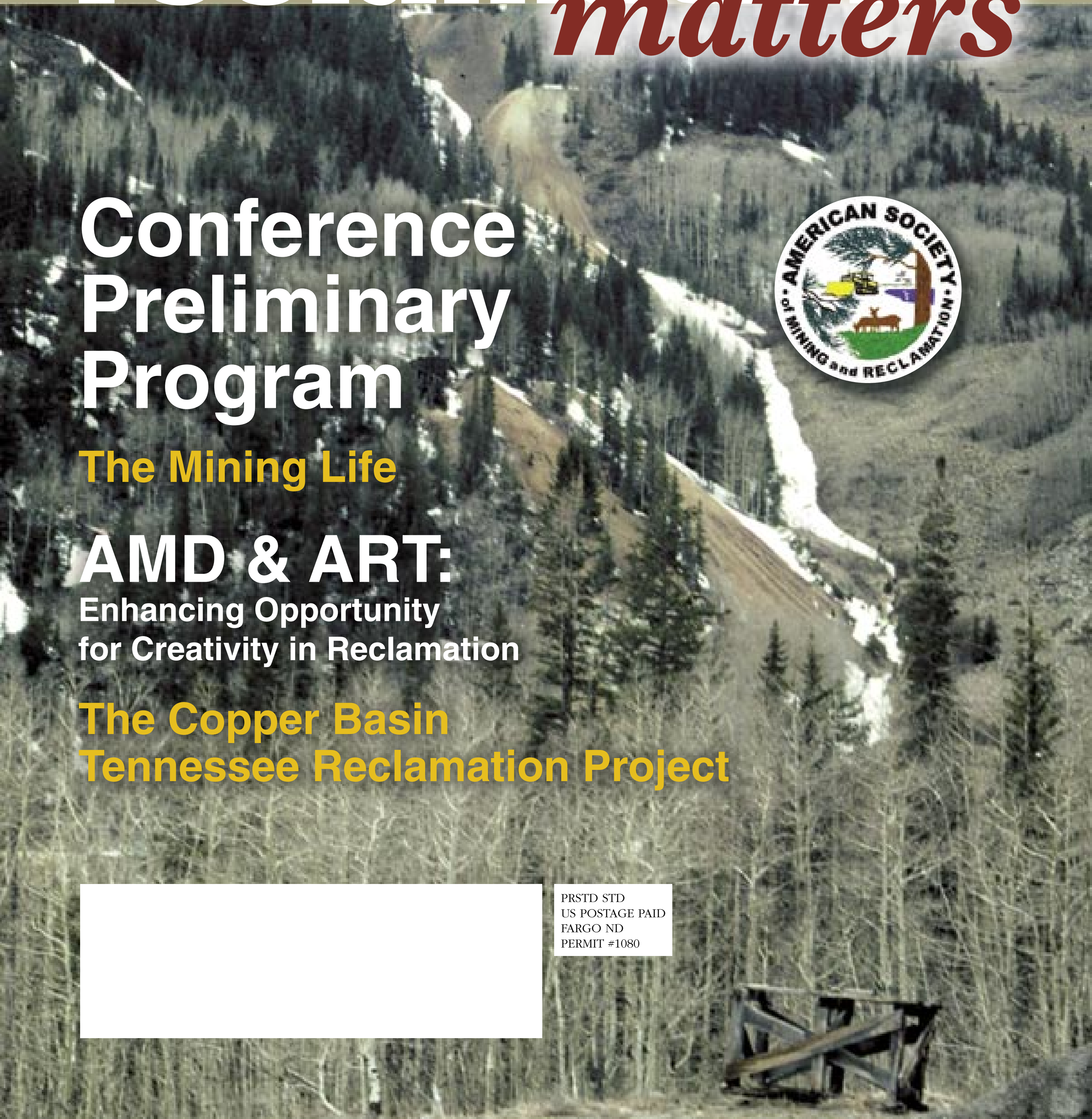
THE OFFICIAL PUBLICATION OF THE AMERICAN SOCIETY OF MINING AND RECLAMATION

Spring/Summer 2005

reclamation matters



Conference Preliminary Program

The Mining Life

AMD & ART: Enhancing Opportunity for Creativity in Reclamation

The Copper Basin Tennessee Reclamation Project

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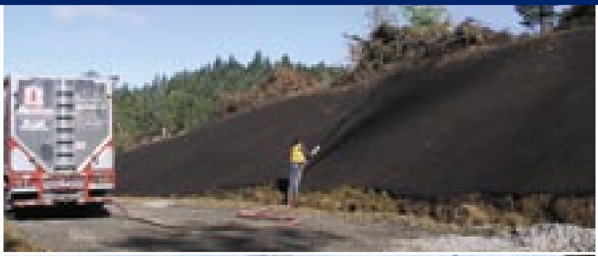

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Published for:
American Society of Mining and Reclamation
3134 Montavesta Road
Lexington, KY 40502
Tel: 859-335-6529
Fax: 859-335-6529
http://fp1.ca.uky.edu/asmr/

Published by:
Lester Publications, LLC
2131 NW 40th Terrace – Suite A
Gainesville, FL 32605
Main Line: (877) 387-2700

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Spring/Summer 2005
Volume 2
Number 1

Cover:
Remnants of abandoned underground portals and wasted ore materials from metal mines in Colorado.
Photo by Dr. Jeff Skousen

BY MARGARET DUNN, PG, CPG,
2005 ASMR PRESIDENT

MESSAGE FROM THE PRESIDENT

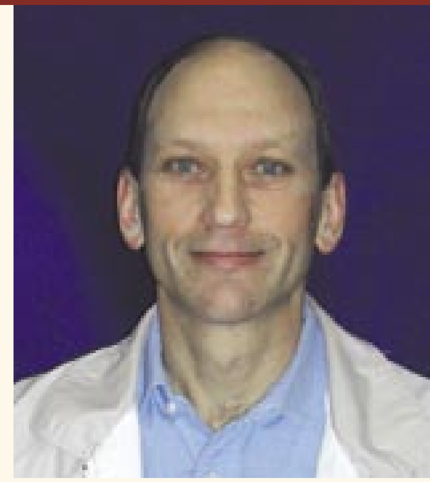
ASMR is Technology Transfer

Every day brings new opportunities to advance mining and reclamation technology. Needless to say, dedicated professionals from diverse specialties sharing "lessons learned", encourages not only rapid development in technology but also sustainable and holistic approaches. Because of the selfless contributions by numerous ASMR members (spearheaded by Terry Toy), the 2005 meeting in Breckenridge, CO has become the Technology Transfer opportunity of the year. No doubt information presented at the meeting will encourage further advances in remining, improvement in passive and active treatment systems (smaller, more efficient, less maintenance) and a better understanding of the interrelationship of site hydrology, soils, land use and geology with the watershed ecosystem.

"Getting the word out" is imperative. Along with the Web site and annual meetings, let us continue to focus on and increase sponsorship and distribution of *Reclamation Matters*. This periodical provides an unparalleled opportunity for our members to describe their area of expertise, for universities and colleges to acquaint future employers with the strengths of their students, and for laboratories and other companies to identify their mining and reclamation services to both the public and private sectors. As the members of ASMR continue to tackle reclamation challenges and to provide solutions that are both economically and environmentally sound, let us in turn support our members by expanding the recognition of their contributions through Technology Transfer. Thank you all for an organization that continues to a make a difference! ■

MESSAGE FROM THE EDITOR

Broaden Your Perspective



BY JEFF SKOUSEN

Like many of you, I get a number of calls and e-mails from people who need help with problems regarding acid mine drainage and land reclamation. I listen or read carefully as the person explains the problem and I attempt to answer the question as simply and directly as possible based on the presented information. Many times, however, extenuating circumstances and other site factors (which are not often detailed over the phone or through email) render my simple answer inappropriate or not applicable, and I wish I could be onsite to see the problem. This often results in a site visit where the problem can be viewed first hand and discussed with local people. Then, together we reach a solution as we evaluate the whole problem with attendant local variations and particulars.

Every time I am asked to help or consult, I generally learn more than the people with whom I work. It is remarkable that the most clever and best ideas originate with those most familiar with the conditions onsite and those who have already thought much about the problem. Sometimes they simply need to offer their ideas to an experienced person with a different perspective to confirm the feasibility of the idea. I am never ashamed to admit that I do not know the answer or cannot solve the problem immediately. By getting together with others (especially with the local talented people), the best solution is usually established as experienced people open their minds and brainstorm.

For example, several years ago we were having trouble dispensing small amounts of chemical into very small flows of AMD. The feeder allowed lime to build up along the side of the channel, which eventually clogged it. It was clear that the chemical needed to be washed out of the channel periodically, but this was difficult due to the small amount of flow. One of the older workers at the site came up with the idea that a bucket could catch the water, dump it when the water reached a certain level in the bucket, then return to be filled again, mimicking a toilet flushing action. He built the mechanism, made some refinements and now this technique is being used on all of our small flow AMD treatment sites. He probably would not consider himself smart or particularly clever, nor does he have advanced training with an academic degree. Yet, the best idea came from a local person who grasped a solution to a problem when we were brainstorming. Sometimes solutions are found when new technologies are applied to old problems, while at other times solutions are found when old technologies are applied to new problems. We need to be open-minded and consider all the possibilities at our disposal. Wild or unique ideas should always be welcome in these types of discussions: the crazier, the better.

Knowledge, experience, creativity and imagination are the keys to problem solving and critical thinking. This June in Colorado, ASMR will sponsor its 22nd annual meeting where the knowledge and experience of people in the reclamation field will be shared in an open and friendly forum. Some of the information will be in the format of research studies, with controlled experiments. Other presentations and posters will be very practical and will allow all of us to gain wisdom from the work and trials of others. Hopefully, the knowledge gained will allow you to broaden your perspective and promote wild and crazy ideas in your area of expertise. ■

Every time I am asked to help or consult, I generally learn more than the people with whom I work.

BY DR. STUART MCGEHEE, BLUEFIELD STATE COLLEGE, BLUEFIELD, WEST VIRGINIA

Dr. Stuart McGehee, Historian

The Mining Life

"Muscle and blood, skin and bones," sang Merle Travis mournfully of mining life, "a mind that's weak and a back that's strong."

Yet, despite the rigors of the bituminous coal miner's profession, aged veterans from the hand-loading era remember their work with a curious affection. The special relationship between man and mineral defined the parameters of the mining life. Although bituminous coal mining was dark, dirty and dangerous work, something about it appealed to many a hardworking coal loader.

Before the widespread introduction of sophisticated underground machines into the process around World War II, coal mining was a highly labor-intensive industry. In other words, thousands of workers laboriously extracted the mineral from an unwilling soil. Yet, the desolate hills and hollows of pre-industrial Appalachia were still largely uninhabited, containing no such teaming workforce. Thus, as the railroads snaked along the river bottoms into the coalfields in the late nineteenth century, companies were forced to import their labor and set up mining communities, literally overnight replacing silent mountains and roaring streams with a boisterous society of steel, smoke and sinew.

