Soil Characterization and Identification of Native Hyper-Accumulating Plant Species for Phytoremediation[1]

A.A. Adesipo*, O.O. Awotoye, A.T. Salami, and D.J. Oyedele[2]

Abstract: Though mining (both legal and illegal) is common in most African countries, reclamation efforts remain limited. Previous studies within the contaminated gold mine sites in the southwest region of Nigeria showed its elevated heavy metal content, negative impacts on the floristic association, and identification of phytoremediation as the preferable remediation technique. For implementation purposes, the aim of study is to characterize the soil properties and identify native hyper-accumulating plants with high level of tolerance growing on three considered sites, an abandoned mining site (Site 1), an active mining site (Site 2), and an undisturbed vegetation site (Control site). Based on recommendations from previous studies, the accumulation and enrichment potential of Pb, Cd, Fe, and Cu in *Crinum jagus*, *Acanthus montanus*, *Musa sapientum*, *Theobroma cacao*, *Chromolaena odorata*, *Melochia corchorifolia*, *Melanthera scandens*, *Palisota ambigua*, and *Pteris togoensis* were determined. Soil and plant samples (leaves, stem, and roots) were analyzed for total heavy metal concentrations using AAS. Influencing soil properties; pH, Electrical Conductivity, textural class, percentage Total Nitrogen, Organic Carbon, and Organic Matter were analyzed at two soil sampling depth (0-20 and 20-40 cm). ERT using ABEM Terrameter at an electrode spacing of 1 m was done to characterize the soil subsurface structure and its heterogeneity nature. All the studied plants show high accumulation potential of Pb with extraordinarily high Fe contents. All the studied species except *Musa sapientum* and *Theobroma caca*, (which are the commonly grown crops), show high accumulating potential for all the metals, however, the hyper-accumulating efficiency of *Crinum jagus* was the most significant among all the species. On all the sites, pH, OM, OC, and total metal content decreases with soil depth. High heterogeneity was noticed in the subsurface (lower than 1 m) on both site 1 and 2, however, site 2 was more evident, and it shows presence of foreign material. Since *Musa sapientum*, and *Theobroma cacao* (the commonly grown plants) are both deep root crops, use of deep root species (tress) in combination with identified hyper-accumulating plant species is recommended.[3]

Additional Key Words: Electrical Resistivity Tomography (ERT), tropical countries, *Crinum jagus*, Bioconcentration Factor (BCF), Translocation Factor (TF), Enrichment Factor (EF).

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2. Adegbite A. Adesipo (* presenter), PhD candidate, Department of Soil Protection and Recultivation, Brandenburg University of Technology, Platz der Deutschen Einheit 1, 03046, Cottbus-Senftenberg; Olusegun O. Awotoye, Professor, Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife Osun state Nigeria; Ayobami T. Salami, Professor, The Technical University (Tech-U), Ibadan, Oyo State; and Durodoluwa J. Oyedele, Professor, Department of Soil Science and Land Resources Management, Obafemi Awolowo University, Ile-Ife Nigeria.

3. Work reported here was conducted near 7°31’30”N, 4°39’03”E.

EVALUATION OF EFFECTIVENESS AND COST-BENEFITS OF WOOLEN RECLAMATION PRODUCTS[1]

Robert Ament, Monica Pokorny, Stuart Jennings, and Eli Cuehlo[2]

Abstract: This research project developed two types of products for study: woolen erosion control blankets (ECBs) and wool incorporated into wood fiber compost at a 40:1 ratio (compost to wool, by air-dry weight). We compared the wool products' performance to standard roadside reclamation products commonly used for revegetating cut slopes: straw/coconut (coir) ECB and wood fiber compost. The primary measure for success for ECBs and the wool additive to the compost was the amount of seeded or desired vegetation established after two growing seasons. The research team evaluated the performance of the woolen and standard products by measuring the percentage of canopy cover of each plant species present in each treatment plot. To conduct the comparative analysis, researchers calculated an average percent canopy cover for each functional group: seeded native grasses, desired non-seeded (volunteer) grasses and forbs, and weeds. Although mean canopy cover of seeded grass species was higher in wood compost with wool, there was no statistical difference in the higher mean amount with only wood compost, 6.4% and 10.2%, respectively. Thus, the project could not determine that cut wool pieces provided a benefit to plant establishment and growth when it is added to compost material. Further experimentation to determine the ideal ratio of wool pieces to add to compost is warranted. The two best performing treatments (i.e. greatest mean seeded grass cover) were the rolled wool/straw ECBs. The 100% wool ECB and 50% wool/50% straw ECB had the greatest mean seeded grass canopy cover after two years. Both of these wool ECBs had more seeded grass canopy cover than the standard 70% straw/30% coir ECB demonstrating their potential as a commercially viable product for revegetation applications. Laboratory tests of the wool/straw ECB demonstrated it was comparable to the specifications of a short-term (Type II B or C) standard ECB used along roadways.

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2. Rob Ament, Road Ecology Program Manager, Western Transportation Institute, Montana State University Bozeman, MT 59717.

Land Application Disposal System Design for Biochemical Reactor Treated Effluent[1]

N.R. Anton*, D.T. Shanight, C.S. Storrar, M.J. Fischer, E.M. Janoviak, and B. Lala[2]

Abstract: Biochemical Reactors (BCRs) are becoming a more accepted technology for treatment of mining influenced water (MIW) by regulators and site owners; however, some issues remain under certain conditions with consistently meeting strict effluent discharge standards to surface water systems. These include primary metals standards and secondary standards that may apply for sulfide, biological oxygen demand (BOD), and nutrients that can be in BCR treated effluent. These secondary constituents can be problematic for aquatic systems. Post-treatment systems consisting of aeration ponds, channels, and wetlands can help to attenuate these secondary constituents; however, adequate space at remote mountainous sites may sometimes not be available, and/or there are seasonal limitations to reliance on wetland-based systems. Land application disposal (LAD) systems could be applied in these cases, which avoid direct surface water discharges and rely on surface and subsurface attenuation of secondary constituents. At the mine waste repository for the Upper Tenmile Creek Mining Area Superfund Site, Montana, collected leachate water has been managed in an active water treatment plant and pilot BCR system, with disposal to a LAD system since 2003. In 2018, design was completed for a full-scale leachate passive treatment system utilizing parallel BCR cells, post-treatment settling, aeration, limestone channels, and a gravity-operated LAD system. It is anticipated that the new system construction will begin in 2019, and the existing water treatment infrastructure is planned to be decommissioned in after the new system is operational and functional. This paper will present the critical passive treatment design components and provide details of the pre-design investigation and design approach for the LAD system, including field siting for the LAD, test pits, soil lithology logging, permeability testing, soil metal sorption studies, metal sorption capacity and water balance calculations, and hydraulic design of the LAD.[3]

Additional Key Words: mining influenced water, passive treatment, BCR post-treatment.

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2. Nick R. Anton, PE (* presenter), Environmental Engineer, CDM Smith, Helena, MT 59601; David T. Shanight, PE and Chapin S. Storrar, PE, Helena, MT, Michael J. Fischer, PE, Denver, CO, and Edward M. Janoviak, PE, and Bledar Lala, Wadsworth, OH, CDM Smith.

3. Work reported here was conducted near 46°25'17.04"N, 112°17'32.05"W.

Prediction of Optical and Non-Optical Water Quality Parameters in Oligotrophic and Eutrophic Systems Using a Small Unmanned Aerial System[1]

Juan G. Arango* and Robert W. Nairn[2]

Abstract: Continuous monitoring can not only be used to measure changes of conditions over time, but also to provide qualitative and quantitative parameters used to develop regulations, policies or guidance in order to protect those ecosystems. Traditional on-the-ground monitoring has proven to be time consuming, susceptible to errors and only to be related to single points in time and space (particularly when monitoring water quality in lakes, rivers, and streams). The purpose of this study was to create statistical water quality models for optical (Total Suspended Solids (TSS), Secchi Disk Depths (SDD) and Chlorophyll-a (Chl-a)) and non-optical (Total Phosphorus (TP) and Total Nitrogen (TN)) water quality parameters in an oligotrophic system (Grand River Dam Authority (GRDA) nursery ponds) and a eutrophic system (City of Commerce, Oklahoma, Wastewater Lagoons) using images from a small Unmanned Aerial System (sUAS) equipped with a multispectral sensor. Statistically relating optical and non-optical water quality parameters to multispectral imagery allows expansion of extrapolated water quality indicators to larger spatial databases. To develop these relationships two sets of data were acquired 1) in-situ water quality measurements and 2) the real reflectance values from sUAS imagery. These reflectance values were extracted under three scenarios: (1) a value to point extraction, using the GPS location of each sampling station, (2) an average value extraction using a buffer zone of 12 ft. (3 meters) around the sampling stations and (3) a point extraction of 162 points using the different kriged surfaces. By using a single variable and multiple variables linear modelling approach, a total of 375 linear models were created and evaluated (315=single variable and 60=multiple variables). The best-fit models were determined by the coefficient of determination (R^2) and the Akaike information criterion (AIC). Results indicate that multiple variables linear regressions in the visible portion of the electromagnetic spectrum (blue, green, and red) best describe the relationship between TSS (R^2 =0.87), Chl-a (R^2 =0.93), TN (R^2 =0.92), TP (R^2 =0.92), and SDD (R^2 =0.86). In addition, this study concluded that statistical interpolation (ordinary kriging) does not improve the relationship between the different water quality parameters and the reflectance values.[3]

Additional Key Words: Remote Sensing, Small Unmanned Aerial System, Water Quality, Optical and Non-Optical Parameters.

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2. Juan G. Arango (* presenter), Graduate Research Assistant and Doctoral candidate, and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, The University of Oklahoma, Norman, OK 73019.

3. Work reported here was conducted near 36° 34’ 08’’ N, 94° 58’ 03’’ W.

Reclamation of Abandoned Mine Lands in Conjunction with Economic and Community Development and Reuse Goals – Implementation of the 2016 AML Pilot Program in Pennsylvania [1]

Dean R Baker[2]

Abstract: The Abandoned Mine Land (AML) Pilot Program, authorized by Congress under the Consolidated Appropriations Act (signed by President Obama on December 18, 2015), provided $30 million of US Treasury Funds to Pennsylvania's (PA) AML Program for federal fiscal year FY2016. Language contained in the authorizing bill specifies that the funding be used "for the reclamation of abandoned mine lands in conjunction with economic and community development and reuse goals. State AML programs, in consultation with economic and community development authorities, shall develop a list of eligible AML projects in Appalachian counties that have a nexus to economic and community development, and select qualifying AML projects that have the potential to create long-term economic benefits." Since this is a pilot program, PA selected fourteen AML sites encompassing a wide variety of project types with a variety of possible economic or community development benefits and partners. PA allocated nearly all the AML Pilot Program funds for the construction of Surface Mine Control and Reclamation Act (SMCRA) Title IV eligible AML and AMD problems. The project partners are responsible to fund and complete non-AML economic revitalization or community development aspects of the projects. PA's 2016 AML Pilot Grant was approved on June 1, 2016 and had a three-year period of performance ending on May 31, 2019. The fourteen projects include: four AMD treatment projects; one underground mine fire project; two water supply replacement projects; one mine headframe/hoist preservation project, five surface mine reclamation projects; and one coal refuse piles removal project. The anticipated benefits include: several industrial development or business park opportunities; significant stream water quality improvement and restored fisheries; restored public lands; increased tourism; public trail development; mining heritage preservation; safety improvements and expansion of a regional airport; reforestation/restoration of American Chestnuts; expansion of a regional botanic garden; and new or upgraded potable water supplies for over six hundred homes and businesses. This presentation will discuss the completed and ongoing reclamation and/or development for each of the fourteen AML Pilot Projects as well as the success in achieving the benefits envisioned for each.

Additional Key Words: Abandoned Mine Lands (AML), Economic Development.

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2. Dean R Baker, P.E., Environmental Program Manager, Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation, Ebensburg, PA 15931.

Native Warm-Season Grasses that Germinate on Command[1]

Brian S. Baldwin, Jesse I. Morrison, and J. Brett Rushing[2]

Abstract: Native grasses are rarely used in reclamation, primarily due to seed dormancy, the lack of germination upon planting. While seed dormancy is an advantage in the wild, it is a hindrance to establishment in reclamation situations. While there are a number of laboratory methods to ameliorate seed dormancy, the effects are often reversible, or may negatively impact seedling development. This work uses standard breeding methods to decrease seed dormancy in seven important warm-season grass species native to the southern United States: upland and lowland switchgrass, big and little bluestem, purpletop, beaked panicum and eastern gamagrass. Success in meeting our objective has been excellent (0.02 to 94% germination, a 4000 fold increase) in some species and modest (1.0 to 40% and 0.067 to 20% germination, a 40 and 300 fold increase, respectively) in others. A serendipitous side effect of selection was an increase in the speed of seedling emergence, in addition to an increase in total emergence. Selection reducing seed dormancy allows for quicker emergence and stand establishment, compared to other comparable native grass varieties[3].

Additional Key Words: grass improvement, reclamation, coverage.

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2. Brian Baldwin (presenter), Professor; Jesse I. Morrison, Associate Research Professor; J. Brett Rushing, Assistant Professor, Plant and Soil Sciences, Mississippi State University, Mississippi State University, MS 39762.
3. Work reported here was conducted near 33.4504° N, 88.8184° W.

Modeling the Effects of Mass Transfer Limitations in Limestone-Based Passive Treatment Systems[1]

Joel Z. Bandstra[*] and William H. J. Strosnider[2]

Abstract: A growing body of evidence suggests that the rates of limestone dissolution and metal hydroxide precipitation in limestone-based passive treatment systems such as open limestone channels or anoxic limestone drains are governed by mass transfer phenomena at the water-rock interface. Because mass transfer limited reaction rates respond not only to the chemical composition of the water but also to local velocity fields and to the physical geometry of the rock, this introduces substantial complexity into the task of predicting treatment system performance either on the basis of process modeling or scale-up of bench-top experiments. In this paper, we couple the geochemical modeling tool, PHREEQC, with mass-transfer correlation theory developed in the contaminant hydrogeology community to explore the potential effects of mass transfer phenomena on pH evolution, alkalinity generation, and metals precipitation during treatment. We present our modeling results in comparison to data collected in both lab- and field-scale systems but we also use the model to introduce the range of phenomenological responses that could arise due to mass transfer limitation. From a design perspective, the effects of local velocity on mass transfer rate presents not only a challenge to predictive modeling but also an opportunity for design optimization. This type of opportunity has been previously exploited in permeable reactive barriers for groundwater remediation by introducing funnel-and-gate structures to achieve optimal flow velocity. In the mine drainage context, mass transfer optimization could be achieved by a mix of limestone size selection and overall system dimensions. We use the model described above to explore the nature of this optimization problem.

Additional Key Words: dissolution, precipitation, reaction rate.

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2. Joel Z. Bandstra (* presenter) and William H. J. Strosnider, Associate Professors, Environmental Engineering, Saint Francis University, Loretto, PA 15940
3. Work reported here was conducted near 40.5601° N, 78.5486° W

French Gulch Restoration – Abandoned Mine to Native Fish Habitat[1]

Matt Barnes[2]

Abstract: The restoration on French Gulch and Moose Creek was completed to support the native fisheries reintroduction goals in the Mount Haggin Wildlife Management Area, MT. This area was mined extensively in the 19th century, resulting in large remnant tailings piles and reduced aquatic habitat. These piles resulted in a confined French Gulch without connection to a functioning floodplain and lack of fluvial complexity. Sinuosity of the existing stream was near 1.0 and the average flood prone width was less than 22'. The reaches confined by tailings were also devoid of pool-tail fines spawning areas and complex wood habitat. At the Moose Creek site, remnant mining impacts were less severe but still inhibited floodplain connection. Stream reaches were identified for reference and varying levels of restoration based on the degree of impacts. Over 100 surveyed cross sections were analyzed with 1D modeling to determine channel dimensions. The restoration areas were also modeled to determine shear stress values and approximate particular areas requiring increased stability and roughness to withstand up to the 4% AC flood. The restoration design provided opportunity to accomplish much of the "lighter" restoration with volunteer and AmeriCorps crews. The more extensive restoration was completed by hired contractors with heavy civil and stream restoration capability. Partnership and continued involvement by engineers, contractors, and land managers throughout the project provided ability to overcome obstacles and to expand restoration where possible. Areas of additional remnant tailings removal were identified during construction and completed to increase flood storage and riparian connection to French Gulch. Construction was completed in fall 2016 ahead of schedule and under budget. Monitoring of stream response in 2017, a prolonged runoff year, with pre-existing, design, and post-projects data for comparison. Pre-existing and post project data were used to estimate percent reduction in sediment load in tons/year for TMDL allocations.[3]

Additional Key Words: Restoration, Mines, Tailings, Native Fisheries, Geomorphology, Construction, Habitat, Water.

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2. Matt Barnes, PE, CFM, Morrison Maierle Inc.
3. Work reported here was conducted near 45°57'5.19"N, 113°1'36.70"W

Abatement of AMD at Abandoned Coal Mines in North Central Missouri: An Overview[1]

P.T. Behum*, D. Wedemeyer*, and M. Meuller[2]

Abstract: Missouri Department of Natural Resources, Land Reclamation Program has conducted three large acid-mine drainage (AMD) abatement efforts in north central Missouri, the Upper Cedar, Old Bevier, and Huntsville Projects. This paper will overview the case history and performance of two of these abatement efforts and preview possible future remediation activities in the region. Both sites lie in the inactive Bevier Coal Field, which historically was one of the largest coal producing regions in the state. The Old Bevier Passive Treatment System is located within the former BeeVeer Mine, a large, historic, area-type surface operation in Macon County. The initial passive treatment facility and associated land reclamation was completed in 1990 (Bevier I) to abate a series AMD discharges captured by a series of French-drains. This facility was subsequently reconstructed with Office of Surface Mining and Reclamation (OSMRE) assistance in 2001 (Bevier II) to ensure protection of the East Fork Chariton River. Efforts are underway for a major maintenance effort for the Bevier II facility in 2019. Passive treatment includes a large highwall drain that acts as an anoxic limestone drain and two, sequential vertical flow ponds. Significant AMD problems also occur to the south in Randolph County in and around the small city of Huntsville, Missouri. These were initially abated with land reclamation and mine seal emplacement between 1984 between 1990, culminating with the elimination of the Huntsville Gob Pile. However, four large AMD discharges remain, which were evaluated between 2003 and 2004 by the U.S. Geological Survey and OSMRE. A reassessment considering new passive technologies are warranted for the Huntsville area discharges. Several feasible options are presented at this time.[3]

Additional Key Words: anoxic limestone drain (ALD), vertical flow pond, and organics, limestone and aglime (OLA) cells, sulfate-reducing bioreactor.

