Water Quality at the BD Mining Company Ash Placement Site, Schuylkill County, PA

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Introduction

At a meeting on November 13, 2008, a concerned party[1] presented the Department with a graph showing occasional spikes in lead and what was perceived to be an upward trend in lead at the Gilberton mine shaft (Figure 1). The mine shaft is the down-gradient monitoring point for the BD Mining ash placement area. It was insinuated to the Department that these spikes and the "trend" indicated pollution that, by his reasoning, was due to ash placement. This Department investigation considers multiple chemical parameters in the BD Mining monitoring data through time and compares the down-gradient monitoring point concentrations to the other monitoring points. We also examine the bulk-chemistry and leaching concentrations for lead in the ash being placed at BD Mining.

The BD Mining site is in Schuylkill County and is permitted for 175 acres to be reclaimed using ash. Ash placement began in 1989. As of the end of 2008 over 5 million cubic yards of ash have been placed at the mine.

The BD Mining site must be evaluated in context. It is located in the Western Middle Field of the Anthracite Region, and more specifically, within the Mahanoy Basin, a narrow synclinal basin that has been deep mined from stem to stern. The deep mining took place from about 1840 to the 1950s. Mining in the Mahanoy Basin and adjacent Shenandoah complex removed an estimated 1.6 billion tons of anthracite during this time period (Reed et al., 1987).[2] The waste rock and unmarketable coal from these mines was deposited on the surface. Virtually the entire valley bottom of the synclinal basin is covered by coal waste (Figure 2). In addition to disturbance from waste coal, surface mining occurred where coal approached the surface. These activities took place before modern environmental laws that would prohibit such devastation. Any analysis of areas involving abandoned mine lands must take into consideration that baseline water quality is severely impacted by "pre-law" mining. This is quite evident at the BD Mining site, where monitoring data from before ash placement shows elevated constituents well above what would be expected in a location that had not been impacted by human activities (Table 1). Two examples are given from early in the data collection period and two more recent samples. Extensive documentation of the impacts to groundwater, surface water, and impacts on aquatic communities by past mining practices within the Mahanoy Basin are provided in Cravotta (2005). Additional background on the BD Mining site can be found in Hornberger et al. (2004).

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[1] Jeff Stant

[2] As a comparison, Pennsylvania currently produces a total of about 70 million tons of coal per year. Anthracite production in 2007 was 210 thousand tons by deep mining and 2.3 million tons by surface mining. Whereas, nearly six million tons of anthracite waste coal was mined during 2007.

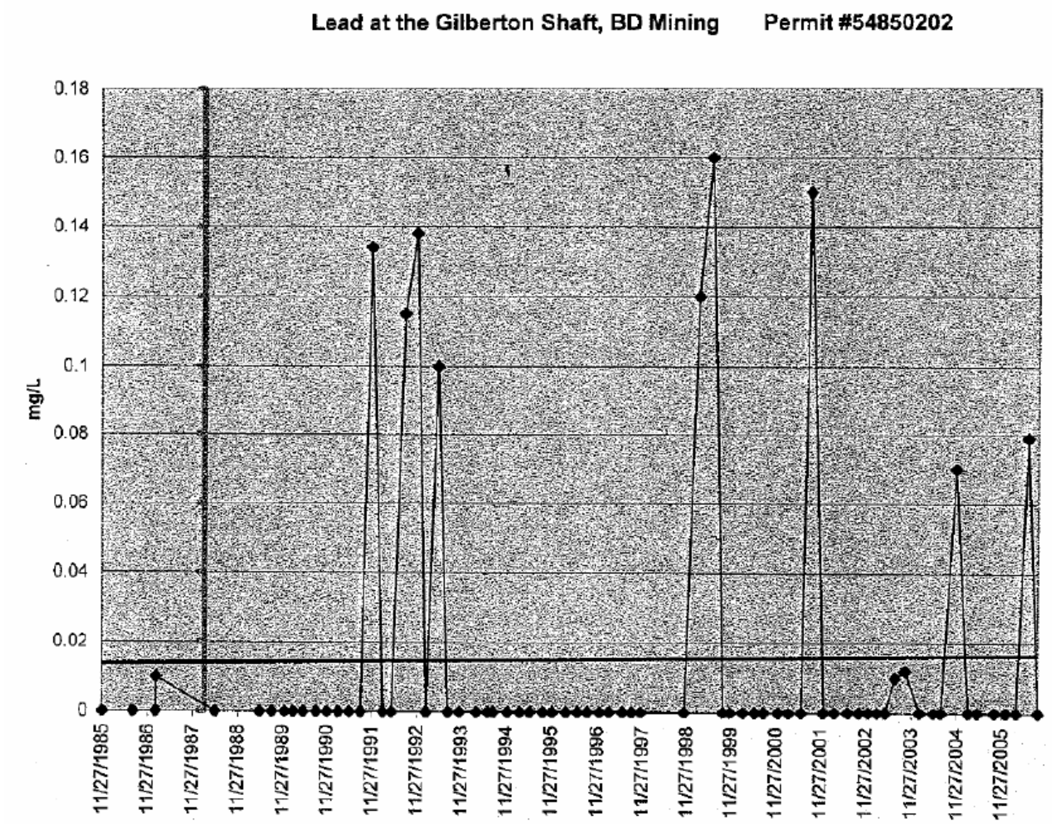

Figure 1. Plot through time of lead concentrations at the down-gradient Gilberton Shaft as presented to the Department on November 13, 2008. This graph is deceptive in that some of the detection limits are as high as 0.1 mg/L, with many more at 0.05 mg/L. No detection limit is zero, as depicted. Thus, the graph exaggerates the contrast between non-detects and detectable concentrations. See Figure 8 for a more valid presentation of data.

Table 1. Representative water quality from the Gilberton Shaft monitoring point. The 1986 data are from before ash placement. Numbers in parentheses are the recommended secondary drinking water standards in milligrams per liter. TDS is total dissolved solids.

Date Sampled	pH	Acidity mg/L	Iron (0.3) mg/L	Mn (0.05) mg/L	Sulfate (250) mg/L	TDS mg/L
07/24/86	6.29	164	54.0	10.70	672	1041
08/26/86	6.29	163	14.0	9.70	644	1250
05/02/08	6.11	4	35.3	6.46	496	770
07/15/08	5.84	<1	35.4	6.99	591	766

Figure 2. The area pictured is just to the north of BD Mining. Everything in this picture, with the exception of the hill in the distance (and to some extent, it too) is abandoned mine lands. Most of the material that can be seen is waste coal. This waste coal is being used to fuel local fluidized bed combustion power plants. The building in the upper right is the abandoned St. Nicholas coal breaker.

Figure 3 is a portion of the USGS topographic map for the Shenandoah Quadrangle. The purple stipple pattern is abandoned mine lands, which includes surface mines, waste coal features and other mining related disturbances. Satellite imagery also shows the environmental devastation from historical mining in the vicinity of BD Mining (Figure 4). This degree of abandoned mine disturbance is not uncommon in the Anthracite Region. Most of the material covering the surface of the Mahanoy Basin and the basins to the north is coal waste. Much of this waste still has BTU value and is being mined to fire Fluidized Bed Combustion power plants that were located nearby to take advantage of this resource. The waste coal has high BTU content because in the past only coal without rock would be burned and fine coal was not considered a resource. Many of the most valuable waste coal deposits are areas where coal slurry was placed. This slurry is often nearly 100% anthracite coal. Coal waste is a nasty source of mine drainage pollutants. Its removal and eventual reclamation of the land has positive impacts on the water quality of the underlying mine pool. There are plenty of other potential sources of pollution in the basin as well. Immediately north of the BD Mining site is a large rail yard. Figure 5 shows a portion of the BD Mining coal ash placement area, with the rail yard in the foreground.