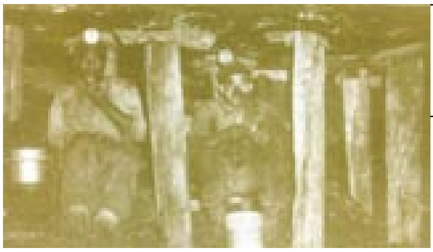
To these small mining towns came thousands of blacks, fleeing the Deep South's endemic segregation, sharecropping, prejudice and poverty. Came, too, scores of Eastern Europeans fleeing religious persecution and political revolution, escaping to new homes in the coalfields. Coal towns were filled with a rich and colorful milieu of race, class, color and religion.

Underground, each man was the same color – black – from the coal dust that caked his hardened, sweaty face. Underground, each man was his own boss, for in the hand-loading era, coal miners were paid not by the hour, but by the ton. This was a powerful incentive, which meant that better workers made more money. Merle Travis' pithy observations notwithstanding, coal mining was a highly skilled trade. Each miner had to timber the roof of his work site, undercut the broad face of the ebony seam, drill a deep hole upward into the coal, pack it with black gunpowder, shoot the charge, and then laboriously hand-load the dislodged lumps of coal. Performing these complex and hazardous tasks by hand in the pitch-black darkness was painstaking and exacting.

Each coal miner produced a finished product in which he could take pride. This was craftsmanship work. Moreover, in an age that often witnessed the bewildering move from farm to factory for many new industrial workers, coal miners still worked the soil with their hands, "harvesting" the mineral. Despite the rough and rugged lifestyle commonly associated with other frontier industries as well, this gave coal miners a sense of worth and dignity of labor.

Even the ever-present danger from gas and dust explosions and roof falls helped to strengthen the special relationship between man and mine, for only the most skilled men could be trusted to perform the delicate operation skillfully and safely. Coal miners tempted death each workday, and the men knew that their

Gary, WV in the Southern West Virginia coalfields.



Lunch break under a crude roof support system in Algoma, WV.

Hand loading in an underground coal mine. (Crowell, 1995, History of Coal Mining in Ohio)

Coal miners tempted death each workday, and the men knew that their survival depended upon the skill of their fellow workers on the shift. Veteran miners shared something that outsiders could never grasp, like the camaraderie of combat-hardened infantrymen.

survival depended upon the skill of their fellow workers on the shift. Veteran miners shared something that outsiders could never grasp, like the camaraderie of combat-hardened infantrymen.

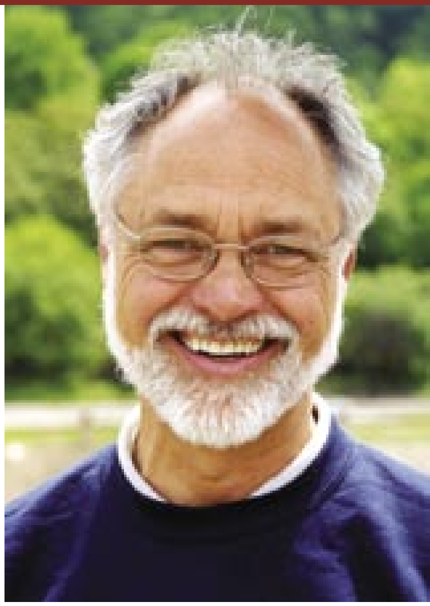
Helping to build close ties among the workers was the very nature of the small and isolated mining towns, which clung to hillsides, dotted ravines and sprawled promiscuously along creek beds throughout the coalfields. In these tiny "walking communities," work and home were closely inter-related. Often the railroad was the only way into or out of the towns, whose miner's homes perched neatly in terraced rows on the steep rugged hillsides. This isolation bred a close-knit tie of family, neighborhood, church and home. Forbidden by a hoary superstition from entering the mines, coalfield women built elaborate support networks based around the work rhythms of the weekly household chores.

Everyone knew everyone else and old-timers especially miss this fierce sense of community. Although the towns were segregated by race and ethnicity, such distinctions vanished at the two most predominant institutions in the community, the mine and the company store. Infrequent incorporated towns supplied commercial and entertainment options not often available in the stark company-run industrial towns.

Because conditions varied widely from town to town, generalization is difficult and imprecise. Research reveals a wide disparity between trim model towns, with bright gardens, sidewalks and verdant scenery, to squalid camps of tarpaper shacks patrolled by armed company thugs. Although it is common to decry the conditions in the mining towns, even the roughest camps were probably superior to the tenement ghetto sweatshops the immigrants encountered in New York or the tenant-farming huts of southern black cotton workers during this same time period.

Such was the mining life. If it seems dark, dirty and dangerous, well, it was. But, the social relations that arose around the production process and the special relationship that existed between man and mine created a truly unique profession; one fondly recalled by many a miner. ■

(Adapted from Coal People Magazine, October 2004).



T. Allan Comp

BY T. ALLAN COMP, PH.D., FOUNDER AND VOLUNTEER DIRECTOR OF AMD&ART, PROGRAM ANALYST, OFFICE OF SURFACE MINING.

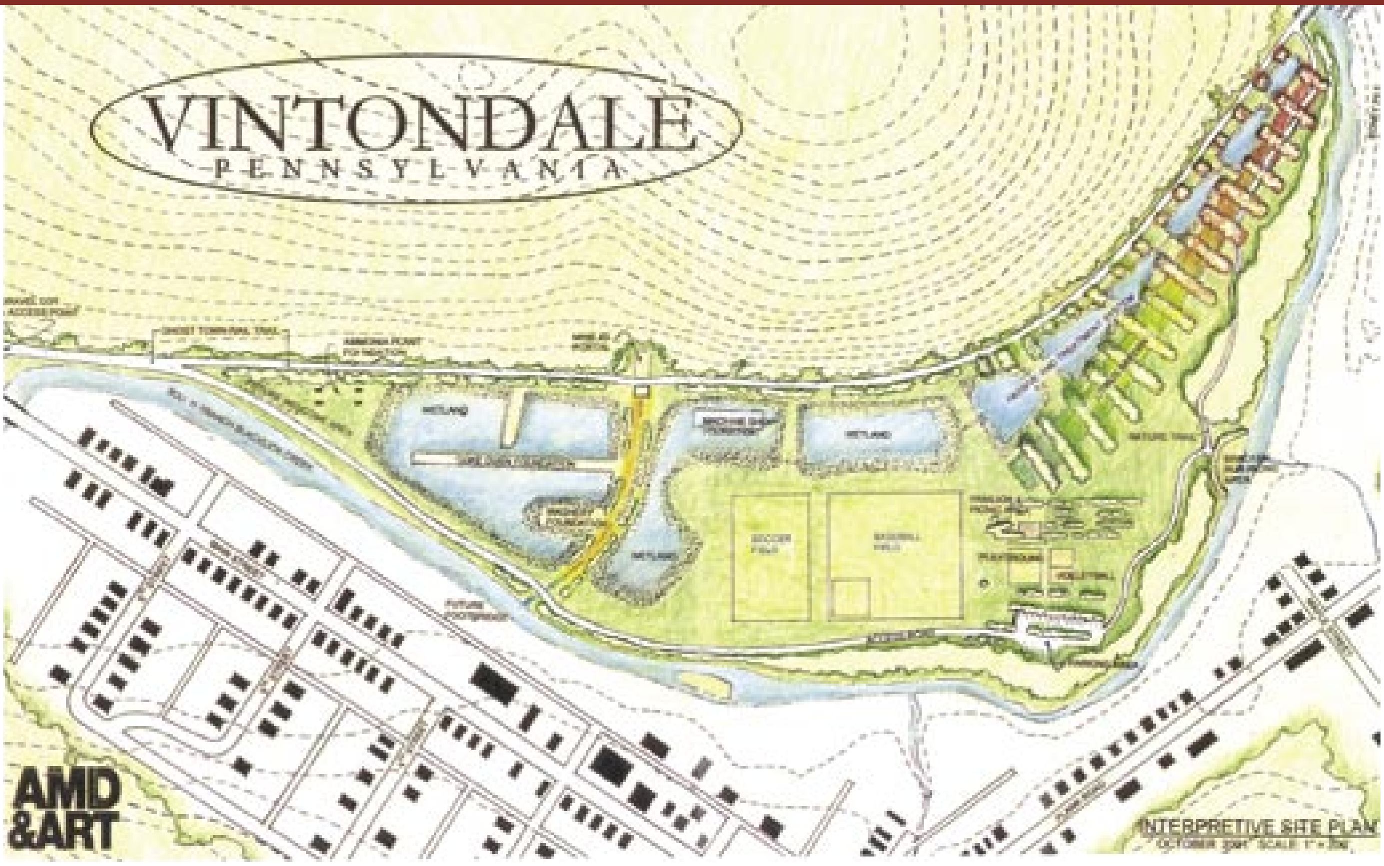
AMD&ART: Enhancing Opportunity for Creativity in Reclamation

In all the AMD&ART materials, you will consistently see a small statement following the AMD&ART name, "Artfully Transforming Environmental Liabilities Into Community Assets." We take that goal seriously. We think "artful" approaches open new perspectives and new constituencies to environmental projects.

For the arts, we returned to the academic definition, which includes writers, designers, sculptors, historians, anthropologists, visual arts and many other unfortunately compartmentalized disciplines. We seek to transform these environmental projects by crossing disciplines to form better, more holistic approaches. Finally, we seek to find the ways to make these multidisciplinary collaborations produce assets (i.e. environmental projects) that people will want, projects that can delight the senses, engage the mind, honor the past, nourish nature and the soul simultaneously and create viable models for other projects to follow. A lasting solution to the complex problems of environmental reclamation must be cultural *and* environmental. A scientific solution may clean the water, but a multidisciplinary solution has the power to both clean the water and to revive community spirit.

Our first project started in the small town of Vintondale, Pennsylvania, in the Appalachian coal country, one of America's forgotten places and perhaps its most neglected ecosystem. Among many other problems, Acid Mine Drainage (AMD)

Picture 1: Acid mine drainage in the South Branch of Blacklick Creek near Vintondale, PA.



Picture 2: Design of the Vintondale remediation project. Wetlands and a series of ponds treat the water from an underground portal.

is acknowledged by the EPA as the largest water-quality problem in this region, afflicting thousands of miles of streams and their communities. I suggest it is also the most emblematic of coal country environmental issues. The rust-orange sediment left by AMD is the orange, silent signature of dying communities, lost biodiversity, and lost opportunity; the emblematic color of slow death. As the surface expression of vast underground industrial activity (coal mining) now abandoned, one writer aptly described AMD as the "gangrenous puss of deep earth wounds."

