpower-Ahlcon plant at Colver, PA) had a neutralization potential (NP) of about 200 tons/1000 tons (ppt). The proposed ash addition rate was 2160 tons per acre averaged over the site, which equates to approximately to 500 tons of calcium carbonate addition per acre. During a later permit revision (December of 1997) the ash addition rate was increased to 3200 tons per acre. Also, the source of the ash was changed to the Cambria Reclamation Plant in Ebensburg (average NP 174 tons/1000 tons). The operator further increased the rate of ash application as mining progressed, due, in part, to emerging water quality problems on site. The ash was to be added to the pit floor, mixed with the spoil, and added to special-handled material at different rates for each coal seam being mined. In some areas ash was added to the surface prior to spreading topsoil. Records show that 28,775 tons of Colver power plant ash were used on the site, and 288,155 tons of Cambria Reclamation ash were applied. The total tons of ash added to the site were 316,930. Weight averaging the two different ashes results in the conclusion that the ash put on the site had the calcium carbonate equivalence of approximately 56,000 tons of pure calcium carbonate. The operator removed coal from approximately 48 surface acres, so ash was applied at approximately 6,600 tons per acre, which is theoretically equivalent to about 1,165 tons per acre of pure limestone. The material was not evenly distributed over the site, however. Areas mined early in the operation received substantially less ash than areas mined later in the operation, and the operator placed a large amount of ash in the west-central part of the site after final coal removal. The second row of table 5.6 summarizes the site overburden with the alkaline ash addition factored in.

Table 5.6. Summary of overburden analysis data for the Laurel Land Development McDermott site.

McDermott Site OBA	**MPA (tons)**	**NP (tons)**	**Available NP (tons/acre)**	**NNP (tons/1000 tons)**	**NP/MPA Ratio**
Raw Overburden	31679	11574	-419	-2.98	0.37
With Alkaline Addition	31679	67497	746	5.31	2.13

5.2.2.2 Mine operations

The McDermott permit was issued in January of 1996 and activated in April of that year. The site was mined primarily with a combination of a dragline and dozers. As is sometimes the case with dragline operations, spoil material was exposed to weathering in an un-graded state for extended periods. Mining began in the north-central part of the mine site, advanced first to the north, and then to the south. The higher cover portions of the job in the west-central part of the site were mined last. Toward the end of the operation, reclamation slowed considerably, and the operator eventually abandoned the site, leaving it partially unreclaimed, the state in which it currently remains.

5.2.2.3 Monitoring results to date at the McDermott Site

Soon after mining began, so did water quality problems. Mining had started in the north-central part of the permit application along the Lower Kittanning cropline. The nearest downgradient monitoring points to that location are a well, MW-2 and a spring, MD-12. Water monitoring data for the McDermott site monitoring points are presented in Appendix 5.C. Monitoring point locations relative to the McDermott site are shown in Figure 5.8.

Figure 5.9 displays the results for some standard mine drainage parameters at MD-12. While the data are highly variable, sulfate, acidity, iron, and manganese clearly increased soon after mining began upgradient of the point. Other parameters such as calcium, magnesium, and chloride increased also. Among the heavy metals, zinc and nickel (typically associated with AMD) increased somewhat. Copper spiked during late 1996 through 1999, but has been near background levels for the past four years, and remained well below the MCL at all times. Lead concentrations showed a similar spike, and frequently exceeded the MCL of 0.015 mg/L from 1997 into early 1999, but have since declined to below the MCL. (Lead concentrations at the monitoring points for the McDermott site will be discussed in more detail later in this chapter.)

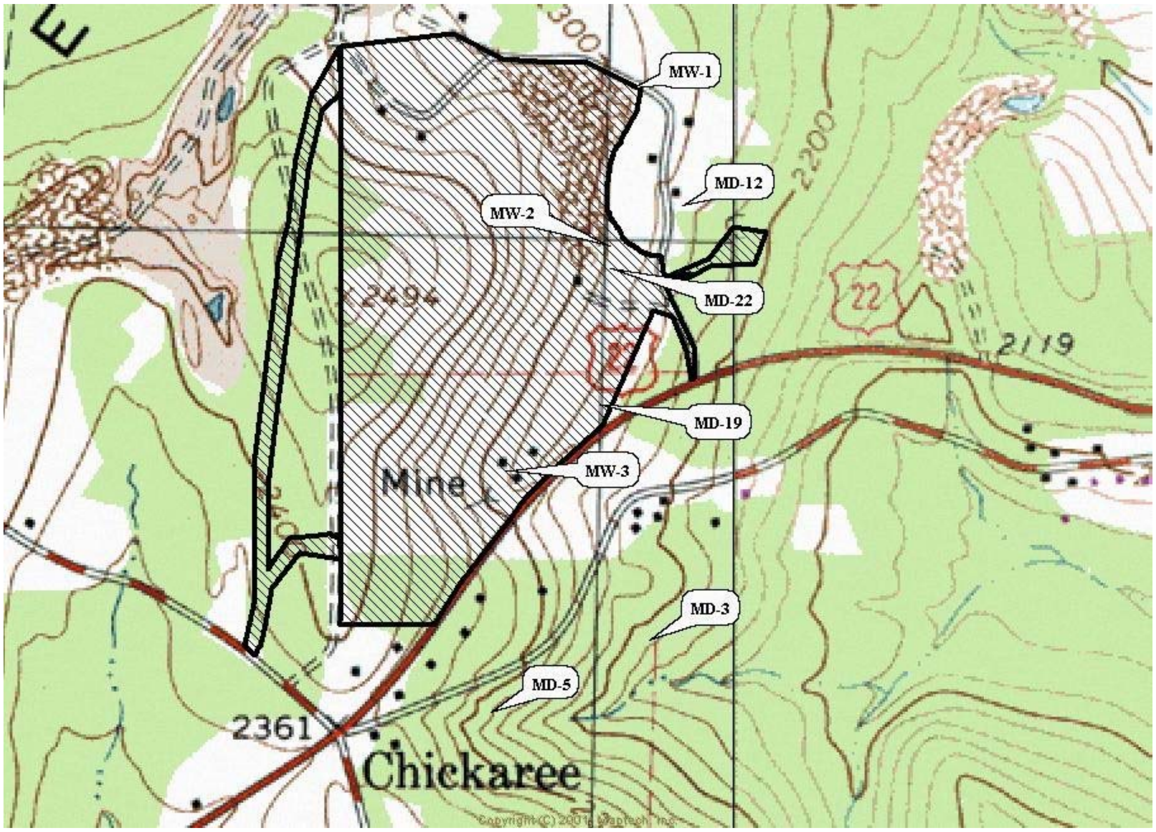

Figure 5.8. Map showing the locations of the McDermott Mine monitoring points.

