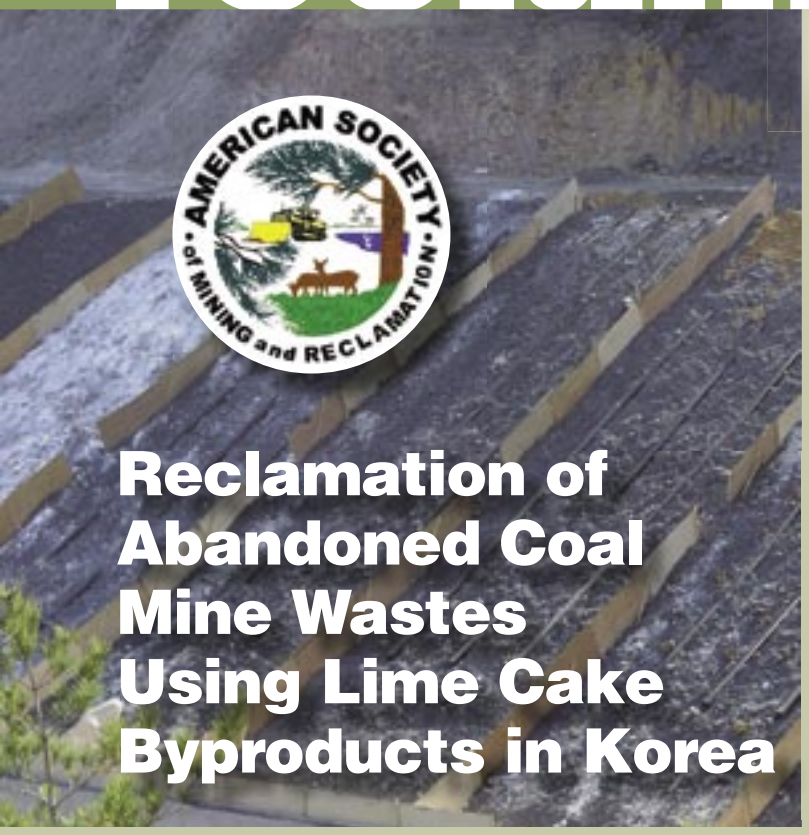
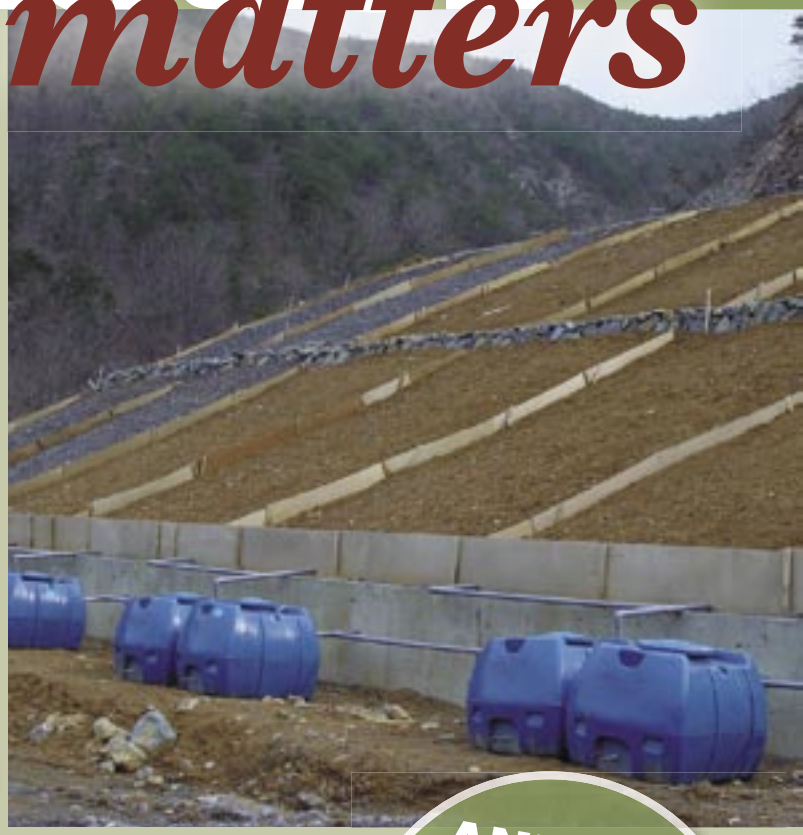
THE OFFICIAL PUBLICATION OF THE AMERICAN SOCIETY OF MINING AND RECLAMATION

Fall 2005

reclamation matters

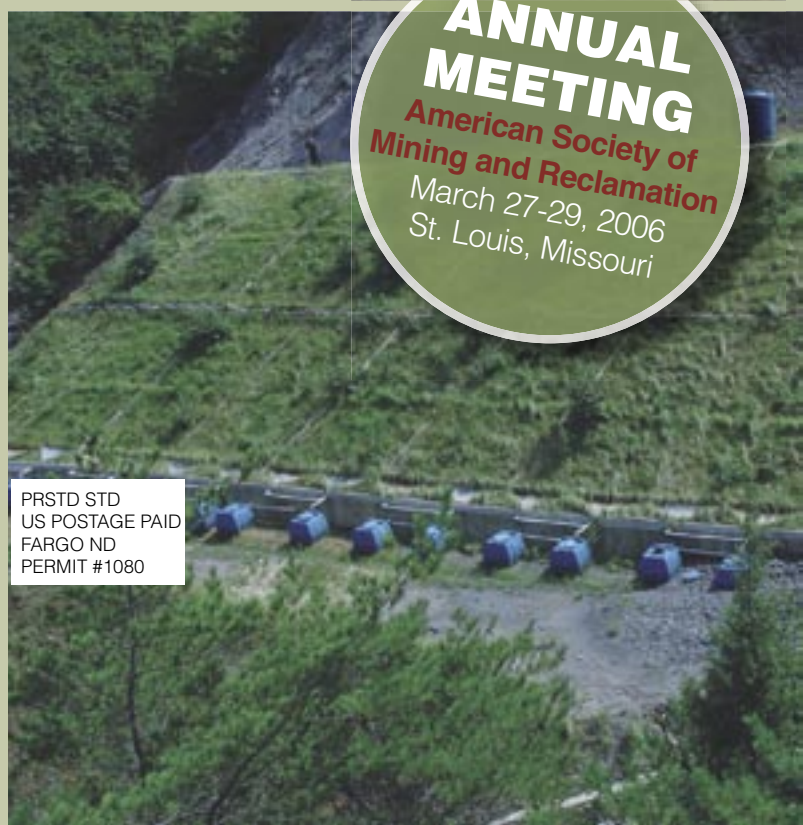


Reclamation of Abandoned Coal Mine Wastes Using Lime Cake Byproducts in Korea



The Appalachian Regional Reforestation Initiative: A Partnership to Promote Reforestation of Mined Lands

THE TRAPPER MINE: A Model of Reclamation Success in the West



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contents

Issue 2 Fall 2005
Volume 2
Number 2

Cover:
A large field demonstration was established to test the use of lime cake on coal refuse in Korea.
See related article inside.