Over the 10-year life of AMD&ART as a project, sustainable and environmentally rational approaches to treating AMD in largely passive systems have proven successful. During these same years, volunteer watershed groups have been organizing to attack AMD and other problems in their watershed, discharge by discharge, stream by stream. With help from a few government programs and private sector firms, they are quietly destabilizing the negative expectations of coal country culture, creating patterns of community success and innovation and organizing constituents into effective, hard-working advocates for their watersheds. At AMD&ART, we are proud to be a small part of this watershed movement.

But, 10 years ago when I started AMD&ART, little of this support system existed, and what did exist, I knew little about. Years earlier, I learned a lot about the work of others in public art, thanks to two Individual Fellowships from the Design Arts Program at the National Endowment for the Arts and a Hirsch Farm Artist Residency. So, I went looking for a team that could work with me on this quest. It would be avowedly inter- and multi-disciplinary. Our team would start with a real understanding based in history, engage serious sculptors and designers in the entire process and make sure we had solid science at every stage. We would work closely with the community so their aspirations would be fully translated into the form and substance of the project. We would keep our process open to solutions that not only fixed the immediate environmental problem, but opened opportunity for broader engagement. Most importantly, it simply could not fail. Failure has happened too often in this region.

Ten years later, AMD&ART is a nationally recognized model with many partners – and a lot more. AMD&ART shows that reclamation can be a celebration, an overt and visible effort by our own generation, a chance to artfully redeem a legacy now too-often identified with mountains of waste coal, rust-coated streams, and economic depression, but equally responsible for the nation building, community development and personal achievement that made this country great. We've proven that treatment systems can become gardens, native plant arboretums, and places of learning. We can create wetlands of wondrous living complexity and transform industrial site remnants into historical reminders, or "ghosts" that invite reflection.

Once-passive community members have become advocates for their new community place – a reclamation project that addresses the environmental problems *and* the people, bringing fresh perspectives and a stronger community.

Vintondale, Pennsylvania, our project site, is a small coal patch town in Cambria County, some 15 miles northeast of Johnstown, nestled deep in the Blacklick Creek Valley. Created by the Vinton Coal Company in the early 20th century, Vintondale is a community whose history was defined by underground mining and vast surface works, yet the tangible reminders of this once-proud past are largely gone. In the 1950s, the last deep mine in Vintondale closed forever. By the 1980s, the colliery site was

Picture 3: View of AMD&ART Treatment System.

Picture 4: AmeriCorps and OSM/VISTA members have been critical to AMD&ART's success. Here are two current staff reworking part of the new wetlands.

the town dump. At the northern edge of the site is the old railroad right-of-way, today known as the Ghost Town Rail Trail, which attracts approximately 75,000 hikers and bicyclists annually, a major factor in selecting this site for restoration. The South Branch of Blacklick Creek, a river severely impacted by AMD, curves around the eastern and southern boundaries of the park and separates it from the town (Picture 1).

To begin the restoration of environmental and community dignity alike, a sequence of wetland cells shaped to fit the topography mark the beginning of the treatment system at the eastern edge of the property (Picture 2). The AMD discharge (50-400 gpm, 2.8 pH) moves through this series of wetland cells, then through a Vertical Flow Pond and a final settlement cell (Picture 3). From there it flows, cleansed of its metallic pollutants and neutralized to a healthy pH, into seven acres of new wetlands (Picture 4). Surrounding the treatment system, planted bands of native trees form our "Litmus Garden," their fall colors reflecting the increasing health of the water, transitioning from deep red to orange, to yellow, then to silver-green alongside the system. This native tree arboretum also creates the opportunity for a fall festival celebrating the Litmus Garden's peak color and Vintondale's recovery.

Beyond the AMD Treatment System, in an area where black bony coal waste once barely supported scrubby grasses and stunted trees, a new seven-acre wetland environment is attracting a variety of birds and wildlife. That environment also reveals the foundation remains of the old Vinton Colliery structures (Picture 5) and this, our "History Wetlands," creates new opportunities for deeper understanding. At the center of the AMD&ART Park, we are working with the community to build an active recreation area – a place filled with baseball, soccer, horseshoes, volleyball, picnic tables and a pavilion – a renewed center of community activity.

At the site of the original Mine #6 portal, we reconstructed the heavy timber frame of the mine opening and filled the opening with a polished black slab etched with the life-size images of miners taken from 1930s film footage of a shift change at Mine #6 (Picture 6). Across the Ghost Town Trail from the portal, a 15- foot by 25-foot platform at grade will become a mosaic map of the entire site, drawn from a 1928 Sanborn Insurance map, opening better understanding of the mine surface works and the surrounding community. At the point where the now-clean water returns to the river, a new installation (whose design was selected from a just-completed national student competition) will mark the place of this victory.

Visitors to Vintondale's AMD&ART Park can walk on interpretive trails that draw together historical information, the science behind passive AMD treatment and the newly healed ecosystem that now thrives in the wake of remediation. I hope residents and visitors alike will gain new perspective on the resilience of nature and the ability of humans to work with the environment in a healing process that creates a new community center. The physical presence of the energized place will symbolize the success of community residents in healing these waters, not only by completing a job never imagined by past generations, but also by creating a new asset for their own families and future.

The multi-disciplinary collaboration that is AMD&ART built this 35-acre site in Vintondale over the last 10 years by gathering over $950,000 in funds – and easily twice as much from donated in-kind work – drawn from many sources, only one from a traditional source of AMD remediation dollars. Partners as diverse in their interests as EPA, PennDOT, OSM, Rockefeller, Heinz, and many others funded the creation of this place. These major contributors were joined by many more small funders, bringing depth and diversity to our efforts and you can find the full citation for each of them at the AMD&ART Web site. As one example of our development process, we first convinced EPA we could create separate new wetlands with the clean discharge from our treatment system, then pre-sold those new wetlands to PennDOT, co-designed them with the Wildlife Habitat Council,

Picture 5: View of new History Wetlands with Vinton Colliery foundations in the foreground. Ghost Town Trail is located at the base of the hill in the background.

used an OSM permit (GFCC) to remove 70,000 tons of bony coal at no cost, partnered with the Army Corps of Engineers to place artificial soil on the entire site, and then, to assure long-term sustainability, we used some of the sale proceeds to establish a trust fund in the local Community Foundation of the Alleghenies to provide funds for maintenance of the treatment system and wetlands in perpetuity. Several other smaller funders made it possible to enhance this work in many ways, creating some of the best (and best interpreted) wetland habitat in the region.

I think there are lessons in AMD&ART successes in Vintondale that can be applied much more broadly. Most importantly, restoring streams contaminated by AMD, or reclaiming any other environmentally devastated area in which people have a stake, benefits from more than technical fixes – sustainable reclamation needs to be more than just a science project. Engaging local citizens in multidisciplinary collaborations that

Picture 6: Mine #6 portal sculpture with life-size images etched from 1930s home movie footage of shift change at Mine #6. The three men pictured at the portal all worked in Mine #6.

Picture 7: Watershed group meetings are important parts of developing community awareness and solidarity. It also allows training and planning for acid mine drainage treatment.

A lasting solution to the complex problems of environmental reclamation must be cultural and environmental. A scientific solution may clean the water, but a multidisciplinary solution has the power to both clean the water and to revive community spirit.

address environmental problems invites healing and creates new pride (Picture 7). I also hope we are establishing a new role for artists and humanists (like me) as well, not as solitary visionaries, but as participants; not as some ultimately mystical or magical process, but an important, useful perspective; not as arbitrator, but as co-worker; one among many disciplines, all equally necessary (but none sufficient!) to the recovery and revitalization of this region and its peoples.

To heal our mine-scarred lands, our streams *and* our communities, we must engage the public in such a way that we create widespread demand for environmental improvement and the better quality of life that a healthy place can provide. Particularly for visible, publicly-funded projects, they must be good enough and broad enough in their appeal to create demand for more projects by voters who want one in their own backyard.

To re-conceptualize AMD treatment in this way is to create a paradigm shift – we really can transform environmental liabilities into community assets! Today, there is another AMD&ART-like project near completion on the campus of the University of Virginia at Wise and many others use AMD&ART as a catalog of ideas for their own sites. Perhaps more important, reclamation and watershed restoration projects as big as the Upper Clark Fork in Montana (part of the largest Superfund site in the U.S) and as small as Crowley Creek, near the Sitka Center for Art and Ecology on the Oregon coast, are using AMD&ART as a model that brings science, the arts and the humanities – and real interdisciplinary collaboration – into the environmental planning process. AMD&ART is demonstrating that reclamation, creatively designed and developed with the help of many partners, can address environmental challenges *and* strengthen a sense of place and pride, bringing all partners new and more positive connections to both past and future. ■

Please see www.amdandart.org for more information.

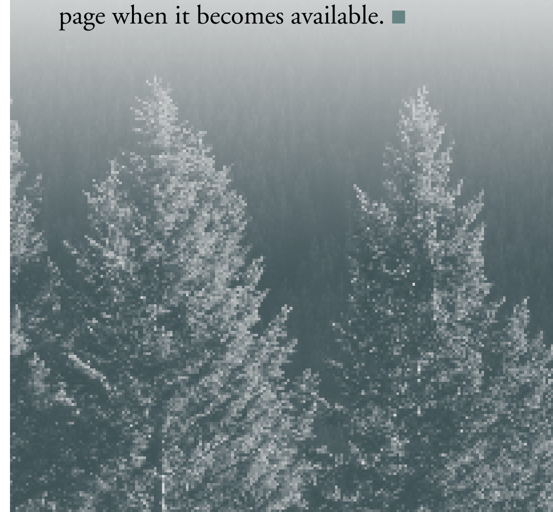
[All opinions expressed herein are those of the author.]

ASMR Meetings for 2006

The proposed ASMR meetings in 2006 (March 26-30) will be a joint meeting with International Congress on Acid Rock Drainage or the 7th ICARD. In addition, other organizations are likely to be co-sponsors including: International Mine Water Association or IMWA, International Network for Acid Prevention or INAP, Acid Drainage Technology Initiative or ADTI, the Environmental Division of the Society of Mining Metallurgy and Exploration or SME, and Rocky Mountain Regional Hazardous Substance Research Center.

ASMR has agreed to be the contact organization for the abstracts, papers and for the reproducing the Proceedings of the Meetings as a CD. Sessions will be arranged into 15 topical sessions. There will be room for only about 75 oral presentations with the remainder of the presentations will be in the form of Posters. Although the deadline for abstracts of oral presentation was February 22, 2005, it is possible that abstracts for poster presentations may still be accepted.

Hotel and registration information will be sent in future newsletters and will also be placed on the ASMR Web page when it becomes available. ■



Preliminary Program

Raising Reclamation to New Heights

You and your family are cordially invited to join us for the 22nd American Society of Mining and Reclamation National Meeting, Breckenridge, Colorado. In the heart of the Rocky Mountains. June 18-25, 2005.

