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THE DEVELOPMENT OF A NATIONAL PROGRAM TO ABATE ACID MINE DRAINAGE THROUGH THE REMINING OF ABANDONED MINE LANDS[1]

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Abstract. Acid mine drainage (AMD) pollution from abandoned mine lands has long been recognized as one of the most serious causes of water pollution in the Appalachians. With reclamation to current-day standards and the use of appropriate best management practices (BMPs), remining can be an effective method for improving water quality. Passage of the Rahall amendment to the Clean Water Act and experience with remining in Pennsylvania and other states lead to EPA's development of a nationwide water quality rule for remining operations. EPA studied the effectiveness of BMPs in abating AMD and developed methods for establishing baseline pollution loads and evaluating postmining water quality. The nationwide rule encourages remining by establishing standardized permitting requirements and encourages pollution abatement through the implementation of effective BMPs.

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Scope of the Problem

The number, size and scope of abandoned mine lands (AML) in the Eastern and Midwestern coalfields is considerable. Nearly 16,000 kilometers of mine drainage-degraded streams and nearly a million meters of abandoned highwalls exist in the Eastern and Midwestern coalfields combined (Table 1). In Pennsylvania and West Virginia, acid mine drainage is the biggest single cause of stream impairment. The total area of dangerous piles or embankments exceeds 2,750 hectares. Excluding surface and underground fire areas, the total area for abandoned mine lands in those states is 16,293 hectares. The number of abandoned underground mine portals is nearly 5,500.

Table 1. Impacted stream miles and AML inventory four major problem types.

State	Degraded Stream Kilometers[1]	Sediment Impaired Streams in Hectares[2]	Dangerous Highwalls in Linear Meters[2]	Dangerous Piles or Embankmts. in Hectares [2]	Dangerous Slides in Hectares[2]
Alabama	106	23	98,315	797	2
Illinois	NA[3]	307	18,584	117	0
Indiana	0	0	2,060	11	0
Kentucky	984	3,854	10,100	293	586
Maryland	705	6	1,783	50	10
Missouri	228	6	9,604	82	0
Ohio	2,459	5,273	9,193	12	49
Pennsylvania	4,918	250	301,690	859	0
Tennessee	2,869	0	4,285	34	29
Virginia	NA[3]	676	24,740	52	50
West Virginia	3,648	68	430,919	476	140
Totals	15,917	10,462	911,273	2,781	866

[1] EPA, Coal Remining – Best Management Practices Guidance Manual, 2001

[2] OSMRE, AMLIS database, 2003

[3] Data not available

Given the modest annual funding for abandoned mine land reclamation, it is unlikely that most of these sites can be reclaimed through AML program funding and even more unlikely that all of the acid mine drainage-impaired waterways can be restored. Moreover, the AML program is scheduled to expire on September 30, 2004 unless reauthorized by Congress. Should AML funding not be reauthorized or reduced from its current levels, the reclamation of abandoned mine lands through active coal remining will become even more important; possibly the sole source of AML reclamation.

Remining

Coal remining is the mining of previously mined surface and underground mine lands, and coal refuse piles. During remining, many of the problems associated with abandoned mine land, such as dangerous highwalls, vertical openings, abandoned coal refuse piles, and acid mine drainage can be corrected without using public funds from the federal Office of Surface Mining's (OSMRE's) Abandoned Mine Land Program. Figure 1 shows examples of abandoned mine lands reclaimed through remining. Skousen et.al. (1977) studied 10 remining operations in West Virginia and Pennsylvania. Remining of these sites by mining companies saved the federal AML reclamation fund nearly $4 million in estimated reclamation costs and resulted in beneficial water quality improvements to receiving streams. In 1987, Congress attempted to address the problems associated with abandoned mine lands by passing the Rahall Amendment (Clean Water Act section 301(p)) to encourage coal remining. The Rahall Amendment allows permit writers to set site-specific limits for pre-existing discharges. These limits may not exceed baseline levels of iron, manganese, and pH. Remining operators also must demonstrate that the remining operation will result in the potential for improved water quality. The statute does not specify how to determine site-specific pollutant discharge levels, or how to demonstrate the potential for improved water quality.

Figure 1a. Abandoned mine lands from a 1940's underground mine in western Kentucky.

Figure 1b. Same site as 1a after remining showing revegetation. Site also has reduced AMD and almost complete coal recovery.

Figure 1c. Abandoned mine lands in central Pennsylvania showing unrevegetated acid-forming spoil and impounded pit water.

Figure 1d. Adjacent site to 1c during remining showing surface regrading and revegetation in foreground. Active coal removal area is in background.

Despite the Rahall Amendment, coal mining companies remained hesitant to pursue remining without formal EPA approval and guidelines. Between 1987 (date of enactment of Rahall Amendment) and 1999, seven states established formal remining programs that issued approximately 330 Rahall permits with site-specific numeric limits for pre-existing discharges. Of these 330 Rahall remining permits, 300 were issued by the Pennsylvania Department of Environmental Protection (DEP).