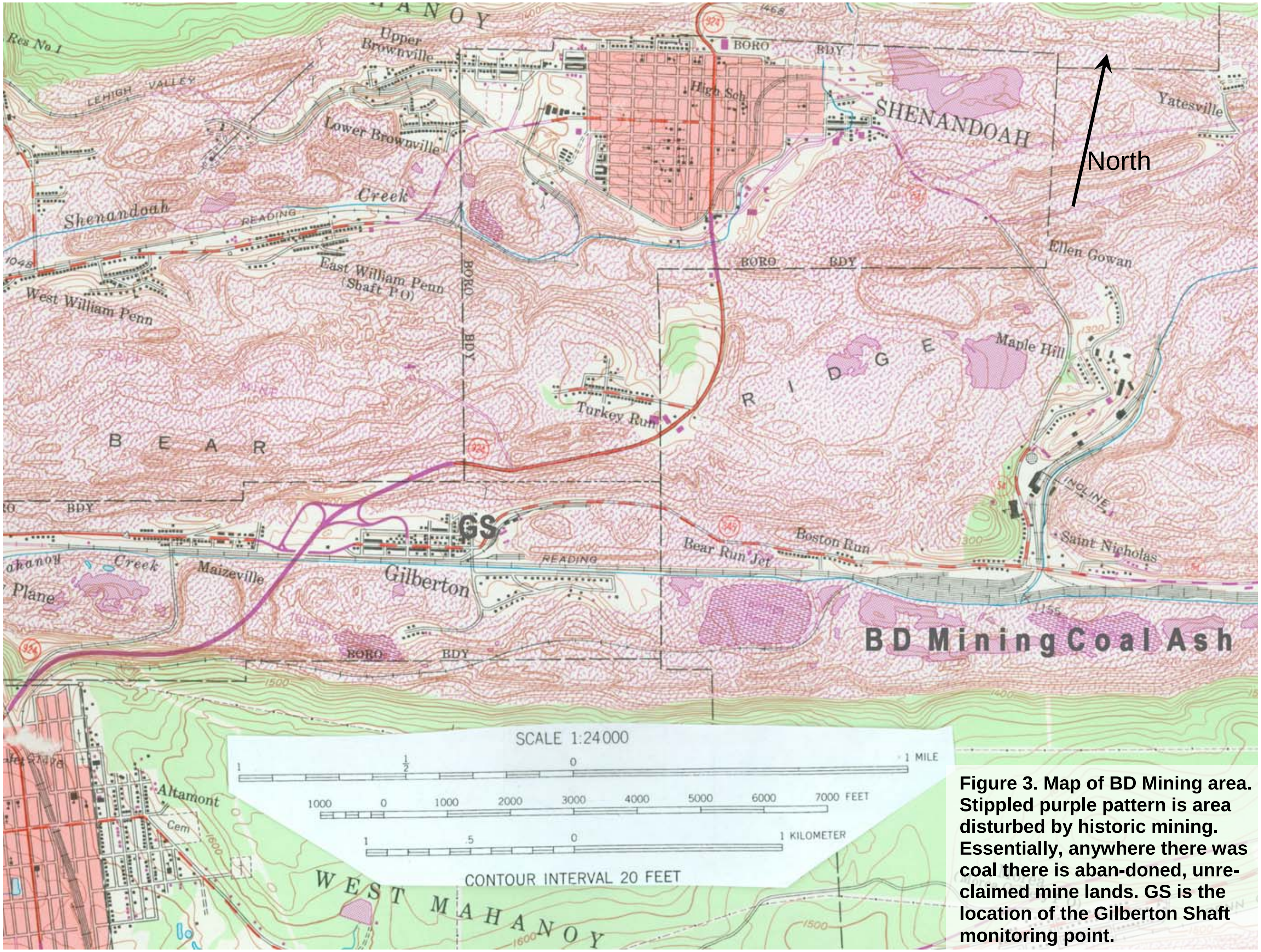

Figure 3. Map of BD Mining area. Stippled purple pattern is area disturbed by historic mining. Essentially, anywhere there was coal there is aban-doned, unre-claimed mine lands. GS is the location of the Gilberton Shaft monitoring point.

Figure 4. BD Mining area. AML indicates some of the abandoned mine features. The Coal Waste from the area just north of BD Mining is going to the Schuylkill Energy site and the ash is being placed at the Ellengowan site. BD Mining's ash is coming from the Gilberton power plant, which is south of the area shown. The revegetated (green) areas are the reclaimed areas where ash was placed. (Image from MSN Live Search Maps)

Figure 5. The BD Mining coal ash placement site is the brown and reddish hill in the mid-distance. The brownish portion is covered with soil and in the process of being revegetated. The reddish material is coal ash that is actively being emplaced. In the foreground is a rail yard. The black material between the train cars and the mine site is abandoned mine material.

Mine Pool Hydrology and the Gilberton Shaft

The Mahanoy Basin is part of the Anthracite Western Middle Field. It is 25-miles long and about 5 miles wide, and runs in an east-west direction. The Mahanoy basin is separated from the rest of the Western Middle Field by the Suffolk Fault (Figures 6 and 7). The extensive deep and surface mining has dramatically altered the surface and groundwater hydrology of the region. Separate mines are hydrologically connected by shafts and tunnels and breached barrier pillars. Unregulated mining deranged the surface topography, and thus surface drainage, such that surface water is often directly conveyed to the deep mine pools. In general groundwater flow is from east to west, although on a local scale water can flow in almost any direction depending on the orientation of mined out rooms and location of tunnels and barrier pillars (Reed, 1987).

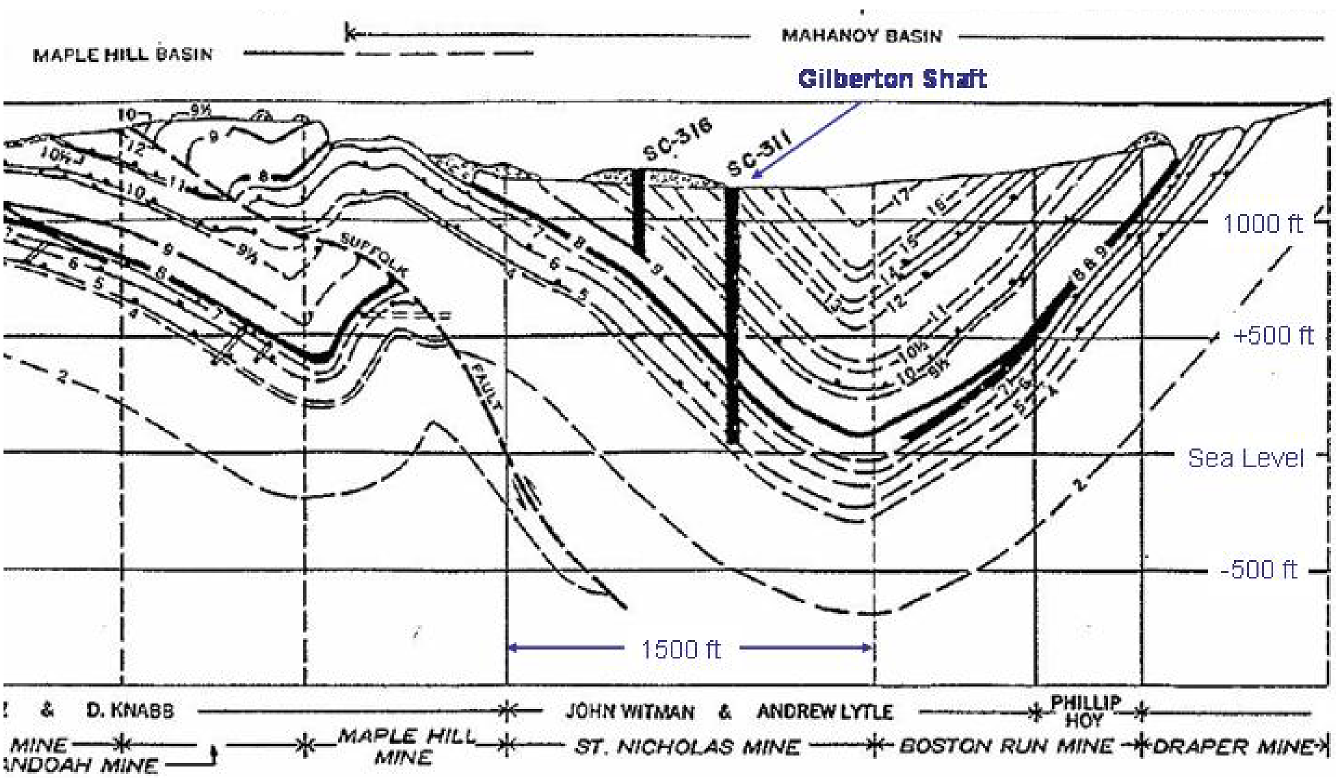

Figure 6. Cross section showing the Mahanoy Basin in the vicinity of the Gilberton Shaft. Location of cross-section is shown in Figure 7. Location and stratigraphic position of the shaft are shown on the cross section. Coal seams are in black and have numbers identifying the seam. There is no vertical exaggeration. Figure is modified from Reed et al., 1987.

The Gilberton Shaft (Figures 6 and 7) is the downgradient monitoring point for the BD Mining site. The shaft is nearly 1100 feet deep and bottoms at an elevation of 66 feet above sea level. Originally the Bureau of Abandoned Mine Reclamation (BAMR) installed a pump to keep the basements at a half-dozen homes in Gilberton from flooding. When the mine pool is higher than 1118 ft above sea level the basements flood. The BAMR pump is set at around 50 feet below the surface and is thus pumping the shallow portion of the mine pool. From 2005 to 2008 the BAMR pump removed an average of 2.8 billion gallons of water per year. In addition to the BAMR pump the shaft has four other pumps. Two were installed by the Gilberton power plant, one by the Gilberton coal breaker, and one by the local fire company. The amount of water that is removed by these is unknown.[3] Pumping is done on an as needed basis and is not continuous by any of the water users.

The portion of the mine pool that is pumped by Gilberton is largely isolated from some other portions of the Mahanoy Basin by Barrier Pillars I and XVII shown on Figure 7. The integrity of the barrier pillars between pillars I and XVII is believed to be compromised.[4] Evidence of the integrity of Barrier Pillar I is the presence of several discharges just upgradient from the pillar. One of these discharges, the Vulcan-Buck Mountain borehole, averaged 3400 gpm from April 1975 to March 1976. Large discharges indicate that water has difficulty flowing past the pillar and thus discharges to the surface. The flooding of basements in Gilberton suggests that Barrier Pillar XVII is also intact and backing up water that would otherwise continue to flow west.

The pumped nature of the Gilberton Shaft results in water being pulled from the upgradient portions of the mine pool and drawn toward the Gilberton shaft. The BD Mining ash placement site is within the recharge area for the water being withdrawn at the Gilberton Shaft.

