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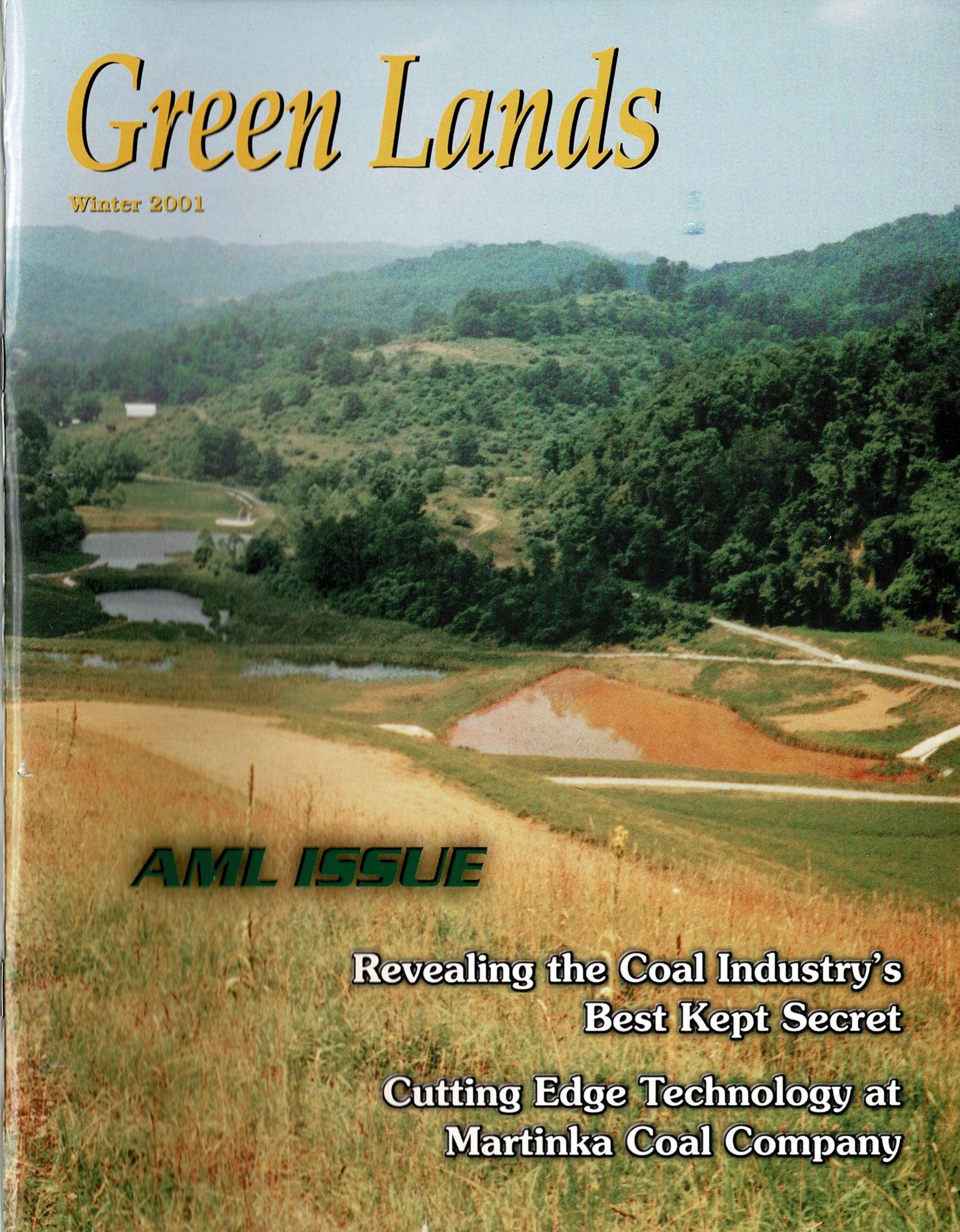

Green Lands

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On the Cover
Grass Run, located just outside of Weston in Lewis County, was reclaimed under the Abandoned Mine Lands program which is funded by the coal industry. Construction was completed during the fall of 2000, at a final cost of $1.45 million. See more AML sites starting on page 16.

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ADVERTISING INDEX

The Coal Industry's Best Kept Secret

"This is the state's only industry-funded program that provides improvements to the community. . ."

Many West Virginians realize and appreciate that 99 percent of West Virginia's abundant and economical electricity is generated from coal. What they don't realize is that the state's coal industry has been providing funding for water systems that improve the quality of life for numerous state residential and business communities throughout West Virginia.

Upgrading water systems throughout West Virginia seems to be the coal industry's "best kept secret" for the past decade.

Since 1990, when attention shifted to clean water systems, the coal industry has provided nearly $50 million to improve water quality and the standard of living for more than 12,000 West Virginians in 13 counties.

"This is the state's only industry-funded program that provides improvements to the community with no direct cost to local residents and one we take great pride in," said Ben Greene, president of the West Virginia Mining and Reclamation Association.

Through the Surface Mining Control and Reclamation Act passed by the U.S. Congress in 1977, the coal industry pays a fee of 35 cents per ton for coal produced by surface mining and 15 cents per ton of coal produced by underground mining.

West Virginia coal operators produced 169.2 million tons of coal in 1999. As required by SMCRA, the industry paid approximately $36.4 million into the fund for last year, which is down from previous years.

A lawsuit by an extreme environmental activist group has contributed heavily to the decrease in production, which is directly related to the reduction in industry contributions to the AML fund that has been used to improve quality of life in West Virginia.

"All the money we have for the water system programs is coal related," said Charlie Stover of the West Virginia Environmental Protection's Office of Abandoned Mine Lands and Reclamation.

Stover also noted that in 2004 the fee collections for the program are due to expire, which could severely reduce the amount of funds provided to the AML program in the state if the program is not continued.

"We need Congressional approval to extend the fee collections so the program will be ongoing beyond that date," he said. "Otherwise fee collections will stop and there is no guarantee that the state will get money for AML projects. Pennsylvania, Kentucky and West Virginia all have problems that cannot be resolved quickly. The federal government wants us to finish up by 2010. I think that is impossible unless they give us additional monies, more than what they are giving us now."

Workers ease a pump station in place during construction in Mingo County. Pump stations such as this one provide pressure to fill up water tanks. Cost of this station was $195,000.

Stover has a list of 13 communities that are considered to be top priorities for water systems, which will cost the state more than $21 million to repair (see figure 1). In fact, the first two projects listed, "Davy to Roderfield" and "Mullens Regional" will cost the state close to $7 million to complete. Stover looks to get only about $5.5 million towards upgrading water systems in 2001.

In most cases however, communities are expected to make up the difference that the industry fund does not provide.

"We do a feasibility study to determine what other things are contributing to the degradation of the ground water table," Stover said.

Some communities, like the town of Davey, have not applied for its alternative funding, so they are a year away from getting this money and will not receive state money this year.

"What I'm going to do, is give them a commitment letter for this amount of money in the year 2002," Stover said.

"Mullens Regional has been contacted and they cannot get their money for a year, but I'm going to give them a commitment letter for the funding in 2002. With the level of funds required, we may have to extend it over two grants."

Stover also explained that once the project is designed it must be submitted to the Public Service Commission.

"Some of our major stumbling blocks are in getting the permits," he said. "The PSC can take 270 days to do a review on one of these jobs. A design has to go in with the permit application."

In 1990, Congress passed the water supply amendment to Title IV in the Surface Mining Control and Reclamation Act that allows state's up to 30 percent of these funds to help communities in need of quality water systems. States are eligible for this money if used towards protecting, repairing, replacing, or enhancing facilities relating to an area's water supply that was adversely affected by coal mining practices prior to 1977.

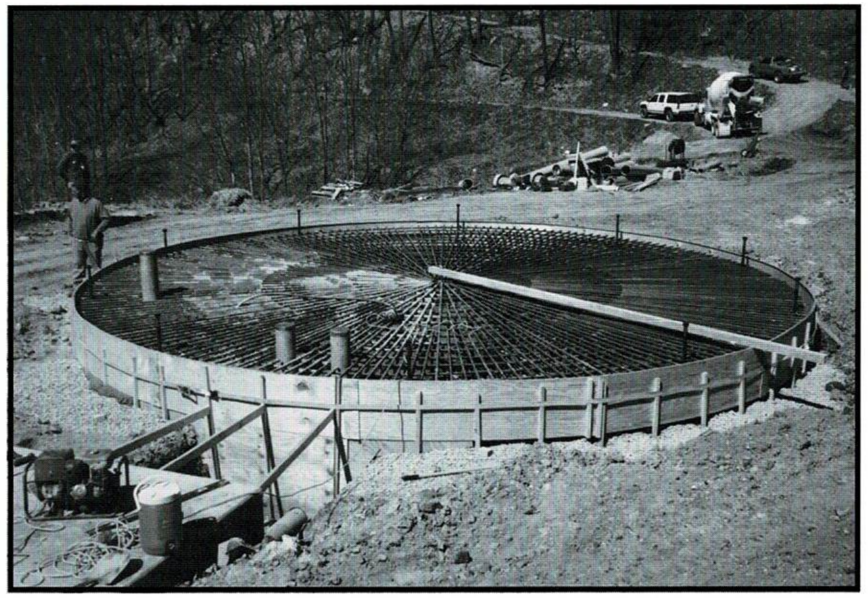
Stover noted that in order for a municipality to be eligible for the grant money, it must be predominately impacted by pre-1977 coal mining activity.

"Below 50 percent is not an eligible project because the way the statute reads, it has to be predominately effected, which is at least 51 percent."

To be considered for such funding, an area or town must submit an application to the Water Supply System Advisory Committee.

"The function of the WSSAC," Stover said, "is to approve the engineering feasibility study by the AML Office and to determine the projected eligibility based on the degradation attributed to eligible mining activities prior to August 3, 1977."

The WSSAC, established by the state's DEP, is charged with identifying and recommending water supply systems to be included in the State's future Abandoned Mine Lands and Reclamation construction grants application.



A foundation for a water tank is being constructed on Buffalo Mountain as a part of the Pigeon Creek project in Mingo County. This particular tank cost about $210,000 and will hold 263,000 gallons. Water tanks provide head pressure for the system.

This committee has representation from the DEP, the State Bureau of Public Health, the Federal Office of Surface Mining, the Public Service Commission, the WV Development Office, the Governor's Office of Community and Industrial Development and the West Virginia Rural Water Association.

"I have recommended to the WSSAC that the governor's Infrastructure Job and Development Council executive secretary be placed on the WSSAC as a voting member," he said. "This would bring the communication closer together as they will attend all of our meetings."

Stover said he has established a priority system that is different now than in years past.

"What I want to do is feasibility studies on all applications that we get," he said. "Then we are going to prioritize those based on the criteria that has been established and maintain a list which will give me a working list."

Figure 1: Eligible projects for the Spring of 2001.

Project	County	Percent Eligible	AML Contribution	Residents	Total Cost
Davy to Roderfield	McDowell	83%	$2,862,836	582	$3,449,200
Mullens Regional	Wyoming	76.8	4,465,920	671	5,815,000
Kingwood	Preston	100	1,500,000	125	1,500,000
Keyrock area	Wyoming	92	1,814,286	175	1,972,050
Mt. Zion	Preston	100	418,750	66	418,750
Coopers Rock/Pisgah	Preston	100	1,623,000	93	1,623,000
Gaymont/Edmund	Fayette	57	1,158,240	258	2,032,000
Belva/Vaughn	Nicholas	67	832,508	114	1,125,135
Spawlick & Arnolds Run	Barbour	71.1	885,906	88	1,246,000
Coaldale & Bramwell Hill	Mercer	80	1,200,000	74	1,500,000
Gauley River Rd.Rt.42	Webster	52	123,651	27	237,790
Kingsville	Randolph	100	1,600,000	45	1,600,000
Hominy Cr.(Rts. 44,20,13,17)	Nicholas	68	3,128,000	171	4,600,000
TOTALS			**$21,633,097**	**2,489**	**$27,118,925**

Funding Provided By The West Virginia Coal Industry For Water Projects Since 1990

Project	County	Coal Industry's Contribution
Cassity Fork	Randolph	$ 883,488
Century Volga/Elk City	Barbour	1,792,132 (Under Construction)
County Rt. 9	Preston	2,932,190 (Under Construction)
Cow Creek/Sarah Ann	Logan	4,766,478
Crooked Creek	Logan	728,824
Cucumber/Berwind	McDowell	6,113,806
Dogtown Road	Preston	927,194
Gauley River	Fayette	614,375
Glen Fork/Sabine	Wyoming	811,423
Godby Branch	Logan	640,119
Heizer/Manila	Putnam	1,470,632
Kanes Creek	Preston	199,184
Kelly's Creek	Kanawha	1,710,851
Marrowbone	Mingo	1,896,838
Mill Creek	Logan	3,000,000 (w/500,000 committed to Plant)
Moundsville Waterline	Ohio	245,373
Neibert Tapin	Logan	1,879,277
Norton Harding Jimtown	Randolph	768,822
Page/Kincaid	Fayette	2,034,605
Pigeon Creek	Mingo	7,354,650
Ragland/Delbarton	Mingo	722,464
Red Jacket/Matewan/Newton	Mingo	2,048,750 (Engineering Estimate)
Reynoldsville/Wallace	Harrison	1,547,000 (Engineering Estimate)
Rt. 41 Maplewood/Danese	Fayette	909,076
Scotch Hill (Newburg)	Preston	1,837,904
Turkey Run	Upshur	410,215
Upper Rum Creek	Logan	783,259
Washington Heights/Jeffrey	Boone	1,471,236 (Under Construction)
TOTAL		**$50,500,165**

The first project in West Virginia was completed in 1992 in the Neibert/Talpin area near Man in Logan County. This water improvement project cost more than $1.8 million, but has provided a dependable clean water supply for more than 1,000 area residents.