BY DAVID CHENOWETH, ASMR PRESIDENT

Taking ASMR to New Heights

"From the testimonials I have received regarding the success of the conference, I feel comfortable in saying that we have taken ASMR to new heights."

We have recently completed our annual conference in Breckenridge, Colorado which was entitled "Taking Reclamation to New Heights." From the testimonials I have received regarding the success of the conference, I feel comfortable in saying that we have taken ASMR to new heights. Thanks to those individuals who worked hard on preparing and presenting technical papers and workshops, we met our goal of the exchange of new reclamation technology. Behind the scenes, the National Executive Committee (NEC) worked hard during two different sessions to find ways to enhance the organization and increase its horsepower as a resource center. All of us on the NEC had a common goal of being able to continually provide valuable and much needed exchange of reclamation ideas and research. Furthermore, we want to be a resource center year-round and not just at the annual conference. *Reclamation Matters* has provided a great catalyst to ASMR for the exchange of research and case studies on a semi-annual basis. Past and future advertisers deserve special recognition for contributing to the success of the magazine.

Our Web site continues to be expanded as a true resource center. We have added an employment section which allows members to list employment opportunities at no charge. We will be working during the months ahead to create a more comprehensive directory that links material providers, consultants, contractors, researchers, practitioners, and academia together.

The NEC has decided to enhance scholarship amounts to encourage students to pursue studies in reclamation-related college programs. The NEC discussed preparing a PowerPoint presentation that could be used by members to educate corporations, university officials, and others on the benefits of being members and contributing and receiving information on reclamation procedures and research.

Just as biologists and ecologists recognize the need for diversity, the NEC recognizes the benefits of having a diverse group of members. In my opinion, we often times promote the organization as benefiting predominantly those with ties to mining. ASMR can and does provide benefits to those individuals involved in any form of land restoration and reclamation including oil and gas companies, landfill operators, Department of Transportation professionals, and land developers to mention a few. Furthermore, our organization benefits professionals employed as engineers, soil scientists, range scientists, wetland scientists, landscape architects, and land planners, etc.

As an owner of environmental consulting and contracting companies, ASMR has personally enhanced my relationship with experts in our field. I now have some of the top reclamation talent in the nation to call on when my staff and I need advice on tough reclamation issues. ASMR has also increased my business opportunities by providing networking opportunities along with being recognized as professionals in our industry.

I thoroughly enjoy and appreciate the opportunity to serve as your president of ASMR. We have some very exciting times ahead of us in the world of reclamation. ■

BY DR. JEFF SKOUSEN

Why Are You Here?

The editor in 1978 when his passion for reclamation began!

"Whatever your reason for being involved in mining and reclamation, I hope you find it as interesting and challenging as I do."

Do you remember why you initially became interested in this reclamation area? Was it thrust upon you by your boss? Some of you may have been assigned to do pre-mining data collection, like environmental surveys for water, plants, and wildlife. You may have been forced to solve an erosion problem, treat water, or plant grasses or trees on disturbed land. You may have been asked why plants were not establishing on a site, and you had to take soil samples to learn more about the soils. Perhaps you were trained as an engineer, but no one in the company had any interest or training in environmental sciences, and you were selected to do it. Maybe you are an outdoor enthusiast and from the start you wanted to work in the environmental and reclamation arena. Some of you simply stumbled onto your jobs and have stayed because you like it.

I grew up on a large farm in the Snake River Valley area of Oregon and Idaho. When I left home to attend college, the last thing I wanted to do was to work so hard again. "Life has to be easier than this," I reasoned. "No one in his right mind would farm for a living." I entered college to major in business administration, but I could not shake my love of the outdoors. Upon the urging of my brother, I took the class "Ecology and Living Systems" when I was a sophomore. I learned about ecosystems, their structure and function, and how each system was unique. I found that living and non-living components of that ecosystem fit together, and the species within the ecosystem filled specific roles and could be found in particular places because of their adapted traits. I also realized that the sun, water, soil, and geology were the underpinnings of the ecosystem. Wow! Suddenly, the world was less mysterious, distinct patterns were evident, and I could see them! For me, that ecology class awoke in me the yearning to work outdoors and to learn about wisely using and conserving our natural resources. This was a life-changing experience and I quickly changed my major to range science and soils. I began with big game range restoration in Utah and have worked on coal mines ever since. My passion for learning continues to grow.

Whatever your reason for being involved in mining and reclamation, I hope you find it as interesting and challenging as I do. There are myriads of questions to be answered, hundreds of ecosystems to understand and reclaim, and thousands of people that need help. Members of the American Society of Mining and Reclamation have answers to these reclamation questions, and also have the experience to apply remedial measures. Fortunately, we have several outlets for sharing our knowledge and expertise with others. So, don't be shy about sharing your experiences. Think about the reasons you work in this field and remember why you started. At the end of the day, I suspect we all can say that we work here because we love the outdoors. ■

BY FORREST LUKE

The Trapper Mine: A Model of Reclamation Success in the West

Trapper Mine is a surface coal mine located in northwestern Colorado approximately 6.5 miles south of the city of Craig. The permit area encompasses approximately 10,300 acres. Mining operations are conducted along the Williams Fork Mountains to recover multiple seams of sub-bituminous coal (9800 BTU/lb, 7.5% Ash, <0.5% Sulfur) for delivery to the adjacent Craig Power Station. Elevations at Trapper range from approximately 6,300 to 7,400 feet above mean sea level. The predominant vegetation type at the site is mountain shrub transitioning to big sagebrush in the lower elevations and aspen in the higher portions of the permit area. The average annual precipitation is 16.7 inches, with roughly one-third of this occurring as snowfall. Soils are well developed, generally deep and formed in alluvium and colluvium derived from sandstone and shale parent materials. Topographically, cultivated lowlands of winter wheat or alfalfa/native grass hay give way to rolling upland hills and long steep slopes historically used as rangeland and wildlife habitat with relatively steeper slopes occurring in the higher elevations.

Mining operations commenced at Trapper in 1977. Three Page 752 LR draglines equipped with 32-cubic-yard buckets are the primary earthmovers on the job and operate concurrently in different areas of the mine. Mining operations are oriented along the dip slope axis on slopes averaging approximately 14 percent. With coal seams dipping more steeply than the overlying topography, overburden depths range from a few tens of feet near the outcrops to approximately 160 feet at the economic limits of recovery.

Wildlife Response

During initial permitting and following the start of mining, grave concerns were raised about the devastating effects of surface mining on wildlife populations in the area. Twenty-eight years later, those concerns have proven to be completely unfounded. Here are some reasons that mining has enhanced wildlife at Trapper.