On January 23, 2002, the U.S. Environmental Protection Agency (EPA) promulgated effluent limitations guidelines under a Coal Remining industrial subcategory at 40 CFR part 434, Subpart G (see http://frwebgate.access.gpo.gov/cfr/index.html) based on a combination of numeric limits and non-numeric best management practice (BMP) requirements. These guidelines also include a provision for non-numeric, BMP-only requirements where monitoring of a pre-existing discharge is infeasible. Under EPA's regulations, numeric requirements are established on a case-by-case basis in compliance with specific statistical procedures to establish and monitor baseline pollutant levels. These numeric effluent limitations are designed to ensure that pollutant discharges do not exceed pre-existing levels. EPA included a requirement for operators to prepare and implement a pollution abatement plan that identifies the characteristics of the remining area and the pre-existing discharges at the site, identifies design specifications for selected BMPs, and includes periodic inspection and maintenance schedules. The pollution abatement plan must demonstrate that there is a potential for water quality improvement.

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Baseline Pollution Load

Establishment of a statistically valid baseline is a key component of a remining permit. The pre-remining baseline is the standard for determining whether the pollution load has been affected by remining. In the event that the pre-remining pollution load level has been exceeded, the baseline also becomes the standard for treatment. A realistic baseline requires an adequate number of samples collected at appropriate time intervals to represent the full range of seasonal variations. The statistical components of establishing baseline pollution load include characterizing the patterns of variation and measuring central tendency, so that any mining induced changes in pollution load can be distinguished from seasonal and random variations.

Fig. 2 shows hypothetical variations in acid loads of an abandoned mine discharge before, during and after remining. In Fig. 2, the acid load varies greatly before remining commences.

Before remining, the discharge usually varied somewhat symmetrically above and below the central value of 500 units per day and generally was contained within the lower and upper control levels (shown as dashed lines). To determine the baseline pollution load, it is necessary to statistically analyze the data for central tendency (e.g. mean or median) and the patterns of variation or dispersion of the individual observation (i.e. samples around the central tendency as shown in Fig. 2).

There are two types of variations in pollution load which are of interest in evaluating monitoring data during and after remining to determine whether or not the variations are within the normal range of baseline conditions: (1) The first and most obvious pattern of variation occurs when there are series of extreme events which consistently exceed the upper control level as shown in Fig. 2. This variation pattern indicates a sudden and dramatic increase in pollution load which may be attributed to remining, and which is referred to as a dramatic trigger. (2) The second pattern of variation of is a trend of gradually increasing (or decreasing) pollution load (as shown on the right side of Fig. 2) where the general pattern of acid load observations is increasing above the baseline central tendency values for an extended period of time without necessarily exceeding the upper control level. As this second pattern of variation is much less dramatic than the first, and takes more time and effort to detect, it is referred to as the subtle trigger. These two patterns of variation are

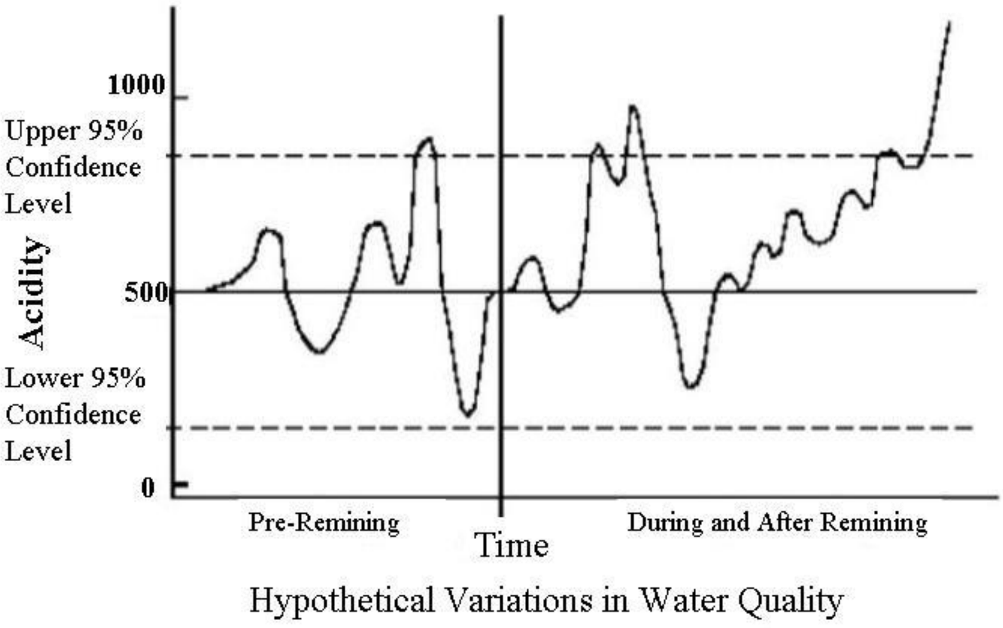

Figure 2. Example of acid load variation before, during, and after remining

referred to as triggers because they can be used to set off or initiate the requirement for a mine operator to treat a pre-existing discharge to a numerical effluent limitation. The treatment triggers must be carefully established so that they are: (a) not set off prematurely or erroneously, adversely affecting the mine operator, or (b) set off too late resulting in additional mine drainage pollution without treatment.