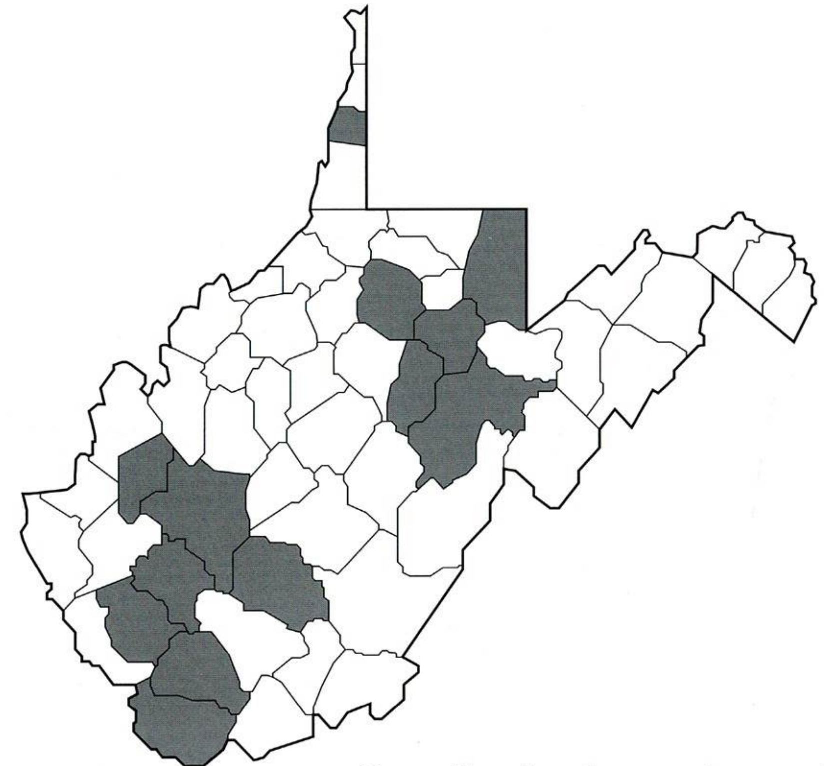
One significant project was Pigeon Creek in Mingo County. That project had five contracts and involved a 26-mile stretch of improved water systems.

"We could spend more money if we could get it," Stover said.

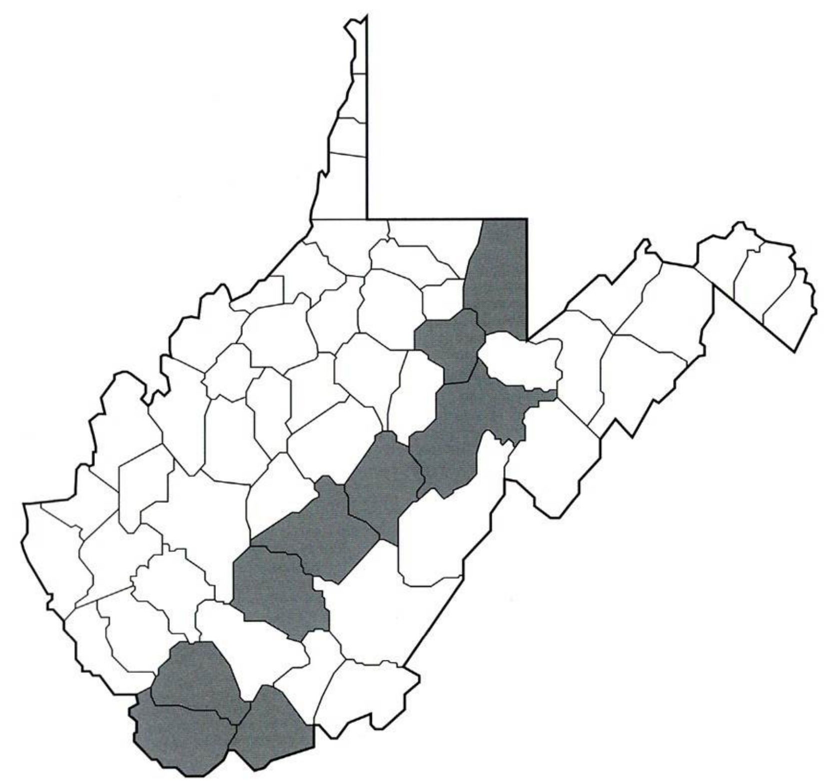
The coal industry is doing its share, many million times over for all of the good citizens of West Virginia.

Future projects that will be prioritized by the WSSAC after the engineering feasibility studies are completed by the AML office.

NAME	COUNTY	RESIDENTS
Drews Creek/Peachtree Creek	Raleigh	403
Glen Rogers	Wyoming	300
Blair/Sharples	Logan	672
Wheatley Branch	Logan	150
Jenny's Creek/Rt. 52	Mingo	290
Moundsville	Marshall	21,000
Elkins/Buckhannon	Upshur	660
Sandy Creek US 50/54	Taylor	60
Bell Creek Rts. 2/7	Fayette	84
Bridge Fork Rts. 60/21	Fayette	18
Jolo/Paynesville/Wolfpen St. Rt. 83	McDowell	Unknown
Glen Rogers	Wyoming	300
Pell, Ken Snyder & St. Joe Area's & Bird's Crk. Rd Rt. 58	Preston	175
Rt. 49 Areas of Lick Crk and Lobato	Mingo	250 People, 7 Businesses/ 3 Churches
Tioga Road Water Ext.	Nicholas	243 People/ 91 Business Cust.
Brushy Fork Committee for Water Service	Harrison	90 plus/10-15 Businesses
Macajah Ridge-Herndon Hts./Itman	Wyoming	150 people/1 Com.
Upper Laurel & Left Frk of Camp Creek	Wayne	450 people/2 Business
North Union Community Rd	Preston	N/A
Beverly & Don Taylor	Harrison	4 People/0 Business
Rt. 20/Gould Community	Upshur	57 homes
Town of Davis	Tucker	800 homes/tourists
Beech Crk & Ben Areas	Mingo	600/10
Pond Gap, Hitop, Spangler	Kanawha	291
Freemansburg Area	Lewis	112/5 Business
Community of Preston -St.Rt.72	Preston	70/28 homes
Town Run Area	Lewis	35/14 homes
7 County Rt. Roads-Gladesville Quad.	Preston	440 people/176 homes
Buckeye/Blazer/Kanetown Roads	Preston	92 People



Counties having water projects since 1990.



Counties eligible for water projects in the spring of 2001.

Carolina Refuse

Marion County

This site consisted of a 50 foot high wall, a seven acre coal refuse pile with steep outslopes that repeatedly eroded into an unnamed tributary of Helen's Run. Uncontrolled surface water runoff washed coal fines into the creek and degraded downstream water quality.

Approximately $290,500 was spent reclaiming the area including excavating and regrading 79,600 cubic yards of coal refuse, installing stream bank protection and conditioning and revegetating 11 acres.

Construction was completed in the spring of 2000.

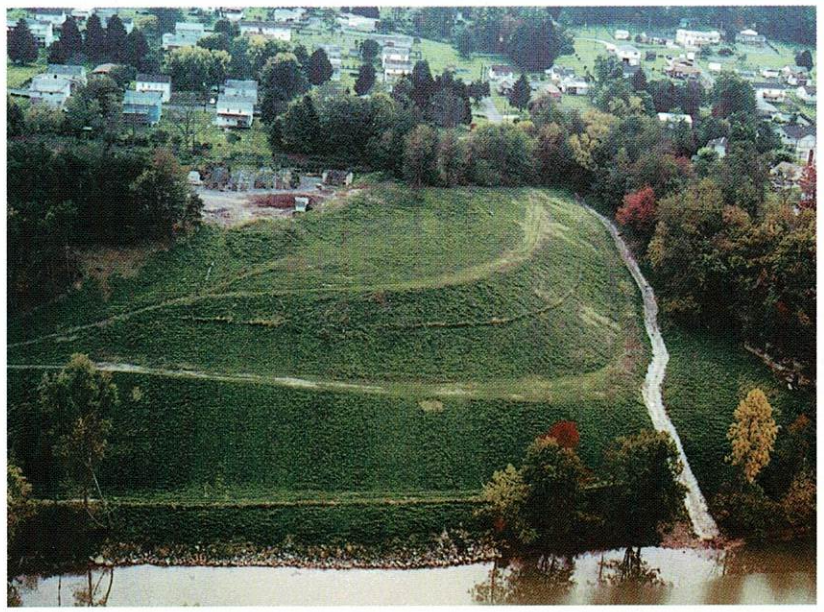
Riffe Mine Dumps and Complex

Raleigh County

Located near East Gulf, this project included four coal refuse piles and deep mine portals which contributed to sediment to Riffe Branch, a tributary of the Guyandotte River. Cost of this project was more than $650,000 and required seven months to complete.

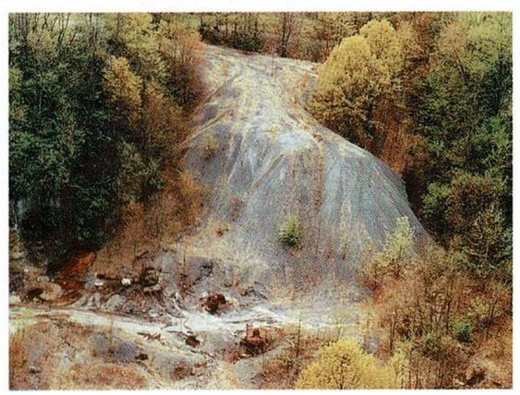
Watson Portals and Refuse

Marion County



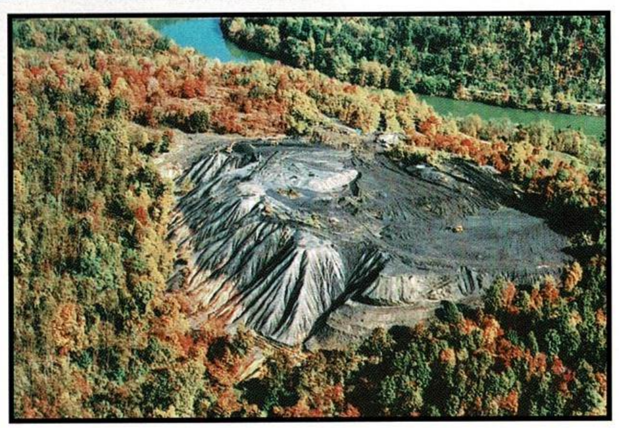
Located along the West Fork River this project consisted of a three-acre coal refuse pile with steep outslopes and three collapsed and draining deep mine portals. Also, the site had numerous hazardous facilities and mining equipment such as an old crane with a 100 foot boom; an old coal shovel; rusted metal bins; a portable loadout and a coal processing plant and other miscellaneous scattered mining debris.

A total of eight acres were regraded and covered with topsoil. Contractors removed five large pieces of dangerous equipment along with seven barges from area. Numerous surface water drainage controls were installed. Final revegetation of 13 acres were completed during the fall of 1999, at a final cost of $435,148.



Edna Refuse and Portals

Monongalia County



Located along the Monongahela River, this 57-acre deep mine complex and coal refuse facility had several large and small coal refuse piles, open and collapsed deep mine portals, and a barge partially submerged in the river.

Several of the 15 portals were completely open with large concrete canopies at their entrance allowing easy access by the public.

Approximately 142,000 cubic yards were excavated and regraded at a cost of $980,000.