Big Game

Baseline aerial winter surveys of big game animals in the Trapper area were conducted before mining in the mid-1970s. Aerial surveys were again carried out in the mid-1980s and most recently during the winters of 1999-2000 and 2000-2001. Survey results indicate that overall big game use within the study area has increased dramatically (Table 1). Elk numbers have increased by an order of magnitude, while pronghorn antelope have increased from zero animals before mining to being a significant presence in the mine area.

Table 1. Average number of big game species before and during surface mining at the Trapper Mine.

	Elk	Mule Deer	Antelope
Before Mining			
1973-76	148	60	0
During Mining			
1982-86	339	120	No data
1999-2001	1,568	92	43

Picture 1: A 350-head Elk herd is utilizing a 1.5-acre shrub planting at the Trapper Mine.

Mule deer numbers have remained stable since the 1970s. Not only have big game animals increased on the Trapper Mine and surrounding area, they are preferentially selecting reclaimed lands as a forage base. A peak aerial count of nearly 4,000 head of elk was documented on Trapper reclaimed lands during December 1999. To put this figure in perspective, in some Western states, total elk populations are fewer than 4,000 head.

Trapper big game surveys convincingly refute the concerns that mining devastates big game species. To the contrary, Trapper reclamation has proven to be a magnet for big game species and has become a highly preferred foraging area (Picture 1).

Columbian Sharp-Tailed Grouse

Populations of Columbian sharp-tailed grouse in the western United States have diminished significantly. The species currently occupies less than 10 percent of its former range. Numerous factors, such as habitat degradation from land use changes, have contributed to this decrease. On Trapper reclaimed lands however, Columbian sharp-tailed grouse populations are thriving. In the year 2001, the average sharptail lek (strutting ground) density documented in northwestern Colorado was 0.07 leks/1,000 acres. Lek density on Trapper reclaimed lands is 1.07 leks/1,000 acres, exceeding the average value by a factor of 14. To ensure the continued success of this species, Trapper is working with the Northwest Colorado Columbian Sharp-tailed Grouse Work Group and the University of Idaho to identify specific reclamation practices that aid in favorable habitat establishment. Trapper hopes to re-establish viable populations of the Columbian sharp-tailed grouse on their areas, as well as adjacent lands.

Other Wildlife

Numerous other wildlife species continue to flourish in and around the mining and reclamation operation. Examples include predators such as mountain lion, black bear, badger, coyote, and red fox. Even smaller mammals are increasing like porcupines, mink, weasels, ground squirrels, deer mice, and rabbits. With increases in the mammal populations, birds of prey have grown. Waterfowl are also abundant in wet and pond areas.

A primary factor to the success of wildlife is likely the sheer productivity of the reclaimed lands as compared to pre-mining productivity. Diverse, adapted, sustainable reclaimed plant communities provide suitable forage for a wide range of species. Habitat diversity is enhanced by replacing overly mature, relatively unproductive tracts of mountain shrub community with grass dominated stands containing healthy forb and shrub elements. The "edge effect" that occurs along the margin of reclaimed lands and undisturbed plant communities provides additional landscape diversity. Micro scale features constructed on reclamation areas, including livestock water tanks and shrub islands, provide topographic diversity, thermal shelter, cover from predators, and water resources for all types of wildlife to exploit.

Vegetation Establishment

Vigorous reclaimed plant communities anchor the reclamation achievements experienced at Trapper. Standard methodologies for reclaiming disturbed lands are employed along with site-specific enhancements developed to maximize reclamation success.

Picture 2: A variety of grasses, forbs, and shrubs are planted at the Trapper Mine.

Seed Mix Selection

Trapper utilizes diverse seed mixtures of primarily native forbs, grasses and shrubs (Picture 2). Seed mixtures and seeding methods are carefully selected to result in the most diverse reclaimed plant communities possible. Trapper has worked closely with government and academic research institutions over the years in arriving at successful methods and species selected, and the results can be seen in the wildlife use of these areas.

Mature Shrub Transplants

A Trapper reclamation goal is establishment of native shrubs on reclaimed areas for wildlife use. To attain this goal, mature shrubs are transplanted directly from areas prior to mining via front-end loader to recontoured and topsoiled areas after mining. In this fashion shrub islands are established encompassing approximately 1.6 acres. About 250 mature shrub pads (front-end-loader transplants) are placed in an island to provide optimum hiding cover for big game. The islands are established 1,400 feet apart and are normally constructed in the late fall when the shrubs are dormant. Trapper has constructed more than 30 shrub islands on reclaimed lands.

Forage Base

Available forage on reclaimed rangeland at Trapper is five times greater than that available in undisturbed mountain brush habitat. In spite of heavy grazing by wildlife, the forage base on Trapper reclaimed lands remains productive (average 1979-1980 pre-mining production = 56.5 g/m^2 versus average 2001 post-mining production = 271.2 g/m^2). Productive and diverse reclaimed plant communities replace pre-mine mountain shrub communities that are generally over mature and somewhat homogeneous (Picture 3).

Erosion Control

Erosion control efforts at Trapper are particularly challenging due to the long steep slopes that characterize the site. This situation is exacerbated by the erosive nature of the unconsolidated spoil and topsoil during reclamation and before vegetation establishment. A wide variety of erosion control techniques, drainage control strategies, and soil erosion control materials have been employed over the years.

Reconstructed Drainages

Trapper has employed numerous techniques including the use of synthetic erosion control fabrics, rock check structures, brush matting, brush filters, and woody seedling transplants to stabilize and armor reclaimed channels. The application of these types of technologies at Trapper provided insight to the advantages and disadvantages associated with each technique and product. Rock check structures have proven to be both effective and economical (Picture 4). These structures are used to dissipate the energy of flowing water within the drainage channel. Debris and sediment tend to be deposited and trapped upstream of the structures, which in turn enhances the establishment of vegetation in the channels and further acts to stabilize the features (Picture 5). These materials are salvaged prior to topsoil stripping operations in an area and are utilized both to mat drainage channels and to repair erosion features that develop on the reclamation. The combination of woody stems and the small amount of topsoil recovered in the brush salvaging operation is ideal for these types of applications (Picture 6).

Water-Harvesting Diversions

Slope lengths at Trapper commonly exceed 5,000 feet, so uncontrolled runoff conveyed over these distances concentrates water and results in the formation of gullies and headcuts. Trapper constructs gently

Picture 3: The reclamation process at Trapper provides for a diverse and permanent vegetation cover that is much more productive than the original mountain brush plant present community before mining.

sloped, water-harvesting diversions to intercept overland flow and convey water along the contour into reconstructed drainage channels. These channels are reinforced to withstand high-volume water flow. This approach effectively reduces the slope lengths and associated erosion. Once vegetation is established, the diversion channels can be removed. Well established permanent vegetative cover (grasses, forbs and shrubs) provides long-term erosion stability required of successfully reclaimed lands.