The chief objective of EPA and the Interstate Mining Compact Commission (IMCC) states in determining the baseline pollution load was to develop a simple quality control approach to the data analysis that is statistically sound. An algorithm for the statistical analysis of mine drainage discharge data is described in EPA’s Coal Remining Statistical Support Document authored by statistician John Fox and others (2001) and in a companion document, “Statistical Analysis of Abandoned Mine Drainage in the Assessment of Pollution Load” (2001) referred to as the “Griffiths Report” in honor of Professor John C. Griffiths who pioneered the procedures used to establish pre-remining baselines. These two reports were published by EPA as the technical support documents for the federal remining regulations. The algorithm included a simple quality control approach using the exploratory data analysis methods developed by Tukey (1977), and used bivariate statistical methods in time series analyses where appropriate. The Fox report includes a succinct description of the statistical methodology used to calculate the baseline pollution load, plus case studies of remining sites and discharge monitoring data.

Pre-existing mine drainage discharges may vary widely in flow and concentration and also in pollutant loading rates. Because there is such a large seasonal component to flow variability, it is necessary that baseline pollution load monitoring cover the entire range of seasonal conditions (generally an entire water year). Smith (1988), looking at long-term records of AMD discharges in Pennsylvania, classified discharges based on three fundamental behaviors: (1) high flow–low concentration/low flow–high concentration response where the flow rate varies inversely with concentration; (2) steady response where changes in flow rate and chemistry are minimal or damped; and (3) slug response where large increases in discharge volumes are not accompanied by corresponding reductions in concentration, resulting in large increases in pollution loading.

Most pre-existing AMD discharges exhibit the first type of behavior. It occurs at surface mines and small underground mines where the capacity for ground-water storage is relatively small and ground-water flow paths are short. Typical for this type of discharge, the flow rate varies greatly and is subject to seasonal flow variations as well as individual precipitation events, similar to the behavior of small surface water tributaries. The second type of discharge represents large volume flows from extensive underground mine complexes, which show comparatively little fluctuation in discharge rate and only minor variation in chemical quality. Short-term fluctuations in flow and quality are subdued, because of the large amount of stored ground-water acting as a reservoir and dampening fluctuations due to individual recharge events. The third type of AMD discharge is subject to extreme variations in flow in response to recharge events. This discharge behavior results where conditions favor the accumulation of water-soluble, acid-bearing salts in the unsaturated zones. Hence, acid concentrations change very little and result in large rapid variations in acid loading. Coal refuse piles provide the most favorable environment for this discharge behavior.

All three discharge types also exhibit some seasonal behavior, with highest flow and loading rates during the seasonal high ground-water conditions and the lowest flows and loadings during low ground-water conditions. For most of Appalachia and the Midwest, high ground-water conditions occur during late winter or early spring. Low flow conditions occur during late summer and early fall. Seasonal variations as well as shorter-term variability make it critical that the baseline sampling program include enough samples to cover the full range of seasonal conditions and to adequately represent the full range of variability.

Two different methods for assessing remining conditions are provided by EPA. Each method includes two different triggers: a single-observation trigger and an annual test comparison. The single-observation trigger is designed to detect a series of extreme loadings that consistently exceed the upper control level established from the baseline data. The annual test comparison or subtle trigger is designed to detect gradually increasing trends in pollution loads. The option of two different methods was made available because of the possibility of different distributions of discharges. Both methods are based on nonparametric statistics, including medians and interquartile ranges. The first method uses the upper limit of a tolerance interval for the single-observation trigger, and a 95 percent confidence interval around the baseline median for the annual test as shown on Fig. 3.

Since the frequency distributions of the water quality, flow and/or pollution load parameters of pre-existing mine drainage discharges are frequently asymmetrical, the order/statistic methods of Tukey (1977) and others are used to compare the baseline monitoring data during mining and post-mining, as shown on Fig. 3. Two box plots are shown on Fig. 3. Each box plot represents five key values of the frequency distribution: the upper and lower extremes (i.e. the range of the data), the median (i.e. the measure of central tendency), and the upper and lower quartiles (i.e. 50% of the observations are within the box representing the interquartile range). The upper quartile also represents a median between the calculated median shown on Fig. 3 and the upper extreme value of the distribution. In the statistical methodology described in Fox et al (2001), three additional successive medians are calculated (i.e. shown as the 8th, 16th and 32nd values on Fig. 3) to determine the Single Observation Limit (L), (also called the “Dramatic Trigger”). This upper quality control limit and its corresponding lower limits (i.e. the lower 32nd value) represents an approximation of the95% tolerance limits of the frequency distribution, using the methods of Tukey (1977), who called these the H-spread, 32nd values. In comparing the medians of two successive years of mine drainage discharge data, or pre-mining and post-mining box plots as shown on