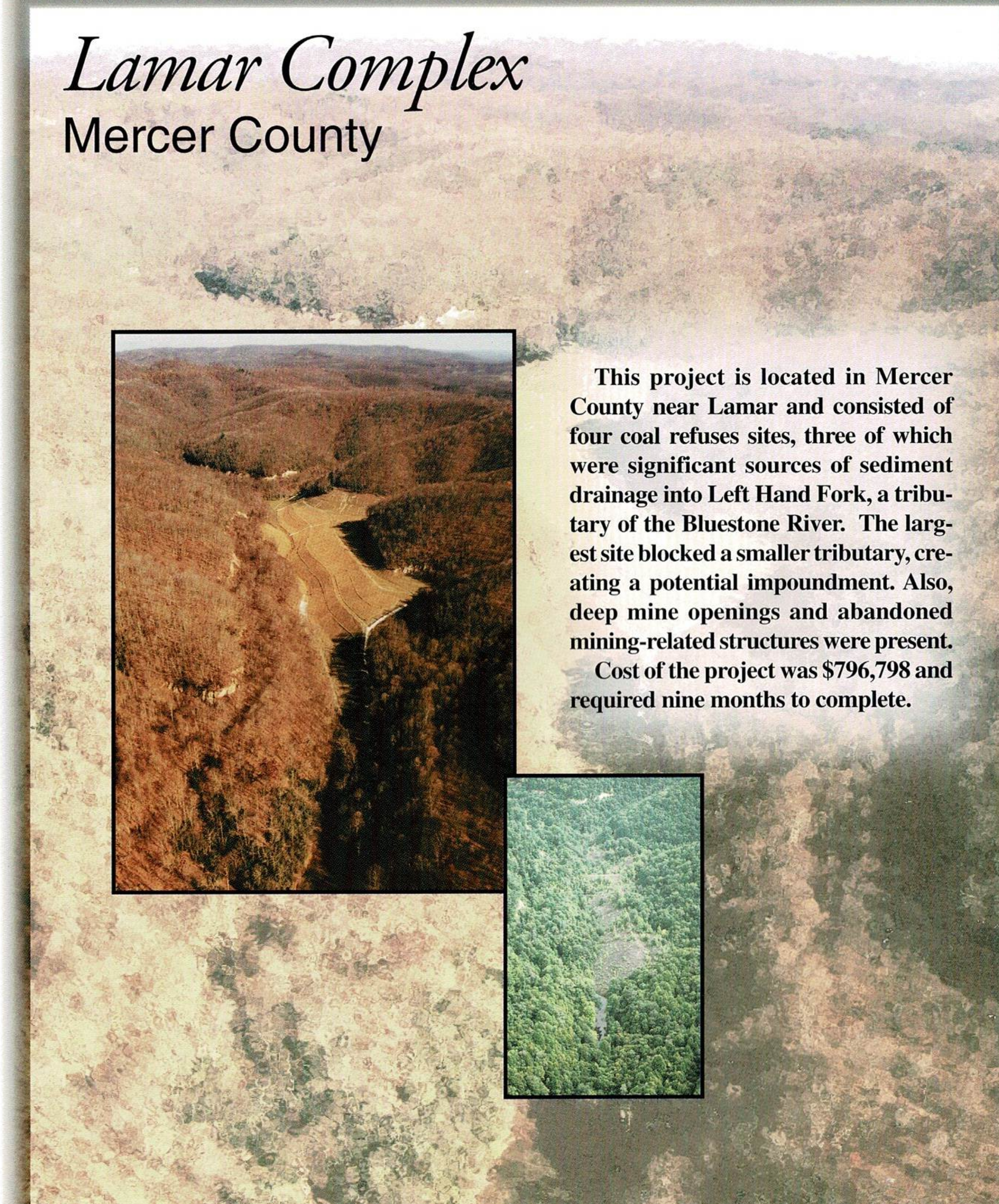
Grass Run Refuse

Lewis County

Located about three miles east of Weston, this 115 acre site had numerous environmental, health, and safety related problems. Contractors regraded and covered 20 acres of toxic coal refuse, and installed around a mile of drainage control channel. Prior to construction, several of the ponds were nearly full of coal refuse and sediment and none of the emergency spillways functioned properly.

The refuse restricted natural flow in the stream channel further exacerbating flooding and erosion problems. Construction was completed during the fall of 2000, at a final cost of $1.45 million.

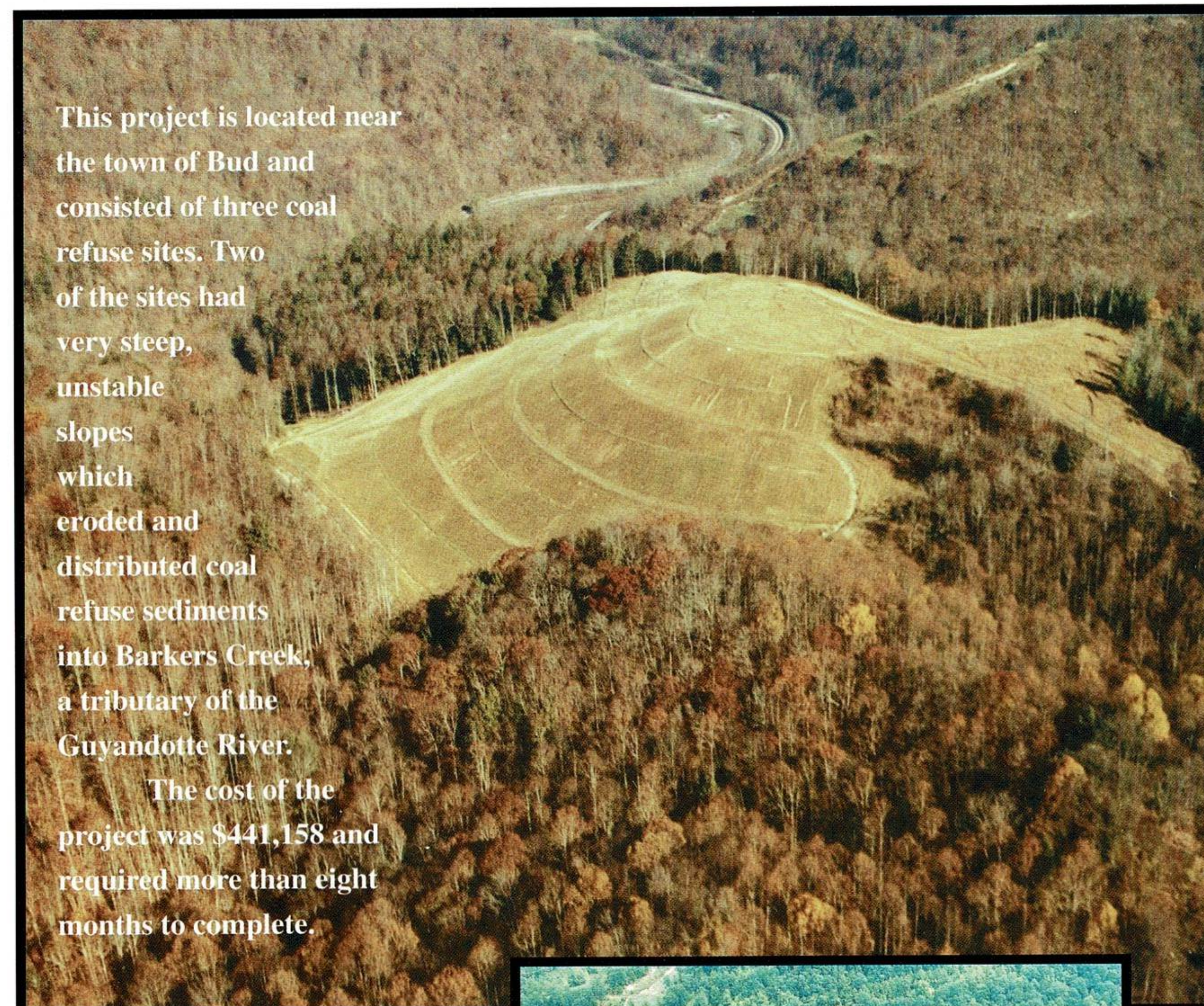
Lamar Complex
Mercer County



This project is located in Mercer County near Lamar and consisted of four coal refuses sites, three of which were significant sources of sediment drainage into Left Hand Fork, a tributary of the Bluestone River. The largest site blocked a smaller tributary, creating a potential impoundment. Also, deep mine openings and abandoned mining-related structures were present.

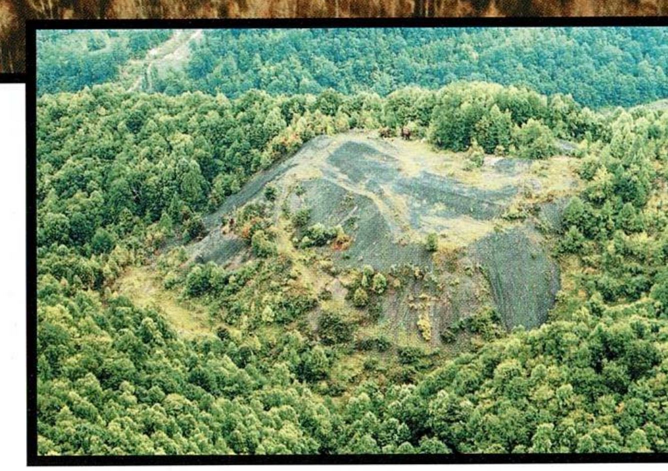
Cost of the project was $796,798 and required nine months to complete.

Big Hollow Mine Dump
Wyoming County



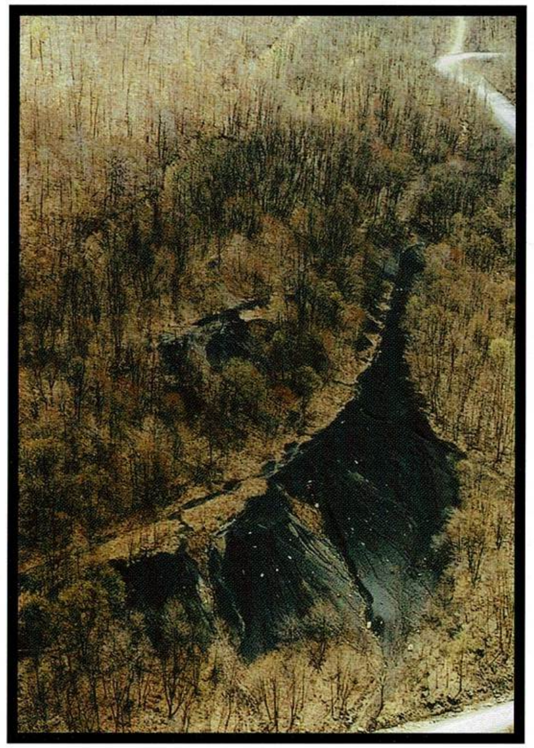
This project is located near the town of Bud and consisted of three coal refuse sites. Two of the sites had very steep, unstable slopes which eroded and distributed coal refuse sediments into Barkers Creek, a tributary of the Guyandotte River.

The cost of the project was $441,158 and required more than eight months to complete.



Piney Swamp Refuse #1

Mineral County



More than 187,000 cubic yards of coal refuse were excavated and re-graded on this 50-acre site near the Maryland-West Virginia border. Numerous surface water drainage controls were constructed, 10 deep mine portals were sealed, more than 2,000 feet of streambank and the entire area was regraded.

Construction was completed during the fall of 2000 at a final cost of more than $1.175 million.

Somewhere Over the Rainbows

A Peabody Conservancy Group subsidiary, in conjunction with WVU, grows trout in treated mine water in hopes of future economic benefit for West Virginia.

Four vehicles come to a stop in front of a serene, tranquil pond that is located just below the Martinka Coal Company's Tygart River mine in Marion County. As the group steps out, Fred Conner, superintendent of the West Virginia operations for the Peabody Conservancy Group, motions toward the unclouded water.

Suddenly, the water ripples slightly and everyone leans towards the water a little closer. There is movement again and it is easy to see rainbow trout gliding through the pond's crystal-clear water.

Since May of this year, West Virginia University has worked closely with Martinka in its research to develop an aquaculture base in the state by using reclaimed mine sites.

The University stocked the company's finishing pond with rainbow trout to determine how the fish would react in a man-made pond filled with treated water from a coal mine.

"Trout require a higher level of oxygen than most fish and they are temperature sensitive. So, if trout can live in the water, you know that quality is good," said Dan Miller, Research Assistant in Aquaculture at WVU's Department of Resource Management.

"Trout require a higher level of oxygen than most fish and they are temperature sensitive. So, if trout can live in the water, you know that quality is good."

