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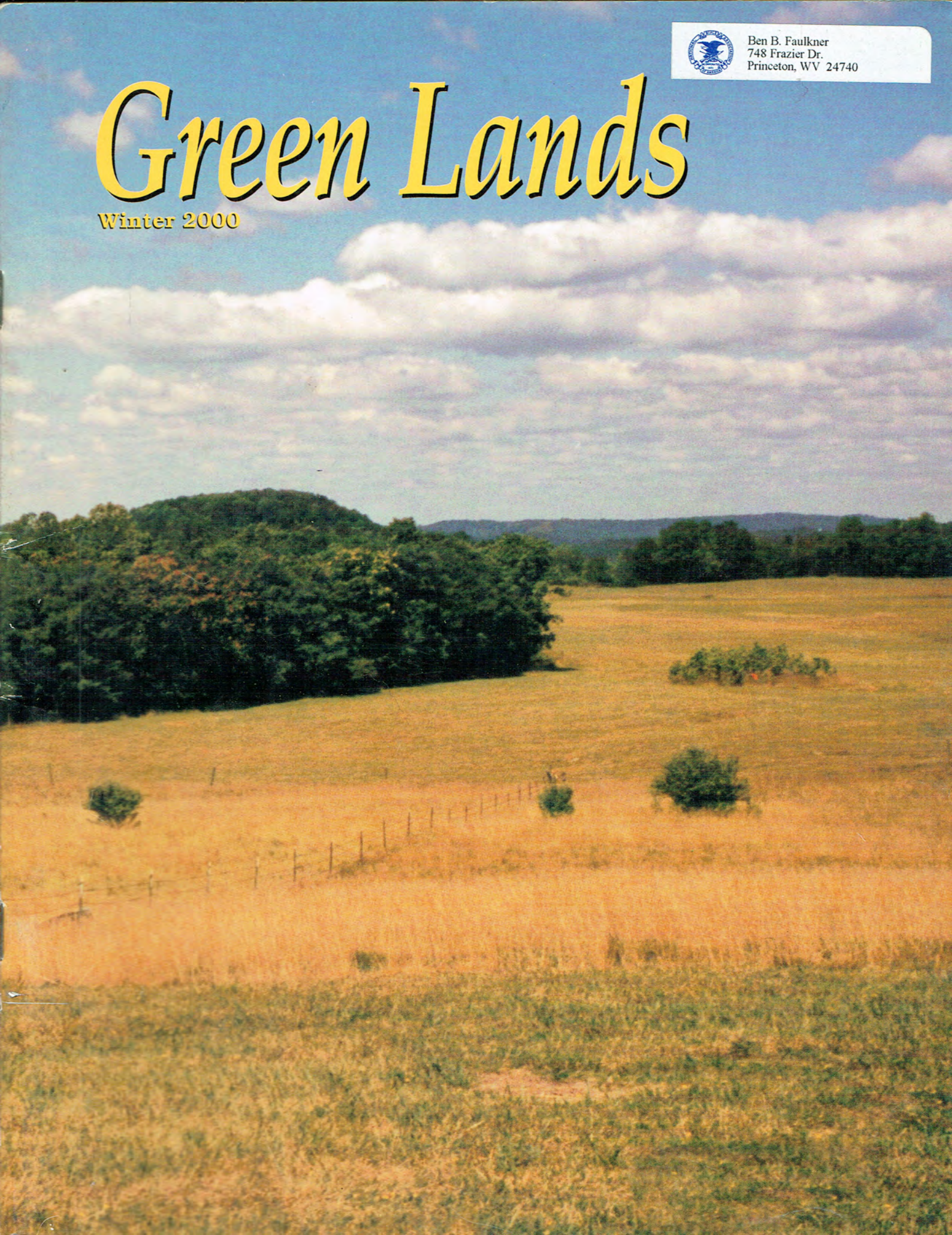

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Volume 30 Number 1

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On the Cover

A look at what was once a coal mine that C&W Coal Company reclaimed into productive farmland. C&W operates in Barbour and Harrison counties and was the recipient of the 1999 David C. Callaghan award presented at the West Virginia Mining Symposium in January. Story on page 18.

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Key Dates for 2000 West Virginia Legislative Session

February 21
Last Day for Bills to be introduced in Senate

February 25
Last Day for Bills to be introduced in the House of Delegates

March 4
Last Day for Bills to come out of respective Chambers

March 11
Session Ends

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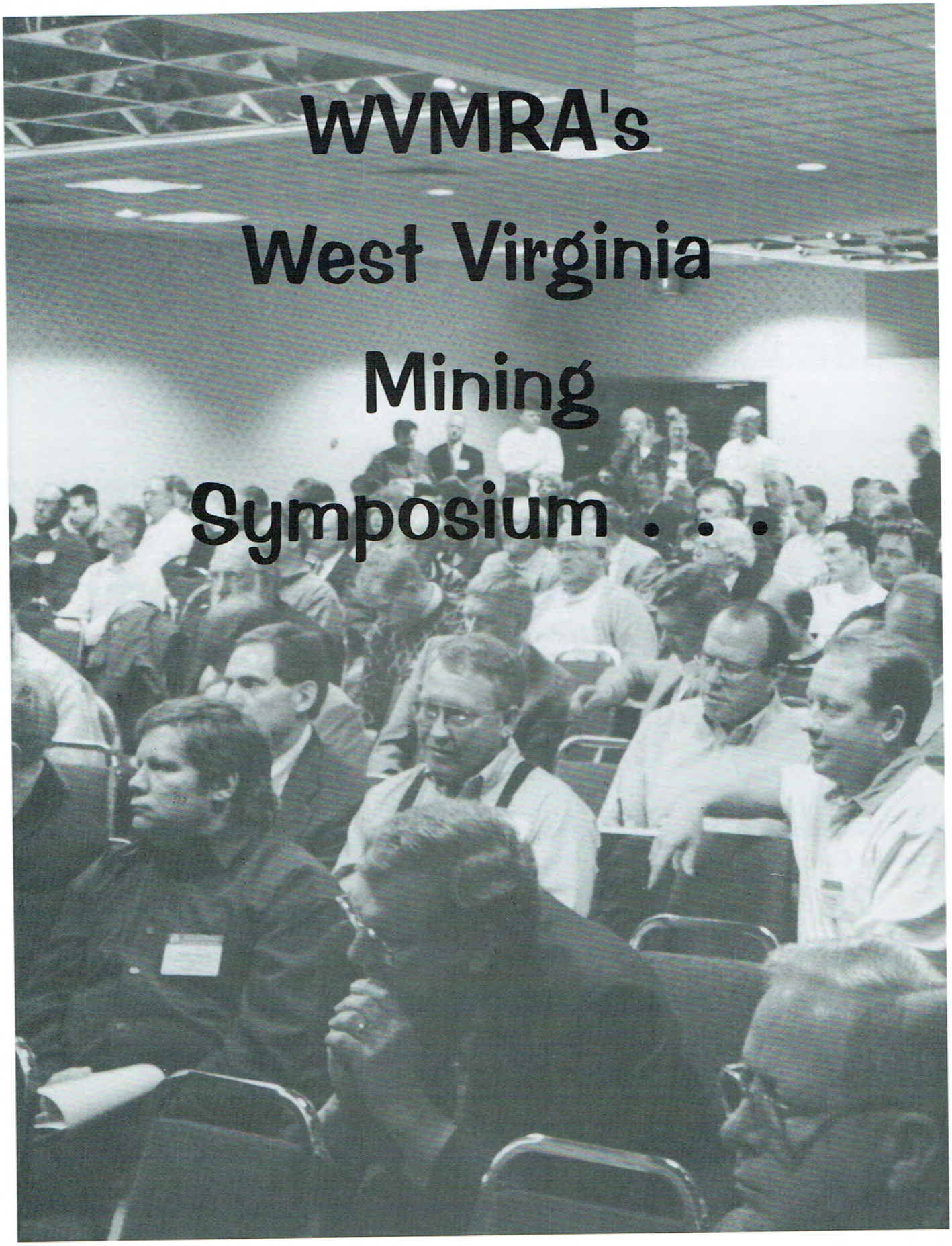

WVMRA's
West Virginia
Mining
Symposium . . .

. . . Still Going Strong After 27 Years

Close to 500 people that represented more than 200 companies from the nation's coal industry traveled to Charleston, W.Va. to partake in the 27th Annual West Virginia Mining Symposium on January 13-14.

This year, the Environmental Protection Agency conducted a workshop "Aquatic Ecosystem Enhancement at Mountaintop Mining Sites" as a part of the Environmental Impact Study to begin the symposium. The EPA portion of the workshop was free to the public.

As in the past, Thursday morning began with the annual buffet breakfast.

For the last several years, however, the breakfast has been graciously sponsored by Heenan, Althen & Roles of Charleston.

Discussion topics for that morning included discussions concerning the EIS process, Coal Bed Mapping and an update of the Bragg et al. v. Robertson et al. lawsuit.

Mike Whitt of the Mingo County Redevelopment Authority concluded the morning session with a presentation on post mining land use in southern West Virginia.

The Mountaineer Guardian awards luncheon was well attended with 25 companies being recognized for excellence in safety within the state's coal industry.

Kingston Mining, Inc.'s underground mine, the Glen Alum Mine in Fayette County, captured the top safety honor by being presented the Barton B. Lay, Jr. Milestones of Safety award for 1999.

Ron Harris, the state's director for the Office of Miners' Health, Safety and Training and Bill Broshears, WVMRA chairman presented the awards.

Harris noted that so many coal companies are doing an outstanding work in safety that is was hard just to stop at 25 companies.

"It's unfortunate that we cannot recognize more companies," he said, "so many are doing a good job."

In 1998, Kingston was recognized nationally as the safest underground coal mine in the country and has received special recognition from West Virginia Gov. Cecil Underwood.

To be eligible for the Mountaineer Guardian award, a mine or preparation plant must have experienced no fatalities during the year and must be nominated by its local Miners' Health, Safety & Training inspector. Winners were selected on the basis of their overall safety programs.

A complete listing of the Mountaineer Guardian award winners begins on page 10.

Ron Harris, began the afternoon session with a year in review for the state's coal industry.

Harris said that the state had nine mining fatalities in 1999, which is up from six in 1998.

Although some may call this a successful year concerning mining fatalities, Harris did not.

"The only way I can call it a successful year is by having no fatalities," he said. "Even one is too many."

Although fatalities were up, Harris noted that roof falls, a major concern in underground mines, were down in 1999.

"They decreased from five to three," he said, "which is a positive sign that we are moving in the right direction."

(Continued on page 8)

The early morning tradition continued as Heenan, Althen & Roles sponsored the mining symposium's buffet breakfast on Thursday as they have graciously done for the past several years.

During the mining symposium, Ron Harris, director of West Virginia's MHS&T, noted that frequency for lost time accidents deceased in 1999.

Harris was also pleased to see that the frequency for lost time accidents dropped from 6.2 to 5.8 last year.

Among other projects Harris said the MHS&T staff is working to expand are getting EMTs in smaller mines and a program that offers mining employees training classes instead of just fining them for safety violations.

More information about MHS&T can be found on its internet site at www.state.wv.us/mhst.

The symposium's afternoon session also included topics on new technology for wheel loaders and drilling, new blasting designs concluding with a preview of the state's legislative session by Senator Oshel Craigo (D-Putnam).

That evening, the WVMRA-sponsored legislative reception was the place to be. Members and friends attended the reception with a good showing from state legislators and staff stopping to discuss issues and interests concerning the coal industry.

Friday morning saw topics that included discussions on the Coalfield Development Office, TMDLs, newly developed Office of Explosives and Blasting and concluded with the a discussion with the DEP staff and Director Mike Castle.