Transportation

Breckenridge is located about a two-hour drive southwest of Denver, Colorado in the Rockies. Although commuter service is sometimes available to Aspen, CO, most visitors will fly into Denver International Airport and take the shuttle or rental car to Breckenridge. Frontier Airlines is the "official" airlines of the conference and is offering a 10-percent ticket discount to those attending the meeting and mentioning the ASMR group code G999 (1-800-908-9069) or www.frontierairlines.com (put code in ticket designator box). The shuttle service from Denver International Airport to Breckenridge is run by Colorado Mountain Express (1-800-334-7433 or www.ridecme.com). The cost is $50.90, one-way. Mention ASMR as the discount code. Rental cars are also available at Denver International Airport.

Hotel Accommodations

The Beaver Run Resort Hotel is the home for the conference. This is a gorgeous hotel in a gorgeous setting. Visit the web site!

Room Prices	
Standard Hotel	$89.00
Deluxe Studio	$99.00
One-bedroom condo	$119.00
Colorado Suite	$119.00
Premium one-bedroom condo	$210.00
2-bedroom condo	$225.00

These are remarkable prices for a Colorado mountain resort! The hotel will honor the prices for five days before and after the conference to facilitate your vacation. The absolute cut-off date for reservations at these prices is May 18, 2005. To make your reservations and for more information, contact Beaver Run Resort, 1-800-288-1282 or www.beaverrun.com.

Exhibitors should contact Rich Vincent at rvincent@state.wy.us or (307) 777-7070 for specifics of the exhibitor package. **Meeting Sponsors** should contact Dave Chenoweth at dchenoweth@wsreclamation.com or (303) 833-1986 for specifics of the sponsorship package.

For Additional Meeting Information

- ASMR Web site: http://ces.ca.uky.edu/asmr
- Richard Barnhisel at asmr@insightbb.com
- Terry Toy at ttoy@du.edu

In addition to the technical program, don't forget:

- The field trips to reclamation sites
- The workshops to expand your skills
- The Society Dinner

Pre-Conference Workshops

Workshop 1: Invasive Weed Issues for Mined Lands and Energy Development in the Western U.S.

Instructor: Dr. Stephen Enloe, Extension Weed Specialist, Department of Plant Science, University of Wyoming
Date, Time, Cost:
Saturday, 18 June, 2005, 1-5 p.m.,
Cost: $40 (Students $25)
Minimum attendees: 15
Maximum attendees: (room size)

This workshop will focus on invasive plant (weed) issues for mined lands and energy development in the Western United States. Topics include: identification and control of the most problematic weeds, potential new invaders in the West, understanding and preventing herbicide resistance, and concepts and use of integrated pest management.

Workshop 2: Ecological Mine Waste Management: A Sustainable Approach to Decommissioning

Instructors: Dr. Margaret Kalin and Dr. Andrew Fyson, Boostrum Research Ltd., Toronto, Canada
Date, Time, Cost:
Sunday, 19 June, 2005, 8 a.m. - 5 p.m.,
Cost: $95
Minimum attendees: 10
Maximum attendees: 75

Passive wastewater treatment technologies based on ecological principles for organic pollutants are gaining gradual acceptance in many industrial sectors in the western world. To a lesser degree, wetlands and bogs have been used to isolate the inorganic pollutants in mine waste waters. But, acid mine drainage generated by mine wastes is a particularly insidious environmental problem and can be successfully treated by passive systems only if the principles of ecological engineering are embraced. Over the past 20 years, projects undertaken in northern Saskatchewan, Ontario, Newfoundland, Brazil and Germany have demonstrated that natural biogeochemical cycles, if properly supported, can effectively counteract many of the negative environmental impacts of mining. In the morning, principles of ecological engineering will be discussed. In the afternoon, a brief overview of completed and ongoing projects applying these principles will be presented.

Workshop 3: Cover Systems for Mine Waste Management – Design, Construction, and Performance Monitoring

Instructors: Mike O'Kane, P. Eng. and Dave Christensen, O'Kane Consultants Inc., Saskatoon, Saskatchewan, Canada
Date, Time, Cost:
Saturday, 18 June 2005, 8 a.m. - 5 p.m.,
Cost: $70
Minimum attendees: 10
Maximum attendees: 50

Constructing cover systems over waste rock or tailings has become a viable alternative to mitigate against the effects of acid rock drainage. The primary purpose of placing cover systems over reactive waste material is to minimize further degradation of the receiving environment following closure of the waste storage facility in the short term; and facilitate recovery of the receiving environment in the long-term. This workshop will present theoretical and case study examples, as well as facilitate discussion, addressing:

- Linking the objectives of a cover system to impacts to the receiving environment;
- Key theoretical cover system concepts;
- Field performance monitoring of cover systems; and
- Sustainable performance of cover systems.

The workshop will be separated into distinct sections where a fundamental understanding for each section will be developed. The workshop instructors will also facilitate discussion amongst the participants through case studies and examples.

Workshop 4: Using AMDTreat to Evaluate Mine Drainage Treatment

Instructors: Brent Means, Hydrogeologist and Bob McKenzie, Supervisory Regulatory Program Specialist, Office of Surface Mining
Date, Time, Cost:
Sunday, 19 June, 2005, 8 a.m. - 5 p.m.,
Cost: $50 (Students $30)
Minimum Attendees: 10
Maximum attendees: 50

This workshop will focus on how to use the AMDTreat software to evaluate treatment methods and economics. The course is divided into three sections — Chemistry section, Treatment section, and AMDTreat section. The course will start by exploring the chemistry of mine drainage as it relates to treatment. This section will focus on the chemistry of Acidity, Fe, Al, and Mn and at the end of this section students will have an understanding of how to treat for each of these constituents. The next section is the Treatment section and will be taught by a person with more than 20 years of experience in designing and operating active and passive treatment systems. This section will explore the pros and cons of different active and passive treatment technologies. During this section, the instructors will perform a "Treatment" titration, which is an innovative method to estimate chemical consumption and evaluate the most cost-effective treatment chemical for specific water. A sludge titration will also be reviewed as a method to estimate sludge volumes. The last section focuses on applying the knowledge gained in the previous sections to the AMDTreat cost-estimating software. AMDTreat software is a flexible tool for estimating treatment costs and evaluating long-term treatment economics. Students will use water and site data and use AMDTreat to perform forward and reverse cost modeling. Also, students will use AMDTreat to evaluate long-term treatment economics.

Workshop 5: Mine Land Reclamation Utilizing GPS Technology at the Dave Johnson Coal Mine

Instructors: Douglas White and Nathan Riddle, Dave Johnson Coal Mine, Glenrock, WY
Date, Time, Cost:
Saturday, 18 June, 2005, 8 a.m. - 12 p.m.,
Cost: $40 (Students $25)
Minimum Attendees: 10
Maximum attendees: 50

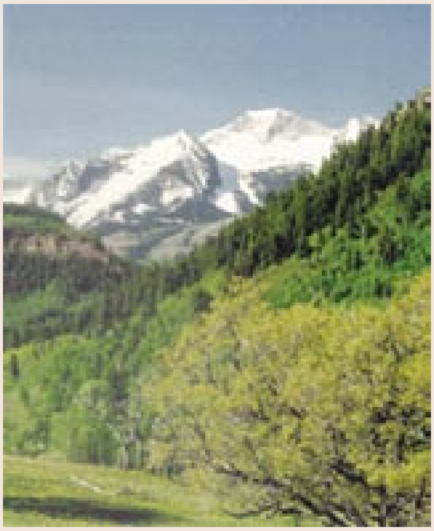
GPS (Global Positioning System) technology, initially justified as a coal production tool, has provided outstanding versatility for the Dave Johnston Mine's transition from coal production through the latter stages of reclamation. This engineering and operating tool enabled both high production and quality control during pit backfill, spoil grading and topsoil replacement to accomplish final land surface reconstruction. Since 1998, Glenrock Coal Company's Dave Johnston mine has been using Caterpillar's Computer Aided Earthmoving System (CAES), equipped in Caterpillar D10 and D11 track type dozers and in a Caterpillar 657 wheel scraper to optimize reclamation of approximately 3,300 acres of surface coal mine disturbance in Wyoming. Utilizing AutoCAD computer software with Quicksurf volumetric add-on software, digital terrain models (DTM) are developed, transmitted via radio program developed by Trimble, to the mobile reclamation equipment on site. GPS control enables real time equipment location and provides operators a visible display of field direction on an onboard computer display.

This workshop will demonstrate the engineering design process, particularly the development of the DTMs and their application for surface mine reclamation. An overview of CAES will be provided.

Workshop 6: Practical Statistics for Reclamation

Instructor: Dr. Dennis Helsel, U.S. Geological Survey, Lakewood, CO
Date, Time, Cost:
Saturday, 18 June 2005, 8 a.m. - 5 p.m.,
Cost: $50 (Students $30)
Minimum Attendees: 2
Maximum Attendees: 75

Methods for describing data, testing for group differences, and computing a regression equation are surveyed. Data used are typical field data, so methods are directly applicable to everyday work. All data and a textbook are provided on CD. Topics include: useful graphs, approaches based on means versus percentiles, how to build a good regression model, what can and cannot be done using Excel. The workshop is a shortened version of the course "Applied Environmental Statistics" (see www.PracticalStats.com), taught by the instructor since 1990. Attendees should contact the instructor (Dennis Helsel at dhelsel@usgs.gov) in advance of the workshop regarding specific interests and possible transfer of datasets.



Workshop 7: Stream Restoration

Instructor: Katherine Salsbury, Intermountain Aquatics Inc, Driggs, ID
Date, Time, Cost: Sunday, 19 June 2005, 8 a.m. - 12 p.m.,
Cost: $40 (Students $25)
Minimum Attendees: 10
Maximum Attendees: 75 (room)

For the past seven years, Katie Salsbury and Jeff Klausmann of Intermountain Aquatics, Inc. have been completing stream and wetland projects throughout the west. Each project has focused on achieving specific habitat improvement, restoration or mitigation goals that replicate the functional values and processes found in nature. This workshop reviews the guiding principles that have provided the foundation for their projects; the techniques that they have used to design, implement and evaluate; and case studies of both "failed" and "successful" projects.

ANNUAL SOCIETY DINNER

The Annual Society Dinner will be held on Tuesday, June 21, 2005 at Carter Park, in the Town of Breckenridge. In the Western tradition, the menu features the barbequed cuisine of "Big Mike," including hickory and applewood smoked ribs, boneless chicken and shredded beef as well as potato salad, baked beans, pickles, rolls, and cookies. Beverages include soft drinks (sodas) and the traditional BBQ libation, namely beer. In addition, there will be entertainment for your dancing pleasure. Festivities begin at 6:00 p.m. with the Society march from the hotel lobby to the park and will end at 9:00 p.m. when the beer runs out or upon the first arrest. Available space requires that we limit this event to the first 250 spirited revelers. Cost is a nominal $30 per person for dinner, drink and entertainment. Your meeting chair suggests: "Don't miss this event. You're gonna like 'Big Mike'!"

