WATER QUALITY CHANGES AND COSTS OF REMINING IN PENNSYLVANIA AND WEST VIRGINIA

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Abstract

Remining is the surface mining of previously-mined and abandoned surface and underground mines to obtain remaining coal reserves. Remining operations create jobs in the coal industry, produce coal from previously disturbed areas, and improve aesthetics by backfilling and revegetating areas according to current reclamation standards. Remining operations also reduce safety and environmental hazards by sealing existing portals and removing abandoned facilities, enhance land use quality, and decrease pre-existing pollutional discharges. Ten sites in the Appalachian Coal Region were selected to: 1) compare the costs associated with remining and reclaiming a site to current standards vs. costs associated with reclaiming the site by abandoned mine land (AML) programs, and 2) evaluate water quality changes before and after remining. All of the remining operations in our study resulted in environmental benefits. Dangerous highwalls were eliminated, spoil piles were regraded, coal refuse left on the surface was buried, and sites were revegetated with a mixture of grasses and legumes to provide productive post remining land uses. In all but two cases, coal mined and sold from the remining operation produced a net profit for the mining company. While AML reclamation removes hazards and improves aesthetics on AML sites, remining these 10 sites saved the AML reclamation fund an estimated $4 million. Water quality after remining improved in all cases. Impediments to remining AML sites should be removed so that mining companies will actively select previously-disturbed and abandoned sites for remining and reclamation.

Introduction

According to state and federal records, approximately 220,000 acres in Pennsylvania and 160,000 acres in West Virginia (690,000 acres in Appalachia) had been disturbed by coal mining before 1977. The Surface Mining Control and Reclamation Act (SMCRA) of 1977 defined abandoned mine land (AML) as lands that were mined, left in an inadequate reclamation status and abandoned before August 3, 1977, with no continuing reclamation responsibility by any individual or company under state or federal laws. The vast majority of this AML acreage was in some stage of natural reclamation with various amounts of grass and tree cover on the site (Ashby 1984, Bramble and Ashley 1955, Hedin 1988, Skousen et al. 1994). A smaller acreage had serious safety and environmental hazards associated with them. Safety hazards included mine openings, unstable spoil and refuse piles, highwalls, abandoned facilities and water or slurry impoundments. Environmental problems included unvegetated areas, extensive erosion and sedimentation, acid soils, and polluted mine drainage.

SMCRA provides for an "abandoned mine land reclamation fund", which is to be used for reclamation of areas affected by past mining. This fund is generated by taxing current coal operations on every ton of coal mined. The money is returned to states with coal regulatory reclamation programs (primacy) to reclaim AMLs that have a high priority rating. Sites that have the potential to affect the health or safety of the public receive the highest priority. While many hazardous sites have been reclaimed since 1977, still more sites need attention and require reclamation, but the money necessary to correct all AML problems far exceeds the amount that may be collected. In fact, the Office of Surface Mining (OSM) is concerned that only an estimated 10 percent of the nation's AML problems will be corrected over the life of the AML reclamation program (originally scheduled from 1977 to 1992). In 1992, Congress reauthorized the coal production tax to generate AML funds from 1992 to 2004. Even with this reauthorization, alternative solutions must be found to reclaim remaining AML sites.

Remining provides an alternative mechanism to reduce safety and environmental hazards, improve aesthetics, enhance land use quality and decrease pre-existing pollutional discharges on AML. Remining allows an operator to remove remaining coal reserves that were left on the site from previous surface or underground mining and reclaim the entire AML site to current reclamation standards. Therefore, remitting operations provide income through coal production, create jobs in the coal industry, and afford environmental enhancement through reclamation of previously-affected areas. Remining has been documented to improve water quality (Hawkins 1994a, 1994b, and 1995) primarily due to reductions in flow from the reclaimed site, which in turn reduces contaminant loadings. Water quality is also improved by removal or burial of high sulfur coal wastes and shale, fragmenting and mixing overlying alkaline overburden with unreclaimed acid spoils, and regrading and revegetating the mine site (Skousen and Larew 1994). Indeed, remitting may reduce the pressure on mining virgin areas. Remining can also clean up a wider diversity of AML sites than the current priority system for selecting AML reclamation sites in state and federal programs.

Remining, however, is not without risks. Pre-remining coal estimates are often incorrect due to inaccurate underground mine maps and unknown surface augering activities. Therefore, less coal may be available for removal from the site than was anticipated. Most mining companies are also wary about mining sites where there is the possibility of a significant long-term water treatment liability. Although remining is occurring, remining companies generally avoid sites that contain pre-existing pollutional discharges because the remining company may be required to chemically treat the AMD for an indefinite period. Recently, these concerns have been lessened by the issuance of "remining NPDES permits" (National Pollutant Discharge Elimination System) that assign no liability unless the remining operation degrades pre-existing water quality.

