Compiled abstracts (Arranged in Alphabetical Order)

Technical Sessions: Monday, June 8, 2015			
	Soils and Overburden Reclamation in Arid or Semi-Arid Environments Moderator, Zenah Orndorff Room 1, Session 1	**Water Management Sulfate Removal Moderator, Bryan Page Room 3, Session 2**	**Forestry — FRA Moderator, Carl Zipper Room 4, Session 3**
2:00 – 2:30	Defining Restoration Success in Wyoming's Natural Gas Fields: Suggestions for Using Reference Sites and Ecological Site Descriptions **by Michael Curran (Student),** and P.D. Stahl	Sulfate Removal from Coal Mine Water in Western PA: Regulatory Requirements, Design, and Performance: Part 1 **by William J. Walker,** Jorge Montoy, and Tyler Chatriand	FRA Step 1-Create A Suitable Growth Medium **by Jeff Skousen**
2:30 – 3:00	Construction and Testing of a Low Permeability Barrier Using Weathered Mine Spoil **by Sarah Smith (Student)** Carmen Agouridis, and Richard Warner	Sulfate Removal from Coal Mine Water in Western PA: Regulatory Requirements, Design, and Performance: Part 2 **by William J. Walker,** Jorge Montoy and Tyler Chatriand	FRA Step 2-Placement of the Growth Medium **by Scott Eggerud**
3:30 – 4:00	Sand Capillary Barriers Increase Water Retention and Facilitate Salt Leaching in Arid Disturbed Lands **by Seth Cude (Student),** Jay B. Norton, Thijs Kelleners, Mark D. Ankeny, and Calvin F. Strom	Biotic and Abiotic Treatment Methods for Remediation of Low Sulfate and Hard Rock Mining-Influenced Water **by Nathan Smith,** N.R. Anton, D.J. Reisman, K.S. Whiting, A.K. Frandsen, K. Saller, M.J. Fischer, and R.L. Olsen	FRA Step 3-Use Compatible Ground Covers **by Jennifer Franklin**
4:00 – 4:30	Evaluation of Appalachian Mine Spoil Leachate Chemistry and Its Associated Geochemical Influences **by Elyse Clark (Student),** W.L. Daniels, Z. Orndorff, C.E. Zipper, and K. Eriksson	Evaluating the Impact of Na-SO_4^{2-} Dominated Ionic Strength on Trace Metal Removal in Vertical Flow Bioreactors **by Julie LaBar (Student)**	FRA Step 4-Tree Species Selection **by Ron Rathfon**
4:30 – 5:00	So Where IS that Treatment Sludge Going in the Waste Rock? **by Michele Coleman,** K.E. Butler, E. Mott, T. Al, and K.D. Phinney	Iron Oxide Accumulation Profiling Within the Initial Oxidation Unit of a Passive Treatment System **by Leah R. Oxenford (Student)**	FRA Step 5-Proper Tree Planting Techniques **by Chris Miller**
5:00 – 5:30	**Soils and Overburden, Geotechnical Engineering, Land Use Planning and Tailings Technical Division Business Meeting Michele Coleman, Moderator**	Passive Water Treatment of Iron, Arsenic, and Manganese at the Empire Mine State Historic Park in Grass Valley, California **by Neal Gallagher,** T.L. Rutkowski, S. Lofholm, D. Ernst, and D. Millsap	Legacy Mine Reforestation **by Michael French**

Wednesday, June 10, 2015			
	Forestry – Wildlife **Moderator, Steve Felch** **Room 1, Session 4**	**Federal and Energy Issues** **Moderator, Joe Friedlander** **Room 3, Session 5**	**Water Management** **Moderator, Leah R. Oxenford** **Room 4, Session 6**
8:30 – 9:00	Successful Reclamation of Kentucky Minelands Using Wildlife-Friendly Mixes **by D.L. Baxley**, J.M. Yeiser, B.A. Robinson, J.J. Morgan, J.N. Stewart, and J.O. Barnard	Appalachian Coal Mining Related Research at US EPA **by Brian Topping**	Recovery of North Potato Creek, Copper Basin, Tennessee **by Ben B. Faulkner** and K.S. Deal
9:00 – 9:30	Bird Diversity and Abundance on Reclaimed Surface Coal Mines in Alabama: Temporal and Habitat Related Variations **by Richard R. Borthwick** and Y. Wang	Coal Combustion By-Products and SMCRA Coal Mines: The Case For and Against New Federal Rules **by Kimery C. Vories**	Case Study: 20 Years of ARD Mitigation After a Bactericide Application **by James Gusek** and V. Plocus
9:30 – 10:00	Validation of a Stream and Riparian Habitat Assessment Protocol Using Stream Salamanders in the Southwest Virginia Coalfields **by Sara Sweeten (Student)** and W.M. Ford	Federal Energy Regulatory Commission Licensing For Microhydropower Utilizing Mine Drainage **by Tim Danehy,** Cody 'Buck' Neely, S.L. Busler, C.F. Denholm, D.A. Guy, and M.H. Dunn	Assessment of Performance of a Passive Treatment System Over a Twenty Year Period in East Central Tennessee **by Terry W. Schmidt** and K. Milmine
	Forestry – Wildlife (Continued) **Room 1, Session 4**	**Bat Symposium** **Craig Walker, Moderator** **Room 3, Session 7**	**Water Management (Continued)** **Room 4, Session 6**
10:30 – 11:00	Genetic Diversity of Brook Trout (*Salvelinus fontinalis*) Populations Isolated Due to Abandoned Mine Drainage in the West Branch Susquehanna River Watershed, PA **by Frederic J. Brenner** and Shawn M. Rummel	Bat News: The U.S. Fish and Wildlife Perspective **by Carrie Allison** M.P. Armstrong and A. King	Biogeochemical Analysis of Spent Media from a Vertical Flow Treatment Pond **by N. Shepherd,** R. Nairn, M. Dunn, C. Denholm, C. Neely, and T. Danehy
11:00 – 11:30	American Elm as a Tool in Mineland Reforestation **by Mary Beth Adams** and P. Angel	Update on Bat Survey Guidelines **by Andy King**, FWS	Replacing an Active AMD Treatment System with Semi-Passive Techniques **by Tyler Chatriand** and William Walker
11:30 - noon	Shortleaf Pine as a Reclamation Species on Former Mining Sites **by J. Holly Campbell**	Update on White Nose Syndrome **by Mike Armstrong**, FWS	Evaluation and Restoration of Passive Treatment System Performance in Pennsylvania **by Ryan M. Mahony,** D.A. Guy, C.F. Denholm, T.P. Danehy, C.A. Neely, S.L. Busler, and M.H. Dunn
	Ecology **Moderator, Michael Curran** **Room 1, Session 8**	**Bat Symposium (Continued)** **Room 3, Session 7**	**Water Management (Continued)** **Moderator, Julie LaBar** **Room 4, Session 9**
1:00 – 1:30	Suggestions for Improvements to Restoration Monitoring **by Michael Curran (Student),** and P.D. Stahl	Brandenbark™: Mitigation Tool for Projects Involving Federally Listed Bark Roosting Bats **by Josh Adams,** Piper Roby, Price Sewell, Jeffrey Schwierjohann, Mark Gumbert, and Michael Brandenburg	Influence of Water Chemistry and Sediment Transport on Biological Recovery Downstream of Lime Dosers **by Henry Legwaila (Student)** and Natalie Kruse

1:30 – 2:00	Benthic Algae, Leaf Breakdown, and Litter Fall in Constructed Streams: The Case for Riparian Reforestation to Replicate Headwater Organic Matter Functions **by Robert J. Krenz III (Student),** S.H. Schoenholtz, and C.E. Zipper	Northern Long-eared Bat (*Myotis septentrionalis*) Management: Insights from a Multi-year Study at Fort Knox, Kentucky **by Alexander Silvis,** W. Mark Ford, and Eric R. Britzke	Total Dissolved Solids and Biotic Condition in Central Appalachian Headwater Streams Influenced by Coal Mining **by Anthony J. Timpano (Student),** Beth Boehme, Stephen H. Schoenholtz, David J. Soucek, and Carl E. Zipper
2:00 – 2:30	Development of Ecosystem Structure and Function on Reforested Surface-Mined Lands **by Brian D. Strahm**, B.N. Avera, J.A. Burger, and C.E. Zipper	Bat Use of Culverted Gates at Abandoned Underground Portals in West Virginia **by Craig A. Walker**	Effect of Leaching Scale on Prediction of Total Dissolved Solids Release from Coal Mine Spoils and Refuse **by Lucas C. Ross (Student),** W.L. Daniels, and C.E. Zipper
2:30 – 3:00	Some Lessons from Long Term Monitoring of Forest Rehabilitation at Three Surface Mine Complexes in Australia **by Neil Humphries**	A Shout in the Dark: The (Cold, Dark) Reality of Applying Acoustic Surveys to Determine Occupancy for Bats in the Myotis Species Guild **by Janet Tyburec** and J. Chenger	Quantitative Sampling to Detect Invertebrate Community Change in Mine-Influenced Streams with Elevated TDS **by Damion Drover (Student),** Stephen Schoenholtz, Carl Zipper, Tony Timpano, David Soucek, and Beth Boehme
	Geotechnical Engineering Moderator Ryan Mahony Room 1, Session 10	**Bat Symposium (Continued) Moderator, Beth A. Botsis Room 3, Session 7**	**Water (Continued) Room 4, Session 9**
3:30– 4:00	Zero Slump Grout for Remote Closure of Mine Openings **by Brad S. Petri and Nathan T. Rouse**	State Perspectives on Bat Protection Issues at Mine Sites **by Beth A. Botsis**	Hydrologic Assessment of a Stream Created on Mined Land **by Whitney Blackburn-Lynch (Student),** C. Agouridis, C. Barton, R. Warner, and T. Maupin
4:00– 4:30	Geomorphic Reclamation Design and Construction of the Teach AML Site **by Derrick Thompson** and M.R. Donner	Panel on Bats	Prediction of Acid-Producing Potentials for Coal Overburden and Waste by Static Geochemical Methods **by Louis M. McDonald,** Mingliang Zhang, Jeff Skousen, and Zhenqi Hu
4:30 – 5:00	Slippery Rock Creek Stream Bank Stabilization **by Daniel Guy,** R.M. Mahony, S.L. Busler, T.P. Danehy, C.F. Denholm, C.A. Neely, and M.H. Dunn	Panel on Bats	The Impact of Surface Coal Mining on Water Quality in the Northern Great Plains **by Joseph D. Friedlander**
5:00 – 5:30	McKinley Mine: A Commitment to Stable Land Forms Utilizing Geomorphic Principles **by Scott Motycka and Kyle Kutter**	Panel on Bats	**Water Management Technical Division Business Meeting Gwen Geidel and Louis McDonald, Moderators**

Thursday, June 11, 2015				
	Forestry Moderator, Kenton Sena Room 1, Session 11	**Water Management Moderator, Buck Neely Room 3, Session 12**	**Grasslands Moderator, Cindy Adams Room 4, Session 13**	**Soils Moderator, Mary Beth Adams Belmont Room, Session 14**
8:00 - 8:30	Ecosystem Evolution and Ecological Storage in Opencast Mining Area: A Case Study of Pingshuo Coal Mine in China **by Xiaoran Zhang (Student),** Z.K. Bai, Y.G. Cao, J. Pan, and X. Fan	The Role of Manganese in Trace Metal Removal **by Paul Eger,** James Gusek, Ben B. Faulkner, K. Dieterman, and C. Kairies-Beatty	Invasive Species on Reclaimed Native Grasslands in North Dakota **by Guy A. Welch**	Effects of Quarry Treatment on the Attractiveness of Reclaimed Limestone Quarries **by Israel A. Legwaila,** Eckart Lange, and John Cripps
8:30 - 9:00	Effects of Soil Amendments on the Growth of Hardwood Trees on Reclaimed Mines in West Virginia **by Kara Dallaire (Student),** Jeff Skousen, and Keith O'Dell	Biochemical Reactor/Anaerobic Wetland Design/Startup Issues **by Paul Eger,** Ben B. Faulkner, and James Gusek	Forage Nutritive Value and Productivity of Grass on Reclaimed and Undisturbed Lignite Land **by David J. Lang,** Brandon Shankle, Jeremy Duckworth, Robert Elmore, and Vitalis Temu	Frac Sand Mining and Reclamation in Wisconsin **by Tom Hunt**
9:00 - 9:30	Engaging the Public in Mine Land Reforestation: Volunteer Tree Planting Projects and Events in Appalachia **by Hannah Angel (Student),** C.D. Barton, M. French, and P.N. Angel	Bioremediation of Selenium in Valley Seep Coal Mining Effluents Using Charophytes (Stoneworts) **by Robin W. Scribailo,** Margarete Kalin**,** and William N. Wheeler	Switchgrass and Miscanthus Yields on Reclaimed Surface Mines for Bioenergy Production Capabilities **by Steffany Scagline (Student)**, Jeff Skousen, and Thomas Griggs	Ecological Risk Assessment of Land Destruction in Large Open-pit Coal Mine – Exemplified for AnTaiBao Open-pit Mine, China **by Sun Qi (Student)** Z.K. Bai, M.M. Xie, Y.G. Cao, X. D. Hu, Y.Z. Jisng, and Y.Q. Lu
9:30 - 10:00	Climate Change and Native Forest Establishment on Surface Mines: A Case Study from Eastern Kentucky **by Elizabeth Rose Clark (Student)**, Christopher Barton, and Andrea Drayer	An Innovative Package Treatment System for the Orcutt-Smail Discharges; a Moderate Flow High Strength Acid **by Jonathan M. Dietz** and M. Morosetti		Progress of the Research Project on Reclaiming Subsidence Land with Yellow River Sediments **by Zhenqi Hu**

	Forestry (Continued) Room 1, Session 11	Water (Continued) Room 3, Session 12	New Technologies Moderator, Brenda Schladweiler Room 4, Session 15	Soils (Continued) Belmont Room, Session 14
10:30 - 11:00	Application of the Forest Reclamation Approach to Establish Nothofagus in Chilean Patagonia **by Eduardo Arellano**, James Burger, Patricio Valenzuela, and Gabriel Rodriguez	Cost Saving and Performance Enhancing Modifications at a Lime-Based Treatment System: Rushton Treatment Plant Case Study **by Jonathan M. Dietz** and T.S. Gourley	Comparison of Point Line Intercept and SamplePoint Data Collection Methods for Total Vegetation Cover, Total Ground Cover, and Time Requirements on Reclaimed Sites in Wyoming **by** Clay Wood, Cindy Adams, and **Brenda K. Schladweiler**	Applying of Geomorphic Reclamation to Excess Spoil Fills in West Virginia **by Peter R. Michael**, Leslie C. Hopkinson, Nathan DePriest, and John D. Quaranta
11:00 - 11:30	Productivity and Site Index Data Support the Efficacy of Luminant's Forestry Reforestation Approach in Texas **by Jeremy Stovall**, J.S. Priest, H.M. Williams, D.W. Coble, and B.P. Oswald	Reclamation of Abandoned Mine Land Using Stabilized Flue Gas Desulfurization Material to Mitigate Acid Mine Drainage **by Chin-Min Cheng,** Robert Baker, Tarunjit Butalia, John Massey-Norton, and William Wolfe	Testing Unmanned Aerial Systems for Surface Coal Mine Oversight Inspections **by Natalie Carter**, L.J. Monette, and D.T. Beaman	Managing Closure and Reclamation Liabilities: Closing the Gap – and Improving the Process **by Mike Slight** and H.W.B Lacy
11:30 - 12:00	**Forestry-Wildlife and Ecology Technical Division Business Meeting Jennifer Franklin and Pete Stahl, Moderators**	Impact of Coal Mine Reclamation Using Coal Combustion By-products (CCBs) on Groundwater Quality: Two Case Studies **by Chin-Min Cheng**, Robert Baker, Tarunjit Butalia, John Massey-Norton, and William Wolfe	Case Study: Utilizing In-Situ XRF Field Measurements, Mobile Gamma Radiation Survey Systems and Geostatistical Techniques to Predict Heavy Metals and Radionuclide Soil Concentrations in Surface Soils at an Abandoned Uranium Mine in Custer National Forest, SD **by Aaron S. Orechwa**	Using Nationwide Permit 49 to Obtain Corps Permit for Mining **by Eddie Bearden**

SUCCESS OF BRANDENBARK™, AN ARTIFICIAL ROOST STRUCTURE DESIGNED FOR USE BY INDIANA BATS (*MYOTIS SODALIS*)[1]

Joshua Adams[2], Piper Roby, Price Sewell, Jeffrey Schwierjohann, Mark Gumbert and Michael Brandenburg

Abstract. The federally endangered Indiana bat (*Myotis sodalis*) is a concern for development projects in nearly half of the United States. The species roosts and rears young under exfoliating bark of trees, which has put it at risk for incurring adverse impacts from most projects that require tree clearing throughout its summer range. Project proponents generally incorporate avoidance and minimization strategies into the planning process. These strategies, however, are not always compatible with project goals and objectives, and mitigation is often required to offset adverse impacts to the Indiana bat. BrandenBark™ is an artificial roost structure that mimics the natural roosting habitat of Indiana bats. To date, 69 BrandenBark™ structures have been installed in 6 states (IL, KY, LA, OH, PA, TN and WV). Of these, 59 (86%) structures have been used by 6 species of bats, including northern long-eared bats (proposed for federal listing) and little brown bats (under status review); however, the majority of use (85%) has been by maternity colonies of Indiana bats confirmed by radio telemetry, capture, or genetic analysis of guano. Of the structures used by Indiana bats at Fort Knox Military Installation (n=21) in north-central Kentucky, 120 emergence counts have been conducted with an average of 81.3±7.1 bats per roost. Although the roost area under BrandenBark™ is slightly warmer ($\overline{X}$ = 24.6±7.2°C [SD]) than that of natural bark ($\overline{X}$ = 23.1±6.5°C), the temperature difference between BrandenBark™ and ambient ($\overline{X}$ = 2.1±2.7°C) is less variable than the temperature difference between natural bark and ambient ($\overline{X}$ = 3.9±4.0°C), possibly indicating a more stable thermal environment. However, both roost types are warmer than corresponding ambient temperatures. BrandenBark™ provides instant long-lasting habitat commensurate with natural roosts, is easy to install and monitor, and does not require the purchase of additional land for placement when used as a mitigation option.

Key words: bark roosting bat

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AMERICAN ELM AS A TOOL IN MINELAND REFORESTATION[1]

M.B. Adams[2], and P. Angel

Abstract: To ensure diversity of forests planted on reclaimed minelands, a variety of native tree species should be planted. One species which has been underutilized in mineland reforestation is the American elm (*Ulmus americana*). Due to Dutch elm disease (DED), this wide-spread and much loved tree species is now rare in most landscapes. However there exist some DED- tolerant trees, and research is ongoing to identify survivor trees which may be resistant to the disease. In 2013 and 2014, putatively DED-tolerant seedlings were planted at 14 sites in the Appalachian coal fields from Alabama to Pennsylvania. Elevations ranged from 220 m to more than 900m, and sites included FRA (Forest Reclamation Approach) sites, sites that had previously been reclaimed (1992-2005), and AML (abandoned mine land) and bond forfeiture lands. Seed was produced at a seed orchard in Delaware, OH, and the seedlings were grown at the West Virginia State Tree Nursery at Clements, WV. Survival, diameter and height were measured on 8 of these sites over the first 2 years following establishment.

Survival on most of the sites exceeded 75% with one exception, that being a site with significant browsing by deer and elk. After one year, the average height of the DED-tolerant American elm seedlings was 42.9 cm, and 61.6 cm after 2 years of growth. Average height of the American elm seedlings was nearly identical to that of yellow poplar, another early successional species. Nor were there significant differences between the 2 species in vigor class or survival. The elm seedlings may have experienced slightly less browsing pressure.

Additional Key Words: Restoration, tree species diversity

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2 Mary Beth Adams, Research Soil Scientist, USDA Forest Service, Morgantown, WV 26505. Patrick Angel, Forester/Soil Scientist, US Office of Surface Mining Reclamation and Enforcement, London, KY 30741

EFFECTIVENESS OF 10 PLANT SPECIES IN THE REMOVAL OF SELENIUM FROM SOIL[1]

M. Aldrovandi and J.A. Franklin[2]

Abstract: Selenium (Se), a non-metal element with properties similar to sulfur, is of particular concern to plant and wildlife health when present in higher amounts in the environment, especially in waterways. Seleniferous soils occur naturally in relative abundance in the western and southwestern United States; they are relatively uncommon in the eastern United States. However, the overburden from surface mining of coal in the eastern states may contain significant amounts of selenium in some locations. Research in the western United States has shown that selenium can be significantly reduced in soils by encouraging the growth of certain species of plants, particularly those in the Fabaceae and Asteraceae families, some of which have the ability to accumulate or phytovolatize selenium. Research on bioremediation of selenium using native species of plants has not been performed in the eastern United States. We are currently testing 10 species, under controlled conditions in a greenhouse, for their potential to phytoremediate seleniferous soils. PVC pots, 10 cm in diameter, were filled with minesoil collected from a reclaimed surface coal mine in Tennessee. A solution of sodium selenite was added to each pot to increase Se levels by 5 mg/Kg dry weight of soil. Seeds of several native species in the Fabaceae and Asteraceae families, along with several native and non-native species currently used for mine reclamation in the eastern U.S., were seeded in pots in Jan. 2015. Selenium content of plant tissue and discharge water will be determined after 2-3 months of plant growth. We hope to identify species that can rapidly reduce selenium discharge from mine sites before it ever reaches sediment ponds and subsequently local waterways.

Additional Key Words: phytoremediation, water quality

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Bat News: The U.S. Fish and Wildlife Perspective[1]

C.L. Allison[2], M.P. Armstrong, and A. King

Abstract: The Northern long-eared bat (*Myotis septentrionalis)* (NLEB) is a medium-sized bat found in 38 states, the eastern Canadian provinces, and west to the southern Northwest Territories and eastern British Columbia. Prior to white-nose syndrome (WNS) the species was common in the northeast and Ohio Valley, though more rare in west. As of May 4, 2015, the NLEB is now listed as a threatened species under the Endangered Species Act. Under the Act, a threatened species is likely to become endangered in the foreseeable future. Also effective May 4 is an interim 4(d) rule that provides flexibility to landowners, land managers, government agencies and others as they conduct activities NLEB habitat. Though the primary threat to the species is WNS, given the range of the species and summer and winter habitat preferences, NLEBs are likely to be impacted by coal mining activities and will, therefore, need to be considered during the SMCRA permitting process.

WNS is a disease affecting hibernating bats. Named for the white fungus that appears on the muzzle and other parts of hibernating bats, WNS is associated with extensive mortality of bats in eastern North America. First documented in New York in the winter of 2006-2007, WNS has spread rapidly across the eastern United States and Canada, and the fungus that causes WNS has been detected as far south as Mississippi. Seven bat species, including two endangered species and one threatened species, have been confirmed with white-nose syndrome. The causative fungus, *Pseudogymnoascus destructans* (P.d.), has been found on an additional five species, including one endangered species, without confirmation of the disease. Bats with WNS act strangely during cold winter months, including flying outside in the day and clustering near the entrances of hibernacula (caves and mines where bats hibernate). Bats have been found sick and dying in unprecedented numbers in and around caves and mines. WNS has killed more than 5.7 million bats in eastern North America. In some hibernacula, 90 to 100 percent of bats have died.