As in the past, the mining symposium concluded with its annual reclamation awards luncheon in which 16 companies were honored for outstanding work.

The reclamation awards are presented to companies that are judged to have outstanding achievements in mine development and construction, land reclamation, water quality enhancement and community involvement.

To be considered for this award, a company must be nominated by its local DEP inspector.

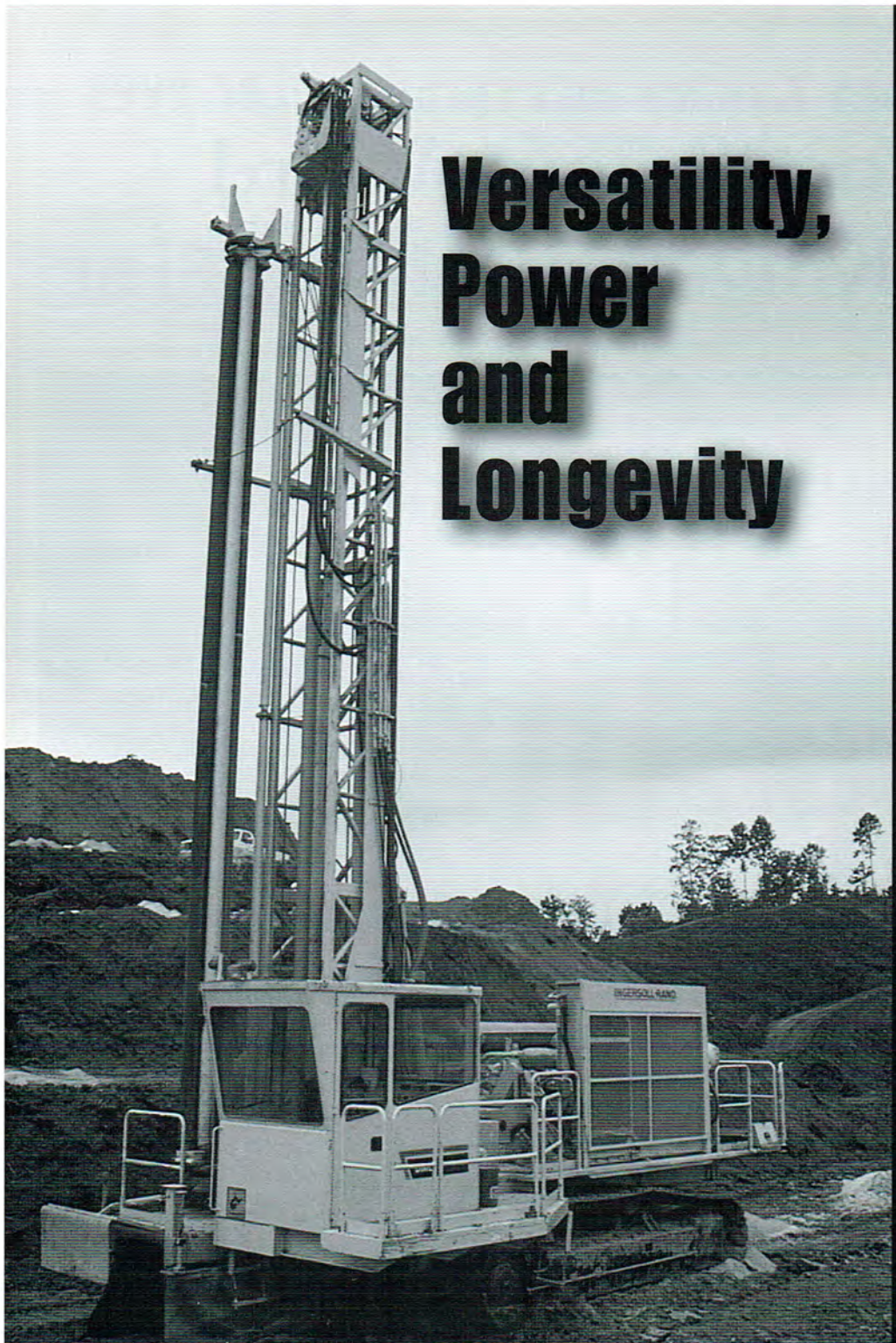
The top honor, the David C. Callaghan award, was presented to C&W Coal Company operating in Barbour and Harrison counties.

"The operations at C&W Coal Company continue to demonstrate the highest standards and long traditions we have come to expect from the West Virginia coal industry," said Ben Greene, president of the WVMRA.

The David C. Callaghan award is named for the former director of the West Virginia Department of Natural Resources and later, of the West Virginia Division of Environmental Protection.

Listing of the 1999 reclamation winners begins on page 18.

DEP Director Mike Castle (far right) along with his staff answered questions and discussed issues during the mining symposium held in January in Charleston, W.Va. Pictured are: (l-r) Charlie Stover, Mike Mace, John Ailes, Ava King, and Mike Castle.



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State's Top Safety Award Goes to Kingston Mining, Inc.

Kingston Mining, Inc.'s Glen Alum Mine, located in Fayette County, was the recipient of the state's top safety recognition for 1999, the Barton B. Lay, Jr. Milestones of Safety Award.

Kingston was one of 25 West Virginia coal companies that were honored in Charleston, W.Va. on Thursday, January 14 for exhibiting outstanding safety practices.

The West Virginia Mining & Reclamation Association in conjunction with the Office of Miners' Safety, Health & Training presented Mountaineer Guardian awards during a luncheon at the 27th Annual West Virginia Mining Symposium.

Kingston Mining, Inc.'s Glen Alum Mine, was the recipient of the 1999 Barton B. Lay, Jr. Milestones of Safety award during the 27th Annual West Virginia Mining Symposium awards luncheon in Charleston, W.Va. on Thursday, January 13th.
Pictured above are (l-r): MHS&T Director Ron Harris, Clark Gilliam, Randy Hansford, Kathy Smith, WVMRA Chairman Bill Broshears, Lacy Lusk, and James Hancock.

"These awards highlight the use of safety-related best practices in the mining industry, and set an example for all to follow," said Dan Miller, vice-president of the WVMRA.

The top award winner, Kingston's Glen Alum Mine, has not experienced a lost time accident and has worked in excess of 320,000 man-hours.

In 1998, the mine received the Sentinels of Safety award which is presented annually to the safest underground mine in the nation.

Also, Kingston received special recognition for its safety record from West Virginia Gov. Cecil Underwood.

Other recognition Kingston has received include the 1998 MSHA's District 4 Pacesetter award and the 1998 West Virginia Mountaineer Guardian award.

The mine has 75 employees and has mined in excess of 1.4 million clean tons of coal.

Ron Harris, MHS&T director said, "The firms recognized during this symposium represent excellence in the mining industry. It's unfortunate that we cannot recognize more companies, so many are doing a good job."

To be eligible for the award, a mine or preparation plant must have experienced no fatalities during the year and must be nominated by its local MSH&T inspector.

Winners for the award are selected on the basis of their overall safety programs.

1999 Mountaineer Guardian Award Nominees

(Recipients in Bold)

Company	Facility	Inspector
Arch of West Virginia	Ruffner	James Mathews
Bandmill Coal Corp.	**Tower Mountain Surface**	**James Mathews**
Banner Coal & Land Co., Inc.	**Mine No. 13**	**Ernie Pyles**
Bluestone Coal Corp.	**Pinnacle Creek Surface**	**Ed Miller**
Browning Fork Coal Services, Inc.	**Mine No. 1**	**Ken Frye**
Buffalo Coal Co., Inc.	A-34 Prep Plant	John Lucas
Buffalo Coal Co., Inc.	**Difficult Bakerstown**	**John Lucas**
Burn Coal, Inc.	**No. 2 Mine**	**Bill Tankersly**
Catenary Coal Co.	**Samples Mine**	**Terry Keen**
Catenary Coal Co.	Tom's Fork Load Out	Terry Keen
C.J.&L. Mining Co., Inc.	**Mine No. 2**	**Milton Smallwood**
Coal-Mac, Inc.	Mine No. 5	James Mathews
Coastal Coal WV, LLC	**Albright Prep Plant**	**Dave Barlow**
Coastal Coal WV, LLC	Whitetail Prep Plant	Dave Barlow
Cranesville Stone, Inc.	**Quarry**	**Dave Barlow**
Dakota Mining, Inc.	No. 2 Mine	Ernie Pyles
Eastern Associated Coal Corp.	**Rock Lick Siding**	**Ernie Pyles**
Elk Run Coal Co., Inc.	**Black Castle No. 4**	**Randall Bailey**
E.T. & S., Inc.	Plant No. 1	Randall Bailey
Fairfax Sand & Crushed Stone	Scherr	John Lucas
Fola Coal Co.	**Peach Orchard Prep Plant**	**Mike Armentrout**
Greenbrier Limestone Co.	**Johnson Quarry**	**Lloyd Collins**
Hampden Coal Co., Inc.	Load Out	Ken Frye
Hawthorne Coal Co., Inc.	Sawmill Run Prep Plant	Barry Fletcher
Hobet Mining & Const. Co., Inc.	H-23 Prep Plant	Randall Bailey
Hobet Mining, Inc.	Jule Fork	Randall Bailey
Hobet Mining, Inc.	Slab Fork	Bill Wolford
Independence Coal Co., Inc.	Liberty Processing	Kerry Herron
Independence Coal Co., Inc.	Twilight II Surface	Randall Bailey
Jaunt, Inc.	Chapmanville Quarry	James Mathews
J. F. Allen Co.	**J.F. Allen Quarry**	**John Meadows**
Kepler Processing Co., inc.	Kepler No. 1 Prep Plant	Gilbert Witt
Kingston Mining, Inc.	**Glen Alum Mine**	**Clark Gillian**
Laurel Coal Corp.	Spruce Lick	Kerry Herron
Long Branch Energy	**Mine No. 16**	**Ernie Pyles**
McElroy Coal Co.	**McElroy Mine**	**Colin Simmons**
Mingo Logan Coal Corp.	**Black Bear PP**	**John Griffith**
Mountain Edge Mining, Inc.	Red Cedar Surface No. 1	Randall Bailey
Northern Resources	Edna Ruth Prep Plant	Gilbert Witt
Paint Creek Terminals	Crown Hill Dock	Robert Cozart
Patton, Inc.	**Mine No. 5**	**Bill Dotson**
Pen Coal Corp.	**Copley Trace No. 1**	**Rod Wallace**
Pen Coal Corp.	Mine No. 5	Richard Boggess
Pioneer Mid-Atlantic, Inc.	Beckley Quarry	Clark Gillian
P.M.I. Coal Co., Inc.	**Mine No. 4**	**Kendall Smith**
Pritchard Mining Co.	Len Creek No.1, Pit 2	Terry Keen
R.H. Armstrong, Inc.	Kelley Mountain Quarry	John Meadows
Rockspring Development, Inc.	**Camp Creek Plant**	**John Griffith**
Romney Stone Quarry	Romney Stone	Dave Barlow
Scorpio Mining, Inc.	Laurel Run Mine	Brian Mills
Simmons Fork Mining, Inc.	Simmons Fork Surface	Ed Miller
Tazz Mining, Inc.	**Still Run No. 5**	**Kendall Smith**
Terry Eagle Coal Co. LLC	No. 1 Prep Plant	Lloyd Collins
United Coals, Inc.	**Stenger/Bond**	**Tom Shingleton**
Vandalia Resources, Inc.	Alloy Dock	Charles Webb
W. A. Mining, Inc.	Caretta No. 2	Janice Molineaux
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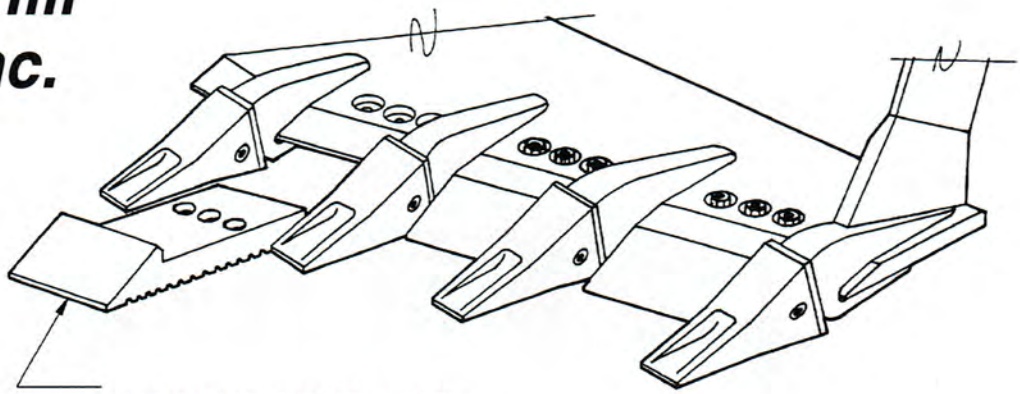