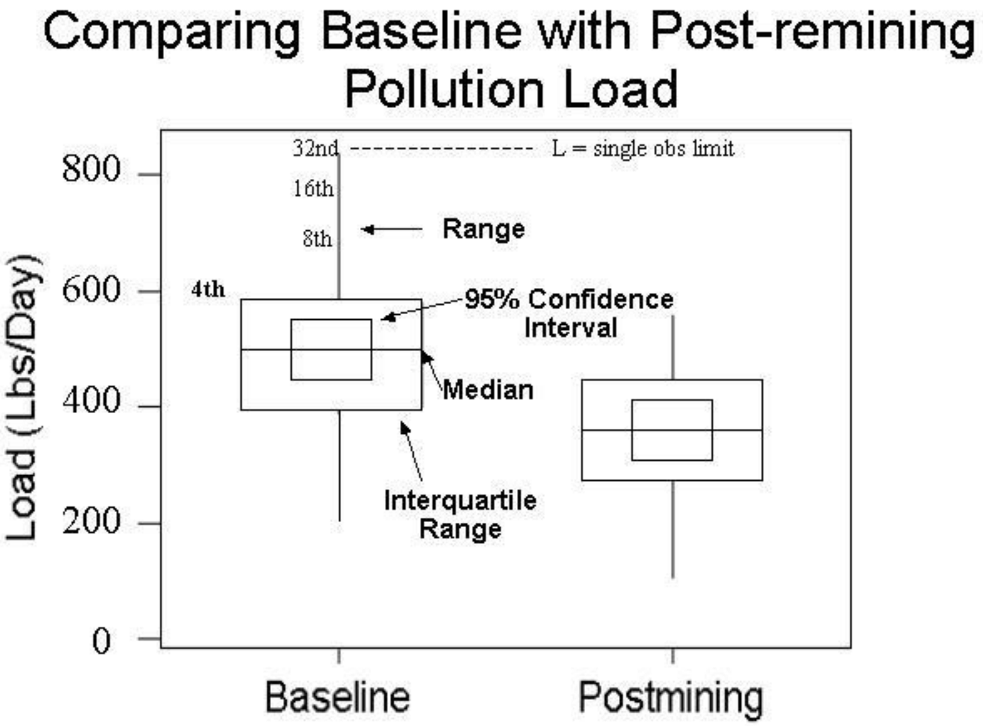

Figure 3. Two boxplots comparing pre-remining baseline with post-mining pollution load data. The vertical line shows the range of data. Upper and lower quartiles are defined by the wider box and the median is shown by the horizontal line. Confidence intervals around the median are delineated with the narrow, inner box. The two sample sets are significantly different if the inner boxes do not overlap.

Fig. 3,an additional statistical test, described by McGill et al (1978) is employed to determine if the difference between the medians is statistically significant. The small boxes within the larger boxes in Figure 3 represent the 95% confidence intervals about the medians. If these two smaller boxes do not overlap, as shown in Figure 3, there is a statistically significant difference (e.g. a post-mining pollution load reduction/improvement) between the medians. This test of medians represents “subtle trigger” evaluation described above.

The second method uses a nonparametric estimate of the 99th percentile of the baseline loadings for the single-observation trigger, and the nonparametric Wilcoxon-Mann-Whitney test is used to compare the baseline and post-baseline medians for the annual test as described in the Fox report (EPA, 2001). This second method is recommended if discharges are to be monitored for a long period of time (at least 60 months), or if the baseline loadings are highly variable, i.e., if the coefficient of variation (CV, calculated by dividing the standard deviation by the mean) is at least 1.25. The first method is recommended in all other situations.

Best Management Practices (BMPs)

There are four types of abandoned mine lands available for remining operations: 1) sites that were previously surface mined, 2) sites that were previously underground mined, 3) sites that were both surface and underground mined, and 4) sites that had coal refuse deposited on the surface. These sites were frequently left unreclaimed and unvegetated, and often pose safety hazards and are associated with pollutional discharges or sedimentation problems. When these areas are remined, they must be reclaimed to today's standards. By its very nature, remining will minimally involve certain BMPs. For example, areas that were previously surface mined, but not reclaimed will require regrading and revegetation. If underground mines are present and remining will recover remaining coal reserves, daylighting will occur. Remining of coal refuse piles will result in refuse removal, regrading and revegetation. Additional BMPs can also be implemented during remining and reclamation. These BMPs can be specifically designed to reduce, if not completely eliminate, pre-existing environmental problems, particularly water pollution. There is no single set of BMPs that apply to all remining operations. The types and scope of BMPs are tailored to specific operations based largely on the pre-existing site conditions, hydrology, and geology. BMPs are designed to function in a physical and/or geochemical manner to reduce pollution loadings. To aid in the design of a pollution-abatement oriented remining plan, EPA published a coal remining best management practices guidance manual (EPA, 2001).

Successful remining operations typically involve implementation of two or more BMPs to improve pre-existing conditions. The BMPs commonly used during remining are shown in Table 2.

Table 2. BMPs commonly used on remining sites.