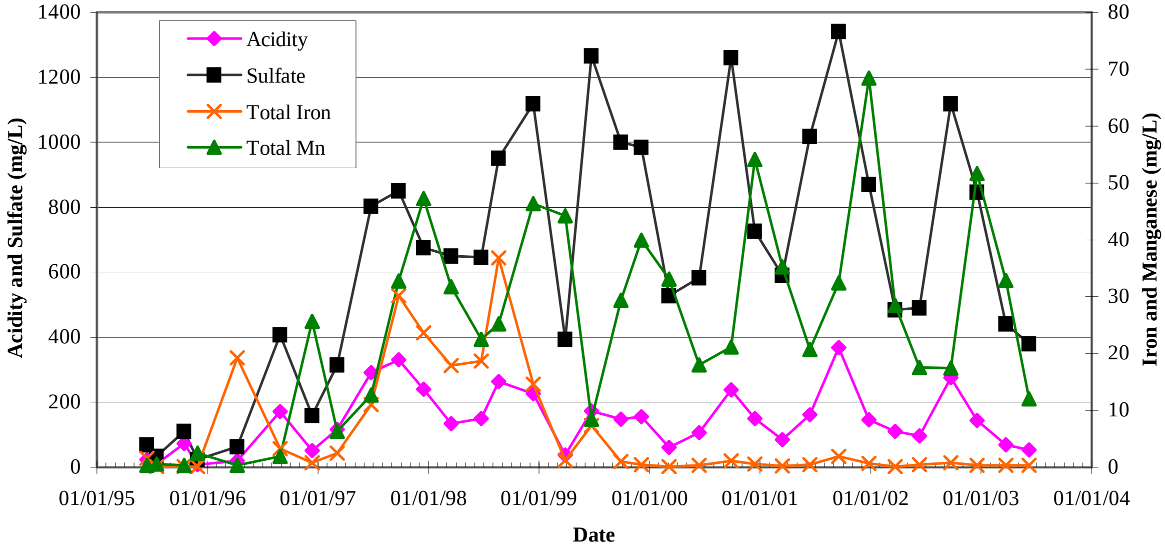

Figure 5.9. Mine drainage parameters at spring MD-12.

Monitoring well MW-2 is one of three monitoring wells placed downgradient of the McDermott site to monitor the results of the re-mining and ash placement effort. Each of these wells is drilled down slope of the LK cropline into the Kittanning sandstone formation. Monitoring well MW-2 showed similar results to those at MD-12. Shortly after mining began, mine drainage parameters began to increase (Fig. 5.10). Calcium, magnesium and chloride increased. Copper increased, although it remained well below the MCL of 1.3 mg/L. Nickel and zinc increased somewhat. As was the case with MD-12, lead concentrations also increased at MW-2, peaking in 1997 at around 0.08 mg/L and declining since.

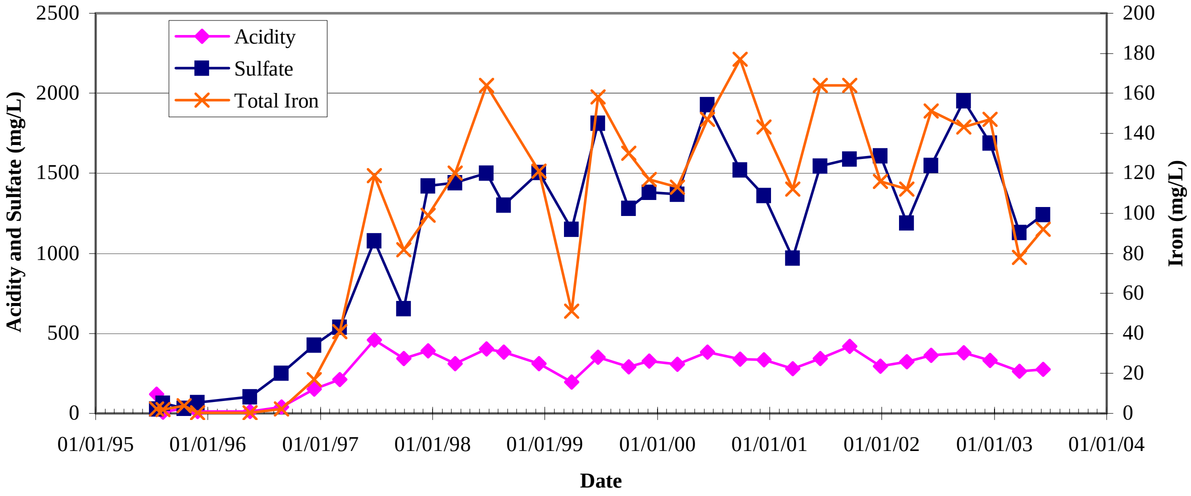

Figure 5.10. Acidity, sulfate and iron at MW-2.

Monitoring well MW-1 is located along the northeastern corner of the McDermott site and is located downgradient of area mined on the McDermott Mine. MW-1 is also located directly downgradient of an area of abandoned mine lands that had been mined prior to the McDermott site. The McDermott Mine reclaimed the abandoned highwall that had been left by the pre-law operation. The monitoring data show that MW-1 was affected by mine drainage by the abandoned mine lands prior to the initiation of the McDermott operation. The data also show that mining on the McDermott site further affected the water quality at MW-1. Figure 5.11 shows the monitoring results for MW-1 for acidity, iron and sulfate.

The McDermott Mine affected areas upgradient of MW-1 early in the operation, during 1996, and the influence on the well in terms of increasing sulfate can be seen as early as the beginning of 1997. Note in figure 5.11 that sulfate increased, while acidity did not. This could be explained either by attributing the increased sulfate to the coal ash, or by an increase in acid mine drainage production, which is being neutralized by the ash.

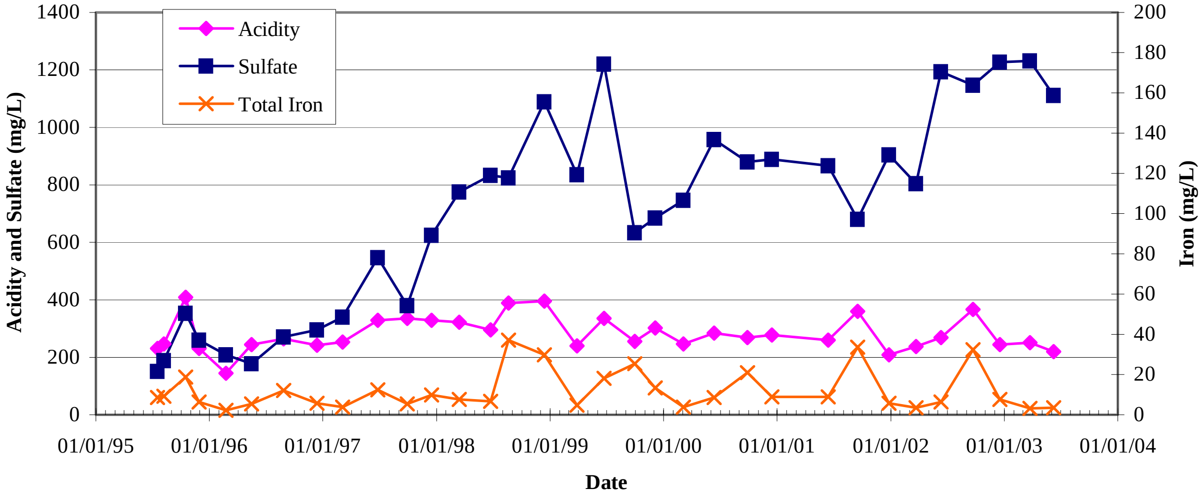

Figure 5.11. Acidity, sulfate and iron at MW-1.