Livestock Watering Tanks

Trapper has constructed many livestock watering tanks or stock ponds on reclaimed areas to provide watering sites for wildlife and to aid in distributing big game across the site. Small excavated depressions (typically less than one acre-foot in size) are utilized extensively to control erosion from both active mining areas and reclaimed areas (Picture 7). Big game animals and other wildlife species are frequently sighted using these watering areas.

Stock ponds are constructed intermittently along drainage channels. The ponds serve two important functions. Initially, they act as sediment traps by slowing sediment-laden runoff waters, thereby allowing eroded materials to settle out and be retained in the structures. In the long run, following the establishment of vegetation, these features act to trap water and provide drinking water sources for wildlife and livestock. Under pre-mining conditions, naturally occurring water sources are sparse. After reclamation, livestock watering tanks provide evenly distributed sources of water allowing animals to more fully utilize the available forage in the area.

Long-term Benefits to the Community

Trapper enjoys a sterling reputation in the community as an outstanding corporate citizen and neighbor and has earned accolades including the Governor's Environmental Award, the Colorado Corporate Responsibility Program's Ethics in Business Award (environmental category), and the Colorado Association of Commerce and Industry's Colorado Company of the Year Award (energy and minerals division). These awards reflect Trapper's unwavering commitment to the local environment and community.

In addition to the related benefits of providing steady employment and economic stability, Trapper has assisted with

Picture 4: Rock check structures are installed in drainage channels to slow the water and allow sediments to fall.

Picture 5: A fully reclaimed channel with rock check structures still in tact

Picture 6: Materials such as topsoil and rocks are collected before mining for placement in drainage channels on adjacent reclaimed lands.

community development projects in the Craig area. Trapper was directly responsible for establishing the Trapper Health Club, a recreational facility that continues to serve the residents of Craig and the surrounding area. Significant contributions of time, equipment, people, and money were also directed toward the construction of the back nine holes of the local Yampa Valley Golf Course. Loudy Simpson Park is yet another community asset Trapper resources played an important role in establishing. Trapper has long emphasized a philosophy of giving back to the local community and proactively seeks out opportunities to do so.

Awards

Trapper's efforts in mining and reclamation have resulted in several awards. They were recognized in 1991 with an OSM Excellence in Surface Coal Mining and Reclamation award. In 2004, they were the recipients of the OSM's Good Neighbor "Gold" Award, along with a "Bronze" level recognition from OSM in 2002 as one of the three best examples of mined land reclamation during the first 25 years of SMCRA. They were also given a 1993 Sentinels of Safety award from the Mine Safety and Health Administration as the country's safest surface coal mine that year. Trapper Mine is proud of its legacy of successful reclamation, community involvement, and safety.

Summary

In the final analysis, wildlife species may well be the primary direct beneficiaries of the reclamation actions taken at Trapper. Trapper is a model for mined land to be reclaimed into stable and productive acreages suitable for a variety of uses including wildlife habitat, grazing, recreation, and crop production. Moreover, the surrounding community will enjoy a lasting positive future of flexible and productive land use. ■

Picture 7: Ponds are constructed in drainage ways for storage of water. This helps distribute wildlife across the property.

American Society of Mining and Reclamation 2006 Annual Meeting

March 27 -29, 2006 • St. Louis, Missouri

The 2006 ASMR annual meeting will be held in conjunction with the SME Meeting, and will include additional sponsors such as ICARD, ADTI, RMRHSRC, IMWA, INAP, and MEND. The 2006 SME technical program is large and diverse with more than 1,000 presentations from the mining and construction industry, academia, and service companies. The program covers all aspects of mining and minerals for every type of professional in the following topic areas:

Coal & Energy
Construction Materials and Aggregates
Environmental
Geology
Industrial Minerals
Mining
Mineral & Metallurgical Processing
International

The Environmental Section, primarily composed of ICARD and ASMR sessions, will have a plenary session at 1 p.m. on Monday, followed by four concurrent sessions over the next 2½ days, including poster and oral sessions. The following technical sessions are organized:

Mine Management
Mining Legacy – Abandoned Mine Lands
Social/Government/Sustainability Issues
Forestry/Ecology
Case Studies
Characterization
Impacts: Surface and Subsurface
AMD Prevention and Control
AMD Prediction
AMD Treatment
Pit Lakes/Backfill Issues
Soils and Overburden
Mine Water Issues – IMWA
Emerging Technologies
Closure/Land Use Issues
Monitoring

- **More thans 500 exhibits will be in the huge conference center**.
- **Several Short Courses and Field Trips** will be available for participants.
- **The ASMR Social Program** will involve:
  - > Reception in the Exhibit Hall Sunday to view posters, March 26
  - > Buffet lunch on Tuesday, March 28
  - > Reception prior to the ASMR Banquet, Tuesday, March 28
  - > ASMR Awards Banquet, Tuesday evening, March 28

This meeting will be well worth your time to attend. Registration materials will be in the 2006 Spring *Reclamation Matters* magazine. Watch for it in February 2006.

Author Deadlines:

Draft Papers	September 30, 2005
Final Papers	December 31, 2005
Meeting	March 26-28, 2006

Further information can be found at
http://www.smenet.org/meetings/AnnualMeeting2006/index.cfm
or http://ces.ca.uky.edu/asmr/ICARD.htm

2005 Award Winners, Scholarship Winners, and Golden Sponsor Awards

Awards

William T. Plass Award
Gerald Schuman • *High Plains Grasslands Res. Sta.*

Reclamationist of the Year
William R. Kirk • *Coteau Properties Co., ND*

Reclamation Researcher of the Year (Tie)
Dr. Peter D. Stahl • *University of Wyoming*

Special Awards
Dr. Donald H. Graves • *University of Kentucky*

Reclamation Researcher of the Year (Tie)
Dr. Jon Bryan Burley • *Michigan State University*

Membership Recruiter Award
Jeff Skousen

Scholarships • Memorial Scholarship Recipients

Recipient for 2004, MS
Abbey Wick • *University of Wyoming*

Recipient for 2004, PhD
William J. Andrews • *Oklahoma University*

A Special Thanks Goes Out to Terry Toy for Chairing the Organizing Committee for the Meeting.

Golden Sponsor Awards

Paul Kos Accepting Golden Sponsorship
for Applied Hydrology International

Brenda Schladweiler accepting Golden Sponsorship
for BKS Environmental Associated

Jamie Salisbury accepting Golden Sponsorship
for Western States Reclamation

Vern Pfannenstiel accepting Golden Sponsorship
for Peabody Western Coal Co.