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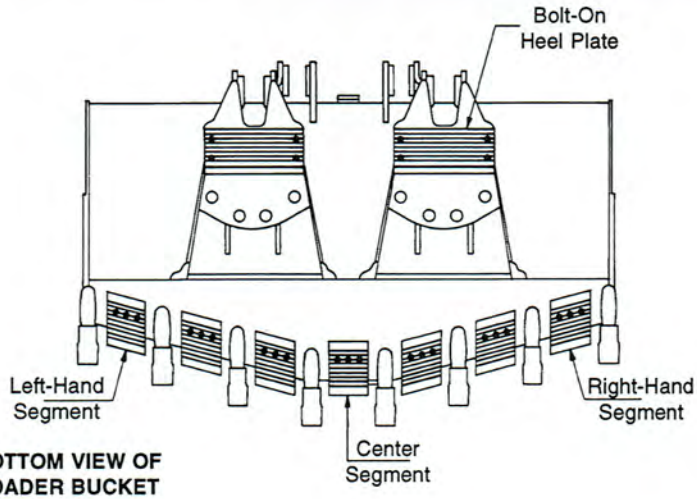

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America's Coal and West Virginia's Coal:

The Foundation Material For Economic Security, Energy Security, and National Security

By: Richard L. Lawson - President, National Mining Association

Let's start this overview of coal in America with some specifics on West Virginia coal in the present and in the future.

Lawson

Last year's statistics suggest that for Americans to have otherwise generated the electric power delivered by West Virginia coal they would have had:

- To import almost an additional 1-million barrels of oil a day;
- or to increase natural gas production by 10 percent.

The 180-million tons of coal West Virginians delivered to the national economy last year provided America with, in turn, approximately the following:

- 4 percent of her total energy requirement, including domestic production and imports;
- Almost 5 percent of all fossil fuel consumed, including oil imports;
- 5 percent of all domestic energy production, including nuclear power and hydroelectric power;
- 6 percent of all domestic fossil-energy production - 6 percent of the energy in all domestic oil, natural gas and coal came from West Virginia;
- Almost 7 percent of the power generated by American electric utilities;
- Almost 10 percent of the power generated with fossil fuels;
- 12 percent of the power generated with coal;
- 47 percent of U.S. coal exports - the only energy America does export in significant quantity;
- And 15 percent of U.S. coal production.

The energy represented by West Virginia's presently recoverable reserve of about 54-billion tons is the approximate equivalent of the following:

- 3 times the proved oil reserve of the United States;
- 4 times the oil reserve of all the nations of Western Europe;
- Almost 4-billion barrels more than the oil reserve of Venezuela, an OPEC nation, a major world producer;
- And 5-billion barrels more than all the oil in Africa, including Libya, also a big producer.

It can be estimated that the West Virginia coal reserve has:

- 7 times the energy content of the natural gas reserve of Mexico;
- 7 times that of Canada;
- Almost three-and-a-half times that of Canada and Mexico combined;
- More than two-and-a-half times that of the United States;
- And about one-and-a-half times the energy content of all the proved natural gas reserves of North America.

The power potential of the West Virginia recoverable reserve also represents approximately the following:

- 11 times America's power requirement last year;
- 59 times our nuclear output;
- And 74 times the combined output with natural gas of all generators.

Now let's put American coal in context - the context of world energy, of the world economy and of world politics.

All modern economic activity begins with energy. It is the difference between the misery of subsistence and a comfortable standard of living - the use of energy to support work, to create wealth, to expand life.

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(Continued on page 41)

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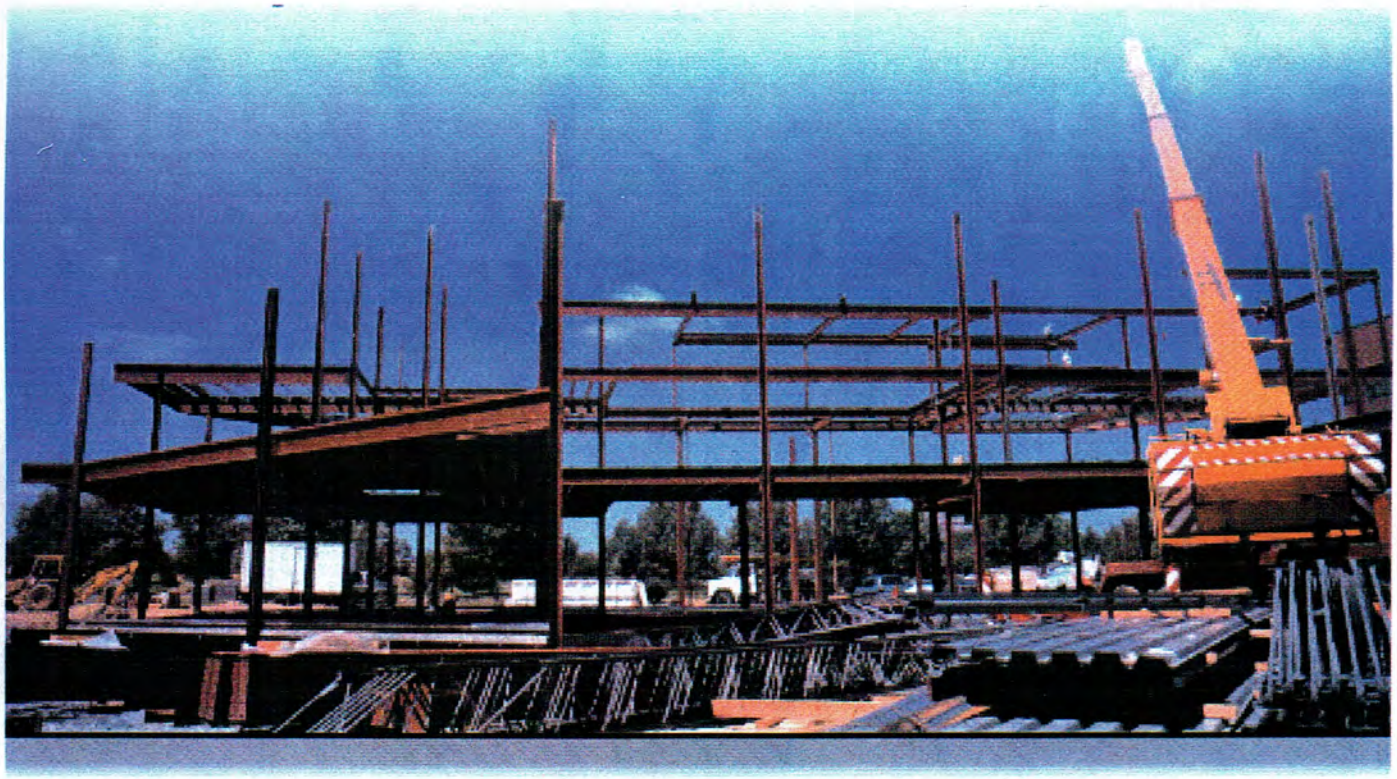

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C&W Coal Company First-Tim

It was the fourth time in 25 years that C&W Coal Company received recognition for its outstanding work in reclamation.

Yet, this year was a little different.

This year, the company stood at the top and for good reason.

C&W Coal Company, which operates in Barbour, Harrison and surrounding counties, was presented the prestigious David C. Callaghan award for 1999 during the 27th Annual West Virginia Mining Symposium luncheon in Charleston, W.Va. on January 14th.

The company was one of 16 West Virginia coal and contracting companies recognized for excellence in environmental enhancement with reclamation.

Through the help and support of C. E. "Jim" Compton, C&W Coal Company was founded by Charles Compton, Bernard Reeves, and William M. "Bill" Compton in 1961.

It was C&W Coal Company of Barbour County that captured 1999 David C. Callaghan award which was presented during the 27th Annual West Virginia Mining Symposium awards luncheon in Charleston, W.Va. on January 14th.

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, former DNR and DEP Director David Callaghan, Bill Compton, Karl Swisher, DEP Inspector Tim Richard, and DEP Supervisor Brent Wiles

However, in 1971, Bill Compton became president of C&W and sole owner in 1974.

It is said that Bill Compton has a great sense of history and holds a deep and abiding reverence for the earth, the environment and simply humankind in general. He is guided by the concept that we do not own the land yet are stewards for the land.

After nearly 40 years, Bill Compton's and C&W Coal Company's record of stewardship speaks for itself.

Since its inception, C&W has permitted in excess of 1,200 acres under a range and variety of permits to include deep mines, tipple loadouts, surface mines, haulroads, and prospects.

In all C&W has had a total of 47 Article 3 (coal) permits and two Article 4 (quarry) permits.
At its peak, C&W Coal employed approximately 70 people and produced an average of 28,000 tons of coal every month.

Back in 1977, a site reclaimed by C&W was featured on the cover of the Fall issue *Green Lands.*

(Continued on page 20)

e Winners of Callaghan Award

In Barbour and Harrison counties, for land stewardship far above and beyond requirements of the law and regulatory program. C&W's policy of responsible remining and careful restoration of abandoned mine lands has resulted in substantial acreage in these counties, which is not only environmentally stable and aesthetically pleasing, but economically productive as well. For nearly 40 years, the company has constantly demonstrated a spirit of commitment to the land and people of central West Virginia that exemplifies the highest standards of the mining and reclamation industry.

(continued from page 18)

The photograph showed an area near State Route . 57 in Barbour County that had bales of hay that littered a field as the post mining land use on the company's reclaimed site. The C&W Coal Co. taken this site over when it was an abandoned mine site.

Although the site had been mined many years before, C&W totally reclaimed the abandoned site while mining a permitted area nearby. Not one pound of coal was taken from the abandoned site for reclamation.

Twenty-two years later in 1999, this same site yielded the 22nd crop of hay, providing strong evidence of a productive land after mining.

C&W Coal was also recognized by the WVMRA in 1983 "for superior reclamation accomplishment in the rehabilitation of previously mined areas through modem overburden handling techniques, elimination of acid mine drainage, and effective permanent revegetation, which has improved the overall environmental integrity of this area in Barbour County."

In 1993, the company was again recognized for exemplary attention to detail and finesse in the planning and construction of drainage control structures and haulroads, with careful attention to the protection of local residents in Upshur County.

Over the past 38 years, C&W Coal Company has reclaimed in excess of 250 acres of pre-SMCRA abandoned mine lands in Barbour County and the surrounding area. This is an impressive accomplishment considering this acreage is above and beyond what C&W had under permit and bond with the state of West Virginia.