Figure 5.12 shows the sampling results at MW-1 for calcium, magnesium, aluminum, and manganese. The McDermott operation clearly caused an increase in manganese in MW-2, with concentrations increasing about 4 times from near 5 mg/L to near 20 mg/L. The increase in manganese confirms an increase in acid mine drainage production as a result of the disturbance of the site overburden. The increase in manganese concentrations, without an increase in acidity, suggests that the additional mine drainage being produced is being neutralized by the ash. The increase in sulfates could be due to either an increase in pyrite oxidation, dissolution of the ash, which in laboratory tests leaches elevated sulfates, or, most likely a combination of both.

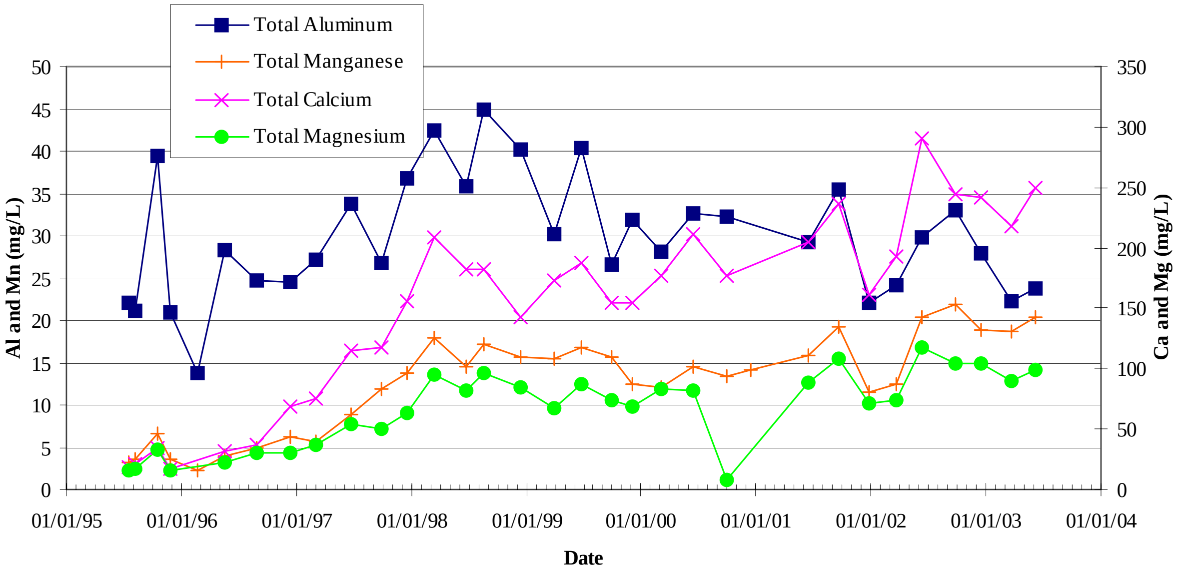

Figure 5.12. Calcium, magnesium, aluminum, and manganese at MW-1.

Calcium and magnesium levels also have increased in MW-2. Aluminum concentrations were elevated prior to the McDermott operation and remain unchanged. Nickel and zinc concentrations at MW-2, although not particularly high have increased somewhat, also suggesting an increase in mine drainage, which is then being neutralized. pH has remained constant in the low 3's. Lead concentrations did not show an increase in MW-1 as they did in MW-2 and MD-12, however, they were relatively elevated in MW-2 in the background and frequently exceeded the MCL throughout the monitoring period, including before the McDermott Mine affected the area.

Monitoring well MW-3 is located along the southeastern edge of the McDermott site. Mining and ash placement did not advance to areas upgradient of MW-3 until mid-1998. Shortly thereafter, acid mine drainage began to show up in the well (Fig. 5.13). Hot acidity, iron, and sulfate all increased substantially. Much of the acidity increase in MW-3 is apparently mineral acidity; pH at MW-3 has not declined and has remained in the low 5's.

Calcium, magnesium, manganese, chloride, specific conductance, and TDS have all increased in MW-3. Among the other metals, nickel and zinc have increased. Copper, chromium, arsenic, and cadmium show no discernible increase. Lead concentrations have been highly variable, but also show no trends and consistently have been below the MCL.

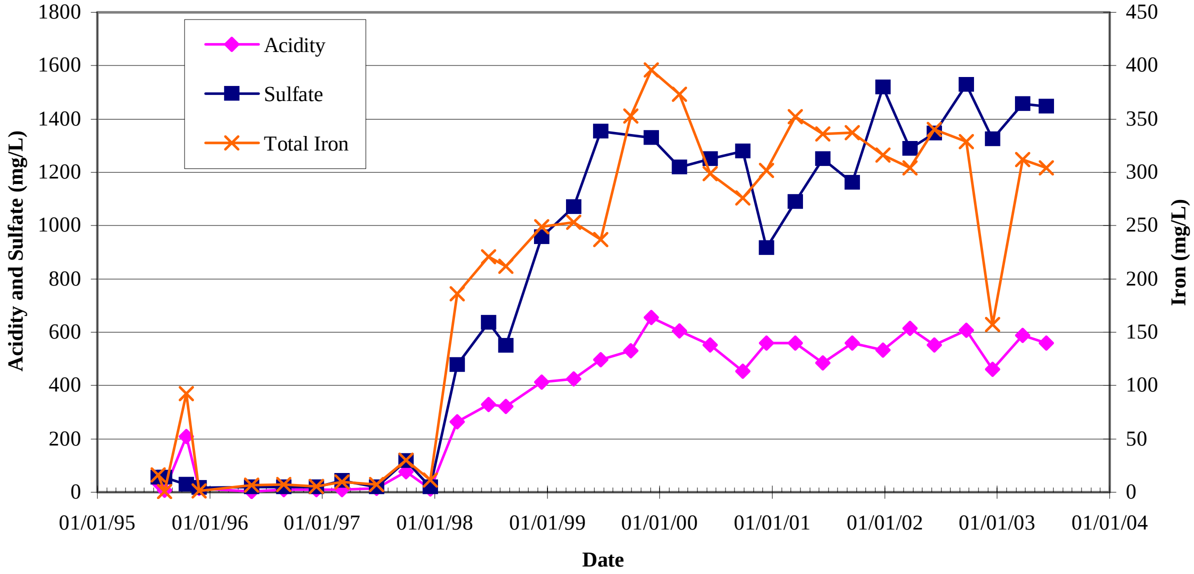

Figure 5.13. Acidity, sulfate and iron at MW-3.