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2. Paul T. Behum, Ph.D. (*presenter), Sr. Hydrologist, Office of Surface Mining and Reclamation, Mid-Continent Region, Alton, IL 62002; Daniel P. Wedemeyer (*presenter), Environmental Specialist III, and Michael Mueller, Reclamation Specialist, Missouri Department of Natural Resources, Land Reclamation Program, Jefferson City, MO, 65102.

3. Work reported here was conducted near 39° 25’ 05” N; 92° 26’ 22” W.

Succession Planning for 2025 – Do You Really Know the Next Generation of Reclamation Researchers?[1]

Stanley E. Bellgard* and Stephen E. Williams[2.]

Abstract: The Resource and Energy sector is going to face significant labour and expertise shortages due to demographic changes in the next 10-years. "Baby-Boomers" are starting to retire, just as the number of big, multi- million dollar mining projects that require significant and diverse senior restoration management expertise and skill are on the increase. There has been continued enrolment in industry-related apprenticeship and university programs, but negative perceptions about mining as a promising career path, and traditionally low rates of female participation are issues of concern. Looking at the latter aspect, technical and female participation in the mining industry was discourage until recently: for example, Canada only allowed woman to be involved in underground-mining activities after 1974. Conversely, resource-rich countries like Mongolia, have commonly allowed woman into many aspects of the mining sector including regulatory roles. Recent data indicates that there are some places where participation is increasing, e.g. women working in the resource industry ranges from 13-20% in Australia. This presentation will propose that the cyclic nature of the mining industry is not conducive to creating a stable talent pipeline: it creates unique challenges in education and vocational training as wells as employment and career advancement levels. The solution to the shortage could lie in primary- and high-schools, which will entail early engagement of students and teachers so that talent can be identified early, and nurtured through to university experiences – with the provision of an end-to-end solution, that gives students a clearly-defined "front-end loaded" career path upon graduating. Participatory- and activity-based approaches are suggested, in this presentation, which will allow students to actively contribute to restoration and habitat-rehabilitation activates and achievements. Cultural exchange could see teachers sponsored into the Resource and Energy industry for six-months, as part of re-training and up-skilling to create a series of industry-advocates to assist with recruitment.

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2. Stanley E. Bellgard (* presenter), Research Scientist, Manaaka Whenua Landcare Research, Auckland, New Zealand. BellgardS@landcareresearch.co.nz and Stephen E. Williams, Professor Emeritus, Ecosystem Science and Management Department, University of Wyoming, Laramie. USA 82072. sewms@uwyo.edu and S. E. Williams & Associates, LLC. sewmsllc@gmail.com

Reclamation of the McLaren Tailings: The Rest of the Story[1]

M. Bennett*, T. Henderson, and A. Coleman[2]

Abstract: In late 1960, Soda Butte Creek was considered the most polluted stream entering Yellowstone National Park. Significant portions of this pollution were coming from the McLaren Tailings impoundment, constructed in the historic channel and floodplain of Soda Butte Creek from 1934 to 1953. The site is located in the New World Mining District near Cooke City, Montana, in an isolated alpine area characterized by short growing seasons, large winter snow accumulations, rapid spring runoff, and dynamic groundwater fluctuations. The Montana DEQ contracted Pioneer Technical Services, Inc. to complete an Engineering Evaluation/Cost Analysis (EE/CA) for the site in 2000, and additional investigations were completed in 2007/2008. Based on the groundwater/surface water modeling, soil stability analysis, and sediment transport modeling results, Pioneer developed a remedial design to stabilize/remove 191,140 cubic meters of mine tailings, mine wastes, and impacted soils; construct an on-site repository, a site-wide dewatering system and water treatment system, and 1,219 linear meters of storm water conveyance channels/infiltration systems; reconstruct 610 linear meters of Soda Butte Creek and Miller Creek; and revegetate 10 hectares. The project turned a previously unusable area back to its historical landscape while cleaning up the contaminated Soda Butte Creek and preserving important fishery and natural resources of Yellowstone National Park. The project was awarded in April 2010, construction began in June, and the project was completed in fall 2015. Given the flexibility built into Pioneer's design, DEQ's receptiveness to value engineering, and the consistent diligence of the contractor (Knife River-Yellowstone Division) the McLaren project was completed 1 year ahead of schedule and $2.5M under budget. After 4 years, the site is functioning as a stable landform. Water quality in Soda Butte Creek has improved to the point where in 2018 DEQ delisted the creek from Montana's list of impaired waters 303d list.[3]

Additional Key Words: Yellowstone National Park, Cooke City Montana, New World Mining District, Mine Tailings, Stream Channel Construction, Dewatering System, Water Treatment.

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2. Marty Bennett, Project Engineer Pioneer Technical Services, Inc. Butte, Montana. Tom Henderson, PhD, Abandoned Mines Section, Montana DEQ Remediation Division Helena, Montana. Autumn Coleman, Section Supervisor, Montana DEQ Remediation Division Helena, Montana.

3. Work reported here was conducted near 40°06'07" N, 88°14' 59" W.

Biological Microencapsulation Coating of Waste Ores and Tailings[1]

Loran Brooks*, Ellen Lauchnor, Chris Gammons, Raja Nagisetty, Dylan Proudfoot[2]

Abstract: Acid rock drainage (ARD) continues to be a significant environmental problem for both operating, closed, and abandoned mine-processing facilities. The wide-ranging nature of waste materials produced during metal resource extraction calls for efficient performance, accurate designs, and sustainable feasibility of remediation technologies. Preventative remediation techniques focus on inhibiting ARD generation at its point source by minimizing the oxidation of metal-sulfide materials with oxygen, water, or oxidizing bacteria. Passivation techniques such as inorganic coatings of sulfidic ores often require the use of hazardous oxidizing agents on the acid generating material prior to treatment and have shown to have reduced effectiveness at low pH. Research at Montana State University and elsewhere has shown the ability of microbially induced carbonate precipitate (MICP) to coat and consolidate porous mediums and to immobilize heavy metals. Montana State University cultivated a native bacterial community from nearby sediments of the Barker-Hughesville and Carpenter-Snow Creek mining districts and tested for the ability to generate MICP. This study presents the current research at Montana Tech of the joint university application of MICP to describe the leachate and runoff chemistry of the mine waste samples prior to and after MICP amendments. Pretreatment and post-treatment sample analysis, leaching tests, and analytical methods including XRF, ICP, SEM, and XRD characterization are presented. The applied feasibility of using MICP to provide sufficient passivation coating on mining waste rock and tailings material preventing the leaching of metals with rainfall and runoff into the surrounding environment is discussed.

Additional Key Words: Acid Rock Drainage, Prevention, Passivation, Treatment, Waste Management.

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2. Loran Brooks (* presenter), Graduate Student, Environmental Engineering, Montana Tech, Butte, MT 59601; Ellen Lauchnor, Professor, Civil Engineering and Center for Biofilm Engineering, Montana State University, Bozeman, MT 59717; Chris Gammons, Professor, Geological Engineering, Montana Tech, Butte, MT 59601; Raja Nagisetty, Professor, Environmental Engineering, Montana Tech, Butte, MT 59601; Dylan Proudfoot, Graduate Student, Civil Engineering and Center for Biofilm Engineering, Montana State University, Bozeman, MT 59717.

Lessons about Geomorphic Reclamation from Sediment Yield Quantification and Erosion Modeling Studies[1]

Nicholas Bugosh[2]

Abstract: The UN State of World Population 2014 report predicts global population will increase to 11 billion by 2100. Increases in land-disturbing activities like mining that can accelerate erosion and sediment yield will accompany that population growth. Geomorphic land reclamation has gained widespread acceptance as a means to mitigate erosion and sediment yield increases associated with that growth and to better satisfy other reclamation criteria like freedom from maintenance and providing an ecologically-integrated landscape that functions and appears similar to the surrounding undisturbed land. Recently completed studies have quantified sediment yield from geomorphically-reclaimed mined lands and have verified that the reclaimed lands can provide sediment yields similar to natural, un-disturbed adjacent lands, but also give insight into key design and construction considerations that can cause the reclamation to miss this performance target. Improper geomorphic design inputs and construction grading practices in a geomorphically reclaimed sub-watershed in Spain caused sediment yield that initially was 385% greater than those in a correctly designed and constructed contiguous sub-watershed until erosional processes resolved these errors and produced sediment yields of 18.4 t ha^{-1} yr^{-1} that further decreased to 4.02 t ha^{-1} yr^{-1} when vegetation established, values that caused no on-site or off-site degradation of the environment (Zapico et al., 2018). Computer modeling of an Australian geomorphic reclamation using SIBERIA indicated that correcting design input and construction errors would reduce modeled sediment yield by 41% from 23.4 t ha^{-1} $yr^{-1}$to 13.9 t ha^{-1} yr^{-1} (Hancock et al., 2019). Measured sediment yield in a U.S. study showed that correctly designed and constructed geomorphic reclamation at a moderately-vegetated site matched the native site sediment yield (11.0 t ha^{-1} yr^{-1}) and the well-vegetated geomorphic reclamation site had 19% less sediment yield (9.0 t ha^{-1} yr^{-1}) than the native site over the 403-day period that represented the 2013 water year (Bugosh and Epp, 2019). These studies indicate that it is essential to use proper design inputs and methods, as well as ensuring construction adheres to the design, to make a geomorphic reclamation project that performs as expected.[3]

Additional key words: Siberia.

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2. Nicholas Bugosh, GeoFluv Technical Director, Carlson Software and Principal, GeoFluv, 2205 North Avenue, Parma, Ohio 44134
3. Work reported here was conducted near: 32^{O} 20’ 00.40” S, 150^{O} 56’ 25.21” E (Australia); 40^{O} 39’ 20.77” N, 2^{O} 02’ 21.02” W (Spain); and 36^{O} 59’ 04.64” N, 108^{O} 08’ 26.47” N (U.S.A.).

CASE STUDY: BAIRD WETLAND MITIGATION 3rd YEAR UPDATE[1]

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

Abstract: The Baird Mine is an active quarry in the Vanport limestone located in western Pennsylvania (PA). The mine permit was originally issued in 1997; however, permitting efforts were later expanded due to the presence of 6.7 acres of wetlands and to potential conflicts with the *Sistrurus catenatus* (Eastern Massasauga Rattlesnake). Of the wetlands to be affected, 5.9 acres were created by drainage from abandoned bituminous coal mining activities. Because of the proximity of the *Sistrurus catenatus*, the PA Department of Environmental Protection required a 2:1 (area-based) wetland mitigation. The mine is currently owned and operated by Allegheny Mineral Corporation, and three onsite wetlands, totaling 13.6 acres, have been constructed. The wetlands were created to maximize potential use by the *Sistrurus catenatus* and to establish a wetland community with diverse flora and fauna. Several reclamation techniques were used to construct the wetlands including the use of microtopography, deep pools, seeding, live stakes, snags, woody debris, and the creation of snake hibernacula. In the fall of 2015, as a small-scale experiment to compare the effectiveness of seeding, a native, obligate wetland seed mixture was used to vegetate one wetland while another was not seeded to allow vegetation by volunteer species. The initial monitoring was completed in 2016 and was presented at the 2016 National Meeting of the American Society of Mining and Reclamation in Spokane, Washington. Aerial photographs and videos were taken with an unmanned aerial vehicle (UAV) to aid in monitoring efforts. After three years of growth, the seeded and unseeded wetlands had a similar species richness, although the vegetative cover was lower in some sections of the unseeded wetland. A state endangered species, *Schoenoplectus acutus*, was planted and successfully established within the seeded wetland. Several non-native species were found in both wetlands; however, several aggressive invasive species were found growing within the unseeded wetland.

Additional Key Words: Wetland Mitigation, Wetland Monitoring, Endangered Species, Invasive Species, Eastern Massasauga Rattlesnake, Revegetation, Mine Land Reclamation, Live Stakes, Unmanned Aerial Vehicle.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers**,** June 3 - 7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.

2. Shaun L. Busler, (* presenter); GISP, Biologist Dan A. Guy, Geologist; Tim P. Danehy, QEP; Ryan M. Mahony, Environmental Scientist; Cliff F. Denholm, Environmental Scientist; Cody A. Neely, EIT, Environmental Engineer; and Henry P. Thorton, BioMost, Inc., 434 Spring Street Ext., Mars PA 16046 and Yan Sheykhet, Engineer, Allegheny Mineral Corporation, One Glade Park East, P.O. Box 1022, Kittanning, PA 16201

Impacts of Soil Stockpiling on Seed Viability and Vegetation Communities[1]

Jennifer Buss*, and Bradley D. Pinno[2]

Abstract: Soil stockpiles will be essential to the reclamation of both large- and small-scale oil and gas sites in Alberta. The number of viable seeds is known to decline over time in soil stockpiles and be concentrated near the surface of both stockpiles and mature forest sites, but there is still uncertainty as to how long soils can be safely stockpiled before these declines start occurring, and to what depth most of the seed bank is stored. To test seed viability in soil stockpiles over time and with depth, we sampled eight stockpiles and six undisturbed forest sites around Fort McMurray and Cold Lake Alberta. Samples were taken from stockpiles aged from six months to older than 28 years old and from depths of 0-5, 5-10, 10-20, 20-30 and 80-90 cm. Samples were sieved, and 500 mL was measured and placed in a greenhouse on top of potting soil to allow seeds to germinate for 4 months. Most seeds germinated from the surface layer, with 92% of seeds germinating from the litter layer in the forested sites and 68% from the 0-5 cm layer in the stockpile sites. The stockpile ages that produced the most seedlings were 1.5, 5 and 7 years old. The 0.5-year-old stockpile produced the smallest number of seedlings (6 total, 0.6% of all stockpile seedlings). Aboveground vegetation was also sampled in June to compare the aboveground and belowground plant communities. We expect the seed bank community to differ from the aboveground community depending on the seed characteristics of different species. It is possible that seeds do not remain viable in stockpiles for a long period of time, and that they germinate on the surface in the first growing season after stockpiling. Therefore, using soil stockpiles for land reclamation in the future may be an issue because of the low number of viable seeds.[3]

Additional key words: seed bank, germination

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019.
2. Jennifer Buss (* presenter), MSc student, University of Alberta, Alberta, Canada; and Bradley D. Pinno, Assistant Professor-Silviculture, University of Alberta, Alberta, Canada.
3. Work reported here was done near Fort McMurray (57.337779, 111.755247) and Cold Lake (54.695861, 110.730858) Alberta.

Non-Traditional Reclamation of Abandoned Mine Lands (AML) to Support Economic Revitalization and Community Development – Implementation of the 2017 AML Pilot Program in Pennsylvania[1]

Eric E. Cavazza[2]

Abstract: The Consolidated Appropriations Act of 2017, (Public Law 115-31), authorized the federal Office of Surface Mining Reclamation and Enforcement (OSMRE) to provide funding for Fiscal Year (FY) 2017 for the Abandoned Mine Land Reclamation Economic Development Pilot Program (AML Pilot Program). The FY2017 AML Pilot Program provided grants to the six Appalachian states with the highest amount of unfunded high-Priority coal AML problems based on OSMRE's AML inventory data as of September 30, 2016. Kentucky, Pennsylvania (PA), and West Virginia each received $25 million, while Alabama, Ohio, and Virginia each received $10 million. The purpose of the funding is to accelerate the remediation of AML sites with economic and community development end uses. The intent of the AML Pilot Program is to explore and implement strategies to return legacy coal sites to productive uses. PA also received $30 million in AML Pilot Program funding in FY 2016 and $25 million in FY2018. State AML programs are required to develop a list of eligible projects in Appalachian counties that demonstrate a nexus with AML or Abandoned Mine Drainage (AMD) cleanup and economic revitalization and community development. From over two dozen AML Pilot project proposals received and evaluated, PA selected 13 projects including: four surface mine reclamation projects; two acid mine drainage treatment projects; six coal refuse pile removal or remediation projects, and one project to remediate a potential subsidence prone area on a college campus. In addition to eliminating a number high-priority AML/AMD features, benefits of the projects include: development of a youth sports complex; creation or expansion of several industrial and/or business parks; a new housing development; protection of college campus buildings from mine subsidence issues; reforestation and restoration of public lands; improved groundwater quality; stream water quality improvement including restored fisheries; increased tourism through public trail development; and removal of refuse material from a floodplain to prevent stream flooding and to develop a community park. This presentation will highlight the planned and ongoing reclamation as well as the anticipated benefits for each of the 13 AML Pilot Projects along with the status of each.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Eric E. Cavazza, P.E., Director, Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation, Harrisburg, PA 17106.