C&W held no legal liability for reclamation and is a demonstration of Bill Compton's personal moral imperative of good stewardship.

"I did nothing," Compton said, "we did it all.

This site was the featured on the cover of the Fall 1977 issue of *Green Lands.* Once abandoned with open pits, C&W Coal Company has reclaimed the site as seen above. It is now productive farmland producing hay for more than 20 years.

Through the dedicated efforts of Bill Compton, C&W Coal Company has reclaimed in excess of 250 acres of pre-SMCRA abandoned mine lands in Barbour and Harrison counties and the surrounding area during the past 38 years.

Everything was possible only with the support of the employees and the cooperation of the state."

However, if it had not been for his commitment to reclamation, these 250 acres would have remained nonproductive, mine wastelands of highwalls and open pits posting a burden upon the state's Abandoned Mine Lands and Reclamation program.

Instead, through Compton's efforts, these sites now provide valuable and productive agricultural lands and wildlife habitat.

Compton exhibits extraordinary spirit and continual commitment to reclamation efforts, the environment, and community improvement.

His passion for the stewardship of the earth and environment is easily demonstrated through his work. All but one of the 49 mining permits issued to C&W Coal were sites that were previously mined with existing highwalls.

Over four decades William M. "Bill" Compton, president of C&W Coal Company, has committed to improvements in industry reclamation standards, betterment of the community.

Ultimately, making an investment for future generations.

Since its inception, C&W has permitted in excess of 1,200 acres under a range and variety of permits to include deep mines, tipple loadouts, surface mines, haulroads, and prospects.

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WEST VIRGINA WILDLIFE AWARD

CATENARY COAL COMPANY

Kanawha County

Presented by the West Virginia Chapter of the National Wild Turkey Federation for outstanding accomplishments in the establishment and enhancement of overall wildlife habitat, with special emphasis on wild turkeys.

Pictured are (l-r): Peter Lawson, Willie Hudson, Eddie Turner, Fred Browning, DEP Inspector Duane Stowers, President of the West Virginia Chapter of the National Turkey Federation Greg Gibbs, and Jim Felber.

WEST VIRGINA WETLANDS AWARD

HOBET MINING, INC. - DAL-TEX COMPLEX

Logan County

Presented by Ducks Unlimited for outstanding accomplishment in the creation and preservation of wetlands wildlife habitat.

Pictured are (l-r): Mark White, West Virginia Duck Unlimited State Chairman Brian Galligan, DEP Inspector Ray Horrocks, Kent DesRocher, and Jim Constant.

JAMES E. "PETE" PITSENBARGER AML AWARD SOUTH

BRADFORD BROTHERS, INC.

Raleigh County

In Raleigh County, near Beckley, for major aesthetic improvements in the regrading and restoring topsoil on more than 40 acres of the Piney Creek abandoned refuse, including proper installation of effective drainage control resulting in a major environmental cleanup, which is readily visible from Interstate 64.

Pictured are (l-r): DEP Land Agent George James,WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Pete Pitsenbarger, Jerry Bledsoe, DEP Inspector Ron Sheets, and Bobb Bradford.

JAMES E. "PETE" PITSENBARGER AML AWARD NORTH

GREEN MOUNTAIN COMPANY

Harrison County

In Harrison County, near Shinnston, for the removal of hazardous materials and the installation of a major drainage system to correct environmental degradation at the long abandoned Owings Mine Complex. A total of 10 mine seals and a SAPS system water quality treatment facility complete this 80-acre site.

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Pete Pitsenbarger, Rod Clay, and DEP Inspector James Baczuk.

ARCH OF WEST VIRGINIA - WYLO MINE

Logan County

In Logan County, near Stowe, for extraordinary attention to detail in the cleanup of Cartwright Branch. This AML-eligible site of abandoned underground mine openings and coarse refuse disposal, which had its beginning in the 1930's, has now been transformed to an aesthetically pleasing, safe and stable environment.

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, DEP Inspector Ron Sheets, Bill Oldani and Frank Simmons.

BUFFALO COAL COMPANY, INC.

Grant County

In Grant County, for outstanding attention to detail in the mining and reclamation of more than 107 acres of disturbed area with particular emphasis on water quality and wildlife habitat near the environmentally sensitive old Stony River Dam. The completed site is now ecologically superior and compatible with natural conditions of that area.

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Don Cussins, John Geroski, Dennis Dolechek, Steve Shaffer and DEP Inspector David Idleman.

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CHAFIN BRANCH COAL COMPANY

Mingo County

In Mingo County, near Gilbert, for long-term commitment to environmental stewardship in mining the Alma and Cedar Grove seams of coal. Reclamation emphasis was placed on wildlife habitat and the use of sediment control structures for future wetlands in the uplands region of the permit.

Pictured are (l-r): Larry Mauk, WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Jimmy Harless, Mike Murphy, and DEP Inspector Timothy Justice.

Quarry Award

CONTINENTAL BRICK COMPANY

Berkeley County

In Berkeley County, near Martinsburg, for extraordinary attention to detail in mining of clay and shale and utilizing the mined area for productive future use. The Eastern Regional Jail Facility was first opened in the early 1990's with a major expansion dedicated in 1999, all built on the nearly 100 acre quarry site.

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Charles Pickett, Jeff Shawyer and DEP Supervisor Brent Wiles.

HAMPDEN COAL COMPANY, INC.

Mingo County

In Mingo County, near Gilbert, for innovative engineering and excellence of design in converting a 30-year-old refuse disposal site into a competitive shooting range for several local law enforcement agencies.

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Jimmy Harless, Mike Murphy, DEP Inspector Timothy Justice, and Larry Mauk.

PEN COAL CORPORATION

Wayne County

In Wayne County, for engineering, upgrading and relocating more than 8,000 feet of public road to complement a major underground mining operation. This major road improvement has enhanced the water quality of Kiah Creek and the East Lynn Lake, as well as the travel of many local residents.

Pictured are (l-r): Robert Marsh, Randy Maggard, WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Steve Capelli Carl Hazelett, DEP Inspector Scott Eggerud, and Randy Hinkle.

PRINCESS POLLY ANNA COAL COMPANY

Greenbrier County

In Greenbrier County, for eliminating more than 700 feet of abandoned highwall, planting a diverse mixture of hardwood trees, grasses and legumes as well as improving water quality on the Little Clear Creek watershed. Overall, aesthetics of the area have been greatly enhanced.

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle,Anthony Taylor, Tommy Scarles and DEP Inspector Russell Keaton.

PATRIOT MINING COMPANY, INC.

Monongalia County

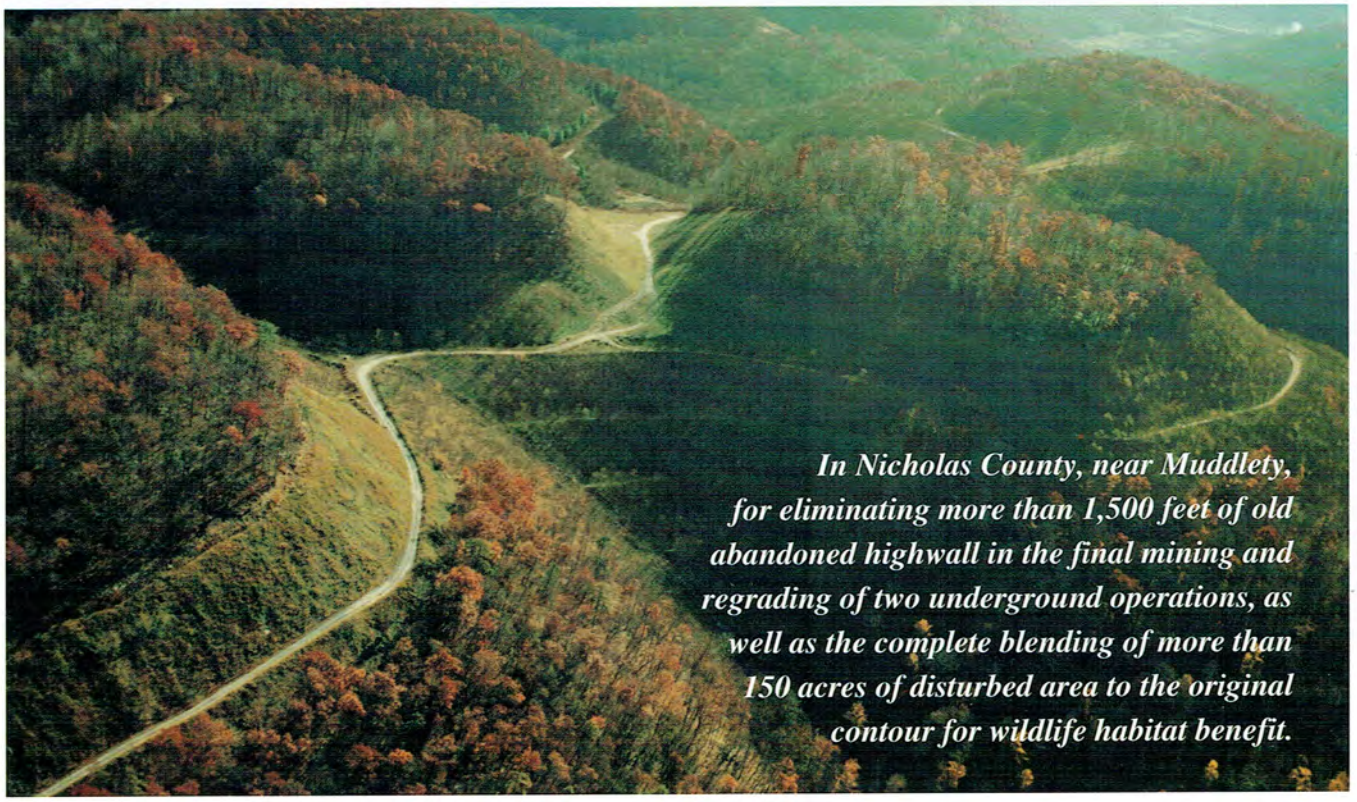
In Monongalia County, near Osage, for the use of Fluidized Bed Combustion ash as an alkaline amendment to guarantee excellent post mining water quality, and for the donation of land, site preparation and revegetation of two soccer fields and a parking lot to the Morgantown Youth Soccer Association.

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Ron Hamric, Brownie Stuart, and DEP Inspector Steve Ball.

PEERLESS EAGLE COAL COMPANY

Nicholas County

Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Frances Meadows, and DEP Inspector Bill Little.



In Nicholas County, near Muddlety, for eliminating more than 1,500 feet of old abandoned highwall in the final mining and regrading of two underground operations, as well as the complete blending of more than 150 acres of disturbed area to the original contour for wildlife habitat benefit.

1999 Reclamation Awards

Quarry Award

PIONEER MID-ATLANTIC, INC.

Raleigh County

In Raleigh County, near Bradley, for the responsible operation of a crushed stone quarry with utmost attention to safety, appearance and stability. The operation practices contemporaneous reclamation with an ongoing tree planting program that provides a pleasing view from the heavily traveled West Virginia Turnpike.