The lead results from the various monitoring points at the McDermott site warrant some discussion, because lead concentrations increased at both MW-2 and MD-12 after mining took place on areas of the site upgradient of those two points. Figure 5.14 shows the lead concentrations with time at various key monitoring points on the McDermott site. Lead concentrations at the monitoring points not included in Figure 5.14 were not remarkable in that they generally were typical of background conditions and showed no discernible change during the monitoring period. Among the three site monitoring wells, the highest lead concentrations prior to the McDermott operation were found in MW-1, the one well that was affected by mine drainage prior to the McDermott operation. (MW-1 was located directly downgradient of a small abandoned surface mine, and its background water quality showed an influence from mine drainage pre-McDermott (Fig. 5.11)). Lead concentrations in MW-1 frequently exceed the MCL (0.015 mg/L), and are unchanged by the additional mining and ash placement conducted directly upgradient of the well by the McDermott operation.

Among the other various sample points where lead concentrations were measured prior to the McDermott operation, lead concentrations were also relatively high in MD-2, a small seep from a deep mine entry, also located on the northern section of the McDermott site. MD-2 was mined out soon after operations began, thus the short monitoring period for that point. The background data collected prior to the McDermott operation show no other points with elevated lead, including deep mine discharges MD-3, MD-5 and MD-1. MD-1 was located near the center of the McDermott site, and MD-3 and MD-5 are located to the southeast of the site. After Laurel Land Development re-mined the McDermott site, lead concentrations increased in MD-12 and MW-2, located on the northern end of the site, but did not increase in MW-3, MD-3, and MD-5, despite the latter three points being clearly degraded by mine drainage generated by the McDermott operation. All areas of the site, north and south, had FBC ash used in reclamation, and because the southern part of the job was mined after the northern part, the ash application rates were generally greater on the southern area. Given all these facts, the source of increased lead in MD-12 and MW-2 appears to be in the coal overburden on the northern end of the site rather than the coal ash.

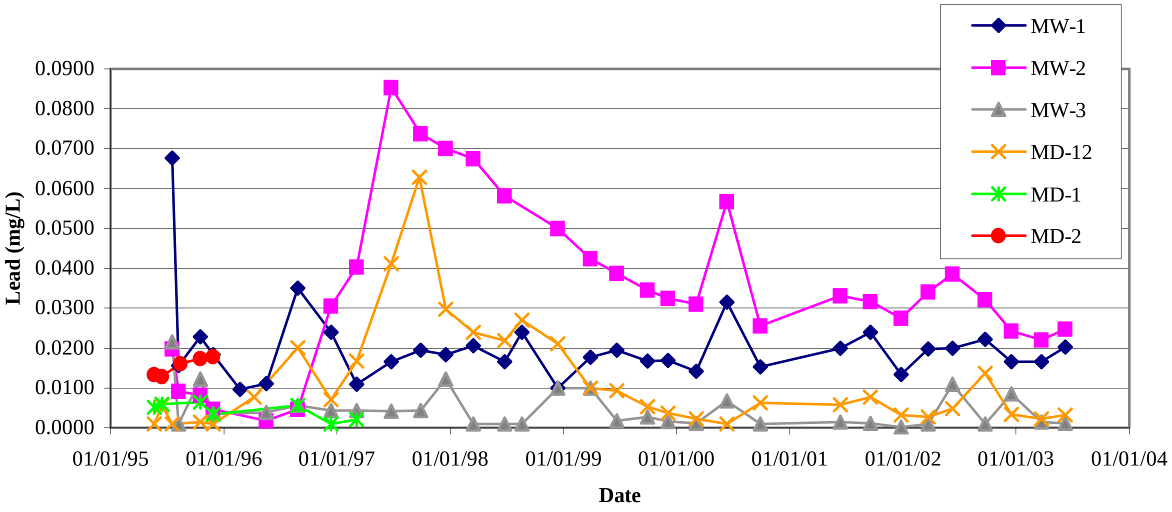

Figure 5.14. Lead concentrations at various monitoring points on the McDermott Mine site.

MD-22 is the discharge from a pit floor drain that the operator installed on the south central section of the site; the pit floor drain was installed as part of an abatement plan in response to the water quality problems that the site monitoring showed were occurring. Water quality for MD-22 is available in Appendix 5.C. The pit floor drain was excavated into the pit floor and filled with limestone. It was intended to collect water flowing across the pit floor, treat it by neutralizing acidity and imparting alkalinity, and discharge it at a location that additional treatment could be applied, if needed. The pit floor drain was partially successful in that it produces a discharge with less acidity than the water seen in the monitoring wells. The discharge from the drain is net alkaline during lower flow periods. As would be expected, the drain discharges water with very high conductivity, sulfate, TDS, calcium, and magnesium. Iron, manganese, aluminum, nickel and zinc, metals typically found in mine drainage, are elevated in MD-22. The sodium and chloride concentrations in the drain discharge are above levels typically seen in mine drainage from shallow flow systems, and may be influenced by the ash. (The chloride levels are consistently well below the recommended level for drinking water supplies, and the sodium levels are much less than would be found in water treated with a conventional water softener.) Metals in MD-22 are relatively low and consistently below the MCL's for those parameters. The metal concentrations are likely affected by the fact that MD-22 is partially treated by the limestone in the trench. However, even during sampling events when the discharge from MD-22 is net acid with a low pH, the heavy metals are low.

In addition to the monitoring points discussed in detail in this chapter, a downgradient spring (MD-19) and two other downgradient abandoned deep mine discharges (MD-3 and MD-5) were further degraded by the McDermott operation. The degradation is in terms of mine drainage parameters, and there is no significant increase in any heavy metal, including lead, or other parameter attributable to the ash placement on the site. Data for MD-3, MD-5 and MD-19 are available in Appendix 5.C.

The McDermott site is located downgradient of an area previously mined by Ace Drilling Coal Company in the late 1970's. Laurel Land Development has asserted that poor water quality on its site is solely due to the Ace Drilling operation, however, several lines of evidence contradict that conclusion, including 1) mine drainage is pervasive across all affected areas of the McDermott site; 2) mining on Ace Drilling occurred about 20 years prior to that on McDermott, yet points downgradient of the McDermott site sequentially worsened only after overburden was disturbed on the McDermott site; 3) mine drainage at points downgradient of McDermott appeared rapidly after overburden disturbance on McDermott.

5.2.2.4 Conclusions regarding the McDermott site

- Re-mining and partial reclamation of the McDermott site caused an increase in acid mine drainage degradation in most downgradient monitoring points; points that were AMD-impacted prior to the McDermott operation worsened (MW-1, MD-3, MD-12, and MD-5), and points that showed no influence from AMD prior to the operation (MW-2, MW-3 and MD-19) became AMD-contaminated shortly after mining occurred upgradient of them.