2005 Meeting Exhibitors

Western States Reclamation

USGS


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Arkansas Valley Seed
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Bowman Construction Supply
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www.graniteseed.com

BKS Environmental Association
www.bksenvironmental.com

Office of Surface Mining
www.mcrcc.osmre.gov

Colorado Geological Survey
http://geosurvey.state.co.us

Colorado Lining International
www.coloradolining.com

Energylabs.com • Energy Laboratories
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Rain for Rent
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Envirocon, Inc.
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Peabody Western Coal

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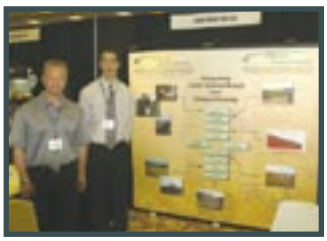

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Office of Surface Mining
www.ott.wrcc.osmre.g

BY J.E.YANG, J. SKOUSEN, Y.S. SHIM, J.P. KIM, K.S. NAM, Y.C. LIM, S.W. CHOI, C.H. WON AND J.M. AN

Reclamation of Abandoned Coal Mine Wastes Using Lime Cake Byproducts in Korea

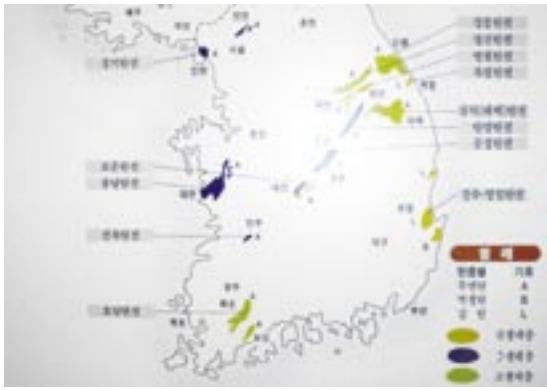
J. Yang is at the Division of Biological Environment, Kangwon National University, Chunchon, Korea; J. Skousen is at West Virginia University, Morgantown, WV, USA; Y.S. Shim, J.P. Kim, K.S. Nam, Y.C. Lim, S.W. Choi, C.H. Won, and J.M. An are at the Coal Industry Promotion Board (CIPB), Chongro-Gu, Seoul, Korea.

Introduction

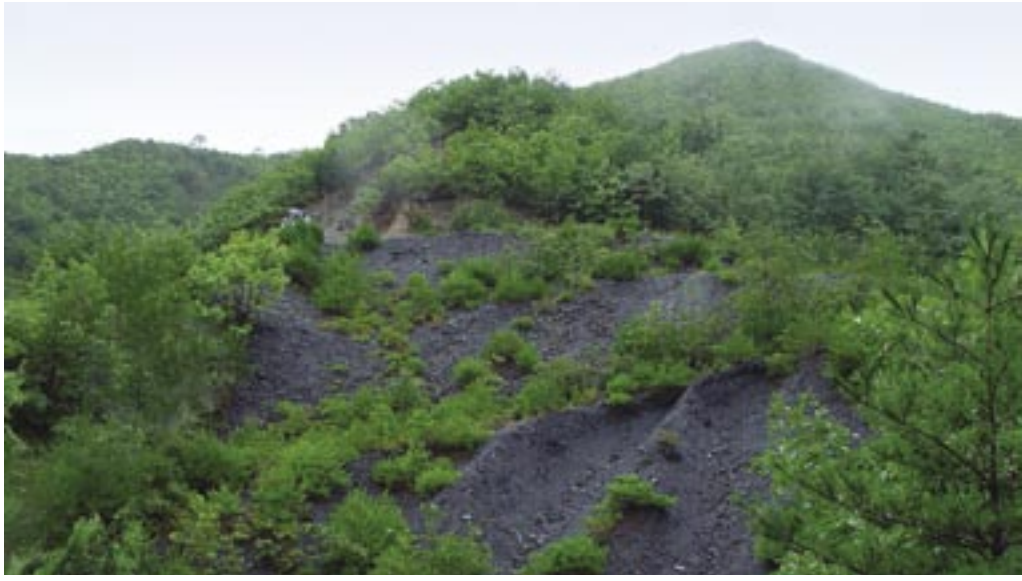
In Korea, more than 300 coal mining operations have been closed or abandoned since the late 1980s due to the depression of the mining industry. Most of these mined areas are located in steep mountain valleys along the eastern coast of South Korea (Picture 1). Enormous amounts of coal mine waste have been left and abandoned on slopes and acid mine drainage (AMD) from waste piles and associated mine portals has been discharging directly to streams, causing detrimental effects on soil and water qualities (Picture 2). The environmental disruptions caused by the closed mines are very serious in Korea.

The Coal Industry Promotion Board in Korea has spent more than $15 million (U.S.) annually to remediate the mine-related damages and to improve the environment. Most of the costs are directed to passive AMD treatment and forest restoration. However, the investment has not been very effective due to the large number of sites, large amounts of AMD, and budget limitations.

A lime byproduct (lime cake) is waste material produced from the Solvay process in manufacturing soda ash. In Korea, more than 3 million tons of lime cake are stock piled. This material has been used in the past to reclaim disturbed lands, but due to recent concerns from environmental groups the lime cake has not been used in reclamation and remains in stockpiles with no plan for proper disposal. The lime cake has very fine particles, low hydraulic conductivities (10^{-8} ~ 10^{-9} cm/sec), high pH, and high EC due to the presence of CaO, MgO, $CaCl_2$ and NaCl as major components (Yang et al., 2002). Due to these physical and chemical properties, the lime cake has potential to be used as a neutralizer for acid-producing materials. The objectives of this research were to determine the effectiveness of using lime cake for reclamation.



Picture 1: Map of South Korea showing the location of coal deposits (in the green); Almost all the mining and abandoned mine land are on the eastern coast area.



Picture 2: Large waste coal piles (gob) are found throughout the eastern coal mining area in South Korea. Runoff from this materials is acid mine drainage.

Materials and Methods

Ten treatments were installed on a large, abandoned coal waste pile to test the application of the lime cake for reclamation of these piles (Picture 3). The slope of the coal waste site was 29 degrees (56 percent). Each plot was 20 x 5 m (L x W) in size and separated by plastic boundaries. Table 1 contains the plot number and treatments. The lime requirement (LR) for the coal waste was determined and lime cake treatments consisted of 25 percent, 50 percent and 100 percent of the LR. The lime cake and calcite were either layered between the coal waste and topsoil or mixed with coal waste and topsoil. Each plot was hydroseeded with grasses and planted with trees. Surface coverage by grasses was determined by computer image analysis.

In each plot, a flume and gutter were connected to a water reservoir to collect all the runoff and leachate from each plot (Picture 4). Three pipes, 5 cm in diameter, were buried in each plot and connected to the reservoir to collect the leachate. Chemical properties such as pH and ion concentrations of the runoff and leachate were analyzed periodically. Efficiency of the lime cake in coal waste reclamation was assessed based on surface cover by plants, neutralization of runoff and leachate, and soil quality.

Table 1. Treatment design and revegetation on the coal waste pile.