Seeding the Future: Wyoming AML Native Plants Project[1]

Gina Clingerman* and Don Newton[2]

Abstract: Wyoming is part of the vast sagebrush steppe ecosystem that at one time extended over 131 million acres. Today only about half of that acreage remains split between 11 western states. There are over 350sagebrush obligate species that live, feed, and breed within this shrinking ecosystem. The Wyoming AML Native Plants Project (AML NP²) is a creative collaboration between federal and state entities, local governmental groups, and non-governmental organizations intent on improving wildlife habitat by re-establishing sagebrush and native plant communities at previously reclaimed mine sites through our creative educational planting projects to cooperatively developing innovative seeding technologies. This presentation will cover the breadth of our projects objectives including out educational planting project where we planted over 2,000 sagebrush seedlings in two years with the help of middle school science students, the partnership we are developing to grow sagebrush seedlings for reclamation and restoration with the Wyoming Department of Corrections at the Wyoming Honor Farm and the Institute of Applied Ecology's Sagebrush in Prison's Project, and the innovative research and design project we have constructed with The Nature Conservancy on seed pod technology. We hope that our work in seed pod technology can be adapted for many reclamation projects from AML to oil and gas and beyond. In summation, we hope to show how the Wyoming Native Plants Project is an inclusive project that is not limited to re-establishing sagebrush and native plant communities but is about thinking beyond regulation into innovation through unique partnerships and educational outreach with the intention of sharing information and technology with other states and reclamation programs.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Gina Clingerman, BLM AML Project Manager, 1335 Main Street, Lander, WY 82520; Don Newton, Wyoming DEQ AML Project Manager, 510 Meadow View Drive, Lander, WY 82520.

Acid Mine Drainage Takes Its Time to Burn Out – a case for Interceding with Spot Treatments?[1]

M. Coleman*, K. E. Butler, and D. Loomer[2]

Abstract: The approximately 120 ha Fire Road surface coal mine, located near Fredericton, New Brunswick, Canada, has been a source of acid mine drainage since the 1980's. Lime neutralization of the mine water was initiated shortly thereafter and periodic deposition of accumulated neutralization sludge back into /onto the waste rock has been occurring since the early 1990's. The source of acid mine drainage, 1-2 wt. % pyrite within the sandstone/conglomerate overburden now backfilled into the mine, will burn itself out with time. Monitoring of site water chemistry through sampling of groundwater wells since 1988 and has indicated that most geochemical parameters including sulphate, acidity and dissolved metal concentrations have been dropping considerably across the site. In the quest to answer management's question of how much longer, predictions were made that "zero lime demand" could be possible within ten years back in 2013. But alas, acid mine drainage isn't quite that predictable. After major drops in those geochemical parameters between 2000 and 2006, many of the rates of change have reduced or plateaued over the past six years and pH's are still depressed at < 4.3. Waiting for natural attenuation of the acid generation could take decades more. Looking for additional remedial options, a laboratory research project was conducted to assess using alkaline surface amendments for spot treatment of high acidity areas. Seafood compost was identified as an effective amendment both on cost and in ease of handling. Additional laboratory and field pilot testing will be required before a full-scale application. This presentation will review the decreases in acid generation rates and high conductivity areas. Some of the pros and cons for the application of alkaline materials to assist in reducing the time to zero lime demand will also be discussed.[3]

Additional Key Words: conductivity, acid mine water, lime neutralization sludge, alkaline amendments, acidity, coal mining, acid waste rock.

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1. Oral presentation at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Michele Coleman (* presenter), Dr. Karl E. Butler, and Diana Loomer, NB Power, 515 King Street, Fredericton , NB Canada E3E4X1.

3. Work reported here was conducted near 46°6'59.2400"N, 66°14'13.1987".

Cost Effectiveness Analysis of Geomorphic Reclamation[1]

Roger Coupal*, Kristina Hufford, and Kurt Reid Fleisher[2]

Abstract: Energy development is an important economic activity in Wyoming and many States in the Rocky Mountain West. These activities supply high paying jobs for communities and are a major contributor to the State Government tax base. Along with these activities and contributions though are ecological damages that can affect ecosystem services that other industries depend upon. This analysis assesses the cost effectiveness of geomorphic reclamation compared to traditional using different indicators. The goal of geomorphic reclamation is to achieve a steady-state landscape between forces and resistances (Troy and Chuse 2004), creating a more stable environment ecological restoration. We use the AML project on the Day Loma Uranium Mining District in Central Wyoming as our case study. We start with a risk adjusted avoided cost comparison or re-remediation on traditional reclaimed areas that have rill and gully erosional problems. We then expand the analysis using a risk adjusted cost effectiveness approach from ongoing work by Fleisher and Hufford (2019) that measure species richness and biodiversity between the two approaches. This latter approach can be used to manage species of concern that depend on the ecosystems. The evidence to date is that in semi-arid areas in Wyoming, though the costs of geomorphic approaches are higher, the costs of re-remediation on traditional approaches make geomorphic reclamation potentially less expensive. Preliminary discounted cost differential estimates make Geomorphic slightly less expensive ranging from 2.5 percent less to 8 percent more, depending upon likelihood of erosion events and relative earthwork costs. Biological indicators perform better in cost effectiveness.

Additional Key Words: Economic efficiency, ecosystem services.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.

2. Roger Coupal (* presenter), Professor, Agricultural and Applied Economics, University of Wyoming,; Kristina Hufford, associate professor, Ecosystems Science and Management, University of Wyoming; Kurt Reid Fleisher, Graduate Student, Ecosystem Science and Management, University of Wyoming.

Cast Blasting as a Cost Saving Reclamation Tool: A Case Study[1]

S.M. Cude[2]

Abstract: Cast blasting is typically used in a production setting to uncover coal, but it can be adapted to surface mine reclamation of highwalls. The main purpose of cast blasting is to use explosive energy to move overburden material to the final location of the spoil pile, thereby reducing mechanical loading, and hauling requirements. When using cast blasting for reclamation purposes, highwall material is being cast to backfill the former production pit. It is possible to use blasting to displace the top part of the highwall to the bottom part of the slope almost getting 100 percent cast-to-final. Cast-to-final for reclamation can be considered as any material below the final grade line that is not moved by equipment. Cast blasting was proposed as a conceptual design, as opposed to mechanical loading and hauling, to move native overburden material for the annual bond release estimates on the Eagle Butte surface coal mine in Wyoming. Movement of native overburden material represented 30% of the total bond cost, and this novel method significantly reduced earth movement cost for annual reclamation bond reporting requirements. All changes to bond release documentation must be approved by the State of Wyoming, and cast blasting for reclamation was approved in this case. Details of the conceptual design will be provided.[3]

Additional Key Words: Overburden; Earth Movement; Bond Release; Backfilling

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.
2. Seth M. Cude, Consultant, RESPEC, Lexington, KY 40508.
3. Work reported here was conducted near 44° 23’ 16” N; 105° 30’ 54” W.

Insect Response to Reclaimed Natural Gas Well Pads in Semi-Arid Wyoming[1]

Michael Curran*, Douglas Smith, Tim Robinson, and Pete Stahl[2]

Abstract: Insects, the most diverse animal group on Earth, provide a wide-array of ecosystem services. However, 'the little creatures that run the world,' are often underappreciated in restoration and conservation studies. Aside from providing biodiversity, insects are critical pollinators and sources of food for higher trophic levels. Four years of field studies have shown insects respond positively to restoration efforts on well pads in the Jonah Infill and Pinedale Anticline natural gas fields. While the first three years of field work focused on collecting insects on well pads with various vegetation communities and comparing them to insects found in adjacent reference systems clearly showed insects are attracted to reclaimed well pads, determining whether insects disperse from well pads was not an objective. The fourth year of fieldwork involved using immuno-marking techniques to determine whether insects are using revegetated well pads as resource islands or sinks. Here, we demonstrate how insects respond to and disperse from well pads undergoing restoration activity.[3]

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: Land of the Reclamation Pioneers, June 3-7, 2019. Published by ASMR, 1305 Weathervane Drive, Champaign, IL 61821.
2. Michael Curran (*presenter), PhD student, Program in Ecology, University of Wyoming, Laramie, WY, USA; Douglas Smith, PhD and Extension Entomologist, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY, USA; Tim Robinson, professor, Department of Statistics, University of Wyoming, Laramie, WY, USA; Pete Stahl, professor and director, Wyoming Reclamation and Restoration Center, University of Wyoming, Laramie, WY, USA.
3. Work reported here was conducted near 42.8679° N, 109.8634° W.

Performance Evaluation of the North Fork Montour Run Passive Treatment System[1]

T.P. Danehy*, R. Beam, R.M. Mahony, C.A. Neely, C.F. Denholm, and D.A. Guy[2]

Abstract: The North Fork Montour Run Passive Treatment System installed in two phases to treat acidic, iron- and aluminum-bearing coal mine drainage was evaluated for both chemical and hydraulic performance in 2018, the wettest year on record in Pittsburgh, Pennsylvania, USA. The anoxic limestone drain constructed in 2004 as part of the mine drainage collection and conveyance system situated underneath Pennsylvania Turnpike Route 576 continues to produce alkalinity despite the presence of aluminum. Six additional treatment components were installed in 2008 that include two parallel Jennings-type vertical flow ponds (VFPs). The VFPs were designed to treat the discharge for 15 years based on a maximum/average 6.9/4.29 l s^{-1} flow and 140/56 kg d^{-1} acid load. The record-setting 147 cm annual precipitation was 50 cm (51%) above normal and the VFPs experienced inflow up to 27.4 l s^{-1} and an acid load of at least 303 kg d^{-1}. While the final treated 12.4 l s^{-1} outflow was measured in April to be acidic for the first time in a decade, the system was able to neutralize 201 kg d^{-1} of acid. Alkaline system effluent was restored in June even though the inflow to the VFPs was 9.4 l s^{-1} and contained 179 kg d^{-1} of acid. The areal acid load reduction as measured at the approximate water surface ranged from 12 g m^{-2} d^{-1} to 81 g m^{-2} d^{-1}. Hydraulic head at each VFP was measured on several occasions with a driving head of 0.99 m needed pass up to 14.8 l s^{-1}. Air lock within the underdrain piping appeared to impede flow on at least one occasion when the discharge from one of the VFPs was increased from 2.8 l s^{-1} to 9.7 l s^{-1} after briefly opening the drain valves. Areal hydraulic load ranged from 6.7 l s^{-1} ha^{-1} to 134.1 l s^{-1} ha^{-1}. As the system was overwhelmed both chemically and hydraulically, the maximum performance that can be expected from this seasoned passive treatment system was quantified.[3]

Additional Key Words: Acid mine drainage, sizing criteria, public-private partnership.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers**,** June 3 - 7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.
2. Timothy P. Danehy (* presenter), (QEP); Ryan M. Mahony, Environmental Scientist; Cody A Neely, Environmental Engineer (PE); Clifford F. Denholm III, Environmental Scientist; and Daniel A. Guy, Geologist (PG) - BioMost Inc., 434 Spring Street Ext., Mars PA 16046; Rich Beam (PG); – PA DEP Bureau of Abandoned Mine Reclamation, Ebensburg Office (Cambria Office) 286 Industrial Park Road, Ebensburg, PA 15931.
3. Work reported here was conducted near 40˚28’28”N, 80˚16’40”W.

Development of a Reliable Field Testing Protocol for Acid-Forming Materials[1]

W. Lee Daniels, Robert (B.T.) Thomas, Ehab Shatnawi, and Emad Farouz[2]

Abstract: Accurate and rapid prediction of the acid-forming potential of geologic materials in a field setting is challenging and most projects and their analysts rely on conventional acid base accounting (ABA) lab procedures to determine relative risk and appropriate liming requirements. Road improvements for Route 220 in Botetourt County, Virginia, will cut and fill large volumes of soil/saprolite/rock materials derived from potentially acid-forming Devonian black shales. VDOT permit requirements mandate separating all handled materials into four different categories of acid formation risk with differing liming and/or placement procedures. We evaluated a combination of rapid field criteria (color, hardness, 1:1 water:soil pH, 30% H2O2 reaction, and 10% HCl reaction) along with conventional ABA lab analyses for over 250 pre-disturbance drill core samples. Combined statistical and meta-analysis of the data sets indicated that > 90% of the samples could be properly placed into correct risk categories via application of the field criteria. From these analyses, we developed a flow chart for sequential field procedures to allow rapid identification and treatment recommendations during active construction operations. The original VDOT categorization and lime treatment criteria were based primarily on % S and ABA net neutralization potential (NNP) values and would have required most native soils and oxidized saprolites to be limed to achieve an NNP of +24 tons of calcium carbonate equivalent per 1000 tons material before final placement, even though they posed essentially no risk of further acid release. The liming prescriptions were modified to employ the ratio of maximum potential acidity (MPA) to neutralization potential (NP) of 3:1 as an alternative target criterion. Active construction was initiated in late 2017 and we will continue to evaluate the effectiveness and efficiency of the field-testing protocol over the project lifetime (~ 2 years).

Additional Key Words: Highway Construction, Acid Base Accounting, Potential Acidity, Liming Requirement, Net Neutralization Potential, Black Shales.

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2. W. Lee Daniels, Professor, School of Plant & Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; B.T. Thomas, Geochemist, Jacobs, 6600 Peachtree Dunwoody Road, Atlanta, GA 30328; Ehab Shatnawi and Emad Farouz, Professional Engineers, Jacobs, 2411 Dulles Corner Park #500, Herndon, VA 20171.

Soil Reclamation after a Bakken Crude Pipeline Release: A Summary of Research Results[1]

T. DeSutter*, P. O'Brien, S. Croat, C. Gasch, F. Casey, and A. Wick[2]

Abstract: The largest terrestrial accidental oil spill in the United States occurred in 2013 in northwestern North Dakota under an agricultural field. This pipeline leak released about 20,000 barrels of shale-extracted Bakken crude to depths of 18 m across about 8 ha[3]. The contaminated soil was remediated using low temperature (200 to 500 °C) thermal desorption (TD) which is an effective method for removing hydrocarbons from soil materials. The goal of this presentation is to provide an overview of the results of laboratory, greenhouse, and field experiments that investigated the feasibility of using TD soil as a replacement for topsoil. Topics to be covered include the effects of TD on soil hydraulic and physical parameters, cation selectivity, alterations in the N cycle and plant available N, surface energy balance, P sorption and desorption, and agronomic implications and crop productivities.[3]

Additional Key Words: crop production, fertility, agronomy, energy balance, degradation

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1. Oral presentation at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.
2. T. DeSutter (* presenter), professor, Dept. of Soil Sciences, North Dakota State University, Fargo, ND 58108; Peter O'Brien, soil scientist, USDA-ARS, The National Laboratory for Agriculture and the Environment, Ames, IA 50011; Samantha Croat, research assistant; Caley Gasch, assistant professor; Frank Casey, professor; and Abbey Wick, assistant professor, Dept. of Soil Sciences, North Dakota State University, Fargo, ND 58108.
3. Work here was conducted near 48°31'27.24"N, 102°51'24.01"W.

Source Control or How to Eliminate Acidophiles and Influence Water Quality[1]

Paul Eger, Jim Gusek, Lee Josselyn, and Tom Clark[2]

Abstract: Effective acid rock drainage (ARD) source control techniques were shown to be effective over 30 years ago, but the lack of consistent, well-documented case studies and application challenges have limited its use. Barite Hill, an EPA superfund site, is a reclaimed open pit gold mine that continues to leach acid and trace metals despite periodic pit lake neutralization and the capping of waste rock stockpiles. Pit lake pH is around 3 with elevated metals; iron concentrations are around 1600 mg/L and copper is about 90 mg/L. The major source of continued acid input into the pit lake appears to be from the reclaimed waste rock stockpile, which contains three distinct zones consisting of unsaturated, transition, and saturated material. Proof of principle ARD source control tests were conducted on a bulk composite waste rock sample from several test pits. The waste rock exhibited a pH of about 3 and contained about 40% fine sand. Three different test protocols were developed for each of the three zones. ARD-inhibitors assessed included sodium lauryl sulfate (SLS), milk, and alkaline amendments alone and in combination. The best indicator of successful treatment was the composition of the microbiological community present in the samples at the end of the test. Treatment was successful in eliminating the acidophilic bacteria in all zones, but no single ARD-inhibiting strategy was capable of treating the entire stockpile. In general, combinations of treatments worked best: SLS/alkalinity for the unsaturated zone, and milk/alkalinity for the transition and saturated zone.

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1. Oral presentation at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Paul Eger, Sovereign Consulting/Global Minerals Engineering; Jim Gusek and Lee Josselyn, Sovereign Consulting; and Tom Clark Solfatara Laboratories.

Evaluating Herbicide Treatment Effectiveness Using GPS Treatment Data & ArcGIS tools: 2016-2018[1]

W. Erickson and Anthony Matthews[2]

Abstract: A reclaimed coal mine (southwestern United States) has performed noxious weed management at various levels of intensity during the life of the mine. Noxious weed herbicide treatments have been conducted since 2010, with emphasis on larger, higher density infestations. In 2017, SMCRA regulatory agencies required an evaluation of herbicide treatment effectiveness. Since 2016 herbicide spot treatments have been recorded with environmental grade GPS units. Precipitation records and herbicide treatment data were used to quantitatively evaluate treatment effectiveness. ArcToolbox Fishnets were used to characterize treatments and perform a Grid Pattern Analysis for treatment effectiveness evaluation. Fishnets were symbolized using quantitative values and three classes (low, medium and high) to display density of noxious weed herbicide treatments. Data was exported to Excel for tabular analyses. This process was repeated for each treatment year and mining area. GIS modeling resulted in an efficient method for numerically and visually characterizing the effectiveness of noxious weed herbicide treatments. This method has now been used to evaluate three years of treatment data (2016-2018). The analyses indicate that herbicide treatment of noxious weed infestations has been effective, although reduction in weed populations due to significant drought has not been quantified.[3]

Additional Key Words: Southwest United States, Invasive Species, Fishnets, MS Excel.

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1. Oral paper presented at the 2018 National Meeting of the American Society for Mining and Reclamation, Big Sky Resort, MT: Welcome Back to Montana: The land of Reclamation Pioneers, June 3-7, 2019. Published by ASMR: 1305 Weathervane Dr., Champaign, IL, 61821.
2. Wayne Erickson, Principal Environmental Scientist, Habitat Management, Inc., Englewood, CO 80112; and Anthony Matthews, Licensed Commercial Pesticide Applicator, Habitat Management, Inc., Englewood, CO, 80112.
3. Work reported here was done near 35.669, -108.996.