The U.S. Fish and Wildlife Service (Service) has also introduced several revisions to the Indiana bat survey guidelines (also used for the NLEB) for the 2015 survey season, including approval of three acoustic I.D programs for presence/probable absence surveys. Because the majority of bat surveys are conducted on behalf of surface mining operations, qualified biologists that survey for bats should be familiar with revisions to the survey guidelines and the conditions of their State and federal permits.

Additional Key Words: northern long-eared bat, survey guidelines, white-nose syndrome

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2 C.L. Allison, M.P. Armstrong, and A. King, U.S. Fish and Wildlife Service

ENGAGING THE PUBLIC IN MINE LAND REFORESTATION: VOLUNTEER TREE PLANTING PROJECTS AND EVENTS IN APPALACHIA[1]

H.Z. Angel[2], C.D. Barton, M. French, and P.N. Angel

Abstract: Created by the Office of Surface Mining Reclamation and Enforcement and the seven state regulatory authorities in Appalachia, the Appalachian Regional Reforestation Initiative (ARRI) re-establishes healthy, productive forest habitat on active mines, abandoned mine lands, and mines that were previously reclaimed to non-forested post-mining land uses in the eastern coal fields. Green Forests Work (GFW) is a nonprofit organization formed out of ARRI as an economic development plan for Appalachia, styled after the Civilian Conservation Corps of the 1930s to restore forest ecosystem services on mine-scarred lands and to create jobs in the process. From 2009 to 2014, ARRI and GFW have partnered with state and federal agencies, watershed groups, coal operators, conservation groups, environmental organizations, faith-based groups, and numerous universities, colleges, and high schools to coordinate 170 tree planting projects/events on mines throughout Appalachia. This work has resulted in the planting of more than 1.2 million trees on nearly 2,000 acres of previously reclaimed mine sites where reforestation was not attempted, or where the results were undesirable. ARRI's and GFW's role in these endeavors is to facilitate communication, provide technical assistance, and to match funding sources with suitable mined land and volunteer groups. The volunteer tree planting events facilitated by ARRI and GFW engaged 534 partner organizations and 9,619 volunteers and participants, who contributed approximately 70,875 volunteer hours. Among the volunteers, a total of 5,220 were 24 years old or under, supporting the Secretary of the United States Department of Interior's Engaging the Next Generation Youth Initiative and the spirit of volunteerism across the United States.

Additional Key Words: Legacy Mines, Forestry Post Mining Land Use, Forestry Reclamation Approach, Office of Surface Mining Reclamation and Enforcement, Surface Mining Control and Reclamation Act.

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APPLICATION OF THE FORESTRY RECLAMATION APPROACH TO ESTABLISH *NOTHOFAGUS* IN CHILEAN PATAGONIA.[1]

Eduardo Arellano[2], James Burger, Patricio Valenzuela, and Gabriel Rodriguez

Abstract: Surface coal mining in the Chilean Patagonian region causes severe forest and grassland disturbance, altering the landscape and affecting sensitive vegetation naturally adapted to growing in extreme site conditions. Previous reclamation experiences focused on establishing grassland using exotic herbaceous species. Restoring the native *Nothofagus* forest has not been successful due to poor reforestation practices that did not consider seedling sensitivity to soil moisture stress and desiccating winds that cause high seedling mortality. The objective of this study was to develop reclamation practices for restoring the *Nothofagus* forest that included top soil removal and placement, ground cover establishment, and tree planting on a new coal mine located in Magallanes Region, Chile. Using the forestry reclamation approach model developed in the Appalachian region of the U. S., we selected suitable top soil material and identified microsite conditions that promote natural forest regeneration. Despite the high landscape variability, natural forest regeneration occurred on microsite conditions where shrubs and native grasses protected the seedlings. Our preliminary results show that a combination of biotic and abiotic factors influence the success of *Nothofagus pumilio* on disturbed sites. The replaced top soil materials were suitable for tree development. The use of shrubs, woody debris, and tree shelters as protection systems improved seedling survival and early growth. When accounting for these eco-physiological and site factors, we have developed a Forestry Reclamation Approach for the Magallanes Region that shows promise of success.

Additional Key Words: Reforestation, tree planting, mined land, Nothofagus forest

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REVIEW OF REFORESTATION EFFORTS OF THE BITUMINOUS DISTRICT FOR ABANDONED MINE LAND RECLAMATION OF PENNSYLVANIA[1]

Dean Baker[2] and Tom Malesky

Abstract: Pennsylvania has completed thousands of acres of abandoned mine reclamation. Post-reclamation land use and erosion control are the two factors that have driven final reclamation stabilization. As part of numerous reclamation projects over the past 25 years, the Department has incorporated tree planting into their final mine reclamation plans.

The Department has realized many successes as well as many failures. By revisiting these sites to monitor survival rates, the Department is able to determine the overall success or failure of its reforestation effort.

For years, final stabilization of reclaimed abandoned mines included an effort to plant heavy grasses for erosion control, usually some variety of a trefoil and fescue mix. These seed mixes worked well for erosion control, but they have limited the survival rate of our tree planting effort.

The main focus of the Department's reclamation efforts has always been to abate hazards. Keeping reclamation costs minimized allowed more hazards to be addressed. Therefore, not much focus was spent on making alternative reclamation efforts such as reforestation a priority.

More recent, the Department's reforestation effort has modernized. Enhancing our hazard abatement effort by redefining our final grading and seeding procedures has led to what we hope is cost-effective reclamation and a better reforestation effort.

With limited resources, it is difficult to sustain ongoing monitoring of completed projects for tree survival rates. However, the Department has taken an interest in its past reforestation effort and with assistance of summer interns, we have started to compile some data that will help us understand to what level of success our past efforts have been in relation to our overall reforestation effort. A PowerPoint presentation of our ongoing efforts to help in the reforestation of reclaimed abandoned mines in the Bituminous coal fields will be presented.

Additional Key Words

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RE-ESTABLISHMENT OF WYOMING BIG SAGEBRUSH USING CONTAINER GROWN SEEDLINGS[1]

D.C. Balthrop[2] and P.D. Stahl

Abstract: Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis) has declined in distribution and abundance over the past 50 years due to ecological and anthropogenic landscape alterations such as wildfire, invasive species, eradication, energy development and agricultural conversion. This decline has resulted in significant amounts of historical Greater Sage-Grouse habitat left unsuitable for the bird's survival requirements and in need of restoration. The typical method of broadcast seeding has proven difficult in areas with already established vegetation, giving the need to implement new restoration techniques. This study attempts to develop an effective method for transplanting Wyoming big sagebrush seedlings propagated from locally adapted seed and soil that will maximize the amount of soil moisture available to them through snow catchment fencing, fabric mulch and seedling planting density. A total of 648 sagebrush seedlings were planted in the spring of 2014 onto a 2-year old burn site using a randomized complete block design. Preliminary results show that the use of polypropylene fabric mulch to eliminate interspecific competition and retain soil moisture significantly increases the production and survival rate of transplanted seedlings. As of October 2014, survival for seedlings with and without fabric mulch was 90.4% and 76.8% respectively, with a three-fold increase in height and width for seedlings planted with the fabric mulch treatment. Management implications for this method include planting shrub islands on burn areas in order to reintroduce a seed source or planting into critical habitat areas where sagebrush has been lost or damaged.

Additional Key Words: restoration, wildlife habitat, sage-grouse, transplanting

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BUR PRODUCTION AND CANKER INCIDENCE ON BACKCROSSED RESTORATION CHESTNUT TREES[1]

J. M. Bauman[2], C. Cochran, J. Chapman, and K.E. Gilland

Abstract: American chestnut (*Castanea dentata* Marsh. Borkh.) is a once-dominant hardwood species with the potential to be a valuable restoration tree for use on surface mined lands in the Appalachian region. Coupling soil-ripping and plow and disking with plantings of American and backcrossed chestnuts have resulted in high seedling survival on a reclaimed surface mine site in southeast Ohio. The objective of this study was to evaluate flowering, chestnut bur production (seed), and natural cankers caused by chestnut blight fungus (*Cryphonectria parasitica*) on three chestnut genotypes after seven field seasons. Pure American (*Castanea dentata*), and two types of *C. dentata* × *C. mollissima* hybrids (BC_2F_1 and BC_3F_1) were documented. When reproduction potential was compared among seed types, there were no differences; all chestnuts trees were flowering and producing chestnut burs after 7 seasons. Soil treatment had no impact on flowering incidence; however, hybrid genetic line had a mild effect. Canker incidence and presence of flowers were not related statistically. When natural canker incidence was compared, pure American chestnut exhibited the most infection ($P < 0.0001$). There were also notable treatment effects, plots that applied the deep ripping had greater disease incidence on pure American chestnuts ($P < 0.0001$). Long-term survival and stand stability will depend on chestnut's tolerance to the blight at an age of fruiting and flowering. Results after seven years suggest that hybrids are exhibiting a decrease in blight incidence and are flowering and producing burs. Employing deep ripping methods to backcrossed American chestnut plantings provide a viable method for hardwood seedling establishment in soils impacted by surface mining.

Additional Key Words: Arrested succession, directed plantings, backcross breeding program, soil subsurface methods, reclaimed mine lands, The American Chestnut Foundation.

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SUCCESSFUL RECLAMATION OF KENTUCKY MINELANDS USING WILDLIFE-FRIENDLY MIXES[1]

D.L. Baxley[2], J.M. Yeiser, B.A. Robinson, J.J. Morgan, J.N. Stewart, and J.O. Barnard

Abstract: Between 1992 and 2012, a projected 6.8% of the Southern Appalachian region was converted from forest habitat to surface coal mineland (US EPA 2005). Despite this period of growth, U.S. coal production in 2012 was more than 7% below the 2011 total, and current market projections for U.S. coal production have become uncertain (U.S. Department of Energy, 2014). With millions of acres coming out of coal production, opportunity exists to optimize reclamation of these areas to benefit wildlife and pollinator populations. Our primary study objective was to assess experimentally the efficacy of hydro seeding wildlife-friendly seed mixes to meet Surface Mining Control and Reclamation Act (SMCRA) bond requirements for fish and wildlife habitat (80% vegetative cover) on Kentucky mine sites. To our knowledge, this is the first study aimed at bridging the scientific gap between subjective and quantitative management recommendations regarding grassland mineland reclamation efforts. We studied mineland re-vegetation success of three different seed mixes (typical, wildlife-friendly, and a hybrid mix) at 27 plots across three sampling sites located in Perry, Knot, and Breathitt Counties, Kentucky. Within five years of establishment, the wildlife-friendly seed mix successfully met SMCRA requirements (mean cover of wildlife-friendly plots = 86.07%, 95% CI [75.94, 96.20]). There is vast potential for implementing native grassland habitat on abandoned and reclaimed minelands in Appalachia. Habitat structure and heterogeneity are vital to maintaining healthy grassland bird and pollinator populations, and converting minelands to diverse, predominately native grasslands has potential to provide these populations with large areas of diverse habitat.

Additional Key Words: Appalachia, coal mining, grasslands, habitat establishment, Kentucky, reclamation

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USING NATIONWIDE PERMIT 49 TO OBTAIN CORPS PERMIT FOR MINING[1]

E. D. Bearden[2]

Abstract: With the 2012 limits placed by the U.S. Army Corps of Engineers on Nationwide Permit (NWP) 21, effectively leading to the demise of using NWP 21 to allow mining impacts to waters of the U.S., most mining companies have begun to use Individual Permits to obtain Corps authorization for waters impacts as new mine areas are proposed. However, another alternative to obtaining an Individual Permit, which has been, used successfully in Oklahoma and Texas is the use of NWP 49 (remining). The NWP 49 is limited to sites that were previously mined for coal, but new mining may be conducted in adjacent areas if the newly mined area is less than 40 percent of the area being remined plus any unmined area needed for reclamation. The permittee must demonstrate a net increase in aquatic resource functions through reclamation activities and, of course, must obtain approval for a SMCRA permit.

Additional Key Words: U.S. Army Corps of Engineers, Nationwide Permit, Remining, Waters of the U.S.

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INFLUENCE OF WATER CHEMISTRY AND SEDIMENT TRANSPORT ON BIOLOGICAL RECOVERY DOWNSTREAM OF LIME DOSERS[1]

Henry Bedu-Mensah[2], and Natalie Kruse

Abstract: Lime doser treatment for acid mine drainage (AMD) is often used in areas with insufficient space for passive treatment systems and in rural areas where more complex treatment systems would be impractical. In the coal-bearing region of southeastern Ohio, four lime dosers are currently in use treating AMD in four watersheds: Monday Creek, Sunday Creek, Raccoon Creek and Leading Creek. The dosers were installed between 2004 and 2012 and varied results have been achieved. In Raccoon Creek, previous studies support the theory that stream geomorphology and natural alkalinity sources in the watershed support recovery of fish and macroinvertebrate communities. In this study, we assessed field parameters (pH, conductivity and temperature) and velocity monthly for 8-11 miles downstream of each doser (distance depending on watershed). Water quality parameters iron, aluminum, manganese and sulphate were also monitored periodically. Downstream reaches field parameters and water quality profile for the dosers were analyzed with multivariate regression and compared to assess differences in biological recovery. The installation of each doser has led to chemical and biological improvement in the downstream reaches; however, the improvement has not been consistent between the watersheds. Average pH of all the downstream reaches met the target of 6.5 units. However, biological targets (12 MAIS score) are met at approximately 2.5, 4.8 and 7.4 miles downstream of the Monday, Raccoon and Sunday Creek dosers respectively. Biological target for Leading Creek is not met at all. Study period pH values range from 6 to 11 for downstream reaches of Raccoon and Monday Creek dosers. Study period downstream doser pH values for Sunday Creek range from 5.2 to 9.7 while that for Leading Creek ranges from 4.7 to 11.3. Preliminary data suggests that reduction in sediment load, precipitation of dissolved metals and additional alkalinity loads downstream of the doser treatment lead to better biological improvement.

Additional Key Words: Active treatment, MAIS

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HYDROLOGIC ASSESSMENT OF A STREAM CREATED ON MINED LANDS[1]

W. Blackburn-Lynch[2], C. Agouridis, C. Barton, R. Warner, and T. Maupin

Abstract: Surface mining is a commonly used method for extracting coal in the Appalachian coalfields of the U.S. This particular mining practice produces excess spoil or overburden, which is largely placed in adjacent valleys resulting in the creation of valley fills. These valley fills bury headwater streams, which in turn negatively impacts the hydrologic characteristics of downstream ecosystems. In 2008, the University of Kentucky designed and constructed a 3,000 ft intermittent headwater stream on an existing valley fill as a proof-of-concept. The goal of the project was to evaluate whether or not a stream could be recreated on mined lands, particularly a valley fill. As part of the project, the hydrograph characteristics discharge volume, peak discharge, discharge duration, time to peak, lag time, and response time were evaluated from three watersheds: (1) unmined, forested watershed (control), (2) restored (stream creation), and (3) unrestored (traditional mined land reclamation practices). After four years of monitoring, results indicate that the stream recreated on the crown hydrologically is similar to the unmined, forested watershed during storm events; however, differences were noted during base flow. The recreated stream exhibited baseflow for a shorter period time largely due to a lack of connection to the water table. For the section of stream below the toe of the valley fill, few differences were found between the recreated stream and the unrestored watershed. Results of this study are being used to guide additional stream restoration efforts on minded lands in the Appalachian coalfields.

Additional Key Words

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BIRD DIVERSITY AND ABUNDANCE ON RECLAIMED SURFACE COAL MINES IN ALABAMA: TEMPORAL AND HABITAT RELATED VARIATIONS[1]

R.R. Borthwick[2] and Y. Wang

Abstract: Few publications investigate landscape-level effects of mining or mine-reclamation on wildlife populations, assess cumulative impacts of mining from multiple sites at the landscape scale, or consolidate existing information for management decisions. We contribute to these knowledge gaps by investigating temporal and habitat relationships of avian communities on reclaimed mines by using unlimited-detection radii point-counts for bird community data, and fixed radii vegetation plots at the same 200 plots across 27 small-scale surface coal-mines throughout north-western Alabama. Mines were grouped into three habitat categories (grassland, conifer, mixed [<60% conifer]) and three temporal categories (9-14 years since closure, 15-20 years, and ≥20 years) resulting in nine treatment categories with three replicates of each treatment. No significant differences were observed in diversity across habitats (P = 0.206), but grasslands were highest, followed by mixed then conifer forests. Mines greater than 14 years since closure showed non-significantly higher diversity than younger mines or recently disturbed control sites (P = 0.086). Rarefied species richness was not different across treatments. Avifauna showed species-specific effects linked to time, habitat, and time/habitat interactions with 20 species having significant differences. Young grasslands, medium aged conifer forests, and older conifer forests were significantly more diverse than young conifer forests (P = 0.047); no other treatments showed significant differences. With the exception of 9-14 year old grasslands, 9-14 year old mines had the lowest diversities, and 15-20 years had the highest diversities. Even in productive eco-regions with small-scale mines, reclamation can take more than a decade to maximize diversity in songbird communities. Short-term reclamation goals can be better met by targeting grassland species with grassland reclamation or targeting more species by diversifying vegetation composition. These findings align with Forest Reclamation Approaches encouraged through the Appalachian Regional Reforestation Initiative.

Additional Key Words: avian, diversity, abundance, habitat, succession

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IMPROVING REMEDY SUSTAINABILITY THROUGH USE OF LOCAL CONSTRUCTION MATERIALS[1]

Todd Bragdon[2], Cody Lechleitner, Mark Nelson, and Dan Meyer

Abstract: Large quantities of construction materials are often required to complete abandoned mine remediation projects. At the East Fork Ninemile Waste Consolidation Area (EFNM WCA) in the Coeur d'Alene Basin, Idaho, construction material requirements included riprap, buttress fill, aggregate and cover materials. A number of potential sources were considered, and a local zone of the Precambrian Pritchard Formation was selected as the most sustainable source of construction materials for the project. The use of this material presented potential environmental risks associated with the close proximity of the quarry to known areas of mineralized rock. However, these risks were effectively managed through implementation of rock characterization, management and quality assurance activities. The EFNM WCA quarry project provides a case study for cost-effectiveness and improving sustainability of mine remediation projects through the use of local construction materials in naturally mineralized areas.

The use of local construction materials provides an excellent opportunity to execute cost-effective reclamation, improve sustainability and reduce the environmental footprint of a mine remediation project. For example, haulage of construction materials from off-site quarries requires substantially more fuel consumption and increased cost compared to use of local construction materials. The use of local construction materials supports the triple bottom line approach to sustainability, which considers environmental, social and economic factors to optimize project sustainability.

An important consideration when utilizing local construction materials produced from a naturally mineralized district such as the Coeur d'Alene basin is to ascertain whether the proposed quarry area contains naturally mineralized rock that could cause adverse effects to the environment. Prior to quarry development at the EFNM WCA, a geological evaluation was conducted to assess the rock for total metals content, leachable metals content and acid generation potential. A Demonstration of Methods Applicability study was then conducted to optimize the use of field instruments such as Field Portable X-Ray Fluorescence (FPXRF) to support construction quality assurance (CQA). This information was incorporated into a CQA plan, which provided for testing of produced construction materials for metals concentrations that could represent direct contact, leachate migration or acid rock drainage risks. An unexpected zone of potentially acid generating rock was intersected within the deepest portions of the quarry, and the CQA activities provided data to identify and mitigate this issue prior to production of construction materials with potential to generate acid rock drainage.

Additional Key Words: Soil and Overburden Topic – Selecting/Blending Overburdens to Match Desired Reclamation Land Use, Carbon Footprint in Reclamation

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GENETIC DIVERSITY OF BROOK TROUT (*SALVELINUS FONTINALIS*) POPULATIONS ISOLATED DUE TO ABANDONED MINE DRAINAGE IN THE WEST BRANCH SUSQUEHANNA RIVER WATERSHED, PENNSYLVANIA[1]

Frederic J. Brenner[2] and Shawn M. Rummel

Abstract: The West Branch Susquehanna River watershed is located in northcentral Pennsylvania and contains some of the most pristine brook trout (*Salvelinus fontinalis*) habitat in Pennsylvania. However water quality issues, such as abandoned mine drainage (AMD) and acid deposition have contributed to the decline of brook trout throughout the watershed. Over 20% (1,200 stream miles) of the watershed is impaired by AMD alone. At the population level, one of the negative consequences of AMD is the isolation of brook trout populations and the subsequent loss of genetic diversity in these populations. The purpose of this study was to determine the extent of genetic diversity in brook trout populations isolated by AMD. Tissue samples were collected from brook trout populations in headwater streams throughout the West Branch Susquehanna River watershed. Nucleic DNA was isolated from the samples and primers were designed to amplify microsatellites in the DNA sequence. Using gene scans, the amount of heterozygosity and homozygosity was determined for each fish sampled. Our results indicate that there is isolation due to AMD based on the high frequency of homozygosity observed in the samples. The results of this study demonstrate the importance of prioritizing AMD restoration efforts to areas that will reconnect previously isolated brook trout populations.

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SHORTLEAF PINE AS A RECLAMATION SPECIES ON FORMER MINING SITES[1]

J.H. Campbell[2]

Abstract: Shortleaf pine (*Pinus echinata*) is a valuable eastern pine species that is drought tolerant, adaptable to soils of low fertility and pH, and proven to have good growth and survival on mine reclamation sites. Across its 22 state range, shortleaf is a native species throughout traditional mining areas and is best suited to south and west-facing slopes in these areas. Shortleaf is a long-lived pine (250 plus yrs on average), but is often used as a pioneer species on reclamation sites. As a pioneer, pines provide services that improve growing conditions for later successional species, including increased soil nutrients, improved soil structure, an ectomycorrhizal propagule source, and sufficient, but not excessive, shade. Additionally, shortleaf pine provides food and habitat for wildlife and valued timber products. Since the 1980's, shortleaf has lost 53% of its native range, notably east of the Mississippi River. This decline stems from land-use change, species preference, fire exclusion, and forest health issues. Increased interest in the species has attracted range-wide stakeholders and financial assistance to support restoration efforts. Planting shortleaf on mine reclamation sites, where appropriate, provides a species that is competitive on poor soils and contributes to the restoration of a valuable, yet declining, native pine.