Pre- and Post-Conference Field Trips

Field trips limited to 30 people with the exception of the horseback riding excursion, which is limited to 14 people. Register early!

Field Trip 1: Blue River/ Snake River water quality improvement projects

Coordinators: Linda Figueroa (lfiguero@mines.edu), Kathy Smith, Carol Russell
Date, Time, Cost: Sunday, June 19, 2005, 8:00 a.m. - 5:00 p.m., $75

Purpose: The Blue River and Snake River are part of the Blue River Watershed that supply water and support recreational activities in Summit County, Colorado. Historic mining activity has resulted in water quality impairment associated with AMD into the watershed. Economic and land use activities in Summit county are varied and thus addressing water quality issues requires the cooperation of the watershed's multiple stakeholders. Attendees will view water quality impaired zones of the watershed and associated reclamation and remediation efforts. Water quality issues will be presented from multiple perspectives.

Agenda: Buses will pick up attendees in front of the Beaver Run Resort at 8 a.m. Stops on the field trip include: the Blue River Restoration project, French Gulch/ Wellington Oro site, Pennsylvania Mine, and Shoe Basin. Lunch and transportation included in the cost.

Field Trip 2: Anglo Gold/ Ashanti Cresson Mine

Coordinators: Linda Figueroa (lfiguero@mines.edu), Dave Chenoweth
Date, Time, Cost: Sunday, June 19, 2005, 8 a.m. - 4 p.m., $60

Purpose: The Cripple Creek & Victor (CC&V) Gold Mining Co. is a joint venture between AngloGold/Ashanti (Colorado) Corp. and the Golden Cycle Mining Co. Anglo Gold/Ashanti is the manager of the CC&V operations. CC&V has been conducting gold mining and precious metal extraction operations in the Cripple Creek Mining District since 1976. The current operation, the Cresson Mine permitted in 1994, incorporates typical modern surface mining methods. At the Cresson Mine, the leaching of the gold is accomplished out of doors in a valley leach facility. Exploration activities include extended drilling to greater depths, as well as the use of aerial photography and remote sensing techniques. Environmental compliance activities include management of air quality, storm water and hazardous wastes. Over 100 acres have been reclaimed to beneficial use since the Cresson Mine project was initiated.

Hard hats, boots, and safety glasses are required. Hard hats and safety glasses provided by the Colorado School of Mines are available with advanced notice.

Agenda: Buses will pick up attendees in front of the Beaver Run Resort at 8:00 a.m. A 10:00 a.m. arrival at Cripple Creek is expected. The tour will be presented in two parts; one in the morning and another in the afternoon session. A lunch break will be held in between. Departure from Cripple Creek at 2:00 p.m. is anticipated with a return to Breckenridge at 4:00 p.m. Lunch and transportation are included in the cost.

Field Trip 3: Horseback riding tour of Coal Basin

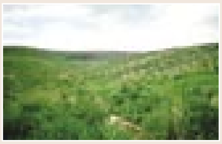
Coordinators: Dan Mathews (daniel.mathews@state.co.us), Henry Austin
Date, Time, Cost: Thursday afternoon and all day Friday, June 23-24, 2005, Depart 1:00 p.m. Thursday and return 8:00 p.m. on Friday, $340
[limited to 14 people]

Purpose: Explore the high remote reclamation sites in the Coal Basin on horseback. Redstone is located on the Crystal River, in a scenic, almost Alp-like setting. It is a historic coal mining town – an artsy/craftsy laid back tourist destination. Coal mining in nearby Coal Basin was initiated by turn of the century entrepreneur John Cleveland Osgood in the 1890s. Modern mining began in Coal Basin in the 1950s and continued until around 1990, when the company (Mid Continent Resources) filed for bankruptcy. Reclamation operations were initiated by the State of Colorado Division of Minerals and Geology (DMG) in the mid 1990s and have now been largely completed. There were more than 400 acres disturbed, including an extensive road network, five separate mine portal locations at elevations up to 11,000 feet, two large coal refuse piles, a rock tunnel waste pile, a central facilities area and wash plant, numerous coal stockpile areas and coal handling facilities including an overland conveyor route. The portal locations are remote and now accessible only by foot or horseback (general public) or ATV (authorized personnel). Remedial steep slope reclamation work in recent years has been by helicopter and manual labor.

Agenda: Buses will pick up attendees in front of the Beaver Run Resort at 1:00 p.m. and arrive in Redstone in the late afternoon. Explore the historic town of Redstone in the evening and have dinner on your own. Depart Redstone Inn at 7:00 a.m. for tour; get saddled up and head on out at 8:00 a.m. We expect to be back in Redstone at 5:00 p.m. and to Breckenridge by 8:00 p.m. Breakfast and lunch on Friday, hotel, transportation, horses and gear included in the cost.

Field Trip 4: Yampa River basin, surface coal mine reclamation tour

Coordinators: Dan Mathews (daniel.mathews@state.co.us), Henry Austin, Forrest Luke
Date, Time, Cost: Friday-Saturday, June 24-25, 2005, two full days, $200



Purpose: This tour will highlight revegetation and wildlife issues and practices on three surface coal mines in Northwestern Colorado's Yampa River Basin, located between Meeker and Steamboat Springs, CO. These mining operations have been nationally recognized for the very positive impact of reclaimed lands on big game species and Columbian Sharp-tailed Grouse. Wildlife response to reclamation activities will be highlighted and discussed. Various woody plant establishment approaches and study plots will be observed. The visit to the plant center will focus on the successful development of plant cultivars for use in mined land applications. We will also take a look at ongoing cultivar development research projects.

Agenda: Buses will depart the Beaver Run Resort on Friday, June 24, at 7:00 a.m. The first stop will be the Upper Colorado Environmental Plant Center near Meeker, CO. Friday afternoon the tour will include the Colowyo Coal Company L.P., Colowyo Mine; and that evening overnight in Craig, CO, with a BBQ in a local park hosted by the Associated Governments of Northwest Colorado. Saturday, June 25, the morning tour will include the Trapper Mining Inc., Trapper Mine in Craig; and the afternoon tour will include the Seneca Coal Company, Seneca Mines, in Hayden, CO. From the Seneca Mines, the tour will return to the Beaver Run Resort in Breckenridge by approximately 7:00 p.m. Lunch on both days, hotel and transportation included in cost.

Field Trip 5: Climax Molybdenum Mine and Upper Arkansas bios lids reclamation and watershed impacts

Coordinators: Linda Figueroa (lfiguero@mines.edu), David Chenoweth, Kathy Smith
Date, Time, Cost: Friday - Saturday, June 24-25, 2005, two full days, $200

Purpose: This tour will cover exploration through reclamation activities at Climax Molybdenum Mine, biosolids reclamation activities in the Upper Arkansas and a case study assessment of water quality in the Lake Creek watershed impacted by natural ARD using mineralogy and remote sensing. The Climax Mine is a world-class molybdenum mine located at high altitude in the Colorado Mountains. The tour will visit the tailings impoundment and overview the mine facilities. The ongoing reclamation activities include water treatment, waste rock reclamation, using biosolids, tailing pond capping and re-vegetation and test plots. Research has consistently demonstrated that biosolids are highly effective, in many cases more so than topsoil replacement, for restoration of disturbed ecosystems. The Upper Arkansas River alluvium is the location of an on-going high-altitude remediation and biosolids demonstration. Many areas of the Western U.S. contain mineralization that includes large sulfide bodies, natural acid rock drainage (ARD) from sulfidic alteration that adversely affects the water quality of the host watershed. The Colorado Geological Survey and a team of remote sensing experts from industry are conducting a National Aeronautics and Space Administration (NASA)-funded study of the ARD impacted Lake Creek watershed in the upper Arkansas River basin of Colorado using remote sensing technology to characterize, map, and monitor water quality in such watersheds.

Agenda: Buses will pick up attendees in front of the Beaver Run Resort at 8:00 a.m. on Friday. The first day will include a half-day at the Climax Mine site and a half-day on touring biosolids demonstration sites on the Upper Arkansas. After an overnight in Leadville, the next day will be an all-day watershed impact tour. Expected return time to Breckenridge is 7:00 p.m. Box lunches, Saturday breakfast, hotel and transportation included in cost. You are on your own for dinner on Friday night.

Preliminary Program

American Society of Mining and Reclamation 2005 National Meeting, Breckenridge, Colorado

Saturday, June 18			
	Workshop: Cover Systems for Mine Waste Management – Design, Construction and Performance Monitoring (full day)	Workshop: Practical Statistics for Reclamation (full day)	Workshop: Mine Land Reclamation Utilizing GPS Technology (half day). Workshop: Invasive Weed Issues for Mined Lands (half day)
Sunday, June 19			
	National Executive Council Meeting (full day)		
	Workshop: Ecological Mine Waste Management: A Sustainable Approach (full day)	Workshop: Using AMDTreat to Evaluate Mine Drainage Treatment (full day)	Workshop: Stream Restoration (half day)
	Field trip: Anglo Gold/Ashanti Cresson Mine (full day)	Field trip: Blue River/Snake River Water Quality Improvement Projects (full day)	
Afternoon	Poster Setup		
Evening	Welcome Gathering and Reception		
Monday, June 20			
Morning	**Plenary Session** Welcome, ASMR President Speakers: Stuart Sanderson, Colorado Mining Association; Gail Norton invited or representative; Dr. Tom Noel, Colorado historian ASMR General Business Meeting and Announcements		
Afternoon	Session A: Methods for Toxicity Assessment of Mine Wastes	Session B: Long-term Effects of Topsoil Depth on Soil and Plant Systems	Session C1: Effective Public Education Tools We Can All Use [spouses and children welcome]
			Session C2: Powder River Basin Water Quality and Use
	Ecology Technical Division Meeting	Soils and Overburden Technical Division Meeting	Geotechnical Engineering Technical Division Meeting
Evening	Exhibitor Reception and Poster Viewing		
Tuesday, June 21			
Morning	Session A: Forestry: Reclamation and Revegetation	Session B: Mine Hydrology and Erosion Characteristics	Session C1: Trace Metal Source and Remediation
Lunch time	Annual ASMR Awards Banquet		
Afternoon	Session A: Forestry: Reclamation and Revegetation	Session B: Mine Hydrology and Erosion Characteristics	Session C2: Characterization of Reclaimed Soils
	Forestry and Wildlife Technical Division Meeting	Water Management Technical Division Meeting	International Tailings Technical Division Meeting
	Land Use Planning and Design Technical Division Meeting	Poster Session: Presenters with their posters during this time	
Evening	Annual Society Dinner: Barbeque in the Park with Entertainment		
Wednesday, June 22			
Morning	Session A: Revegetation: Establishment, Design, and Evaluation	Session B1: Microbiological Studies of Mine Materials	Session C1: Mine Water Monitoring and Treatment
		Session B2: Salinity: Weathering and Movement	
Afternoon	Session A: Revegetation: Establishment, Design, and Evaluation	Session B3: Waste Utilization	Session C2: Treatment of Acid Mine Materials
		Session B4: Development and Reclamation of Disturbed Environments	
Evening	Student Paper Awards and Exhibitor Raffle		
Thursday, June 23			
Morning	Session A: Aquatic Communities: Biology, Chemistry, and Economic Impacts	Session B: Methods and Technologies for Mine Sites and Materials	Session C: Mine Regulations, Remediation, and Economic Applications
Afternoon	National Executive Council Meeting (half day)		
Friday, June 24 and Saturday, June 25			
Two-Day Field Trips	Horseback Riding Tour of Coal Basin	Yampa River Basin, Surface Coal Mine Reclamation Tour	Climax Molybdenum Mine and Upper Arkansas Biosolids Reclamation and Watershed Impacts