Dan Miller, Research Assistant in Aquaculture at WVU's Department of Resource Management.

"West Virginia has a real advantage over other states that use surface water in trying to commercially raise trout," he said. "The waters from the mines here stay at a constant 55 to 60 degrees all year and that is ideal for growing trout."

Miller noted that other states' commercial trout farms are hindered during the summer when the temperature increases and oxygen is reduced causing the saturation point to decrease, which is a natural occurrence.

The study at Martinka is the first phase of the University's research. There are 50 trout in a cage, which are fed twice a week with processed trout feed and an additional 50 trout living freely in the pond as well.

Trout in the pond live off of zooplankton and phytoplankton. Zooplankton are micro-organisms that feed off of the phytoplankton. However, without phytoplankton, zooplankton will not develop and the fish would not have a natural food source.

The pond being used in the study covers about two acres and averages about five feet in depth. "At that depth the sun goes through to the bottom, and I expected the summer temperatures to cause problems for the trout if the water from the plant was not flowing," Miller said.

Conner always beams with pride, when he tells visitors that the trout have had "zero mortality due to any water quality problems."

And so does his company. The Peabody Conservancy Group, Martinka's parent company, is based in St. Louis and was created two years ago to oversee reclamation efforts to insure environmental compliance at all closed and suspended operations for Peabody and its subsidiaries.

"One of our main goals is to return the land and water to a condition equal to or better than pre-mining conditions," said Bill Broshears, group executive - mining services for the Peabody Conservancy Group.

Miller concurs, "this is a very encouraging site. I am impressed with the quality of water and the management of the water treatment at Martinka. I expected some acute mortality, but there has not been any mortally due to plant operations."

WVU started the research project this past May and is expected to be complete by May of next year. Trout that were originally placed in the cage and the pond were about eight to nine inches in length. Miller thought that those in the pond have grown to about 16 inches in less than six months.

"I am truly impressed with how well the trout have done," he said. "The 50 in the pond are growing at a much faster rate than commercially grown fish. But, we have to understand that there is not much competition in that pond right now. That pond can hold thousands of fish."

Since Miller is so high on the success of the initial research, he is hoping to continue the project, pending available funding, to measure trout growth.

"We are not measuring trout growth yet, we really wanted to see first how well the fish would survive with this project," he said. "We hope to introduce another group of fish, but we are not sure of the amount yet. We have to be careful and not have too many because we may get waste that would exceed the company's NPDES permit standards. It's the waste that has an effect on the stream and we don't want to deteriorate water quality."

In the second phase, Miller intends on purchasing a multi-probe that will measure various crucial water parameters for the trout such as temperature, conductivity, turbidity, and pH.

Martinka's 50 rainbow trout, like the one above, have grown at a faster rate in its pond than commercially grown fish.

The probe will be able to store more information without having to physically be present to record the data.

"This will be a little more in-depth research than what we are doing now. We can monitor the pond on an hourly basis accruing six weeks of data without running out of memory, then download it into a computer. Now we just measure water temperature twice a week. The probe can give us an even better understanding on how we select mine sties in the future," he said.

Although this project originated last year with Martinka, there are presently three other mine sites in the northern part of the state undergoing the same type of aquaculture research.

"We selected Martinka because of the large constant flow of water and it is in a close proximity to WVU," Miller said. "McDowell County has some great sites, but it is farther away (from WVU). There are 30 sites around the state that fit our criteria, but every site is unique when looking for a mine site for such a project."

Just to be considered as a possible research site, a mine must have a water flow of 1,000 gallons per minute. At Martinka, a newly constructed water treatment plant can manage up to 12,000 gallons a minute. Water is treated from the surface as well as its underground mine that was closed in 1995.

If the research continues to be as successful as anticipated, Conner noted that the company has an old treatment plant on Guycees Run that could possibly be turned into a warm water fish hatchery. It could harbor such species such as bass, blue gill and catfish.

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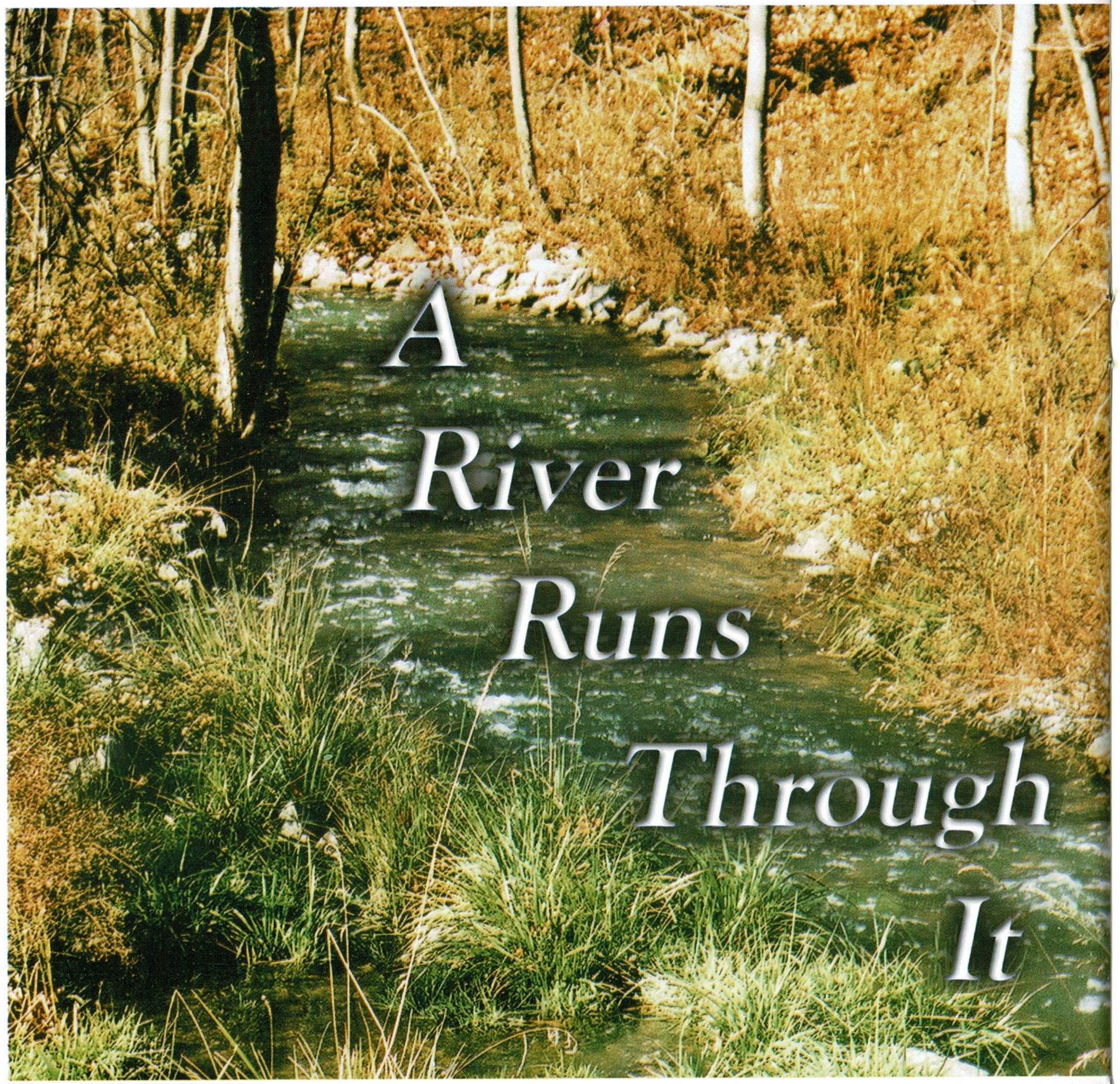


A River Runs Through It

Martinka Coal Company constructs a water treatment system like no other in the world.

"There is nothing else like it in the world. This is a brand new thing," said Dr. Al Stiller, professor of chemical engineering at West Virginia University. "Martinka has put together a plan that actually is a beautiful demonstration of what we can do with technology, when we are allowed to do it."

Under the watchful eye of Stiller, officials at Martinka Coal Company created a state-of-the-art, one-of-a-kind water treatment system at their Tygart River operation in Marion County, which produces the best water in the area.

The Peabody Conservancy Group, based in St. Louis, was created two years ago to oversee reclamation efforts to insure environmental compliance at all closed and suspended operations for Peabody and its subsidiaries, including Martinka.

Bill Broshears, group executive - mining services for Peabody Conservancy Group said "one of our main goals is to return the land and water to a condition equal to or better than pre-mining conditions."

Until 18 months ago, Martinka had two separate water treatment systems, one that treated water from its underground mine, which closed in 1995, and one that treated surface runoff from the refuse areas.

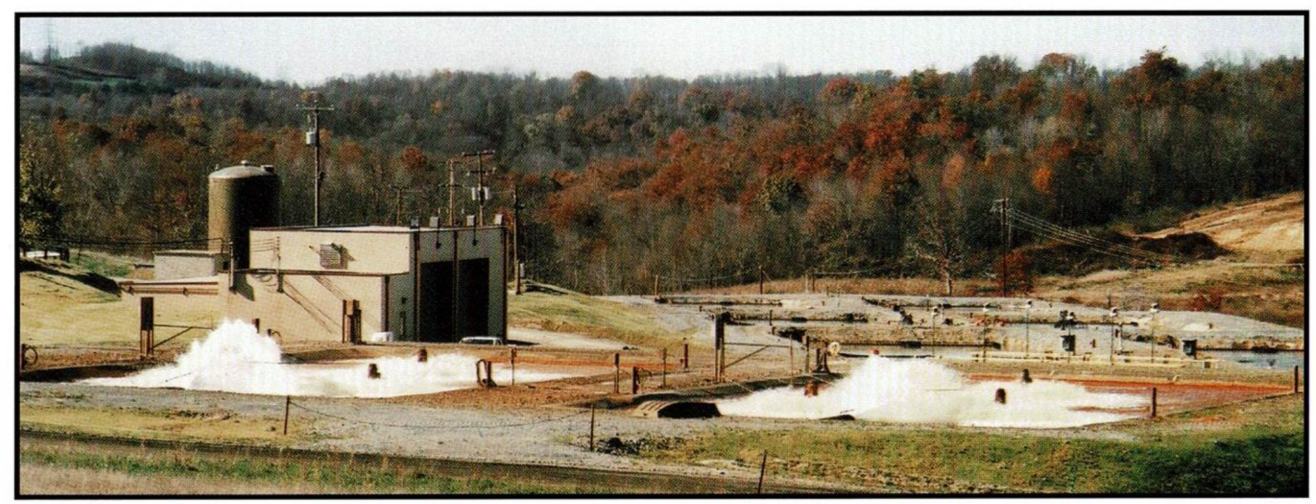
However, what makes this an unusual circumstance is that the surface water is acidic while the underground mine water is alkaline.

"Although having an alkaline underground mine pool itself is unique, to have an alkaline source and an acid source at the same mine at the same time is very unique," Stiller said. "I've been around acid mine drainage for more than 20 years and I don't know of any other situation where you could actually find that environment."

About five years ago, company officials found themselves in a quandary. Although water was carefully being treated before being released, a white substance, later determined to be calcium carbonate, was precipitating on rocks in Guyses Run, a tributary of the Tygart River.

"Everybody thought the iron was the problem, but it wasn't," Stiller said. "In fact, all of the treatments they tried, didn't do anything about the white precipitate on the streambed. The only conclusion you could draw was that this was an alkaline mine drainage system, not an acid mine drainage system."

What perplexed everyone even more is that the calcium carbonate was not appearing until the treated water reached Guyses Run.



Martinka's new water treatment plant is the only one like it in the world. It can treat water from its alkaline underground mine and acidic surface runoff simultaneously.

"It wasn't precipitating in the water treatment system," Stiller said. "We concluded that when the surface area of the water increases with respect to the volume of the water, as in the stream, carbon dioxide would leave the stream water and precipitate out calcium carbonate on the rocks. This is very typical of limestone environments. The streams that exit limestone caves have this same phenomena."

Stiller noted that in this scenario, the chemistry is unique. Rocks from the mine are black shale, rich in pyrite and produce acid. Overburden made of sandstone and limestone were mixed with the shale and dissolved in the sulfuric acid. This produces a carbon-dioxide-rich atmosphere.

"Now the mine is rich in carbon dioxide, so the water is rich in carbonic acid that dissolves more limestone in the form of calcium bicarbonate," Stiller said.

Stiller ran tests in precipitation, coagulation and aeration and found that the water in the ponds lasted about 24 hours and that wasn't enough time for the calcium carbonate precipitation reaction to take place.