This study was conducted to: 1) compare costs of reclaiming remined sites to current standards and costs estimated for AML reclamation, and 2) evaluate water quality changes between pre- and post-remining discharges. Five of the sites are located in western Pennsylvania and the other five are in West Virginia.

Materials and Methods

Coal operators and consultants were contacted to gather information on 10 remining sites. Surface mine permits were also used for gathering information. Based on diagrams of slope and acreage in the mining and reclamation plan in the permit, we calculated volumes of overburden moved during remining, and these volumes were confirmed by interviewing personnel on-site during remining operations. Costs for moving material were estimated at $1.00 per cubic yard for material regrading, and $ 1.25 per cubic yard for excess overburden handling. During this interview with on-site personnel, operators were also asked to explain special reclamation procedures they may have used on the site during remining and the costs for these activities. Topsoiling and revegetation costs were estimated at $2,500 per acre. Total reclamation costs for the remining site were then determined. Tons of coal removed from the site were also determined from coal records and income received from coal sales was calculated based on the tonnage sold and the selling price of the coal at the site (varied between $25 and $32 per ton). Net profit or loss was estimated by subtracting mining and reclamation costs from coal sales. Using basic formulas from the West Virginia Division of Environmental Protection(WVDEP) AML Office and interviews, we calculated the costs of reclaiming these sites to AML standards. This calculation was based on the acreage previously disturbed (not on the size of the remining permit), and included estimates of overburden volumes and the cost of regrading, elimination of highwalls, topsoiling, and revegetation.

Water quality changes were evaluated based on documentation of pre-existing discharges (the flows and quality) vs. post-remining discharges (flows and quality). Costs for treating pre- and post-remining discharges were calculated on a spreadsheet. The spreadsheet calculates the tons of acidity per year based on average flows and acid concentrations and the amount of chemical necessary to treat the discharge (Skousen et al. 1996). Costs for chemical treatment were based on 20% liquid caustic (NaOH) at $0.60 per gallon for discharges less than 50 8pm, and calciumoxide (CaO) at $240 per ton for flows greater than 50 8pm (Skousen and Ziemkiewicz 1996). The cost to treat AMD per year were determined by doubling the chemical costs for caustic systems and tripling the chemical costs for CaO systems to account for sludge handling costs, pumping, and other incidental costs.

Results and Discussion

Table 1 contains general information for each remining site. These sites were located in western Pennsylvania and north-central West Virginia. The majority of remining activities occurred in the 1 980's, and the sites varied in size from 8.7 to 450 acres. All of the sites showed the effects of past surface mining activities including abandoned highwalls, coal refuse on the land surface, and unreclaimed spoil piles. During remining, some of the sites daylighted underground mine workings, while others encountered surface mining auger holes.

The Hooks site is located in Butler County, PA. About 8.7 acres of land previously disturbed by surface and underground mining were remined for the remaining Brookville coal reserves (lower Allegheny formation, also referred to as the Clarion coal). Prior to remining, the site consisted of an open surface cut, unreclaimed spoil, and coal waste (gob) associated with abandoned underground mining operations. The site was remined under a subchapter F remining permit approved in 1987 by the State of Pennsylvania. Mining occurred between October 1987 and September 1989. During reclamation, spoil piles and highwalls were regraded to approximate original contour, one clay seal was constructed in a deep mine opening, and all disturbed areas were revegetated with grasses and legumes. All bonds associated with remining have been released. The site currently has an excellent vegetative cover and there are no visual remnants of me past or recent mining activities. Total mining and reclamation costs for the site were estimated at $375,000 (Table 2). The permit application estimated that the recoverable coal reserves to be 53,500 tons, but more deepmine workings were encountered than expected and the actual total coal recovery was approximately 40,000 tons. Estimated AML reclamation expense was $56,500. A estimated net profit of about $625,000 was obtained by remining this site.

One mine water discharge existed on the site previous to remining (Table 3). Four years of monitoring indicated that the discharge was slightly degraded (average acidity=10 mg/L, average sulfate=164 mg/L). The discharge flowed at an average 188 8pm, but surged during wet periods to more than 500 8pm. The applicant considered more rapid runoff and less infiltration due to reclamation a highly positive consequence of remining. As part of the remining application, costs of chemical treatment were estimated. Costs for a calcium oxide treatment system followed by a sedimentation pond for sludge collection were estimated for the pre-remining discharge at $2,980 per year.