BMP	**Description**
Regrading	Restoration of positive drainage on unreclaimed mine spoils
Revegetation	Establishment of a diverse and ample vegetative cover in areas that were poorly vegetated due to effects of past mining
Daylighting	Exposure by surface mining of a deep-mined coal seam, with the purpose of removing the remaining coal.
Special Handling	The selective placement of acid-generating overburden rock within backfill to minimize acid production from that material
Alkaline Addition	The importation of calcareous material to a site that is naturally deficient in neutralizing rock.
Passive Treatment	Chemical or biological treatment of water by means that generally require less attention than conventional treatment.
Coal Refuse Removal	The elimination or reduction of abandoned coal waste piles. The sites are in due course regraded and revegetated. The material is generally consumed in power plants.
Biosolids Addition	Application of nutrient- and organic-rich sewage sludge as a soil amendment for enhancement of plant growth.
Mining of Highly Alkaline Strata	Intentionally encountering and mixing naturally-occurring calcareous rock during the remining process.
Alkaline Redistribution	The process of taking excess calcareous material from a portion of a mine and placing it in areas of the mine that lack calcareous materials.
Water Handling Systems	Any BMP that is designed to reduce the amount of surface water infiltration into spoil, or channel ground water through the spoil to reduce contact with acidic spoil, or to lower the water table.

Remining Impacts on Water Quality – the Pennsylvania Experience

Overall Water Quality Performance

The Pennsylvania Department of Environmental Protection (DEP) and it's predecessor the Department of Environmental Resources, began issuing remining permits in 1984. Initially, these were a handful of pilot projects, authorized under consent agreements. By 1986, state remining regulations became final and the number of remining permits authorized climbed sharply. Hawkins (1995) documented improved water quality from Pennsylvania remining sites, primarily due to reductions in flow from reclaimed mines. Any decrease in flow directly translates to decreased pollution loads. By 1999, over 300 remining operations had been permitted. It was time to take a critical look at how these operations were affecting water quality. Anecdotal data suggested that there were many sites where preexisting discharges improved or disappeared, and relatively few sites that incurred treatment responsibility. The requirement to established a pre-remining baseline coupled with a requirement for monthly post-remining monitoring made it possible to do a rigorous analysis of the effectiveness of remining in abating preexisting mine drainage problems.

By 1999, 112 remining permits had been completely reclaimed and enough time had passed for pre-existing discharges to reestablish. Post-remining water quality was compared with the pre-remining baseline (Smith, et. al. 2002). It was expected that some modest improvements to water quality would be realized, especially due to flow decreases resulting from regrading and revegetation. The actual results were much more dramatic. Nearly half of the permits showed significantly decreased or eliminated pollution load (Fig. 4). Pollution load reductions resulted in roughly equal proportions from reduced flows and decreased concentration. Only a very few permits showed increases in pollution load. Overall, pollution load changes were most dramatic for acidiy (61% decrease), aluminum (43% decrease) and iron (35% decrease). The most modest change was for manganese, which nonetheless showed an overall 13% decrease. Overall flows declined by 23%, indicating that although the BMPs were effective in decreasing flows, they also must have impacted water chemistry in order to achieve loading reductions greater than the decrease in flow. These loading decreases are shown in Table 3.

The study examined all of the sites where reclamation was complete - 112 out of over 300 permits. These sites were collectively responsible for reducing acidity load by over 7,200 kg/d (16,000 lbs/d). A conservative estimate of the value of this load reduction is that it would cost approximately $3 million/year to treat this much acid load at a single treatment site. Of course, the cost to treat this much load at multiple sites would be substantially greater. This study makes it clear that the benefit from remining extends well beyond achieving reclamation of abandoned mine lands to include substantial improvements in water quality. However, it should also be noted that Pennsylvania DEP required levels of BMP implementation that it believed would result in reasonable prospects for improved water quality and that, despite this approach, there were a few sites where pollution loads actually increased.