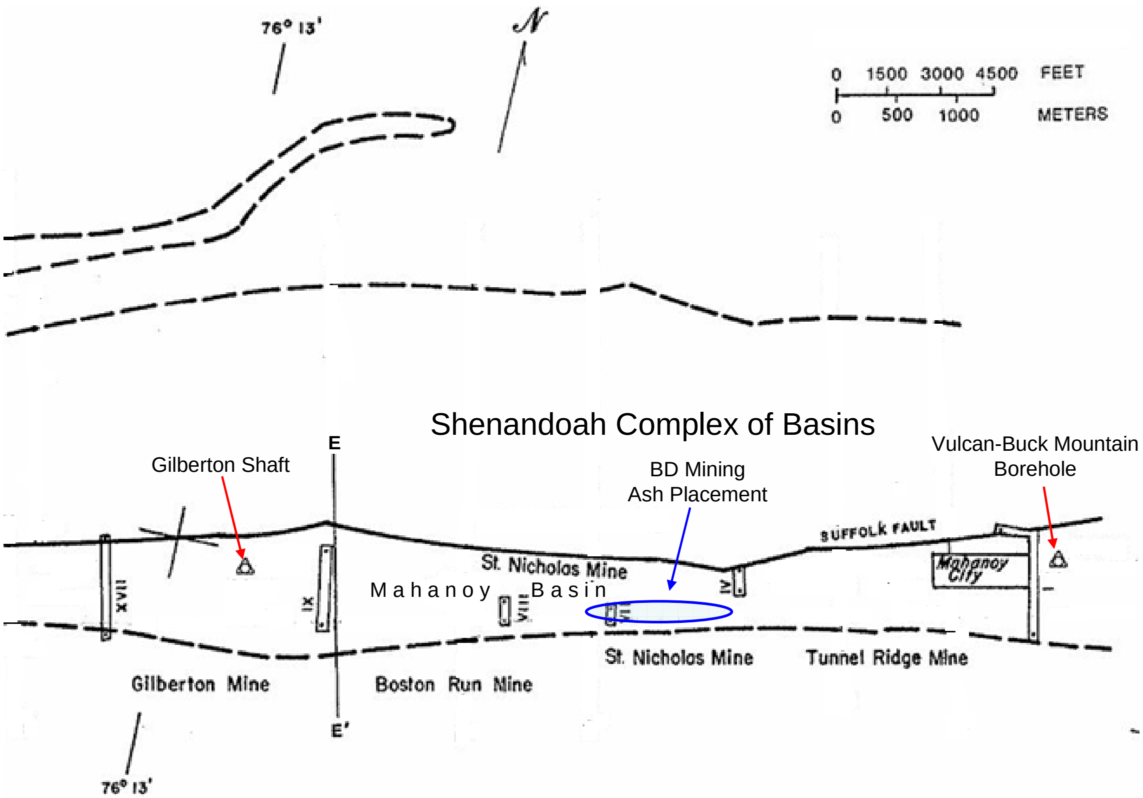

Figure 7. Schematic map showing relative locations of BD Mining ash placement area, location of Gilberton Shaft and location of barrier pillars. Barrier pillars are the bars with dotted ends that are identified by Roman numeral. Barrier pillars I and XVII are shown as intact in Kehn and Wagner (1955) and Danilchik et al. (1955). Barrier pillars IV, VII, VIII and IX are of very questionable integrity. Line E-E' indicates the location of the cross section shown in Figure 6. Figure modified from Reed et al., 1987.

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[3] Personal communication with and data supplied by Jack Buckwalter, Bureau of Abandoned Mine Reclamation, April 7 and 8, 2009.

[4] For example, they are not continuous across the basin. Also their locations are shown differently depending on which map one consults. The depictions on Danilchik et al. (1955) and Kehn and Wagner (1955) are different from those shown in Reed (1987).

Lead Concentrations in Groundwater

Figure 8 shows lead concentrations at the Gilberton Shaft and at two other monitoring points. The Gilberton Shaft data are the same as those used by the concerned party. The data are from Department files and are accessible by anyone in the general public.

From the beginning of data collection in 1986, through 1998, the lead values were reported as '0' reflecting a "non-detection" (or below an unspecified detection limit) of lead in the water sample. This indicates a low concentration, but not '0'. From 1998 forward data less than the detection limit were reported as the detection limit value. From 1999-2001, the lab detection limit was 0.10 mg/l, after that, at various times, it was 0.05, 0.03, 0.01 and for current samples (2008) it is 0.002 mg/l. A trend line generated through these data shows an apparent increase in lead. However, the trend line is derived primarily from the detection limit values, not the actual measured values.

The lead concentrations at the Gilberton Shaft (i.e., mine pool) were compared with values at the other monitoring points. In Figure 8, it is clear that post 1998, when the mine pool lead values (shown in red) were high, the other monitoring point(s) (blue and green) were equal to or in excess of the down-gradient value.

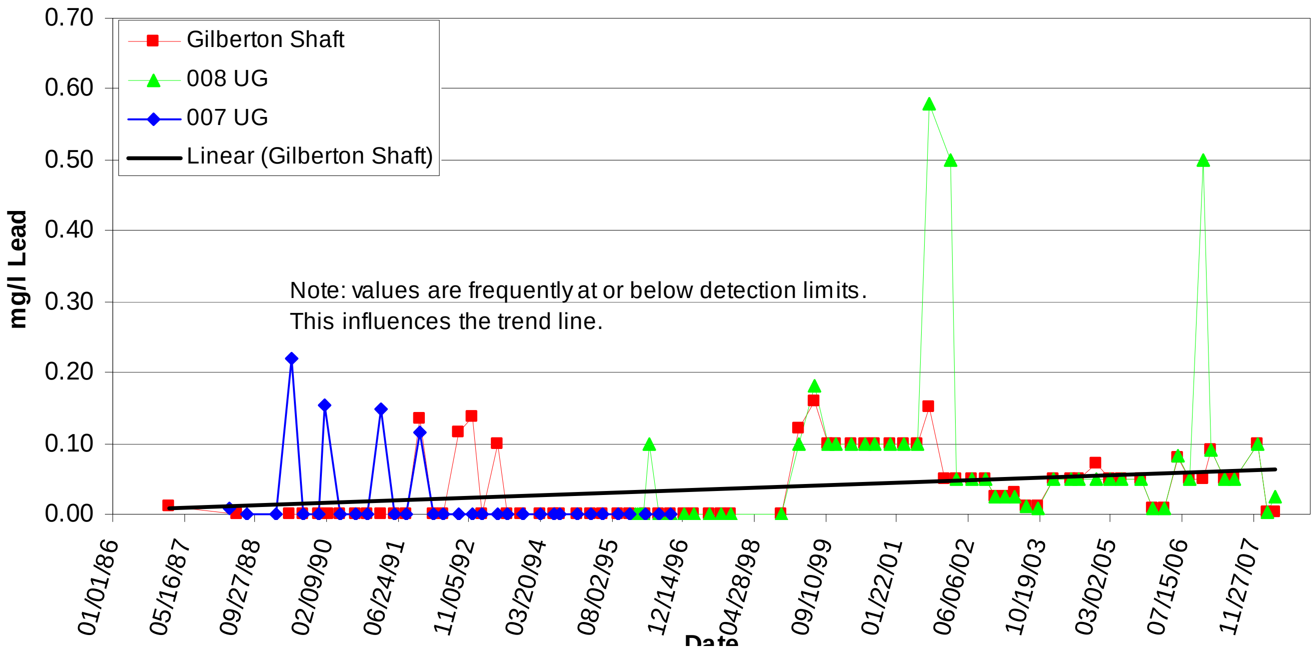

Figure 8. Plot through time of lead concentrations at the monitoring wells and Gilberton Shaft monitoring points. "Plateaus" of values, where all measurements are the same concentration (such as from 09/10/99 to 01/22/01), indicate detection limits. The trendline is through the down-gradient Gilberton shaft data. The trendline represents nonsense since it is primarily a derivative of varying non-detect and "less than" values, which have been reported differently through time.

Total suspended solids (TSS) were examined to see if that variable had an influence on the lead concentration, since it is known that suspended solids can influence lead concentrations (Cravotta, 2005). Sample preservation, which includes acidification of the sample to keep metals in solution, can dissolve metals from suspended particles and rocks. The metal released from these particles would not normally be released to the groundwater since they would remain with the particle. When this occurs the metals can appear higher than what would actually be in the groundwater.[5] Lead and suspended solids are both plotted on Figure 9, with TSS as the dotted line corresponding to the same color for the appropriate monitoring point. This comparison shows basically no relationship between TSS and lead.

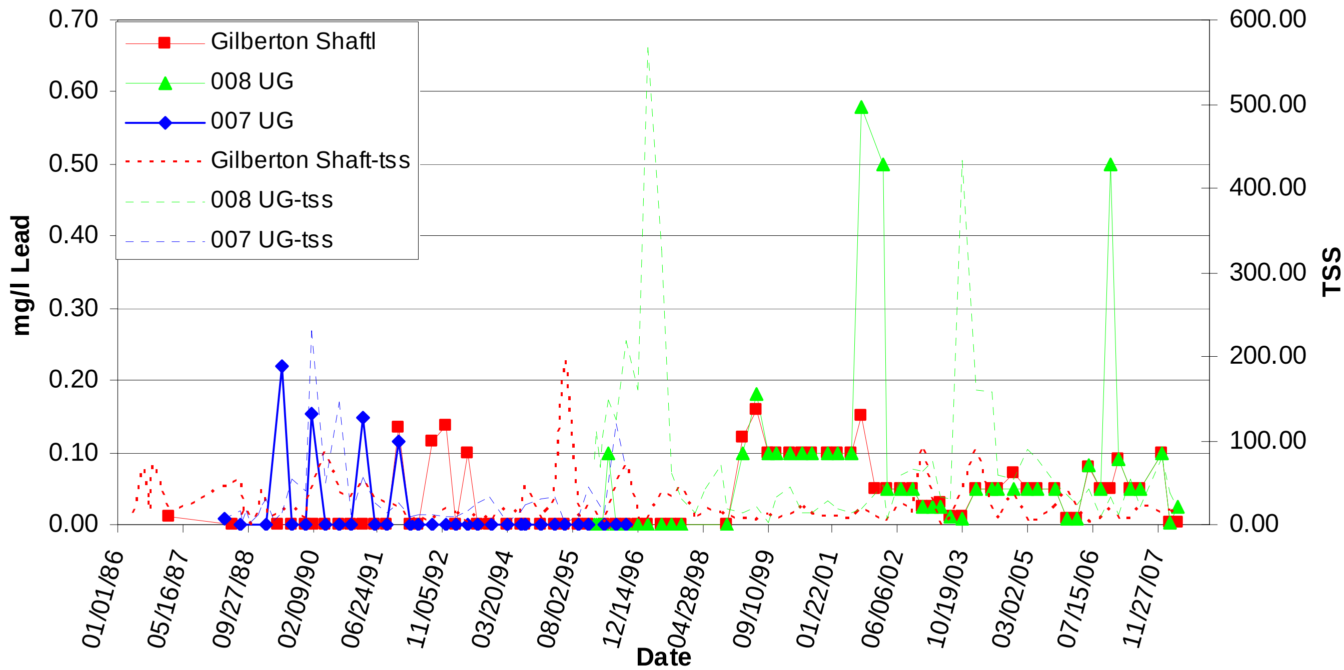

Figure 9. Comparison of lead and total suspended solids (TSS) through time. Lead concentrations are shown by symbols and solids lines connecting the symbols. Suspended solids are shown by a dashed line. Dashed and solid lines of the same color represent the same sample point.