Additional Key Words: Shortleaf Pine Initiative

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TESTING UNMANNED AERIAL SYSTEMS FOR SURFACE COAL MINE OVERSIGHT INSPECTIONS[1]

N.L. Carter[2] , L.J. Monette, D.T. Beaman

Abstract: The Office of Surface Mining Reclamation and Enforcement (OSMRE) personnel have been evaluating the use of small Unmanned Aerial Systems (sUAS) as a tool to help achieve its minimum oversight inspections on surface coal mines as directed by the Surface Mining Control and Reclamation Act of 1977 (SMCRA). In 2012, OSMRE used the RQ-16A T-Hawk Micro Air Vehicle (T-Hawk) to determine if this technology is a viable option for increasing OSMRE's ability to meet or exceed its mandated minimum number of oversight inspections on an annual basis. Fifteen sites were selected from OSMRE's randomly generated oversight list to be flown with the T-Hawk over a three-day period for discovering how much territory can be covered and at what cost. The sites were selected based on location to one another with reasonable travel time between sites. The T-Hawk not only captured high quality images of mining related structures, but also provided a cost to benefit ratio for the use of this technology. The cost to benefit ratio for use of the T-Hawk for oversight inspections was compared to both the use of a manned aircraft as well as the cost for conducting on the ground inspections alone. More concentration was spent on the efficiency of the T-Hawk by using it in a practical real time application. The use of manned aircraft is by far the fastest way to view large areas, but the financial burden is cost prohibitive. The biggest cost savings seen using the T-Hawk is time, with financial costs being at an acceptable level once the initial investment is made. Incorporating the T-Hawk into OSMRE's oversight inspection activities can more than double the number of oversight inspections completed each year.

Additional Key Words: Office of Surface Mining, OSMRE, THawk, UAV

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REPLACING AN ACTIVE AMD TREATMENT SYSTEM WITH SEMI-PASSIVE TECHNIQUES[1]

Tyler Chatriand,[2] and William Walker

Abstract: Severe acid mine drainage (AMD) has occurred for over 30 years at an inactive coal mine in western Pennsylvania, degrading the headwaters of a tributary throughout a 500-acre watershed. AMD is currently mitigated at a downstream collection point with an active lime dosing and clarification plant; however, 2 miles of reclaimed mine lands remain impacted by AMD pollution. A comprehensive site investigation was undertaken in order to identify and characterize the sources of AMD and identify treatment alternatives that would repair the impacted stream, as well as reduce existing operating treatment costs. The investigation included drilling/well installation and aquifer testing to evaluate subsurface conditions and groundwater/surface water interaction, stream gaging with pressure transducers and sampling for contaminant loadings analyses, test pit excavations, and isotope analyses. In summary, four primary AMD sources were identified throughout the site, including three coal refuse disposal areas and an underground mine drain. Through the characterization of the mine wastes, several treatment alternatives were identified that will reduce operating costs by 50%. In addition, waste rock piles were examined in order to evaluate innovative source control methods to treat the acid generating materials in place. This discussion presents the findings of the investigation, the methods used for characterization, and touches on the accomplishments to date toward implementing a semi-passive treatment system.

Additional Key Words: acid mine drainage, active, semi-passive, treatment, alternatives, characterization

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RECLAMATION OF ABANDONED MINE LAND USING STABILIZED FLUE GAS DESULFURIZATION MATERIAL TO MITIGATE ACID MINE DRAINAGE[1]

Chin-Min Cheng[2], Robert Baker, Tarunjit Butalia, John Massey-Norton, and William Wolfe

Abstract: A full-scale demonstration project using stabilized flue gas desulfurization (FGD) material in the reclamation of an acid mine drainage (AMD)-producing abandoned mine land (AML) is to be carried out at the Gallia County, southeast Ohio. An estimated two millions tones of stabilized FGD material from the nearby Gavin coal fire power plant of American Electric Power is to be placed against a section of the abandoned highwall along with geotextile material to re-contour the area, as well as to neutralize and reduce the discharge of AMD. The neutralization capacity of the stabilized FGD material and the partitioning of constituents in the liquid and solid phases during neutralization are evaluated by a series of batch and column leaching studies. A number of potential reclamation designs are tested in a 1.2m×1.2m×3.7m bench-scale testing module, which allows different reclamation scenarios to be tested in a laboratory setting under near real field conditions. The goal is to find an optimal design that permits adequate contact between AMD and stabilized FGD material, which yields expected AMD mitigation results. In the bench-scale testing, the changes of piezometric head and water quality are measured as AMD percolating through the FGD fill. A geotechnical model predicting the flow AMD within the FGD fill and a geochemical model calculating the change of AMD water quality will be established and calibrated. Currently, at the project site, water samples and hydrogeological parameters are collected from groundwater monitoring wells, AMD discharging points, and receiving ponds to establish background level. The progress of the project will be discussed.

Additional Key Words: Coal combustion by-products, Stabilized FGD material, Coal mine reclamation, Acid mine drainage mitigation

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IMPACT OF COAL MINE RECLAMATION USING COAL COMBUSTION BY-PRODUCTS (CCBS) ON GROUNDWATER QUALITY: TWO CASE STUDIES[1]

Chin-Min Cheng[2], Robert Baker, Tarunjit Butalia, John Massey-Norton, William Wolfe

Abstract: Currently, two full-scale, coal mine reclamation demonstration projects, i.e., Conesville Five Points and Cardinal Star Ridge, of varying constructability scales and fill material combination are carried out at eastern Ohio. Approximately 1.2 million metric tons of stabilized FGD material and FGD gypsum have been used to reclaim a highwall complex at the Conesville Five Points site. FGD gypsum is used at the Cardinal Star Ridge site, which is a highwall pit with an estimated capacity of 0.5 million metric tons. The environmental impacts on the water quality of the upper-most aquifer systems underlying the sites have been monitored on a monthly basis. More than 18 months' worth of background water data were collected before the reclamation began at both sites. Principal component analysis, hydro-chemical analysis, and geochemical modeling were used to elucidate potential hydro-geochemical processes involved in the underlying aquifer systems. Based on the data collected over a period of more than three years, the water qualities at both sites changed since the reclamation began. The concentrations of a number of monitoring parameters (e.g., SO_4^{-2}, Ca, Mn, Cr, Si, Sr, Tl, and/or Na) were found to exceed the estimated maximum background concentration levels (i.e., upper prediction limits or UPLs) in one or more of the sampling locations. Results from the hydrogeochemical analysis suggested the observed water quality impacts during the study period were unlikely due to the seepage of the leachate from the backfilled FGD by-products. Alternatively, it is plausible that the dewatering of pit water during site preparation and backfilling of FGD by-products changed the hydrogeological conditions of the underlying aquifers, resulting in changes in groundwater quality. The water quality at both demonstration sites will be continuously monitored for long-term evaluation.

Additional Key Words: Coal Mine Reclamation, Coal Combustion By-products, Beneficial Use, Groundwater Quality

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EVALUATION OF APPALACHIAN MINE SPOIL LEACHATE CHEMISTRY AND ITS ASSOCIATED GEOCHEMICAL INFLUENCES[1]

E.V. Clark[2], W.L. Daniels, Z. Orndorff, C.E. Zipper, and K. Eriksson

Abstract: Surface coal mining in Central Appalachia influences the total dissolved solids (TDS) in streams draining areas disturbed by mining operations. The TDS in mining-impacted streams is affected by various factors including rock type, spoil mineral composition, and spoil weathering status. More than 40 mine spoil samples from Central Appalachia were collected for geochemical analysis. The objectives of this study were to describe the leaching patterns for selected ions and to investigate mineralogical influences on leachate chemistry. Each spoil material was packed into a PVC column and leached twice a week with 2.54 cm of water for a total of 40 unsaturated leaching cycles. Leachate concentrations of Al, As, Cd, Cu, Fe, Ni, Pb, Se, Zn, and major ions were measured. For mineralogical analysis, a representative sample of each spoil was prepared as a thin section, analyzed using petrographic microscopy, and classified based on mineral point counts and abundances. The percentages of metal oxides in feldspars were also determined via microprobe analysis.

The geochemical composition of the column leachates was variable over the 40 leaching cycles. The concentrations of individual ions throughout the leaching cycle and relative proportions of ion release through the leaching progression were examined and related to the original mineralogical composition. The abundant minerals in the spoil samples included feldspars, quartz, and micas. Bulk analysis of the feldspars indicated an average oxide equivalent of 70-80% SiO_2 and Al_2O_3, and 10-20% Na_2O and K_2O. The feldspar component of the spoils exhibited varying degrees of alteration to kaolinite which may contribute to acid neutralization potentials. Ion release patterns and mineralogical data were evaluated with the overall goal of characterizing TDS leaching potential and developing a model of TDS release from Appalachian mine spoils.

Additional Key Words: Total Dissolved Solids (TDS), mineralogy

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SO WHERE IS THAT TREATMENT SLUDGE GOING IN THE WASTE ROCK?[1]

M. Coleman[2], K.E. Butler, E. Mott, T. Al, and K.D. Phinney

Abstract: The approximately 120 ha backfilled Fire Road Mine strip coal mine in eastern Canada has been a source of acid mine drainage since the mid 1980's. Lime neutralization treatment of drainage has been continuously ongoing. Placement of the treatment sludge back onto and into the backfilled mine site may be a factor in reducing the mine water acidity. Groundwater chemistry has been intensively monitored using a series of groundwater wells within and bordering the disturbed areas but the data is limited by the spacing of the wells. .

Apparent conductivity and electrical resistivity surveys have been instrumental in identifying the locations of the highly conductive mine water and the treatment sludge both seasonally and spatially after dredging periods. Additional work was conducted during the summer and fall of 2014 and the winter of 2015 to further investigate seasonal variations in conductivity and the shorter-term (several month) impact of sludge on the conductivity distribution in the waste rock.

The results document minor seasonal impacts on conductivity compared to the longer-term decreases in conductivities across the mine site. Freshly deposited sludge impacts varied conductivity within the waste rock but the results were dependent on whether deposition was in the vadose zone or the mine water saturated zone.

This would be useful information for determining sludge depositional locations in the future so as to possibly have a more targeted but larger impact on localized mine water characteristics. Improving the mine water chemistry to "zero lime demand" is the ultimate goal for mine water treatment at this location.

Additional Key Words: conductivity, resistivity, aluminum, acidity, pyrite, mine water, coal mining, geology field camps

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OSMRE/VISTAS AT WORK: BUILDING CAPACITY TO MEET CHALLENGES IN PRE-REGULATORY MINING AREAS[1]

Dr. T Allan Comp[2], Sarah Meade, Amy Showalter, and Cody Zirkle

Abstract: The OSMRE/VISTA Team was founded to address the socio-economic and environmental impacts of pre-regulatory mining. During its 12-year history, VISTAs on the Team have secured over $13.5 million in grants for host communities and marshaled nearly 800,000 hours of volunteer time from community members (equivalent to 385 years of volunteer service).

In 2006, OSMRE estimated more than three million people in Appalachia lived within one mile of Abandoned Mine Lands (AML), defined by the Code of Federal Regulations as "un-reclaimed" coal-mined lands that existed before August 3, 1977, and for which there is no continuing reclamation responsibility. AML related environmental problems include surface and ground water pollution, and abandoned or sediment-clogged streams. These environmental conditions contribute to persistent poverty, high obesity rates and poor overall health. Incentives for business relocation and basic services have dwindled, while population and property values have plunged, leaving communities with limited capacity to provide solutions.

Similarly, in the Southwestern Rocky Mountains and High Desert, the boom-bust nature of mining towns in the hardrock mining west created a legacy of rural communities struggling with similar challenges: high rates of poverty, unemployment, and economic distress, often overlooked in the shadow of the success experienced by nearby communities.

Though distance separates these two areas, the issues the communities face are similar.

These communities are unified by the OSMRE/VISTA Team. OSMRE/VISTAs work in the field to bring fresh eyes, an injection of hope, and hard work to address existing environmental and socioeconomic challenges.

Additional Key Words: AML, mining impacts, environment, socio-economic, water pollution, poverty, boom-bust, coal, Hardrock, community solutions

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SAND CAPILLARY BARRIERS INCREASE WATER RETENTION AND FACILITATE SALT LEACHING IN AIRD DISTURBED LANDS[1]

Seth Cude[2], Jay B. Norton, Thijs Kelleners, Mark D. Ankeny, Calvin F. Strom

Abstract: Low annual precipitation and high salt contents significantly impede successful reclamation of disturbed lands in arid and semiarid regions. By utilizing a capillary barrier of sand above and below native topsoil and placing this in a shallow depression available moisture was captured and retained for an extended period of time. Captured snow moved multiple pore volumes of water through the germination zone carrying soluble salts with it. The bottom sand layer reduced the upward movement of salts thereby maintaining a decreased salinity in the germination zone. Twenty-four plots were tested on two field sites in the fall of 2013 in a complete randomized block design. Plots included a broadcast seeding (control), a shallow depression, a sand mulch, a capillary barrier, a dual sand barrier and a dual sand barrier with clay wicks to consolidate water. A significant increase in native grass emergence was observed in all treatments except the control on one site and in three treatments on the other site. Laboratory column studies quantified the water savings with sand capillary barriers. Seven treatments with four replicates were tested in a complete randomized block design. Initial equilibrium conditions were created through use of a constant standing water table for wetting and a sand table for drying. Evaporation measurements were done by weight for 30 days. Volumetric water content was then measured at 5 different heights of each column. Up to a 90% reduction in evaporation was seen with 3cm of sand, and increased overall soil moisture content was observed throughout the profile when a capillary barrier was present.

Additional Key Words: reclamation, soil structure, soil physics, water harvesting, salinity, evaporation

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DEFINING RESTORATION SUCCESS IN WYOMING'S NATURAL GAS FIELDS: SUGGESTIONS FOR USING REFERENCE SITES AND ECOLOGICAL SITE DESCRIPTIONS[1]

M.F. Curran[2] and P.D. Stahl

Abstract: In recent decades, restoration ecology as a science and the practice of ecological restoration have experienced rapid advancements. These advancements are due, at least in part, to increases in anthropogenic land disturbance and increased remediation requirements associated with natural resource extraction. Restoration ecologists should aim to strengthen relationships between the academic community, the practitioner community, and regulatory agencies to improve ecological restoration as a practice. The Society for Ecological Restoration International has compiled a list of ecosystem attributes, which are indicative of restoration success. However, restoration success is often defined to practitioners by agencies with regulatory jurisdiction over specific areas of land. On federally owned lands in Wyoming, both the state of Wyoming Department of Environmental Quality and US Department of Interior's Bureau of Land Management (BLM) have regulatory authority. Differences occur between, and among, these regulatory agencies and all measure restoration success in comparison to reference sites on adjacent, undisturbed lands. Disparities in regulatory restoration success standards and inadequate selection of reference sites make implementing restoration plans difficult for practitioners and cause complications in assessing restoration success. The scientific community should learn from and attempt to provide constructive improvements to practitioners and regulatory agencies. Land reclamation data was obtained from an oil and natural gas operating company, a restoration practitioner company, and regulatory agencies. Evaluation of regulatory success standards and selection of reference sites were made from an ecological perspective. This talk aims to highlight some problems with current reference site selection, as well as make suggestions for improving selection in the future. In addition, as the NRCS, US Forest Service and BLM have recently signed an interagency agreement to use Ecological Site Descriptions (ESDs) for future land management, this talk will discuss suggestions for improving ESDs and how they can be incorporated into restoration success criteria.

Additional Key Words: restoration success, ecological site description, oil and gas restoration, interagency cooperation

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SUGGESTIONS FOR IMPROVEMENTS TO RESTORATION MONITORING[1]

M.F. Curran[2], and P.D. Stahl

Abstract: As with any type of project, monitoring is critical to track progress, evaluate success, identify problems, and make informed decisions for future management. Additionally, for projects to be successfully managed, a clear definition of success is necessary. On BLM lands in Wyoming, all oil and gas well pads undergoing reclamation are compared to an undisturbed reference site, which is often defined by a single 100 m transect. In a heterogeneous landscape, a single 100 m reference transect fails to capture variability or depict an adequate representation of a reference area. Likewise, a single transect on a site under reclamation may fail give an accurate representation of the reclamation site as a whole. In most cases, field technicians sample restoration sites and reference areas by selecting locations they believe to be most representative of an area which should be avoided because it is subject to observer bias. Since sampling is representative and monitoring techniques vary between years, analyzing vegetative trends is difficult because reference sites are used as measuring sticks for success, our ability to define success and set restoration targets is limited by inconsistencies in monitoring and may vary greatly from year to year. In order to evaluate vegetative trends, site stability and self-sustainability, long-term monitoring plans should be incorporated into overall reclamation plans. A sound monitoring plan must be unbiased, statistically reliable, repeatable, and economical. Due to the increasing demand for vegetation monitoring, sampling techniques should strive to become more cost-efficient and information-rich than in the past. While there are pros and cons to different vegetation sampling techniques, many studies have shown significant differences in results when multiple methods are used. Therefore, a long-term monitoring plan should incorporate standard techniques and permanent sampling areas to identify trends and evaluate habitat quality, site stability, resiliency and self-sustainability. This talk will discuss strengths and weaknesses associated with different monitoring methodologies and make suggestions on improvement.

Additional Key Words: monitoring, unbiased reporting, evaluating restoration success, efficiency in monitoring

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HEIGHT OF THREE HARDWOOD SPECIES GROWING ON MINE SITES COMPARED TO NATURAL CONDITIONS[1]

Kara Dallaire, Jeff Skousen, Jamie Schuler[2]

Abstract: Coal is an important source of energy for electricity and is used to make steel and various other products. West Virginia is the largest coal producing state within the Appalachian region. Surface mining of coal drastically disturbs ecologically diverse forests and the reforestation of these areas after mining is an important first step to helping restore their ecosystem functions. After mining, operators are often left with brown and gray sandstone to use as topsoil substitutes. Brown sandstone has been more weathered and has physical and chemical properties that are better for tree growth (lower pH, higher percent fines, and higher available nutrients) than gray sandstone. Two study sites were established on former mine sites in West Virginia to assess the effects of brown and gray sandstone, with and without mulch treatments, on tree establishment. Tree growth data for northern red oak, white oak and tulip poplar, as well as soil samples (analyzed for pH, EC, percent fines, and extractable nutrients) have been collected annually for the last 10 years. The pH of brown sandstone was 5.2 to 5.4, gray sandstone was 6.5 to 6.8, and mulch treatments were 7.0. Percent fines ranged from 42 to 60% on all treatments. The mulch treatment had high levels of Ca (197 $cmol_c$/kg). The height growth of each tree species on both mine sites was compared to the growth of trees growing on clear-cut areas at the Fernow Forest, WV. In addition, an estimated site index prior to disturbance was calculated and used to predict tree growth rates. Tree heights (25 to 175 cm) on gray sandstone were significantly lower than height on brown sandstone (197 to 544 cm) for all three species. Trees on mulched plots were up to229 cm taller than trees on un-mulched plots. Tulip poplar height on the brown treatment (544 cm) was greater than on a clear-cut area with a site index 62 at 10 years (503 cm). Tree heights were lower on mined sites compared to heights calculated from pre-mining site indices, but mulching improved height growth of trees.

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FEDERAL ENERGY REGULATORY COMMISSION LICENSING FORMICROHYDROPOWER UTILIZING MINE DRAINAGE[1]

T.P. Danehy[2], Cody 'Buck' Neely, S.L. Busler, C.F. Denholm, D.A. Guy and M.H. Dunn

Abstract: The Federal Energy Regulatory Commission (FERC) issued a license in September 2014 authorizing the Antrim Treatment Trust to modify and expand an existing off-grid microhydropower generating facility and to connect to the regional power grid as a net-producer of electricity. Located in Tioga County in the Susquehanna River Basin, the Antrim Microhydropower Project is one of 1,023 hydropower facilities licensed in the United States and has the smallest capacity of the 18 projects licensed within the Commonwealth of Pennsylvania. The Antrim facility is the only known grid-connected, licensed hydropower project that utilizes mine drainage as the water source. Mine drainage issuing from an abandoned underground bituminous coal mine, after treatment with a lime-based active system, is directed into a forebay and then conveyed through a penstock to a powerhouse where dual 20-kilowatt Turgo-type turbines are used to generate electricity. Plant operation expenses are reduced and excess electricity can be sold in order to help to sustain the non-profit treatment trust. This case study documents the permitting process and aspects related to using mine drainage in a microhydropower facility.

Additional Key Words: AMD, Tioga County, Pennsylvania, Antrim, turbine, water treatment.

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AN OVERVIEW OF LIGNITE MINE REFORESTATION AT LUMINANT'S MARTIN LAKE MINES IN EAST TEXAS[1]

Dan Darr[2] and Sid Stroud

Abstract: Luminant, a subsidiary of Energy Future Holdings Corp., is a competitive power generation business, including mining, wholesale marketing and trading, and development operations. Luminant has more than 15,400 megawatts of generation in Texas, including 2,300 MW fueled by nuclear power and 8,000 MW fueled by coal. Since initiating surface mining operations in Texas in 1971, Luminant has mined over 1 billion tons of lignite, helping to fuel 12 coal-fired electric generating units and supplying reliable, affordable electricity to Texas consumers. Years before the federal "Surface Mining Control and Reclamation Act of 1977", Luminant made a commitment to reclaim the land's topography, soil, vegetation, water resources, and wildlife habitat. To date, using sound agronomic and forestry practices, innovative techniques, and the application of independent research findings, the company has reclaimed nearly 77,000 acres that now meet or exceed pre-mine productivity. The resulting reclaimed land is a valuable resource base for current and future landowners. That commitment to successful reclamation and environmental stewardship is very evident in the company's reforestation program through which Luminant has planted over 37 million native tree seedlings over the last 40 years. Although the company's reforestation program grew slowly at first, Luminant's techniques and seedling sources have developed and improved over the years. Since 1995, the annual planting effort has exceeded 1 million trees annually, peaked at 2.3 million in 1999, and has exceeded 1.2 million annually for the last five years. Building upon Luminant's strong commitment to restoring the land, the reclamation objectives at Martin Lake mines in Panola and Rusk counties in the "Piney Woods" of East Texas are principally focused on reclaiming the land to commercial forestland and wildlife habitat. Luminant views mine reclamation and reforestation as an opportunity to renew an important natural resource that will contribute to the local economy. Timber production is an important industry in East Texas and therefore the majority of trees planted annually are native Loblolly Pine. To achieve quality wildlife habitat and species diversity, Luminant also plants a wide variety of native hard mast and soft mast producing species carefully selected for long-term quality, along with companion native grasses and forbs. With 76 percent of all post-mine land at Martin Lake mines reclaimed to forest cover types, the company's reforestation efforts are establishing valuable forest assets that not only compliment the native cover types, but support the local forest industry-based economy.

Additional Key Words: surface mining, research, reclamation, environmental stewardship, Martin Lake, timber production, loblolly pine

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USE OF A DISPERSED ALKALINE SUBSTRATE AND LIMESTONE BEDS TO TREAT ACID MINE DRAINAGE AT SOUDAN MINE, MINNESOTA[1]

K.E. Dieterman, C.L. Kairies-Beatty, P. Eger[2]

Abstract: Soudan Mine, the oldest and deepest iron mine in Minnesota, was mined for almost 80 years and is now used as an historical, scientific and educational site. Since mining stopped in the 1960s, the mine has been continuously dewatered at an average rate of 60 gallons/minute. As groundwater and surface water flow through the surrounding geology and into the mine, oxidized metal sulfides are released into the mine water. Although the overall discharge is circumneutral, copper and cobalt exceed water quality limits. Currently, the overall discharge is treated on the surface with a commercial ion exchange system, which is effective but expensive. If individual sources can be treated within the mine, the surface treatment system could be eliminated.