"The trick is to force the chemistry that you want and make it happen fast enough so that by the time the water leaves the system, we don't have any problems with it down stream."

Ultimately, the decision was made to shut down the two older treatment systems.

"We combined both plants though a series of pumps and piping and built one plant to handle both waters," said Fred Conner, superintendent of the West Virginia operations for the Peabody Conservancy Group. "Refuse water is very acidic and offsets the alkalinity in the mine water. So actually the best scenario is to blend the two waters. That way we use fewer chemicals in the process."

The $4.5 million plant, which can handle twice the capacity of the two older systems combined, has treated 2.75 billion gallons of water since its completion in May 1999.

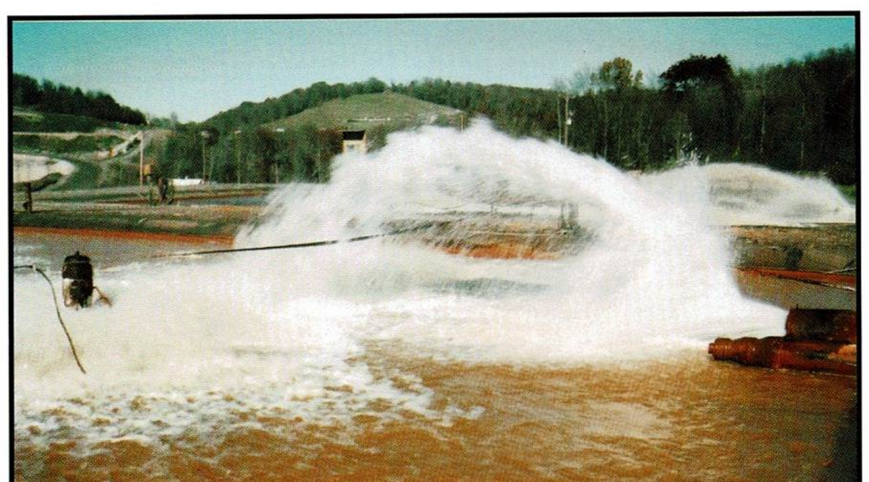
"We can treat as much as 12 thousand gallons a minute," Conner said. "It's a flexible, or two-sided system. We can treat straight refuse water rate of one to two thousand gallons a minute and at the same time, treat underground mine water at a rate of five to ten gallons a minute.

Every piece of equipment at the treatment plant is computer controlled and produces a continuous readout. Readings are based on pH, so operators can get any kind of a blended scenario to produce the desired quality of water.

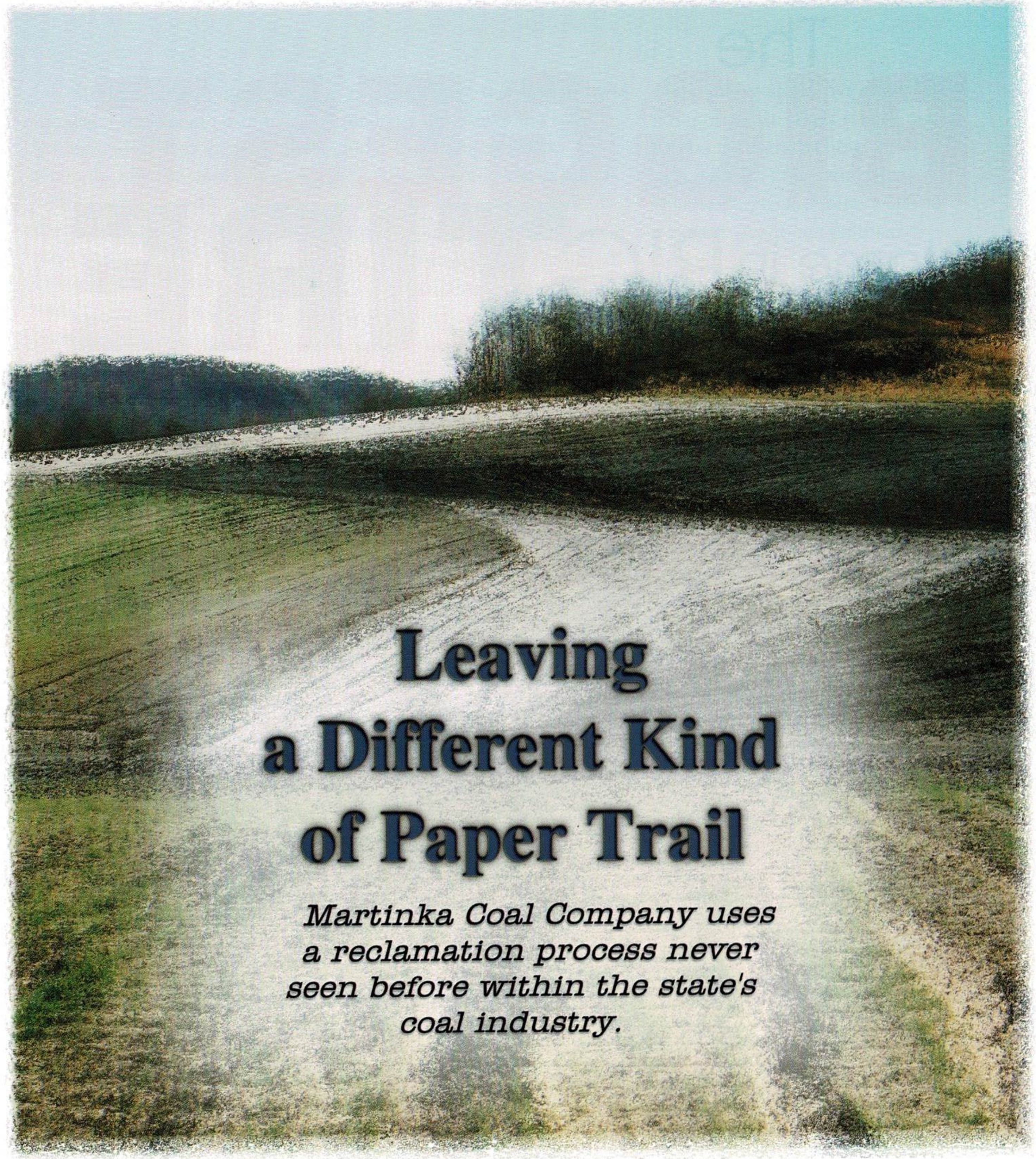
Water from the three refuse sites is collected at various locations and is pumped to one central location into the plant. Water levels in the collecting ponds are monitored through fiber optics.

"If the water gets high the computer automatically kicks

***(See Treatment on* page 39)**



Martinka's $4.5 million water treatment plant, which can handle twice the capacity of its two older systems combined, has treated 2.75 billion gallons of water since its completion in May 1999.



Leaving a Different Kind of Paper Trail

Martinka Coal Company uses a reclamation process never seen before within the state's coal industry.

West Virginia is known for having some plentiful natural resources, such as coal, timber, white water, just to name a few.

What it does not have is plenty of topsoil.

In this state, the topsoil layer is extremely thin and not very plentiful.

Maybe with all the mud slinging during the last state's election campaigns, it's no wonder there is very little topsoil left.

Even so, the Surface Mining Control and Reclamation Act, a federal law created by the U.S. Congress in 1977, states that coal operators must replace topsoil removed "or the best available subsoil, which is best able to support vegetation."

As a result, trying to preserve quality topsoil has been a constant frustration for coal operators for many years, as Martinka officials discovered when reclaiming refuse areas at their Tygart River operation in Marion County.

"The soil we did find was very sandy and would not stay on the slopes," said Fred Conner, superintendent of the West Virginia operations for the Peabody Conservancy Group. "It would wash off the slopes very quickly."

Martinka will have covered 135 acres in BioMix by March 2001. The material placed on the refuse acts like a sponge to control erosion and can hold 14 inches of rain.

The Peabody Conservancy Group, is based in St. Louis and was created two years ago to oversee reclamation efforts to insure environmental compliance at all closed and suspended operations for Peabody and its subsidiaries.

"One of our main goals is to return the land and water to a condition equal to or better than pre-mining conditions," said Bill Broshears, group executive - mining services for the Peabody Conservancy Group.

Instead of struggling with an ever-persistent erosion problem, company officials ventured "outside the box" and tried a new alternative to reclamation, one that has never been done in the West Virginia coal industry.

Peabody officials contacted Browning-Ferris Industries, which claim to have developed a "cure" for the lack of topsoil and the acid mine drainage problem in West Virginia.

"I truly believe we have stopped nearly all of the generation of AMD out of those refuse piles," said Joe Laubenstein, manager of the pulp and paper group for BFI.

And, from Martinka's standpoint, Conner is quite happy with the results. "We have absolutely no erosion problems at all," he said.

"Even on two-to-one slopes we've had zero erosion, even before grass was on there."

As it turns out, BFI has created synthetic soils called Short Paper Fiber® and BioMix®.

Short Paper Fiber® is a material composed of low permeability moist clay and paper fibers.

"We use paper fiber that is too short and cannot go into the manufacturing of paper," said Joe Laubenstein, manager of the pulp and paper group for BFI.

BioMix® is blend of specific soils and special fertilizers that maintains high water retention capabilities. After placement of the BioMix® soils, special seed varieties are used to enhance wildlife habitats and improve water evapotranspiration, which reduces AMD generation.

"We make sure the paper fiber is cut to a particle size of 3/8" or less, then we add the necessary nutrients," he said. Fiber for the SPF® and BioMix® is collected from American Fiber Resources, a recycling paper mill in Fairmont, then transported to the Meadowfill landfill in Clarksburg to be manufactured into the final product.

"We manufacture about 200 tons of BioMix® and SPF® every hour at the landfill," Laubenstein said. "We put down 4,516 tons per acre at the site."

BFI has helped reclaim 135 acres at Martinka since 1995. The project is scheduled for completion in March 2001.

"We started at an Anker Energy site in Phillipi in August, and we plan to be there for the next three years," he said. "The problem is we only have one paper mill in West Virginia and that limits the amount of mines we can reclaim."

Laubenstein noted that he is planning to bring in more paper fiber from the Cincinnati area next year.

"I could do five or six sites, but I don't have enough fiber," he said. "The paper mill only makes 700 tons a day. I need 2,500 if I bring on other mine sites."

BFI places two 12-inch layers of the synthetic soil onto the refuse in order to get the results desired.

The layer adjacent to the refuse material is the "SPF® Barrier Layer" or engineered soil and is created by mixing paper fiber at the Meadowfill landfill with soil from its expansion to achieve an impermeable layer.

On top of that layer is the "SPF® Vegetative Layer" or the agronomic layer, which stops water and oxygen from getting into the pyrite that causes acid mine drainage. The "BioMix® Vegetative Layer" is manufactured by adding special fertilizers and using enhanced seed varieties resulting in a reclamation process that stops AMD generation.

According to Laubenstein, the fibers shrink and swell just like a huge sponge retaining much more water than natural topsoil.

"The material can actually hold 14 inches of rain," he said. "If you notice how green everything is on those refuse areas, it is because even during the dry periods, you still have all that moisture available for grass to grow. The beauty of the whole thing is that we stop water from penetrating into the refuse piles and it also holds all of the rainfall on top of these refuse piles."

Through extensive research, BFI has taken an old technology and with it designed and created a new frontier. With confidence, Peabody officials have reclaimed their site in a way no other coal company has previously done. Their actions have benefited the entire industry as well as the environment.

When technology works, it works well by providing a future for everyone.

Treatment from page 34

on and pumps that water to the central location so that the plant can treat the water," Conner said. "It also has an automatic shut down when the pond gets too low for the pumps to pick up the water."

Once it gets into the system, the plant filters out iron. To do this, it goes into an aeration plant to aerate the water and add caustic soda to raise the pH to the point where the ferrous iron turns to ferric and also eliminating the presence of calcium carbonate. The water goes into a series of ponds that settles out the iron, drains its way to a polishing pond and finally into the Tygart River.

"We trim the pH with hydrochloric acid to ensure we don't have any problems with the calcium deposit down stream before it reaches the river," Conner said.

The final result - high quality water with a 6.7-6.9 pH entering the Tygart River.

"It's better than the drinking water in Fairmont," Stiller said.

Getting Rid of that Spare Tire

Martinka Coal Company goes above and beyond to clean up a perennial problem in West Virginia.

The word "inheritance" usually portrays the image of good fortune and prosperity.

However, when Eastern Coal Company, bought 800 acres in Marion County from American Electric Power in 1992, "inheritance" was deemed to have a new meaning.

While reclaiming its Tygart River operation, Martinka Coal Company, a subsidiary of Eastern, only recently discovered that along with the purchase of land and coal, came old worn out tires, thousands of them.