Seed Enhancement Technologies for Native Plant Restoration on Reclaimed Mine Lands[1]

M. Eshleman* and C. Riginos[2]

Abstract: Revegetation of reclaimed mines presents many challenges, particularly in arid environments where invasive annual grasses are pervasive. In the semi-arid West, cheatgrass (*Bromus tectorum*) often invades habitats after disturbance making it particularly difficult for sagebrush, a slow growing woody shrub, to reestablish. To improve revegetation outcomes we are testing a seed enhancement technology that allows you to seed and spray herbicide at the same time. This is achieved by encasing seeds in a pod containing activated carbon, which adsorbs herbicide. The aim of the technology is to give desirable, native species a chance to establish with reduced competitive pressure from invasive species. In lab trials, herbicide protected pods have been shown to enhance the emergence of native grasses relative to bare seeds after spraying the soil surface with herbicide. We are now testing the technology for its potential to augment native plant cover on reclaimed uranium mines in central Wyoming. In fall 2018, we set up a field trial at three mine sites on both a wet and dry slope to test whether herbicide protection pods with Indian ricegrass (*Achnatherum hymenoides*) and Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis*) will improve emergence in the field compared to bare seed. We will present preliminary results from this field experiment and discuss the potential for seed enhancement technologies to improve restoration in the sagebrush ecosystem.

Additional Keywords: Restoration, Abandoned Mine Lands, Revegetation,

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1. Oral presentation at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Maggie Eshleman (* presenter), restoration scientist, The Nature Conservancy, Lander, Wyoming 82520; and Corinna Riginos, conservation scientist, The Nature Conservancy, Lander, Wyoming 82520.

Restoration of Native Grasslands to Provide Monarch Habitat on the Enbridge Valley Crossing Pipeline in the South Texas Sand Sheet[1]

Tony Falk*, Keith Pawelek, Forrest Smith, and Devin Hoetzel[2]

Abstract: Restoration of vegetation on large pipeline right-of-ways is a difficult process in the South Texas Sand Sheet, which is characterized by highly variable and seasonal rainfall, and extremely sandy topsoils. These climatic and edaphic challenges are magnified when also attempting to utilize native species in order to create nectaring habitat for monarchs and pollinators. Through a cooperative effort lead by Enbridge and King Ranch Inc., and in collaboration with South Texas Natives Project of the Caesar Kleberg Wildlife Research Institute and private landowners of Kenedy County, TX, we attempted to restore 89.5 km of the Valley Crossing Pipeline in South Texas. A seed mix comprised of 19 ecotypic, commercially available native species was drill seeded beginning late autumn 2017 through construction completion in early 2018. Following planting, drought conditions ensued until September 2018, when much of the planted right-of-way received >38 cm of rain. In October 2018, we began collecting vegetation data from the seeded right-of-way, and from directly adjacent undisturbed points. Vegetation was sampled at 1,341 m intervals along pipeline. Vegetation was sampled using a 0.25 m^2 frame to measure plant density, and a 100 pace, step-point transects was used to measure percent basal cover of vegetation and bare ground. Overall, in terms of revegetation a successful outcome has been achieved. We found percent basal cover and plant density to be nearly identical on and off the right-of-way, although most vegetation established on the right-of-way to date is not of the seeded native species. Establishment of monarch nectar plants and seeded native grasses has been limited, primarily because of early competition from weedy volunteer vegetation and from extensive amounts of volunteering non-native grasses, especially common Bermudagrass on the right-of-way. We hypothesize that as time since soil disturbance increases, and competition from weedy plants declines, planted species will begin to emerge. We will continue to monitor this project to provide recommendations for future restoration efforts in this region, and to determine the ability to provide monarch habitat on large pipeline rights of ways, a topic of nationwide interest.

Additional Key Words: reseeding, pollinators, revegetation

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2. Tony Falk (*presenter), anthony.falk@tamuk.edu, Assistant Director South Texas Natives Project, Texas Native Seeds Program (TNS), Caesar Kleberg Wildlife Research Institute (CKWRI); Keith Pawelek, keith.pawelek@tamuk.edu, Associate Director, TNS, CKWRI, forrest.smith@tamuk.edu, Dan L Duncan, Endowed Director, TNS, CKWRI; and Devin Hotzel, Devin.Hotzel@enbridge.com. Manager of Stakeholder Outreach, Enbridge.

3. Work reported here was conducted near 27° 10’ 20” N; 97° 48’ 5” W.

Tree Response to Soil Treatments on Quarry Overburden [1]

J.A. Franklin* and D.S. Buckley[2]

Abstract: Multiple studies have investigated the suitability of different tree species for reforestation of reclaimed coalmines, and the results from various regions suggest that many native tree species, including commercially important species such as pines and oaks, are viable choices. A 2x3 factorial experiment to test the effects of fertilizer application, lime application, and surface grading on tree seedling growth and survival was established on 4.5 ha of quarry overburden in 2008. Twelve rectangular plots were constructed: six were lightly graded with a single pass of a bulldozer, and the other six remained ungraded. Liquid lime was applied to one half of each plot, and fertilizer (20:20:20) was applied at a rate that provided 100 Kg/ha or 400 Kg/ha N to randomly selected plots in a manner that created three replicates of all lime, fertilizer, and overburden placement treatment combinations. Seedlings of *Castanea dentata* (American chestnut), *Pinus echinata* (shortleaf pine) and *Quercus alba* (white oak) nursery seedlings were planted, and one quarter of each plot was left unplanted. No herbaceous cover was seeded. After eight years, white oak survival was consistently good across plots with an overall average of 88%. Survival of American chestnut was 65%, while survival of shortleaf pine was 66%. After 8 years of growth, American chestnut had an average height of 1.96 m and root collar diameter of 41 mm, while pine showed the most growth at an average height of 2.14 m and diameter of 67 mm. Despite a high survival rate, oak height at the end of the study was only 0.8 m with a diameter of 24 mm. Initial fertilization had a lasting effect on tree growth, particularly on pine, while initial lime application had little influence on tree growth.

Additional Keywords: hardwoods, amendments, reforestation.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.

2. Jennifer Franklin (* presenter), professor, Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN 37804; David Buckley, professor, Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN 37804

3. Work reported here was conducted near 36°00’49” N, 84°11’ 26” W.

Effects of Grazing Management and Climate Change on Extent of Semiarid Riparian Meadows[1]

B.A. Fulcher*, J.B. Norton, and M. Kasten[2]

Abstract: Field sampling and remote sensing techniques were used to assess effects of long-term uncontrolled livestock grazing and recent management improvements on riparian meadows in the upper Sweetwater River Basin in Fremont County, Wyoming. Over a century of uncontrolled grazing has led to the formation of hummocks causing severe degradation to the riparian meadows. To study the effects of grazing on the wetlands, the Bureau of Land Management constructed livestock exclosures on six different riparian meadows ranging from 8 to 30 years old. This work builds upon field research that quantified changes in soil carbon storage and the width of the wetlands by quantifying the change in wetland extent over the past 30 years using high-resolution (WorldView-2) satellite data and moderate resolution (Landsat) satellite data with a longer temporal series. Training data from the field was used to predict the current wetland extent for the high spatial resolution scenes using the randomForests R package. To quantify the change in wetland extent over the past 30 years, the high-resolution data was used to train the moderate resolution data allowing for the comparison of areas with long-term heavy and light grazing pressure to predict effects of improved grazing management on recovery of the degraded wet meadows. Results of this work will inform management and restoration of riparian wet meadows that provide important water, wildlife, and forage resources.[3]

Additional Key Words: Remote Sensing, WorldView-2, Landsat, hummocks.

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1. Oral case study presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.

2. Brandon A. Fulcher (* presenter), Masters Student, University of Wyoming, Laramie, WY 82071 ; Jay B. Norton, professor, soil science, University of Wyoming, Laramie, WY 82071; and Mike Kasten, Masters Student, University of Wyoming, Laramie, WY 82071

3. Work reported here was conducted near 42°27'47"N, 108°30'58"W.

Assessing Physiographic Controls on Snow Accumulation and Vegetation Cover in Traditional and Geomorphic Mineland Reclamation Using Airborne Lidar and High-Resolution Satellite Data[1]

E.A. Gage, Kurt R. Fleisher, and Kristina M. Hufford[2]

Abstract: Physiographic variables drive landscape differences in pedogenic and ecological development in both natural and reclaimed landscapes by affecting the basic energy balance of sites. Simple variables like slope and aspect, as well as more integrative metrics derived from elevation data such as solar insolation can provide insights into hydrologic and ecological function important for successional development and reclamation performance. This analysis quantifies physiographic characteristics of mineland reclamation sites in central Wyoming[3] using digital elevation models derived from airborne lidar, comparing landscapes reclaimed using traditional and geomorphic reclamation techniques and relatively undisturbed landscapes. We quantify landscape heterogeneity, as driven by reclamation technique, and evaluate the consequences of physiographic differences on snow accumulation and post-reclamation vegetation cover as derived from analyses of high-resolution satellite imagery. Supervised image classification and machine learning algorithms are used to derive snow and vegetation cover data. These are then statistically compared between reclamation treatments, undisturbed controls, and field measurements of vegetation cover and functional type. Results provide inferences on post-reclamation ecological trajectories. More than a decade after reclamation, we found clear differences in treatments that were influenced by differences in landscape physiography and heterogeneity.

Additional Key Words: mine reclamation, remote sensing, restoration ecology, disturbed lands

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2. Edward Gage (presenter), Research Scientist, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071; Kurt R. Fleisher, Graduate Research Assistant, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071; and Kristina M. Hufford, Associate Professor, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071.

3. Work reported here was conducted near 42° 47' 20.4" N, 107° 40' 6.0" W.

Challenges to Mine Backfilling in Poor Rock Formation with High Artesian Mine Water Pressure[1]

Mohamed Gamal, Dave Hibbard, and Melissa Bautz[2]

Abstract: This presentation covers the challenges faced during the recent backfilling of mine voids in areas that were previously mitigated in the late-1980's and mid-1990's. The mines are located within poor to very poor-quality bedrock at the Glenrock No.1 and No.2 Mines in Wyoming. In addition, parts of the No. 1 and No. 2 Mines are flooded under high artesian pressures and are likely the cause of localized flooding within adjacent homes due to the unusually high-water table. The artificially confined conditions are caused by the collection of surface and groundwater down stratigraphic dip and lower elevations within portions of the mine. . This condition is likely the direct result of historic coal mining activities. The previous mitigation attempts and the poor-quality rock required an innovative mitigation approach and special grout mix design, which resulted in the injection of large grout volumes in areas previously mitigated. The mitigation was executed in such way to ensure that mine voids, rubble, and weak disturbed overburden rock were sufficiently filled with grout. Grouting existing voids and fractures within the rock overburden significantly reduces the permeability of the weak and fractured rock above the mine to provide ample sealing to prevent water migration as well as artificially high artesian pressures. Another challenging aspect was the elasto-plastic rebound of the poor-quality rock that caused grout return to ground surface upon cessation of grout injection and recommendation will be presented to minimize and control such events. A detailed groundwater study was performed to determine if the deformation associated with mine subsidence in Glenrock caused fracturing of the weak overburden rock allowing permeation of water to assist in creating artificial artesian conditions within and above the historic Glenrock No.1 and No. 2 Mine. The results of this study will be presented.[3]

Additional Key Words: grout flowability, refusal criteria.

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2.
3. The work reported here was done near 42°51'41.33"N - 105°51'43.34"W

Spaghetti Hole: Retrofit Options for an Aging Passive Treatment System[1]

John Gaughan*, Nick McKnight, Logan Madison, Travis Taske[3], Jim Eckenrode, and William Strosnider[2]

Abstract: For the past 17 years, Spaghetti Hole passive treatment system has been treating net-acidic abandoned mine water from a seep in the Glenwhite watershed located in Western Blair County, PA. The discharge water quality has remained consistent over the life span of the site [pH: 3.67, $CaCO_3$: 0 ppm, Fe: 0.825 ppm, Al: 7.20 ppm, Mn: 2.49 ppm]. The system consists of three treatment cells: a stabilization basin, vertical flow pond, and settling pond. Initially, the mine water effluent was treated sufficiently [pH: 7.53, $CaCO_3$: 234 ppm, Fe: 0.146 ppm, Al: 0.200 ppm, Mn: 1.72 ppm]. As time passed, treatment efficiency has decreased as expected [pH: 6.5, $CaCO_3$: 71.5 ppm, Fe: 0.550 ppm, Al: 2.00 ppm, Mn: 2.73 ppm]. Increased short-circuiting due to clogging has resulted in average percentage bypassing of 43.9% (12.2 L/s). After assessing the current water quality, a design solution has been developed to retrofit more recent treatment technology and practices to the Spaghetti Hole passive system.[3]

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2. John Gaughan (* presenter), Undergraduate; Nick McKnight (* presenter), Undergraduate; Logan Madison (* presenter), Undergraduate; Travis Tasker (advisor), Post Doctorate; Jim Eckenrode (advisor), Laboratory Manager; William Strosnider (advisor) Associate Professor, Environmental Engineering, Saint Francis University, Loretto, PA 15940.

3. Work reported here was conducted near 40.5164° N, 78.5164° W.

Preliminarily Assessing Ferrate (Fe(VI)) as an Acid Mine Drainage Treatment Option[1]

J.E. Goodwill[2], J.A. LaBar, D. Slovikosky, and W.H.J. Strosnider

Abstract: Ferrate (Fe(VI)) is a strong oxidant with alkaline properties that has been recently gaining traction in water treatment applications. However, despite its growing prevalence, promising properties, and relative ease of formulation, it has not yet been explored as an acid mine drainage (AMD) treatment option. Our study was executed to preliminarily assess the viability of ferrate as an option for the treatment of net-acidic AMD from a partially flooded coal mine in western Pennsylvania. We focused on the oxidation of Mn and Fe as well as the subsequent precipitative removal of both Mn, Al, and Fe. Two different dosing approaches were applied: Fe(VI) only, and Fe(VI) with sodium hydroxide (NaOH) added simultaneously. When only Fe(VI) was added, the oxidation of Mn and Fe was incomplete, even at stoichiometrically excessive amounts, indicating Fe(VI) auto decay or forced formation (e.g. activation) of Fe(V/IV) were competitive pathways in low pH matrices. When NaOH and Fe(VI) were added simultaneously, the oxidation of Fe was complete, an Mn oxidation approached the theoretical stoichiometry of a net 2 electron transfer resulting in Fe(III) and Mn(IV). The formation of Mn(VII) was noted at Fe(VI) dosages above this stoichiometric requirement, which would be problematic in full-scale systems that are not continuously monitored and adjusted. Resultant Fe(III) and Al(III) particles were relatively large, suggesting success in subsequent removal through gravity-driven clarification. Resultant Mn(IV) particles were relatively small and settled water turbidity approach 50 NTU, indicating that additional particle destabilization and aggregation may be required to meet Mn effluent and other water quality goals. Overall, Fe(VI) seems viable for the treatment of AMD especially when sourced through the wet-oxidation method due to the coexistence of NaOH in the product stream. However, much more research is required to answer extant fundamental mechanistic and application questions[3].

Additional key words: oxidants, chemical addition, dosing

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2. Joseph E. Goodwill (presenter), assistant professor, department of civil and environmental engineering, University of Rhode Island, Kingston, RI 02881; Julie A. LaBar, assistant professor, science department, Centenary University, Hackettstown, NJ 07840; Debbie Slovikosky, undergraduate student, environmental engineering program, Saint Francis University, Loretto, PA 15940; and William H.J. Strosnider, associate professor, environmental engineering program, Saint Francis University, Loretto, PA 15940.
3. Work reported here used waters from a mine discharge near 40.367135°, -78.646209°.

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ATLANTIC CITY IRON MINE, WYOMING CASE STUDY POST-RECLAMATION 17-YEAR STATUS[1]

James J. Gusek, P.E., and Brenda K. Schladweiler[2]

Abstract: In the early 1990's, an 81 ha (200 ac) tailings impoundment at an abandoned taconite operation in Wyoming was a source of blowing dust. The tailings portion of the site qualified for reclamation under Wyoming's Abandoned Mine Land program and adjacent un-reclaimed waste rock dumps, railroad fills, and a tailings decant pipeline were eventually included in the project. As described in previous ASMR papers and presentations (1999 and 2004), the reclamation design included: incorporating commercially available organic amendments and fertilizers into a 300 mm (12 in.) thick "cap" of a sterile gravelly clay loam cover material, planting trees in the protective wind/snow shadows of rock berms and rock snow fences, lowering the water level in a flooded mine pit that was feeding uncontrolled seeps, and constructing a tailings pond spillway that allows flood control while minimizing seasonal water level fluctuations in the pond. Reclamation was virtually complete in 2001. A highway that was originally re-routed around the site in the 1960's was returned to its original alignment (across a waste rock dump and the tailings basin) in about 2005. Historic Google Earth™ imagery from 1994, 2006, 2012, and 2014 and observations during a half-day site tour in the fall of 2018 provide the basis of an informal assessment of the site's current status, which reclamation techniques appeared to work or not, and an educated guess as to how the ecology of the site may continue to evolve.

Additional Key Words: Tailings, Waste rock, Alpine revegetation.

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2. James J. Gusek, P.E., Sr. Engineer, Sovereign Consulting Inc. Lakewood, CO 80228 (jgusek@sovcon.com); Brenda K. Schladweiler (* presenter), President, BKS Environmental Associates, Gillette, WY 82717.