One of the major sources of cobalt has a pH of 2.5 with 45 mg/l iron and 13.5 mg/l aluminum. A limestone dispersed alkaline substrate (DAS) (first developed by Rötting et al, 2008) followed by a limestone bed system was evaluated in several laboratory experiments to determine neutralizing and metal removing abilities. Columns and limestone beds were each run at hydraulic residence times of 12 and 24 hours. If proven successful, the limestone DAS treatment system will be used to treat acid mine drainage at Soudan Mine and could potentially be adapted for use elsewhere.

Additional Keywords: passive treatment system, dissolved metal removal

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COST SAVING AND PERFORMANCE ENHANCING MODIFICATIONS AT A LIME-BASED TREATMENT SYSTEM: RUSHTON TREATMENT PLANT CASE STUDY[1]

J.M. Dietz[2] and T.S. Gourley

Abstract: The Rushton deep mine is located near Phillipsburg, Pennsylvania. The Rushton treatment system, a lime-based chemical treatment system, treats pumped AMD from the closed deep mine at a rate between 15 and 30 MLD (million liters/per day). The mine water has moderate "hot" acidity (200 mg/L as CaCO3), with elevated iron (100 mg/L), manganese (8 mg/L), and aluminum (10 mg/L). The mine water also contains elevated carbon dioxide acidity ranging between 100 and 150 mg/L as CaCO3. In 2010, studies were initiated to evaluate the impacts of the mine water chemistry on the performance of the existing treatment system. Based on the results, a number of system improvements and modifications were made to the treatment system. The improvements included: 1) installation of a new pre-aeration system to remove carbon dioxide from the mine water and add dissolved oxygen to meet the iron oxidation requirements; and 2) elimination of aeration and replacement of mixer impellers in the existing reactor tank to improve lime dissolution and minimize secondary reactions (i.e., calcite precipitation). The pre-aeration system was installed in the summer of 2013 and the reactor modifications were completed in the spring of 2014 at a total cost of $0.8 million. The improvements have resulted in a decrease in overall operating costs by $0.25 million from the decrease in lime usage and electricity consumption. The volume of sludge has also decreased by approximately 50% by eliminating the precipitation of calcite associated with the carbon dioxide contained in the mine water and the added carbon dioxide from aeration previously provided in the reactor tank. This decrease in sludge production will increase the sludge storage capacity in the deep mine injection locations. The presentation will provide a discussion of the various study components, installation/modifications, post-construction performance, and future cost-saving modifications to be implemented.

Additional Key Words: acid mine drainage, lime treatment, hydrated lime

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AN INNOVATIVE PACKAGE TREATMENT SYSTEM FOR THE ORCUTT-SMAIL DISCHARGES; A MODERATE FLOW HIGH STRENGTH ACID MINE DRAINAGE[1]

J.M. Dietz[2] and M. Morosetti

Abstract: The Orcutt-Smail discharge is located near Corsica, Pennsylvania in Jefferson County. The AMD is a moderate flow (300 to 800 lpm) high acidity (700 mg/L as CaCO3) discharge with elevated iron (200 mg/L), manganese (70 mg/L), and aluminum (10 mg/L) that emanates from an old deep mine associated with a bond forfeiture surface mine. In 2008, a passive treatment system was constructed to provide permanent treatment of the discharges at a cost of over $1 million. Within several years of operation, the passive treatment system failed, as indicated by increasing acidity and metal concentrations in the system effluent. Iron Oxide Technologies, LLC developed an innovative package treatment system, in cooperation with W.K. Merriman, Inc., for the AMD at the site. The package treatment system consists of a reactor system, a lime slurry system, and a control system. The reactor system consists of several processes combined in a single steel tank including, pre-aeration, lime slurry dissolution mixing, and aeration/oxidation of iron and manganese. The lime slurry system consists of a lime-slurry storage tank and lime-slurry pumps to feed the lime slurry to the reactor system. The control system includes electrical components to operate the various mechanical components, a pH controller and electrode, and an internet-based monitor and alarm system for remote monitoring of the system (e.g., reactor pH and storage tank levels). The overall treatment system also utilized converted passive treatment units for settling and storage of metal precipitates (i.e., sludge). The package system was installed in the Summer/Fall of 2014. It began operation in November 2014 with continuous operation since startup. The presentation will provide a discussion of the various components, performance of the treatment system, and characteristics of the solids produced.

Additional Key Words: iron, manganese, oxidation, chemical treatment, lime slurry

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QUANTITATIVE SAMPLING TO DETECT INVERTEBRATE COMMUNITY CHANGE IN MINE-INFLUENCED STREAMS WITH ELEVATED TDS[1]

Damion Drover[2], Stephen Schoenholtz, Carl Zipper, Tony Timpano, David Soucek, and Beth Boehme

Abstract: Recent studies associating declines in biotic condition of streams with elevated total dissolved solids (TDS) from surface mining in the Central Appalachian coalfields have employed established multimetric indices (MMI; e.g. Virginia Stream Condition Index, West Virginia Stream Condition Index, Genus Level Index of Most Probable Stream Status) using benthic macroinvertebrates to assess stream condition. As part of the protocols for generating MMIs, researchers use semi-quantitative sampling methods (e.g. D-nets and kick nets). The calculated index metrics derived from semi-quantitative protocols cannot reliably include population densities per unit-area of stream bottom. We are using Hess samplers to quantitatively assess benthic macroinvertebrate community structure in mining-influenced and reference streams. We are measuring a variety of stream habitat variables, including specific conductance, TDS and major ion concentrations. The presentation will describe how macroinvertebrate taxa densities differ in response to varying stream habitat variables that include specific conductance. Results of this approach from three reference and nine test streams in the Central Appalachian coalfields will be presented.

Additional Key Words: multimetric, macroinvertebrate, density, Appalachian, coalfields

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BIOCHEMICAL REACTOR/ANAEROBIC WETLAND DESIGN/STARTUP ISSUES [1]

Paul Eger[2], Ben B. Faulkner, and James Gusek

Abstract. Passive systems that create reducing conditions for the conversion of objectionable dissolved parameters such as selenium, iron, aluminum, zinc, copper and other metals to less bio-available forms usually exhibit very high Biological Oxygen Demand (BOD) at startup. Measures to reduce the BOD are critical if adverse impacts to receiving streams are to be avoided. Some of these measures produce unexpected results in the system effluent downstream and in subsequent designed systems. Selection of appropriate organic mixtures and design considerations to facilitate desired hydraulic and chemical results are often site-specific. Several case studies at coal and metal mine sites illustrate important lessons that aid in refinement of the passive system design discipline.

Additional Key Words: mine drainage, mining influenced water, BOD, mine water management

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THE ROLE OF MANGANESE IN TRACE METAL REMOVAL[1]

Paul Eger[2], James Gusek, Ben B. Faulkner, K. Dieterman, and C. Kairies Beatty

Abstract. Limestone beds are an effective method for passively removing manganese from mine drainage. These are generally placed at the end of the treatment system, since iron must be oxidized before substantial amounts of manganese can be removed. Manganese removal occurs via biological and abiotic mechanisms in oxidizing conditions and subsequent precipitation onto the limestone surface. The ability of manganese oxides to remove trace metals is documented in the literature but there is little quantitative data from operating passive treatment systems. Data from several systems was analyzed and removal rates were estimated. At one of the sites, water with high BOD was introduced into the limestone bed and previously adsorbed metals were released. Laboratory experiments are underway to quantify metal removal rates for copper and cobalt.

Additional Key Words: mine drainage, mining influenced water, mine water management

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EIGHTH INTERNATIONAL ACID SULFATE SOILS CONFERENCE AT UNIVERSITY OF MARYLAND, JULY 17-23, 2016[1]

Delvin S. Fanning[2], Martin C. Rabenhorst, Brian Needelman, Maxine Levin, W. Lee Daniels

Abstract: Previous International Acid Sulfate Soils Symposia/Conferences took place in Wageningen (Netherlands) 1972; Bangkok, Thailand 1981; West Africa – Dakar, Senegal and Guiné Bissau 1986; Ho Chi Minh City, Vietnam 1992; Tweed Heads, Australia 2002; Guangzhou, China 2008, and Vaasa, Finland 2012. None have been held in the U.S., but a two day field tour supported by the international acid sulfate soils working group and SSSA, which traversed primarily Coastal Plain sites in Delaware, Maryland and Virginia, took place for World Congress of Soil Science in Philadelphia in 2006. Papers from the first four symposia appeared as publications of the International Land Reclamation Institute, Wageningen. Those of the 5th Conference were published in a special double-issue of the Australian Journal of Soil Research, whereas those of the 6th were by Guangzhou Science & Technology Press and those of the 7th by the Geological Survey of Finland. The term acid sulfate soils came into use for the first symposium by Leen Pons (deceased 2008, called in a book honoring him, the Father of the International Acid Sulfate Soils Symposia/Conferences) and other organizers. In an initial paper, Pons proposed that the term *"Acid Sulphate Soils be used in the widest sense of the expression. As such this expression pertains to all materials and soils in which as a result of processes of soil formation, sulfuric acids either will be produced, are being produced or have been produced in amounts that have a lasting effect on main soil characteristics".* This broad definition includes potential, active, and post-active acid sulfate soils and soil materials, of which by current tentative plans, examples of all three forms will be shown on field trips for the 8th Conference. Three field trips are tentatively planned for the 8th Conference: 1) a pre-conference tour on Sunday, July 17; a mid-conference tour on Wednesday, July 20; and a post-conference tour Friday (and possibly Saturday), July 22 (-23). In a paper at the 1st Conference, David Rickard described iron sulfides accumulation in estuarine soils and sediments from sulfate in sea water and iron from iron oxides as organic matter is oxidized by S-reducing bacteria by an overall process we now call sulfidization. Rickard, at Cardiff University, Wales, UK, in 2012 published (Elsevier) a book, Sulfidic Sediments and Sedimentary Rocks that documents that many sediments and sedimentary rocks throughout geologic columns contain pyrite accumulated by such processes. In another paper at the 1st Conference, Nico van Bremen, who completed his doctoral dissertation at Wageningen on acid sulfate soils in Thailand, described processes that take place when *sulfidic materials* (that he subsequently helped to re-define for *Soil Taxonomy*) are exposed to aerobic conditions to undergo what we now call sulfuricization, to form *sulfuric horizons*. At the 8th Conference we hope to honor these and other early acid sulfate soils workers. Previous conferences have emphasized what some call Coastal Acid Sulfate Soils. During the 8th Conference we hope to show that acid sulfate soils principles apply to many soils in the U.S. and that engineers and others involved in land disturbance activities and issues need to pay attention.

Additional Keywords: conference, acid sulfate soils, *sulfidic materials*, *sulfuric horizon*, sulfidization, sulfuricization.

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RECOVERY OF NORTH POTATO CREEK, COPPER BASIN, TENNESSEE [1]

Ben B. Faulkner,[2] and K.S. Deal

Abstract. The Copper Basin of Tennessee drains in part to North Potato Creek of the Ocoee River. It is one of the most dramatically impacted mining areas in the US. As part of voluntary remediation efforts, Glenn Springs Holdings committed to actions with long-range goals of restoring biodiversity and biointegrity to the stream. This work follows decades of land reclamation and reforestation efforts on the 9,000 hectare site. In November, 2014, regulatory authorities approved the by-pass of all chemical treatment of surface waters in North Potato Creek, effectively signifying the success of mitigation efforts in the watershed aimed at water quality improvement. Land reclamation, chemical and passive treatment systems, restored streams, tailings/mine waste reclamation, and pit disposal were implemented to facilitate this watershed recovery. Successful efforts were based on pit limnology and leak studies, subsidence monitoring, stream diversion, and stormwater studies as the recovery of the watershed was documented with biomonitoring. Glenn Springs continues to implement its adaptive water management strategy: characterize drainage and influences, divert unaffected drainage, capture and treat affected drainage, sequester acid producing materials, mitigate remaining problems with passive systems, and evaluate with biologic indicators.

Additional Key Words: Ducktown TN, acid mine drainage, water management

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[2] Ben B. Faulkner, at Bratton Farm, Princeton, WV – Consultant to GSHI, Kenneth S. Deal, Site Manager, Copper Basin Project of Glenn Springs Holdings, Inc. a subsidiary of Occidental Petroleum Corporation.

THE IMPACT OF SURFACE COAL MINING ON WATER QUALITY IN THE NORTHERN GREAT PLAINS[1]

Joseph D. Friedlander[2]

Abstract: A review of water sample analyses at the Freedom Mine, a large surface lignite coal mine in North Dakota, was conducted to compare actively mined and reclaimed lands water quality with baseline and background water quality. Comparisons were made for average and median values over the entire study period, annually, and also seasonally through separate snowmelt and rainfall comparisons. For parameters evaluated for regulatory purposes, a review of twelve years of data collected and reported to government agencies shows surface water quality is comparable between mine discharges, runoff in reclaimed stockponds and wetlands, and undisturbed baseline and background conditions. Based on this review of a substantial data set over a long period, surface coal mining was not shown to negatively impact surface water quality, both during active operations and following final land reclamation.

Additional Key Words

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PASSIVE WATER TREATMENT OF IRON, ARSENIC AND MANGANESE AT THE EMPIRE MINE STATE HISTORIC PARK IN GRASS VALLEY, CALIFORNIA[1]

N.T. Gallagher[2], T.L. Rutkowski, S. Lofholm, D. Ernst, and D. Millsap

Abstract: Empire Mine was one of the richest hard rock mines in California. Over its 106 year life, the mine produced nearly 5.6 million ounces of gold before it closed in 1956. The mine property is operated by the California Department of Parks and Recreation as Empire Mine State Historic Park and contains 367 miles of now flooded underground workings. While the mine was active, the Magenta Drain Tunnel (portal) was used to dewater the underground workings. Following closure, mining influenced water (MIW) continues to discharge from the portal. Flow rate from the portal varies seasonally and contains arsenic, iron, and manganese in excess of Federal and State primary and secondary standards. NPDES permit limits for arsenic, iron, and manganese from the portal flow are 10, 300, and 50 µg/L respectively. Arsenic, iron, and manganese in portal MIW have averaged 70, 5,900, and 2,330 µg/L respectively, since November 2011.

Since November 2011, a full-scale passive treatment system (PTS) has treated MIW from the portal. The PTS consists of a 4,930 m^3 settling pond, followed by a 0.4 hectare aerobic wetland, and a 0.5 hectare horizontal-flow manganese removal bed (MRB). Inflow rate has averaged 12 l/s and peaked near 43 l/s. Metal removal results have improved over time, corresponding with maturation of the PTS. Since February 2013, the PTS has provided effective removal of permitted metals to trace levels. Arsenic, iron, and manganese in effluent averaged 6.5, 348, and 699 ug/L, respectively over the life of the PTS through 2012, and since 2013 have dropped to 3.6, 50, and 38 ug/L, respectively. Areal manganese removal rates of up to 1.2 and 0.4 g/m^2/day have been observed in the wetland and MRB respectively. In addition to metals removal, flow through the PTS has also increased pH, increased dissolved oxygen, and reduced turbidity.

Additional Key Words: acid mine drainage (AMD), abandoned mines, constructed wetlands

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THE INFLUENCE OF VEGETATION ON TOTAL DISSOLVED SOLIDS IN RECLAIMED MINE LANDS[1]

A.C. Gondran[2], K.J. McGuire, B.D. Strahm, J.R. Seiler, C.E. Zipper

Abstract: One of the major issues currently facing mine land reclamation is total dissolved solids (TDS) impairing surface water quality. Recent research has focused on how to limit TDS generation by selecting low TDS materials for topsoil substitutes or valley fills, and hydrologically isolating high TDS materials. However, little has been done to assess the role vegetation may play in minimizing TDS loading in surface waters through uptake and evapotranspiration. In a new study, we are quantifying the effect vegetation has on TDS generation by comparing vegetated and un-vegetated paired plots. Plots were established on different spoil types with ages 0-15 years that have been revegetated with herbaceous and woody species. The un-vegetated plots were as similar as possible to the vegetated plots except that vegetation was removed by harvest or herbicide. TDS fluxes below the rooting zone are being measured seasonally with ion exchange resins to quantify the leaching differences between vegetation type and age. In addition, plot-level variables such as vegetation biomass, root biomass, and soil properties will be used as predictor variables in a multiple regression analysis to generalize about the types of reclamation practices or conditions that can minimize TDS generation across post-mining landscapes. We expect to find lower solute fluxes from the rooting zone in vegetated plots versus un-vegetated plots, and with our results, we aim to determine reclamation strategies that can optimize vegetation communities to decrease TDS generation from reclaimed mine lands.

Additional Key Words: total dissolved solids, reforestation, and water quality

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USING ELECTRICAL RESISTIVITY IMAGING TO TRACK WATER MOVEMENT THROUGH SURFACE COAL MINE VALLEY FILLS[1]

B. M. Greer[2], T. J. Burbey, C. Zipper, E. T. Hester

Abstract: Surface coal mining has caused significant land-use change in central Appalachia in the past few decades. This landscape altering process has been shown to affect water quality and aquatic communities in the mining-influenced headwater streams of this biodiverse ecoregion. Increase in total-dissolved solids (TDS) is one of the most common effects, and is usually measured via its surrogate parameter, specific conductance (SC). The SC of valley fill effluent is a function of fill construction methods, materials, and age; yet hydrologic studies that relate these variables to water quality are sparse due to the difficulty of implementing traditional hydrologic measurements in fill material. We tested the effectiveness of electrical resistivity imaging (ERI) to monitor subsurface hydrologic flow paths in valley fills. ERI is a non-invasive geophysical inverse technique that maps spatiotemporal changes in resistivity of the subsurface. Because resistivity is the inverse of conductivity, it can reveal both geologic structure and hydrologic flows. We paired ERI with artificial rainfall experiments to track infiltrated water as it moved through the valley fill. Results indicate that ERI can be used to identify the subsurface geologic structure and track advancing wetting fronts or preferential flow paths. We observed that the upper portion of the fill profile contains significant fines, while the deeper profile is primarily large rocks and void spaces. The artificial rainfall experiments revealed that water tends to pond on the surface of compacted areas until it reaches preferential flow paths, where it infiltrates quickly and deeply. We observed water moving from the surface down to >15 m depth in 75 minutes. ERI applications can improve understanding of how fill construction techniques influence subsurface water movement; and in turn aid in the development of valley-fill construction methods that will reduce environmental impacts.

Additional Key Words: Geophysical Inverse Modeling, Stormflow, Preferential Flow, Conductivity

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CASE STUDY: 20 YEARS OF ARD MITIGATION AFTER A BACTERICIDE APPLICATION[1]

J. J. Gusek[2] and V. Plocus

Abstract: This project was first described in a paper by Rastogi and Plocus at the ASSMR 1997 meeting in Austin, TX. The Fisher site is a backfilled and reclaimed (in 1984) surface coal mine in western Pennsylvania, USA. A post-closure toe seep at the site discharged ARD generated in pyritic rock zones within the backfill into a passive treatment system (PTS). In 1995, sodium hydroxide and bactericide solutions were injected through cased boreholes into the pyritic zones in a two-step process: NaOH solution followed by bactericide. Post-injection, the toe seepage exhibited net-alkaline chemistry. Based on the prevailing wisdom at the time, the effects of the injection event were expected to be temporary. Two decades later, the beneficial effects of the two-step injection event persist and bond release for the site is pending. Over 25 years of seep chemistry monitoring data suggest that the steady-state condition of net alkalinity in the seep water entering the PTS may be permanent. The current belief is that the initial suppression of *Acidithiobacillus ferrooxidans* bacterial community with the injected reagents has been maintained by the seasonal infusion of bactericidal organic acids derived from the robust vegetative cover. The situation appears to be self-sustaining.

Additional Key Words: sustainability, surfactant, coal, ARD, probiotics

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SLIPPERY ROCK CREEK STREAM BANK STABILIZATION[1]

D.A. Guy[2], R.M. Mahony, S.L. Busler, T.P. Danehy, C.F. Denholm, C.A. Neely, and M.H. Dunn

Abstract: The Slippery Rock Watershed Coalition has addressed the impacts of abandoned mine drainage for over 20 years; however, with the construction of multiple passive treatment systems and subsequent improvement in water quality, other sources of pollution are now more apparent. The Slippery Rock Creek Watershed Conservation Plan, completed in 2011 for the Pennsylvania Department of Conservation and Natural Resources, lists eliminating stream bank erosion as a priority action item. Slippery Rock Creek, located within five counties in western Pennsylvania, is a 6th-order stream with a long-term median flow of 14,440 L/s (510 cfs). Multiple projects along the main stem of Slippery Rock Creek in Worth Township, Butler County were completed using a variety of traditional and bioengineering techniques to reinforce eroding stream banks including grading, stone toe protection, root wads, livestakes, brush layering, and rolled erosion control blankets. The use of woody material within the installation not only helps to stabilize the slopes but also provides habitat, shade, and an organic carbon source for fish and macroinvertebrates. In addition to the stream bank stabilization, a 15.2-meter (50-foot) riparian buffer was established to help ensure long-term slope stability. Two projects will be highlighted including the Robinson Lane Project (2012) and the Slippery Rock Campground Project (2014). In 2011, the Foundation for Pennsylvania Watersheds funded the Robinson Lane Project to protect a 61.0-meter (200-foot) segment of stream bank along Slippery Rock Creek in Worth Township, Butler County, due to excessive erosion resulting in the significant loss of property. Subsequently, in 2014, the Pennsylvania Department of Environmental Protection awarded a grant for the Slippery Rock Campground Project to protect and stabilize 243.8 meters (800 feet) of stream bank on the opposite bank. Additional stream bank stabilization projects along Slippery Rock Creek are planned for the future.

Additional Key Words: Stream Stabilization, Slope Stability, Bank Erosion, Erosion Control, Bioengineering, Sedimentation

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CLIMATE CHANGE AND NATIVE FOREST ESTABLISHMENT ON SURFACE MINES: A CASE STUDY FROM EASTERN KENTUCKY[1]

Elizabeth R. Hansen[2], Christopher Barton and Andrea Drayer

Abstract: Reclaimed mine soils in Appalachia tend to exhibit physicochemical characteristics that are not similar to topsoil that occupied the site prior to mining. As such, native forest species may not be suitable for establishment under the conditions of the post-mining soil environment. In a time of climate change, native species establishment may be further hindered on these disturbed landscapes. Pine forests are speculated to be much more responsive to climatic variation than deciduous forests. In the central hardwood region that includes Kentucky, oaks could be replaced by southern pine species due to climatic changes. The consequence of combined land-use disturbance and climate change on native forest establishment is unknown. A factorial experiment examining the use of soil amendments (mulch, fertilizer, mycorrhizae) on forest establishment was initiated in 2004 on a surface coal mine in eastern KY. Fifty-four 15 x 15 meter plots were created and half of the plots received an application of 40 tonnes per acre of a wood chip/manure compost mixture. All plots were subsequently ripped to a depth of approximately 2-meters using a dozer and surface amendments were applied. Two tree species; northern red oak (NRO) *(Quercus rubra*) which is a dominant native hardwood species and loblolly pine (LP) (*Pinus taeda*) a non-native southern pine species were planted in the plots. Each plot received 100 seedlings spaced on 1.5 meter centers. Four years after planting, mean survival was 77% for LP and 60% for NRO. Mean growth at Year 4 was 2,532 cm^3 for LP and 62 cm^3 for NRO. By Year 10 dramatic differences in mean growth were observed between LP (199,144 cm^3) and NRO (1,250 cm^3). Year 10 mean survival remained higher for LP (49%) than NRO (30%). Although return of the native forest ecosystem is often a reclamation goal, pressure from non-native species could be problematic on disturbed mine lands if climate change species distribution models prove to be accurate.