Conference Registration Form

American Society of Mining and Reclamation 22nd National Meeting, Breckenridge, Colorado June 18-25, 2005

Conference Registration

	Cost	No.	Total
Regular (access to all sessions and exhibition hall, 4 continental breakfasts, 2 lunches, Awards lunch, 3 receptions, morning and afternoon break refreshments)	$325	____	$______
Late Registration (same as above, after May 31, 2005)	$400	____	$______
Student Registration (certified student member of ASMR)	$200	____	$______
One-day registration	$175/day	____	$______
Spouse/Guest Lunch tickets	$20	____	$______
Society Dinner	$30	____	$______

Workshops

	Member cost (student cost)	No.	Total
Workshop 1: Invasive Weed Issues for Mined Lands	$40 ($25)	____	$______
Workshop 2: Ecological Mine Waste Management	$95 ($95)	____	$______
Workshop 3: Cover Systems for Mine Waste Management	$70 ($70)	____	$______
Workshop 4: Using AMDTreat to Evaluate Mine Drainage Treatment	$50 ($30)	____	$______
Workshop 5: Mine Land Reclamation Utilizing GPS Technology	$40 ($25)	____	$______
Workshop 6: Practical Statistics for Reclamation	$50 ($30)	____	$______
Workshop 7: Stream Restoration	$40 ($40)	____	$______

Field Trips

	Cost	No.	Total
Field Trip 1: Blue River/Snake River water quality improvement projects	$75	____	$______
Field Trip 2: Anglo Gold/Ashanti Cresson Mine:	$60	____	$______
Field Trip 3: Horseback riding tour of coal basin	$340	____	$______
Field Trip 4: Yampa River Basin, surface coal mine reclamation	$200	____	$______
Field Trip 5: Climax Molybdenum Mine and Upper Arkansas biosolids	$200	____	$______

Total registration cost for conference, workshops, field trips, social dinner	TOTAL:______
Credit card processing charge	$5.00
GRAND TOTAL	**TOTAL:______**

[Refund policy: No refunds after May 31.
Prior to May 31 = total registration will be refunded less a $50 fee]

Badge Name: ________________________________

Organization: ________________________________

Mailing address: ________________________________

City/State: ________________________________

Phone: ________________ Fax: ________________

Email: ________________________________

Method of Payment

☐ Check made to ASMR (attached)

☐ Purchase order (attached)

Credit card: Only Visa ☐ or Master Card ☐

Card number ________________________________

Exp. Date ________________________________

Card Holder Name
(print please): ________________________________

Please mail this form with check or purchase order to Ms. Karen Escobar, Department of Geography and Environmental Sciences, University of Denver, 2050 East Iliff Ave. Denver, Colorado 80208
Questions about registration: call Karen Escobar at (303) 871-2513 or Terry Toy at (303) 871-2667.

BY J. STEVEN RAUGUST AND VIRGINIA T. MCLEMORE, SUPERVISING ENGINEERING GEOLOGIST, MWH, TEMPE, ARIZONA; AND SENIOR ECONOMIC GEOLOGIST, NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES, SOCORRO, NEW MEXICO.

The Natural Defenses of Copper Flat Sierra County, New Mexico

Introduction

Purpose of the Copper Flat Investigation

The purpose of this investigation was to compile and assess the existing ground- and surface-water quality in the vicinity of an existing mine pit lake, waste rock piles and mine tailings impoundment at Copper Flat, Hillsboro district, New Mexico, 23 miles southwest of Truth of Consequences and five miles northeast of Hillsboro. Data from existing historical reports and documents were reviewed, interpreted, and integrated. Raugust (2003) summarized the potential for environmental impacts of the mine pit lake, waste rock piles and tailings impoundment based on existing conditions. This paper focuses only on the mine pit lake. Water quality data associated with this research have been incorporated into an electronic format that will become part of the New Mexico Mines Database (McLemore et al., 2003).

Geology

The predominant geologic feature of the Hillsboro district is the Cretaceous Copper Flat strato-volcano. This structure is eroded to a topographic low and is approximately four miles in diameter (Hedlund, 1985).

The core of the volcanic complex is intruded by a quartz monzonite stock, the Copper Flat Quartz Monzonite (CFQM). This stock has a surface expression of approximately 0.4 square miles and has been dated by the argon-argon ($^{40}Ar/^{39}Ar$) techniques to be 74.93 +/- 0.66 million years old (McLemore et al., 2000). The surrounding andesites also have been dated using argon-argon techniques to be 75.4 +/- 3.5 million years old (McLemore et al., 2000). At least 34 dikes radiate out from the quartz monzonite intrusion.

The Copper Flat porphyry copper deposit is one of the older Laramide porphyry copper deposits in the Arizona-

Picture 1: View of the Copper Flat Mine, New Mexico in 1982 (Hydro Resources, 2002). Tailings and mill are in the foreground, with the pit in the background.

Sonora-New Mexico porphyry copper belt and is characterized by low-grade hypogene mineralization that is concentrated within a breccia pipe in the CFQM stock.

The CFQM is a medium to coarse-grained, holocrystalline, porphyritic intrusion that consists of potassium feldspar, plagioclase, hornblende, biotite and trace amounts of magnetite, apatite, zircon and rutile, with local concentrations of pyrite, chalcopyrite, and molybdenite (McLemore et al., 2000). Current proven and probable reserves are 50,210,000 tons of ore containing 0.45 percent copper (Hydro Resources, 2002).

History of Hillsboro Mining District

Ore was first discovered in the Hillsboro district in April 1877 along one of the veins that extend southwest of the Copper Flat stock (Jones, 1904; Dunn, 1982). Several exploration activities occurred at Copper Flat between 1952 and 1982 (Raugust, 2003). In 1982, the Copper Flat Partnership, Ltd. with Quintana Minerals Corporation (QMC) as the mine operator, developed and operated an open pit copper mine, including a 15,000-ton-per-day flotation mill and a tailings impoundment, at the Copper Flat site. The mine operated for three months before it ceased operation due to unfavorable economic conditions. During three months of operation, the mine produced 7.4 million pounds of copper, 2,306 ounces of gold, and 55,966 ounces of silver (Hedlund, 1985). The plant was placed on a "care and maintenance" status until 1986 when the facilities were sold and dismantled. The mining leases were returned to Inspiration and the site was partially reclaimed. Picture 1 is an aerial photo from 1982.

Gold Express Corporation of Denver, Colorado acquired the property in 1991 and prepared a draft environmental assessment. In 1993, the Bureau of Land Management (BLM) notified Gold Express that an environmental impact statement (EIS) would be required due to concerns related to water resource issues (BLM, 1999).

In 1994, the Alta Gold Company of Henderson, Nevada acquired the Copper Flat Project from Gold Express. Alta Gold and consultant, ENSR of Fort Collins, Colorado prepared a final draft EIS in 1999. The EIS was never released because Alta Gold declared bankruptcy in 1999 (BLM, 1999). Hydro Resources, Inc. of Albuquerque, New Mexico now owns the property (Hydro Resources, 2002).

Study Area Investigations

Surface Features

Surface features of the Copper Flat mine area include a mine pit lake, rock storage piles, the former mine and mill areas, and a tailings impoundment area. Land disturbed by the Copper Flat mine includes 358 acres of public land managed by the BLM and 331 acres of private lands. The pit and the pit lake

Ore was first discovered in the Hillsboro district in April 1877 along one of the veins that extend southwest of the Copper Flat stock (Jones, 1904; Dunn, 1982).

compose an area of approximately 12.8 acres, with a depth of approximately 40 ft. The elevation of the pit bottom in 1986 was 5,380 ft. The surface water elevation in 1999 was 5,420 ft (BLM, 1999). The existing overburden waste rock piles have been identified as the north, west, south and east (SRK, July 1998).

Mine Pit Lake Investigations

The water chemistry of the waters of the mine pit lake is influenced by: surface water discharge to the pit, occurring almost exclusively during heavy rain, geochemistry of the pit wall rock and surrounding rock storage piles, and groundwater recharge.

Mine Pit Lake and Grayback Gulch Surface Water

The pit lake has been sampled 65 times between 1989 and 1998 (BLM, 1999; Bakkom and Salvas, 1997) (Table 1). Samples were collected at various locations and depths. Typically, the samples were analyzed for pH, major cations and anions, and metals. Sample analytical suites varied and sometimes the samples were filtered and sometimes not.

Table 1. Pit lake water sample collection summary (BLM, 1999; Bakkom and Salvas, 1997).

Investigator	Number of Samples	Sampling Time Interval
New Mexico Environmental Improvement Board (NMEIB)	2	April 3, 1989
Gold Express	16	February 11, 1991- March 17, 1997
Alta Gold	31	May 24, 1994- October 1, 1997
Balkkom and Salvas	16	November 15, 1996 and October 8, 1997

There are several unnamed springs and seeps in the area west of the pit in the Animas Hills and along Grayback Gulch. As observed by Newcomer et al. (1993), these springs and seeps were flowing in March, but dry by early May and are therefore ephemeral. The springs west of the pit drain into the bowl-shaped Copper Flat area (Newcomer et al., 1993). In 1993, attempts were made to measure the discharge of these springs and seeps. Where possible, the flows were measured with a 60-degree, V-notch weir or estimated (Newcomer et al., 1993). Seeps and springs sampled by Newcomer et al (1993) are named SWQ-1, SWQ-2, SWQ-3, BG, BG-2, and Warm Spring, and a seep denoted as acid drainage. This seep appears to have been an intermittent seep slowly discharging from a rock storage pile.

Surface-water samples were first collected from Grayback Gulch in 1977, prior to the mining activities of QMC (BLM, 1978). These surface water samples appear to have been collected quarterly during 1976 and 1977, and sample locations are identified as Station A, where the creek enters the QMC property; Station B, approximately 300 feet east of the present mine pit rim; and Station C, where the creek leaves the QMC property (BLM, 1978).