- Both DEP and the permittee were aware prior to the operation that the site overburden analysis identified the potential for AMD production, thus the applicant formulated the alkaline addition plan to address this concern.
- In terms of total tons of ash and total calcium carbonate equivalence, the amount of alkaline ash imported to the site met and exceeded that originally proposed. A re-evaluation of the overburden analysis results showed that, although the original mining plan was not completely followed, that fact did not significantly worsen the site NNP deficiency, as compared to the pre-mining prediction.
- Some operational practices likely exacerbated AMD production from the site: 1) reclamation of affected area was not always timely; 2) ash delivery was intermittent, leading to the need to stockpile ash, which was then subject to pozzolanic hardening prior to its use; 3) the site was ultimately abandoned by the operator leaving an unreclaimed area open to accelerated weathering and high infiltration rates. However, monitoring data show that AMD formation began almost immediately with overburden disturbance on the site, and AMD production would likely have occurred even had good mining practices been followed.
- An ash addition rate of 6600 tons per acre (calcium carbonate equivalence of 1165 tons per acre) did not prevent AMD formation on this site. The alkaline addition rate achieved a site-wide NNP of 5.31 tons/thousand tons, however, the ash application rate was not uniform across the site.
- For at least some monitoring points, the data suggest that ash is neutralizing some AMD, but not enough to cause the site to produce net-alkaline water, and AMD production was clearly not prevented.
- A review of the water quality data for this site shows no evidence of contamination from ash utilization. Sodium and chloride concentrations are elevated at some points relative to levels typically found in acid mine drainage from shallow flow systems, indicating that ash may be the source of those parameters, however, the levels are not high enough to be considered contamination. Ash is probably contributing to the elevated calcium levels seen at some points. Lead levels increased at two monitoring points as a result of the operation, but the pattern of its occurrence, and an evaluation of background data, point to the overburden on the northern end of the site as the source. It is possible that the ash is contributing to sulfate concentrations, but that is difficult to separate from the AMD influence.
- Results at this site were similar to those at sites where alkaline addition in the form of waste lime was added to sites in the face of clearly poor overburden quality, and the result was production of additional AMD.

5.3.3 Reclamation of A Bituminous Coal Bond Forfeiture Site—Abel-Dreshman Site

Pennsylvania’s significant abandoned mine reclamation obligation has been widely documented. The total cost of reclaiming the state’s abandoned mine lands has been estimated as high as $15 billion. The vast majority of that legacy of polluting discharges is attributable to older sites that were either mined before or shortly after the advent of modern permitting requirements that were brought into effect in 1978-1982. In an evaluation of post-mining water quality associated with the surface mine permits issued by Pennsylvania DEP between 1977 and 1996, Smith (1999) found that predictive capabilities improved markedly with time. Less than

1% of the permits issued between 1987 and 1996 resulted in a discharge requiring treatment, while the failure rate for sites from 1977 through 1986 was 10-20%. Very few surface mining permits issued today in Pennsylvania results in water quality problems. The McDermott site described in section 5.2.2 is an example of one that did.

The Abel-Dreshman site is an example of a site that was permitted just prior to modern understanding of acid mine drainage and its prevention, and the Abel-Dreshman site also produced pollution and was left partially reclaimed by the original permittee. Coal ash was not placed on the Abel-Dreshman site, when it was mined, but was subsequently used as an alkaline addition agent, when the site was reclaimed. The Abel-Dreshman site was previously reported on by Schueck et al., (2001), however, additional water quality data are now available, which are included in this chapter. (See Appendix 5.D for the raw water sampling data from the Abel-Dreshman site.)

5.3.3.1 Site characterization/ setting

DEP issued the Abel-Dreshman Surface Mining Permit # 10800101 to Chernicky Coal Company on June 17, 1980. The permit authorizes mining of 55.5 acres of Middle Kittanning Coal (MK). The prevalent rock type on this site is sandstone, which was deposited in a brackish water environment. The site is located on Seaton Creek in the Ohio River drainage basin.

The Abel-Dreshman site was permitted at a time when overburden analysis was rarely used, and no overburden analysis was performed for the initial site application. However, in 1984, after Chernicky Coal Company had mined and abandoned a significant portion of the site, another company proposed to take over the site to finish the mining and reclamation. Because the mining done to that point on the site had created water quality problems, DEP required overburden analysis as part of that attempt to transfer the site. Two holes were drilled, both on the Abel tract, since the Dreshman tract had little recoverable coal remaining on it.

DEP did not authorize the additional proposed mining, because the overburden analysis showed a strong potential to generate additional mine drainage pollution if mining continued. The data show a clear deficiency of NP (neutralizing material in terms of calcium carbonate equivalence) on the site, as shown by the negative NNP in terms of both tons/1000 tons and tons/acre. The information provided in Table 5.7 under the heading “Tons $CaCO_3$/needed to provide:” shows for each drill hole how much calcium carbonate would need to be added to each acre represented by that drill hole to meet certain benchmark values shown to have significance by Brady et al., (1994) and Perry and Brady (1995).

On a mass-average basis, the two overburden holes on the site, OB-1 and OB-2, included 56% sandstone and 91.1% sandstone, respectively. In a study of Allegheny Formation rocks in West Virginia, diPretoro and Rauch (1986) reported a propensity for sites with high percentages of sandstone in their overburden to produce acid mine drainage.

Table 5.7. Summary of the overburden analysis data for the Abel-Dreshman site.

		Net Neutralization Potential			**Tons $CaCO_3$/acre needed to provide:**		
Drill Hole #	**Highwall Cover Height**	**tons/1000 tons**	**tons/acre**		**6 ton/1000 ton excess**	**12 ton/1000 ton excess**	**% SS**
		Thresholds			**Thresholds**		
		without	**with**	**without**	**with**	**without**	
OB-1	56	-2.33	-227	-215	780	1320	56.5
OB-2	46	-9.27	-612	-740	1090	1696	91.1

5.3.3.2 Mine operations

Chernicky Coal Company took the first cut on the Abel-Dreshman site in July 1980, and mining continued intermittently until June 1982. Approximately 65 of the 74.5 bonded acres were affected. The site was mined as two operations, with one pit on the Abel parcel and one pit on the Dreshman parcel. Routine sampling by the DEP inspector on July 29, 1982 revealed the first signs of AMD contamination on the site at a sediment pond and at a spoil discharge (Table 5.8).

Table 5.8. Sample results of July 29, 1982 showing the quality of AMD occurring on that day. Flow is in gpm, pH is in standard units, and all other parameters are in mg/L.

Description	**Flow**	**pH**	**Alk.**	**Hot Acidity**	**Total Fe**	**Total Mn**	**Total Al**	**SO_4**	**Net Alk.**
Sediment Pond		3.3	0	359	5.5	91.7	25.3	1300	-359
Spoil Discharge	5	5.4	17	105	33.1	43.6	0.81	900	-88

Samples collected by DEP during 1982 and 1983 further documented that the site was producing AMD. Due to a variety of problems with the site, DEP initiated bond forfeiture proceedings in March 1983. The initial operator had abandoned two pits on the site, one of which flooded with groundwater. On March 1984 the Department measured the impoundment's dimensions at 150 ft. L x 60 ft. W x 40 ft. and measured the other pit at 75 ft. L x 50 ft. W x 40 ft.