Additional Key Words: climate change, forest reclamation approach, soil amendments, topsoil replacement.

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THE APPALACHIAN FOREST RENEWAL INITIATIVE: DEMONSTRATIONS OF LEGACY MINE LAND REFORESTATION ACROSS APPALACHIA[1]

T.L. Heim[2], C.D. Barton, M. French, and P.N. Angel

Abstract: The Appalachian Forest Renewal Initiative (AFRI) is a program to restore forests on mine land in the Appalachian coal mining states (including Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia). AFRI is funded with Federal funds provided by the United States Forest Service and is a partnership with the National Fish and Wildlife Foundation, the Appalachian Regional Reforestation Initiative, Green Forests Works, and the Appalachian Mountains Joint Venture. AFRI is focused on: 1) Restoring forest habitat on small- to medium-sized areas across the coal mining region of Appalachia; 2) Targeting sites that include a mixture of existing forest, streams, and previously mined lands that are adjacent to biologically rich protected Federal, state, or NGO lands; 3) Performing work that results in new forest establishment, stream restoration, and forest management to improve habitat for bird species and water quality on early successional and mature forest landscapes; 4) Integrating practices that include stream restoration, timber/fuels management, and tree planting using a modified version of the Forestry Reclamation Approach (FRA) that is designed for unused surface mined lands, invasive plants management, etc., to accomplish multiple ecological/habitat enhancement objectives; and, 5) Reaching out to non-traditional stakeholders like county governments, planning district commissions, economic development councils, water utilities, and mining community partners such as coal and gas companies and forest landowner groups, among others. Conventional mine land reclamation is characterized by excessive mine soil compaction and vegetative covers of exotic grasses, legumes, shrubs, and forbs that leaves the land in a state of arrested natural succession and highly compromised hydrology. Successful reforestation of these lands requires the mine soil compaction to be mitigated by ripping the ground with a large bulldozer pulling one or more ripping shanks. The ground is cross-ripped on a pattern of 2.4 m by 2.4 m and to a depth of up to 1.2 m deep. The exotic vegetation is eradicated with herbicide and a diverse mix of high-value native trees and shrubs are planted in the intersections of the rips. This poster will focus on the reforestation work accomplished on AFRI projects in Kentucky, Tennessee, and Virginia.

Additional Key Words: Cross-ripping, Tree Planting, Forestry Post Mining Land Use.

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IDENTIFICATION OF ECTOMYCORRHIZAL FUNGI FORMING SYMBIOTICASSOCIATION WITH THE AMERICAN CHESTNUT[1]

Shiv Hiremath[2], Kirsten Lehtoma, and Carolyn McQuattie

Abstract. We conducted a systematic study to identify ectomycorrhizal fungi (ECM) that form functional symbiotic interactions with chestnut tree roots. The goal of this study was to utilize suitable fungi for restoration of the American chestnut, which was devastated by the blight disease caused by the fungus *Cryphonectria parasitica*. Most reports about chestnut association with ECM fungi are from field isolated root samples. However, very few systematic studies have been attempted in the laboratory to determine mycorrhiza formation with preferred ECM fungi under controlled conditions. We used a semi-sterile set up where seedlings were grown and inoculated with fungal mycelia and formation and progression of mycorrhization was monitored using transmission electron microscopy and molecular analyses. We tested 10 species of ectomycorrhizal fungi that had the potential for forming mycorrhiza with the chestnut trees. We were successful in getting 5 of them to form ectomycorrhiza (*A. rubescens, C. geophilum, L. bicolor, L. laccata, P. tinctorius*) as determined by the presence of mantle and Hartig net in transmission electron microscopy analyses. Fungi from these tissues were re-isolated and confirmed to be the species used for inoculation. In addition to morphological analyses, root tips were also used to isolate fungal DNA and their identity was established through nucleotide sequencing of the ITS region using polymerase chain reactions (PCR).

In our field experiments in reclaimed mined locations, we have detected several species of ectomycorrhizal fungi that formed association with the American chestnut. Determination of their identity indicated that while some were known species, at least a couple of them appeared to be novel strains not characterized before. All these strains appeared to be more suitable for the survival and establishment of the chestnut in harsh conditions. We are trying to apply laboratory inoculation techniques to produce chestnut seedlings inoculated with these fungi for planting in reclaimed mined areas.

Additional Key Words: root colonization of fungi, transmission electron microscopy, chestnut restoration, American chestnut.

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PROGRESS OF THE RESEARCH PROJECT ON RECLAIMING SUBSIDENCE LAND WITH YELLOW RIVER SEDIMENTS[1]

Zhenqi Hu[2]

Abstract: China is the number one coal production country. The output of coal has reached to 4 billion tons, which is accounting for 48% of total coal output in the world. As 90% coal output come from underground mining. The land subsidence is very serious due to coal mining. Therefore, reclaiming subsidence land with Yellow river sediments could not only restore the subsided land, but also benefit Yellow river management. A national Key project on reclaiming subsidence land with Yellow river sediments was approved in 2012. This paper introduced the background of the project and the progress. Based on taking soil samples in the reclaimed land with Yellow river sediments every year since 2012, the soil properties of the reclaimed land and their changes with time were introduced. Some countermeasures for improving the soil productivity were discussed.

Additional Key Words: soil properties, mining subsidence, reclamation of land, river sediments

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SOME LESSONS FROM LONG TERM MONITORING OF FOREST REHABILITATION AT THREE SURFACE MINE COMPLEXES IN AUSTRALIA[1]

R.N.Humphries[2]

Abstract: The rehabilitation of forest and other woody vegetation ecosystems on mineral extraction sites is commonplace and a major post-mining land use and ecosystems throughout Australia. Owing to the need for government certification (under Australian Government and State legislation) for mine closure, long term monitoring of the establishing forests or other woody ecosystems is typically undertaken using agreed completion criteria which are predictive of rehabilitation achievements.

The collation and review of the monitoring results provide an opportunity to identify key processes and practices that might be used to enhance the rehabilitation achievements in Australia and elsewhere. Monitoring results for forest rehabilitation schemes at two (mineral sand, coal) surface mines in sub-tropical Queensland and one in Western Australia (bauxite) were examined.

Whilst it is evident that woody vegetation comprising several native tree and shrub species can be readily established, the resulting vegetation communities, in the short-term can be notably different in their composition and structure to the targeted and locally occurring native types.

It is concluded that forest structural formation in combination with species composition are of importance in establishing the trajectory of the developing forest type, ecosystem functioning and sustainability. Species composition is likely to influence initial forest structure, and the need for intervention practices, such as thinning, that may be required to achieve the necessary structural formation and ultimately the targeted native forest types. The principles established apply irrespective of the mineral and climatic types examined.

Additional Key words: native forests, structural formation, mineral sands, coal, bauxite

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USE OF NATIVE VEGETATION REFERENCE SITES IN THE SPECIFICATION AND EVALUATION OF FOREST REHABILITATION OF SURFACE MINES[1]

R.N.Humphries[2]

Abstract: The rehabilitation of forest and other woody vegetation ecosystems on mineral extraction sites is common place and a major post-mining land use and ecosystems throughout Australia. Owing to the need for government certification (under Australian and State legislation specified completion criteria which are indicative of rehabilitation goals are or have been achieved) there is often referral to and comparison with reference or so called 'analogue' native vegetation sites.

Examples of the ways in which reference sites have been used and interpreted, and their role and limitations are examined in relation to the rehabilitation of mineral sand, coal and bauxite surface mines in Queensland and Western Australia. Reference have been adopted for a range of different purposes, including specification (i.e. seeding and planting mixtures), monitoring (i.e. setting of metrics to measure) and assessment (i.e. setting of criteria to judge), sometimes singularly and other times collectively for individual mining schemes.

It is found that the use of reference sites in designing rehabilitation species has been particularly useful, although not used to its full potential and with less focus as to the outcome that might have been expected. In respect of monitoring and assessment, the choice of metrics and criteria used, and hence the reference sites used, are questioned given that the comparative assessments made are typically between early and mature stages in forest development. Perhaps the most significant and unrecognised limitation in the use of reference sites has been where mine site conditions (micro-climate, topography, hydrology, soils etc.) are fundamentally different and the expectation of replicating the forest vegetation of reference sites should be low or nil.

It is argued, that the limitations of the use of reference sites needs to be recognised by both the mining industry and the regulators. Where they are used they must be appropriate for the purpose and site conditions, and other vegetation, successional and ecosystem types may have to be found and used rather than those occurring locally on undisturbed ground.

Additional Key words: completion criteria, mineral sands, coal, bauxite

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FRAC SAND MINING AND RECLAMATION IN WISCONSIN[1]

T.C. Hunt[2]

Abstract: Progressive Reclamation Principles and Practices Create More Resilient Landscapes. Planning mining operations tailored toward the approved post mining land use avoids 11th hour calamities. Performing a site analysis and pre-mining natural and cultural resources inventories are essential for realizing reclamation possibilities; site hydrology is a principal consideration. Carrying out a seamless integration of the four Rs – the right materials at the right time in the right amount in the right place help ensure a successful reclamation outcome. Monitoring and measuring during the reclamation process establish the best long-term quality control practices.

Additional Key Words: Industrial Sand Mining, Land Planning, Ecology, Geomorphic Reclamation, Natural Resources Inventory

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Geochemical Characteristics of Low versus High TDS Potential Strata in Central Appalachian Surface Coal Mines[1]

D.K. Johnson[2], W.L. Daniels and C.E. Zipper

Abstract: Surface coal mining is associated with elevated total dissolved solids (TDS) levels in adjacent Appalachian headwater streams. This study was conducted to analyze the geochemical differences in low versus high TDS potential materials in order to predict leachate ion composition. Thirty-one vertical weathering sequences were sampled from eight surface coal mines throughout the central Appalachian coalfields. Strata were sampled down through the mining column from the soil surface through fractured, weathered rock into unweathered rock. A sample of each distinct layer was collected (for a total of 202 individual samples) and mechanically crushed to < 2mm. Deionized water was then added to each sample to form a saturated paste, allowed to sit for one hour, stirred, allowed to sit again for thirty minutes, and then extracted using vacuum filtration. The extract was analyzed for electrical conductivity (EC), mg L^{-1} sodium (Na), calcium (Ca), and magnesium (Mg) by ICP-MS, and sulfur (S) by ICP-AES. EC was used as a proxy for TDS and samples were grouped as relatively low (<0.3 dS m^{-1}), medium (0.3-1.0 dS m^{-1}), or high (>1.0 dS m^{-1}) in TDS potential for comparison. Simple linear regression of elemental concentrations against EC gave the following adjusted r^2 values for the low, medium, and high EC groups, respectively: S - 0.64, 0.56, 0.97; Na - 0.21, 0.01, 0.16; Mg - 0.28, 0.13, 0.14; and Ca - 0.26, 0.06, 0.01. Adjusted r^2 values generally increased between EC and S as the relative EC level increased. Inversely, adjusted r^2 values generally decreased between EC and Na, Ca, and Mg as the relative EC level increased. In summary, the release of some ions (e.g. sulfate-S) has a strong influence on EC at all TDS levels, but the release of other ions (e.g. Ca, Mg) exerts a stronger influence at relatively low TDS levels as sulfate release is diminished.

Additional Key Words: Electrical conductivity, weathering, sulfur, calcium, magnesium, sodium.

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ALTERNATE SEDIMENT CONTROL RULES ALLOW ACCELERATED SEDIMENT POND REMOVAL SCHEDULE[1]

William R. Kirk[2]

Abstract: The need to complete reclamation activities within a peripheral mine area of the Freedom Mine, a large surface lignite coal mine in North Dakota, prompted an accelerated schedule of sediment pond removals in order to minimize equipment access issues inherent with a typical pond reclamation timetable. The peripheral mine area is included in one surface coal mining permit that encompasses approximately 7,245 acres. The surface water management plan associated with the mining permit required the construction of 42 sedimentation ponds; the quantity dictated by numerous, incised drainages located within the mine area. Between 1998 and 2011, nine sedimentation ponds were either mined out or reclaimed; while in the past three years, 31 sedimentation ponds, including one MSHA-regulated impoundment, were reclaimed by mine personnel. Since access to the 31 pond sites would become more difficult as reclamation activities progressed, the need to accelerate the removal of these remaining sediment ponds became a critical component of the overall reclamation plan for the permit area. A proposal to State regulatory agencies to utilize alternate sediment control rules resulted in favorable responses which ultimately lead to the accelerated sediment pond removal schedule for a significant number of impoundments.

Additional Key Words: reclamation plan, equipment access, incised drainages, impoundments

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BENTHIC ALGAE, LEAF BREAKDOWN, AND LITTERFALL IN CONSTRUCTED STREAMS: THE CASE FOR RIPARIAN REFORESTATION TO REPLICATE HEADWATER ORGANIC MATTER FUNCTIONS[1]

R.J. Krenz[2], S.H. Schoenholtz, and C.E. Zipper

Abstract: Forested headwater stream fauna typically depend on riparian organic matter subsidies as basal energy resources. Constructed stream mitigations are intended to replace headwater ecosystem structure and function lost due to mining activities, however, these streams often remain de-canopied following construction. Reductions in canopy cover not only minimize litterfall income, but also increase solar irradiance and heating that can foster in-stream generation of organic matter as benthic algae. Shifting the origin and quality of energetic resources can negatively affect stream communities; therefore, facilitating reference-like organic matter dynamics in constructed streams is essential to replacing headwater ecosystem functions as a whole. During two study years (Sept. 2010 – Sept. 2012), we compared functional metrics including litterfall input, leaf breakdown, and benthic algal accrual rates between eight constructed streams and four reference streams. Additionally, we related select functional metrics to environmental variables to determine factors, which likely control these functions. Mean litterfall input to forested reference streams (561 g m^{-2} yr^{-1}) was nearly four times the constructed stream mean (142 g m^{-2} yr^{-1}). Reference stream leaf breakdown in both coarse (0.021 d^{-1}) and fine mesh (0.011 d^{-1}) exceeded constructed stream means (coarse = 0.012 d^{-1}; fine = 0.007 d^{-1}) by approximately 40%, and macroinvertebrates contributed less to breakdown in constructed streams (0.006 d^{-1}) relative to references (0.010 d^{-1}). Benthic algal accrual in constructed streams (0.046 d^{-1}) was nearly double the mean reference rate (0.025 d^{-1}), and this disparity was particularly pronounced during fall and summer. Among constructed streams, elevated temperatures were associated with breakdown and fall algal accrual rates dissimilar to reference condition, while increased irradiance likely fostered rapid summer algal accrual. Collectively, our results suggest that effective riparian reforestation may promote reference-like organic matter functions by providing stream shading, thermal buffering, and a similar quantity and quality of source organic matter.

Additional Key Words: stream restoration, stream mitigation, stream ecosystem function, periphyton accrual, organic matter dynamics.

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APPLICATION OF REMOTE SENSING FOR MINE REVEGETATION MAPPING IN THE FIRE AFFECTED AREAS OF JHARIA COALFIELDS, INDIA: A CASE STUDY [1]

Pradeep Kumar[2], and Rajesh K Chopra

Abstract:

Problem Statement: Application of Remote Sensing for Mine Revegetation Mapping in the Fire Affected Areas of Jharia Coalfields, India

Application of remote sensing technique for accurate mapping of mine vegetation in the fire affected areas has increasingly become an issue of vital importance. This is especially true for the Jharia Coalfield, about 250km to the west of Kolkata, India, which is an exclusive storehouse of prime quality coking coal as well. This sickle shaped coalfield, having an area of about 450 sq km, occurs in the form of a basin and is truncated with a major boundary fault on the southern flank. In this Coalfield, an estimated 1800 million tons of coal resources are blocked due to mine fires. The first fire was detected, in 1916, in the Khas Jharia mines.

Methodology: In this work, we have studied the use of thermal infra-red data for coal fire detection and mapping over a period of about 5 years, and used satellite imagery to develop a model for quantifying fire dynamics, and the rate of fire movement. We have also integrated remote sensing analysis with GIS/GPS for developing a geo-referenced digital database for this Coalfield.

Results and Conclusion: Based on the above, we have signposted a way toward developing an environment-friendly strategy for the revegetation of the fire affected mines of this region as it is apprehended that if the long-term plan of the coalfield is not seen in proper perspective, the coalfield, after about 30 years, will probably be deserted, having smoking mine fires, inundated underground mines, large subsided areas, unreclaimed open pits & overburden dumps of various shapes and sizes. On a hindsight, we have delved into the efficacy of remote sensing technique for accurate mine vegetation mapping in this fire affected Coalfield.

Additional Keywords: Satellite Imagery, TIR data, Mine Fire, Revegetation

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MCKINLEY MINE: A COMMITMENT TO STABLE LAND FORMS UTILIZING GEOMORPHIC PRINCIPLES[1]

Scott Motycka[2], and Kyle Kutter

Abstract: McKinley Mine is a surface coal mine located in western New Mexico. Coal production began in 1962 and ceased in 2009, leaving extensive lengths of final pits and highwalls, areas of ungraded spoil, areas where reclamation had been performed using conventional reconstruction methods, and large areas of undisturbed watersheds that contributed stormwater runoff to the disturbed area.

Conventional reclamation at the mine had utilized terraces and down drains to create stable landforms, which have traditionally required long-term maintenance. A move to geomorphic reclamation was made to introduce topography during the final grading that resembled that of pre-mining topography in order to create a final landform with long-term stability and sustainability, requiring minimal long-term maintenance. An added benefit is that the final reclaimed land conforms to the look of the pre-mine land and is ascetically pleasing.

A combination of post-mining topography and hydrologic control structures were designed to reconstruct stable reclaimed watersheds. A multi-computer program design approach enabled geomorphic topography to tie into watershed slopes and concentrated flow features at adjacent undisturbed and previously reclaimed areas. The use of various hydrologic control structures (unlined and armored channels, drop structures, loose rock check dams, small depressions and sediment control ponds, etc.) provided stable conveyance of concentrated stormwater flow onto, within and from the reclamation.

Several years have passed since the final reclamation activities have been completed and vegetation has been established. The reclaimed areas are showing great results and should require minimal maintenance during the extended responsibility to leave a world-class product for future generations to enjoy.

Additional Key Words: Additional support was obtained from Mary Siemsglusz, P.E. Associate and Senior Consultant, Frank Rivera, P.E. Senior Consultant, and David Burris, EIT Project Engineer of Golder Associates, Inc.

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EVALUATING THE IMPACT OF NA-SO_4^{2-} DOMINATED IONIC STRENGTH ON TRACE METAL REMOVAL IN VERTICAL FLOW BIOREACTORS[1]

J.A. LaBar* and R.W. Nairn[2]

Abstract: Vertical flow bioreactors are used to remove trace metals from mine drainage through a variety of mechanisms. Some or all of these mechanisms may potentially be impacted by non-traditionally examined qualities of mine drainage, such as ionic strength. A laboratory column study was performed with two sets of bioreactors containing spent mushroom compost and being fed either "low" ionic strength (~10^{-3} M) or "high" ionic strength (~10^{-1} M) influent. Both influents contained approximately the same concentrations of five divalent trace metals Cd, Mn, Ni, Pb, and Zn, with target initial concentrations of 0.50 mg/L. Effluents from all columns were collected every two weeks for one year and analyzed for total and dissolved metals, sulfate, sulfide, alkalinity, pH, DO, ORP, and conductivity. Both sets of bioreactors were successful at decreasing concentrations of Cd, Ni, Pb, and Zn by >75%, with the "high" ionic strength effluent consistently exhibiting lower concentrations of Cd, Pb, and Zn than the "low" ionic strength effluent. The "low" ionic strength columns, however, were significantly more effective at removing Mn, with an average 60% removal while the "high" ionic strength columns removed <15% Mn on average. Volume adjusted removal rates for Cd, Pb, and Zn in the "high" ionic strength columns were 78.5, 79.6, and 72.8 mg/m^3·d, respectively, and 77.1, 71.7, and 67.8 mg/m^3·d in the "low" ionic strength columns. Conversely, removal rates for Mn and Ni were 52.4 and 72.7 mg/m^3·d, respectively, in the "low" ionic strength columns and 9.8 and 66.0 mg/m^3·d in the "high" ionic strength columns. Differences in removal rates are likely due to differential effects on removal mechanisms, such as sorption, complexation, carbonate formation, and sulfide precipitation. Increased ionic strength appears to have both positive and negative effects on trace metals removal in vertical flow bioreactors.

Additional Key Words: Passive treatment, removal mechanisms

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ONE STEP FORWARD – TWO BACKWARD: EVALUATING AND MEASURING ECOSYSTEM FUNCTION AND COMPLETION CRITERIA IN MINE REHABILITATION[1]

H. Lacy[2], D. Jasper, and S. Birch

Abstract: A multitude of process in measuring and assessing restoration, and the progress of rehabilitation over mine rehabilitation and mine waste have developed through the last 50 years. Many of these are based on systems formed from earlier times in the evaluation of natural rangeland landscapes, under grazing pressure, and in forestry and agricultural environments. Monitoring a range of parameters which relate to the biophysical functioning of the landscape and providing land managers with a relatively simple, repeatable system to provide them with a good understanding of how their rehabilitation programs are developing and performing over time – has not been easy to achieve. Selection of the correct tools for this process for mine landforms in different environments has often been a controversial process.

This paper considers the forces that create this moving tension between selection of the appropriate tools for measuring completion criteria and the roles of multiple stakeholders in that tension within Australia, and abroad, and to check in and see if there is any resolution on this matter. Many monitoring tools have become highly evolved, but are constantly subjected to challenge through emerging remote sensing technology, which offer the proposition of removing the hand on boots on the ground assessment by scientists and land managers of ecosystem function, toward electronic tools, and remote – third party evaluation.

The paper will discuss the evolution of tools such as Ecosystem Function Analysis (EFA), floral - vegetation and soil and stability assessment tools, along with remote sensing process and their current application in Australia. The paper will develop discuss the process in selection of a balanced and integrated toolbox of monitoring techniques which are efficient, cost effective and provide the necessary data to enable the land or rehabilitation manager to make informed decisions in a timely manner while progressing with their restoration programs.