Figure 10 is a boxplot comparing the monitoring wells and down-gradient lead analyses. The similarity of the two boxes shows that the distribution of lead concentrations is essentially the same at the two types of monitoring points. The medians are essentially meaningless numbers because of the large number of non-detects or below-detection analyses, since more than half the values were below detection. The upper quartiles (75% of the data falls below this value, which is represented by the top of the box) are 0.065 mg/L for down-gradient and 0.066 up-gradient, that is, essentially identical. The monitoring well water has some outlier values represented by asterisks.[6]

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[5] Acid is added to "fix" samples for laboratory analysis by achieving a pH below 2.0. This keeps metals in solution and prevents them from precipitating onto the sample container. However, the low pH can also dissolve metals from particulate matter and release them into the water sample. These particulate-bound metals in most instances would not have been mobile under field conditions. DEP is implementing sampling protocols that will reduce the occurrence of this issue, including field filtering of samples and purging of wells before sampling.

[6] Outliers are values greater than 1.5 times the interquartile range beyond the 75th percentile (upper boundary of box).

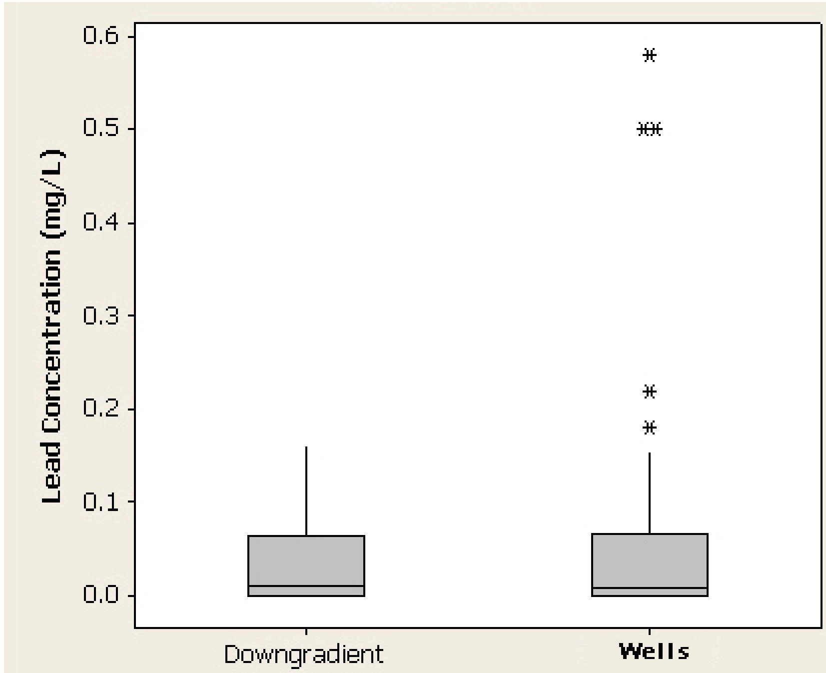

Figure 10. Comparison of lead concentrations at monitoring wells and down-gradient (Gilberton Shaft) monitoring points. The two populations are essentially identical.

In examining Figures 8, 9 and 10, the following is clear: (a) The monitoring wells also show occasional spikes in lead, often coincident with the increases at the Gilberton Shaft monitoring point. Spikes at the wells often show higher concentrations than at the down-gradient point. (b) Spikes in lead do not correlate with spikes in suspended solids. (c) There is no meaningful trend through time for lead at the Gilberton Shaft.

Lead Concentrations in the Ash

The same concerned party that presented us with Figure 1 mentioned to the first author on July 17, 2008 that during the Clean Air Task Force study of Pennsylvania coal ash they had observed elevated lead concentrations for leachate for the Schuylkill Energy and Gilberton coal ashes. Gilberton ash goes to the BD Mining site. Schuylkill Energy ash does not go to the BD Mining site, but the source is similar to that for Gilberton (both use waste coal from the area around BD Mining) so an examination of both sources is worthwhile. The data were evaluated and are shown in Figures 11 and 12. In both cases the higher values were during the early period of sampling and recent values are well under the leaching limits.

DEP requires two types of chemical analyses for evaluation of the suitability of coal ash for beneficial use: bulk chemical analysis and leaching data. Bulk chemistry provides the total amount of an element that is present in the ash. The fact that something is present in the bulk analysis does not mean that it is mobile. Therefore leaching is required to determine the elements that could leach into the groundwater. Both types of data are evaluated in the discussion below.

Schuylkill Energy Plant: The Schuylkill Energy ash, showed some higher concentrations of lead during the first year of data collection (1990) (Figure 11). These samples are not part of the fly ash/bottom ash mixture that has been routinely placed at the site, but were “bottom ash” (apparently alone) and “conditioned fly ash” (whatever that may be). In any event, no values higher than the (new) leaching limit of 0.375 mg/L have been observed after 1990. It should be pointed out that the acceptable leaching threshold in 1990 would have been 1.25 mg/L and the highest values are well under that level. All recent measurements for lead (since 2000) have been below detection.

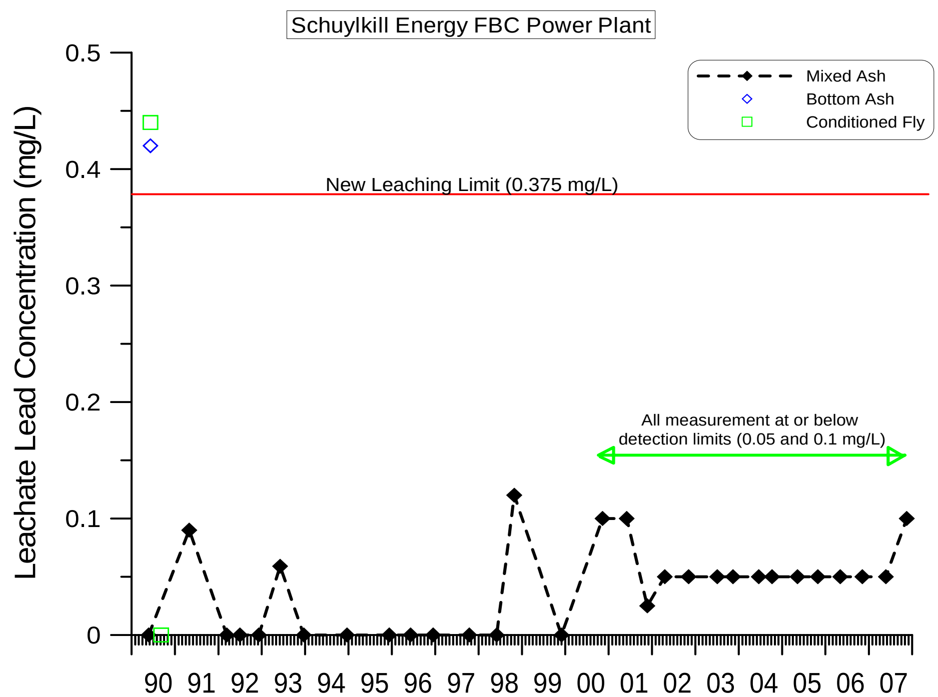

Figure 11. Schuylkill Energy lead leachate concentrations through time.

Gilberton Plant: The highest concentrations at the Gilberton plant are associated with samples from “Boiler 1” and “Boiler 2” fly and bottom ash (Figure 12). Samples identified as such were not collected after 1990. The mixture of ash normally shipped to the mine site has been sampled since 1988. None of these analyses exceed the new leaching limit of 0.375 mg/L. In 1990 the leaching limit would have been 1.25 mg/L and the highest values were well within that limit. All samples since 2000 have been below detection.

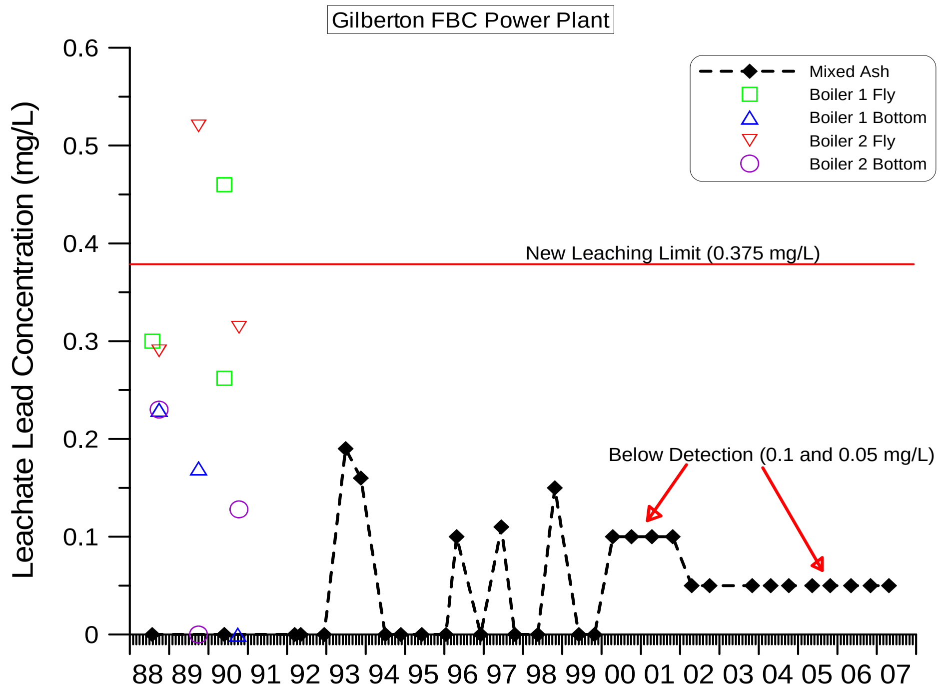

Figure 12. Lead leachate concentrations for the ash from the Gilberton power plant through time.