3. Work presented was conducted near 42°32'12.66"N; 108°44'18.54"W.

Successful Revegetation Techniques for Legacy and Active Mine Sites[1]

Brent Hardy[2]

Abstract: Historic and active mining activities have disturbed large areas throughout the U.S. which now require site reclamation and revegetation. Frequently onsite or imported topsoil is unavailable, present in very limited quantities, or heavily impacted by pH, salts, metals or other materials that make native plant establishment and growth difficult to achieve. Stockpiling soils degrades the natural biological life, destroys soil structure, decreases organic matter and commonly mixes subsoils with surface soils. All these factors make revegetation challenging and when combined with short growing seasons and arid climates pushes us to maximize our effectiveness. Today's technology in spray applied amendments and stabilization products, counteract these negative physical and chemical impacts. They also assist Mother Nature in speeding up the process of soil building, nutrient cycling, and stockpiling of organic matter using natural, biological, and manmade additives. This presentation will address several of the field techniques, design approaches, and soil amendments that have proved successful at different capping and closure sites across the arid west and mountain states. We will provide examples of lessons learned from both successes and failures on projects at multiple site installations and results from field testing sites. Attendees will be given knowledge and approaches that will help extend reclamation budgets through cost and time savings in the field[3].

Additional Key Words: Erosion control, reclamation, soil amendments, plant establishment

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2. Brent Hardy (presenter), Soil Scientist, ACF West, Boise, ID 83709.

3. Work reported here was conducted near 42° 39′ 15″ N; 111° 36′ 16″ W.

Techniques to Refine Initial Amendment Selection for Dispersed Mine Tailings Reclamation[1.]

A.Harley and J. Willis[2.]

The Waldorf Mine is located in the Argentine Mining District of Colorado[3.]. Mining activity in the area began in the 1850's and continued through the 1950's. Dispersed tailings from a now-collapsed mill is located at elevations ranging from 11,300 to 11,400 feet. An Engineering Evaluation/Cost Analysis (EE/CA) indicated that incorporation of lime and organic amendments for in-situ phytostabilization was the recommended reclamation alternative. Further refinement was undertaken through evaluation of various materials to be sourced for reclamation at the site. Due to access difficulties, reducing the material to be hauled to site was important for cost savings. In-house testing included additional lime testing and germination trials to ensure that adequate and sufficient amendment rates for the site. Lime rates were originally estimated based on a single buffering test, a generic test. As lime efficiency varies between sources, a lime rate addition trial with lime sourced for reclamation was undertaken to determine the rate required to reach a target pH of 7.5. Based on this testing, the amount of lime was reduced by 30% from the recommendations of the EE/CA. To ensure sufficient lime was available to neutralize residual acidity, kinetic NAG testing was also undertaken. Germination trials were used with various organic materials at various rates to determine. Based on the results of the trial a composted forest product was utilized that reduced the estimated cost by 20% as well as reduced haulage costs. Following incorporation of the amendments, confirmation sampling was undertaken and tested for pH values to ensure that the amendments were properly incorporated into the dispersed. Despite a poor snow pack and drought conditions, adequate germination was achieved during the first growing season.

Additional Key Words: Phytostabilization

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2. Andrew Harley PhD (Presenter) Principal Geochemist, Duraroot LLC, Keenesburg, CO and Jason Willis PE, Program Manager, Trout Unlimited, Salida, CO
3. Work reported here was conducted near 39º38'15"N, 105º46'03"W

Soil Water Chemistry of Reforested Mine Site in West Virginia[1]

A. Hass[*], J.G. Skousen, and R. Cantrell[2]

Abstract: Proper reclamation of surface coal mining sites is essential for adequate restoration of ecosystem services, such as clean water. In this study, we present results of soil water chemistry in reforested experimental site and discuss the underlying conditions and mechanisms governing the system. The effect of Forestry Reclamation Approach practices, namely the use of oxidized vs reduced sandstone spoils as topsoil replacement material, and loose vs compacted placement thereof are evaluated at ca.12 years reclaimed sites. Two large experimental plots (ca. 2.8 hectare each) established in 2005 using brown sandstone or gray sandstone spoils as topsoil replacement material. Each plot was further split into two subplots where the material was compacted or loosely placed. Shallow wells and zero-tension pan lysimeters (30 to 80 cm deep) installed near three random locations within each treatment plot (spoil type x placement practice) during early spring of 2017. Water samples were collected weekly during 2017 and 2018 growing seasons and analyzed for elemental and ionic composition, total alkalinity, total and organic and inorganic carbon, as well as dissolve oxygen, pH, temperature, and redox potential. Results of the two years are discussed and compared to on-site surface runoff water composition and to that of soil water in adjacent, non-disturbed forest.[3]

Additional Key Words: redox potential, spoil, brown sandstone, Forestry Reclamation Approach.

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2. Amir Hass (* presenter), Associate Research Professor, Agricultural and Environmental Research Station & Biology Department, West Virginia State University, Institute, WV 25112; Jeffery G. Skousen, Professor, Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506; and Robert Cantrell, Soil, Water and Natural Resources Lab manager, Agricultural and Environmental Research Station, West Virginia State University, Institute, WV 25112.

3. Work reported here was conducted near 38° 02′ 42″ N; 81° 30′ 30″ W.

Anna S Mine: A Century of Mining, Acid Mine Drainage, and Remediation[1]

Robert Hedin[2]

Abstract: The Anna S Mine (Tioga County, Pennsylvania) has supported underground and surface coal mining activities in the Bloss coal seam since the 1890's. The mining is in poorly buffered net acidic strata located above the regional drainage. The mine drainage is low pH with elevated concentrations of Al, Fe, and Mn. In the 1970's surface mining along the crop daylighted portions of the underground workings. The effects of the surface mining on water quality were documented by a USGS investigation, followed by monitoring associated with the surface mining permit. Daylighting activities significantly worsened the chemistry of the mine drainage, caused severe water quality problems in Babb Creek, and degraded water quality downstream in Pine Creek, a nationally recognized cold water fishery. The degradation prompted the formation of the Babb Creek Watershed Association (BCWA) who lobbied aggressively for remediation actions. In 2003/04 two passive treatment systems were installed to treat mine water discharging from the Anna S mine at a total cost of $2.5 million. The systems, which utilize vertical flow ponds and constructed wetlands, are the largest passive treatment project ever undertaken by a non-profit organization in Pennsylvania. Since their installation, the systems have continuously produced net alkaline effluents, which has contributed to restoration of good water quality in Babb Creek. In 2010, both Babb Creek and Pine Creek were removed from the degraded stream list and reclassified as high quality cold water fisheries. The BCWA has managed the operation of the systems since their installation. This responsibility includes sampling, routine maintenance, and major maintenance projects in 2014 and 2016 when the organic substrates in the VFPs were replaced. The presentation will present the 45-year record of chemical and hydrologic characteristics of mine water discharges from the Anna S mine. The presentation will highlight the degradation caused by the daylighting operations, natural improvements in water chemistry in decades since completion of mining, benefits realized by the passive treatment, and the full cost of the passive systems.[3]

Additional Key Words: Passive Treatment, Babb Creek, Pine Creek.

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2. Robert Hedin (presenter), Hedin Environmental, Pittsburgh, PA 15228.
3. Work reported here was conducted near 41°37'18" N, 77°18' 05" W.

Financial Assurance for Long-Term Reclamation[1]

D. Sutton*, D. Herrera[2]

Abstract: Resistance to new mines is growing, especially in cases where sulfide minerals are present and there is a real or perceived risk of long-term water contamination. There is a movement afoot to ban any type of mining that might require ongoing or long-term water treatment. Recent catastrophic tailings dam failures have added fuel to the resistance to opening new mines or expanding existing mines considering the perpetual liability. Higher living standards and a growing world population will increase the demand for metal. How will the higher demand for metal be met if the supply is curtailed by prohibiting mining? This paper touches on the experience Spectrum Engineering has had as the operator of six water treatment plants at the orphaned Zortman, Landusky, Kendall, and Gilt Edge mines, and our recent experience assisting the Minnesota DNR and PolyMet mining company. Spectrum assisted in determining the amount and type of financial assurance required for PolyMet's proposed polymetallic sulfide mine in Northern Minnesota where long term water quality is an issue. The financial assurances for disturbed land reclamation are straightforward; however, when geochemistry and waste streams become more complex and the long-term water chemistry is less certain, the mining company's financial assurance becomes very complicated. What does a mining company need to do to justify the science and financial assurances to satisfy the public and regulators? What does the public and regulators need to know to ensure compliance? What type of financial assurance is appropriate? How long will it be required? How will it be estimated? How will it be managed? How will the uncertainty be quantified? An attempt will be made to answer these questions.

Additional Key Words: Financial Assurance, Bonding, Geochemistry, Trust, Risk, Economics.

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2. Don Sutton P.E. and Drew Herrera P.E. (* presenters), Mining and Civil Engineers, Spectrum Engineering, 1413 4th Ave North, Billings MT, 59101.

Evaluating the Role of Optical Depth on Spectral Reflectance Data from sUAS-Mounted Multispectral Sensors and Handheld Hyperspectral Radiometers with Relation to Development of Water Quality Models in Mine Drainage Systems[1]

B. K. Holzbauer-Schweitzer[*] and R. W. Nairn[2]

Abstract: Remote sensing of terrestrial and aquatic ecosystems is a demonstrated tool in environmental monitoring. As part of a larger study to develop water quality models based on the spectral reflectance of surface waters, this project examined the influences that underlying substrates (e.g., iron oxides in mine drainage systems) may play in model development. The work was completed at the Mayer Ranch Passive Treatment System (MRPTS) in the Tar Creek Superfund Site, the Oklahoma portion of the historic Tri-State Lead-Zinc Mining District. A high-resolution, small Unmanned Aerial System (sUAS)-mounted multispectral sensor and a hand-held hyperspectral radiometer were used to examine the effects of physical water depth (from water surface to substrate surface) and optical depth (depth of light penetration through the water column) on resulting spectral reflectance data and its relationship to *in-situ* water quality data. Both instruments produce reflected radiant energy signatures which may be impacted by underlying substrates if the optical depth exceeds the physical water depth. Three locations within the PTS were examined three times. Samples from three locations were collected and analyzed for moisture content, loss-on-ignition, total metal concentrations via field portable X-ray fluorescence, and wet and dry spectral reflectance. Results from these analyses revealed the following means: moisture content of 82 ± 1.5 %, organic matter of 12 ± 2.7 %, and total metal concentrations for Pb, Zn, and Cd of 50 ppm, 9000 ppm, and below detectable limits, respectively. When comparing the peak reflectance within the visible portion of the electromagnetic spectrum, wet substrates reflected approximately 55 percent more light energy. If the depth of the water column exceeded the optical depth of light penetration, the spectral reflectance of the substrate did not impact the overall spectral signature measured from either device. However, when the optical depth of light penetration exceeded the physical water depth, the overall signature was impacted. When applying statistical models relating spectral reflectance to water quality in optically shallow waters, not only do constituents in the water (e.g., total suspended solids, chlorophyll-a, and colored dissolved organic matter) impact the overall signature, but the surface of the underlying substrate does so as well. Therefore, spectral reflectance and *in-situ* water quality may not be strongly correlated.

Additional keywords: Spatial Modeling, Iron Oxides, Tar Creek

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2. Brandon K. Holzbauer-Schweitzer, Graduate Research Assistant and Ph.D. Candidate (student) and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

3. Work reported here was conducted near N 36.922, W 94.872.

Land Reclamation Planning for Underground Coal Mining Areas and Case Studies in China [1]

Zhenqi Hu[2]

Abstract: Coal is the most important energy in China. 85% of coal output comes from underground mining in China. With the excavation of coal from underground, land subsidence is serious, which also produced a lot of environmental problems. Land reclamation plan is the key for repairing the damaged the land and environment. This paper conducted research on the principle and classification mined land reclamation planning. A general technical procedure for land reclamation planning was presented. Based on several case studies for abandoned and active coal mines in China, the methods and results of land reclamation planning were discussed.

Additional Key Words: reclamation planning, coal mining, subsidence

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2. Zhenqi Hu, professor, School of Environment Science and Spatial Informatics, China University of Mining and Technology, Xuzhou, Jiangsu, China, 221116.

Evaluation of Restoration Achievement for the Release of Upland Grasslands from Statutory Aftercare Provisions at a Surface Mine in South Wales, UK: The Deployment of Two Recently Developed Agricultural Methodologies[1]

R Neil Humphries and R Thompson[2]

Historically, in the UK, the measures of success to document and assess the condition and suitability of land restored for agricultural purposes on completion of their statutory five-year aftercare period has been to describe the soil physical characteristics of the soil profile and less of available (chemically extractable) plant nutrients (P, K, Mg) and soil reaction (pH). Whilst still relevant, the realisation by parts of the agricultural industry that the sustainable use of soils is dependent on its biological and physical condition has led to the development and deployment of other indicator methodologies; such as laboratory microbial incubation (nutrient cycling) techniques and visual descriptors (physical structure) for the condition of the soil profile. In this paper the use of the historical approach is compared with both the incubation and visual assessment approaches now being used widely by the agricultural industry to assess two types of restored grassland due to be released from statutory aftercare at a mine site in South Wales, UK. All three methodologies indicate that land restored to open moorland grassland and enclosed pasture are in a sufficiently fit condition for the intended land agricultural use and could be released from the five-year aftercare requirement. We conclude that the newer agricultural approaches have additional merits and could be adopted routinely for the evaluation of restored land to agricultural grassland.

Additional Key Words: microbial incubation, nutrient cycling, soil structure, soil condition.

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2. R Neil Humphries (presenter), Natural Resources Manager, Celtic Energy Ltd, Caerphilly, CF83 2AX, Wales, UK and Robert Thompson, Operations Director, Celtic Energy Ltd, Caerphilly, CF83 2AX, Wales, UK.

A Recently Translocated Woodland Plant-Soil Ecosystem: Some Early Outcomes and Lessons Learnt[1]

R Neil Humphries[2]

Whilst the translocation of wildlife habitats (soils and their vegetation) is now referred to in UK national planning policy as potential mitigation action for both mineral and the built developments, and although it is now commonplace, it remains controversial and as a last resort where prime ecosystems are involved. None is more contentious as woodland translocations where those designated as 'semi-natural ancient woodland' (i.e. have been in situ for some 400 years or more) are involved, and there is a presumption against the granting consent for developments adversely affecting them. In this paper, the early outcomes of a translocation of part of such a woodland following the granting of planning consent to extend a nationally important granite resource is reviewed with lessons learnt. Here, we found that weediness and its control in the short-term appears to be paramount and may determine future success. As with the translocation of other ecosystems, the condition of the woodland pre- translocation and the actions taken subsequently are likely to be of overriding importance, and may be too easily overlooked. These findings are of relevance beyond the mineral extraction industry given that built developments such as the UK Government's plans to construct a high-speed rail network (HS2) could directly affect a hundred or more such woodlands where translocation will be offered as mitigation.

Additional Key Words: wildlife habitats, ancient woodland, oak woodland, woodland regeneration, woodland management.

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2. R Neil Humphries, Blakemere Consultants Ltd, Dorchester DT1 3RZ, UK.

Day Loma Pit –Water Filled Pit Backfill Method[1]

H.J. Hutson[2]

Abstract: BRS, Inc. has designed and managed the initial backfill of the Day Loma abandoned uranium mine pit in the Gas Hills Uranium District for the Wyoming Abandoned Mine Land program. The reclamation of the Day Loma pit is part of a larger project to address a uranium mining district that included over 1,000 acres of disturbed ground with a total of four open pits and multiple spoils areas to be completed in a 15-phase project. The Day Loma pit presented some unique challenges for backfill as it included a 23-acre open water body with depths up to 65' when the work began. The total earthwork quantity to reclaim the Day Loma Pit to the ultimate geomorphic reclamation surface is 12.5 million cubic yards. When complete, a total of 2,580' of dangerous highwalls will be eliminated. The pit water was covered in two annual phases, moving a total of 5 million cubic yards from the highwalls and spoil piles into the water-filled pit. Off-site dewatering allowed backfill to be introduced without significantly varying the pit water level. As the majority of material used for the project was clay, backfill stability was of particular concern. Specific methods were employed to emplace a stable backfill into the water-filled pit. The bottom of the pit was filled with a fine material fraction with a slime consistency. As backfill proceed, this material was displaced in front of the advancing stable backfill. Near the end of the backfill operations, approximately 200,000 cubic yards of slime remained in the pit, which was managed by a combination of covering, mixing, displacing, and spreading. The construction cost total for the two phases included in this presentation was approximately $7.9 million, of which approximately $300,000 was required to complete the mud covering and mixing.[3]

Additional Key Words: Uranium mine

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2. Harold J. Hutson, PE, PG, BRS Inc. Senior Engineer and Project Manager, Riverton, WY 82501.
3. Work reported here was conducted near 42° 43' 48" N; 107° 40' 00" W.

An Analysis of Cost Factors in Geomorphic Mine Reclamation[1]

H.J. Hutson[2]

Abstract: BRS, Inc. has completed over 20 large scale geomorphic mine reclamation projects or construction phases for the Wyoming Abandoned Mine Land program starting in 2007. The Wyoming AML has been a leader in geomorphic reclamation, which has yielded projects, which are more stable and require less maintenance, provide for increased vegetation diversity and habitat values, and are more aesthetically pleasing than traditional reclamation employed in the past. The construction cost total for the projects included in this presentation is approximately $50 million, with over 27 million cubic yards of earthwork moved in the reclamation efforts, which reclaimed approximately 1,500 acres of abandoned, mine sites using geomorphic reclamation techniques. Reclaimed sites included open pits, highwalls, mine waste piles, degraded channels, and subsidence areas on both coal and uranium mine sites. Cost data has been tabulated and analyzed for each project. Factors including market forces, fuel costs, and site-specific conditions have been considered with respect to their impact on competitively bid geomorphic reclamation projects. The data shows that, properly planned and constructed, the earthwork costs for a geomorphic reclamation project are driven by the excavation parameters such as material type, haulage length and gradients, and other work requirements much like any other earthwork project without any significant increases in costs to complete the geomorphic reclamation projects.