Additional Key Words:

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FORAGE NUTRITIVE VALUE AND PRODUCTIVITY OF GRASS ON RECLAIMED AND UNDISTURBED LIGNITE LAND[1]

David J. Lang[2], Brandon Shankle, Jeremy Duckworth, Robert Elmore and Vitalis Temu

Abstract: Lignite lands in Mississippi occupy 400,000$^+$ acres in the upland and alluvial floodplain soil regions from Memphis, TN to Meridian, MS. Two active lignite surface mines in Choctaw and Kemper counties disturb 200+ acres of land per year that are reclaimed with suitable plant growth media (SPGM) that comes from either non-prime farmland (PFL) upland red oxidized materials or PFL that is mostly alluvial floodplain topsoil. Approximate original slopes were restored, but limited to less than 8% rather than 30%$^+$ slopes on highly eroded upland sites. Grass (forage) productivity was measured on small plots on undisturbed upland and alluvial floodplain native soils in Choctaw County, MS. Two studies with common bermudagrass (*Cynodon dactylon*) were on PFL farmland Oaklimiter (Oa) and Chenneby (Ch) soil and compared with reconstructed PFL soil. Fertilizer was applied to the undisturbed sites at 0, 200 and 400 lbs/acre of 15-5-10 after each harvest every 30-40 days, but at only one rate (400 lbs/acre) to the reclaimed site. Small samples were collected to determine dry matter yield and ground to determined forage nutritive values by near infrared spectroscopy (NIRS). Minerals were also determined by inductively coupled plasma spectroscopy (ICP). Forage yield ranged from 3000 to 10,500 lbs/acre on the undisturbed Oa site and from 3000 to 8600 lbs/acre on the Ch sites and 8000 to 9000 lbs/acre on reclaimed PFL land. Protein levels of bermudagrass were 9.9 to 11.5% growing in reclaimed soil were similar to protein levels of bermudagrass growing on undisturbed PFL at 9.4 to 11.7%. Nutrient uptake of P, K, Ca and Mg were similar between the sites. Digestibility was greater than 60% at each site indicating that productive land was reclaimed for livestock production.

Additional Keywords: Prime Farmland, Livestock Production, Alluvial Floodplains

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OCCURRENCE OF NATIVE SPECIES FOLLOWING LIGNITE MINE LAND RECLAMATION IN MISSISSIPPI[1]

David Lang[2], Victor Maddox, Judd Sanborn, and Rebecca McGrew

Abstract: Lignite coal is removed from nearly 100 acres of upland coastal plain soil in the Red Hills region of Mississippi yearly. The Ultisol topsoil is highly eroded and the substitute materials approved for reclamation include this thin layer of topsoil mixed with oxidized layers of subsoil. This mixture contains the biological activity of the existing topsoil and associated seed banks from the prior forested and cropping history of the past 100's of years. Interwoven in this landscape are narrow strips of fertile alluvial floodplain that also have centuries of past forests and cropping. All of this floodplain topsoil is salvaged and used for prime farmland reconstruction. Together, these soils and subsoils were mixed and laid out in a mosaic during the mining reclamation process in accordance with mining regulations through 2011. Initially, the reclaimed land was planted to exotic species (*Cynodon dactylon* and *Urochola ramosa*) and fertilized just once with 840 lbs ac^{-1} 13-13-13 to stimulate initial growth needed for ground cover, soil erosion control and land stabilization. Into this low level of soil fertilization and relatively weak competition is planted native loblolly pines (*Pinus taeda*) and native and exotic hardwoods such as various *Quercus* species. Within five years much of the *Cynodon* and *Urochola ramosum* species have diminished and the understory of pines is replaced by a largely native collection of volunteer plants such as *Solidago, Eupatorium, Gnaphalium, Erigeron,* and *Desmodium,* species including native grass species like *Andropogon virginicus, Andropogon glomeratus, Andropogon gerardii, Sorghastrum nutans, Panicum virgatum, Vulpia elliotea, Hordeum pusillum and Agrostis hiemalis,* among others. Strips of *Panicum virgatum* cultivar 'Alamo' were planted in a silvopasture arrangement with loblolly pines. Growth of these pines and interplanted switchgrass has been excellent with several of the abovementioned native species volunteering in the pine strips to replace the initially planted exotic species. Reclamation in 2014 has shifted to focus on more prime farmland reclamation utilizing bermudagrass hay while pines and hardwoods are still being reclaimed with red oxidized substitute soil to meet productivity requirements.

Additional Key Words: native naturalized succession, suitable plant growth media (SPGM)

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EFFECTS OF QUARRY TREATMENT ON THE ATTRACTIVENESS OF RECLAIMED LIMESTONE QUARRIES[1]

Israel A. Legwaila, Eckart Lange, and John Cripps

Abstract: Establishment and operation of quarries causes a number of different environmental impacts. The most important of these affects the visual quality of landscapes. It is caused by the destruction of the visual form and character of a landscape. When reclaiming the quarries and based on their intended after-use, different treatments can be applied which in-turn can elicit different responses from people based on their attractiveness.

This study sort to establish the effects of quarry treatment on people's perceptions of the attractiveness of reclaimed quarries. Ten scenarios of reclaimed quarries representing four different quarry treatments (backfilling, bench planting, natural recovery, and restoration blasting) combined with three common after-uses (agriculture, woodland, nature conservation) were simulated using Simmetry 3D. From the simulations, fifty still images were captured and used as visual stimuli in a survey of seventy student of the University of Sheffield. Participants were asked to rate the images on attractiveness on a scale of 1 – 5, (1 being "very unattractive" and 5 being "very attractive").

Overall, it was found that participants liked reclaimed quarry landscapes that contained water and trees more than those that had plain landscapes with highly visible quarry rock faces. Quarries with woodland (3.35) after-use and restoration blasting (3.37) treatment were found to be more attractive while those that went through natural recovery (2.90) were least attractive. However, there was no significant difference between agriculture and nature conservation as well as nature conservation and woodland after-uses. There was also no significant difference between backfilling and restoration blasting treatments. It was therefore concluded that even though participants preferred landscapes with trees and water in reclaimed quarries, they also liked to see glimpses of the quarry wall as a sign of industrial archaeology. This knowledge provides an opportunity to treat selectively different parts of quarries as such providing different after-uses within the quarry. It provides an opportunity for judicious use of fill material for purposes of re-vegetation in the different parts of the quarry.

Additional Key Words: restoration blasting, bench-planting, reclamation, limestone

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DELINEATION OF SURFACE COAL MINING AND RECLAMATION HISTORY IN APPALACHIA USING SATELLITE IMAGERY[1]

Jing Li [2], Patricia F. Donovan, Carl E. Zipper , Randolph H. Wynne, and Adam J. Oliphant

Abstract: Surface mining disturbances have attracted attention globally due to extensive influence on topography, land use, ecosystems, and human populations in mineral-rich regions. Development of remotely sensed data series, such as those generated by Landsat satellites, and emerging analysis techniques for such data make it feasible to reconstruct regional mining and reclamation histories. Our goal is to produce a 28-year disturbance history for surface coal mining for the southwestern Virginia segment of eastern USA's central Appalachian coalfield. Leaf-on Landsat satellite images for 24 growing seasons over the 1984-2011 period were obtained. The method was developed and applied as a four step sequence: vegetation index selection, persistent vegetation identification, mined-land delineation by year of disturbance and re-vegetation trajectory classification. The overall classification accuracy and Kappa coefficient of mining disturbance date were 0.9029 and 0.8892, respectively. Most surface coal mines were identified correctly by location and by time of initial disturbance. Approximately 10 percent of Southwestern Virginia's, Appalachian coalfield area was disturbed by surface coal mining over the 28-year study period. Approximately 20 percent of the Appalachian coalfield surface within the most intensively mined county (Wise County) was disturbed by surface coal mining over that same period. Analysis of vegetation-index trajectories for mined lands in years following the mining disturbance revealed conditions that extend from persistent bare ground to fully vegetated. Information generated by these analyses can be applied to gain further insight concerning mining influences on terrestrial ecosystems, water quality, other essential environmental features; to improve understand of post-mining ecosystem recovery on a regional scale; and to inform mining and reclamation policy development.

Additional Key Words: Change Detection; Disturbance/Recovery Trajectories; Landsat; Remote Sensing

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EVALUATION AND RESTORATION OF PASSIVE TREATMENT SYSTEM PERFORMANCE IN PENNSYLVANIA[1]

R.M. Mahony[2], D.A. Guy, C.F. Denholm, T.P. Danehy, C.A. Neely, S.L. Busler, and M.H. Dunn

Abstract: Passive treatment systems have been successfully treating abandoned mine drainage since the technology was developed in the late 1980's. Since that time, over 300 publicly-funded passive treatment systems have been installed throughout the bituminous and anthracite coalfields of Pennsylvania. As the treatment systems mature and for various other reasons, a decline in overall system effectiveness in a portion of these projects has been noted. In 2010, a Pennsylvania Department of Environmental Protection grant allowed Stream Restoration Incorporated to provide watershed groups, nonprofit organizations, and government agencies with technical assistance related to the monitoring, operation, and maintenance of passive systems across Pennsylvania. To date, approximately 34 systems have been evaluated with maintenance being conducted on select systems as needed to improve performance. Maintenance activities have included replacing broken valves, cleaning clogged pipes, stirring treatment media and washing limestone aggregate. An overview of the improvement efforts along with monitoring data for select systems will be presented to demonstrate the increase in treatment performance after maintenance activities were conducted including De Sale Phase 2 (Butler County), Bear Run #1 (Indiana County), and Dents Run 3895 (Elk County). In some cases, minor design improvements were needed while other sites had issues stemming from system installation, accumulation/plugging of metal precipitates, and other items including broken valves. The experience gained from identifying and addressing long-term performance issues can lead to improved design of future systems as well as help numerous government agencies and watershed organizations sustain water quality improvements through implementation of practical, cost-effective practices.

Additional Key Words: Water Treatment, Acid Mine Drainage, Operation & Maintenance, Vertical Flow Pond, AMD, O&M

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Prediction of Acid-Producing Potentials for Coal Overburden and Waste by Static Geochemical Methods[1]

Louis M. McDonald[2], Mingliang Zhang, Jeff Skousen, and Zhenqi Hu

Abstract: Acid mine drainage (AMD) is one of the most severe environmental issues facing the mining industry. Characterized by high concentrations of acidity, heavy metals and sulfate, AMD causes severe environmental contamination and ecological degradation when not controlled or treated. Therefore, the prediction of acid producing potential before mining is critical to minimize the impacts and manage sulfide bearing mine wastes. AMD production potential in several coal mine overburden and refuse materials from the USA and China was determined using the acid base accounting (ABA) and net acid generation (NAG) techniques, and compared to a 14-week kinetic leaching test. The neutralization potential (NP) determination in ABA begins with a subjective evaluation of the carbonate content (fizz rating) that prescribes the amount and concentration of acid to be added to a ground sample before back-titration. Sixteen of the samples were treated with the assigned, next larger and next smaller fizz rating solution. Solution pH and Al, Fe, Ca, Mg, K, Na and Mn concentrations were determined. There was generally good agreement between the ABA and NAGpH methods to assign acid production potential and both compared favorably with the kinetic leaching test results. Using a higher fizz rating (which meant adding more acid for reaction) resulted in larger NP estimates, and higher Al and Fe concentrations of the initial solutions. Consistency between the results from the kinetic leaching tests and static tests (ABA, NAG pH) indicated that static geochemical tests are suitable for preliminary evaluation of AMD potential and identify samples with either high acid- or alkaline-producing potential.

Additional key words: coal waste; overburdens; acid-base accounting; net acid generation; acid mine drainage prediction

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METHODOLOGY FOR APPLYING GEOMORPHIC RECLAMATION TO EXESS SPOIL FILLS IN WEST VIRGINIA[1]

Peter R. Michael[2], Leslie C. Hopkinson, Nathan DePriest, and John D. Quaranta

Abstract: A methodology for applying geomorphic landform design principles to excess spoil fills in West Virginia was developed and evaluated. Although successful in the southwestern United States, challenges to applying geomorphic reclamation to steep-slope terrain in Central Appalachia were previously identified: (1) regulatory agencies' current intent to limit the down-gradient reach of excess spoil fills; (2) the challenge of designing and constructing "natural" landforms that are stable in a youthful, erosional landscape. The methodological approach presented in this paper addresses these challenges. This approach was carried out in a case study and then analyzed with respect to fill volume, channel stability, and landform stability. Potential ecological improvements over the conventional design resulted from preserved stream length and greater diversity in slope gradient and aspect. However, none of the geomorphic designs generated satisfied all evaluation criteria simultaneously or complied regulations governing the placement of excess spoil.

Additional Key Words: landforming, natural landscaping, stream restoration, mine reclamation, excess spoil fills, valley fills, durable rock fills.

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CASE STUDY: WASTE CHARACTERIZATION OF AN ABANDONED URANIUM MINE USING GAMMA SURVEYS AND XRF FIELD SURVEYS[1]

A. Orechwa[2]

Abstract: Extensive uranium strip mining from lignite reserves took place in the North Cave Hills complex at Custer National Forest located in South Dakota, United States during the early 1960s in an effort to supply uranium to the U.S. government. Over 250 acres of radiologically affected land has been identified as a non-time critical CERCLA removal action by the U.S Forest Service and the U.S. Environmental Protection Agency in 2007. Risk-based soil cleanup levels were established for contaminants of concern found at the site. Numerous scientific studies have been conducted at this site, but none have utilized the combination of the techniques identified within this paper. This study characterized the physical surficial extent of heavy metal and radionuclide concentrations of the surface soils at six study areas using advanced double sampling techniques. An X-ray fluorescence (XRF) field survey was performed on a baseline grid system at the study areas, these measurements were correlated to laboratory confirmation samples in order to provide definitive estimates of heavy metal concentrations including uranium, molybdenum, and arsenic. Similarly, a mobile GPS-integrated radiation detection systems were used to collect gamma readings over each study areas. Gamma radiation signatures were then correlated to predict the radium-226 soil concentrations in spoils and mine waste at each study area. Advanced GIS geostatistical interpolation techniques, in addition to environmental monitoring statistics, were applied to the large data sets, and final soil cleanup boundaries were developed for the removal action design. The data collected during this study have been used to develop a site wide removal action strategy and engineering design plans.

Additional Key Words: radiation, soil prediction, removal action, mine reclamation, arsenic, radium, kriging, spatial interpolation, abandoned mine cleanup, superfund, CERCLA, USFS

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IRON OXIDE ACCUMULATION PROFILING WITHIN THE INITIAL OXIDATION UNIT OF A PASSIVE TREATMENT SYSTEM[1]

L.R. Oxenford and R.W. Nairn[2]

Abstract: Iron oxidation, hydrolysis, and settling are key processes promoted in passive treatment systems to remove iron from influent acid mine drainage (AMD). Development of a solids accumulation profile for the oxidative unit of a passive treatment system provides insight into system performance and recovery/reuse applications. This study delineates the deposition profile of accumulated iron oxide precipitates over the first full five-year period (2009-2014) of operation for the Mayer Ranch Passive Treatment System receiving ferruginous lead-zinc mine drainage at the Tar Creek Superfund Site. Depth measurements of sequential, discrete core samples within the initial oxidation pond and secondary surface flow wetlands were used to map the accumulation of solids via spatial kriging, with bathymetric verification as a secondary method. *In-situ* water measurements included pH, temperature, specific conductance, dissolved oxygen, and oxidation-reduction potential; turbidity and total alkalinity were measured and water samples were collected for laboratory determination of total and dissolved metals (EPA methods 3015 and 6010), sulfate concentrations, and the settling rate of solids. The physical and chemical characteristics (point of zero charge, of selected core samples were evaluated for local and bulk phase material characterization via spectrometric and gravimetric methods (color, density, surface area, shape, composition, point of zero charge, % crystallinity, % water content, % organic content) as well as SEM microscopy. Accumulation profile mapping, supported by seasonal iron removal profiles (Jan, Apr, Jul, Oct) during 2009-2012 and iron particulate transport dynamics (2012-2014), provide a comprehensive view of iron oxyhydroxide dynamics within the initial oxidative unit of a passive treatment system for long term system management.

Additional Key Words: iron oxidation, solids transport and accumulation, Tar Creek

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IDENTIFYING AND RESOLVING PASSIVE TREATMENT SYSTEM HYDROLOGIC OPERATION AND MAINTENANCE ISSUES[1]

B.J. Page[2], N.L. Shepherd, and R.W. Nairn

Abstract: By definition, passive treatment systems are designed to require limited operation and maintenance commitments. However, these systems do require periodic maintenance. The Mayer Ranch Passive Treatment System near Commerce, Oklahoma, part of the Tar Creek Superfund Site and Tri-State Lead-Zinc Mining District, was completed in late 2008. The system has demonstrated consistent and significant water quality improvements, despite limited elevation head differences through the gravity-driven series of ten process units. Recently, hydrologic and hydraulic concerns impacting system operation have arisen. Surface water elevations in the initial oxidation pond (cell 1), parallel surface flow wetlands (cells 2N and 2S) and parallel vertical flow bioreactors (VFBRs, cells 3N and 3S) increased above design elevations. It appeared that elevated surface water levels in the VFBRs resulted in "stacking" of water in upstream process units (C2N, C2S and C1). After identification of issues, seven pressure transducers were deployed throughout the system to help identify and quantify potential sources of and changes in water level elevations. Pressure transducer data indicated that the likely cause of elevated C1 water levels was partial blockage of an effluent pipe. To address that issue, an innovative solution was developed to jet out the connections between Agridrain structures and associated pipes. VFBR hydraulic problems were determined to likely be due to decreased hydraulic conductivity of the treatment media (spent mushroom substrate/wood chips/limestone sand) and/or perforated drain system. The treatment media likely needs to be "stirred" and rejuvenated. To help alleviate problematic water level elevation issues associated with the VFBRs, a temporary siphon system was implemented that bypassed a portion of the flow to the next process units.

Additional key words: hydraulics, water levels, surface water elevations, hydraulic conductivity

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APPLICATION OF LOW SLUMP GROUT TO INCREASE STABILITY OF KARST NETWORK[1]

Brad S. Petri[2], and Nathan T. Rouse

Abstract. A significant near-surface karst network was uncovered during the excavation of a reclaim stockpile area for a new underground limestone mine. This network, which occurred on a limestone / shale contact zone, was mapped to determine the severity and possible influence on the surface infrastructure. It was found that a portion of the network was directly under the location of the primary conveyor drive tower. The drive tower, a critical component of the conveyance system, was designed to carry a substantial load. Therefore, an analysis was performed to determine whether the karst features would affect the stability and safety of the drive tower. In order to quantify this possible impact, a 2-D stress analysis was performed using Rocscience Examine 2D. This analysis included section cuts oriented longitudinally and perpendicularly to the centerline of the conveyor. Field observations identified the need to reduce the impact of weathering on the exposed shale within the karst feature directly under the drive tower. Due to safety concerns, workers were not permitted to enter the karst features; therefore, remediation work was completed from a safe distance. The chosen remediation method included pumping low slump cementitious grout 50 ft. into the karst feature to create a floor-to-roof dam. Once the dam was created, the remaining karst void under the drive tower was filled with flowable, high slump concrete. The concrete provided supplemental support to the in-situ rock while preventing the shale in the karst feature from slaking due to environmental influences.

Additional Key Words: Mining, limestone, shale, conveyor, excavation, rock mechanics, remediation, stability, concrete.

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ANIMAL WASTE AND FGD GYPSUM EFFECTS ON BERMUDAGRASS AND SOIL LEACHATE NUTRIENT CONTENTS[1]

J. J. Read[2], A. Adeli, D. J. Lang, and N. R. McGrew

Abstract: In previous experiments on newly relcaimed coal mine soils in northeastern Mississippi, applying 22.4 Mg poultry litter ha^{-1} yr^{-1} enhanced bermudagrass (*Cynodon dactylon* L.) biomass and selected soil quality parameters. Additionally, co-application of 11.2 Mg ha^{-1} FGD gypsum and litter reduced soil bulk density by 9% and increased cation exchange capacity by 9% and organic C by 25%, as compared to litter only. Apparently, organic (manure) and inorganic (gypsum) amendments in these replicated plots (3.7 x 12.2 m) improved soil physical and chemical properties which may in turn influence the nutrient cycling and leaching. Objective of this follow-on study was to determine the fate of applied N and P in forage biomass (kg ha^{-1}) and in soil leachate in summer 2013 and 2014. Four treatments of 896 kg ha^{-1} NPK fertilizer (13-13-13), 22.4 Mg ha^{-1} poultry litter; 22.4 Mg ha^{-1} swine compost, and litter + FGD gypsum were split-applied without incorporation in May and August 2013 and 2014. Leachate water was collected periodically at 60-cm depth using suction lysimeters, and contents of inorganic N (nitrate + ammonium) and total P expressed as the product of volume and nutrient concentration (mg L^{-1}). Average P load was greatest with poultry litter and least with NPK fertilizer. Among litter-amended plots, somewhat greater forage biomass in 2013 than 2014 (4.8 vs. 4.3 Mg ha^{-1}) was associated with low leachate P content of approximately 51 x 10^{-6} g on 18 June and 16 x 10^{-6} g on 25 July, as compared with 130 x 10^{-6} g in June and 97 x 10^{-6} g in July 2014. In contrast, leachate N content on these dates was not affected by changes in forage biomass and values in 2013 and 2104 were approximately 162 and 68 x 10^{-6} g, respectively. This study addresses factors contributing to variability in N and P leaching.

Additional Key Words: composted pig mortalities, forage dry matter, nitrogen, phosphorus, poultry manure, rooting zone.

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EFFECT OF LEACHING SCALE ON PREDICTION OF TOTAL DISSOLVED SOLIDS RELEASE FROM COAL MINE SPOILS AND REFUSE[1]

L.C. Ross[2], W.L. Daniels and C.E. Zipper

Abstract: Modern surface coal mining in the Appalachians drastically disturbs and alters the landscape and frequently elevates total dissolved solids (TDS) levels in receiving streams. Previous research efforts have used a simple column method to study TDS elution from various mine spoil and refuse samples. However, the applicability of these laboratory column predictions to the field has been questioned. The objective of this study was to assess the column method relative to larger scale experimental leaching vessels using one mine spoil and two coarse coal refuse samples. A typical non-acidic mine spoil sample from SW Virginia was crushed to $\leq$ 1.25 cm and placed into PVC columns (~ 10 cm x 40 cm) in the laboratory, and leached unsaturated with simulated acidic rainfall. The same mine spoil was also placed into larger "mesocosms" (~1.5 m^3) at run-of-mine size consist and barrels (~0.1 m^3; screened to $\leq$ 15 cm) and allowed to leach under natural environmental conditions for two years in the field. Similarly, two coarse coal refuse samples were leached in columns and barrels. Leachates were analyzed for pH, electrical conductivity (EC) and ionic composition. Two-year field leaching results confirmed that the column method was a reasonably accurate predictor of TDS release from the mine spoil relative to the two larger leaching scales examined. However, there were significant differences at times during the study, including during initial peak TDS elution (e.g. 1,750 µS cm^{-1} from columns cs. 2,250 µS cm^{-1} from mesocosms), likely due to spoil preparation methods and exposure to natural field leaching conditions. Field leaching also produced a distinct seasonal EC pattern (e.g. subdued late summer peaks) not observed in the columns. In contrast, significant differences were seen between the column and barrel leachate parameters for the coarse coal refuse samples that were counterintuitive.