On February 3, 1997, DEP entered into a landowner reclamation agreement through which Amerikohl Mining Company, Inc. would complete the reclamation on the abandoned site. The reclamation was performed from September 1997 until September 1998. Amerikohl did no additional mining on the site, so there was no additional disturbance of acid-producing overburden. The reclamation plan included the mixing of 200,000 tons of Scrubgrass Generating Project CFB ash to the mine spoil as an alkaline addition agent in an attempt to offset the deficiency in the mine spoil that had been documented by the site overburden analysis. The Scrubgrass facility is located in Scrubgrass Twp., Venango County. As part of the plan, the entire site was to be reclaimed to the standard typically required in Pennsylvania, known as approximate original contour or AOC. Records show that only 83,600 tons of ash were actually mixed with the site overburden. According to NP tests performed on the ash, it had approximately 600 tons per 1000 tons of $CaCO_3$ equivalent. This number is quite high for CFB ash, but apparently, because the plant was still being adjusted at that point, lime utilization was rather inefficient. Approximately 1235 tons of ash were added to each of the 50 affected acres equating to 1003 tons of 100% $CaCO_3$ equivalent. This amount would provide a little more than a 6 tons/1000 ton excess NP (calculated with thresholds) across the site (Table 5.7).

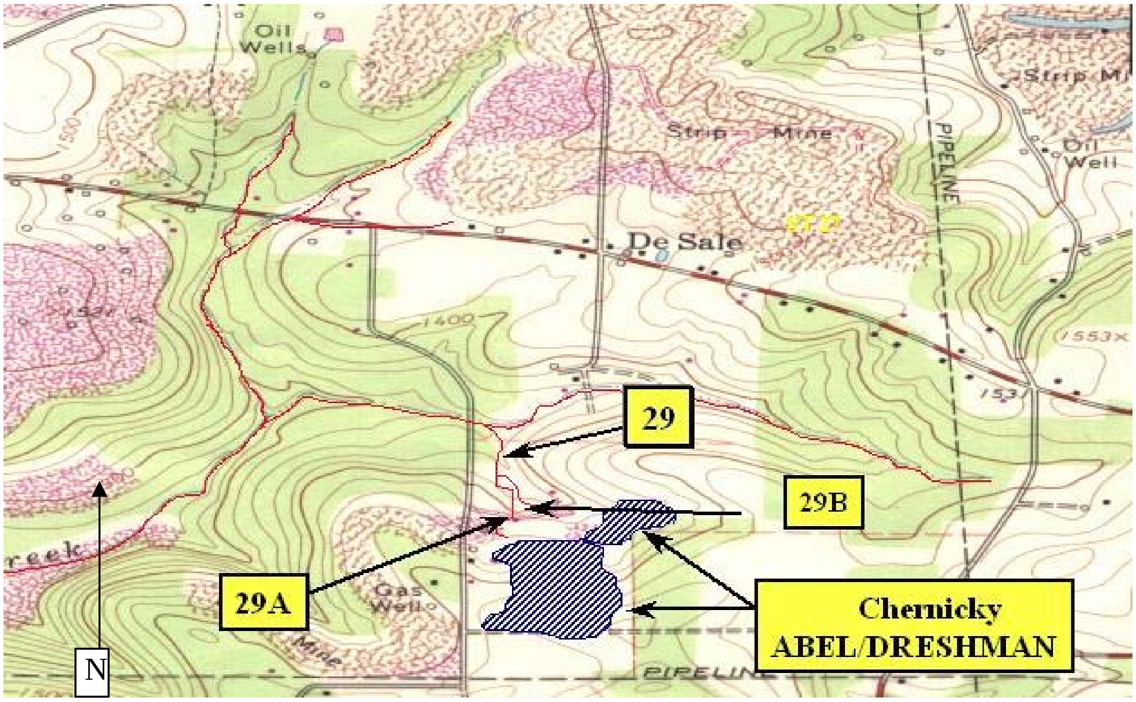

Figure 5.15. Map of the Abel-Dreshman site and monitoring points.

The Abel-Dreshman site consists of two parcels, and placement of the ash was slightly different on the two areas. The ash generator added water at the plant to condition the ash for dust control, sufficient to bring the ash up to a moisture content of about 21%. Bottom dump trucks transported the ash to the site. A bulldozer then promptly mixed the ash and spoil while pushing both into the pit. The floor of the existing pits was covered with a layer of the ash, approximately 2 to 3 feet thick. (The flooded pit was pumped prior to ash placement.) On the Abel parcel much of the ash was spread in layers due to non-availability of equipment and breakdowns, where it was thoroughly mixed with the spoil on the Dreshman site. Amerikohl placed and compacted a layer of ash one to two feet thick on both parcels before placement of the final topsoil material.

5.3.3.3 Monitoring results from the Abel-Dreshman site.

The Department chose three downgradient springs as monitoring points for the Abel-Dreshman project. The springs are identified as sample points 29, 29A, and 29B. Point 29A is downgradient of the Dreshman tract, 29B is downgradient of the Abel tract, and 29 is located just below the confluence of the flows represented by 29A and 29B.

Table 5.9 summarizes water monitoring results for certain mine drainage parameters at point 29A. Comparing the period prior to ash addition and backfilling (prior to September 1997 – 1998) to the periods during and following the application of ash (after September 1998) shows a marked decrease in metals concentrations at monitoring point 29A. The data also show a significant increase in pH and net alkalinity. (Negative acidity values in this case were reported by the laboratory as 0 acidity, so where net alkalinity is referenced herein, it is alkalinity minus any acidity reported.) Sulfate concentrations are unchanged.

Table 5.10 shows summary mine drainage parameter results for point 29B, broken into the same subsets as were the data for 29A. In the case of 29B there was little change in pH, but net alkalinity did improve substantially, as did manganese.

Table 5.9. Summary of mine drainage parameter results at point 29A, comparing the periods, before, during and after ash application and reclamation.

MP-29A	**Pre-Ash Application**	**During-Ash Application**	**Post-Ash Application**
# of samples (n)	9	9	11
Median pH (su)	3.5	3.7)	6.1)
Average Net Alkalinity (mg/L)	-185.3	-207.	-35.2
Std. Deviation Net Alkalinity	56.9)	50.6	80.7
Average Total Iron (mg/L)	2.1	15.1	0.8
Std. Deviation Total Iron	1.5	13.7	1.2
Average Total Manganese (mg/L)	44.6	76.3	32.7
Std. Deviation Total Manganese	25.5	19.7	23.1
Average Total Aluminum (mg/L)	3.5	3.1	1.3
Std. Deviation Total Aluminum	1.0	2.1	1.5
Average Total Sulfate (mg/L)	835.6	942.7	817.2
Std. Deviation Total Sulfate	377.5	292.6	202.0

Table 5.11 includes summary data for point 29, which represents water quality of the combined flows of 29A and 29B. Net alkalinity and pH increased, while iron, manganese and aluminum decreased, when the pre-ash water quality data are compared to the post ash data. Sulfate concentrations have also decreased.

The pH at point 29A may have declined somewhat over the past two to three years (Fig. 5.16), while the pH values at 29B and 29 have been stable, and may still be increasing slightly.

Table 5.10. Summary of mine drainage parameter results at point 29B, comparing the periods, before, during and after ash application and reclamation.