The bulk analyses for lead were also examined for the Gilberton ash. Figure 13 is a boxplot showing the distribution of lead in the ash from the Gilberton power plant. The median is 27.6 mg/kg. The highest value (represented by the tip of the upper whisker) is 57.2 mg/kg. For comparison, granite typically has 20 mg/kg of lead[7] and the DEP lead limit for clean fill is 450 mg/kg. Thus, the median is in the range of that for granite and the highest value is nearly an order of magnitude lower than the clean fill standard.

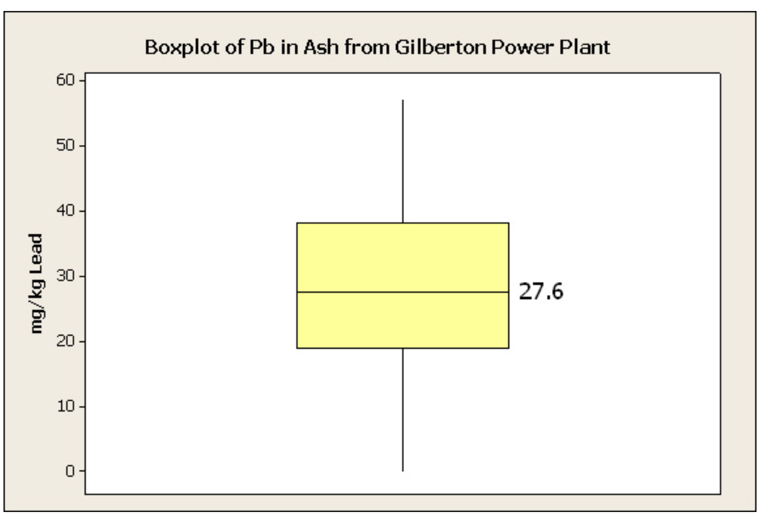

Figure 13. Distribution of lead in the ash from the Gilberton power plant. Q1 = 19.0, Q3 = 38.1.

[7] See Table 2.8 in Smith and Huyck, (1998).

AES Thames: About one third of the ash brought to BD Mining since 2002 has been from the AES Thames power station in Connecticut. They have been providing separate samples for their fly and bottom ashes. Figure 12 is a boxplot showing the distribution of lead in the sampled ash. Plots of the leaching data for AES Thames are not included because lead has always leached just at or below detection.

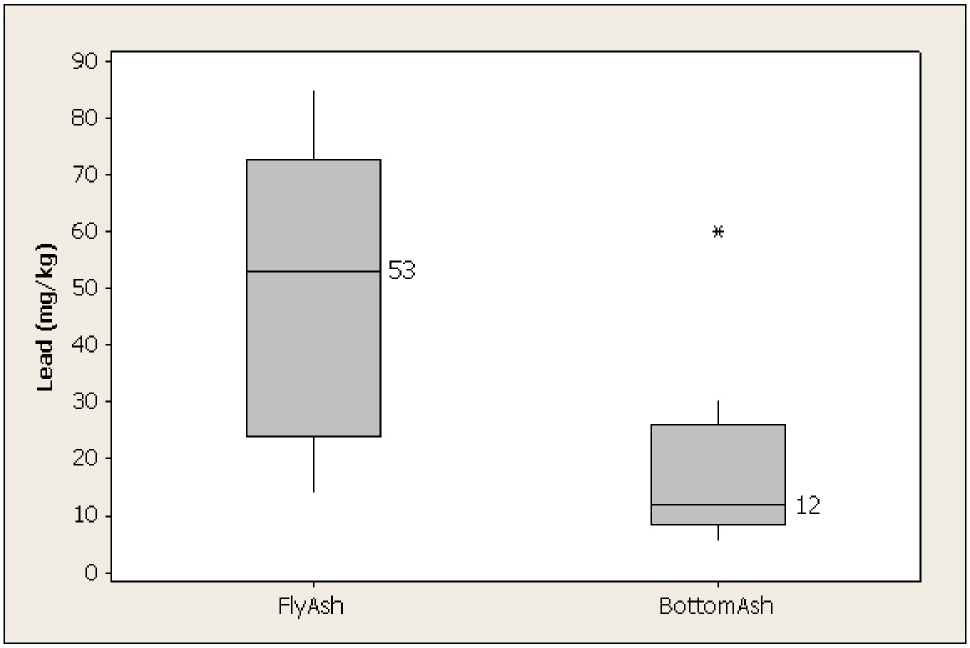

Figure 12. Distribution of lead in the fly and bottom ash from the Thames power plant source. The number to the right of the box is the median concentration.

Syracuse Energy Corporation – Trigen: Ash has been coming from the Syracuse-Trigen source for only the past couple of years and is a fairly small proportion of the overall ash. The highest lead measured from this source is 10.4 mg/kg, just above the detection limit of 10 mg/kg. Other samples were below the detection limit. Leachate lead is below detection.

Discussion on Lead in BD Mining Ash: The lead in all the ashes coming to the BD Mining site is well below the lead concentration that would qualify a material as “clean fill” in Pennsylvania. The greatest source of ash at BD Mining, Gilberton plant ash, has about the same lead concentration as granite. None of the ashes leach lead at levels of concern, nearly always being below detection. An examination of leaching chemistry and bulk chemical analysis for lead in the ashes used at BD Mining indicate that they contain low concentrations of lead and will not leach lead at problematic levels.

Iron Concentrations

Figure 13 shows the monitoring data for iron. The trendline in black is modeled for the data points in red (Gilberton Shaft down-gradient of ash). In a pattern that will be repeated with other constituents, the trend in the mine pool concentrations is improvement – lower iron through time.

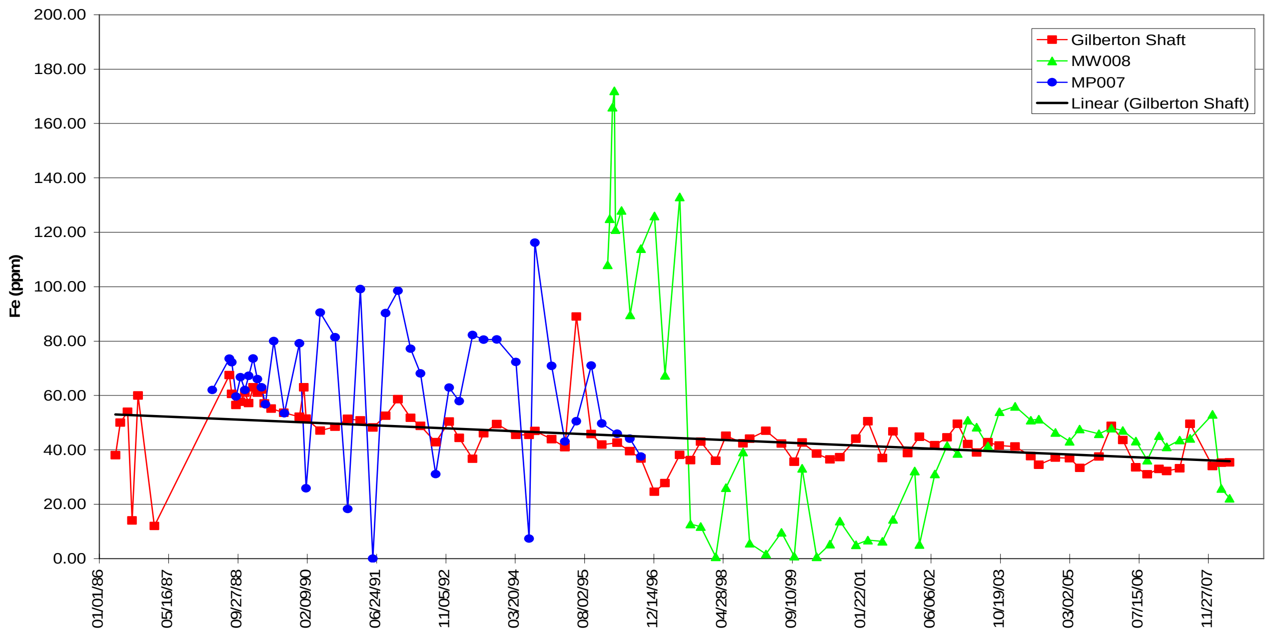

Figure 13. Concentration of iron through time. The trendline is through the data for the down-gradient Gilberton Shaft. Monitoring well 007 (in blue) was replaced in 1995 by well 008 (in green).

The post 1995 well data (in green) shows high values through 1997, low values from 1997 to mid-2002 and consistent middle values from 2002 to 2007 with a current trend downward. This high-low-high pattern will be repeated in some of the following graphs. We have no explanation for this behavior.

Throughout 1988-present, the down-gradient Gilberton mine shaft (in red) is fairly consistent and clearly trending downward. Thus, iron concentrations have been improving through time at the down-gradient Gilberton Shaft.