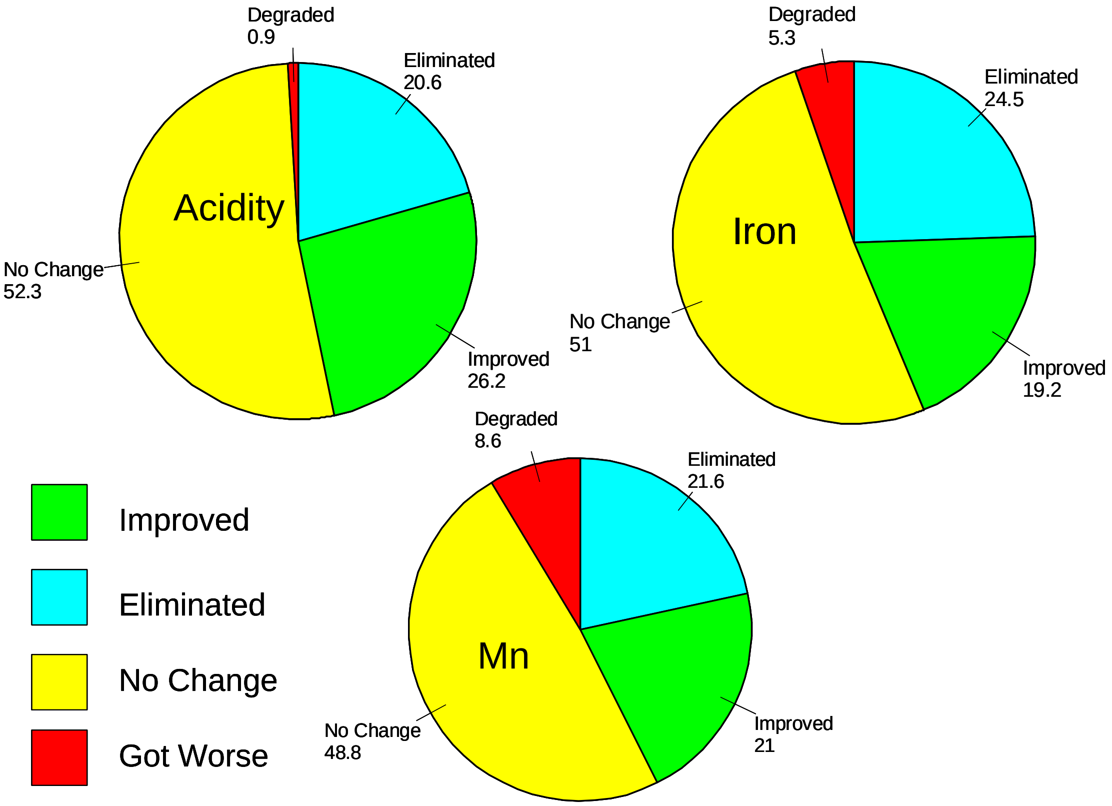

Figure 3. Distribution of change in pollution loading for acidity, iron, and manganese experienced on 233 pre-existing discharges from 112 Pennsylvania remining sites.

Table 3. Summary of net change in pollution load at 112 Pennsylvania remining operations.

Parameter	Number of mines	Number of discharges	Total baseline median load	Total post-mining median load	Total change in load	Percent change in median load	Percent change due to flow
Net acid load, lb/day	109	233	26,091	10,175	-15,916	-61.01	37.96
Iron load, lb/day	100	208	1,485	967	-518	-34.82	64.32
Manganese load, lb/day	75	162	246	216	31	-12.63	193.13
Aluminum load, lb/day	56	116	702	399	-303	-43.09	21.06
Sulfate load, lb/day	109	223	44,580	31,405	-13,175	-29.55	78.39
Flow, gpm	110	227	4,256	3,248	-1,008	-23.70	100.00

Individual BMP Performance

The effectiveness of the BMPs listed in Table 2 were statistically evaluated by comparing premining and postmining water quality for 231 discharges from 112 reclaimed remining sites in Pennsylvania (see EPA's BMP Guidance Manual, 2001). At the sites evaluated, a BMP was rarely used alone. BMPs typically were used in combination. To evaluate the effectiveness of individual BMPs, a logit-link logistic regression model was used. The model can be used to make predictions of the likelihood that a discharge pollution load will either improve (decrease) or be eliminated as the result of a given BMP. The number of discharges that were "significantly degraded" was so few (for example, 2 out of 225 discharges had resulting increases in acidity load) that these discharges could not be included in the statistical evaluation. For this reason, the evaluation had two possible outcomes, (a) no difference and (b) at least improved (i.e., either improved or eliminated). The–parameters that were evaluated were flow and loads for acidity, iron, manganese, aluminum, and sulfate.

Statistically the two most effective BMPs in terms of load improvement were biosolids addition and alkaline redistribution. Biosolids addition is used on mine sites that have poor pre-remining vegetative cover, and can result in luxuriant vegetation, which increases transpiration. Biosolids may also reduce the amount of oxygen entering the mine spoil.

The incorporation of calcareous materials was broken into four BMPs: alkaline redistribution (i.e., the redistribution of naturally-occurring alkaline strata so that it is present throughout the backfill), mining alkaline strata, alkaline addition at rates greater than 224 Mg/ha (100 tons/acre), and alkaline addition using rates less than or equal to 224 Mg/ha. The most effective of these was alkaline redistribution, which resulted in improvement for all parameters. Mining of alkaline strata improved acidity and sulfate loads, but not metal loads. Alkaline addition at rates > 224 Mg/ha improved only acidity load. Alkaline addition at rates less than 224 Mg/ha had no effect on pollution loads. The decreasing success from alkaline redistribution to alkaline addition < 224 Mg/ha is probably due to progressively decreasing quantities of calcareous materials.

Special handling also had no effect on pollution loads. Special handling plans are often complex and difficult to carry out. The removal of coal refuse resulted in improvement for acid load, but not for the other parameters. Over the long term, however, improvement inevitably will result from implementation of this BMP. Removing refuse results in the elimination of pollutants.

Although BMPs typically were less effective when used alone, heaping BMP upon BMP also was not an effective solution. Statistically, water handling and special handling were less effective when used together than when used separately. The BMP combination of regrading, revegetation, daylighting, special handling and water handling was not effective at water quality improvement. Complex plans are difficult to carry out, are more expensive, may require handling material more than once, are difficult to inspect and are therefore, less likely to be performed as planned. Another explanation is that this effect may be the result of sites that were the most problematic from an acid drainage abatement standpoint. In an attempt to get the best result from difficult conditions, as many BMPs as possible were applied in the hope that collectively, they would overcome what may have been insurmountably difficult AMD abatement challenges.

In summary:

- Regrading, revegetation and daylighting account for much of the reduction in pollution load.
- Although the sample size was small, biosolids application appears to be an effective BMP.
- Plans that incorporate large quantities of calcareous material are effective BMPs. The larger the amount, the more effective. Negligible amounts, such as < 224 Mg/ha (100 short tons/acre), are not effective at reducing pollution load.
- Complex abatement plans with many BMPs do not necessarily improve the prospects for pollution load reduction.