Remining at the Hooks site successfully eliminated hazardous remnants of past mining and created a productive, visually attractive site. Water quality, which was marginally contaminated before remining, was improved with chemical treatment costs being reduced by two-thirds. Average flow rates decreased by 43%, which was largely due to the elimination of extremely high flow events. Acidity and metal concentrations were similar in both pre- and post-mining data sets. Sulfate concentrations doubled with remining. Contaminant loadings decreased overall because of lower flow rates.

The Dellich site is located in Butler County, PA. The site was an abandoned surface mine with a highwall, open final cut and unreclaimed spoils below the entire remining area. The company reclaimed 12 acres of surface spoils, eliminated 4,500 feet of highwall, daylighted 3 acres of underground mine, mined 10 acres of solid Middle Kittanning coaland augured an additional 17 acres. The site currently has no visual vestiges of the AML conditions and is being used by the landowner for livestock grazing. The total cost of mining and reclaiming the site was $879,000, while the estimated AML reclamation expense was estimated to be $84,500. The mining operation produced about 76,000 tons of Middle Kittanning coal. The 3 acres of daylighted underground mine produced 5,000 tons, 34,000 tons were recovered by surface mining solid coal, and 37,000 tons were recovered from auguring operations. Over $ 1 million in estimated profit resulted from the remining of this site.

Three discharges existed on the Dellich site before remining. The discharges were characterized by low to moderate flows of marginally acidic (7- 10 mg/L) water. Remining improved water quality at the site primarily by decreasing flow. Flow from one discharge was completely eliminated by remining, while the flows from the other two discharges were decreased by ~70% and ~25%. Concentrations of Fe, which were <2 mg/L before remining, remained low. Concentrations of acidity decreased slightly. Concentrations of sulfate increased by ~450 mg/L at each dischargepoint.

The Beal site is located in Butler County, PA. Prior to remining, the site consisted of unreclaimed spoils, piles of refuse associated with an abandoned underground mine, subsidence depressions, and collapsed mine entries. There mining job consisted of 22.5 acres of Middle Kittanning coal, which was mined between August 1984 and July 1996. During mining and reclamation, 3 acres of deep mine workings were daylighted, refuse was reburied using special handling techniques, 2,000 feet of highwall were eliminated, 6 acres of spoil were recontoured, and the site was vegetated with grasses and legumes. A total of 19.5 acres of solid Middle Kittanning coal were also mined. All bonds associated with the remining were released. The site is currently being used as a hayfield and pasture. Total mining and reclamation costs for the site were about $ 1.1 million and the estimated AML reclamation costs for the original 6 acres of disturbed area were estimated at $39,000. The mine produced approximately 75,000 tons of Middle Kittanning coal for an income of almost $ 1.9 million. Three acres of daylighted underground mine produced 5,000 tons and 70,000 tons of coal were recovered from 19.5 acres of solid coal. A net profit was estimated at close to $800,000.

Previous to remining, three discharges were identified at the Beal site. One discharge, which flowed at an average rate of 26 8pm before remining, was eliminated by mining activities. Flow rates at the other two discharge points were decreased, but not eliminated with remining. One of the two discharges was marginally contaminated before remining (pH 5, acidity=23 mg/L) and improved slightly with remining. Resulting contaminant loadings were about 50% less than pre-remining. Sulfate concentrations increased slightly with remining. The second discharge carried the bulk of pre-remining water pollution. The eight pre-remining water samples from this discharge averaged 110 mg/L acidity, <1 mg/L iron, 15 mg/L manganese, and 388 mg/L sulfate. Remining improved the discharge by decreasing flow by 50%, acidity concentrations by 65%, and manganese concentrations by 40%. Sulfate concentrations increased by 50%. Contaminant loadings were markedly decreased by remining. Acidity loadings, in particular, decreased by 88%.

The **Solar** job is located in Allegheny County, PA. The area was the site of the abandoned Solar underground mine and extensive surrounding surface mining activities. All mining was in the Pittsburgh coal bed. Prior to remining, there existed approximately 380 acres of underground coal workings and 450 acres of unreclaimed surface mines(generally ringing the site along the coal crop line). Waters flowing from the underground mine and surface refuse piles were all extremely acidic. The site was remined under a cost-plus contract with a local utility. The terms of the contract allowed remining of coal with much higher overburdens than is normally the case. In this area, remining operations generally take no more than 50 feet of overburden cover, but the average overburden cover for this job was approximately 150 feet. When the contract expired and was not renewed, remining ceased.