Manganese Concentrations

Manganese results (Figure 14) show a similar pattern to the iron. The trend for the down-gradient point is downward (improvement) through time. The monitoring wells show similar responses through time as those observed for iron. The well data are variable with extreme values in 007 and a high-middle-high pattern on the 008 up-gradient point. As with iron, the most recent samples at the downgradient Gilberton Shaft have lower concentrations than earlier data.

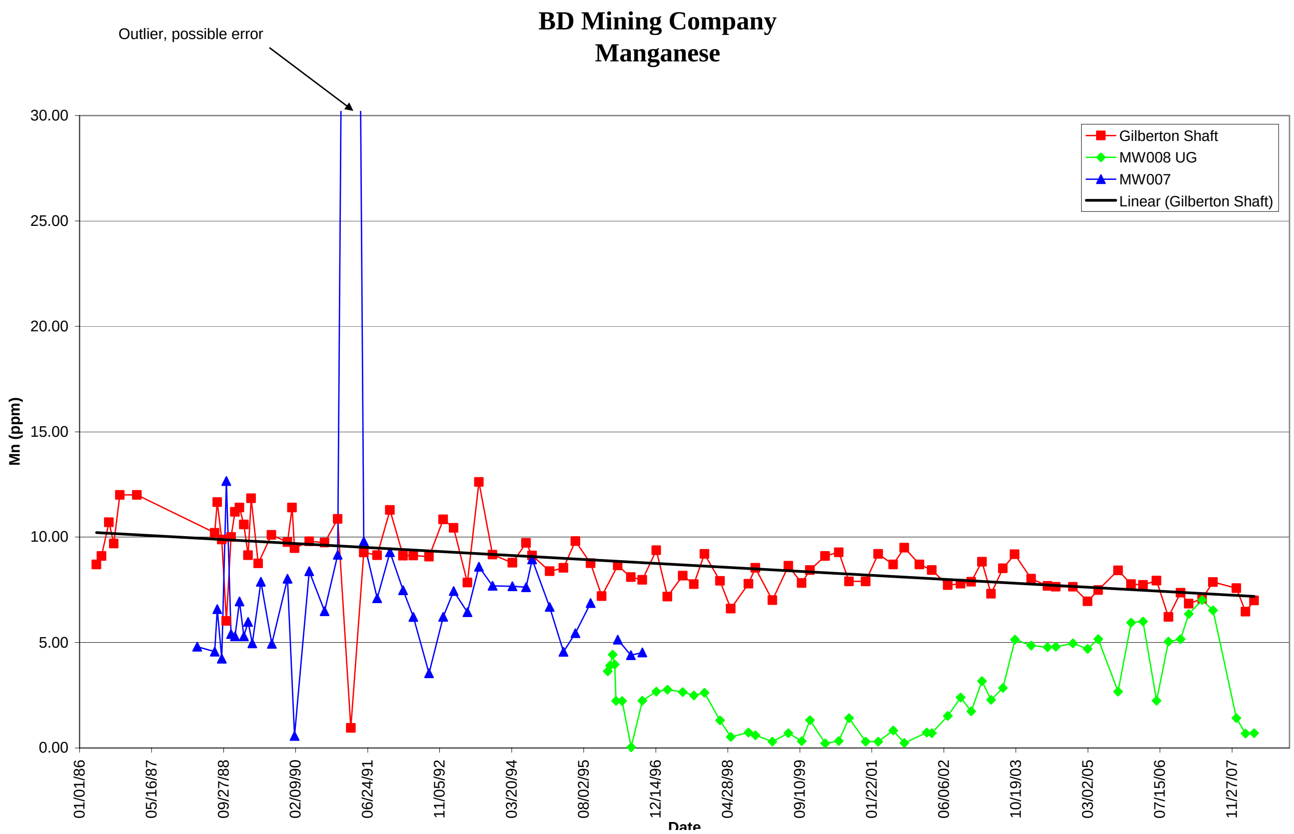

Figure 14. Concentration of manganese through time. The trendline is through the data for the down-gradient Gilberton Shaft.

Sulfate Concentrations

Sulfate is a common constituent of mine drainage and is a prevalent constituent of many coal ashes, especially fluidized bed ashes such as those produced by the Gilberton power plant. Sulfate (Figure 15) at the down-gradient point shows the same pattern (decreasing through time) as iron and manganese. The monitoring wells show variability and the same pronounced high-low-high pattern from 1995 to 2006 as with iron and manganese with recent samples having lower concentrations. Sulfate is a parameter that tends to leach readily from ash, so a decline in sulfate levels indicates that leachate from the ash is not having a negative affect on the mine pool.

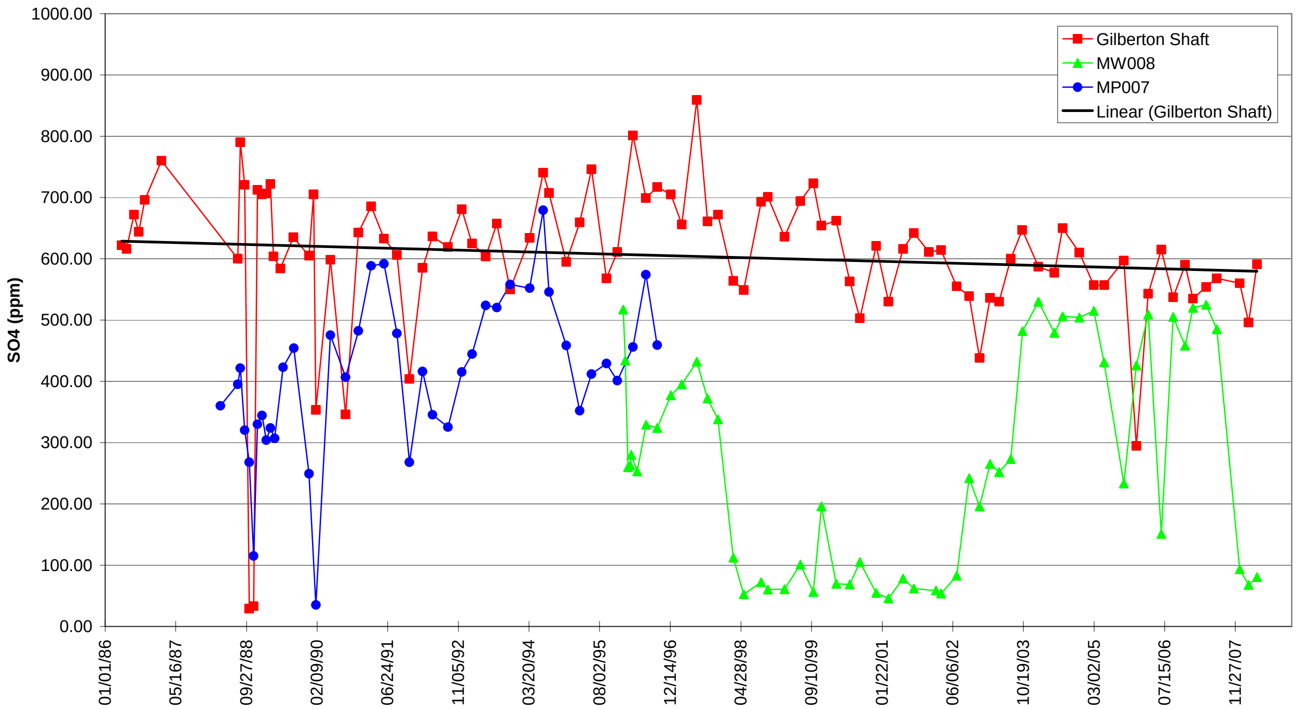

Figure 15. Concentration of sulfates through time. The trendline is through the data for the down-gradient Gilberton Shaft.

Alkalinity Concentrations

The alkalinity (Figure 16) is highly variable but produces an overall increasing trend. Increasing alkalinity is an improvement to mine discharge quality and probably indicates a decrease in acid sources within and into the mine pool.

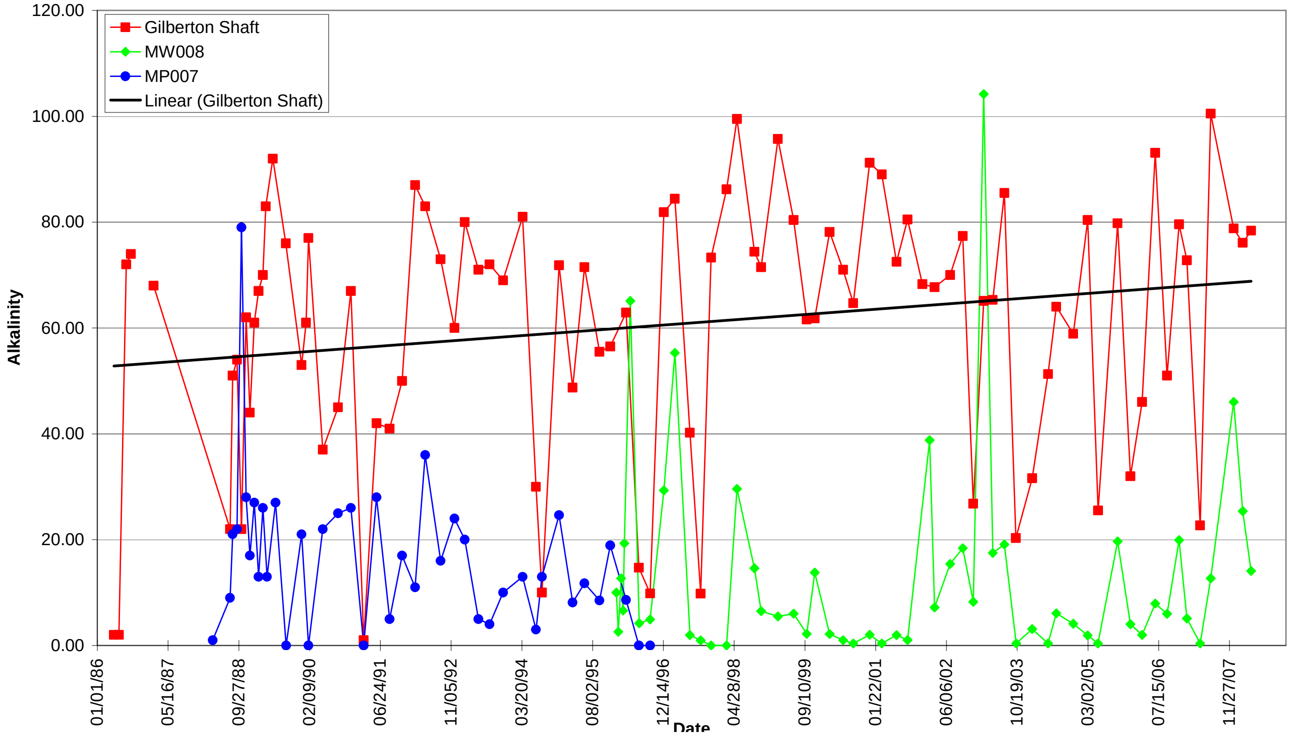

Figure 16. Concentration of alkalinity through time. The trendline is through the data for the down-gradient Gilberton Shaft.