These discarded tires were resting quietly in a distant, small hollow for half a century, and to everyone's surprise were discovered less than six months to be within the boundaries of company land.

Earlier this year, a state law was created that gave the West Virginia Department of Highways responsibility to cleanup illegally discarded tires that were dumped throughout the state.

"All I heard was 'Colfax tire pile,'" said Russ Rader, Manager, Waste Tire Program for the state's Department of Highways

As Rader investigated, he found there were an estimated 1 million tires that spanned over a 1/2 mile area and crossing over several property lines.

When Rader met with Fred Conner, superintendent of the West Virginia operations for the Peabody Conservancy Group in August, it was unclear if the tires were on the company's property.

"We had seen articles in the paper about a large tire dump below our property," Connor said. "We started investigating to see where exactly the property lines were and it was determine that part of those tires were on our property."

The Peabody Conservancy Group, Martinka's parent company, is based in St. Louis and was created two years ago to oversee reclamation efforts to insure environmental compliance at all closed and suspended operations for Peabody and its subsidiaries.

"One of our main goals is to return the land and water to a condition equal to or better than pre-mining conditions," said Bill Broshears, group executive - mining services for the Peabody Conservancy Group.

Rader estimated that there were as many as 80,000 tires that have invaded Martinka's property.

"The bulk of which were passenger tires," he said.

Nonetheless, Martinka officials quickly took action to resolve the negative situation.

"They acknowledged the problem and immediately acted on the situation," Rader said. "It would be nice if everyone who has environmental issues would take the appropriate measures like Martinka did."

"The tires were on a remote piece of property that we didn't use," Conner said. "When it was originally purchased it was planned to be used for a continuation of a refuse area, but since the (underground) mine has been shut down, we did not have to use that piece of land."

Although Martinka officials acknowledge the area needed to be cleaned up, haphazardly removing the tires from the property could cause

Delegate A. James Manchin (D-Marion), left, takes a moment to look over the pile of about 80,000 discarded tires with Fred Conner of Peabody.

the company problems with existing permits and threaten water quality of a nearby stream.

"This company is extremely proud of its water quality from its operation," Rader said. "They are very sensitive to this issue. They were always being extremely careful about water pollution."

Consequently, company officials opted to take charge of the situation themselves.

Although working closely with the state, Martinka hired an independent contractor to remove the tires and reclaim the area. Even by removing just a small portion of this gigantic environmental mess, this, in turn, saved the state and taxpayers hundreds of thousands of dollars.

Planning for removal of the tires started in September and by October, the contractor began removing the pile. The project is scheduled to be finished in late December.

"If Martinka hadn't decided to help us and clean up the site, I don't know what we would do," said Cody Starcher, a Marion County Commissioner and resident of the Colfax area.

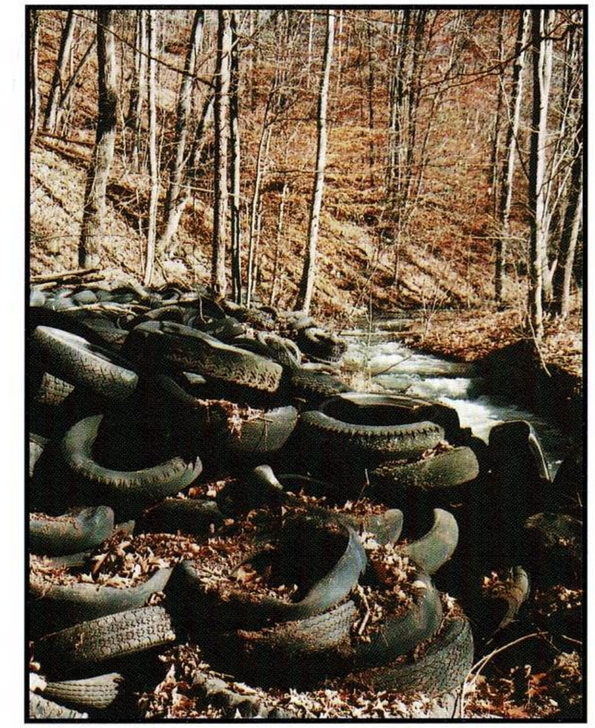
"It's been a terrible problem for 50 years, way before Martinka owned the land. We just don't have the manpower or the money to handle so many."

The tires were shredded at the Meadowfill landfill located nearby. Instead of taking up precious landfill space, the pieces are then used as cover or placed in the water drain instead of stone. Rader noted that by doing this, the disposed tires qualify as a beneficial use instead of waste.

Although there are an estimated 12 million illegally disposed tires cluttering up West Virginia, Martinka continues to go out of its way to help cleanup the state.

"I don't know of any better gesture of Martinka helping the community by cleaning up those tires," Starcher said. "They have gone above and beyond their duty as a corporate citizen."

A problem that has existed in the area for what some say as long as 50 years, Martinka officials began in October to clean up its inherited tire pile. The project was completed in December (bottom).



A Road Leading to the Past

Brushy Run is the only coal mine ever to operate in Pendleton County and reaches back to the 1930's. It has recently been reclaimed by the state's Office of Abandoned Mine Lands and Reclamation.

Pendleton County, located on the western slope of the Allegheny Mountains on West Virginia's border with Virginia, is one of a minority of Mountain State counties with virtually no coal heritage. In fact, the only coal mine ever known in the county has been reclaimed by the Abandoned Mine Lands section of the State's Division of Environmental Protection.

Known now as the "Brushy Run Mine and Road Restoration Project," the mine had a short run of production during the Great Depression of the 1930's. The one-acre site was originally part of a 1,000 acre tract owned by the Harman family near Brushy Run on remote Spruce Mountain. The family used the acreage as pasture for sheep and cows.

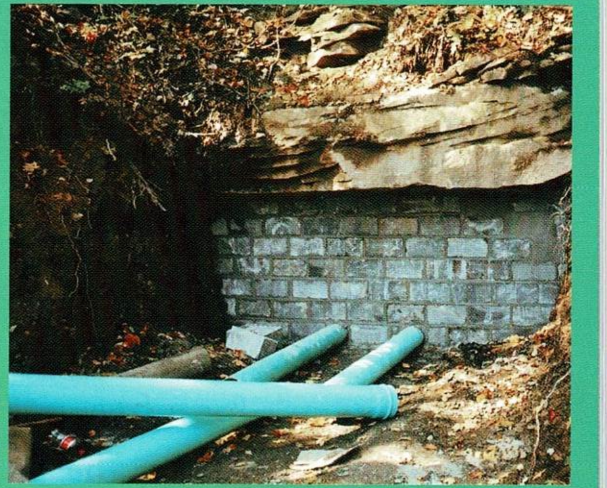
When the family patriarch passed away, the land was sold to a man named Alt Rosewell. Mr. Rosewell in turn transferred the tract to the U.S. Forest Service.

In the 1930's, the mineral rights were sold to former House of Delegates Speaker Ralph Hiner of Franklin. Mr. Hiner constructed an access road up the mountain and opened a small two portal mine. Production was short lived. It is believed that the mine filled up with water. Due to the remote location there was no electricity available to pump and the mine was closed.

In those days, a closed coal mine tended to be forgotten and such was the case with the Brushy Fork mine. Some 65 years later, the Forest Service, which still owns the land, became interested in cleaning up the site. USFS approached AML, which agreed to provide the design, bidding process and inspections of the reclamation work USFS provided $40,000 to fund the project.

The Brushy Run Mine and Road Restoration Project involved the complete reclamation of the mine, located 4-5 miles south of the town on Onego, in Pendleton County. Two mine portals were sealed to prevent acid mine drainage, which was feeding into Brushy Run, a native trout habitat. Small coal refuse piles near the portals were regraded, covered with topsoil and seeded. Limestone riprap channels were constructed to carry water off the site to control erosion. The access road, which was extremely steep and severely eroded was revegetated with a seed mixture compatible with native wildlife.

Official coal reserve figures for West Virginia do not include Pendleton County. With the completion of the Brushy Fork Project, the brief coal mining story of the county has passed into history.



(Opposite page) the road that leads to the old underground mine just outside of Onego in Pendleton County. (Top) the old tipple, (Middle) the entrance to the only underground mine in the county after it was unearthed (Bottom) after more than 60 years since being active, the mine is sealed.

Coal Calendar 2001

January

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

15 **West Virginia Governor's Inauguration,** Charleston, WV.

18 **Tug Valley Mining Institute Meeting,** Brass Tree Restaurant, Williamson, WV. Call (304) 664-4006 for dinner reservations.

20 **U.S. Presidential Inauguration,** Washington, D.C.

21 **Mountain State Coal Classic Banquet,** Raleigh County Armory, Beckley, WV. Contact Terry Miller (304) 252-8528.

22-27 **Mountain State Coal Classic Basketball Tournament,** Raleigh County Armory, Beckley, WV. Contact Terry Miller (304) 252-8528.

February

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

14 **West Virginia Legislative Session resumes** (until April 14th).

14-16 **28th Annual West Virginia Mining Symposium,** Charleston House Holiday Inn, Charleston, WV. Contact Patty Bruce (304) 346-5318.

23 **Kentucky Water Resources Annual Symposium,** Four Points Barcelo Hotel, Lexington, KY. Contact Julie Back, (859) 257-4634, or e-mail: jdback00@pop.uky.edu.

Comparison of Water Quality from 12 Underground Coal Mines in 1968 and 1999

J. Demchak, J. Skousen, P. Ziemkiewicz, West Virginia University, Morgantown, W.Va.;
and
G. Bryant, Environmental Protection Agency, Wheeling, W.Va.

ABSTRACT

Acid mine drainage (AMD) from both abandoned surface and underground mines is a serious problem. The flow of water and changes in quality over time from abandoned mines is important in determining remediation strategies. Acid mine drainage from surface mines is estimated to last for 10-20 years, while estimates of acid drainage from underground mines vary from 10-100s of years.

Twelve underground mine discharges in West Virginia were studied to compare water quality changes between 1968 and 1999 to see if our data are consistent with other studies. Each of the discharges were categorized into one of three groups: undisturbed since 1968, affected by surface mining since 1968, and reclaimed. Comparing water quality between 1968 and 1999, the discharges in the undisturbed category showed a 35 to 48% improvement in acid concentration and a 34 to 92% reduction in iron concentration. The discharges affected by surface mining showed the most dramatic improvement. For acidity, iron, and aluminum, the percent improvements were all above 50%, and in most cases were above 90%.

In the reclaimed category, the three sites showed improvements in acid concentration ranging from 60 to 74% and a 61 to 94% reduction in iron concentration. The results of this study indicate that underground mine water discharges improve over time. If the underground mine is remined or "daylighted," the acidity and metals in the water are greatly reduced since the source of the acidity (the pyrite in the coal) is removed.

INTRODUCTION

Coal was first mined in the United States near Richmond, VA in 1750. Coal mining was performed by small operators using only picks and shovels on surface coal outcrops where little soil cover occurred. During the 1800s the demand for coal increased forcing the development of underground mines. Paone et al. (1978) estimated that about 1.5 million acres of land in the United States had been disturbed by coal mining operations by 1971. No estimate has been made of the miles of underground passages and areal extent where coal has been removed by deep mining.

One of the environmental consequences of surface and underground mining is the generation of acid mine drainage (AMD) where high sulfur coal and associated rocks are disturbed. According to the U.S. Environmental Protection Agency (1995), approximately 10,000 km of streams have been affected by acid mine drainage in the northeastern U.S. (Pennsylvania, Maryland, Ohio, and West Virginia). Mines abandoned prior to 1977 generate more than 90% of AMD in streams and rivers in this region and most of this acid drainage stems from underground mines.

Acid mine drainage forms when sulfide minerals are exposed to oxidizing conditions. Upon exposure, sulfide minerals oxidize in the presence of water and oxygen to form highly acidic, sulfate-rich drainage. Acid mine drainage is characterized by high sulfate concentrations, high levels of dissolved metals (Fe, Al, Mn, etc.) and pH <4.5. Drainage quality from underground mines depends on the proportions of acid (pyrite) and alkaline (carbonate material) minerals in the coal and surrounding rock. If these reactants (pyrite, oxygen, water) are reduced or eliminated, generation of AMD will slow or cease.

The potential for AMD formation is widespread in northern West Virginia, so measures should be taken during mining to preclude or reduce the problem. Surface mining increases porosity and hydraulic conductivity of rock placed in the backfilled area, thereby introducing oxygen and additional water. Backfilling, covering with soil, and revegetation is the primary method of reducing or stopping acid mine drainage, but treating the acid-producing rock directly is a practice that has been implemented on many surface mine sites. A common preventative measure in areas prone to acid mine drainage is the use of alkaline amendments (Brady et al. 1990, Perry and Brady 1995, Rich and Hutchinson 1990, Rose et al. 1995).