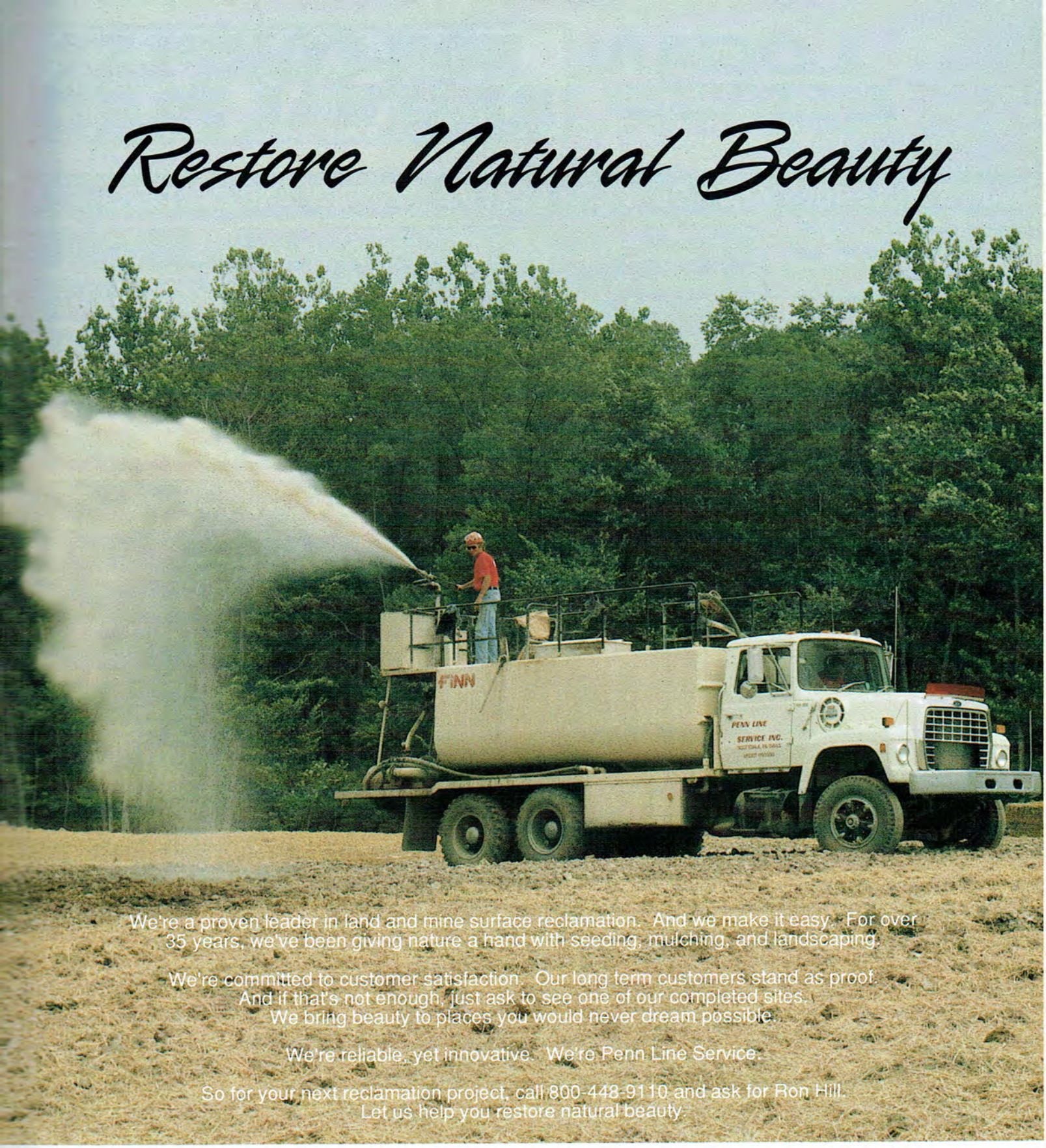
Pictured are (l-r): WVMRA Chairman Bill Broshears, DEP Director Mike Castle, Ed Treadway, and DEP Inspector James C. Lucas.

STANLEY INDUSTRIES, INC.

Upshur County

In Upshur County, near Hodgesville, for the remining and cleanup to modern reclamation standards of more than 60 acres of abandoned highwall and spoil resulting in a return to approximate original contour with excellent post mining water quality.

Pictured are (l-r): Wayne Stanley, WVMRA Chairman Bill Broshears, DEP Director Mike Castle, David Stanley, and Gary Stanley.



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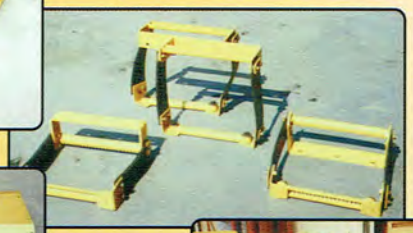

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America's and West Virginia's Coal *(from page 16)*

been important in America's prolonged growth of the 1990s, especially electric power. It's estimated that 13 percent of the nation's power is required for the activities associated with computers - their fabrication, their operation, their peripherals and the functions of the Internet.

The world's primary energy is imported petroleum. Two-thirds of the world's reserves and the dominant producers are in the Mid East, a politically volatile region. A larger share is in the hands of the Organization of Petroleum Exporting Countries, an organization that joins Mid East producers with other significant producers in a cartel dedicated to maximizing the worldwide price of oil.

This unique combination of price volatility and political instability associated with imported oil have had the following consequences:

- A worldwide economic disruption due to price spikes that followed the Oil Embargo of the early 1970s;
- Another global economic disruption that followed the fall of the Shah of Iran in the late 1970s;
- A big geopolitical disruption with a multi-national military deployment to keep the trade routes open and to stabilize the region during war between two major producers in the late 1980s - the Iran-Iraq War;
- And the bigger geopolitical disruption of the Persian Gulf War in 1991, brought on by Iraq's move to acquire dominance of the region.

The volatility has been dampened for the present by factors that include the following:

- Increased efficiencies in use;
- Competition from new, non-cartel producers;
- Displacement of oil both in and by electric power;
- And finally, but foremost in importance, by an unaccustomed stability in the geopolitics of the Mid East - a stability both caused and enforced by the continuing presence of young Americans on military deployment.

However, world energy demand is projected to increase by more than 50 percent over the next 20 years as the developing world begins truly to develop. Fossil fuels will remain the world's overwhelmingly dominant energy.

Many forecasters think the global demand for imported oil will begin to overrun supply in the period 2000-to-2010; that the instabilities will soon appear in new forms.

The world's proved reserves of fossil fuels break down as follows:

- Natural gas -14 percent;
- Imported oil - 17 percent;
- And coal - 69 percent.

The U.S. domestic reserve of recoverable fossil fuels breaks down out as follows:

- Oil - 2 percent;
- Natural gas - 3 percent;
- And coal - 95 percent.

The energy content of the recoverable U.S. coal reserve of 275 billion tons represents roughly the following:

- 17 percent of the world's fossil energy;
- 25 percent of the world's coal;
- 55 percent of the energy in the world's combined reserves of oil and natural gas;
- 100 percent of the energy in world oil;
- And 120 percent of that in world natural gas.

Every ton of coal that America and the world use represents about 3.8 barrels of imported oil they won't require.

Electric power is the most versatile and widely required energy - used in industry, in commerce, in personal life. Almost every economic activity or amusement or convenience requires electric power, and it can be used to improve the performance of most existing activities.

Electric power is the feedstock of much activity and the genesis of more. An abundance of power is a condition requisite for a modern economy. Its presence is required for strength and growth, its absence a predicate for decline.

If power is not in the right place at the right time in the right amounts at the right price, everything either slows down or - in the case of computers - goes down.

The average of international power rates in dollars per 1,000 kilowatt-hours compares as follows:

- Japan — $269 for household power and $185 for industrial power;
- Germany — $204 for households, $101 for industry;
- The European average — $137 for households, $79 for industry;
- And the U.S. — $84 for households, $47 for industry.

The average of U.S. rates for industrial power - with coal delivering 56 percent of utility generation - is the lowest among the world's major industrial nations, and they rank as follows:

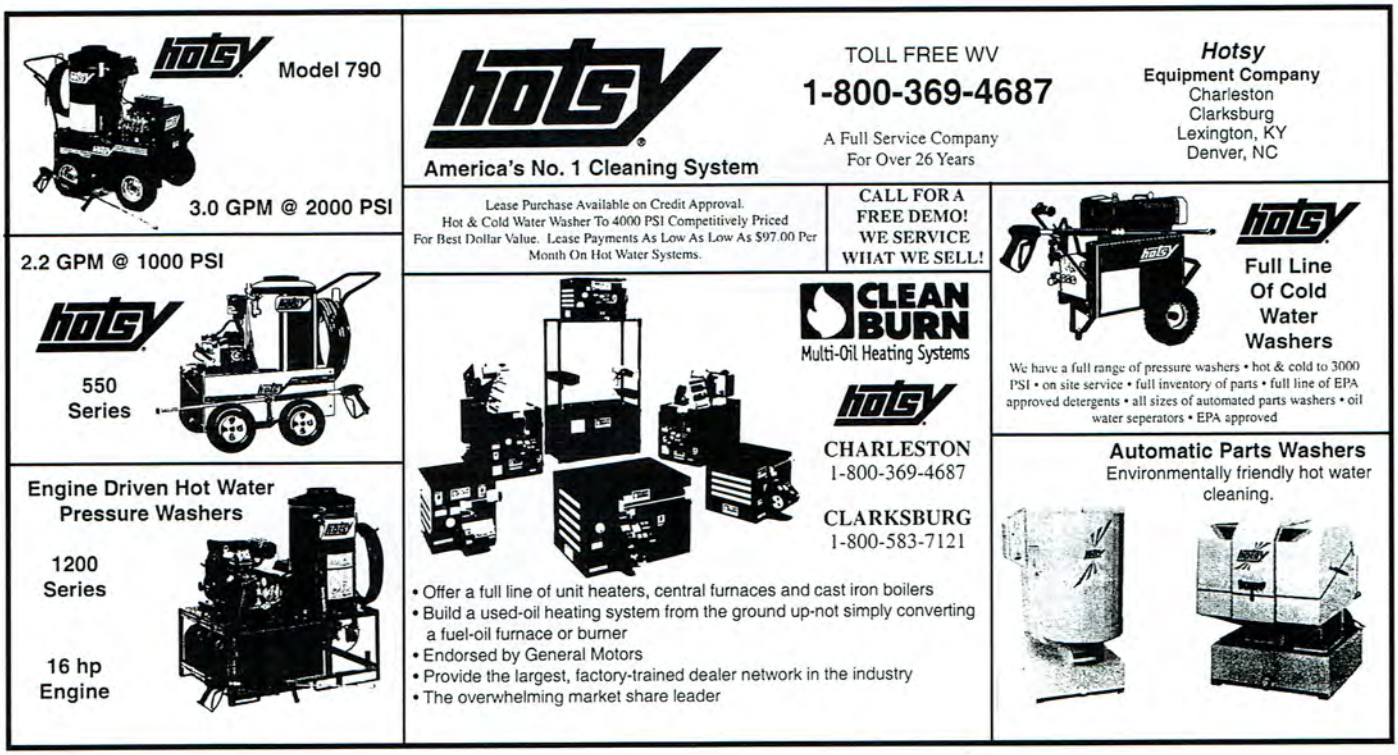
- 37 percent below the average for Europe;
- 49 percent below Germany, where subsidized coal and nuclear power predominate;
- And 73 percent below Japan, where nuclear and liquid natural gas predominate.

Low cost power from coal is one of America's competitive and comparative advantages in the world economy. Low cost power from coal is an edge for the goods and services of all American workers - especially including coal from West Virginia.

West Virginia is America's second-ranked producer of coal, the fourth-ranked holder of reserves. Technological development underway has the potential to extend the utility of the reserve and also reduce the temporary disruption associated with mining.

Federal outlooks say America may require an additional 1.3-trillion kilowatt-hours a year of electric power over the next 20 years - 1-trillion to accommodate growth and another 300-billion, or so, to offset the anticipated decline of nuclear generation.

This is more electric power than now required in combination by our principal economic competitors,



Japan and Germany; more than now consumed by the five largest economies of the European Union.