Approximately half of the underground mine workings was removed during there mining operations.

Much of the pre-remining data for the Solar Mine was obtained from an Operation Scarlift report prepared for Pennsylvania by Ackenheil and Associates (1976). The Operation Scarlift report considered the cost of subsidized daylighting of the Solar mine. In particular, the net cost of daylighting 87 acres of deep mine and reclaiming 200 acres of AML was evaluated. The remining subsidy proposed by the Operation Scarlift report in 1976 was estimated at about $10 per ton of coal mined. This subsidy, which was proposed to be paid by the Commonwealth's AML program, was subsequently paid by the electrical utility. The coal operator reports that remining operations in this area typically recover about 5,000 tons of coal per acre. Based on the 180 acres that were mined, total mining and reclamation costs were $17.8 million, and the AML reclamation expense of the original 450 acres of unreclaimed area was estimated at $2.9 million. The 180 acres of remined Solar Mine produced approximately 900,000 tons of coal, for a total income of $22.5 million. The difference between costs and income brought an estimated net profit of $4.7 million. Remining eliminated dangerous highwalls, pits, and spoils and created a well vegetated, gently rolling site that blends in with the surrounding landscape. Part of the reclaimed site is being used for a livestock operation.

One major mine water discharge flowed from the Solar Mine, and this source was identified in the Operation Scarlift report as the single largest contributor of AMD to Raccoon Creek. As part of the Operation Scarlift investigation, water costs were estimated at $250,000 per year for a lime plant designed to treat the AMD. The treatment plant was never constructed. Our estimate of water treatment costs with calcium oxide was more than double the estimated hydrated lime treatment costs. Water quality was dramatically improved as a result of remining. Improvement resulted from decreased flow rates and contaminant elimination. With the completion of remining activities, discharges developed at three locations and all three discharges are currently alkaline with negligible metal concentrations. These estimates indicate that flow from the site decreased by about 50% with remining and reclamation of AML.

Not all the Solar Mine was remined. A small discharge currently flows from the southern portion of remaining Solar underground mine workings. This discharge is highly acidic and is chemically similar to the pre-remining discharge. The dramatic improvement of water quality in the remined Solar Mine is attributable to the removal of coaland associated black shale, and the fragmentation of a limestone bed that lies above the coal bed.

The Rider Mine was located adjacent to the Solar Mine in Allegheny County, PA. It was mined between 1984 and 1989 under the same cost-plus contract used for the Solar job. The site consisted of an 80-acre underground mine(Pittsburgh coal) ringed by approximately 110 acres of unreclaimed surface mines. Water discharging from the Rider Mine was highly acidic and polluted the headwaters of Potato Garden Run. The overburden averaged 60 feet and ranged as deep at 120 feet. The underground mine was completely remined. Refuse from both the Rider and Solar operations was disposed of on the Rider site. The remining aspects of the job are completed and most bonds are released. The site is well vegetated and blends into the surrounding landscape. The processing plant is currently being dismantled and one large coal fines pond still requires reclamation.

Pre-remining data for the Rider job was obtained from the 1975 Operation Scarlift Report. The report recommended the partial daylighting of 35 acres of underground mine and the regrading of 110 acres of unreclaimed surface mines. The subsidy for partial daylighting of the Rider Mine and reclamation of surrounding AML was estimated in 1976 at approximately $16 per ton of coal recovered. In actuality, the entire 80 acre underground mine was daylighted. The total cost of mining and reclaiming the 190 acre site was $9.3 million. Reclaiming the 110 original acres by AML reclamation was estimated at $715,000. Approximately 240,000 tons of Pittsburgh coal were recovered from the Rider daylighting operations. Because the operation was a cost-plus contract, the operator realized a net profit due to the subsidy. Because of high mining and reclamation costs on this site, we estimated that a subsidy of about $3.3 million was needed for this operation to break even (or about $ 14 per ton).

Two discharges flowed from the Rider site before remining. Both discharges were acidic, but flows, acidity concentrations, and loadings were considerably less than for the Solar Mine. Remining caused both discharges to become neutral to alkaline.

Remining eliminated most of the dangerous highwalls, pits and spoils and created a well vegetated, gently rolling site. Two water-filled pits, which were sources of water used in coal processing, remain on site and await reclamation. The water quality problems associated with two pre-remining discharges were completely eliminated. Both points now discharge neutral water with negligible contaminant concentrations. According to the mine inspector, no other major discharges developed after remining was completed. The refuse pile, which was capped with a waste lime product and spoil, discharges alkaline water with very low metal concentrations.