Plot Number	Treatments	Lime Treatment Methods	Vegetation*
1	Coal waste only		Grass and trees
2	Coal waste + Lime cake (LR 100%)	Mixed	Grass and trees
3	Coal waste + CaCO3 + topsoil	Layered	Grass and trees
4	Coal waste + CaCO3 + topsoil	Mixed	Grass and trees
5	Coal waste + Lime cake (LR 100%) + topsoil	Layered	Grass and trees
6	Coal waste + Lime cake (LR 100%) + topsoil	Mixed	Grass and trees
7	Coal waste + Lime cake (LR 50%) + topsoil	Layered	Grass and trees
8	Coal waste + Lime cake (LR 50%) + topsoil	Mixed	Grass and trees
9	Coal waste + Lime cake (LR 25%) + topsoil	Layered	Grass and trees
10	Coal waste + Lime cake (LR 25%) + topsoil	Mixed	Grass and trees

*Grasses: Orchard grass (*Dactylis glomerata*), Kentucky Bluegrass (*Poa pratensis*) and Eulalia (*Miscanthus sinensis*);
Trees: Pine tree (*Pinus densiflora*), Birch (*Betula platyphylla*) and Alder (*Alnus firma*)
LR: Lime requirement as CaCO3

Table 2. Chemical characteristics of the lime cake, coal wastes, and topsoil.

Sample	pH (1:5)	EC (1:5)	OM	P_2O_5	LR	Exchangeable			
						Ca	Mg	K	Na
		dS m^{-1}	g kg^{-1}	mg kg^{-1}	Mg ha^{-1}	----- $cmol_c$ kg^{-1} -----			
Lime Cake	11.2	19.6	8.3	7.9	-	233	50.2	2.3	77.9
Coal Waste	3.5	0.2	16.5	9.1	16.5	4	0.3	0.1	0.1
Topsoil	6.5	0.1	0.8	15.7	0.4	4	0.5	0.1	0.1

OM: Organic matter based on the loss on ignition (LOI)
LR: Lime Requirement (as $CaCO_3$)

Picture 3: Plots were 20 m long by 5 m wide on a 56% slope. Plot 1 with coal waste only can be seen in the upper left hand corner with calcite, lime cake, and topsoil treatments extending to the right (see Table 1). Pipes were installed to collect the drainage.

Picture 4: Application of amendments and installation of water collection tanks were completed and the plots were hydroseeded in May.

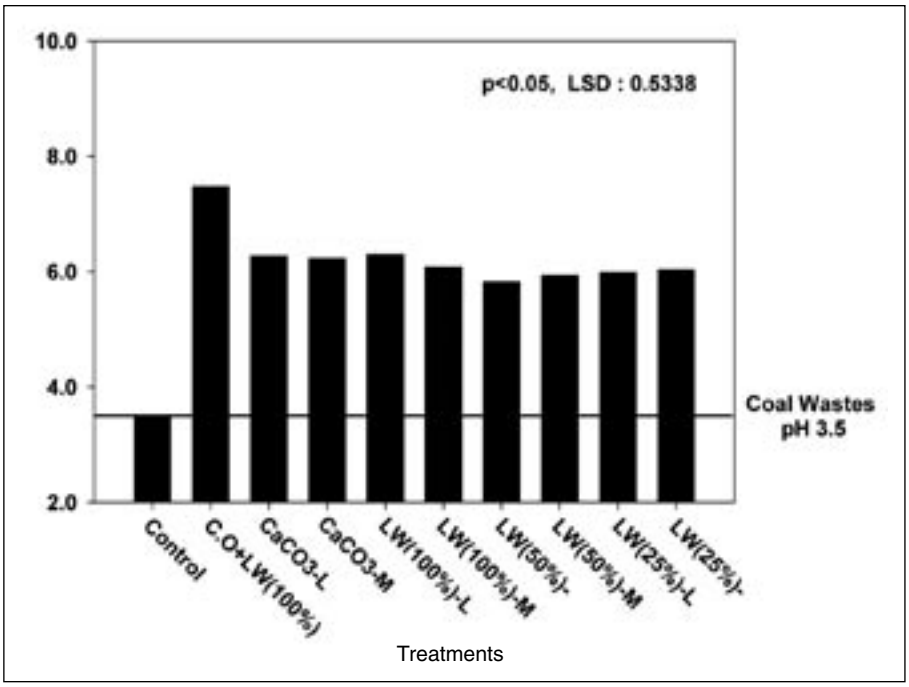


Figure 1. Soil pH in each treatment plot (Control is Coal Waste Only; C.O, Coal Waste; LW, Lime Cake; L, Layered; and M, Mixed)

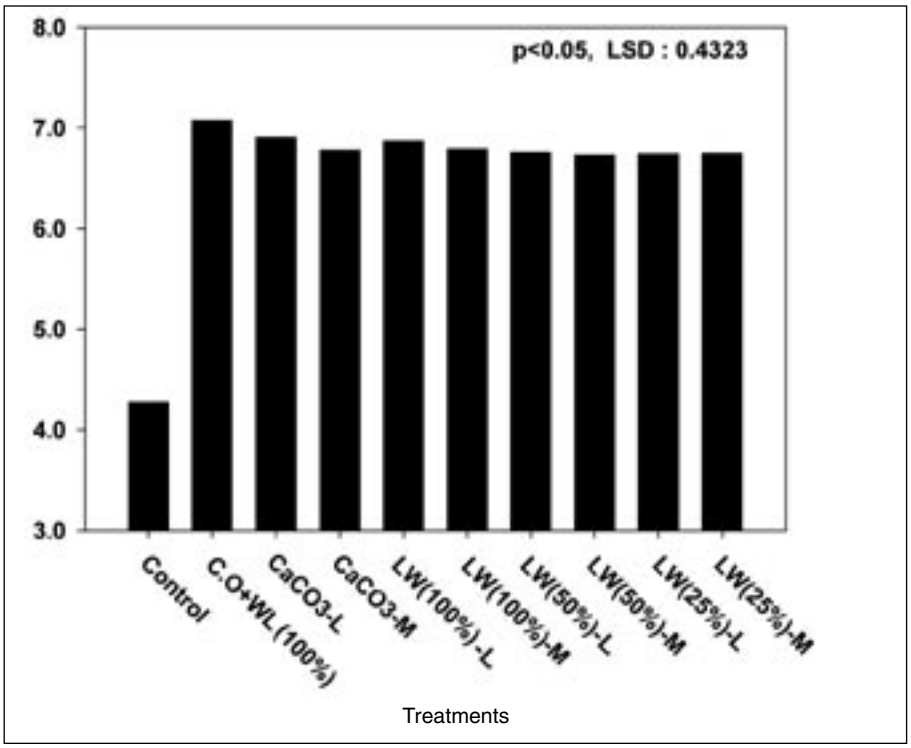


Figure 2. Runoff and leachate pH of each treatment plot (Control, Coal Waste Only; C.O, Coal Waste; LW, Lime Cake; L, Layered; and M, Mixed)

Results and Discussion

Chemical Properties of the Coal Waste, Lime Cake and Topsoil

The pH of coal waste was 3.5, and 16.5 Mg of $CaCO_3$ per ha (7.3 tons/ac) (table 2) were needed to adjust the pH to 7.0. The lime cake was high in bases such as Ca, Mg and Na with a high pH (11.2) and high electrical conductivity (EC: 19.6 dS m^{-1}). The topsoil was obtained from a nearby road cut and was low in fertility.