Additional Key Words: Natural Regrade™, Wyoming Abandoned Mine Land Program, construction costs

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2. Harold J. Hutson, PE, PG, BRS Inc. Senior Engineer and Project Manager, Riverton, WY 82501.

A River Runs Through It: Designing and Permitting the Stibnite Gold Project[1]

Dale Kerner[2]

Abstract: The Stibnite Mining District has played a significant role in providing strategic and critical mineral resources to mid-20th century wartime efforts and associated economic benefit to a rural part of central Idaho. Understandably, the socio-political environment in which these activities occurred prioritized productivity and much of the mining at Stibnite occurred ahead of substantive environmental regulation. Today, the legacy issues that remain at Stibnite continue to impact water quality and ecosystem productivity in the Salmon River drainage, one of the nation's premier anadromous fisheries and recreational waterways. Midas Gold Idaho, Inc.'s Stibnite Gold Project (SGP) incorporates comprehensive restoration of these historical impacts into plans for further mining at Stibnite, mitigating conditions that impair water quality, fisheries, and wildlife habitat in the East Fork of the South Fork of the Salmon River drainage. [3].

Additional Key Words: legacy, water quality, ecosystem productivity, restoration, fisheries, habitat

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2. Dale Kerner, Permitting Manager, Midas Gold, 405 S. 8th Street, Suite 201, Boise, Idaho 83702.
3. Work reported here was conducted near 44.898171N, -115.339269W.

Emergency Response to Historic Pit Mine Washout Leads to Improved Resiliency, Functionality, and Aesthetics[1]

Pete Kero*, Jessica Olson, and Linda Johnson[2]

Abstract: On April 24, 2018, water from the historic Hector mine breached an earthen berm, lowering pit water levels four meters, washing sediment into the Embarrass River Diversion Channel, and taking out utilities and 60 meters of the Mesabi Trail bicycle path. The Minnesota Department of Iron Range Resources and Rehabilitation acted quickly to remove sediment from the channel and temporarily stabilize the wash-out ravine. Designs for trail and utility restoration were provided in August, and construction was 95% complete by November 2018, incorporating multiple features to enhance utility accessibility, site resiliency, and aesthetics.[3]

Additional Key Words: mine water management, restoration.

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2. Pete Kero*, P.E., Project Manager, Barr Engineering Company, Hibbing, MN, 55746; Jessica Olson, P.E. Sr. Water Resources Engineer, Barr Engineering Company, Duluth, MN 55802; Linda Johnson, Director of Mining and Property Development, Minnesota Department of Iron Range Resources and Rehabilitation, Chisholm, MN 55719.

3. Work here was conducted near 47º 32’ 28” North and 92º 18’ 40” West.

Geochemistry of Improved Groundwater Quality Resulting from Adit Plugging, Glengarry Mine, New World District, Cooke City MT USA[1]

Lisa B. Kirk*, Lauren R. Bozeman, Allan R. Kirk, and Mary Beth Marks[2]

Abstract: Construction of hydraulic adit plugs within the historically mined Glengarry Adit at Cooke City MT effectively reduced discharge by more than 95% and resulted in groundwater rebound that flooded underground workings. This study evaluated geochemical controls of groundwater quality through comparison of changes in mineral saturation states and metal sorption potential. Monitoring of water quality in the adit has occurred since the 1980s via collection of samples from the discharge at the adit portal prior to closure and from a monitoring well screened within the adit post-closure. Aseptic collection of biomass allowed characterization of microbial community present. The Geochemist Workbench SpecE8® and React® models were used to speciate the aqueous chemistry of the adit water, calculate changes in the relative equilibrium of the water with respect to Fe, Mn, and Al oxyhydroxide and sulfate minerals resulting from the adit closure, and to calculate potential for sorption of metals to precipitated ferrihydrite. Following closure, alkalinity rose from below detection to almost 5 mg/L in 2012, along with increased pH from an average of 3.5 to over 5.5 post-closure. This shift prompted precipitation of aluminum and iron-oxyhydroxide minerals followed by metal sorption and associated increases in dissolved iron and sulfate, primarily due to dissolution of jarosite. The closure design has thus successfully reduced sulfide oxidation substantially within the Glengarry adit, increased the stability of iron oxyhydroxide minerals able to sorb the trace metals Cu, Pb, and Zn, thus improving both surface and groundwater quality, which supports the use of this approach in other mine closure settings.[3]

Additional Key Words: hydraulic adit plug, ARD, jarosite, geochemical modeling.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019.

2. Lisa B. Kirk (* presenter), and Lauren R. Bozeman, Enviromin, Inc., 524 Professional Dr., Bozeman MT 59718; Allan R. Kirk Geomin Resources, Inc., 524 Professional Dr., Bozeman MT 59718; Mary Beth Marks, Gallatin National Forest, 10 East Babcock, Bozeman MT 59715.

3. Work reported here was conducted near 45° 0' 57.7620" N, 109° 54' 59.5800" W.

Field-Testing Transgenic American Chestnuts on Reclaimed Coal Mines[1]

Sara K. Klopf* and Jason Holliday[2]

Abstract: Prior to the introduction of a non-native fungal pathogen in the late 1800s, the American chestnut (*Castanea dentata*) was a dominant hardwood tree in eastern North America. Its abundant mast made it an important food resource for both animals and humans, and the rapid spread of the blight was devastating to eastern forest communities. Organizations including the American Chestnut Foundation have been using hybrid/backcross-breeding to introduce blight resistance from Chinese chestnut (*Castanea mollissima*), but while there have been some promising results, resistance levels in resulting offspring are variable. Recently, efforts to develop blight-resistant trees have involved genetic modification to insert candidate blight resistance genes from Chinese chestnuts. Bioassays of GM chestnuts have shown promise, but their viability in the field is still being assessed. From a regulatory perspective, reclaimed coalmines in need of reforestation provide an excellent locale for field-testing GM chestnuts, as there is little opportunity for genetic material (e.g. pollen) to escape the study site and pollinate compatible species. Over 2014 and 2015, we planted two cohorts of GM chestnuts comprised of multiple genetic constructs (background genotype x inserted genes) on a reclaimed coal mine in southwestern Virginia. The aim was to select promising candidates for increased production that could be planted in a larger scale study. To assess their viability, trees were phenotyped monthly during the growing season, including recording any visible indications of blight. Height and basal diameter were measured after planting and at the end of the growing season. Growth and survival varied among constructs. By 2016, a number of trees, both GM and non-GM, developed blight cankers, several of which resulted in stem dieback and resprouting, but some constructs appear to have more blight resistance. In spring 2018, we inoculated trees with a virulent strain of *C. parasitica* to a) assess canker development and b) quantify gene expression through RNA-sequencing to determine whether resistance genes are being expressed after inoculation. Inoculation data will not be available until spring 2019, but we hope to ascertain whether differences in resistance to natural blight infection correlate to differences in gene expression. [3]

Additional Key Words: *Cryphonectoria parasitica*, *Castanea dentata*, genetic modification, reforestation.

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2. Sara K. Klopf (* presenter), Research Associate, School of Plant and Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; Jason Holliday, Professor Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg, VA
3. Work reported here was conducted near 36°59'9"N, 82°42'5"W.

Establishing Native Grassland Plants on Mineral Sands Mines in Virginia [1]

Sara K. Klopf*, W. Lee Daniels, and Zenah Orndorff [2]

Abstract: Mineral sands mining for ilmenite, rutile and zircon in southeastern Virginia results in compacted soils with low fertility and high variability in texture. Typically, land is reclaimed to upland pasture and often returned to row crop agriculture, but there has been growing interest in using alternative vegetation to reduce maintenance requirements and benefit wildlife. In spring 2016 we initiated a study to assess the feasibility of planting native grassland species as low-maintenance, high-resilience pollinator plots. We created four seed mixes of native grasses, legumes, and forbs: a high diversity, high seeding rate mix (HDHR); a high diversity, low seeding rate mix (HDLR); a low diversity, low seeding rate mix (LDLR); and a low diversity, high seeding rate mix (LDHR). We established four replicates of each mix at two different mining sites (Brink and Concord), and have monitored vegetation establishment twice per growing season. Overall, vegetation cover is higher at Brink and dominated by planted grasses (*Schizachyrium scoparium* and *Panicum virgatum*) as well as *Coreopsis lanceolata*, while the lower vegetation cover at Concord is dominated by *Chamaecrista fasciculata*, and to a lesser extent, *Andropogon gerardii* and *Desmodium canadense*, all of which we planted. While native weedy species (particularly *Ambrosia artemesifolia*) represented the dominant cover in 2016, by 2017 and 2018 weed cover had decreased by over 75% and been replaced by our planted species. In general, high diversity mixes (HDLR and HDHR) had greater cover and richness of planted species and lower weed cover than the low diversity mixes (LDLR and LDHR), although lower diversity mixes resulted in greater planted legume richness by 2018. We have observed no differences in any of our cover or richness metrics that resulted from seeding rate, suggesting that native plant establishment could be more affordable than expected. We hope these preliminary results may encourage the planting of native pollinator plots on other reclaimed mine soils in the Coastal Plain region.[3]

Additional Key Words: Revegetation, plant diversity, seeding rate, pollinator plant species.

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2. Sara K. Klopf (* presenter), Research Associate, School of Plant & Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; W. Lee Daniels and Zenah Orndorff, School of Plant & Environmental Sciences, Virginia Tech, Blacksburg, VA.
3. Work reported here was conducted near 36º46’33” N; 77º34’55” W and 36º37’10” N; 77º38’16” W.

Developing a Long-Term Hydrologic Monitoring Plan for Surface Coal Mines[1]

K. D. Krogstad[2]

Abstract: One of the primary metrics for responsible operation and effective reclamation of a surface mine is water monitoring. Reclamation must consider the quantity and quality of groundwater and surface water before, during, and after mining. It is vital to develop a plan that will stand up to scientific and legal scrutiny in the future. A sampling plan must include locations, schedules, methods, and analytes to be studied. Federal, state, and local statutes will generally provide a framework that must be accommodated. Historical data and analyses will provide clues to potential issues. Obviously, as scientists, we want all the data we can get, but a sampling plan also must acknowledge the operations of the mine. Stations located in areas to be mined will be destroyed as mining progresses, and replacements must be in place ahead of time to maintain continuity. Stations in remote areas may be impossible to access during certain times of the year. New wells will be installed in reclaimed areas. Ownership of and access to surrounding lands may change. A monitoring plan must adapt to changing conditions without loss of continuity. In today's society, it is unlikely that most of us will ever be involved in the development of a mine from initial concept to reclamation, so generally there will be an existing monitoring plan in place. Knowing the strengths and weaknesses of a monitoring plan may be crucial to preparing a legal defense, and any monitoring plan should be open to improvement.

Additional Key Words: monitoring, reclamation, hydrology, permitting.

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2. Kevin D. Krogstad, Hydrologist, Montana Department of Environmental Quality Coal Section, Helena, Montana.

Effects of Precipitation Patterns on Sediment, Nutrient, and Biofilm Dynamics in an Acid Mine Drainage Stream[1]

J. Brancho, N.A. Kruse Daniels*, and M. L. Vis[2]

Abstract: Although acid mine drainage (AMD) in the Appalachian Coal Basin has been studied for decades; the effects of climate change on these streams are not well documented. Climate change predictions for this area include increased storm frequencies and intensities, which may alter AMD generation and iron hydroxide precipitation. These processes substantially affect nutrient availability and the biological communities inhabiting these streams. This study investigates the potential effects of climate change on a treated AMD stream, Hewett Fork, by quantifying changes in nutrient concentrations, sediment transport, and algal biofilm biomass during normal and storm conditions. Nitrate, sulfate, and total reactive phosphorus concentrations were measured during each sampling event. Sediment transport was measured by quantifying sediment deposition and total suspended solids (TSS). The biological response to these conditions was measured by comparing algal biofilm biomass, quantified as chlorophyll a concentration, on stream rocks. Coupled with long-term meteorological, discharge, and chemistry data, the results of this study were used to create two conceptual models of Hewett Fork's behavior during normal and storm conditions, respectively. Antecedent precipitation index (API) was used as an indicator of runoff potential to analyze the effects of recurring storm events on stream behavior. As API increased during both normal and storm events, TSS concentrations increased, while chlorophyll a, conductivity, and sulfate concentrations decreased. TSS, nitrate concentration, and sediment deposition were higher overall during storm events. Total reactive phosphorous concentration remained low at all sites during the sample period, indicating that Hewett Fork may be phosphorous-limited. The results of this study indicate land use, mining, and treatment systems may contribute to lasting negative impacts on the biological community of Hewett Fork, if storms become more frequent and intense. Additionally, the inverse relationship between chlorophyll a values and sediment transport suggests current velocity may also exert significant control on the system.[3]

Additional Key Words: stream recovery, climate change, coal.

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2. Jennie Brancho, student, Environmental Studies, Ohio University, Athens, OH 45701; Natalie A. Kruse Daniels (* presenter), associate professor, Environmental Studies, Ohio University, Athens, OH 45701; and Morgan L. Vis, professor, Environmental and Plant Biology, Ohio University, Athens, OH 45701.

3. Work reported here was conducted near 39°22'44" N, 82°15'57" W.

Development of a GIS Tool for Estimating Post-Mining Water Levels in Underground Coal Mines of Ohio[1]

R. Steinberg[*], Z. Matthews, N.A. Kruse Daniels, D.L. Lopez, J.R. Bowman, and N. Sullivan[2]

Abstract: A need for estimating post-mining water level for underground coal mine permitting has been addressed through development of an algorithm relating pre-mining to post-mining water level based upon data from wells and boreholes used in underground coal mine permits in Ohio. Using Model Builder in ArcGIS Pro, a tool was built that applies the algorithm and estimates post-mining water level at well locations in a permit application. The input layers to the tool include a digital elevation model (DEM), a raster layer of coal elevation, a raster layer of coal thickness, a point layer with well locations including details of the overburden encountered in that well and static water level measurements, and a layer of pre- and post-SMCRA underground mines. These data layers are projected over the permit area and used to calculate variables in the algorithm. Variables used in the algorithm to estimate post-mining water level include: surface elevation, elevation of coal, thickness of coal, thickness of clay and shale in the overburden, thickness of sandstone in the overburden, thickness of limestone in the overburden, accumulated volume of coal mined, area of underground mines within a 4-mile buffer, and average annual precipitation. The algorithm calculates estimated post-mining water level by using the maximum coal volume proposed in the permit as accumulative volume of coal mined and setting the elevation of the bottom of each well location to the elevation of coal. The estimation points are then compared with the DEM to identify areas at risk for surface discharge. The points were transformed into a spatially interpolated layer representing water level. With low enough error, this surface was also compared to the DEM to determine areas at risk for discharge. This methodology can be undertaken for other regions to relate hydrologic, geologic, and mining parameters to post-mining water level.

Additional Keywords: groundwater, potentiometric surface, mapping.

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2. Rebecca Steinberg (* presenter) and Zachary Matthews, students; Natalie Kruse Daniels, associate professor, Environmental Studies, Ohio University, Athens, OH 45701; Dina L. Lopez, professor, Geological Sciences, Ohio University, Athens, OH 45701; Jen R. Bowman, environmental program manager and Nora Sullivan, environmental specialist, Voinovich School of Leadership and Public Affairs, Ohio University, Athens, OH 45701.

Streamflow Variability and Treatment System Effectiveness in a Changing Climate[1]

N.A. Kruse Daniels*, Z. Matthews[2]

Abstract: Mining impaired watershed are frequently treated with passive or active treatment schemes that treat multiple discharges in one location or over-treat in one location to manage acid mine drainage (AMD) inputs at nearby locations. Treatment system effectiveness can vary based on the flow regime of the AMD input, the treatment train itself, and the receiving water body. Using the Stoertz Water Quality Evaluation Method, the impact on treatment system effectiveness, measured as increase in net alkalinity and decrease in Fe + Al + Mn concentration in the receiving water body, at varying flow conditions has been determined. Long-term monitoring locations used for this evaluation have data for at least five years, up to fifteen years. While results varied between watersheds, two main patterns stood out. First, in watersheds receiving AMD from larger underground mine workings, critical chemical conditions were reached in low flow periods in the summer. This time period is coupled with low flow conditions which may limit the flow through treatment systems if they are not fed directly from the AMD source (e.g. a source pond fed steel slag leach bed), whereas systems fed directly from an AMD source (e.g. lime doser) met the treatment need in critical conditions given enough flow to transport and dissolve the alkaline material. Second, in watersheds with primarily surface mining impacts, critical chemical conditions were reached in the rising leg of storm conditions. The effectiveness of treatment systems varied in these conditions. Long-term discharge data at three USGS gauge stations associated with mining impaired watersheds in southern Ohio were analyzed to determine both the inherent variability in flow between years and to identify any trends in flow variability with changing climate. While not statistically significant, increased summer rainfall is apparent, potentially changing the timing and nature of critical chemical conditions in treated AMD streams.[3]

Additional Keywords: climate change, acid mine drainage, coal mining, remediation.

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2. Natalie Kruse Daniels (* presenter), associate professor, Environmental Studies, Ohio University, Athens, OH 45701; Zachary Matthews, student, Environmental Studies, Ohio University, Athens, OH 45701.
3. Work reported here was conducted near 39°22’44” N, 82°15’57” W.