The Fairfax site is located in Tucker and Grant Counties, West Virginia. The site was ringed by a 40 ft highwall for the Little Pittsburgh coal with extensive abandoned underground works. The company daylighted 94 acres of underground workings by mountaintop removal and reclaimed the abandoned highwalls and spoils between 1981 and 1990. The site currently is an attractive landscape that is revegetated with grasses, legumes and trees. Total mining and reclamation costs were estimated at $6.9 million, while reclaiming the original 54 acres of disturbed land by AML were estimated at $351,000. The operation produced 244,360 tons of Little Pittsburgh and Morgantown coal, which produced almost $7.3 million in income. Net profit was estimated at $330,000.

Six discharges existed on the site before remining. The flows of these discharges were not determined before remining and, according to the operator, all discharges were about pH 6.0 (for comparison, we assumed an acidity of 10mg/L). After remining, water quality was measured for 14 months and showed the discharges to have an average flow of 1,088 8pm, pH of 6.5, average acidity of 5 mg/L, and an iron concentration between 0.5 and 1.0 mg/L. It is hard to conceive of the water actually becoming worse on this site due to remining. The calcareous shale overlying the Little Pittsburgh coal was specially handled and placed on the Little Pittsburgh pavement to seal it from water and to neutralize the acidity. Since there was no definitive data taken from point sources before remining, it is believed that water quality coming from the site has been improved.

The Benbush site is located in Tucker County, West Virginia. The site had been surface mined and augered by a previous operator. The remining operator recut the 12,000 linear feet of highwall to economic limits (to an average of about 70 feet of overburden cover), daylighted pre-existing auger holes, augered further into the hillside from his final highwall, eliminated the new highwall and reclaimed the entire site to current standards. The 211-acre site is beautifully vegetated and no visual signs of AML conditions are apparent. The total cost of mining and reclamation for this site was about $14.5 million. Estimated AML expense for the 205 original disturbed acres was $ 1.3 million. About 514,800 tons of Upper Freeport coal were produced from the operation, producing an income of $15.5 million. Net profit on the site was estimated at nearly $l million.

A 12-month baseline study reports nine discharges from the site. Like Fairfax, no flows were measured before remining, but the water pH was around 5.5 with an average of 10 mg/L acidity concentrations. Four of the discharges were eliminated and others that have appeared or remain have a pH of 6.1 and a slightly decreased average acid concentration of 7 mg/L.

The Big Mountain site is located in Greenbrier County, West Virginia. The Sewell coal bed had been surfacemined previously, leaving a highwall. The currant remining operator recut the highwall along the Sewell coal and augered the coal, and also surface mined the Castle coal bed 150 feet above the Sewell. The spoil generated from the overlying Castle coal bed and the recut of the Sewell coal was used to eliminate highwalls and cover pre-existing spoil piles. The operation was 67 acres and the total cost of mining and reclamation was about $7. 1 million. The AML expense to reclaim the original disturbed 35 acres was estimated at $227,500. The operator reports 188,581 tons of coal were removed with an income of about $6 million. A net loss of about $ 1 million was estimated on this operation.

Only one pre-remining discharge was recorded on the site and it flowed at an average of 10 8pm with an average acidity concentration of 40 mg/L, and iron concentration of 5 mg/L. After remining, the discharge increased inflow to an average of 20 mg/L, but no acidity or metals were found in the water. The operator was estimated to lose money on this remining operation, but the remining activity greatly improved the visual appearance of the site and improved the water quality of a mildly acidic seep.

The Buffalo #1 and #2 sites are located in Harrison County, West Virginia. The Pittsburgh and Redstone coals had been mined previously in this area. This area is known for producing alkaline water after surface mining due to the abundance of alkaline red shales in the overburdens of both coal beds. Underground mining of these two coal bed soften produces slightly acidic to neutral water, but laden with suspended iron. The remining operator recut the highwall of the Pittsburgh coal and completely removed the Redstone coal by mountaintop mining on both sites. The Buffalo #2 site mined an area of 180 acres, while the Buffalo #1 site mined approximately 145 acres. Total mining and reclamation costs were $8.3 million at Buffalo #2 and $7.3 million at Buffalo #1. The cost of reclaiming these sites by conventional AML programs was estimated to be $910,000 on 140 acres at Buffalo #2 and $780,000 for 120 acres at Buffalo #1. About 828,000 tons of coal were removed on Buffalo #2 (income of $23 million with an estimated net profit of $14.8 million) and 669,000 tons were removed on Buffalo #1 (income of $18.7 million and an estimated net profit of $940,000). No water quality problems existed on the site prior to or after remining.