Acid drainage from abandoned underground mines is more problematic and hard to correct. The mines are partially caved and flooded, thereby restricting access. Reliable mine maps are often unavailable to determine mined out sections. Accessing the reactive areas of pyrite oxidation is nearly impossible. Acid mine drainage from underground mines can come from "below drainage" mines, where water that would normally fill the underground mine is pumped to the surface during active operation. After the mine is closed, water pumping ceases and the underground mine fills with water. In most cases, the water quality improves over time because the oxygen supply to drive pyrite oxidation is stopped, thereby shutting off the acid-producing reaction. So, inundation or flooding of "below regional drainage" underground mines is a technique that gradually improves the water from these mines (Donovan et al. 2000, Lambert and Dzombak 2000).

Acid mine drainage also comes from "above drainage" underground mines. Most of these mines are developed "up dip," which allows water entering the mine from infiltration to naturally drain out of the mine through the portal. No pumping is required during mining and the water does not accumulate in the mine, therefore the mine remains dry enough for continued coal removal.

Some above drainage mines are developed "down dip," which means that water entering the mine flows to the working area at the coal face and must be removed by pumping. Once water pumping in down dip mining ceases, water then can fill the mine with the potential for explosive outbursts of water ("blow outs") where an insufficient coal barrier was left in place (Skousen and Foreman 2000). Regardless of its up dip or down dip mining method, above drainage deep mines have the potential to continually generate acid drainage since oxygen and water are continually present in the mine. Periodic flushing of the acid salts with the fluctuating water table in the mine can cause poor quality drainage for decades.

Unlike surface mines, opportunities for alkaline amendment in underground mines are limited. Rock dust and other lime products may be layered on underground mine walls, floors, and ceilings, but this technique has limited success in high pyrite underground mines. Another technique being used after mining in above drainage deep mines involves injection of alkaline materials on 8- to 16-m centers to fill mine voids with non-permeable materials. This technique replaces the void space (where both water and oxygen necessary for AMD formation occur) with the grouting material. Mixtures of class F fly ash and 3 to 5% portland cement have been successful in filling voids (Burnett et al. 1995) and various mixtures of other materials such as coal combustion byproducts have also been used with success (Gray et al. 1997, Rafalko and Petzrick 2000, Ziemkiewicz and Skousen 2000).

Another important technique to improve water quality from abandoned above drainage deep mines is remining. Remining or "daylighting" returns to a previously mined area for further coal removal. It has been shown that remining reduces acid drainage by decreasing infiltration of water, covering the exposed acid-producing material with soil materials, and removing the coal which is the major source of pyrite. Hawkins (1994) studied 57 discharges from 24 remined sites in Pennsylvania and found contaminant loadings were either reduced or unchanged after remining. Reduction in loads came primarily from a decreased flow rather than large reductions in concentrations. Remining has many advantages. It reduces environmental hazards, improves aesthetics, enhances land use quality, and decreases pre-existing pollutional discharges (Hedin et al. 1997).

Determining the long-term behavior of acid-producing materials is critical in predicting longevity of the acid discharge. Researchers in the Appalachian region have stated that AMD from surface mines has a defined life of 10-20 years. The majority of pyrite available for reaction is either exhausted or the pyrite surface becomes coated. Once this happens, improvements in drainage quality are apparent as acid salts are leached from rocks by natural precipitation and no more acid salts are generated (Meek 1996).

Acid discharge longevity from above drainage underground mines in the U.S. is less understood because it is difficult finding reliable water quality data and tracing historical information of a specific discharge point. Acid discharges of underground mines in the U.K were given an exponential rate of decay in pollutant strength, based on volume of mine voids (Glover 1983). Younger (1995) indicated that acid in discharges from underground mines can be separated into two types. The first type of acid comes from leaching of stored acid salts (vestigal), while the second type is the creation of new acidity from water table fluctuations (juvenile). Younger (1995) suggested that AMD longevity at any given site depends on flushing of stored salts (which is influenced by the interconnectness of mine voids and caving frequency, gradient and slope of the mine floor, hydraulic conductivity of rock within the mine, and recharge rates) and the generation of new acidity (which is affected by pyrite surface area, and humidity, moisture, and oxygen within the mine). Younger (1997) concluded that underground mine discharges can improve within 10 years as stored salts are leached, but may not improve for 100 years or more if new acidity is continually being generated and leached.

This study evaluated the discharge quantity and quality from 12 above drainage abandoned underground mines at two time periods. Data from a 1968 study were used to locate AMD discharges for sampling in 1999. After locating and sampling the water quality, we compared the 1968 data to our data collected in 1999.

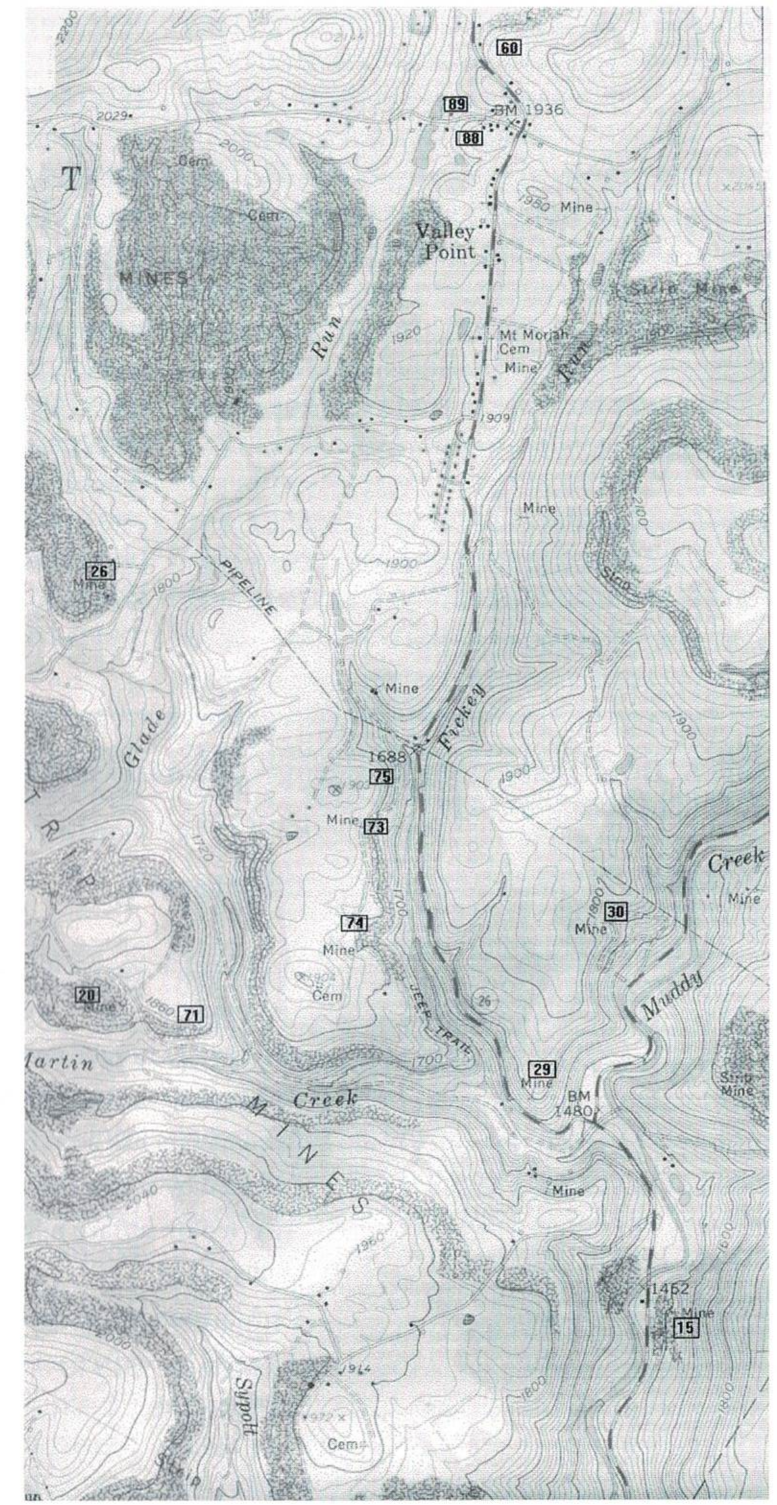
MATERIALS AND METHODS

Twelve abandoned underground mine discharges were chosen for comparison. All sites were above drainage drift mines, were located in Preston County, WV, were all within 16 km of each other, and were all sampled in 1968 (Figure 1). The discharges were all draining to various streams within the Muddy Creek Watershed from the Upper Freeport coal seam (Table 1). The drift mining method was generally used in hilly areas where coal seams outcrop along the contour and where the seam is nearly flat or slightly dipping. The mining direction (up dip or down dip) was not determined at each site for this analysis, but most were mined up dip based on knowledge of historical mining practices in the area.

The Upper Freeport coal seam was the most extensively mined in our research area by the drift underground mining method. The Upper Freeport coal is the topmost strata of the Allegheny Formation of the Pennsylvanian System. Freeport coal is relatively low in sulfur (<1.5% S) and has a comparatively low ash content (8 to 12%). It is a multiple-bedded coal seam that is divided into a top coal and bottom coal, separated by a shale interlayer, all of which average a total of six feet thick (Hennen and Reger 1914).

The Allegheny Formation is capped by the Upper Freeport coal and overlying strata in the Conemaugh Group contain several massive sandstones and some shales. Limestone or alkaline-bearing rock units are not generally found within 50 m above the Upper Freeport coal in this area, so very little overlying geologic material is available for acid neutralization.

Figure 1. Location of underground mines sampled for this study. All occur between Albright and Valley Point near Rt. 26 in Preston County, West Virginia.



1968 Sampling Techniques

Field crews were sent out in 1967 and 1968 to identify all coal mines within the Monongahela River Basin and to sample AMD discharges. Each crew worked from a 7.5 minute USGS topographic map on which they outlined mine boundaries and indicated mine openings. Field sheets were also completed at each site with location information as well as the stratigraphic section of rocks. If a discharge of water from a mine site was found, the flow was measured and the water was sampled. Field measurements of water pH (electrometric pH meter) and temperature (thermometer) were taken and recorded.

Two water samples were taken from each discharge: 1) unfiltered water was put into a plastic liter bottle and put on ice to analyze later in the laboratory for acidity, alkalinity, and pH; and 2) filtered water was put into a 100-mL glass bottle and treated with acid for metals analysis (total iron, manganese, aluminum). Water samples were analyzed by a certified laboratory using standard methods at the time. The flow was measured wherever possible using a bucket and stop watch. For larger flows, the crew would install a V-notch weir and measure flow rate.

1999 Sampling Techniques

Point discharges were located in 1999 based on the USGS topographic map marked by the 1968 crew. Discharges were sampled as close to the mine portal as possible. Flows were calculated using a measured cross-sectional area and flow velocity or an estimate was made. Two water samples were taken at each sample point: 1) a 250-mL unfiltered sample was taken for general water chemistry (pH, conductance, acidity, and alkalinity), and 2) a 25-mL, filtered sample was acidified to pH <2 with .5 mL concentrated sulfuric acid. The acidified water sample was preserved for metal analysis.

Table 1. Description of the 12 underground mines and their discharges sampled in 1968 and 1999.

Discharge #	Mining Method[1]	Disturbance Type	Receiving Stream
15	I-drift	Reclamation has occurred	Muddy Creek
20	I-strip & drift	Undisturbed	Martin Creek & Glade Run
26	I-strip & drift	Affected by surface mining	Glade Run
29	I-drift	Affected by surface mining	Fickey Run
30	A-drift	Reclamation has occurred	Muddy Creek
60	I-strip & drift	Affected by surface mining	Glade Run
71	I-drift	Affected by surface mining	Martin Creek
73	I-drift	Undisturbed	Fickey Run
74	I-drift	Reclamation has occurred	Fickey Run
75	I-drift	Affected by surface mining	Fickey Run
88	I-drift	Undisturbed	Glade Run
89	I-drift	Undisturbed	Glade Run

[1] I = inactive mine at time of sampling in 1968; A = active mine at time of sampling in 1968.

Water pH, alkalinity, and acidity were determined by a Metrohm pH Stat Titrino Titration System (Brinkman Instruments, Westbury, NY). Conductivity was measured using an Orion Conductivity Meter Model 115 (Beverly, MA). The metal analysis was performed using an Inductively Coupled Spectrophotometer, Plasma 400 (Perkin Elmer, Norwalk, CT).