Frequently Asked Questions and Common Misconceptions

While promulgating the remining rule, a series of workshops were conducted throughout the Appalachian coal mining region to explain the rule and how it can be implemented in a remining regulatory program. Through questions and discussion at these workshops, it became clear that the following terms and concepts needed to be explained:

- Hydrologic connection

- Commingling of waters
- Encountered and unencountered discharges
- Discharge relocation and the hydrologic unit concept
- Use of passive treatment technologies as a BMP

Hydrologic Connection

Discharges where the water originates partially or entirely from a defined recharge area are said to be hydrologically connected to that area. The actual flow path of the ground water from the recharge zone to the discharge point does not have to be clearly defined. A discharge can be hydrologically connected to a remining operation without ever being physically encountered by that operation.

Commingling

Commingling is the mixing of two wastewater streams prior to treatment or discharge. For example, allowing an abandoned underground mine discharge to mix with pit water in an active remining operation. The term commingling does not apply to natural groundwater flow from an active or abandoned mine in a groundwater recharge area to some downgradient abandoned mine drainage discharge point. Natural groundwater flow does not include drilling boreholes to convey pit waters to a lower aquifer or underlying abandoned underground mine, nor blasting the strata beneath the pit floor to induce fracture flow to underlying strata.

Encountered verses Unencountered

An encountered discharge is a pre-existing pollutional discharge that is physically intercepted during mining. This water commonly ends up in the active pit and usually cannot be separated from the normal ground water that a mining operation intercepts, thus becoming commingled. Encountered discharge examples include a coal outcrop discharge that is mined through, dewatering of a flooded pit or daylighting into a flooded deep mine. Once encountered, this water must be treated to the more strict CFR 434 effluent standard until it is no longer encountered. Once an area is no longer being actively mined and has been regraded, the mine water is no longer being encountered and the alternate effluent standard established from baseline applies.

An unencountered discharge is a pre-existing pollutional discharge that is hydrologically connected to, but not physically intercepted by, the mining operation (Fig.4a); a discharge that will be or has been intercepted during mining but has been physically rerouted (e.g., piped or trenched) away from the active operation (Fig. 4b); or an encountered discharge that was intercepted during the operation, but is no longer being encountered (e.g., that portion of the mine has been regraded or reclaimed) (Figs. 4c and 4d). Unencountered discharges within the permit boundary are subject to the alternate remining effluent limits. Those outside of the permit boundary may or may not be subject to the alternate effluent limits depending on state-specific regulations and case law.

Discharge Relocation and Hydrologic Units

It is common for pre-existing discharges to be relocated in the course of remining. Remining may also change the number of mine discharges after reclamation. For example, where several discrete discharges existed pre-remining, after the entire area is surface mined and replaced with highly conductive mine spoil, the result may be a single but higher volume discharge at the structural low-point of the mine. To address pollution loading accounting problems that could result from this effect, hydrologic units can be established for discharges that originate from or are fed by a common recharge area. A total pollution load effluent limit can be established for each hydrologic unit that can be applied to the relocated or the new number of post-remining discharges. Pre-remining baseline data can be directly compared to post-remining data using the hydrologic unit method.

Use of Passive Treatment as a BMP

Under the recently promulgated remining rule, passive treatment technologies were included as one of the BMPs that can be used. Questions have arisen concerning the difference between passive treatment technology used to ameliorate pre-remining discharges and its use to treat a newly-created discharge. To be considered as a remining BMP, passive treatment must:

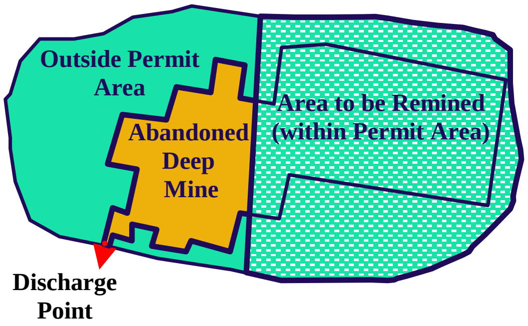

Figure 4a. Example of an unencountered discharge.

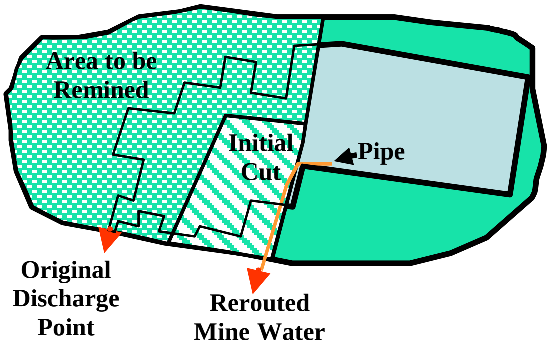

Figure 4b. Unencountered discharge and rerouted mine waters during cut 1.