Effects of Lime Cake on pH of Coal Waste

The pH of the coal waste was 3.5 but increased to 7.5 when mixed with lime cake without the topsoil (plot 2) (Figure 1). However, plots treated with $CaCO_3$ and lime cake either layered or mixed with the lime requirement of 25%, 50% and 100% (plots 3 to 10) were stabilized at about 6.0 irrespective of the amounts of lime cake. This might be due to the pH buffer capacity of the topsoil. The neutralizing effects of lime cake were equivalent to the calcite. This result indicated that coal waste had less buffering capacity for pH than the topsoil. Thus, the combined treatment of lime cake with topsoil neutralized the acidic coal waste.

Effects of Lime Cake on Chemical Properties of Runoff and Leachate

Figure 2 shows the pH of the runoff and leachate collected in the tanks at the bottom of experimental plots. Data were averaged over measurements from April to August. The runoff pH of the coal waste was 4.3 but increased significantly to the range of 6.7 to 7.1 with treatments of calcite and lime cake. There were no significant differences in runoff pH among treatments of calcite and lime cake, layered or mixed, or amounts of lime cake. This is due to the combined effects of lime cake and buffering capacity of the topsoil.

Table 3. Vegetation cover percentage at each treatment plot during June to August.

		Treatment Plots*									
Month		1	2	3	4	5	6	7	8	9	10
June	%	16	13	14	15	16	26	22	30	25	26
August	%	33	27	46	46	40	37	37	46	53	61

*Refer to Table 1 for the treatment combination.

Picture 5: Vegetation cover was around 50% after the first growing season on the coal waste plots treated with lime cake by-products and limestone.

Picture 6: Vegetation cover was about 10% on untreated coal waste plots.

Initial Al concentrations in the runoff ranged from 30 to 60 mg/L, but those levels were sharply decreased with time to less than 2 mg/L (Yang et al., 2004). Concentrations of Fe in the runoff fluctuated with date and precipitation, but decreased from around 10 mg/L initially to <1 mg/L with lime cake treatments.

Effects of Lime Cake on Revegetation of the Coal Wastes

Table 3 shows the percentage of grass cover in each treatment plot during June to August (Pictures 5 and 6). Seeding of orchard grass (*Dactylis glomerata* L), Kentucky bluegrass (*Poa pratensis* L.) and Eulalia (*Miscanthus sinensis* Anderss) were done at the end of May. The grasses covered only 16 percent of the coal waste plot in June but the cover increased with time to 33 percent in August. Growth of grasses was enhanced with the combined treatments of lime cake and topsoil (plots 5 to 10). The increase in surface cover from June to August was higher with the 25 percent lime cake treatments (plots 9 and 10), which is probably related to the high salt content of the lime cake. Bioassay tests in the greenhouse revealed that seed germination of these grasses was highest when lime cake was applied at 25 percent of the lime requirement (LR) but germination was significantly suppressed at the 50 percent and 100 percent treatments. The results suggest that high salts content of the lime cake might be a limiting factor in revegetation of coal waste.

Summary

Field plots were used to test the effects of the lime cake on the reclamation of coal wastes by examining the chemical qualities of soil and water (runoff and leachate) and surface cover of grasses. Lime cake treatments increased the pH of the coal waste from 3.5 to 6, and raised the pH of runoff and leachate from coal waste from 4.3 to 6.7. Concentrations of Al and Fe in the runoff and leachate were significantly decreased with lime cake. Surface cover of grasses on coal waste was significantly increased with the lime cake. The amount of lime cake at 25 percent of the lime requirement was sufficient to neutralize the acidic coal waste and allowed germination of grasses. Either layering the lime cake between the coal waste and topsoil or mixing with coal waste could be adopted as reclamation methods. The combined treatment of lime cake and topsoil is recommended for revegetation in the coal waste piles. ■

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The Appalachian Regional Reforestation Initiative:
A Partnership To Promote Reforestation of Mined Lands

The goal of planting more native hardwood trees on active and abandoned coal mines in the Appalachian region is one step closer to reality.

Getting more hardwood trees planted on coal-mined lands is the goal of an agreement signed Dec. 15, 2004 by a broad-based partnership including the coal industry, the federal government, and seven Appalachian states.

Meeting to sign the agreement at Stonewall Jackson Lake State Park in West Virginia—the heart of Appalachian coal country—were representatives of the U.S. Office of Surface Mining (OSM); the U.S. Forest Service; the federal Department of Energy; the Appalachian coal mining states of Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia and West Virginia; the coal industry; environmental organizations; land companies; and academia (Picture 1).

Together they form the Appalachian Regional Reforestation Initiative (ARRI). The Statement of Mutual Intent creates a new state and federal project to promote and encourage the reforestation of coal mined lands.

"We're here to share our experience," said Butch Lambert of the Virginia Department of Mines, Minerals and Energy. "We're here to make a commitment to promote reforestation, to develop an initiative through which we can get coal companies involved in planting more trees - and not just more trees, but more viable and valuable trees."

Picture 1: Representatives of federal and state governments, the mining industry, and forestry interests gathered at Stonewall Jackson Resort in West Virginia to sign the Appalachian Regional Reforestation Initiative statement of mutual intent in 2004.

"Over the last 50 years of surface mining in Appalachia, the vast majority of mined land was originally forest." said Brent Wahlquist, director of OSM's Appalachian Regional Office. "It is our hope that through this initiative, perhaps 50 or 100 years from now it will be forest again, and be virtually indistinguishable from the rest of the landscape" (Picture 2).

Reforestation of coal-mined lands has the potential to provide many environmental and economic benefits. Environmental benefits include diversity of plant species, natural succession of native forest plants, enhanced wildlife habitat, soil and water conservation, improvement of overall water quality, and carbon sequestration. Economic benefits are also made possible by reforestation. They include increased timber value; landowner tax reductions; enhanced recreational opportunities; jobs for the local economy; and local tax revenue.

Reforestation provides an environmentally and economically viable post-mining land use option for both the landowner and the mining company.

A core group of the ARRI began meeting in May to address ways to increase the planting of more high-value Appalachian hardwood trees on active and abandoned coal mines through the use of Forestry Reclamation Approach (FRA) technology. This reclamation

Picture 2: Much of the area that has been and will be surface mined in the eastern United States is covered by trees, which have been harvested periodically for the past 150 years.

Picture 3: Oak and Sycamore trees are growing well on this seven-year-old mined site in Kentucky. The Forestry Reclamation Approach advocates practices that will reduce soil compaction and herbaceous competition.

technology will provide for the sound restoration of healthy productive forest on mined lands in the Appalachian region.