Additional Key Words: Electrical conductivity, leaching columns, mesocosms

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GREEN REMEDIATION OF ACID MINE DRAINAGE IMPACTED WATER USING AN INDUSTRIAL BYPRODUCT: FILTER-COLUMN STUDY[1]

A. RoyChowdhury[2], D. Sarkar, R. Datta, and Y. Deng

Abstract: Acid mine drainage (AMD) pollution is a major environmental concern, in surface mining sites, worldwide. AMD is a metal-rich acid solution, which, if left untreated severely damages the aquatic system. Existing AMD treatment technologies are mostly expensive and/or time consuming, and not environmentally or ecologically sustainable. This study used the metal binding and acid-neutralizing capacity of an industrial by-product, namely drinking water treatment residuals (WTRs), to treat AMD water collected from the Tab Simco coal mine in Carbondale, Illinois. The ultimate objective of this study is to design a filter media using locally generated aluminum (Al) and calcium (Ca)-based WTRs to remove contaminants from AMD water, and neutralize its acidic pH. WTR-filter bed-columns were prepared using 15 cm x 2.54 cm clear PVC pipes. Based on our previous hydraulic test results, WTRs were mixed with sand, at 1:6 ratio, to increase the permeability of the filter media. Al- and Ca-WTRs were mixed at 1:1 ratio. AMD water was passed through the column at a flow rate of 15 mL/min. The filter bed had a volume of 53 mL, and representative samples were collected from different bed volumes up to 24 hr. Preliminary results showed that the WTR filter bed removed 99.7% of the initial Fe conc. (137 mg/L), 94% of the initial Ni conc. (4 mg/L), 96% of the initial Zn conc. (11 mg/L), 98% of the initial Pb conc. (10 mg/L), 100% of the initial As conc. (5 mg/L), and 99% of the initial Cu conc. (4 mg/L) from the AMD water. Also an increase of pH from 2.07 to 6.15 was observed during this study. Scaled-up studies are ongoing. Our results demonstrated that this "green" (recycling of a waste product), inexpensive (raw materials obtained free-of-charge), and environment friendly method has the potential to effectively treat AMD-impacted water.

Additional Key Words: Water Treatment Residuals (WTRs), Passive AMD Treatment

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SOIL AND WATER QUALITY IN AN AMD-IMPACTED ABANDONED MINE SITE IN SOUTHERN ILLINOIS[1]

Abhishek RoyChowdhury[2], Dibyendu Sarkar, Rupali Datta, and Yang Deng

Abstract: Acid Mine Drainage (AMD) pollution is one of the largest environmental problems associated with mining areas. Due to the complex nature of AMD, and its array of consequences, reclamation of AMD impacted soil and water is always a challenging task. Site characterization is the first step towards an appropriate reclamation approach, as site specificity plays a vital role in AMD generation. This study was focused on the Tab-Simco site, an abandoned coal mine located 6 miles southeast of Carbondale, Illinois. Between the years 1890-1955 this area was affected by underground coal mining, followed by surface mining in the 1960's and 1970's. In 1996, the Tab-Simco site was reported as one of the most highly contaminated AMD sites in the mid-continent region. The objective of this study was to collect the AMD impacted soil and water samples from different locations of the Tab-Simco site, and characterize them to develop an effective reclamation approach. Soil and water samples were analyzed for pH, electrical conductivity, RCRA 8 metals, and total Al, Fe, Cu, Ni, and Mn concentrations. Water samples were also analyzed for total SO_4^{2-} concentration. Soil samples were also analyzed for total S content, and Acid Base Accounting (ABA). The results of our study showed that the site was severely impacted by AMD. Average pH of soil and water samples was 2.63 and 2.07 respectively. Total S content (0.5 ± 0.01 %) and Net Neutralization Potential (-22.1 to -6.75 Kg $CaCO_3$/ton) indicated the acid producing nature of the soil type. The results also showed that AMD-impacted soil possessed high concentrations of metals like Fe (41012 ± 10 mg/Kg), Zn (419 ± 63 mg/Kg), Ni (175 ± 5.9 mg/Kg), Cr (152 ± 15 mg/Kg), Cu (148 ± 2.1 mg/Kg), Pb (145 ± 25 mg/Kg), As (127 ± 16 mg/Kg). Additionally AMD-impacted water contained high concentrations of metals: Fe (137 ± 5 ppm), As (4 ± 0.01 ppm), Zn (11 ± 0.9 ppm), Pb (7 ± 1.2 ppm), Cr (1 ± 0.04 ppm), Al (80 ± 15 ppm), Cd (1 ± 0.01 ppm), Cu (4 ± 0.05 ppm), and Ni (3 ± 0.25 ppm); and SO_4^{2-} (2481 ± 50 ppm). This study provided detailed insight, and the latest extent of the decades-long, active AMD pollution in the Tab-Simco site. Currently, our research group is developing a green remediation process of AMD impacted soil and water, and this study plays a vital role in that process.

Additional Key Words: Tab-Simco mine, Acid Mine Drainage.

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SWITCHGRASS AND MISCANTHUS YIELDS ON RECLAIMED SURFACE MINES FOR BIOENERGY PRODUCTION CAPABILITIES[1]

Steffany Scagline[2], Jeff Skousen, and Thomas Griggs

Abstract: Changes in climate and increases in environmental risks have been attributed to the combustion of fossil fuels due to global industrialization. The use of nonrenewable energy sources and their impacts on the environment and society are driving demand for development of renewable energy sources. For example, 2007 US legislation requires that 25% of transportation fuels must be made from renewable sources by 2022. Bioenergy crops that have the capability to meet these new standards are switchgrass (*Panicum virgatum*) and Miscanthus (*Miscanthus x giganteus*). Both species are warm-season perennial grasses that have high biomass production potential under low soil fertility requirements. West Virginia provides an abundance of reclaimed surface mine lands that could be used to produce bioenergy crops. This study determined dry matter yields of two switchgrass varieties (Kanlow and Bowmaster) and two miscanthus varieties (Private and Public). All species and varieties were planted in 2010 at Alton, a reclaimed surface mine in central West Virginia. This site was reclaimed in 1985 with less than 15 cm of soil being replaced over mixed overburden. Grass and legume species were planted, and soils were fertilized and limed according to regulations. Miscanthus yields after the fifth year of harvest averaged 13,700 kg ha^{-1} for Public and 16,100 kg ha^{-1} for Private. Switchgrass yields after five years averaged 7,900 kg ha^{-1} for Kanlow and 7,300 kg ha^{-1} for Bowmaster. Both varieties of switchgrass were greater than the target yield of 5,000 kg ha^{-1}, a threshold for economically feasible production.

Additional Key Words: Biomass, warm-season perennial grass, renewable energy sources, alternative energy.

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ASSESSMENT OF PERFORMANCE OF A PASSIVE TREATMENT SYSTEM OVER A TWENTY-YEAR PERIOD IN EAST CENTRAL TENNESSEE[1]

T. W. Schmidt[2] and K. Milmine

Abstract: A passive treatment system consisting of an Anoxic Limestone Drain (ALD) with approximately 6,000 tons of limestone, two basins, and two wetland cells was constructed at a reclaimed surface mine in east central Tennessee in 1995. The system was originally designed for a flow rate of 200 gallons per minute to treat total iron concentrations of 100 mg/L and meet permit effluent limits. The system performed remarkably well for approximately 15 years. Several years following construction, the flow rates peaked at more than double the design flow, which stressed the passive treatment system, but the discharge water quality targets continued to be met. In 1999/2000, a supplemental ALD system was designed and constructed to address high flow periods. In 2009, sludge cleanout was performed at the primary basin of the original passive treatment system. The sludge management was successful with nearly all of the sludge removed from the primary basin resulting in restored retention and settling capacity for the passive treatment system. Sludge was contained in the Geotubes, dried, and subsequent sold for beneficial reuse and recycling in the paint pigment industry. In 2010, NPDES effluent limits for manganese were lowered requiring upgrades to the treatment systems. The 1995 treatment system was hydraulically connected to the 2000 treatment system, manganese removal beds were installed, and additional settling capacity provided. The final effluent has met new manganese effluent limits since completion of construction upgrades in 2012.

Additional Key Words: acid rock drainage, passive water treatment, anoxic limestone drain, manganese, AMD, ARD

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BIOREMEDIATION OF SELENIUM IN VALLEY SEEP COAL MINING EFFLUENTS USING CHAROPHYTES (STONEWORTS)

Robin W. Scribailo[2], Margarete Kalin**,** and William N. Wheeler

Abstract: Charophytes or stoneworts occur naturally in alkaline waters of high conductivity throughout regions of the United States and the chemical and physical parameters that support the growth of these algae are relatively well understood. Charophytes have been demonstrated to effectively reduce concentrations of many cations as well as Ra-226, U, and As in mine waste water ponds. The biomass, anchored in the sediment, forms dense underwater meadows that trap suspended solids and provide a large surface area for the adsorption of dissolved contaminants. Selenium, which is a major contaminant of concern in waste streams, is chemically similarity to As, and therefore should be effectively adsorbed to charophyte biomass. This application was studied in alkaline effluents generated from mountain-top coal mining operations in West [2]Virginia. Four (4) valley seep ponds were initially chosen for study. Two of these ponds supported natural stonewort populations. Effluent and stonewort biomass were collected and analyzed to estimate Se removal capacity. In those ponds with stoneworts, Se concentrations in the effluent were up to 7 µg L^{-1} lower than inflows. Those ponds without stoneworts showed no concentration differences or increases between inflows and outflows. The Se concentrations in the charophyte biomass ranged from 2.2 to 8.0 $mg.kg^{-1}$. The stonewort biomass removed up to 0.07 g Se m^{-2} in the sparsely populated pond and up to 0.9 g m^{-2} in the densely populated pond. These observations along with an analysis of sediment cores from the ponds with stoneworts suggest that these plants may be useful in reducing effluent Se concentrations. Valley seep ponds experience extensive sedimentation, which must be removed on a regular basis. After dredging, the introduction of stonewort biomass or propagules would facilitate its rapid colonization, provide a stable sediment, control TSS, and could reduce the costs of mandatory selenium removal from these waste waters.

Additional Key words: stoneworts, charophytes, bioremediation, selenium, alkaline coal mine

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NORTHERN LONG-EARED BAT (*MYOTIS SEPTENTRIONALIS*) MANAGEMENT: INSIGHTS FROM A MULTI-YEAR STUDY AT FORT KNOX, KENTUCKY[1]

Alexander Silvis[2], W. Mark Ford, and Eric R. Britzke

Abstract: Listing of the northern long-eared bat (*Myotis septentrionalis*) as threatened likely will impact resource management activities involving forest removal or harvesting in the eastern United States. Unfortunately, little research directly has focused on roost conservation measures for this species. We conducted a large-scale manipulative experiment on the impacts of roost removal on the northern long-eared bat on the Fort Knox Military Reservation, Kentucky that has yielded valuable insights for conservation of this species. In particular, our targeted roost removal experiment provides preliminary evidence that loss of a single primary roost may not negatively impact colony social structure, roost selection, or spatial location. In contrast, we found evidence that loss of a ~25% of secondary roosts may cause colony fragmentation, but not necessarily change colony spatial location or pattern of space use. Secondarily, our data provide some guidance for documenting maternity colony size, number of roosts used, and spatial extent. We found that the number of roosts located per individual bat was positively related to the number of days a bat was tracked (mean tracking period = 5.7 ± 1.4 days), but that averaged across colonies, there were diminishing returns to tracking >10 bats with regard to number of roosts located. Our data also suggest that though distances moved between sequentially used roosts are positively related to reproductive condition, a buffer of 1.5 km around any located roost would provide coverage for all roosts used by an individual colony.

Additional Key Words: roost removal, roost loss

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MANAGING CLOSURE AND RECLAMATION LIABILITIES: CLOSING THE GAP – AND IMPROVING THE PROCESS

M. Slight[2] and H.W.B Lacy

Abstract: In recent times, with the global mining industry's focus on Sustainable Development there has been a significant focus on mine closure and reclamation performance and reporting through the development of the International Council on Mining Metals (ICMM), the Global Reporting Initiative and the Equator Principles. In addition financial reporting obligations under International Financial Reporting Standards and the Sarbanes Oxley Act have also lead to better understanding and improvements with industry closure performance, liability management, and reporting.

Under these sustainable development principles and financial reporting obligations, mining companies are required to consider mine closure planning and associated cost estimates across all life cycle phases of the mine. Internal processes have been developed within mining companies to better understand their closure liabilities and obligations and likely costs and cost estimating processes are generally developed for long term life of mine (asset) planning and budgeting, financial reporting for corporate balance sheet provisioning purposes, and regulator reporting for environmental bonding and financial assurances.

These days mining companies need to plan for, prepare, and actually mine for closure right from the start of a project. This means that their closure and reclamation liabilities throughout each stage of the mine life cycle phases; exploration, during feasibility studies and mine construction, start up and operations through to the last day of production and beyond must be understood, planned for, managed and controlled.

This paper will discuss how these closure liabilities are calculated, how they are utilised internally within an organisation and what must they deliver in terms of improvement, performance, and reputation. In addition is there a real understanding of the requirements from a board, management, regulators, stock market, and stockholder level and how does company policy and standards for managing these liabilities affect transparency under these sustainability principles and financial reporting standards?

Additional Key Words: Closure liabilities, closure cost estimating, closure liability reporting and transparency.

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BIOTIC AND ABIOTIC TREATMENT METHODS FOR REMEDIATION OF LOW SULFATE AND HARD ROCK MINING-INFLUENCED WATER[1]

N.T. Smith[2], N.R. Anton, D.J. Reisman, K.S. Whiting, A.K. Frandsen, K. Saller, M.J. Fischer, R.L. Olsen

Abstract: CDM Smith completed bench-scale treatability testing to study applicability of passive or semi-passive treatment for remediation of mining-influenced water (MIW) in the Coeur d'Alene Basin, Idaho. MIW types included near-neutral, low-sulfate (approximately 40 milligrams per liter) MIW with elevated cadmium, lead, and zinc, as well as acidic water with elevated sulfate and metals. Geochemical modeling and batch testing were used to determine applicable abiotic treatment technologies. Column studies were then performed using addition of carbon dioxide followed by neutralization with limestone. Column studies were also completed to simulate biochemical reactor (BCR) treatment methods. A comparison of pretreatment of low-sulfate water through addition of gypsum or magnesium sulfate to raise sulfate concentrations, versus non-pretreated water was completed. For the acidic, higher sulfate content water type, tests included addition of ethanol, methanol, or slurried ChitoRem® to gravel-filled columns (to simulate *in situ* addition of amendments), as well as an ethanol-dosed BCR. Columns were operated continuously for a period of approximately three months, with periodic sampling and analysis of redox parameters, pH, metals, and geochemical parameters. Volatile fatty acids and bacterial deoxyribonucleic acid and messenger ribonucleic acid testing were also completed to assess the microbial community. Electron microprobe analysis was used to help ascertain metal removal mechanisms. Overall, abiotic treatment appears to be a favorable remediation technology for the low-sulfate water type, while injection of slurried ChitoRem® or an ethanol-dosed BCR performed well for the acidic MIW. The comparison of pre-treated versus non-pretreated low-sulfate water testing indicates that addition of sulfate through liquid dosing of magnesium sulfate is a viable option for generating strong sulfate reducing conditions. The non-pretreated column performed well, but did not generate strongly reducing conditions or large amounts of sulfide, and metal removal was most likely related to sorption of metals to the substrate versus precipitation of metal sulfides.

Additional Key Words: SRB

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CONSTRUCTION AND TESTING OF A LOW PERMEABILITY BARRIER USING WEATHERED MINE SPOIL[1]

Sarah Smith[2], Carmen Agouridis, and Richard Warner

Abstract. Surface mining transforms consolidated rock into a number of smaller fragments, some of which can contain selenium and high specific conductance producing constituents. When carried from the site by drainage that has interacted with problematic spoils, these constituents can have a harmful effect on the aquatic environment (e.g. $EC_{25°C}$>500 µS cm^{-1}). One method of minimizing these impacts is to isolate the problematic spoil using a low permeability barrier that can be created using standard mining equipment. Prior research by Rosa et al. (2013) found that, in a laboratory setting, saturated hydraulic conductivity values between 5.9 x 10^{-8} (low) to 3.1 x 10^{-7} (high) cm s^{-1} were achievable using weathered sandstones. No studies have been conducted examining field-based saturated hydraulic conductivity values. Because laboratory settings allow for greater levels of control than typically achievable *in situ* in the field, laboratory measured saturated hydraulic conductivity values are typically lower than those measured in the field. The objectives of this study were to 1) evaluate field saturated hydraulic conductivity levels on a low permeability barrier constructed from weathered sandstones at a surface coal mine in eastern Kentucky, and 2) compare field-based saturated hydraulic conductivity values to those obtained in the laboratory. To meet the objective of the study, a low permeability barrier was constructed using mining equipment (CAT 777 rock truck). Spoil moisture content-density relationships and spoil saturated hydraulic conductivity-moisture content relationships were developed using samples of the spoil used to construct the low permeability barrier. Three double-ring infiltrometers were installed in the low permeability barrier to measure *in situ* saturated hydraulic conductivity. Four core samples were collected from the low permeability barrier to measure saturated hydraulic conductivity in the laboratory. Preliminary results indicate that field saturated hydraulic conductivity values are similar to those measured in the laboratory. These findings suggest that a low permeability barrier can be successfully constructed from weathered sandstone using heavy mining equipment.

Additional Key Words: Proctor, hydraulic conductivity, spoil isolation.

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PRODUCTIVITY AND SITE INDEX DATA SUPPORT THE EFFICACY OF LUMINANT'S FORESTRY REFORESTATION APPROACH IN TEXAS[1]

J.P. Stovall[2], J.S. Priest, H.M. Williams, D.W. Coble, and B.P. Oswald

Abstract: Lignite coal mining in east Texas has resulted in the reclamation of thousands of hectares of forest land over the last four decades. Loblolly pine plantations are a common reclamation land use, although pre and post-mining productivity and site index (SI) have not previously been compared, as this is not required by SMCRA or the Texas Railroad Commission. At Luminant's Oak Hill and Beckville mines 72 plots were installed on loblolly pine plantations ranging in age from 2 to 32 years. Stand measurements were combined with the destructive harvest of one tree at each site to 1) create a SI model specific to these mines using stem analysis, 2) compare SI models with non-mined land and pre-mining estimates, and 3) quantify stand-level biomass productivity as compared to non-mined lands. The post-mining height-age model did not differ from non-mined lands in east Texas or the pre-mining SI estimated from the soil survey. While SI curves on the mined lands were slightly lower (e.g. 0.7 m) than those for unmined land for ages between 15 and 25 years, they displayed higher (e.g. 1.5 m) values at ages 25 – 35, indicating that mineland reclamation may actually increase carrying capacity of these sites by the end of the first rotation. Models of biomass production also indicated greater productivity than stands on unmined land at the end of one rotation, provided planting densities and density management are similar. This was in part attributed to lower stem taper on the trees on mined lands resulting in greater volume on a per-tree basis. These results indicate that Luminant has successfully restored these lands to a productivity level equal to or greater than the pre-mining condition by tailoring their reclamation and silvicultural practices to the conditions found in the western Gulf Coastal Plain.

Additional Key Words: loblolly pine, plantation forest, forest reclamation, biomass equations

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DEVELOPMENT OF ECOSYSTEM STRUCTURE AND FUNCTION ON REFORESTED SURFACE-MINED LANDS[1]

B.D. Strahm[2], B.N. Avera, J.A. Burger, and C.E. Zipper

Abstract: Forest restoration or reforestation efforts often focus on a narrow set of relatively short-term objectives that are most easily assessed based on the return of forest structure. In the central Appalachian coalfields of the United States, current reforestation efforts focus on the rapid restoration of metrics like ground cover, stem density, or species diversity. As a result, decades of research in these systems have focused on the short-term goals of improved seedling survival and establishment. The Appalachian Regional Reforestation Initiative's Forestry Reclamation Approach is one such technique that is currently promoted as an increasingly feasible and appealing option for reclaiming post-mining landscapes throughout the Appalachian region. Despite the success of such reforestation strategies, very little is actually known about the restoration of ecosystem function associated with these reforestation efforts. This study was initiated to characterize the linkages between the rates of development of forest structure and key functions associated with forest ecosystems. A chronosequence of four reclaimed and reforested stands (ages 5, 11, 21, and 30 years) and an unmined reference stand, representing the pre-mining forest condition, were identified in southwestern Virginia. Within each age cohort, three replicate stands were characterized for structural attributes including forest biomass, basal area, stem density, species composition, ecosystem organic carbon and nitrogen pools, and microbial biomass. Throughout the 2013 growing season, forest ecosystem functions such as soil greenhouse gas [i.e., carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4)] fluxes, nutrient supply/availability, and microbial activity were monitored. Results indicate that some ecosystem structural attributes (e.g., microbial biomass) rapidly return to the pre-mining condition, and that certain associated ecosystem functions (e.g., soil CO_2 efflux and nitrogen cycling) correlate strongly with the return of forest structure. However, other ecosystem functions (e.g., soil CH_4 consumption) were completely decoupled from forest structural development over the 30-year reclamation period. This research shows that while the restoration of some ecosystem functions can be tied to structural development, the return of forest structure does not necessarily imply the complete restoration of ecological function along the same time frame. Thus, restoration strategies that facilitate plant processes may be quite different from those required to restore the microbially mediated processes, which are equally important to the restoration of functioning forest ecosystems.

Additional Key Words: ecological function, forest ecosystem development, forest soils, carbon and nutrient cycling, soil respiration, microbial biomass

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ECOLOGICAL RISK ASSESSMENT OF LAND DESTRUCTION IN LARGE OPEN-PIT COAL MINE— EXEMPLIFIED FOR ANTAIBAO OPEN-PIT MINE, CHINA[1]

Q. Sun[2], Z.K. Bai, M.M. Xie, Y.G. Cao, X D. Hu, Y.Z. Jisng, and Y.Q. Lu

Abstract: Ecological risk in mining area is different from that in common area. In recent years, most researchers made ecological risk assessment from the perspective of landscape ecology and the risk of heavy metal pollution, however relatively less attention has been paid to the comprehensive risk in the coal mining area. In this paper, a comprehensive assessment model is used to explore the ER value as exemplified by AnTaiBao (ATB) open-pit mine of Shanxi province, China. First, mining area ecological risk sources are identified from two aspects, production process of the mining and land destruction type in mine area; and a typical open-pit mine ecological risk causal chain in Loess Plateau Region has been constructed. Second, ecological index based on remote sensing and land-use type was developed specially for assessing mining area ecological sensitivity. The index is combined with six indicators which were adjusted by the important ecological indicators frequently used in assessing regional ecology and special ecological situation in mining area. Third, the data of the cumulative effect evaluation of land destruction and GIS-based ecological sensitivity evaluation are applied to quantify the comprehensive value of ecological risk. The results show that: un-reclaimed dump is the highest risk area (32.91% of the total area). Due to the reclamation measures and management for many years, reclaimed dump and industrial site are stable (9.66% of the total area). However, the unscientific dump process and weak supervision caused soil and vegetation degradation, therefore, some part of reclaimed dump show a higher risk (26.46% of the total area). The open pit is the lowest risk area (30.97% of the total area). It's helpful to take the corresponding management level and constructing the preventive measures according to the risk value of different area. This study helps to improve the effectiveness of land reclamation and land management in the open-pit mine.

Additional Key Words: Land destruction evaluation; Ecological sensitivity assessment (ESA); Land reclamation; Prevention tactic.