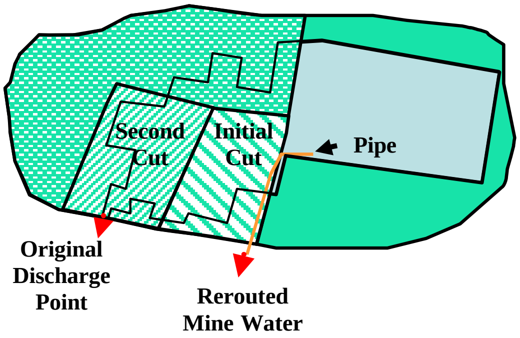

Figure 4c. Now unencountered discharge and rerouted mine water during cut 2 (second cut has been reclaimed).

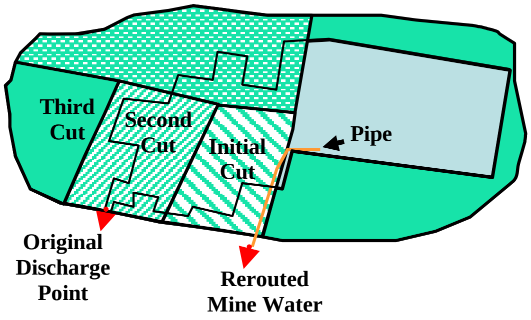

Figure 4d. Encountered discharge and rerouted mine water during cut 3.

- be an integral part of the pollution abatement plan that is developed and submitted as part of the remining permit application.
- have specifications as proposed by the operator in the application and approved by the regulatory authority in the issued permit.
- not have been required by an enforcement action due to noncompliance for water quality that arises during or after mining.
- not preclude bond release, unless the alternate (remining) effluent limits are being exceeded.

BMP-Based Remining Permits

Due in large measure to the demonstrated track record of remining in improving water quality, many state mining agencies believed that the time was right to establish a class of remining permits that, rather than establishing specific numeric effluent limits for pre-existing discharges, would base compliance on a demonstration that the required BMPs were successfully and completely implemented. This became known as the BMP-based remining permit. It was recognized that there were several circumstances where the establishment of a valid baseline pollution load was impossible, or that it would be impossible to judge whether a baseline had been exceeded or indeed to even treat the discharge if the baseline was increased. These situations fall into four general classes:

1. Diffuse seepage zones where the discharge is not amenable to collection and flow measurement.
2. Discharges that occur as direct baseflow to receiving streams and therefore are impossible to collect, measure or treat.
3. Discharges located on cliff faces or very steep areas that cannot be collected and measured or treated.
4. Discharges that are so large relative to the size of the remining operation that it would be impossible to detect any remining-induced effect.

Fig. 5a through 5d show examples of these situations. In these cases, conventional remining permits cannot easily be applied, resulting in a disincentive to remining. Recognizing this problem, Pennsylvania DEP requested authorization under EPA's Project XL program to conduct a pilot project to permit 8 remining operations using a BMP-based approach rather than with specific numeric effluent limitations for preexisting discharges (other discharges from the operation still have conventional numeric effluent limits). Under the Pennsylvania model, compliance was measured based on fully completing all components of the abatement plan, including the successful implementation of all BMPs. Further, compliance also required that in-stream water quality monitoring, as measured at a key stream monitoring point, meet baseline (pre-remining) standards or improve. Although the implementation of this pilot project continues, Pennsylvania anticipates the development of a regular permitting program using this approach. Further, the EPA remining regulations authorize a BMP-only permit in the four limited cases where baseline monitoring is not feasible. On these permits, given the absence of any numerical effluent limits, a well thought out and completely implemented pollution abatement plan will be especially important and is one of the reasons for EPA's development of a BMP guidance manual.

Figure 5a. Drainage from an abandoned underground mine discharging directly into receiving stream with no suitable location to monitor flows.

Figure 5b. Acid drainage seeping directly from the face of an abandoned highwall.

Figure 5c. Discharge from an abandoned underground mine that discharges directly to a stream via boreholes.

Figure 5d. Drainage from the Jeddo Tunnel mine discharge near Hazleton, PA. Flow at the tunnel is 3,100 l/sec (50,000 gpm) making it virtually impossible to detect any impact from a small remining operation.

Summary and Conclusions

Remining is an effective means of improving water quality from pre-existing pollutional discharges. It is also a viable method of reclaiming abandoned mine lands, without the use of AML funds or other public monies. Prior to the implementation of remining regulations, many coal resources were rendered unrecoverable due to potential treatment liabilities. Remining regulations, which require the implementation of BMPs designed to improve water quality and limit liability to baseline water quality conditions, effectively remove the undue legal liability and made these reserves feasible for remining.

There are two principal components of a remining plan. First, it is necessary to establish a statistically valid pre-remining baseline pollution load so that there is a basis for determining the impact of the remining operation on pre-existing discharge quality. If the baseline were exceeded following remining, it would also establish the required level of post-remining treatment. Second, the permittee must develop and implement a pollution abatement plan that incorporates BMPs designed to reduce pollution loading rates from pre-existing discharges.

In many cases, the pre-existing discharges are improved by pollution abatement procedures implemented during remining and reclamation. The track record to date for remining has been nothing less than remarkable. The overall success rate for 112 sites in Pennsylvania was better than 98%. Because of this high success rate, an additional class of remining permits was developed that bases performance on implementation of BMPs rather than on effluent limits from pre-existing discharges.

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