Laboratory Testing to Optimize Retention Time in Auto-Flushing Limestone Beds[1]

J.A. LaBar*, C.A. Neely, C.F. Denholm, T.P. Danehy, W.H.J. Strosnider[2]

Abstract: Auto-flushing limestone beds (AFLB) have been presented as an innovative solution to the widespread problem of armoring and clogging of traditional, flow-through limestone beds. A baffled limestone bed was constructed in 2012 to treat the Puritan discharge outside of Portage, PA. Plans are in place to retrofit the current system through the addition of AFLB. In order to determine if AFLB would result in improved water quality and to determine the optimum retention time for metals and acidity removal and alkalinity generation, bucket tests were conducted in spring 2018. A total of eight bucket tests were conducted, each in triplicate. Time which water was in contact with the limestone prior to flushing and settling was varied in each test, ranging from 4 to 24 hours. After the first settling period, each test was run again to simulate a second limestone bed. Alkalinity and pH were measured immediately at the end of each contact or settling period and acidity and dissolved Fe, Al, and Mn samples were collected. Average pH of the influent was 3.03 and average acidity and alkalinity were 110 mg/l and 0 mg/L, respectively. Average dissolved Fe, Al, and Mn were 5.29 mg/L, 10.7 mg/l, and 1.34 mg/L, respectively. All bucket tests were effective at removing Fe to below the detection limit (0.10 mg/L) and Al to an average 0.12 mg/L. Mn removal was mostly negligible, with noticeable removal in two of the longer duration tests. All acidity was neutralized and pH raised to an average of 5.91 within the first contact period in all bucket tests, with additional improvement during the second contact period. The majority of alkalinity was generated during the first contact period, with more generated during the second. Tests where all water was added at the beginning of the contact time resulted in better water quality than tests where water was added gradually throughout the contact time. Although longer retention times generally resulted in improved water quality, results may exceed water quality criteria such that a shorter retention time may be sufficient. These results will be used to aid in the design of the improved Puritan treatment system.

Additional Key Words: bucket test, acid mine drainage, alkalinity, acidity.

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2. Julie A. LaBar (* presenter), assistant professor, Science Department, Centenary University, Hackettstown, NJ 07840; Cody A. Neely, engineer, BioMost, Inc, Mars, PA 16046; Clifford F. Denholm, environmental scientist, BioMost, Inc, Mars, PA 16046; Timothy P. Danehy, environmental scientist, BioMost, Inc, Mars, PA 16046; William H.J. Strosnider, associate professor, St. Francis University, Loretto, PA 15940.

Mine Landforms in Australia; Evolution and Benchmarking[1]

Harley Lacy[2]

Abstract: Stable, non-polluting, rehabilitated landforms that meet a final land use, reflecting the demands of the community and regulators, has required a steady change in approach in Australia. Leading to companies taking responsibility via a suite of important changes including; waste characterization, landform design and managed construction. Open cut mining in Australia rapidly expanded in the last 50 years, volumes moved per annum, once small, are in excess of many millions of tons per project. This expansion commenced in the 1980's just as the author became involved in landform rehabilitation for a multi mine gold company, and as the first research groups started to conduct waste dump rehabilitation research in Australia. Since that time the author consulting to many multi pit mines, and benchmarked widely across Australia, engaged in building capacity of mining professionals by learning from successful, and not so successful, landform construction and rehabilitation techniques applied at a wide variety of mines. We will present a study of a historical rehabilitation technique for application to landforms orientated in such a way that makes them difficult to rehabilitate using currently acceptable closure and rehabilitation techniques. We benchmarked the moonscaping technique, across a series of large and small mines, predominantly mining iron ore, in the Pilbara region of Western Australia, to learn from both historic and current closure and rehabilitation activities undertaken within this large, dynamic, mineral producing province. The technique appears to stand the test of time and provides an insight, not only for further study, but to inform and learn from both historic and current closure and rehabilitation activities undertaken. Landform rehabilitation is a time dependent process, it's important we reflect, review and respond to see if learnings of the past can be brought into the future and applied to retrospective landform design, construction and closure.

Additional Key Words: Techniques, Moonscaping, Rehabilitation, Capacity Building.

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2. Harley Lacy, Closure Adviser - Stantec, and Director MCMS Pty Ltd. Restoration Ecologist/ Environmental Manager. PO Box 2042 Subiaco Perth, West Australia 6904.

30 Years of Reclamation and Remediation in the Silverton Caldera of Colorado[1]

Steven Lange

Abstract: The Animas River in the area around Silverton, San Juan County, Colorado has been adversely impacted by high loading of iron, aluminum, cadmium, copper, lead, zinc, arsenic, and nickel. Metals loading in the Animas River has limited aquatic life, including the trout fishery downstream from Silverton. The metals loading in the Animas River is due to acid rock drainage formed from a combination of natural weathering of mineralized rocks and residues from over 100 years of mining. Sunnyside Gold Corporation (SGC) was formed and acquired the Sunnyside Mine in the Upper Animas basin in 1985. Since 1985, SGC has engaged in more than 30 years of reclamation and remediation in the Silverton Caldera. Actions included removal of mine waste from owned and area mines, treatment of water discharged from mine portals, seasonal treatment of the flow in Cement creek, installation of bulkheads in mine workings, and stabilization of tailings deposits. Evaluation of the results of the actions demonstrates that the actions of SGC have substantially reduced acid rock drainage and metals loading in the Animas compared to what would have otherwise been the case.

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1. Oral presentation at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

Golden Sunlight's Outside Ore Program[1]

Steve Lloyd[2]

Abstract: The Golden Sunlight Mine has been operating its outside ore program since 2011. During this time, the mine has taken in over seven hundred thousand tons of legacy dump material, and tailings. The mine has paid out over forty million dollars to small miners. This program received the BLM Environmental Excellence Award in 2013. The presentation will cover the What, Where, Who, Why, and How the outside ore program works.[3]

Additional Key Word: Reclamation, Historic Mine Waste Cleanup

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2. Steve Lloyd, Chief Metallurgist, Golden Sunlight Mine, Whitehall, MT, 59759.
3. Work reported here was done near 45.901389 - 112.011667.

Restoring the Hydrology – Key to Successful Reclamation at the Riley Pass Uranium Mine Site[1]

Mary Beth Marks, Michael Hatten, and Mark Donner[2]

Abstract: The Riley Pass Uranium Mine Site (Site) is located on the Custer Gallatin National Forest in the North Cave Hills of Harding County, South Dakota, approximately 25 miles north of Buffalo South Dakota and 25 miles south of Bowman, North Dakota. During the late 1950s and early 1960s, extensive, unrestricted strip mining occurred on lands in the Riley Pass portion of the North Cave Hills. Mining consisted of removing overburden from the bluffs to access uranium-bearing lignite coal beds, which in places were 80 feet below the original ground surface. The mines cover approximately 316 acres encompassing high walls, pit floors, and spoils. Due to the erosive nature of the surrounding soils and the harsh climate, contaminants of concern (arsenic, molybdenum, uranium, thorium, and radium 226) have been exposed and mobilized, resulting in a risk to human health and the environment. USDA Forest Service is lead agency for the Site under its Comprehensive Environmental, Response, Compensation and Liability Act of 1980 (CERCLA) authority. An Engineering Evaluation/Cost Analysis was completed for the Site in November 2006. The primary objective of the removal actions is to isolate the contaminated mine waste onsite and leave the final reclaimed surface in a physically stable condition. The Site consists of 12 bluffs; response actions have been completed at eight bluffs. Through both bankruptcy and fraudulent transfer court settlements, the Forest Service received funding to complete Site reclamation. Traditional reclamation approaches, such as uniform slopes, rock lined ditches and terrace for drainage were included in past designs and reclamation work. Given the area's climate and the highly erosive nature of the Site's soils, natural landform reclamation techniques were selected to stabilize the Site, both physically and chemically. The intent of this reclamation technique is to restore the pre-mining hydrology, both surface and sub-surface. Natural landform reclamation includes the design of naturally functioning slopes, stream channels, and subsurface flow, to the extent possible. Native vegetation and rocks were also employed to mimic the surrounding undisturbed bluffs. Two natural landform restoration projects have been completed at the Site. The techniques used, and the engineering design and construction of these projects will be presented. Challenges encountered during the design implementation will be discussed, including material balance, surveying for quantities and steep slope construction work. Three years after project completion, this natural landform reclamation approach successfully stabilized (physically) the mine waste and spoils on site and created a fully functioning landscape that can support the pre-mining uses at the site, such as wildlife habitat, ranching, recreation and traditional cultural uses.

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2. Mary Beth Marks, Forest Geologist, USDA Forest Service, Custer Gallatin National Forest, Bozeman, MT; Michael Hatten, P.E., Project Engineer, Tetra Tech, Helena, MT; Mark Donner, P.E., Engineer, Trihydro Corporation, Laramie, WY.

Reclamation Case Study: Road Decommissioning in Indiana and Pennsylvania Gulches, White River National Forest[1]

Tony Matthews and Jesse Feeback[2]

Abstract: During the falls of 2017 and 2018, roughly three miles of roads and trails were decommissioned within Indiana and Pennsylvania Gulches, White River National Forest, Breckenridge, Colorado. The project was located in high-altitude sub-alpine forest. Various reclamation/rehabilitation techniques were used to blend roads into the surrounding landscape/topography. Creating wildlife habitat, especially for vulnerable species such as the Canada lynx, was another goal. Reclamation involved comprehensive techniques that addressed vegetation, hydrology, soils, and wildlife. Compacted soils were ripped using an excavator and hand broadcasted with a seed mix formulated using a previous vegetation inventory from the site. Roads were recontoured to the original topography and steep areas were covered with geotextile blankets. Alternating rock water bars were installed in stream road crossings to create meanders and attenuate flow velocities. Willow stakes and transplants were used to help restore stream side vegetation and stabilize streambanks. Spruce saplings were planted in the reclaimed roads. Viewshed breaks were created to discourage hikers from walking on reclaimed roads. Observations of 2017 areas are positive and adaptive management was used in 2018, and will be used on future projects, to improve road decommissioning results.[3]

Additional Key Words: Rocky Mountains, Revegatation, Erosion Control.

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2. Tony Matthews, Office Manager, Habitat Management, Inc., Englewood, CO 80112; Jesse Feeback, Staff Scientist, Habitat Management, Inc., Englewood, CO 80112.
3. Work reported here was done near 39.420, -106.003.

The Use of Advanced Membrane Filtration as an AMD Remediation Method[1]

M.J. McCluskey[2]

Abstract: Acid Mine Drainage, or AMD, constantly poses a challenge to mine operators and state / federal regulators around the country. Specific to Pennsylvania, while mine operators are required to treat AMD, many more discharges exist that are defined as abandoned and have no treatment. While passive or active chemical treatments are always chosen for remediation of such AMD sources, significant capital costs tend to keep the total number of projects to a minimum. Additionally, active systems tend to fall to disrepair due to high operational and maintenance costs. To combat this problem, InnoH2O Solutions partnered with a local coal company to solve these complex remediation problems. InnoH2O spent 5 months evaluating and testing different types of AMD to evaluate the effectivity of advanced membrane filtration on the remediation of AMD. InnoH2O was able to achieve very significant results with significant reductions of Iron, Aluminum, and Manganese along with tremendous Sulfate reductions. Net acidic flows were stripped of their dissolved metal load, without the use of any chemicals or additions, and then adjusted to meet NPDES requirements for pH. Typical metal reductions exceeding 99 percent were achieved along with 85 percent reductions in sulfates; conductivity was reduced by greater than 95 percent. Overall water recovery rates of 99.5 percent were achieved during the course of testing. Laboratory testing of the process has been completed and field trials will be beginning in early to mid-2019.

Additional Key Words: acid rock drainage, net acidic water remediation.

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2. Michel J. McCluskey, President and SME, InnoH2O Solutions, LLC, Somerset, PA 15501.

Industrial Hemp as a Potential Crop for Reclaiming Disturbed and Contaminated Soils[1]

Louis M. McDonald[2]

Abstract: Industrial hemp (*Cannabis Sativa L.*) is the same plant as the marijuana used for medicinal or recreational purposes except that it has been bred to produce lower concentrations of THC (*delta-9 tetrahydrocannabinol*), the psychoactive ingredient in marijuana. By law, industrial hemp must contain less than 0.3% THC. New federal legislation has allowed for an expansion of industrial hemp acreage. Industrial hemp can be harvested for its grain or fiber. The grain is a high-quality food, feed product, and produces a high value oil for the supplements and cosmetics market. The fiber market is still relatively small. Cannabis produces a large amount of biomass in a relatively short period of time. It also is known to be salt tolerant and accumulate toxic metals of concern, making it a potential income-producing biomass crop for disturbed and metal contaminated soils. Here we report on our preliminary experiments on industrial hemp germination response to salt stress (up to 80% germination at 10 ds/M as NaCl) and metal uptake from a multi-metal contaminated soil (increase in tissue metal concentration with soil metal concentration). We will also discuss some of the agronomic, regulatory, and economic hurdles for industrial hemp to become a viable biomass crop for disturbed and contaminated soils.[3]

Additional Key Words: Cannabis, abiotic stress, germination, plant growth.

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2. Louis M. McDonald (presenter), Professor, Environmental Soil Chemistry and Soil Fertility, West Virginia University, Morgantown, WV 26506.

3. Work reported here was conducted in a laboratory and greenhouse near 38º35’51” N, 80º27’65”W.

Assessment of Native Warm Season Grasses for Post-Mining Reclamation[1]

Jesse I. Morrison, Melanie K. Parker, N. Rebecca McGrew, and Brian S. Baldwin[2]

Abstract: The Red Hills Mine, located in Ackerman, MS, is an operating large-scale surface strip mine for lignite. Current reclamation practices use browntop millet [*Urochloa ramosa* L.] and bermudagrass [*Cynodon dactylon* (L.) Pers.; BG]. The objective of this study is to evaluate growth, yield, and forage nutritive value of native warm season grasses (NWSGs) compared to BG when managed as a hay crop. Species tested were big bluestem (*Andropogon gerardii* Vitman; BBS), little bluestem [*Schizachyrium scoparium* (Michx.) Nash; LBS], indiangrass [*Sorghastrum nutans* (L.) Nash; IG], upland switchgrass (*Panicum virgatum* L.; USWG), and BG. Whole plots were divided into subplots with 1-cut and 2-cut systems with and without supplemental fertilizer. Tiller counts in 2017 showed replication differences at two and four-week counts. Big bluestem and LBS produced the greatest number of tillers in 2018. Native warm season grasses produced greater yields than BG. Little bluestem out-yielded BG in both years. Mineral concentrations were sufficient for cattle in 2017, and declined in 2018. Native warm season grasses qualified as a hay crop for prime farmland, which is only defined by yield[3].

Additional Key Words: switchgrass, big bluestem, bermudagrass, little bluestem, nutritive value, prime farmland.

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2. Jesse I. Morrison (presenter), Assistant Research Professor, Plant and Soil Sciences, Mississippi State University; Melanie K. Parker, Natural Resources Intern, Red Hills Mine, Ackerman, MS; N. Rebecca McGrew, Regulatory Manager of Environmental Affairs, North American Coal, Plano TX; Brian S. Baldwin, Professor; Plant and Soil Sciences, Mississippi State University, Mississippi State University, MS 39762

3. Work reported here was conducted near 33.3101° N, 89.1728° W.

Removal of Gaseous and Aqueous Biogenic Sulfide from Vertical Flow Bioreactor Effluent via Solar-Powered Blowers[1]

Robert W. Nairn* and Taylor Wall[2]

Abstract: Passive treatment system vertical flow bioreactors (VFBRs) may produce excess sulfide, a source of nuisance odors and toxicity. Aqueous sulfide concentrations greater than 0.002 mg/L are considered chronically ecotoxic and prolonged human exposure to gaseous concentrations greater than 20 ppmv leads to fatigue, poor memory, and dizziness. In this study, a novel sulfide removal approach using a custom-designed solar-driven system with activated carbon filter (ACF) was evaluated. The study site, the Southeast Commerce passive treatment system (SECPTS) at the Tar Creek Superfund Site (the Oklahoma portion of the abandoned Tri-State Lead-Zinc Mining District), addresses 380 L/min of net alkaline mine waters. The system consists of an oxidation pond, surface flow wetland, VFBR, and final polishing unit (FPU). VFBR effluent enters a closed odor control structure (OCS) from which the sulfide-rich atmosphere is pulled into the ACF (containing 180 kg of activated carbon media) using a solar-powered vacuum blower. Solar-powered pressure blowers re-aerate the water column through float-mix aerators in the post-VFBR FPU. Aqueous sulfide concentrations were determined by laboratory analyses of surface grab water samples and gaseous sulfide concentrations were field-measured using a handheld gas detector and Draeger hydrogen sulfide gas detection tubes. Throughout the sampling period (December 2017-October 2018) maximum aqueous sulfide concentrations in the VFBR effluent were 84 mg/L and gaseous sulfide concentrations in the OCS atmosphere were 950 ppmv, although values were typically lower. FPU effluent aqueous sulfide concentrations measured 0.13 ± 0.28 mg/L. ACF exhaust gaseous sulfide concentrations measured 41± 56 ppmv. Over the study period, approximately 14,000 kg S were retained by SECPTS, presumably mainly via bacterial sulfate reduction in the VFBR. Additionally, 100 kg gaseous S entered the ACF with 30 kg retained in the ACF media, 20 kg leaving the ACF as exhaust to the open atmosphere and 40 kg leaving the ACF in liquid form as sulfuric acid. Evaluation of the off-the-grid renewable energy-powered sulfide-removal and aeration systems indicates that they enhance water quality improvement effectiveness, efficiently remove gaseous sulfide and may be especially attractive for use in remote locations and/or at sites where operation and maintenance budgets are limited.