Federal law will require its generation and sale in a free market by a restructured and competitive electric-power industry. The restructuring is under way now. The law has two purposes in this regard: To provide low-cost power in abundance; and to direct that power to displace economically and politically volatile imported oil in critical sectors of the economy.

Nuclear power is not a consideration for new power. It was pushed aside by problems of politics and public perception. The same forces are at work on hydroelectric generation. It too may decline.

Therefore, the choices left to generate power in large volumes are the fossil fuels - oil, natural gas, and coal. The environmental community also advocates waste, wood and biomass.

The competition in power will be based on sales price. Fuel cost is a most important component in the price of power. Federal statistics disclose the average price of utility fuel has gone down as coal use has risen.

These same statistics also note the following recent average fuel costs across the range of consumers:

- Natural gas - 381 cents per million British thermal units;
- Residual oil - 246 cents;
- Wood and waste - 188 cents;
- And coal - 137 cents.

The world's proved reserves of fossil fuels break down as follows:

- *Natural gas -14 percent;*
- *Imported oil - 17 percent;*
- *Coal - 69 percent.*

The U.S. domestic reserve of recoverable fossil fuels breaks down out as follows:

- *Oil - 2 percent;*
- *Natural gas - 3 percent;*
- *Coal - 95 percent.*

Waste and wood: To generate half the 1.3-trillion kilowatt-hours would require a 1,200 percent increase in output.

The other so-called renewables: Wind and solar generation require subsidies and market allocations at present. They contribute only about only about one-tenth of one percent of all power.

Natural gas: To generate half the 1.3-billion kilowatt hours would require production of an additional 7-trillion cubic feet a year, based on last year's performance in power. Last year's gas production was only 19-trillion cubic feet. Imports were 3-trillion cubic feet.

Imported oil: To generate half would require an additional 3-million barrels a day, more than enough to influence the world market for oil. The objective of the National Energy Policy Act is to reduce dependence on imports, not increase it.

Here, then, is where U.S. coal and West Virginia coal fit into the life of America and Americans:

- It is important to the economic security of the people - to the economy's most vital component and required commodity, electric power;
- It is important in the energy security of the nation - 95 percent of fossil reserves;
- And it is important to National Security - a means by which to influence and moderate the requirement to send young Americans to the Persian Gulf.

Coal will be a critical factor to America's continued success in the 21st Century.

And West Virginia coal will be no less critical to effectiveness of American coal.

Water Management Techniques for Acid Mine Drainage Control

By Jeff Skousen and John Foreman

In 1999, the Acid Drainage Technology Initiative published "A Handbook of Technologies for Avoidance and Remediation of Acid Mine Drainage." The Handbook is comprised of five chapters: 1. Introduction, 2. Alkaline Addition and Overburden/Refuse Reclamation, 3. Engineered Structural Techniques, 4. Active Treatment Technologies, and 5. Passive System Technologies. The Handbook can be obtained by contacting Kelley Shillingburg (formerly Wolfe) at WVU (304-293-2867 x5444) or by the internet via www.wvu.edu/~agexten/landrec/land.htm . *This article is a condensed version of Chapter 3 of the Handbook.*

Surface Diversion

Diverting surface water above a mined site to decrease the amount of water entering the mined area is highly recommended in acid-producing areas. This technique can control water volume and direction and minimize the effects of acid mine drainage (AMD) on receiving streams.

Surface diversion of runoff involves construction of drainage ditches to move surface water quickly off the site before infiltration or to limit its movement into the backfill. The diversion is accomplished either by ditching on the uphill side of surface mines or by providing new channels or impervious channels of existing surface streams to convey water across the disturbed area.

A strategy for alkaline loading can be accomplished by diverting surface water into beds of alkaline material (slag or other lime materials) to pick up alkalinity and allowing the alkaline water to flow into spoils or underground mine pools. Alkaline loading of water upgradient of mined areas or before it enters the backfill buffers the effects of subsequent contact with acid water.

Soil Covers and Plastic Liners

Covers are constructed from natural or man-made materials that retard or divert the movement of water and oxygen into areas containing acid-producing rock. Soil covers can achieve substantial reductions in water flow through piles, but generally do not control AMD completely. Plastic liners are rarely used in mining because covering large volumes of waste with a liner is usually too expensive. However, this method may be appropriate in settings where isolation of small pods of acid-producing material is possible.

At the Upshur Mining Complex in West Virginia, Meek (1994) reported covering a 20-ha spoil pile with a 39-mil PVC liner. This treatment reduced acid loads by 70%.

In Illinois, a soil cover system was developed for a coal refuse pile that was a graded and compacted, and overlain by a compacted clay liner and a protective soil cover (Gentile et al. 1997). Infiltration was reduced by about 18% initially compared to an unreclaimed refuse surface. Over time as the material in the cover consolidates and becomes vegetated, the cover should reduce infiltration by 80% or more.

Dewatering

Removing water, one of the principal reactants in pyrite oxidation, should theoretically stop the production of AMD. Without water to move reaction products from the surfaces of pyrite, no contamination of waters should occur. While this can be done in a laboratory setting, complete removal of water in nature is nearly impossible. However, reducing the amount of water contacting pyritic material and containing water that is in contact with acid-producing materials may reduce the impacts of AMD to off-site water bodies and streams.

Removing water before it contacts pyritic material

by pumping may also be done. A series of peripheral deep wells were installed to dewater abandoned deep mines adjacent to the Crouch Mining Dahlquandy surface mine in Britain to allow the water to be discharged without treatment (Norton 1987).

This mine is one of the largest open cast mines in the UK and the drainage from surrounding deep mines required chemical treatment before discharge. The water quality from pumped wells was alkaline and metal concentrations were low enough to allow water to be discharged to receiving streams without treatment. Another benefit was the improved working conditions in this pit with respect to water management.

Draining water away from pyritic materials as rapidly as possible may keep water from reacting and forming acid products. Water may move around mine tailings or compacted refuse of low permeability if placed within high-permeability overburden within a backfill. If the permeability contrast between the tailings and the surrounding material is large, groundwater will flow around the tailings mass rather than through it, and metal leaching will be minimized. This phenomenon is indicated at the Falconbridge Fault Lake tailings site (St-Arnaud 1994).

Drains can be installed in various places to move water from one area to another. Chimney drains collect water from a backfill or valley fill and convey the water through a long, high, column of coarse sandstone.

Highwall drains collect water from the highwall along permeable channels of sandstone or limestone. French drains are small, distinct constructed channels in disturbed rock, usually along the pavement, where water is directed to flow out of the fill. Blanket or bottom drains are constructed by forming a coarse, permeable rock covering along the entire fill bottom to allow water to move out of the fill through the base.

All of these methods are reliable methods for moving water from spoil, refuse, and fills. However, in one case a blanket drain in a hydrologically isolated surface mine in WV did not reduce AMD formation (Geidel and Caruccio 1984).

Inundation

Water diversion away from acid-producing materials or dewatering is not always the best approach when these materials can be rapidly and permanently inundated, thereby minimizing oxidation of acid-forming materials. Inundation is only suggested where a water table may be re-established to cover the materials (such as below drainage deep mines) and has not been recommended for surface mined lands or above drainage deep mines in the mountainous Appalachian region. Complete inundation has been successful in other areas where acid-producing materials are submerged in lakes or other permanent impoundments.

Constructing impoundments to inundate isolated areas of surface mines has been used to minimize or eliminate AMD. Saturation of acid-producing spoils may not always improve pH, but there is usually some reduction in metal concentrations. However, the drainage often has a less deleterious effect on downstream water quality than that from unreclaimed areas.

The creation of an impoundment in the final cut of a surface mine forms recreation areas, aids in recharging the water table in the local area, and can eliminate or greatly reduce the amount of pollution from AMD and silt. The impoundment can also be designed so the body of water will completely flood any deep mine workings or auger mining holes, thereby limiting pyrite oxidation. Orava et al. (1997) reported that in-pit disposal of 3 million tons of spoil from an open pit gold mine inhibited acid generation. The elevated water table flooded the tailings and caused an improved water quality in the pit. Flooding of inactive zinc and lead mine workings at the Eagle Mine in Colorado submerged about 80% of the mined ore body. Water pH has increased from 3 to 6, and Zn concentrations have decreased from 350 mg/L to 50 mg/L (Neukirchner and Hinrichs 1997). Perry et al. (1997) found that acid-producing materials placed in a seasonal water table produced AMD in the eastern coal fields of the U.S. Fluctuating water tables or partial flooding produced worse drainage than that predicted for either "dry" or submerged placement.

The disposal of acid-producing materials in an impoundment to limit its exposure to air and water has been used for decades with mixed results. Many coal slurry impoundments have been constructed for disposal of pyritic materials near coal preparation plants. In most

cases, acid products are stored in the slurry impoundment and are released as water drains from the impoundment. Many coal refuse disposal sites must treat the drainage with chemicals before discharge.

Disposal of sulfide tailings under a water cover, such as a lake or fjord, has been used extensively. Wet covers also include flooding of above ground tailings ponds. Fraser and Robertson (1994) found tailings submerged in four freshwater lakes were not reactive and dissolved metal concentrations in the lake water were very low. Pedersen et al. (1994 and 1997) concluded that little Cd, Pb or Cu were being released from submerged tailings in Anderson Lake in north-central Manitoba, Canada (See also Amyot and Vezina 1997, Arnesen et al. 1997, and Dave and Vivyurka 1994).

Inundation of an underground mine can be an effective method of decreasing AMD by depriving pyrite of oxygen. In addition, if overlying rocks contain carbonate minerals, flooding can provide additional alkalinity by increasing the volume of alkaline strata in contact with mine water.

On the other hand, if the mine walls contain readily soluble oxidation products of sulfides, inundation will cause a temporary increase in acid concentrations that should decline over time. If the water table fluctuates and the mine does not remain inundated, oxidation of pyrite can cause continued water pollution and the temporary increase in acid concentrations becomes an increase that does not decline over time (Younger 1997).

Underground Mine Sealing

Throughout most of the Appalachian coal fields, abandoned underground mines are the principal source of AMD pollution. This is based on the sheer number and areal extent of abandoned underground mine workings where older mines were developed up-dip to promote gravity drainage.

The AMD problems associated with older underground mines can be aggravated by inadequate barrier pillars between mines, inadequate outcrop barriers, and hydraulic interconnection of adjacent mine complexes.

While AMD problems associated with some of these older mines can be addressed by remining the abandoned mine complex, this option is not economical for most abandoned mine complexes in the Appalachian coal fields (Skousen et al. 1997).

Mine sealing can minimize the AMD pollution associated with abandoned underground mines. The primary factor affecting the selection, design and construction of underground mine seals is the anticipated hydraulic pressure that the seal will have to withstand when sealing is completed.

A dry mine seal is a wall across a mine entrance where water does not drain from the entrance. A wet mine seal is a wall across a draining mine entrance that allows water flow through the seal but prevents air from entering the mine. Production of AMD can be inhibited to the extent that the seal raises the water level in the mine and inundates the workings.

Although complete blockage of adits at the down-dip side of underground mines has been attempted in order to prevent drainage and to raise the water level in the mine, this procedure has commonly led to breakout of the water, sometimes explosively, either at the seal or at nearby locations. The placement and construction of mine seals, therefore, must be carefully planned and executed.

Surface access seals (or dry seals) are installed in entries where little or no hydrostatic pressure will be exerted on the seals. The primary functions of these seals are to eliminate access to the mine and to decrease AMD production by limiting movement of air and water into the deep mine. Dry seals are typically constructed of concrete block, masonry, or concrete-flyash mixtures, and are often backfilled from the front side of the seal (Figure 1 and Picture 1).