The Forestry Reclamation Approach steps are:

- Create a suitable rooting medium for good tree growth that is no less than four feet deep and comprised of topsoil, weathered sandstone, or the best available material.
- Loosely grade the topsoil or topsoil substitute to create a non-compacted growth medium.
- Plant native and non-competitive ground covers.
- Plant two types of trees; early succession species that provide for wildlife enhancement and soil stabilization, and commercially valuable crop trees.
- Use proper tree planting techniques.

These forestry reclamation steps are based in academic research and practical experience, including that done initially by Dr. Clark Ashby, formally of Southern Illinois University and Willis Vogel, formerly of the U.S. Forest Service. Currently research is ongoing at the Starfire Reforestation Project through the University of Kentucky under the direction of Dr. Donald Graves (Picture 3), at the Powell River Project in Virginia led by Dr. James Burger of Virginia Tech, and at West Virginia University by Dr. Jeff Skousen. ■

Individuals who signed the agreement for their organizations were:

Brent Walquist, *OSM Appalachian Region*
Reed E. Detring, *National Park Service*
D. Michael Baines, *USDA Forest Service*
Lee Barclay, *U.S. Fish and Wildlife Service*
David Ledfor, *Rocky Mountain Elk Foundation*
Fred Conner, *Peabody Energy*
Jeff D. Bitzer, *Catenary Coal Co.*
Kent DesRocher, *Arch Coal of West Virginia*
Scott Perkins, *International Coal Group, Birch River Mine*
Rick Williams, *Williams Forestry*
William H. Gillespie, *Gillespie Forestry Services*
David Arnold, *TN Department of Agriculture and Forestry*
Tim Eagle, *TN Department of Environment and Conservation*
David S Buckley, *University of TN*
Susan Bush, *KY Department of Natural Resources*
Donald Graves, *Carmen Agouridis and Richard Warner, University of KY*
Robert Zik, *TECO Coal and Chairman Professional Engineers in Mining KY*
Representative Rocky Adkins, *Majority Leader, KY Legislature*
Stephanie R. Timmermeyer, *WV Department of Environmental Protection*
Todd Groh, *WV Division of Forestry*
Lawrence T. Beckerle, *WV State Chapter of Quail Unlimited*
Richard Herd, *National Mine Land Reclamation Center at WVU*
William B. Raney, *WV Coal Association*
G. Nevin Strock for J. Scott Roberts, *PA Department of Environmental Protection*
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Michal Jones-Stewart, *PA Mining Professionals*
Gerald Collins, PE, *VA Department of Mines, Minerals, and Energy*
Eugene E. Stoots Jr., VA Dept of Forestry
James A. Burger, *Virginia Tech*
Michael Garner for Ed Larrimore, *MD Mining Program*
Michael Sponsler, *OH Department of Natural Resources*
Charles Gorbel and David M. Hix, *OH State University*

For more information on the Appalachian Reforestation Initiative, please see our Web site at http://arri.osmre.gov.

Or contact: Patrick Angel, Office of Surface Mining (606) 878-6440

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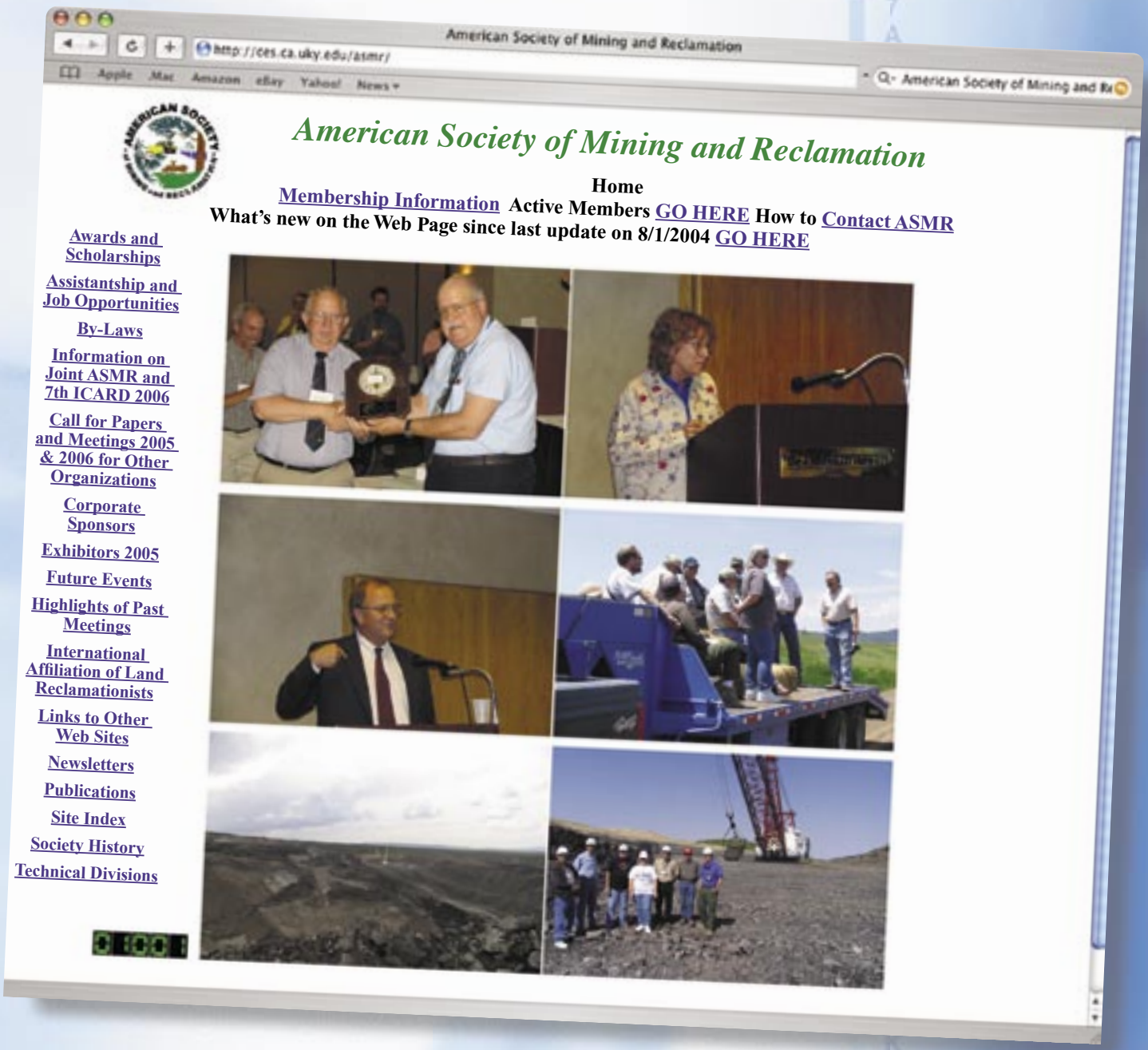

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