In comparing 1968 and 1999 data, we made several assumptions. We assumed that the water samples were taken at the same discharge locations and in a similar manner between studies and that the techniques for analyses were also equivalent. Changes in flow conditions were also a concern, since 1999 was a very dry year. Additional samples will be taken during the spring and fall of 2000 to evaluate flows and concentrations during varying flow periods. We also will check climatic data prior to the 1968 sample collection dates and compare it to climatic data in 1999 and 2000.

RESULTS AND DISCUSSION

The discharge data were organized into three categories: **undisturbed** since the original sampling in 1968, **affected by surface mining** since the original sampling, or **reclaimed.** Each discharge point was classified based on observations made during sampling in 1999 and also from reviewing the field notes made by the collector in 1968. The undisturbed sites had no noticeable change at the portal face or within the surrounding area that would affect the recharge of water into the mine or the outflow of water from the portal. However, in all cases, the portal was caved and certainly other unmeasureable changes occurred within the mine over time. The sites affected by surface mining had been remined (surface mined and some portion or all of the underground mine had been "daylighted") where additional coal from the deep mined areas had been removed and the surface was reclaimed. The reclaimed sites had been reclaimed by the AML program, meaning that the underground mine portal had a wet seal installed and the surface around the portal had been reclaimed. Only the face of the underground mine portal was affected with little influence on the underground mine workings.

Undisturbed

Discharge 88 (Table 2) showed an improvement in water chemistry for the parameters that we measured. The discharge flows from a caved portal (Picture 1) and houses have been built in the area around the caved mine opening. The flow was about the same at the two sampling times, and acidity decreased from 675 to 412 mg/L in the past 30 years. No metal analysis was available for this water in 1968.

Discharge 89 (Picture 2) showed concentration decreases over time, except for a slight increase in aluminum from 29 to 32 mg/L. A small amount of white precipitate was visible in the stream bottom when we sampled, which is probably aluminum hydroxide precipitate. The flow was about the same. Water pH increased from 3.6 to 4.6 and iron decreased from 53 to 10 mg/L.

Discharge 20 decreased in acidity from 490 to 253 mg/L and actually had some alkalinity. The 1968 field notes of this site say that the area around the portal was roughly reclaimed and the discharge flowed through spoil. The water appears to flow through the same spoil even now. The flow was greater at the 1999 sampling, increasing from 6 to 56 L/min. The increase in flow may be caused by the underground works intercepting water from adjacent mines, or the flow may have been increased due to surface recharge through cracks into the mine or collection of surface water from the reclaimed area.

Discharge 73 exhibited an improvement in water chemistry, but flow was higher in 1999 (increased from 3 to 57 L/min). The 1968 notes stated that this discharge was sampled

Table 2. Comparison of water quality and quantity from underground mines that have remained undisturbed since the original sampling in 1968.

Discharge #	Flow L/min	pH	Acidity mg/L	Alkalinity mg/L	Iron mg/L	Aluminum mg/L
88						
1968	11	2.8	675	0	NA*	NA
1999	11	4.1	412	0	37	53
89						
1968	4	3.6	390	0	53	29
1999	19	4.4	228	2	10	32
20						
1968	6	3.0	490	0	105	17
1999	56	6.4	253	79	69	1
73						
1968	3	2.8	1670	0	237	157
1999	57	4.4	1087	0	19	78

*NA—data not available

near wet auger holes. This increased flow may be a result of pressure build-up in the mine causing it to flow out of the hillside through old spoil. The pH increased from 2.8 to 4.4, and the acidity decreased from 1670 to 1087 mg/L. Due to the increase in flow, however, the acid load actually increased from 7 to 89 kg/day.

Affected by Surface Mining

Discharge 60 (Table 3) showed a dramatic improvement in water chemistry from 1968 to 1999, indicating that remining greatly improved water chemistry (Picture 3). Little floc is visible due to the small amount of iron present in the water now, which decreased from 228 to 7 mg/L. Excavation has occurred in the area and the surrounding area was surface mined and reclaimed.

Discharge 26 also improved in water chemistry. The area above and surrounding the discharge has been surface mined and the discharge itself flows through old spoil. The iron decreased from 158 to 4 mg/L between 1968 and 1999, and the acidity decreased from 1765 to 283 mg/L. The improvement may have occurred either because of the remining or because the acid salts were leached from the spoil, or a combination of both.

Discharge 29 runs off a hillside from a surface mined area where the portals of the underground mine were daylighted and a gob pile was removed. The acidity decreased from 1920 to 498 mg/L and the iron decreased from 378 to 16 mg/L.

Discharge 71 shows a tremendous improvement in water chemistry. The discharge flows out of caved portals, then through a gob pile. The area surrounding the portal has been surface mined. The water then flows through a valley bottom creating a swampy area devoid of vegetation. The flow was slightly lower in 1999 and the acid concentration has decreased from 2315 to 135 mg/L. The pH increased from 2.7 to 3.8. Metal concentrations are greatly reduced from 640 to 10 mg/L for iron, and 161 to 5 mg/L for aluminum.

Table 3. Comparison of water quality and quantity from underground mines that have been affected by surface mining since the original sampling in 1968.

Discharge #	Flow L/min	pH	Acidity mg/L	Alkalinity mg/L	Iron mg/L	Aluminum mg/L
60						
1968	15	3.1	1705	0	228	146
1999	4	3.7	152	0	7	14
26						
1968	NA*	NA	1765	0	158	151
1999	8	3.9	283	0	4	33
29						
1968	17	2.8	1920	0	378	89
1999	19	3.4	498	0	16	42
71						
1968	57	2.7	2315	0	640	161
1999	38	3.8	135	0	10	5
75						
1968	4	2.4	1300	0	288	112
1999	11	4.9	119	1	13	1

*NA—data not available

Discharge 75 flows down a ditch from an area that has been mined. It flows from two caved portals and then through a gob pile. The acidity has decreased from 1300 to 119 mg/L and the pH has increased from 2.4 to 4.9 in the past 30 years.

Reclamation has Occurred

Discharge 15 (Table 4) exhibited an improvement in water chemistry. The land on the surface around the portal was reclaimed by the West Virginia AML program and the portal had a wet seal installed. The water flows through two pipes in the wet seal and down a grouted channel (Pictures 4 and 5). The flow was slightly different between 1968 and 1999 (from 1134 to 945 L/min) and the acidity decreased from 2140 to 658 mg/L. The metals decreased from 576 to 121 mg/L for iron, and aluminum was reduced from 108 to 39 mg/L.

Discharge 30 showed an improvement in water chemistry. The surrounding area was surface mined (but did not affect the underground mine) and a rock-lined ditch was placed to channel the flow. The acidity decreased from 2515 to 1001 mg/L and the iron decreased from 422 to 166 mg/L. Aluminum decreased by 75%.

Discharge 74 showed an improvement in water chemistry and the flow was lower in the 1999 sampling (decreased from 49 to 11 L/min). In 1968, the discharge came from one air shaft, two portals, and went through a gob pile. In 1999, the gob pile has been reclaimed and no visible portals or airshafts can be found. The discharge is now located at the

Table 4. Comparison of water quality and quantity from underground mines where reclamation has occurred since 1968.

Discharge #	Flow L/min	pH	Acidity mg/L	Alkalinity mg/L	Iron mg/L	Aluminum mg/L
15						
1968	1134	2.6	2140	0	576	108
1999	945	3.5	658	0	121	39
30						
1968	102	2.9	2515	0	422	301
1999	94	4.2	1001	0	166	76
74						
1968	49	3.0	1505	0	288	84
1999	11	3.9	390	0	17	34

edge of the reclaimed area and is captured in a pond. The acidity decreased from 1505 to 390 mg/L and the iron has been reduced from 288 to 17 mg/L.

Percent Changes in Water Chemistry

Percent changes in each parameter were calculated to observe trends (Table 5). It is apparent that water quality improvements occurred for undisturbed discharges, and all four had similar or increased water flow. The undisturbed discharges showed acidity concentration improvements ranging from 35 to 48%.

Surface mining (remining) accelerated improvement in water quality from deep mines. Average improvements were much greater than undisturbed deep mine sites. For acidity, iron and aluminum, the percent improvements were above 50% and in most cases above 90%.These results confirm that remining, even in adjoining areas, can greatly improve the quality of underground mine discharges. Reclamation by the AML program also improved the water chemistry, with an improvement from 60 to 74% in acidity and a decrease of greater than 60% in iron concentration.

CONCLUSIONS

Acid mine drainage from underground mines showed water chemistry improvements at all 12 discharge sites. Acidity and iron concentrations were lower after 30 years, while aluminum concentrations were improved at all but one site. The undisturbed discharges all showed improved water chemistry. Increased flow may be caused by additional water from adjacent mines flowing into the underground mines or other changes in the mine void causing a redirection of water to the observed outlets.

The discharges affected by surface mining exhibited the most dramatic improvement in water quality. The improvement was much greater at these sites due to further removal of high sulfur coal, burial of toxic materials, and reclamation.

All three of the reclaimed sites improved in water quality, and the percent changes in water chemistry were slightly better than those found for undisturbed sites.

The study shows that if above drainage underground mines are left undisturbed for a long period of time, the water quality will improve, which supports previous studies on acid release from underground mines. Remining accelerates improvement in water quality. If surface reclamation around the portal occurs, an improvement in water quality a little better than that of undisturbed sites will occur.

It is not known how these discharges may change during the next 30 years. If left undisturbed, these discharges may decline another 30 to 50% in acidity from the 1999 values, or in other words continue a gradual decline in acidity according to a decay curve as suggested by Glover. Or, the discharges may eventually reach a point where the pyrite available for oxidation in the mine is nearly exhausted, and chemical/biological reactions and natural amelioration may cause neutralization of the water. Further historical research into the area surrounding underground mine discharges will be important in determining causes of water quality changes and give a better understanding of how changes occur over time. For example, factors like the opening and closing dates of the mine, the amount of void space in the mine that is inundated, and water quality data from older or intermediate time periods will help us observe the changing trends in water quality.

This paper is the preliminary work of a larger study that focuses on determining acid discharge longevity from acid-producing, above drainage underground mines in northern West Virginia. Further research will expand the sampling area, develop a model to predict longevity based on several factors (e.g., overburden chemistry, pyrite content, mine area and void space, and water hydraulics) and extend the results to other watersheds.

Table 5. Percent changes in water chemistry and load between 1968 and 1999. Positive values represent percent improvement in the parameter and negative values (in bold) represent percent degradation in the parameter.

		Acidity	Iron	Aluminum
Undisturbed				
	88	39	NA*	NA*
	89	42	81	**-10**
	20	48	34	94
	73	35	92	50
Affected by Surface Mining				
	60	91	97	90
	26	84	97	78
	29	74	96	53
	71	94	98	97
	75	91	95	99
Reclaimed				
	15	69	79	64
	30	60	61	75
	74	74	94	60

*NA—data not available

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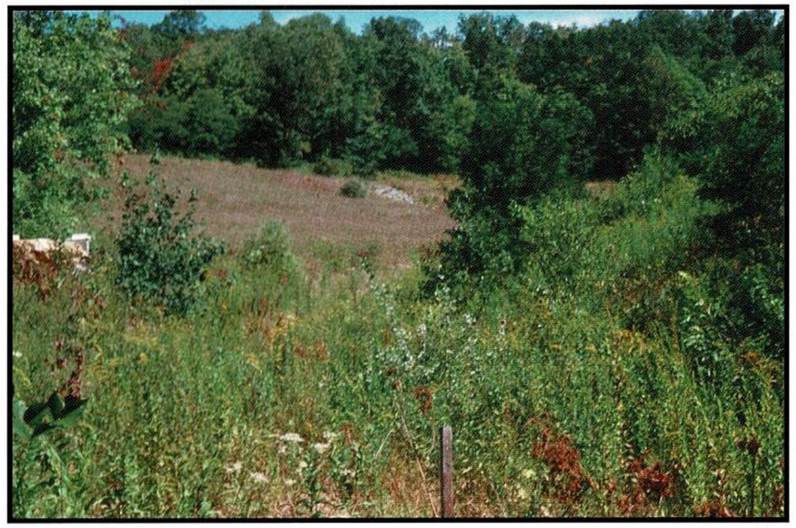
Site 88 is an undisturbed site. The seep emerges from the collapsed portal, creating a large area of Fefloc.

Site 89 is an undisturbed site. The seep emerges from the portal and discharges into a pond.



Site 60 is a surface affected site. The seep emerges in the grassy area near the wooden stake.

Site 15 is a reclaimed site, done by the WV AML program. This riprapped grouted channel conveys discharge down the hill to Muddy Creek.

The pipes at Site 15 extend back into the mine through the seal placed at the portal, thereby allowing flow out of the mine.