Trace Metals

Figures 17 through 19 show zinc and nickel concentrations through time. Figure 17 shows data for the down-gradient Gilberton shaft and monitoring well results for zinc. This figure shows all data, including extreme (outlier) values. Figure 18 is just the down-gradient data, minus the most extreme value. Figure 19 shows nickel concentrations through time. Monitoring for nickel began in 1994. These two parameters show decreasing trends through time, consistent with all the other decreasing trends observed at the down-gradient Gilberton Shaft monitoring point.

Other trace metals (As, Cr, Cu, Cd, Hg, and Se) were not plotted because the vast majority of values were below detection throughout the history of monitoring, making a plot essentially meaningless. As with lead, a few rare higher values occasionally occur, but show no trend.

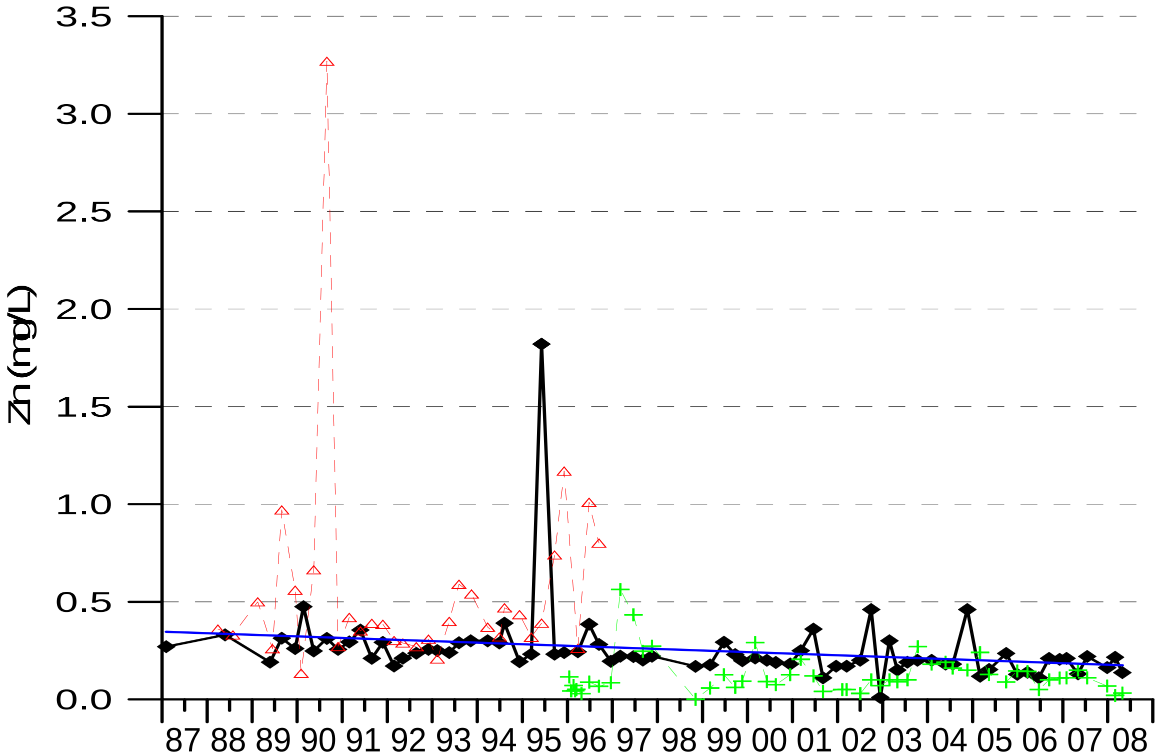

Figure 17. Zinc concentrations at up-gradient and down-gradient (Gilberton Shaft) monitoring points. All data are shown.

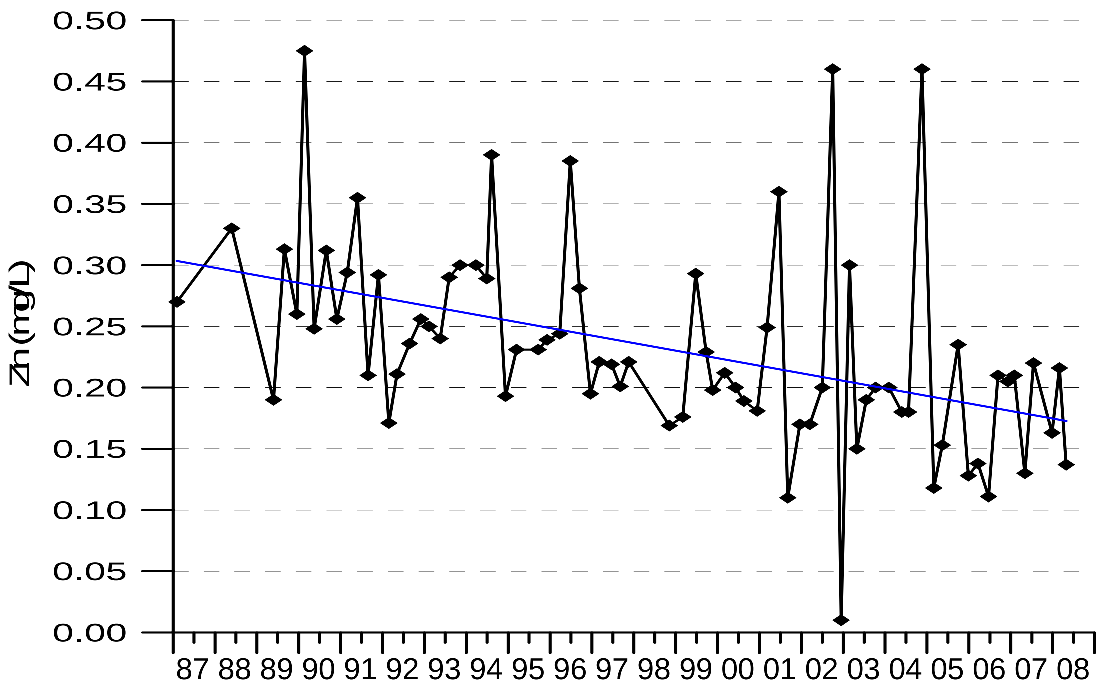

Figure 18. Zinc concentrations at the down-gradient (Gilberton Shaft) monitoring point, absent the one value that was greater than 0.5 mg/L.

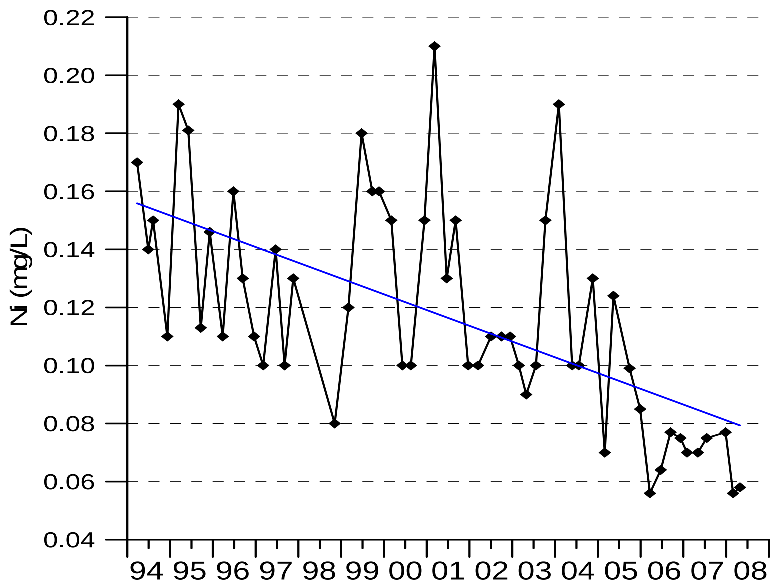

Figure 19. Nickel at the down-gradient (Gilberton Shaft) monitoring point.

Calcium and Magnesium

If anything should be leaching from the ash it would be calcium and magnesium, which occur in large concentrations and are fairly mobile. Figure 20 shows calcium and magnesium concentrations plotted through time. Both elements are decreasing through time.