In August of 1997, Alta Gold's consultant, Steffen, Robertson, and Kirsten (SRK), observed and sampled seeps in the pit wall at locations PW-1 and PW-2. Also in August of 1997, SRK observed and sampled a seep from the toe of the West rock storage pile. These were the first recorded seeps in four years of site study by SRK (SRK, Dec., 1997, and July, 1998).

Mine Pit Lake and Groundwater

Prior to 1996, only one well was available for sampling groundwater in the vicinity of the pit lake. This monitoring well, GWQ-4, is located approximately one-half mile east of the existing pit. SRK drilled two new monitoring wells, each with dual completion, in 1996. Monitoring well GWQ96-22 was drilled up-gradient of the mine pit and well GWQ96-23 was drilled down-gradient. GWQ96-22A is the shallow completion and GWQ96-22B is the deep completion of the GWQ96-22 well cluster. GWQ96-23A is the shallow completion and GWQ96-23B is the deep completion of the GWQ96-23 well cluster (SRK, Dec., 1997). Table 2 presents a summary of the sampling activities of GWQ96-22 and GWQ96-23 wells.

Results

Surface Water Quality, Mine Pit Lake

The water quality of the pit lake does not exceed New Mexico Water Quality Control Commission (NMWQCC) surface water numeric standards for livestock and wildlife as of 1998 (NMWQCC, 2001). Historically, only copper concentrations exceeded the NMWQCC numeric standard of 0.5 mg/L. The most recent surface water sample to exceed this standard was collected in February 1993, with a concentration of 2.6 mg/L.

Since 1994, pH measurements have consistently remained neutral to alkaline. Copper has not exceeded the numeric standard for livestock and wildlife since 1993. Although sulfate and TDS are gradually increasing over time, there are no numeric surface water quality standards for these parameters. The drop in the elevation of the surface of the lake in recent years (about 10 ft from 1993 to 1997) may explain the increase in TDS, which has caused the increased concentration of salts in the pit lake (SRK, Dec. 1997).

Analysis of the anions and cations from pit water sample data collected on April 3, 1989, September 21, 1995, and July 21, 1998 indicate that even though the water quality is poor, the pit water does not exceed any livestock or wildlife standards. The pit water has consistently high contents of calcium, chloride, and sulfate relative to surface water in Greyback Gulch and local groundwater.

Table 2. GWQ96-22 and GWQ96-23 groundwater sample collection summary (BLM, 1999).

Investigator	Monitoring Well	Number of Samples	Sampling Time Interval
Alta Gold	GWQ96-22A	16	July 13, 1996-October 15, 1998
Alta Gold	GWQ96-22B	2	July 13, 1996 and February 5, 1997
Alta Gold	GWQ96-23A	16	July 14, 1996-October 15, 1998
Alta Gold	GWQ96-23B	4	July 14, 1996-April 1, 1997

The surface water chemistry found in the lake can be explained by:

- The inflow of neutral to alkaline groundwater has relatively low concentrations of TDS and sulfate (SRK, Dec. 1997).
- The composition of the host rock is acid-buffering. The composition of the host rocks includes approximately five percent calcite, 30 percent feldspar, and one percent other carbonates. The dissolution of the calcite in the host rocks and the precipitation of gypsum and geothite around the pit lake indicate that acid buffering is occurring (SRK, Dec. 1997).
- The typical volume of disseminated pyrite in the rocks surrounding the pit lake is one to five percent. The pyrite is disseminated throughout the groundmass of the host rock limiting access of water and air to allow oxidation. In addition the pyrite is coarse-grained, which limits the surface area, when it is exposed to oxidation (SRK, Dec. 1997).
- Low precipitation in the area is probably the most important reason for the relatively good quality of the pit lake surface water with respect to pH and concentration of metals. Low precipitation limits the flushing of oxidized products into the environment via runoff, seep, and discharges (Chavez, 2003).

The net effect is that while sulfide oxidation is occurring, the transport of the oxidation products is slow, except locally in the Copper Flat area.

Surface Water Quality, Greyback Gulch and Local Seeps

Surface water samples collected from locations along the ephemeral Greyback Gulch, SWQ-1, SWQ-2, and SWQ-3 indicate higher quality runoff upstream of the mine site (SWQ-1) than downstream (SWQ-2 and SWQ-3). Although pH measurements remain neutral to alkaline in samples collected from both upstream and downstream location, TDS and sulfate concentrations are greater downstream and have increased over time. In SWQ-2, downstream of the mine pit, nitrate has exceeded domestic use NMWQCC numeric standard (10 mg/L) four times from 1981 to 1998, with a maximum nitrate concentration of 14.5 mg/L. No numeric standard for livestock or wildlife has ever been exceeded in samples from these three locations.

The downstream surface water in Greyback Gulch has higher proportions of calcium, chloride, and sulfate than upstream surface water for one set of data collected from SWQ-1, SWQ-2, and SWQ-3 in March/April 1993. The upstream surface water has a higher proportion of bicarbonate. This may indicate that some of the alkalinity upstream is being consumed by acid via neutralization as surface water moves over and through the Copper Flat ore body.

Possible reasons for the lower surface water quality in the downstream sample locations in Greyback Gulch are:

- evaporative concentration of dissolved load of anions and cations;
- gypsum dissolution, which is regionally widespread;
- water-mineral interactions within the copper-porphyry deposit; and
- disturbance from the construction of roads and rock storage piles and stream diversion (SRK, Dec. 1997).

Water in the pit lake does not exceed New Mexico Water Control Commission (NMWACC) surface water numeric standards for livestock and wildlife as of 1998 (NMWACC, 2001).

There have been a few intermittent seeps from the pit wall and rock storage piles. Typically, these seeps do not flow except following heavy precipitation. When they do flow, they are typically acidic and have high concentrations of anions, cations and metals. Historically, seeps have been identified on the southern wall of the mine pit (PW-1 and PW-2) and from the East and West waste rock piles. Typically, surface water from these seeps are characterized with pH concentrations of 2 to 3, except PW-2 with a pH of 8.16, high TDS concentrations of 5,000 to 25,000 mg/L, and high sulfate concentrations of 3,000 to 22,000 mg/L. Concentrations of surface water from these seeps have exceeded NMWQCC surface water livestock and wildlife numeric standards for aluminum, cadmium, copper, cobalt, selenium, and zinc.

Ground Water Quality

The pH measurements both up- and down-gradient range from approximately 7 to 8.2. TDS is less than the NMWQCC numeric groundwater standard of 1,000 mg/L NMWQCC, 1995). However, the TDS concentration of the groundwater down-gradient of the mine pit is increasing gradually over time and approaching the numeric standard. Sulfate concentrations also are lower than the NMWQCC numeric groundwater standard of 600 mg/L; however, the sulfate concentrations in the down-gradient well are increasing with time.

An appropriate conceptual model of the Copper Flat mine pit lake is that of a local hydraulic sink. Historical sampling of well GWQ-5, further to the east, indicate that water quality in the vicinity may have been affected naturally by the presence of the ore body prior to mining in 1982 (BLM, 1999). Concentrations of sulfate sampled in 1981 by SHB from GWQ-5 range from 477 mg/L to 575 mg/L, which is higher than the sulfate concentrations in well GWQ-96-23A immediately down-gradient of the pit (<450 mg/L). Concentrations of TDS also sampled in 1981 by SHB from GWQ-5 range from 1,070 mg/L to 1,260 mg/L, which is higher than the TDS concentrations in the well GWQ-96-23A (<1,000 mg/L).

The groundwater up-gradient of the mine pit (well GWQ-96-22A and B) is high quality with relatively high proportions of chloride and sulfate. Groundwater down-gradient of the pit (GWQ-96-23A and B) shows relatively higher proportions of bicarbonate and calcium, and relatively lower proportions of sulfates. Pre-Quintana mining (June 15, 1981) groundwater data collected from down-gradient wells GWQ-5 and GWQ-6 show similar anions and cation distributions to post Quintana mining activities (1996 and 1998). This indicates that groundwater quality down-gradient of the ore body reflects the natural weathering of the Copper Flat porphyry system.

Recommendations

Mine Pit Lake

The mine pit lake appears to be geochemically stable under existing conditions. Presently, the surface water appears to be fit for livestock and wildlife. Although the surface water does not exceed NMWQCC domestic or irrigation standards, it is not recommended for that use because of occasional geochemical variability from irregular, heavy precipitation. Such heavy precipitation and water level fluctuation does affect the chemistry of pit lake water; therefore, periodic monitoring of water quality is reasonable, especially because it is currently a source of water for livestock and wildlife.

Surface Water Quality

The surface water quality in Greyback Gulch does not exceed any NMWQCC numeric standards. However, nitrate has been exceeded in the past at location SWQ-2. The quality of the surface water is lower downstream of the mine pit. However, the contributing factors to the water quality degradation is probably from naturally occurring processes such as evaporation and exposure to the copper porphyry ore body. Certain re-contouring, re-vegetation, and soil amendments might improve the surface water quality in downstream reaches, but such actions are difficult to justify considering the current land use of cattle grazing and potential mineral development.

Low water quality seeps only occur during times of high precipitation. Although infiltration of rainwater might be arrested by significant restoration program of re-contouring, re-vegetation, and soil amendments, most of the documented seeps drain into the bowl-shaped mine pit lake.

Groundwater

Groundwater quality down-gradient of the mine pit has deteriorated with respect to sulfate and TDS from 1996 to 1998. However, more time-based sampling data would be required to ascertain whether this is a real trend or transient phenomenon. Annual monitoring of wells GWQ-96-22A, GWQ-96-22B, GWQ-96-23A, GWQ-96-23B, GWQ-5 and GWQ-6 would be very useful in establishing groundwater quality trends over time. It appears from the existing data that the ore body is likely the most significant contributor to water quality down-gradient of the pit, and that additional data would be useful in evaluating this hypothesis. ■

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BY BEN B. FAULKNER, FRANKLIN MILLER, FRANK RUSSELL, AND KEN FAULK

The Copper Basin Tennessee Reclamation Project

Picture 1: Location of the Copper Basin near Copperhill, Tennessee.

Picture 2: US Highway 64 crossed through the Copper Basin showing the barren landscape.