MP-29B	**Pre-Ash Application**	**During-Ash Application**	**Post-Ash Application**
# of samples (n)	9	9	11
Median pH (su)	4.5	4.7	4.7
Average Net Alkalinity (mg/L)	-36.3	-18.7	-5.0
Std. Deviation Net Alkalinity	17.1	16.2	8.0
Average Total Iron (mg/L)	1.1	0.1	0.2
Std. Deviation Total Iron	1.7	0.1	0.3
Average Total Manganese (mg/L)	27.7	7.0	5.9
Std. Deviation Total Manganese	37.0	3.3	2.5
Average Total Aluminum (mg/L)	2.5	1.8	1.4
Std. Deviation Total Aluminum	0.6	0.8	0.7
Average Total Sulfate (mg/L)	335.1	190.6	213.1
Std. Deviation Total Sulfate	289.7	63.7	69.5

Table 5.11. Summary of mine drainage parameter results at point 29, comparing the periods, before, during and after ash application and reclamation.

MP-29	**Pre-Ash Application**	**During-Ash Application**	**Post-Ash Application**
# of samples (n)	9	9	11
Median pH (su)	3.6	3.8	4.8
Average Net Alkalinity (mg/L)	-117.8	-104.3	-2.8
Std. Deviation Net Alkalinity	39.5	58.1	11.8
Average Total Iron (mg/L)	1.5	6.4	0.2
Std. Deviation Total Iron	0.6	11.2	0.2
Average Total Manganese (mg/L)	43.3	38.3	9.5
Std. Deviation Total Manganese	18.2	18.8	4.1
Average Total Aluminum (mg/L)	2.9	2.7	0.9
Std. Deviation Total Aluminum	0.5	2.1	0.5
Average Total Sulfate (mg/L)	634.7	624.8	295.6
Std. Deviation Total Sulfate (mg/L)	237.1	258.7	75.2

Net alkalinity at all three points appears to have declined slightly over the past three years (Fig. 5.17), but still remains above pre-ash placement and reclamation values. Possible reasons for a decline in net alkalinity at the monitoring points could be a decline in available NP in the backfill with time, or it could be due to climatic effects (e.g., rainfall). The higher net alkalinities tend to occur during the wetter seasons of the year, and over much of Pennsylvania, 2001 and 2002 were relatively dry. Continued monitoring will reveal if net alkalinity stabilizes or continues to decline.

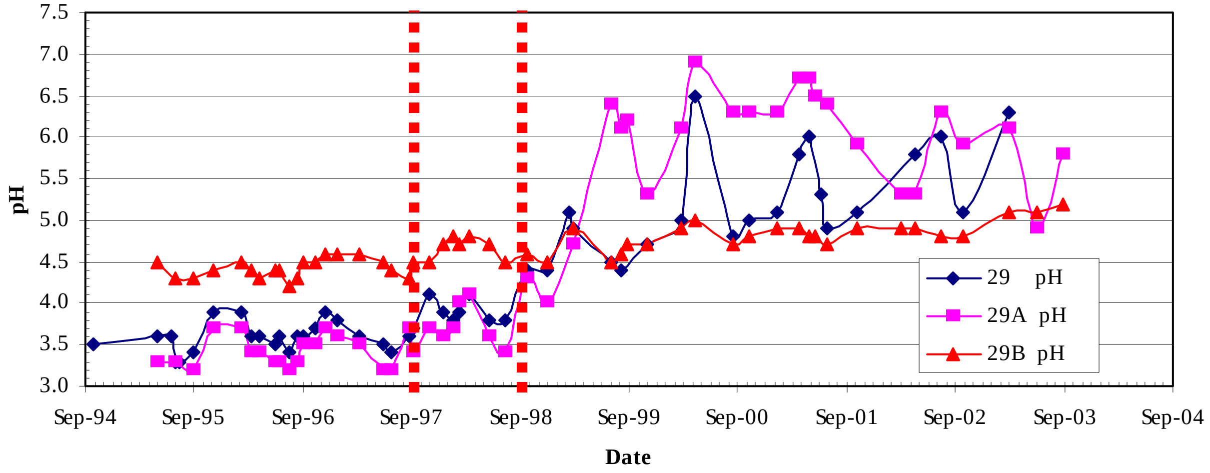

Figure 5.16. Graph of pH with time at points 29, 29A and 29B. The two vertical lines bracket the period during which ash placement and reclamation took place.

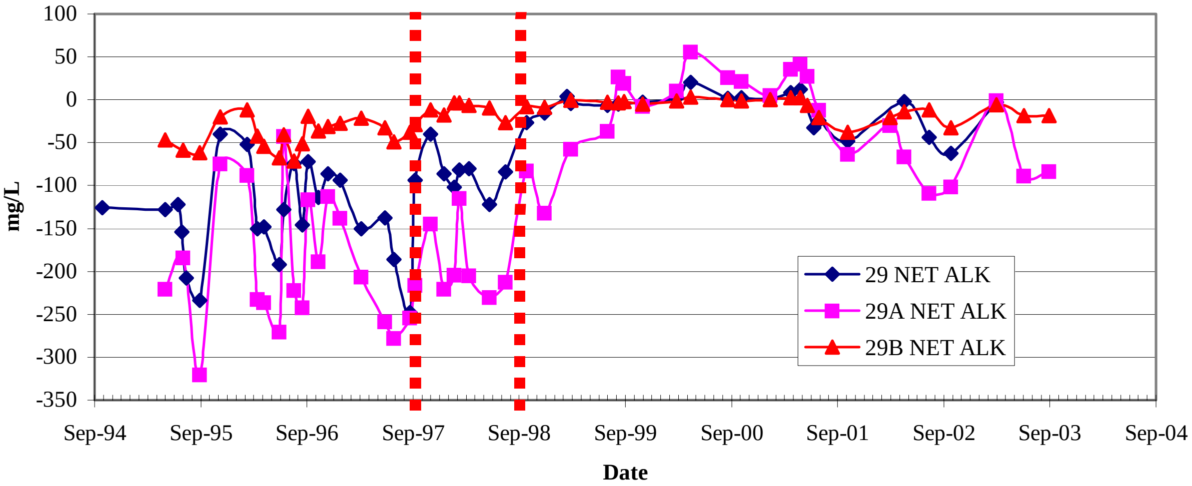

Figure 5.17. Graph of net alkalinity with time at points 29, 29A and 29B. The two vertical lines bracket the period during which ash placement and reclamation took place.

The primary AMD metals (iron, manganese, and aluminum) declined at points 29, 29A and 29B after the site was reclaimed with the addition of ash. Figure 5.18 displays the available data for aluminum at the three points. Aluminum concentrations at all three points appear to be stable since 1999. The removal of aluminum from down stream areas is particularly significant, due to aluminum's toxicity to aquatic life. The data for iron and manganese, while not presented in graphic form here, show similar patterns to that seen for aluminum.