Summary

All of the remining operations described in this paper resulted in highly significant environmental benefits. Previous to remining, all sites were characterized by dangerous and unsightly AML conditions with vertical highwalls of heights varying from 30 to 70 feet, barren landscapes, and poor water quality. Remining eliminated most of the AML scars and produced productive, valuable land. In addition, in all but two cases, remining produced significant profit to the remining operator and, in the process, provided jobs and state and federal tax money. The remining of the Solar and Rider sites in Pennsylvania were subsidized by a local utility. The Solar and Rider remining operations had spectacular water quality results. Highly acidic discharges were replaced with alkaline discharges. The refuse pile, where pyritic wastes from the Solar and Rider sites were buried, also discharges alkaline water. Most importantly, the receiving stream, Potato Garden Run is now alkaline and the quality of Raccoon Creek, which was dead in the 1970's, is significantly improved. For the three Butler county sites in Pennsylvania, pre-remining water quality problems were minor, so the improvements were not remarkable. Water quality at Fairfax and Benbush in West Virginia was improved slightly, and the acid water at Big Mountain was eliminated. No pre-remining water quality problems were known at the Buffalo #1 and #2 sites and post-remining water quality is also good.

The cost of these environmental improvements differed among sites as a result of the problems encountered on each site and their size. For the Hooks, Dellich and Beal sites, the full costs of mining and reclamation of the site were born by the coal companies. The same was true of all the West Virginia sites. The reclamation of these sites by remining companies saved the AML reclamation fund nearly $4 million in estimated reclamation costs. Clearly, this type of reclamation is preferred to publicly-financed AML projects. The Rider and Solar operations were conducted under a unique cost-plus mining contract that likely cost the utility rate payers ~$10/ton of coal mined. While expensive, the net cost of the two operations were still considerably less than reclamation options. In particular, the daylighting operations that caused the water quality improvements would never have been undertaken by a public agency. The results suggest privately financed remining projects are highly cost effective, and that subsidized remining activities can be another tool to be considered in stream restoration projects.

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Table 1. Characteristics of sites remitted for coal in Pennsylvania and West Virginia.

	Hooks	Dellich	Beal	Solar	Rider	Fairfax

Location (County)	Butler, PA	Butler, PA	Butler, PA	Allegheny, PA	Allegheny, PA	Tucker, Grant V
Permit Numbers	10823013 10820113	10830109	10840103etal.	2669BSM4 02813012	02803001	S-
Permit Issuance	1987	1984	1984	1969	1980	
Mining Period	87-89	84-86	84-86	70-91	84-89	
Mined Area (acres)	8.7	12.9	22.5	450.0	190.0	
Linear Ft Highwall	_	4,500	2,000	_	_	
Coal Seam	Clarion	Middle Kittanning	Middle Kittanning	Pittsburgh	Pittsburgh	Morgantown Little Pittsburg
Receiving Stream	Trip to Slippery Rock Creek	Findlay Run Slippery Rock Creek	Glade Run Slippery Rock Creek	Potato Garden Raccoon Creek	Potato Garden Raccoon Creek	Little Camp Ru
Previous Mining Activities	Surface and Underground	Surface and Underground	Surface, Under-ground, Refuse	Surface and Underground	Surface and	Surface and Underground
Preremining Data Source	Permit file	Permit file	Permit file	Operation Scarlift Report	Operation Scarlift Report	Permit file
Post-remining Data Source	Consultant's Records	Consultant's Records	Consultant's Records	DEP permit file	DEP permit file	Consultant's Records

Table 1. Characteristics of sites remined for coal in Pennsylvania and West Virginia.