The lack of hydraulic head allows these seals to be simple in construction and low cost. These seals have good long term effectiveness due to the lack of hydraulic head (pressure) on the seals.

Air trap seals (wet seals) are installed in mine entries where mine discharges flow from the mine. These seals were installed extensively in the 1930's through the Works Project Administration (WPA) mine sealing efforts. Wet seals almost always were constructed with concrete blocks (Figure 2) and either holes were left or

pipes were inserted into the block wall to allow drainage. Unfortunately, the long term effectiveness of these old wet seals was generally poor. Failures occurred when debris and sediment clogged the hole or pipe, thereby increasing the head of the impounded water and resulting in collapsing or leaking seals. A study done by the US Bureau of Mines (Borek et al. 1991) showed that 14 mine seals installed in 1967 were all intact and only a few leaked. Water quality from the mines actually improved over time.

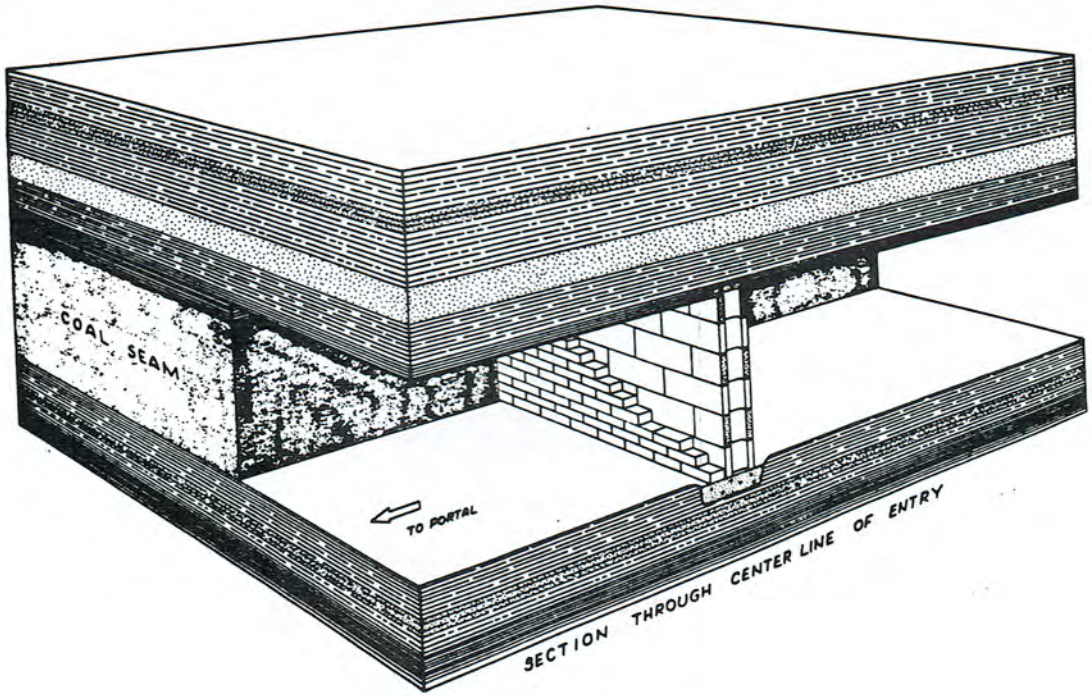
Due to the leaking or collapse of many wet seals, hydraulic mine seals are being constructed in most current wet sealing situations. This type of mine seal serves as a structural bulkhead and acts as a water tight dam capable of withstanding the maximum hydrostatic head that may develop as a result of flooding the mine complex (Figure 3 and Picture 2). Cracks and fissures from surrounding rock, which may allow water migration around the seal, are also treated to restrict water conduction. Water movement around seals can be minimized by pressure grouting of adjacent strata, increasing the mine seal thickness, and installing additional seals.

Accessibility of the mine and seal location are important design considerations. Dry or wet seals placed at easily-reached portal entrances are considerably cheaper than portals with poor access. In many cases, mine seals can be remotely placed through drill holes (Figure 4).

Foreman et al. (1969) constructed 69 remotely-placed, deep mine seals at Moraine State Park in Pennsylvania to abate discharges from 22 abandoned mine complexes draining to Lake Arthur. Maksimovic and Maynard (1982) assessed the seals and concluded that alkalinity and Fe in water from the mines increased, and acid loads decreased. Overall, they found mine sealing improved the water quality of Lake Arthur (see also Foreman et al. 1970).

Foreman et al. (1979) designed and constructed a large clay dike and 35 hydraulic drift seals at Lake Hope

Figure 1. **A typical masonry block dry seal used to seal an underground mine entrance when no water is draining from the portal.**



State Park in Ohio. Nichols (1983) found water pH from the mines had increased nearly two units and a viable bass fishery has been reestablished in Lake Hope. Measurements in 1998 showed water quality from the mines is still around pH 6.0. Mine seals placed in slope and shaft mines also have been successful (see Foreman and Foreman 1985 and 1992).

Barriers

Coal barrier pillars are intact blocks of coal left unmined to provide hydraulic barriers for water management as well as to provide roof support. Coal barrier pillars can be classified as peripheral barriers (intact coal at the edge of the deep mine works) or internal barriers (intact coal located in the interior of the mine works). Typically, peripheral barriers at abandoned mine sites are accessible if the barriers are situated above regional drainage, but peripheral barriers below drainage and internal barriers at abandoned mine sites are usually unventilated and often flooded making them unsafe.

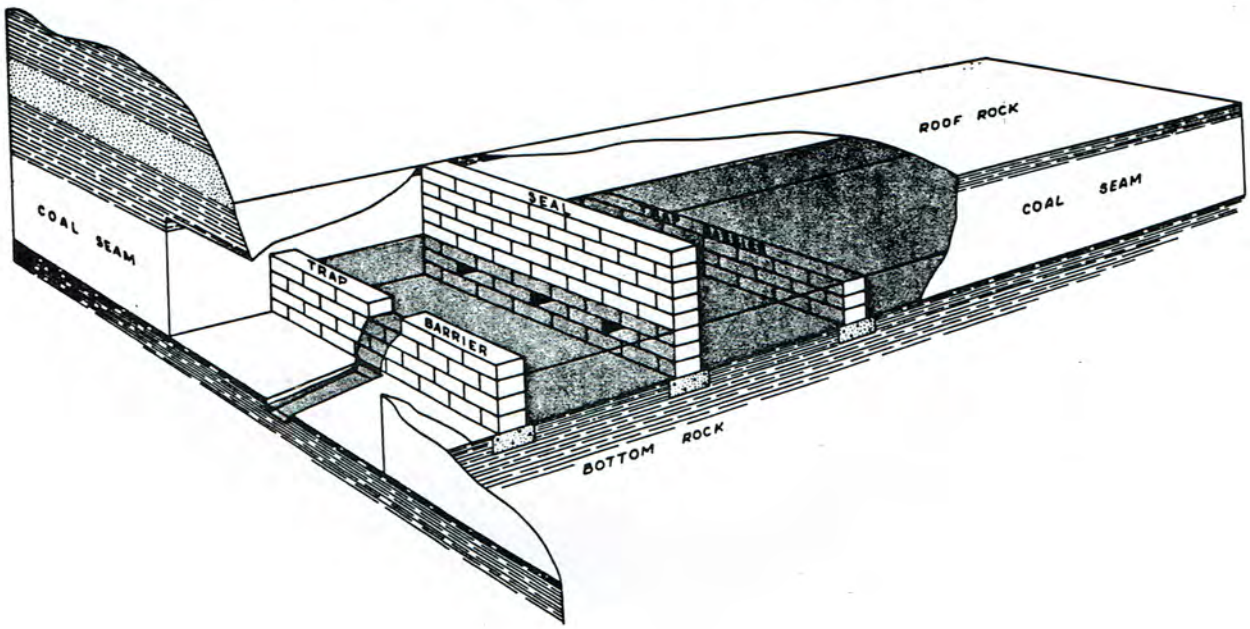
Foreman et al. (1979) constructed a large clay dik and 35 hydraulic drift seals at Lake Hope State Park i Ohio. The clay dike was constructed to replace th outcrop coal barrier along the edge of the mine. The dik allowed the mine complex to achieve full inundatic when coupled with the construction of the mine seal.

Foreman and Foreman (1985) constructed a co crete mine seal in the breached barrier of the activ Island Creek Coal Company Providence #1 deep mi in Kentucky. The miners had inadvertently mine through the barrier into the adjacent, abandoned Hal Luton #9 deep mine which was fully flooded at th time. The breach flooded 60% of the active Providen mine causing temporary closure.

The MSHA-approved mine sealing project w totally successful and allowed the mine to be reopene and returned to full productivity (other examples are Foreman and Glenn 1980, Foreman et al. 1977, a Foreman et al. 1982).

Alkaline slurry trench barriers were constructed

Figure 2. **An old style wet seal constructed of masonry block. Holes were left or pipes were inserted into the block wall to allow for water drainage. The pipes or holes often became clogged over time thereby causing water to back up in the mine and eventually bursting through the seal or other nearby area.**



the Stewart Run and Nutter Run sites in West Virginia to cause inundation of adjacent underground workings. The barriers were placed during surface remining activities. Several problems occurred during barrier construction so that complete inundation of the underground works did not occur, but the water quality has improved steadily since the barriers were placed in 1978 (Moore 1989, Skousen et al. 1999).

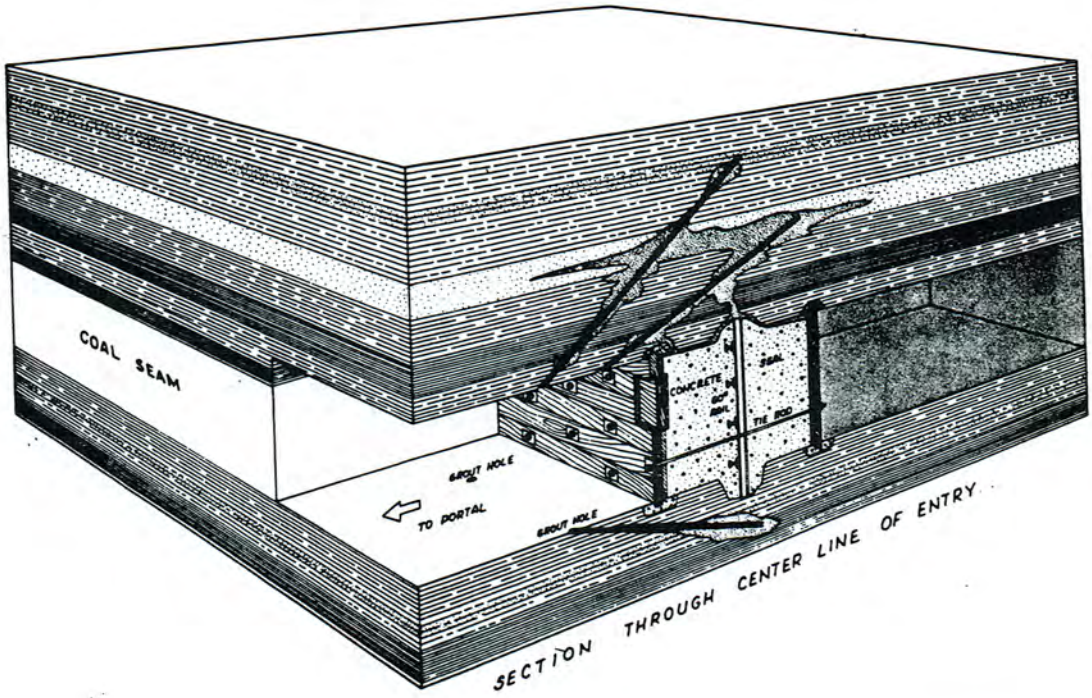
Grout Curtains and Walls

Grouts can be used to separate acid-producing rock and groundwater. Injection of grout curtains may significantly reduce the volume of groundwater moving through spoil and thereby greatly reduce the amount of AMD coming from a site. In one sense, grouting to form curtains or walls is analagous to underground water diversion. Gabr et al. (1994) characterized the groundwater flow of an acid-producing reclaimed site where a 1.5-m thick wall was installed by pumping a mixture of Class F fly ash and portland cement grout into vertical boreholes near the highwall.