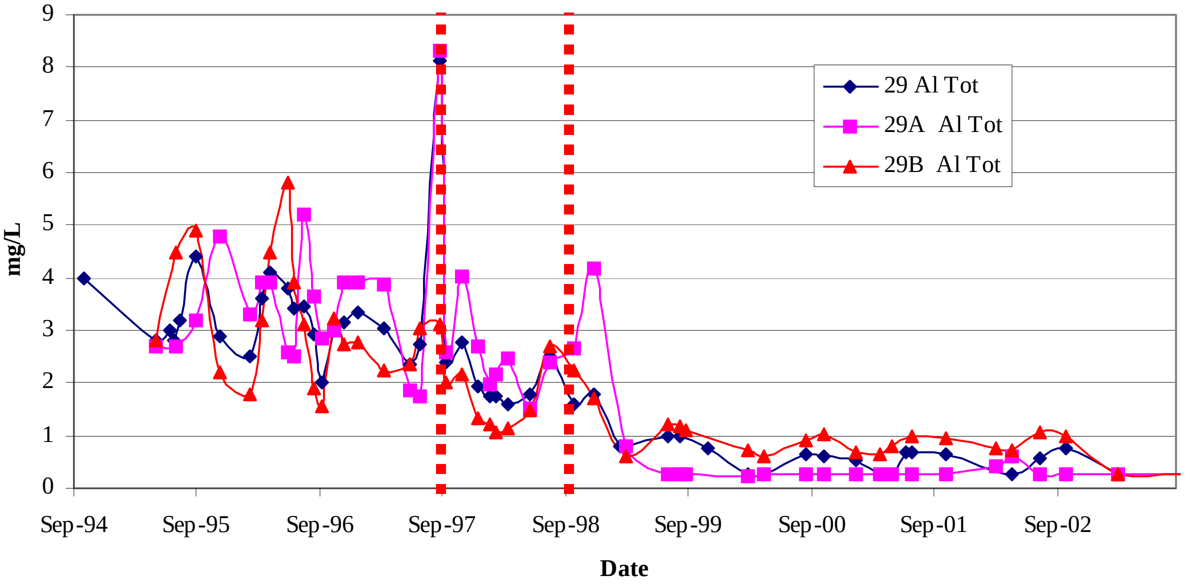

Figure 5.18. Graph of aluminum concentrations with time at points 29, 29A and 29B. The two vertical lines bracket the period during which ash placement and reclamation took place.

Monitoring was conducted at 29, 29A, and 29B for additional parameters beyond the traditional AMD parameters (Appendix 5.D) Most of these additional results are unremarkable. Sodium concentrations appear to have increased at point 29A, which also showed the largest increases in pH and net alkalinity when compared to the other two monitoring points discussed here. Sodium concentrations also increased at the Revloc and McDermott sites at some points downgradient of the ash placement areas, but in no case were the numbers particularly high. The concentrations of toxic metals including selenium, mercury, copper, chromium, cadmium and arsenic are consistently below detection limits throughout the monitoring period at all three points. Lead concentrations have occasionally been at detectable limits, but are generally low, and show no increase after reclamation of the site with ash.

5.3.3.4 Conclusions regarding the Abel-Dreshman site

- Overburden analysis data for this site show that the site overburden had significant potential to generate acid mine drainage and little potential to generate alkalinity.
- Reclamation of the site with coal ash resulted in increases in pH and net alkalinity and decreases in AMD metals in monitoring points downgradient of the site.

- The ash used on the site appears to be generating alkalinity in that the overburden did not have the capability to do so. Reclaiming the site by backfilling it and adding a layer of compacted ash to the surface may also have contributed to water quality improvements.
- Net alkalinity has declined at the monitoring points over the past two to three years, but water quality appears to be otherwise stable, and remains substantially improved as compared to pre-ash placement.
- There is no indication of increases in heavy metals or other pollutants at downgradient monitoring points as a result of the use of ash on the site.
- Downgradient water quality is likely much better than it would have been had the site simply been reclaimed without the use of ash.

5.3 CONCLUSIONS

Abandoned coal refuse piles are a significant environmental liability in the Bituminous Coal Region of Pennsylvania, and traditional AML approaches toward reclaiming the piles do little to abate the associated water quality problems. Not only do these piles produce a leachate of highly concentrated AMD character, they also can leach elevated levels of toxic metals, such as arsenic, copper, and lead. The use of FBC ash in the re-mining and reclamation of two large refuse piles at Revloc, PA has resulted in a large reduction in pollution load from site discharges and in a substantial improvement in downstream quality on the South Branch Blacklick Creek. Both flows and concentrations of pollutants have declined at the largest discharge points. Re-mining and reclamation are on going at these sites, and further water quality improvements are expected. Monitoring data show no significant negative impacts to downgradient water quality from the use of FBC ash on the sites. Selenium concentrations have increased somewhat, however, the two points with the most-elevated selenium are low-volume seeps downgradient of an area where final reclamation has yet to be achieved. Burning of waste coal to generate electricity is now a common practice in PA. Not only does this practice turn environmental liabilities into an energy source, the by-product in the form of FBC ash is particularly suited to aid in the full reclamation of waste coal piles.

At the Laurel Land Development, Inc. McDermott site, the use of FBC ash as an alkaline addition agent was unsuccessful in preventing mine drainage formation. Water quality data indicate that the large quantity of ash placed in the backfill may be neutralizing some AMD, but has not prevented the formation of AMD, and has not generated net alkaline water. Several downgradient monitoring points have been degraded with AMD at the McDermott site. While operational complications, such as an intermittent ash supply, stockpiling of ash before incorporation into the backfill, and delayed and incomplete site reclamation may have contributed to the site problems, they likely are not the sole cause of the problems. Using alkaline addition in the form of ground limestone to prevent AMD on mine sites where predictive indicators strongly point toward AMD production has historically not been highly successful in PA. The production of AMD on the McDermott site, despite a relatively high rate of alkaline ash addition, suggests that it may be even more difficult to overcome an overburden deficiency with FBC ash than it is with limestone. FBC ash probably can be best utilized on active mine sites as a sealing or encapsulating material to limit the contact of water with high-sulfur pit floors and pit cleanings, or as a best management practice, where alkaline addition is not necessarily needed to prevent AMD production, but where it may be helpful in abating preexisting AMD problems. Water quality data at the McDermott site show that, while the ash did not prevent AMD formation, it also did not cause pollution in terms of increased non-AMD metals in downgradient monitoring points.

At the Abel-Dreshman site, the use of FBC ash in the reclamation of an abandoned surface mine resulted in an improvement in downgradient water quality. The use of ash appears to have increased the net alkalinity of downgradient monitoring points, increased the pH, and decreased metal concentrations. Net alkalinity appears to have declined recently, but remains above pre-ash placement levels. Overburden analysis on the Abel-Dreshman site indicates that the overburden is unlikely to generate any alkalinity on its own. The Abel-Dreshman ash project was purely a reclamation project, and no additional overburden was disturbed. That is one fundamental difference between Abel-Dreshman and McDermott. On the McDermott site, the area of fresh overburden disturbance was large relative to the area of re-mining and abandoned mine reclamation. Also, the NP of the ash used at Abel-Dreshman was much higher than the NP of the ash used at McDermott. Downgradient water monitoring at Abel-Dreshman shows that the use of ash in site reclamation caused no metal contamination.