Most individuals involved with mine reclamation have heard of the Copper Basin in Tennessee, which is located at the point where Georgia, Tennessee, and North Carolina meet (picture 1). At one time, it was considered to be the largest manmade biological desert in the nation. Fifty square miles of barren, eroded landscape, visible from outer space, could not escape the attention of even the most unobservant driver between Atlanta and Knoxville (picture 2). Hillsides were originally timbered to obtain fuel for open roasting of copper ore beginning in the mid 1840s and mining at the site has continued for more than a century. With sparse or no vegetative cover, runoff water eroded massive quantities of silt to the Ocoee River. Bright orange streams conveyed acidity and metals from the largest shaft metal mines east of the Mississippi. Abandoned and collapsing mine works and other deteriorating facilities and waste piles posed significant physical hazards. Today, one must pay closer attention to see mining remnants as they drive by Ducktown, TN (picture 3). Reforestation efforts led by industry assisted by government agencies and academic institutions that began in the 1920s have turned most of the former moonscape into just another drive in the forested countryside of the Smoky Mountains. Some 16 million trees (mostly pine) have eased the visual impact from US 64, and there is hope that the quality of the two affected watersheds, North Potato Creek and Davis Mill Creek will continue to improve.

This dramatic change is a result of the years of cleanup effort by the mining and chemical companies operating in the Basin and the natural attenuation that only time can provide. In the last few years, the Copper Basin has been the site of one of the largest and most complex land reclamation and water quality projects in the country. Both the Tennessee Department of Environment and Conservation and USEPA Region IV sought a solution to the problems at the site with Glenn Springs Holdings (a subsidiary of Occidental Petroleum) while avoiding Superfund National Priority List status. An unprecedented cooperative agreement led to the area being designated as a Superfund Alternative site. This allowed huge cost savings as the voluntary agreement focused on a phased remedial plan to stop the flow of contaminants to the Ocoee River and restore biological integrity to the North Potato Creek watershed.

Erosion presented in historic photographs of the Copper Basin rivals even the most dramatically abandoned surface mines, but mining, begun in 1843, was conducted solely by underground methods as the ore bodies were narrow and deep. Trees were cut and used to fuel open-pit smelting of the raw ore, which was burned slowly in large heaps for two to three months to lower its sulfur content. The escaping smoke and other steps in the smelting operation released sulfur dioxide into the air. Soon the area's vegetation was either removed for fuel or killed by fumes. This, combined with steep terrain and high annual rainfall, created severe

Picture 3: Denuded landscape in a 1973 photo compared to the same location in a 1996 photo.

Picture 4: The vegetation in the area was removed by timbering and was killed due to sulfur dioxides from smelting of copper ore, both of which lead to severe erosion.

erosion (picture 4). Sulfuric acid production replaced mining as the prominent industrial activity in the 1980s.

In the early 1970s, North Potato Creek was diverted through a 3,000-foot tunnel to Davis Mill Creek, and the first open pit surface mining was conducted within an abandoned reach of North Potato Creek. The 20-acre final pit was left open to provide a sediment trap to protect the Ocoee River as North Potato Creek was restored to its original alignment. Sediment loads for the basin had been so high that planners expected the 200-foot-deep pit to fill with sediment in a few years, but the successful reforestation effort has curbed erosion to the extent that the pit will remain viable for many more years to clarify the water from the 15-square-mile watershed. It will also be used as a clarifier and final repository for metal precipitates produced as a new water treatment plant treats up to 972 cfs (436,000 gpm) expected in a 10-yr, 24-hr storm in the watershed (picture 5). The lime plant will employ a novel approach drawing highly acidic and metal laden water from deep in the stratified pit to accelerate the neutralization reactions of the mildly acidic and low metal content of the creek flow, resulting in formation of metal precipitates.

The agreement with EPA required Glenn Springs to conduct a study to determine the appropriate remedial action to alleviate contaminant discharge from North Potato Creek into the Ocoee River. As part of the study, a streamlined risk assessment based on human health screening values determined that current conditions posed no human health risk. Consequently, ecological impacts were the principal focus of the study. Chronic and acute ecological screening values were used to determine that metals (namely aluminum, cadmium, cobalt, copper, iron, manganese, lead, and zinc) were the contaminants of potential ecological concern.

In the past few years, Glenn Springs Holdings has accomplished many objectives that move the Copper Basin Project toward the ultimate objective of eliminating health and safety risks, protecting the Ocoee River, and restoring biointegrity in North Potato Creek:

Safety

- More than five miles of acid resistant chain-link fence have been installed to limit access to the mine collapses. Time Domain Reflectometry technology is used to monitor for additional subsidence.
- Less prominent mine collapses have been stabilized with clean fill.

Picture 5: One of the largest lime treatment plants has been installed at the Copper Basin site.

Picture 6: A pipeline of 3,000 feet made up of 63-inch diameter pipe was a construction challenge.

Water Quality

- North Potato Creek and Davis Mill Creek were adding enough metals to the Ocoee River to make two automobiles every day. Refurbishing a lime AMD plant in one watershed and constructing a new plant in the other (perhaps the world's largest capacity) has reduced this load to nearly zero.
- The load in the most dramatically affected watershed, (five-square mile Davis Mill Creek) has been reduced by diverting the flow from the upper 3.5 square miles of the watershed through 3000 feet of the world's largest diameter (63 inches) polyethylene pipe (picture 6).
- PCBs and lead have been contained by removal and capping of affected areas
- A demonstration passive treatment system continues to remedy the 300+ gpm flow in McPherson Branch after six years of operation. A constructed stream segment provides suitable habitat for the alkaline, metal free effluent to support benthic macroinvertebrates (picture 7).
- Mine wastes and their hydraulic influence in dumps and along the transportation corridors have been characterized by methods including x-ray diffraction, acid-base accounting and interstitial pore analysis. A first phase effort to dispose of much of the mine waste in a major mine collapse is proposed.
- The flooded acidic deep mines have been continuously pumped and chemically treated to prevent gravity discharges to the streams.
- The Ocoee River has exhibited remarkable visible improvement as seen at the Olympic Whitewater Center (picture 8).
- Annual biosurveys that compare the recovering reaches and tributaries against a reference section upstream of mining activities serve as another measure of performance of remedial efforts.

Revegetation

More than 300 acres of barren tailings flats, a major source of wind erosion, have been successfully revegetated and planted with over 80,000 trees. Research has been conducted by the University of Tennessee and Tennessee Wildlife Resources Agency.

Preserving History, Ensuring The Future

- Glenn Springs has partnered with the Copper Basin High School and other Basin schools, offering resources and speakers for its ecology and science classes and provides a full college scholarship each year.
- The company has also partnered with the Ducktown Basin Museum to help preserve the historic past of the Copper Basin. Former mining engineers and the museum curator assist in archiving valuable mining structures, records and artifacts, all visible at the museum and which overlooks a purposely unreclaimed portion of the basin.
- Future-use improvements are designed to provide an economic and recreational asset for the Ducktown/Copperhill region and the state of Tennessee. The improvements would encourage cultural, historic, and environmental tourism through enhancements of historic mining features, and would be important to the region's economy. Plans within the next 10 years include expanding the Ducktown Copper Basin Museum as the center of walking/bicycle trails that connect with local and regional trail systems, interpretive trails and outdoor classrooms designed to educate the visitor about mining operations, post-mining land stewardship practices, and the natural history of the area. ■

Picture 7: The McPherson roast yard is now a passive treatment system. In addition to neutralizing the stream, the wetland liner prevents infiltration of mine wastes beneath.

Picture 8: The Ocoee River has exhibited a dramatic change in appearance.

In the last few years, the Copper Basin has been the site of one of the largest and most complex land reclamation and water quality projects in the country.

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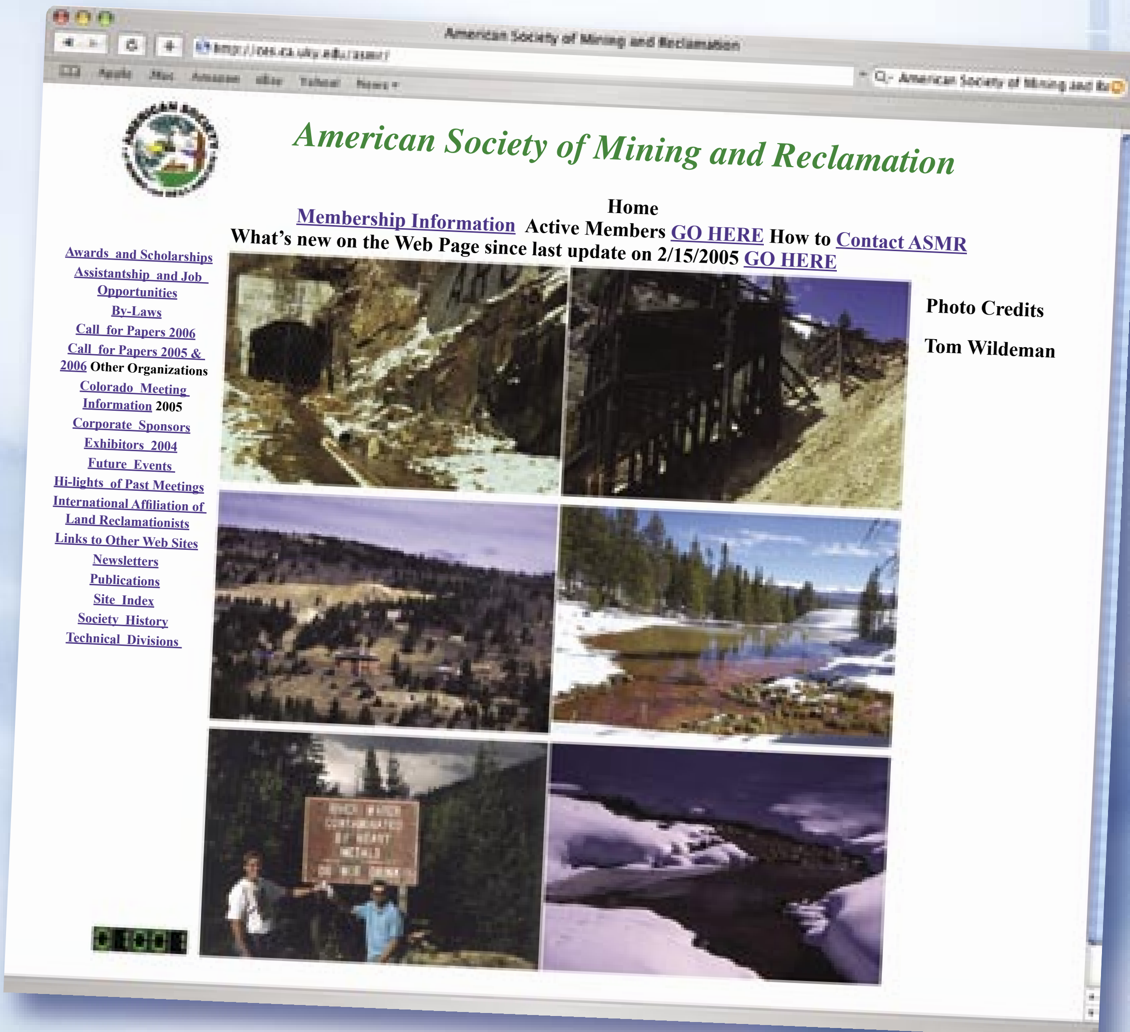

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