After two years, the grout wall reduced groundwater inflow from the highwall to the spoil by 80%, resulting in one of two seeps completely drying up and substantially reducing the flow of the other seep.

Foreman et al. (1973) constructed a grout curtain along Interstate 80 in Pennsylvania to abate seepage through an inadequate coal barrier, which was causing slippage of the road-cut highwall and AMD pollution to the Clarion River. The grout curtain was placed by drilling injection holes along the top of the road-cut. After grouting, no further discharges or slippages were observed.

Figure 3. **A hydraulic wet seal with a underground barrier dam. The new style wet seals often serve as structural bulkheads for water containment (sometimes with outlets for water) and builders will often pressure grout surrounding strata to eliminate leaks. The bulkhead also controls subsidence at the underground mine entrance.**



Underground Mine Filling and Injection

Due to the miles of passages in underground mines where coal has been removed, huge volumes of void space are available for mine pools to develop, and this water is often acidic. Filling the mine voids completely or creating barriers inside the mine to break up interconnected underground pools may be used to control flow and improve drainage quality.

Materials to fill underground mines must be cheap and readily available, so waste products such as steel slags and fly ash are generally used in these situations.

A mixture of Class F fly ash and cement kiln dust was injected down a series of holes into the Longridge Mine in West Virginia. Limestone barriers were placed into three areas and grout materials were injected behind the barriers, thereby creating three unconnected segments in the mine. Preliminary investigations show that the injection has resulted in a 90% reduction in flow from the mine.

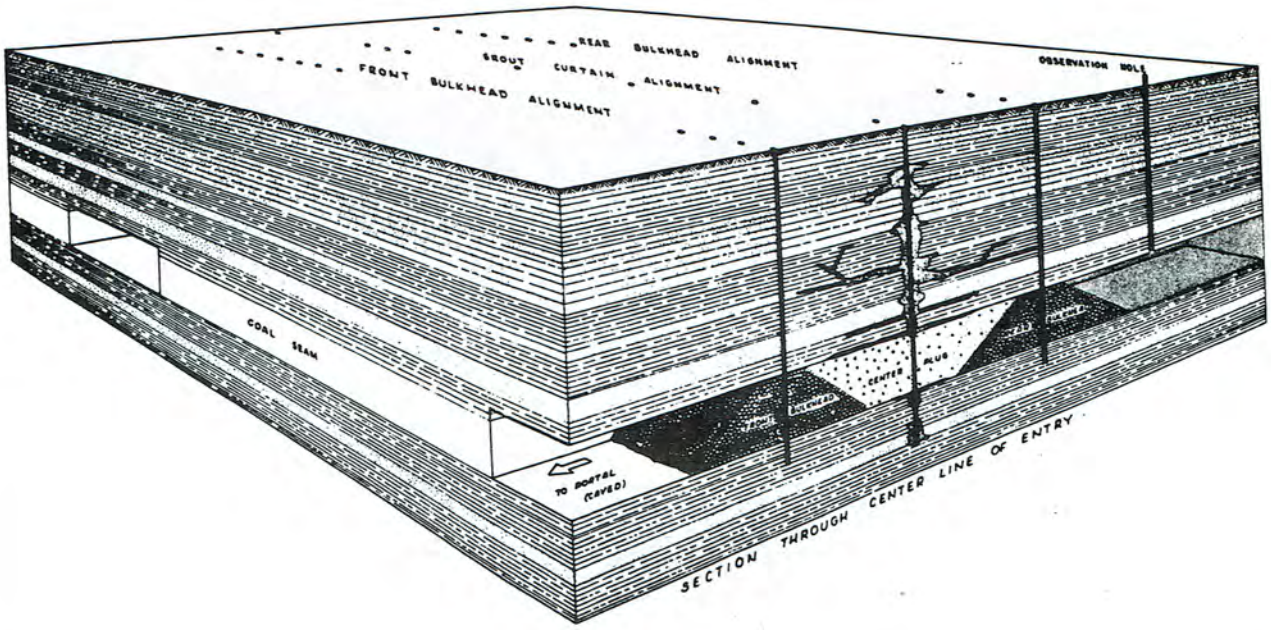
At the Frazee Mine in Maryland, a Class F fly ash, along with FBC and FGD ashes were injected to improve drainage quality. The mine was larger than originally anticipated and the entire mine void was not filled. Slight improvements in water quality have been noted 18 months after injection.

At the Mettiki mine in Maryland, a mixture of FGD ash, coal refuse and calcium-generated AMD sludge has been injected into underground mine works. Metal concentrations have dropped substantially and water pH has increased from 3 to 4.5.

Conclusion

Water management techniques for controlling AMD include water diversion, soil covers and plastic liners, dewatering, inundation, underground mine sealing, barriers, grout curtains and walls, and underground mine filling by injection. Each method is suited for specific situations and good success can be realized when adequate planning, design, and construction are practiced. Water diversion is one of the easiest and cheapest

Figure 4. **A remotely-placed hydraulic seal. These seals must be placed by drilling holes for injecting the rock or barrier material, and cracked rock materials around the seal must also be pressure grouted.**



methods for reducing the amount of water in contact with acid-producing materials.

Special care and planning are essential in designing and constructing mine seals and when using grouting techniques for underground mine filling or barrier construction.

Acknowledgments

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Picture 1. A concrete block dry seal placed at an abandoned mine land reclamation project in West Virginia. (Photo courtesy of the West Virginia Division of Environmental Protection, Office of Abandoned Mine Lands and Reclamation).

Picture 2. A hydraulic wet seal was constructed with a gravel bulkhead for water and subsidence control at the Douglas Abandoned Mine Land Reclamation Project.

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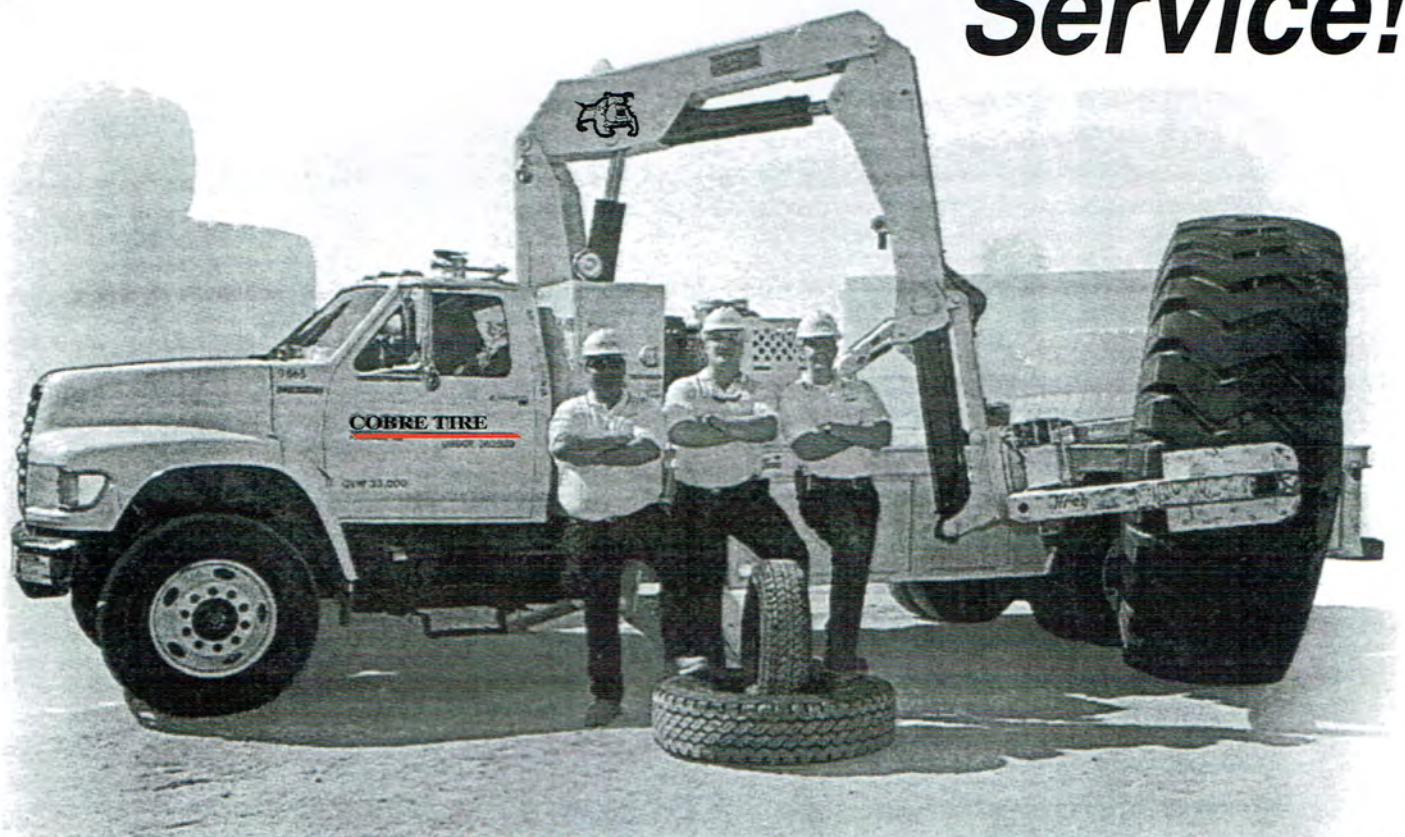

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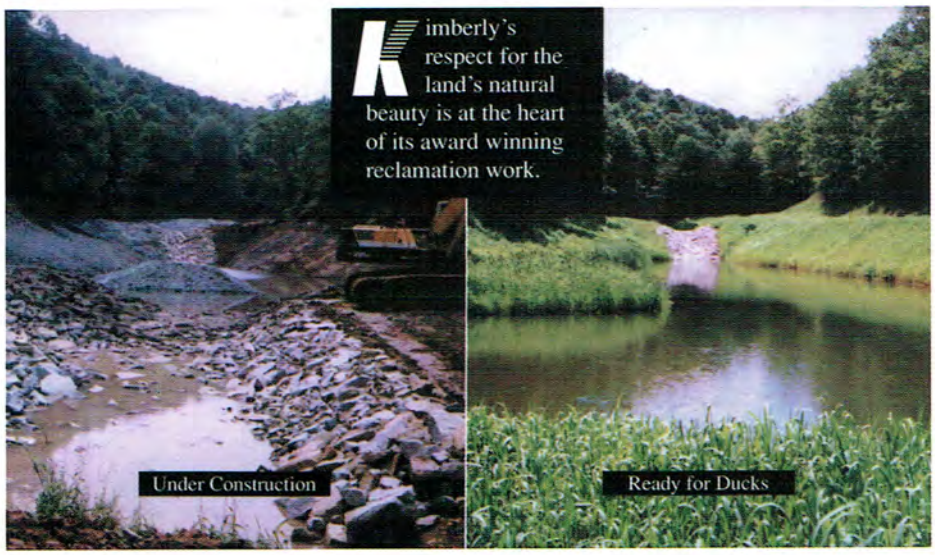

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