	Hooks	Dellich	Beal	Solar	Rider	Fairfax	Benbush	Big Mountain	Buffalo #2	Buffalo #1
Location (County)	Butler, PA	Butler, PA	Butler, PA	Allegheny, PA	Allegheny, PA	Tucker, Grant WV	Tucker, WV	Greenbrier, WV	Harrison, WV	Harrison, WV
Permit Numbers	10823013 10820113	10830109	10840103 et al.	2669BSM4 02813012	02803001	S-25-81	S-26-81	S-3070-88	S-21-85	S-76-83
Permit Issuance	1987	1984	1984	1969	1980	1981	1981	1988	1985	1983
Mining Period	87-89	84-86	84-86	70-91	84-89	81-90	81-86	89-95	85-89	83-85
Mined Area (acres)	8.7	12.9	22.5	450.0	190.0	101.0	211.2	67.0	180.0	145.0
Linear Ft Highwall	----	4,500	2,000	----	----	8,400	12,300	2,400	17,832	13,000
Coal Seam	Clarion	Middle Kittanning	Middle Kittanning	Pittsburgh	Pittsburgh	Morantown Little Pittsburgh	Upper Freeport	Sewell and Castle	Pittsburgh and Redstone	Pittsburgh and Redstone
Receiving Stream	Trip to Slippery Rock Creek	Findlay Run Slippery Rock Creek	Glade Run Slippery Rock Creek	Potato Garden Raccoon Creek	Potato Garden Raccoon Crrek	Little Camp Run	Snyder Run, N Fork Blackwater	Brown Creek, Little Clear Creek	Buffalo Crk, West Fork River	Buffalo Crk, West Fork River
Previous Mining Activities	Surface and Underground	Surface and Underground	Surface, Under-ground, Refuse	Surface and Underground	Surface and Underground	Surface and Underground	Surface and Auger	Surface and Auger	Surface and Auger	Surface and Auger
Preremining Data Source	Permit file	Permit file	Permit file	Operation Scarlift Report	Operation Scarlift Report	Permit file	Permit file	Permit file	Permit file	Permit file
Post-remining Data Source	Consultant's Records	Consultant's Records	Consultant's Records	DEP permit file	DEP permit file	Consultant's Records	Consultant's Records	Consultant's Records	Consultant's Records	Consultant's Records

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Table 2. Estimates of overburden materials moved, total reclamation costs, coal tonnage and income, and estimated AML expense.

	Hooks	Dellich	Beal	Solar	Rider	Fairfax	Benbush	Big Mountain_	Buffalo
Overburden Regrading (Sl/cu.yd)	$211,667	$484,000	$756,400	$14,520,000	$ 8,873,000	$5,488,314	$ 12,100,000	$3,630,000	$7,13
Excess Overburden Handling ($l.25/cu.yd)	$138,750	$363,000	$264,500	$l,700,000	-	$l,192,750	$l,865,253	$4,448,772	$l,02
Surface Water Diversions Sales, Etc. ($3,000/scal)	800 1 seal	4,500 ft	2,000 ft	Other Costs $l,193,000	-	-	-	-	-
Topsoiling/Revegetation Costs (ac x $2,500)	8.7 ac $21,750	13 ac $32,250	22.5 ac $56,250	180 ac $450,000	190 ac $475,000	101 ac $252,500	211.2 ac $528,000	67 ac $167,500	1' $44
Total Cost Reclamation	$375,167	$879,250	$l,077,150	$17,863,000	$9,348,000	$6,933,564	$14,493,253	$7,134,079	$8,35

Coal Removed (tons)	40,000	76,000	75,000	900,000	240,000	244,360	514,800	188,581	82
Income Received ($/ton at site)	$l,000,000	$l,900,000	$l,875,000	$22,500,000	$6,000,000	$7,260,800	$15,487,000	$6,074,000	$23,18
NET PROFIT (Income-Reclaim.)	$624,833	$1,020,750	$797,850	$4,637,000	$-3,348,000	$327,236	$993,747	$- 1,060,079	$14,83
Estimated AML Expense	8.7 ac	13 ac	6 ac	450 ac	110 ac	54 ac	205 ac	35 ac	1·
(ac x $6,500)	$56,550	$84,$00	$39,000	$2,925,000	$715,000	$351,000	$l,332,500	$435,500	$1,15

Table 2. Estimates of overburden materials moved, total reclamation costs, coal tonnage and income, and estimated AML expense.