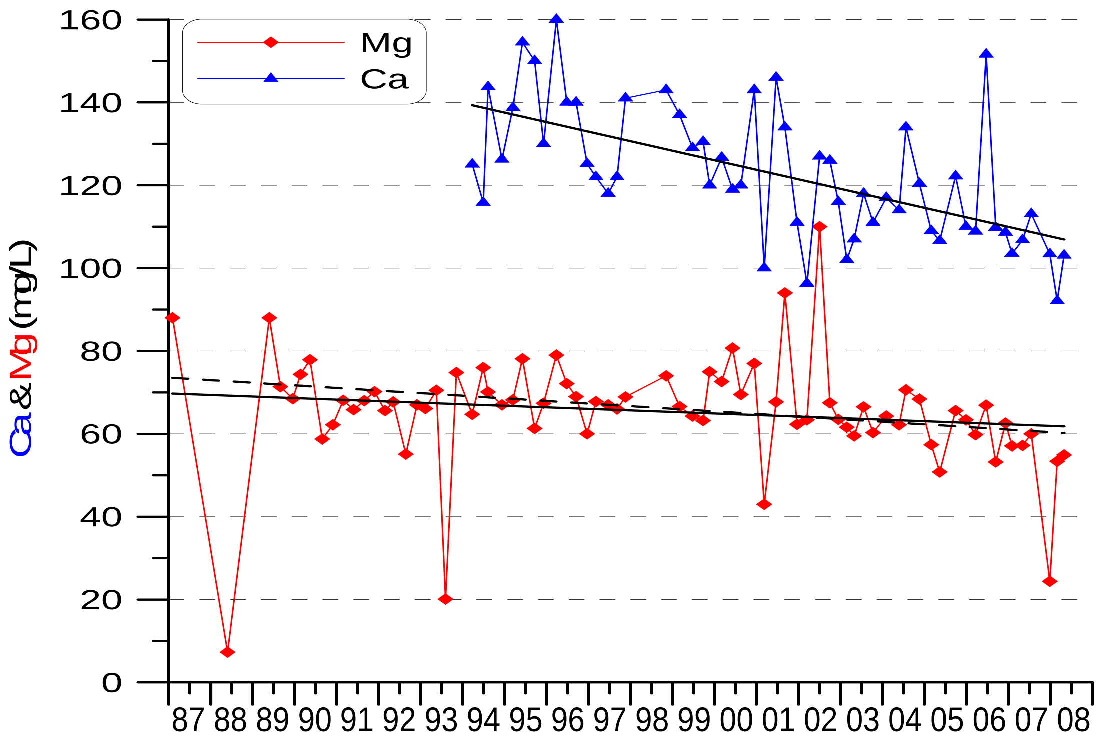

Figure 20. Plots of calcium and magnesium through time. The dashed best-fit line through the calcium data is the best fit when the most extreme low value is eliminated. The solid line represents the best fit using all data.

Total Dissolved Solids

Finally, Total dissolved solids (Figure 21) follows a similar pattern to iron, manganese and sulfate – a general trend downward for the mine pool and the high-low-high pattern with a recent trend downward for monitoring point 008. Total dissolved solids are a reflection of the cumulative concentration of all chemical constituents in the water. Figure 17 shows that the overall concentration of "stuff" in the water is less in 2008 than was the case in 1986.

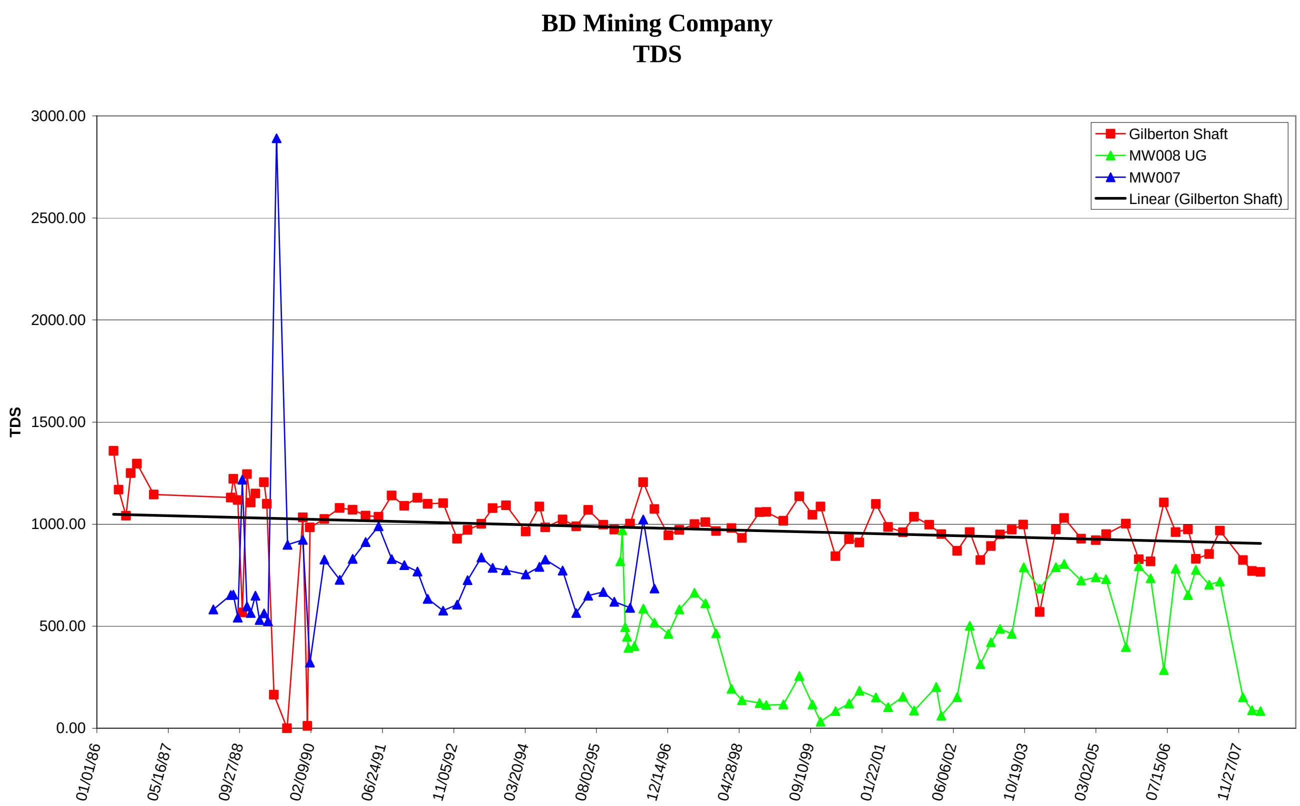

Figure 21. Concentration of Total Dissolved Solids (TDS) through time. The trendline is through the data for the down-gradient Gilberton Shaft.

Discussion and Conclusions

A few observations can be safely made:

1. The lead concentrations at the Gilberton Shaft are below detection about 80 percent of the time. There are occasional spikes that are above detection. The spikes that occur at the downgradient Gilberton Shaft monitoring point are similar to, but often lower than, those at the monitoring wells. Statistically the wells and down-gradient lead populations are the same.

2. Assuming, for the sake of discussion, that the few upward spikes in lead are real (that is, not the result of sampling or laboratory error), to simply assume that ash is the cause is naïve, it would ignore other more probable sources, and is scientifically disingenuous. Numerous current and former human activities result in drainage to the underlying deep

mine pool. The whole area was extensively impacted by previous mining. There is a rail yard immediately adjacent to the BD Mining site, which has been there for decades or longer.

3. Mine pool water quality is improving through time. Improvements are seen in iron, manganese, sulfate, total dissolved solids, zinc, nickel, calcium, magnesium and alkalinity. These are substances known to occur in coal ash. It is clear that the ash, at a minimum, is not having a negative effect on the underlying mine pool since the mine pool is improving through time for all these parameters. It is reasonable to suggest that reclamation, removal of waste coal and ash placement have resulted in improvements to the mine pool quality.

4. The “spiky” nature of the lead is completely different from the behavior of any of the other parameters plotted. The other parameters show clear trends toward improvement. It is unlikely that lead could independently leach from the ash while so many other parameters in the mine pool are improving through time. Even calcium, sulfate and magnesium, which constitute a huge portion of the ash, are decreasing through time. If anything were to leach one would expect it to be calcium, sulfate and magnesium. If lead were truly leaching from the ash there should be other parameters, such as nickel and zinc, showing similar behavior, but this is not occurring. It is not supported that the ash is leaching measurable quantities of any constituents but, instead, functioning as a low permeability stable mass. The most reasonable explanations for the occasional high lead are that it is from a non-ash source or it is sample collection or analytical error of some sort. The vast majority of the time lead is below detection.

5. Lead levels in the bulk chemistry for the ash being placed at BD Mining are well below the 450 mg/kg that would make a material acceptable as clean fill. The Gilberton ash, which makes up the bulk of the ash at BD Mining, has lead concentrations similar to granite. The leaching levels for lead for all sources are almost always below detection. The chemical analyses of the ash do not support ash as a source for lead.

6. The assumption that lead must somehow be tied to ash is unsupported as discussed above. If lead is actually occasionally elevated, it is more likely that there is some other explanation than ash as the source. Ash is the one material that has been placed in the area that has been subjected to extensive chemical testing and permitting requirements.

7. To apply drinking water standards as the compliance standard for the mine pool water in the Mahanoy Syncline is unreasonable. The water has been polluted for decades, perhaps a century. This water has not been potable, nor will it be potable in the foreseeable future. Table 1 shows that the water was undrinkable before ash placement and, although the water has improved, it is still undrinkable.

8. The commentator concerned about water quality in this location ignored the overall improvements of the mine pool through time, clearly exhibited by other indicative parameters closely associated with coal ash. These data were available to the commentator.

9. Over 5 million tons of ash have been placed above the mine pool that is sampled at the Gilberton Shaft. Despite this, or perhaps as a result of this, chemical constituents are decreasing through time. That is, the mine pool quality is improving. Elements such as calcium, sulfate and magnesium, which occur in very large quantities in ash, are decreasing in the mine pool water.

There is no evidence to support the allegation that ash at the BD Mining site is having a negative impact on the mine pool water quality as sampled at the Gilberton Shaft. To the contrary there have been clear improvements to water quality through time at the Gilberton Shaft.

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