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VALIDATION OF A STREAM AND RIPARIAN HABITAT ASSESSMENT PROTOCOL USING STREAM SALAMANDERS IN THE SOUTHWEST VIRGINIA COALFIELDS[1]

S.E. Sweeten[2] and W.M. Ford

Abstract: Within the central Appalachia Coalfields, the aquatic impacts of large-scale land uses are of particular ecological concern. Coal mining practices, particularly surface coal extraction and associated valley fills, both directly and indirectly effect physical stream habitat and water quality. Additionally, many residential areas in this region are concentrated in the stream valley whereby they impact stream and riparian habitat. For example, runoff and untreated sewage into area streams continue to degrade water quality. Identification and quantification of land use impacts to ecosystems are a necessary first step to aid in mitigation of negative consequences to biota. However, oftentimes quantifying physical environmental quality such as stream and riparian habitat can be quite difficult, particularly when there are time or fiscal limitations. Standard protocols such as the U.S. EPA's Stream Habitat Rapid Bioassessment Protocol have been established to be cost and time effective (Barbour et al 1999). This protocol estimates ten different stream and riparian conditions on a scale of 0 to 20. However, using estimations can be problematic due to large potential variation in the scoring depending on differences in training, experience, and opinion of the personnel doing the estimations. In order to help negate this and provide a simplified process, the U.S. Army Corps of Engineers (USACE) developed a functional assessment for streams that measures 11 stream and riparian parameters along with watershed land use to calculate three different scores, a hydrology score, biogeochemical score, and habitat score. In our study, we examined the correlation of stream salamanders to the three USACE scores. In the summer of 2013, we visited 70 sites (sampled three times each) in the southwest Virginia coalfields to collect salamanders and quantify stream and riparian microhabitat parameters. Using an occupancy analysis we found strong relationships among three *Desmognathus spp.* and the USACE scores. This finding supports the use of the USACE protocol for stream and riparian habitat assessment.

Additional Key Words: Central Appalachia; headwater streams; rapid assessment; coal mining

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GEOMORPHIC RECLAMATION DESIGN AND CONSTRUCTION OF THE TEACH AML SITE[1]

D.R. Thompson[2] and M.R. Donner

Abstract: Geomorphically stable design concepts or landform grading techniques has gained wide acceptance and has been implemented by Abandoned Mine Land (AML) programs and mining companies to reclaim sites. When applied correctly, geomorphic or landform grading technique result in diverse reclamation landscapes that blends with the native terrain to alleviate physical site hazards while also improving long-term site stability. The Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation, Mines and Minerals Bureau (Bureau) became interested in applying the landform grading technique on an AML site to determine if there were advantages to reclaiming the site using this technique over the traditional terrace and down drain technique prevalent in Iowa. The Teach AML Reclamation Project, completed during the summer of 2014, is one of the first sites in Iowa to be designed and reclaimed completely using a landform grading approach. The site is a former 1960's coal strip mine area consisting of impacted water, a pit lake, remnant highwall, spoil/overburden piles, and clogged streams that were left in place following mining activities. The site was largely devoid of vegetation and had acid generating conditions. The Project Team developed a reclamation landform design that reduced remnant highwalls, backfilled the pit lake, addressed unsuitable spoils and coal fines, re-established stream channels, and re-established grazing lands for the landowner's livestock. The pit lake was neutralized from a pH of 3.4 using hydrated lime and de-watered prior to placing backfill. Through the course of the project, approximately 164,400 m^3 of overburden and mine spoils was moved and neutralized to backfill the pit lake, reduce the highwall, construct stream channels, and mitigate the acid generating conditions. The end result is a reclamation project that alleviates legacy hazards, returns disturbed lands to productive uses, and that blends in with adjacent undisturbed areas.

Additional Key Words: Topographic Reconstruction, Landform Grading, Alternative Post-Mining Land Use, Channel Reconstruction, Iowa, Unsuitable Spoils, Acid Generating

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TOTAL DISSOLVED SOLIDS AND BIOTIC CONDITION IN CENTRAL APPALACHIAN HEADWATER STREAMS INFLUENCED BY COAL MINING[1]

Anthony J. Timpano[2], Beth Boehme, Stephen H. Schoenholtz, David J. Soucek, Carl E. Zipper

Abstract: Recent research has revealed that biotic condition (as measured using benthic macroinvertebrate community structure) is negatively associated with elevated total dissolved solids (TDS) in central Appalachian headwater streams influenced by coal mining. Since 2008, we have been conducting research to describe the biotic response to TDS in such streams. In 2008, seasonal (fall and spring) biomonitoring and water sampling were initiated in southwestern Virginia streams spanning a gradient of TDS (including reference streams), and where apparent influence from non-TDS stressors was minimal. In 2011, the monitoring network was expanded to include southern West Virginia streams, and continuous monitors for specific conductance (SC) were installed. We intensified biological monitoring in 12 streams, sampling approximately monthly from June 2011 to November 2012. Seasonal biomonitoring extended through spring 2014 and continuous SC monitoring in 25 streams is ongoing. Mining-influenced streams had ionic compositions typical of alkaline mine drainage in the region, dominated by SO_4^{2-}, HCO_3^-, Ca^{2+}, and Mg^{2+}. Streamwater SC/TDS exhibits consistent seasonal patterns characterized by autumnal maxima and spring minima during baseflows, and short-term dilutions in response to precipitation. Water SC, TDS, and SO_4^{2-} levels are associated negatively with scores for a benthic macroinvertebrate multimetric index that is used to determine Clean Water Act compliance in Virginia. Several biotic metrics, including mayfly (Ephemeroptera) richness, have varied by season consistently during the monitoring period. Significant intra-annual variation of biotic metrics including mayfly richness was observed, but differences in community structure among streams with varying levels of SC/TDS occurred consistently during the period of intensive biomonitoring. We are currently determining if continuous SC data can improve biotic-condition prediction in mining-influenced streams relative to using SC derived from conventional seasonal sampling. Continuous SC data should improve understanding of SC/TDS exposure patterns that may be driving biotic condition in the mining-influenced, elevated-TDS streams of central Appalachia.

Additional keywords: conductivity, mayflies, macroinvertebrates, major ion toxicity

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APPALACHIAN COAL MINING RELATED RESEARCH AT US EPA[1]

Brian Topping[2]

Abstract: The United States Environmental Protection Agency (EPA) has been commissioning, conducting and following independent research on coal mining practices for many years. EPA's current research falls within three main areas: the biological response to mining, methods for measuring and identifying the biological response to mining, and multipurpose projects. Research focused on the biological response to mining include understanding background and ionic stress driven macroinvertebrate drift, other macroinvertebrate responses to ionic stress, and measuring the long term effects of surface coal mining on macroinvertebrate and fish communities. Projects looking into the methods for measuring and identifying biological responses include the development of a field-based method to develop ambient aquatic life water quality criteria for conductivity. EPA's two large multipurpose research projects are in eastern Kentucky. One project focuses on watershed analysis with sampling from the headwaters to the mainstem rivers in three HUC 12s. The other multipurpose research project is investigating the differences in individual characteristics of hollow-fill siting, construction and water quality outcomes post reclamation. While EPA has many active research projects, there are still many research questions that could benefit from further study. These questions for future research fall into two main categories: better understanding conductivity and ionic stress, and studying the effectiveness of specific mining practices and their effect on the quality of the water coming off the mine site. While EPA's current research and future research questions are important, time during the presentation will be set aside for answering questions and soliciting recommendations for the most important research topics to address and opportunities to create new research partnerships.

Additional Key Words: conductivity, Appalachia

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A SHOUT IN THE DARK: BAT DETECTORS AND SIGNAL ANALYSIS SOFTWARE AS SURVEY TOOLS FOR DETERMINING *MYOTIS* SPECIES OCCUPANCY[1]

J. Tyburec and J. Chenger[2]

Abstract: Bat detector deployments are replacing physical capture efforts for bat surveys. They are being promoted as easy, efficient, and effective ways to sample habitats for species occurrence without the time, energy, effort, and training involved in identifying bats in the hand. Several permitting agencies have promoted acoustic surveys for bats and have developed guidelines for their implementation. These guidelines rely heavily upon advances in the automatic classification of echolocation recordings provided by newly developed signal analysis software programs. Unfortunately, most of these auto-classification programs are being applied to bat surveys without full knowledge of their limitations. Moreover, information inferred from the results of auto-classifier outputs do not necessarily represent reality the way a more exact science such as genotyping does. Instead, results represent a mathematical "likelihood" which is by no means a certainty. Yet often results from acoustic surveys are reported with confidence levels that are quite disproportionate to reality. Not all bats are equally likely to be detected and/or confidently identified to species. And, this is especially true with species from the *Myotis* genus. Here we present several case studies to illustrate the biases inherent in acoustic surveys, caveats when interpreting auto-classifier results, and examples of assumptions made, which are often not supported by actual field results.

Additional Key Words: bats, echolocation, *Myotis septentrionalis*, *Myotis sodalis*, acoustic recording, acoustic identification, threatened and endangered species

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COAL COMBUSTION BY-PRODUCTS AND SMCRA COAL MINES: THE CASE FOR AND AGAINST NEW FEDERAL RULES[1]

Kimery C. Vories[2]

Abstract: Placement of Coal Combustion By-Products (CCBs) has taken place at coal mines regulated under the Surface Coal Mining Control and Reclamation Act of 1977 (SMCRA) since its passage 38 years ago. The issue of the adequacy of SMCRA regulation of CCB placement has been one of the most intensely investigated subject areas related to environmental protection by SCMRA other than acid mine drainage and reforestation. These investigations have been undertaken by the U.S. Environmental Protection Agency (EPA), the USDOI Office of Surface Mining Reclamation and Enforcement (OSMRE), and the National Academy of Science.

The National Academy of Science published the results of its investigation in 2006. The OSMRE published an advance notice of proposed rulemaking March 14, 2007. Eight years later, the proposed rule is still under development by OSMRE.

The focus of this presentation is to the address the relative adequacy of these investigations and their findings as they relate to the need for additional Federal rulemaking. The presentation will show how most of the investigations to date have focused on opinion and hearsay rather than facts. The best and most useful facts, studies and information provided to date on the subject can be found in the 114 technical articles presented at six national technical forums conducted by and published by OSMRE. The presentation will point out that there seems to be universal agreement between EPA, OSMRE, and the National Academy of Science that SMCRA as it currently exists, if fully implemented, is adequate to address the concerns of CCB placement at SMCRA permitted mines. Yet to date, OSMRE has not conducted a comprehensive oversight study to determine if each of the States where CCB placement occurs is fully implementing its SMCRA program such that any inadequacy in the SMCRA rules could be determined based on the facts.

Additional Key Words: Environmental Protection, Coal Combustion By-Products, and Federal Rulemaking

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BAT USE OF CULVERTED GATES AT ABANDONED UNDERGROUND PORTALS IN WEST VIRGINIA[1]

C. Walker[2]

Abstract: Abandoned underground portals have typically been closed with conventional bat-friendly gates. However, sometimes traditional gates cannot be installed for safety or other reasons. The West Virginia Department of Environmental Protection has installed culverts (plastic or metal) with bat gates installed on the end on some of these. Due to concerns by the U.S. Fish and Wildlife Service over whether these types of gates would be used by bats, WVDEP and OSM undertook a study of these culverts. Thirty-eight culvert gates and one traditional gate were sampled using harp traps in late September and early October 2014. Six bats, including one Indiana bat, were captured at 3 sites. Bats were caught at each type of gate (plastic culvert, metal culvert, and standard gate). Airflow at the openings where bats were caught varied from low-moderate to none. Bat detectors recorded passes of non-captured bats ranging from none to 26 at capture sites. No White Nose Syndrome symptoms were recorded on any captured bats.

Additional Key Words: White Nose syndrome, Indiana bat

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SULFATE REMOVAL FROM COAL MINE WATER IN WESTERN PENNSYLVANIA: REGULATORY REQUIREMENTS, DESIGN AND PERFORMANCE: PART 1[1]

William J Walker[2], Jorge Montoy and Tyler Chatriand.

Abstract: The listing of the Monongahela River as an impaired waterway prompted the Pennsylvania Department of Environmental Protection (PADEP) to adjust aqueous discharges to the river to contain no more than 250 mg/L of sulfate. In response to this we conducted an analysis of water treatment options for a coal mining company at several non-operating mines in western Pennsylvania. The analysis reviewed cost and performance data for active and passive systems deemed capable of treating sulfate to 250 mg/L in mine water containing 3000 mg/L at an average flow rate of 1000 gpm. The review and analysis revealed that design requirements would have to include a mostly passive system that could remove metals and sulfate with minimum sludge production and yet perform in a predictable controlled manner year round with a well-defined acceptable O&M process and cost. Early experimental results allowed the mining company to enter into a consent order with PADEP to build and operate a full scale system by December 2016 and to transfer the technology to two PADEP coal mine water discharges. Part 1 will present the initial experimental results, the details of the treatment options analysis and the final design elements required for the now-operating, pilot scale ethanol bioreactors.

Additional Key Words:

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SULFATE REMOVAL FROM COAL MINE WATER IN WESTERN PENNSYLVANIA: REGULATORY REQUIREMENTS, DESIGN AND PERFORMANCE: PART 2[1]

William J Walker[2], Jorge Montoy and Tyler Chatriand

Abstract: An ethanol fed bioreactor system was designed and constructed in 2014 to remove sulfate in alkaline mine water to 250 mg/L sulfate prior to discharge. The unique design elements are described and consist of metals removal circuit, ethanol feed circuit, twin bioreactors bedded with large cobbles and seeded with sulfate reducing bacteria but containing no additional carbon source.

The pilot test was designed to treat a 10 gpm source of mine water containing approximately 3000 mg/L of sulfate, 100 mg/L Fe, and 2 mg/L Mn with a $COD/SO_4^=$ ratio of about 1.0. After only 4 weeks of operation, the bioreactors were able to achieve the testing goals.

Chemical performance to date has shown that sulfate reduction approaches 1500 mmol SO4/ m^3/day, one of the highest rates observed in the literature. Effluent sulfate ranges from 57 to 400 mg/L at 16^{o}C and about 1000 mg/L at 4^{o}C. The bioreactor produced an average of 1400 mg/L of total alkalinity. Effluent metal concentrations were; 1 mg/L Fe, 0.2 mg/L Zn and 0.01 mg/L Mn. The recirculation loop removes 90% of iron in the original settling pond prior to entering the reactors to minimize sludge accumulation.

Micro-mineralogical analysis shows Fe occurring mainly as FeS with some Fe(Zn)S and some iron oxyhydroxides. Manganese solids are primarily carbonates and are formed in the reactors where alkalinity is produced and not in the settling ponds. Material balance and species distribution for sulfur was found to be: S^o (67%) > FeS and MetalS (11%) > $SO_4^=$ (14%) > H_2S^- and $HS^=$ (g) (8%). Scheduled 2015 activities include monitoring performance with temperature and optimization of flow rate, ethanol feed, carbon source evaluation and elemental sulfur production.

Additional Key Words:

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INVASIVE SPECIES ON RECLAIMED NATIVE GRASSLANDS IN NORTH DAKOTA[1]

G.A. Welch[2]

Abstract: Kentucky bluegrass (Poa pratensis), smooth bromegrass (Bromus inermis) and crested wheatgrass (Agropyron cristatum) are becoming increasingly prevalent on native grasslands in the Northern Great Plains. These non-native cool season grasses can invade and displace desirable native vegetation on undisturbed and reclaimed native grasslands which reduces ecological condition, season-long grazing utility and wildlife value of native grasslands. Few effective methods are available to control or contain these species. North Dakota's surface coal mining regulations require that reclaimed native grasslands be established with a diverse, effective permanent vegetative cover of the same seasonal variety native to the area and at least equal in extent of cover and productivity to the natural vegetation of the area. However, North Dakota's surface revegetation success standards for reclaimed native grassland allows mining companies to account for the presence of non-native species on reclaimed native grasslands if they are not detrimental for that use.

Additional Key Words: Kentucky bluegrass, smooth bromegrass, crested wheatgrass

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SUCCESSFUL RECLAMATION OF A FLY ASH LANDFILL WITH ALTERNATIVE FUNDING APPROACH[1]

Andy Willis[2] and Bill Adams

Abstract: What started as a novel idea to economically dispose of coal combustion fly ash for a Florida Electric Utility soon turned into a high liability abandoned cross-valley embankment for a property owner and the Commonwealth of Kentucky. In 1992, Costain Coal Company negotiated a contract to send coal from its Floyd County, Kentucky operations in rail cars to a customer's Power Plant and transport the fly ash from that plant back to Floyd County in those same rail cars, which would otherwise have returned empty. The facility was constructed at a cost of $15 Million, which included both rail car dump and pneumatic rail car handling and pelletizing facilities. This arrangement worked for 8 years until Costain Coal's buyer, Lodestar Energy, filed for bankruptcy and discontinued delivery of coal and subsequent receipt of fly ash.

In December of 2010, an agreement was negotiated between the owner of the fly ash embankment, the new owner of the adjacent coal refuse facility, former investors who were identified as Potentially Responsible Parties (PRPs), MSHA and the Commonwealth of Kentucky's Energy and Environment Cabinet to safely reconfigure the pile. This agreement was contingent on the use of alternative funding from several previously involved parties outside of the normal bond forfeiture and AML system. Working in cooperation with state and federal agencies, the Stratton Branch Fly Ash Disposal site was reclaimed to effectively eliminate a potentially hazardous situation to both the environment and public safety by installing engineered drainage systems and eliminating the potential impounding capacity behind the fly ash embankment.

Additional Key Words: Coal ash, CERCLA, reclamation, AML, MSHA, hazard, impoundment, embankment, design, bond

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COMPARISON OF POINT LINE INTERCEPT AND SAMPLEPOINT DATA COLLECTION METHODS FOR TOTAL VEGETATION COVER, TOTAL GROUND COVER, AND TIME REQUIREMENTS ON RECLAIMED SITES IN WYOMING[1]

Clay Wood, Cindy Adams, and Brenda K. Schladweiler[2]

Abstract: Vegetation data collection is a crucial component of monitoring reclamation success throughout the United States. There are many different methods available to collect vegetation cover data including transects, quadrats, and aerial imagery. Although specific methodology varies between sites and objectives, point line intercept and aerial imagery are two forms of data collection that can be utilized in reporting total vegetation cover and total ground cover for evaluating revegetation success. With advances in technology, image based data collection is being used more frequently to collect various vegetation data. The use of imagery is intended to reduce the amount of time required in the field to collect data. SamplePoint was developed by the United States Department of Agriculture - Agricultural Research Service Rangeland Resources Research Unit, United States Department of Interior - Bureau of Land Management Wyoming State Office, and Berryman Consulting. This program is widely used in image processing to collect vegetation data throughout the United States.

Vegetation cover data were collected using the point line intercept method and images processed through SamplePoint from a coal mine in Northeast Wyoming. Both sampling methods were conducted along each transect with the amount of time required recorded for each sampling method, as well as the subsequent analysis. Results of the data were statistically analyzed to determine if there was a significant difference between the two sampling methods and the time required to collect data, as well as summarize it. Results of this statistical comparison will be presented.

Additional Key Words: vegetation monitoring, vegetation sampling, SamplePoint

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CHINA'S ABANDONED MINING LAND RECLAMATION SYSTEM AND BEST PRACTICES OF DIVERSIFIED RECLAMATION PURPOSES[1]

Luo Ming[2], Zhou Yan, Xiao Wen, Zhang Lijia, and Chen Yuanpeng

Abstract: Unclear condition of abandoned mining land and shortage of reclamation capital are problems confronting many countries in the world. With emphasis on the condition of China's abandoned mining land and the features of land management system in China, the first part of the paper is an introduction of China's abandoned mining land reclamation and planning system. A series of reclamation incentive policies including projects aided by financial fund, occupation-compensation quota and the balance between increase of urban construction land and decrease of abandoned mining land. Then, the paper introduces, under the guidance of planning as well as incentive polices, best practices of abandoned mining land being reclaimed for different purposes ranging from cultivated land, wetland park, to photovoltaic land and industrial park. Finally, the paper comes up with the problems and challenges in co-temporary abandoned mining land reclamation.

Additional Key Words: Reclamation Plan, Reclamation Incentive Policies, Different Reclamation Purposes, Challenges

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ECOSYSTEM EVOLUTION AND ECOLOGICAL STORAGE IN OPEN-CAST MINING AREA: A CASE STUDY OF PINGSHUO COAL MINE IN CHINA[1]

X.R. Zhang[2], Z.K. Bai, Y.G. Cao, J. Pan, and X. Fan

Abstract: Opencast mining area is greatly disturbed by human activities. Landscape change in this area caused by large-scale exploitation of mineral resources leads to the differences between ecosystem in mining area and natural ecosystem. Thus, it is necessary to study the evolution of ecosystem in mining area. Taking Pingshuo opencast coal mine in Shanxi Province, China as an example, this paper is aimed at discussing the spatial-temporal evolution of ecosystem qualitatively, and quantitatively evaluating the ecological level of the mining area. Ecological storage model based on the theory of ecosystem service value is employed. It is composed by state evaluation, process evaluation and capability evaluation, describing the ecological level of study area in aspects of static state, changes and conversion direction separately. Land use information extracted from remote sensing images in 1986, 2000, 2013 is the basic data in this study. The results show that the evolution of ecosystem in Pingshuo mining area can be divided into original fragile ecosystem, extremely degraded ecosystem, rudiment of reconstruction ecosystem, and stabilized reconstruction ecosystem. In addition, the characteristics of land use in each type are different; the ecosystem types of Pingshuo mining area include farmland ecosystem, forest ecosystem, grassland ecosystem, urban ecosystem, and industrial ecosystem, and conversions among these ecosystem types in 1986-2000 and 2000-2013. This is the result of by urban expansion, severe mining activities and land reclamation, are very active; the ESS shows a trend of deterioration, the ESP presents a reverse process, and the ESC influenced by land reclamation and eco-engineering tends to be higher. We conclude that the evolution of ecosystem in opencast mining area can be reflected by land use change; the results of ecological storage model are relatively accordance with the situation; timely and effective land reclamation and other eco- engineering can improve the ecological level of mining area.

Additional Key Words: Land use transformation; Ecosystem service value; Ecological storage state (ESS); Ecological storage process (ESP); Ecological storage capacity (ESC); Land reclamation.

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CURRENT LAND RECLAMATION POLICY AND THE FACING PROBLEMS IN CHINA[1]

Zhao shu-qin[2]

Abstract: The new *land reclamation regulations* promulgated in 2011 is more rigorous and normative on many respects, such as the obligations of reclamation obligor, demarcation of damaged land, control of the quality of reclamation land, than the old one promulgated in 1988. Land reclamation is not only a process of changing damaged construction land into arable land, but also a game process among land reclamation related people. The game is related to the process of current situation analysis and evaluation of the land reclamation, prediction of intended damaged land, evaluation of land suitability, determination of the intended reclamation types and qualities and design of reclamation project, which is closely associated with the quality of reclamation land. This paper found that in the reclamation goals link between land reclamation obligor and oblige, the reclamation technology link between author of reclamation report, reclamation obligor and government managers, the reclamation management link between reclamation obligor and local government all exist games. The establishment of land reclamation planning subject system, alternative system, reclamation security deposit system and the whole system of public participation can effectively avoid the risk facing the reclamation.

Additional Key Words: Destructed land, Prediction of intended damage to land, Land suitability evaluation, Land reclamation stakeholders, Alternative land reclamation plan

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