	Hooks	Dellich	Beal	Solar	Rider	Fairfax	Benbush	Big Mountain	Buffalo #2	Buffalo #1
Overburden Regrading ($1/cu.yd)	$211,667	$484,000	$756,400	$14,520,000	$ 8,873,000	$5,488,314	$12,100,000	$3,630,000	$7,139,000	$5,848,000
Excess Overburden Handling ($1.25/cu.yd)	$138,750	$363,000	$264,500	$1,700,000	---	$1,192,750	$1,865,253	$4,448,772	$1,025,467	$1,443,867
Surface Water Diversions Seales, Etc. ($3,000/seal)	800 ft 1 seal	4,500 ft	2,000 ft	Other Costs $1,193,000	---	---	---	---	---	---
Topsoiling/Revegetation Costs (ac x $2,500)	8.7 ac $21,750	13 ac $32,250	22.5 ac $56,250	180 ac $450,000	190 ac $475,000	101 ac $252,500	211.2 ac $528,000	67 ac $167,500	177 ac $442,500	145 ac $362,500
Total Cost Reclamation	$375,167	$879,250	$1,077,150	$17,863,000	$9,348,000	$6,933,564	$14,493,253	$7,134,079	$8,350,600	$7,293,400
Coal Removed (tons)	40,000	76,000	75,000	900,000	240,000	244,360	514,800	188,581	828,000	669,000
Income Received ($/ton at site)	$1,000,000	$1,900,000	$1,875,000	$22,500,000	$6,000,000	$7,260,800	$15,487,000	$6,074,000	$23,184,000	$18,732,000
NET PROFIT (Income-Reclam.)	$624,833	$1,020,750	797,850	$4,637,000	$-3,348,000	$327,236	$993,747	$-1,060,079	$14,833,400	$942,500
Estimated AML Expense (ac x $6,500)	8.7 ac $56,550	13 ac $84,500	6 ac $39,000	450 ac $2,925,000	110 ac $715,000	54 ac $351,000	205 ac $1,332,500	35 ac $435,500	140 ac $1,152,125	120 ac $942,500

Table 3. Water quality on 10 cites before and after reclining.

	Hooks	Dellich	Beal	Solar	Rider	Fairfax	Benbush	Big Mountain	Buffalo #2	Buffalo #1
Before										
GPM Flow	188	57	128	503 -	121	1,088	1,926	10		
pH	6.0	5.5	4.2	2.9	3.1	6.0	5.5	3.0		
Acid mg~L	10	9	57	1,490	415	10	10	40	Good	Good
Femg/L	1.0	1	< 1	404	30	< 1	< 1	5	Quality	Quality
Cost to treat/yr*	$2,980	$1,060	$6,470	$673,000	$44,540	$9,650	$17,000	$830		
After										
GPM Flow	108	21	71	263	19	1,088	1,926	20		
pH	6.0	5.5	4.9	6.5	6.0	6.5	6.1	6.0		
Acid	10	4	25	0	0	5	7	0	Good	Good
Fe	< 1	< 1	< 1	1	1	1	< 1	< 1	Quality	Quality
Cost to treat/yr*	$960	$175	$1,570	$0	$0	$4,825	$12,000	0		
Chemical	CaO	20% Caustic	CaO	CaO	CaO	CaO	CaO	20% Caustic		

*Costs for calcium oxide (CaO) were estimated at $240 per ton and 20% caustic (NaOH) was $0.60 per gallon (Skousen et d. 1996). Cost to treat/yr were determined by calculating tons of acid per year (flow x acid x 0.0022) times conversion factors (780 for caustic and 0.56 for calcium oxide) and costs for each chemical to treat the acid per year. These costs were then doubled for caustic and tripled for calcium oxide.

Table 3. Water quality on 10 sites before and after remining.

	Hooks	Dellich	Beal	Solar	Rider	Fairfax	Benbush	Big Mountain	Buffalo #2	Buffalo #1
Before										
GPM Flow	188	57	128	503	121	1,088	1,926	10		
pH	6.0	5.5	4.2	2.9	3.1	6.0	5.5	3.0		
Acid mg/L	10	9	57	1,490	415	10	10	40	Good	Good
Fe mg/L	1.0	1	< 1	404	30	< 1	< 1	5	Quality	Quality
Cost to treat/yr*	$2,980	$1,060	$6,470	$673,000	$44,540	$9,650	$17,000	$830		
After										
GPM Flow	108	21	71	263	19	1,088	1,926	20		
pH	6.0	5.5	4.9	6.5	6.0	6.5	6.1	6.0		
Acid	10	4	25	0	0	5	7	0	Good	Good
Fe	< 1	< 1	< 1	1	1	1	< 1	< 1	Quality	Quality
Cost to treat/yr*	$960	$175	$1,570	$0	$0	$4,825	$12,000	0		
Chemical	CaO	20% Caustic	CaO	CaO	CaO	CaO	CaO	20% Caustic		

*Costs for calcium oxide (CaO) were estimated at $240 per ton and 20% caustic (NaOH) was $0.60 per gallon (Skousen et al. 1996). Cost to treat/yr were determined by calculating tons of acid per year (flow x acid x 0.0022) times conversion factors (780 for caustic and 0.56 for calcium oxide) and costs for each chemical to treat the acid per year. These costs were then doubled for caustic and tripled for calcium oxide.