Additional key words: Bacterial sulfate reduction, sulfide production, activated carbon, sorption, toxicity,

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2. Robert W. Nairn (* presenter), Professor, and Taylor Wall, Graduate Research Assistant (student), Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

3. Work reported here was conducted near N 36°55'35.04" and W 94°52'38.40"

Temperature Effects on Selenium Cycling in Simulated Constructed Wetland Microcosms[1]

Michael P. Nattrass*, Jesse I. Morrison, and Brian S. Baldwin[2]

Abstract: Constructed wetland phytoremediation is a passive treatment option for improving water quality of stormwater runoff impacted runoff. Phytoremediation removes contaminants through three primary elimination pathways: rhizofiltration, phytoaccumulation, and phytovolatilization. This research will be conducted to determine the Se mass balance in constructed wetlands planted with cattail and duckweed and evaluate the effect of temperature on aqueous selenium cycling. Phytovolatilization chambers fixed with activated charcoal traps for collecting volatile organic Se were placed in static growth chambers at 15, 20, and 25° C under a 12-hr. photoperiod. Chambers were planted with cattail, duckweed, or unplanted and treated with 25 µg Se L^{-1} as either sodium selenite (Na_2SeO_3) or sodium selenate (Na_2SeO_4). After seven days, total Se concentration was determined in soil, plant, water, and activated charcoal traps by ICP-MS.

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2. Michael Nattrass (* presenter), Student; Jesse I. Morrison, Associate research professor; Brian S. Baldwin, Professor, Plant and Soil Sciences, Mississippi State University, Mississippi State University, MS 39762.

Phillips Mine Fire – A Containment & Extinguishment Design Plan[1]

C.A. Neely*, T.P. Danehy, R.M. Mahony, B.J. Page, M.H. Dunn,
D.A. Guy, D. Baker, and R. Rummel [2]

Abstract: This case study highlights the design and construction approach taken to contain and extinguish a mine fire in the abandoned underground H.C. Frick Coal and Coke Company's Phillips Mine (operational from 1907 to 1944 in the Pittsburgh coalbed). The Phillips Mine is located in North Union Twp., Fayette Co. PA (north of Uniontown, PA). The age and origin of the fire are uncertain, as there are indications of sections within the vicinity of the current fire noted on the original underground mine maps as 'Barren – Coal Burned Out' and 'Burned Sec' dating back to the 1950's and earlier. Presence of the current fire was first observed and reported to the PA Department of Environmental Protection (DEP) in 1997. Subsurface investigations by the PA Bureau of Abandoned Mine Reclamation (BAMR) were performed in 2003 and 2008 to evaluate the fire's extent, potential to migrate, and potential to impact man-made structures. It was determined that site conditions within the Phillips Mine appeared conducive for migration toward reaches of the mine-workings that underlie numerous roadways, residential areas, and occupied structures (including a gas station in close proximity). These findings led to the 2014 contract with BioMost, Inc. to develop a containment and extinguishment design plan for the mine fire. The approach taken and described in this presentation includes drilling and installing 43 steel-cased (and capped) monitoring wells between March and April of 2014. Monitoring in selected wells included measurements for: combustible gas (% LEL), carbon monoxide (ppm), oxygen (vol %), and hydrogen sulfide (ppm). Downhole temperature probes were deployed for continuous temperature readings of mine-atmosphere and mine-pool temperatures (where applicable). The monitoring well data contributed to the interpretation of current impacts and communication of the fire within the underground mine-workings and overlying carbonaceous zone. This information was used to develop the design that was implemented to contain (using a cut-off trench consisting of fire barriers and air barriers) and extinguish (excavate and quench actively burning sections) the Phillips mine fire. Further details of the design and construction status are expanded upon in the presentation.

Additional Key Words: Cold Perimeter, Fire Barrier, Temporary Surface Seal, Firefighting Foam.

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2. Cody A Neely, Environmental Engineer (PE); Tim Danehy, (QEP); Ryan M. Mahony, Environmental Scientist; Bryan J. Page, Environmental Scientist; Margaret Dunn, (PG); and Dan A. Guy, (PG) - BioMost Inc., 434 Spring Street Ext., Mars PA 16046; and Dean Baker (PE); Roger Rummel (PE) – PA DEP Bureau of Abandoned Mine Reclamation, Ebensburg Office (Cambria Office) 286 Industrial Park Road, Ebensburg, PA 15931.

University of Wyoming Extension Reclamation Workshops[1]

Jay B. Norton[2]

Abstract: For effective restoration of stable, ecologically functioning plant communities after drastic disturbances, reclamation practitioners need knowledge about how to manage soils and plants in difficult ecological restoration settings. Reclamation practitioners represent a broad spectrum of professionals from energy, mineral, and natural resources fields, ranging from equipment operators and project managers, to ranchers, wildlife biologists, and soil scientists, who each have important skills and insights, but may lack specific knowledge about ecosystem functioning in semiarid environments. In order to effectively teach fundamentals of effective reclamation, University of Wyoming Extension and the Wyoming Reclamation & Restoration Center developed field-based, hands-on workshops and published Extension Bulletins on specific reclamation topics and techniques. By involving industry and agency professionals from the outset, and changing workshops to respond to stated needs of participants, we believe that we are able to address key needs for effective reclamation. Early in the process, it became clear that workshop participants possessed rich experiences and on-the-ground observations beyond those of the instructors. Many could quickly grasp soil, plant, and ecological concepts presented and apply them to their own experiences. One example of how we attempted to integrate the knowledge of the participants with that of the instructors was to form transdisciplinary groups for the field workshop activities. We had each participate state their name and area of expertise, then asked them to group themselves by expertise; wildlife biologists over there, plant experts over here, range scientists there, etc. Then they were asked to stand shoulder to shoulder and count off in fours (or the appropriate number of groups). This assured that each group had a broad range of the available expertise/perspectives, and that the participants did not group up by discipline. The workshops receive very positive participant evaluations and strive to respond to needs of the targeted professional reclamationists. This presentation describes the challenges of developing and holding effective reclamation workshops for experienced professionals, and our collaborative approach toward meeting those challenges.

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2. Jay B. Norton, Professor, Ecosystem Science and Management Department, University of Wyoming, Laramie. USA 82071. jnorton4@uwyo.edu

Effect of Topsoil Stockpiling and Organic Amendments on Soil Properties and Tree Growth during Gold Mine Reclamation in Ghana[1]

Paul Kofi Nsiah and Wolfgang Schaaf[2]

Abstract: Topsoil is a valuable resource and regarded as the most critical and key element in any successful revegetation following mining activities. Salvaging and stockpiling topsoil and reserving it for future reclamation is thus, often encouraged in mine operations. Studies have, however, demonstrated topsoil stockpiling to have major adverse impacts on soil properties and that stockpiled topsoil would require organic amendment to improve its properties to promote plants' growth. This study was therefore undertaking with the hypothesis that (a) topsoil stockpiling at Newmont Ghana Gold Limited[3] will cause significant adverse impacts on soil properties and (b) amendment of stockpiled topsoil with organic materials like composted sewage sludge and poultry layer manure will significantly promote survival and growth of planted trees. A waste-rock dump measuring 36m by 45m was graded and covered with 70 cm layer of stockpiled subsoil followed by 30 cm layer of stockpiled topsoil. Soil samples, with three replicates, were randomly collected from the site and that of a nearby un-mined site as reference, for determination of pH, nutrients, OM, EC, ECEC, base saturation, bulk density and texture. Poultry layer manure, composted sewage sludge, and no amendment (control) were applied as treatments. Potted-seedlings of five forest tree species were planted in May 2016, followed by application of amendment materials. Diameter and height of all planted trees and number of surviving trees were twice taken to determine tree growth and survival. Statistical analysis revealed that topsoil stockpiling did not have any significant adverse impact on the assessed soil properties, compared with the reference. One-way ANOVA combined with LSD and Duncan post-hoc tests ($\alpha = 0.05$) also indicated there was no significant influence of organic amendment on tree growth. Competition from herbaceous plants and lack of weed control were observed to be the main driving factors hindering survival and growth of planted trees. Planting the intended tree species concurrently with ground cover species in the first growing season combined with adequate weed control are perceived to promote tree growth and survival at the site, rather than application of organic amendments.[3]

Additional Key Words: topsoil, mine-reclamation, organic amendment, revegetation, soil properties, trees

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2. Paul Kofi Nsiah (presenter), Ph.D. Student, Wolfgang Schaaf, Professor in Soil Science, Department of Soil Protection and Recultivation, Brandenburg University of Technology, Cottbus-Senftenberg, Konrad-Wachsmann-Allee 6, 03044 Cottbus, Germany.
3. Work reported here was conducted at Newmont Ghana Gold Limited mine operation at Ahafo-Kenyase, located between latitudes $6^0$40" and 7°15" North and Longitudes 2°15" and 2°45" West.

Analysis of Coal Production, Severance Tax Revenues, and Water Infrastructure Relationships in West Virginia[1]

Hannah Patton*, Emily Sarver, and Leigh-Anne Krometis[2]

Abstract: Central Appalachia is often simultaneously characterized by its richness in natural resources against a backdrop of relatively poor socio-economic indicators. Coal mining, in particular, has traditionally played an important role in the economies of states like West Virginia, but strong reliance on the mining sector has often been blamed for boom-and-bust cycles in rural mining localities. Among the many needs and challenges in these areas is reliable access to potable water, which necessitates reliable infrastructure including system operations, maintenance, and modernization. Coal severance tax programs, such as the Coal County Reallocation Severance Tax Fund, have been established to provide revenues for these investments, however, it is unclear what impact these have ultimately had on water access and quality. Here, we examine several publicly available datasets to explore relationships between coal production, severance tax revenues, water infrastructure and system investments, and Safe Drinking Water Act (SDWA) violations in West Virginia counties. Coal production data for West Virginia was obtained via the Mine Safety and Health Administration (MSHA) database, SDWA violation data for West Virginia water systems was obtained via the Environmental Protection Agency's (EPA) Safe Drinking Water Information System (SDWIS), and coal severance tax data was obtained via the West Virginia State Treasurer's Office. Data was cleaned using Microsoft Access and statistical analysis was performed using R. This study is novel in that it fosters a better understanding of indirect effects of mining on potable water infrastructure in West Virginia. Insights might be valuable in efforts improve water access and quality to residents of both West Virginia and other mining communities.

Additional Key Words: Safe Drinking Water Act (SDWA), coal severance tax, water quality, boom-and-bust cycles.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3-7, 2019.

2. Hannah Patton (* student presenter), Graduate Research Assistant, Biological Systems Engineering, Virginia Tech, Blacksburg, VA 24060; Dr. Leigh-Anne Krometis, Associate Professor, Biological Systems Engineering, Virginia Tech, Blacksburg, VA 24060; Dr. Emily Sarver, Associate Professor, Mining and Minerals Engineering, Virginia Tech, Blacksburg, VA 24060.

Using the Forestry Reclamation Approach in the Western Gulf Region: Impacts on *Pinus taeda* Seedling Growth and Survival[1]

Cassie Phillips*, Jeremy Stovall, Hans Williams, Kenneth Farrish[2]

Abstract: While land reclamation efforts of surface mines have considerably increased stability since the implementation of SMCRA (Surface Mining Control and Reclamation Act), research suggests that resulting soil compaction hinders the productivity of forests post-mining. The Forestry Reclamation Approach (FRA) was developed to improve forest health in the Appalachian region through a five-step process that minimizes soil compaction. The FRA has not yet been tested in the western Gulf Coastal Plain. This study adapted FRA methods for soils and common silviculture practices of the western Gulf. The two-acre study site was installed with a randomized block design with three replicates comparing conventional pan-scraper reclamation used in the region with that of an unmined control and the FRA-style low compaction treatment. Following soil reclamation, we hand-planted containerized loblolly pine (*Pinus taeda*) seedlings of a western Gulf provenance. After three growing seasons, seedlings in the FRA plots had significantly higher tree volumes ($p<0.0001$) when compared to the other two treatments, and a 97% survival rate, while pan-scraper plots had a survival of 86%. Soils samples revealed FRA plots had significantly lower bulk densities than the other two treatments. Between year one and year two tree volumes on control plots increased by 233 cm^3, scraper plots by 141 cm^3 and FRA plots by 969 cm^3. These preliminary results suggest reclamation practices modeled after FRA methods may benefit tree growth and survival in the western Gulf.[3]

Additional Key Words: Silviculture, mining reclamation, tree physiology, soil compaction.

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2. Cassie Phillips (* presenter), Environmental Science Graduate Student, Stephen F. Austin State University, Nacogdoches, TX 75962; Jeremy Stovall, Associate Professor of Silviculture, Stephen F. Austin State University, Nacogdoches, TX 75962; Hans Williams, Dean of the Arthur Temple College of Forestry & Agriculture, Stephen F. Austin State University, Nacogdoches, TX 75962; Kenneth Farrish, Director of Division of Environmental Science, Stephen F. Austin State University, Nacogdoches, TX 75962.
3. Work reported here was conducted near 31° 12' 16.9884" N, 95° 23' 14.4564" W.

Reclamation of Sulfur Borehole Mine Sites and Environment Consequences of S Extraction[1]

M. Pietrzykowski* and J. Likus-Cieślik[2]

Abstract: Sulfur contamination of topsoil, spatial distribution of contamination and surface water chemistry were investigated on an area of over 200 ha of a new forest ecosystem. Common birch and Scots pine growth reaction, vitality, and nutrients supply, as well as wood small-reed (*Calamagrostis epigejos* (L.) Roth) chemical composition were assayed. The chemistry dynamics of soil leaching and the sulfur load leached from the sulfur-contaminated soil-substrates were analyzed. The remediation effect of the birch and pine litter was assayed in an experiment under controlled conditions. It was found that reclamation was effective in a majority of the post-mining site, however hot spots with sulfur contamination reaching even 45,000 mg kg^{-1}, pH <2.0, and EC 6,500 µS cm^{-1} were reported. Surface waters typically displayed elevated concentrations of sulfate ions (average 935 mg L^{-1}), calcium ions (up to 434 mg L^{-1}) and high EC (average 1.8 µS cm^{-1}), which was connected both with sulfur contamination and sludge lime used in neutralization. Wood small-reed was found to be species adapting well to the conditions of elevated soil salinity and sulfur concentration. We noted that an addition of organic matter had a significant impact on the chemistry of soil solutions but did not indicate in short term experiment a remediation effect by increased sulfur leaching[3].

Additional Key Words: **s**ulfur; reclamation; acid mine drainage, salinity, soil contamination.

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2. Marcin Pietrzykowski (* presenter), and Justyna Likus-Cieślik, Professors, Department of Forest Ecology and Reclamation, Institute of Ecology and Silviculture, Faculty of Forestry, University of Agriculture in Krakow, Al. 29 Listopada 46, 31–425 Krakow, Poland
3. Work reported here was conducted near 50°25’46” N; 21°45’2” W. Study was financed by Ministry of Science and Higher Education, Poland, Grant No. Department of Forest Ecology and Reclamation DS 3420.

Tree Growth and Regeneration on Reclaimed Oil Sands Mine Sites in Northern Alberta[1]

B.D. Pinno[2]

Abstract: A guiding principle of land reclamation after industrial developments in Alberta is that reclaimed sites must have an "equivalent land capability" to pre-disturbance conditions. In the mineable oil sands region of the boreal forest, this means that establishing trees and forests on upland reclamation sites is a key priority. Reclamation operations, in particular the choice and placement of cover soils, fertilization, and competition control, have the potential to control the future composition and productivity of these reclaimed forests. Early results for trembling aspen and white spruce establishment and growth will be compared with similar aged fire-origin forests as a natural benchmark. In general, natural aspen seedling regeneration is greatest on lowland origin peat-based reclamation soils due to high water holding capacity and low competition while upland forest-based reclamation soils favour the development of native and non-native vegetation, which can act as competition for trees. The use of stockpiled soil in reclamation can also have negative impacts on tree establishment, particularly if physical soil properties are altered during stockpiling and reclamation. Early fertilization with nitrogen based fertilizers increases competition with no, or only limited, increases in tree growth. In the longer term, aspen and spruce growth on reclamation sites is similar to natural forests in the region with current research focusing on modeling tree growth on different reclamation soil types into the future. Given the long timeframe for oil sands mines, the next phase of related research will address final land uses for these forest reclamation sites.[3]

Keywords: oil sands, mine reclamation, boreal forest, trembling aspen, white spruce, tree growth

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1. Oral presentation at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.
2. Brad Pinno, Assistant Professor - Silviculture, Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada.
3. This work took place in the mineable oil sands region of northern Alberta near 57.2˚N 111.6˚W.

Cost-Effective Strategies for the Restoration of Drastically Disturbed Sites[1]

D. F. Polster[2]

Abstract: Cost-effective methods for the restoration of mining and other drastically disturbed sites can constrain reclamation of sites humans disturb. Natural processes have been restoring natural disturbances (glaciation, natural landslides, volcanic eruptions, riverbank erosion, etc.) for millions of years. By following the methods that these natural processes use to restore the disturbance, cost-effective strategies for the restoration of human disturbances can be developed. The first step in defining recovery strategies is to identify the filters or constraints that are preventing the natural recovery of the site. In many mining situations, elements such as steep slopes (angle of repose waste rock dumps) or compacted surfaces such as the tops of waste rock dumps and haul roads create constraints that only weeds can address. By identifying and then dealing with the constraints the natural recovery processes can be allowed to operate. In most cases, local pioneering species will move into prepared sites for free and quickly and there is no need for extensive planting programs. If the site is very large or there are not pioneering species nearby, then seeding with the seeds of suitable pioneering species is an appropriate option. Making disturbed sites rough and loose creates condition that fosters the natural establishment of pioneering species and is inexpensive compared to traditional reclamation treatments.[3]

Additional Key Words: Natural processes; addressing constraints; ecological solutions.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. David F. Polster (presenter), M.Sc. Restoration Ecologist, Polster Environmental Services Ltd. 6015 Mary Street, Duncan, BC Canada V9L 2G5.

3. Work reported here was conducted in Western Canada and the Pacific NW USA from 1977 to present.

BIRD USE IN A RESTORED RIPARIAN CORRIDOR, SOUTHWEST MONTANA[1]

R. Prodgers and N. Kohler[2]

Abstract: One century after mine waste left 32 km-long Silver Bow Creek and its floodplain contaminated with acidic heavy metals, the State of Montana reclaimed it. While limited bird use occurred before remediation, large and varied populations quickly repopulated. Three of the most important habitats are open water, wetlands, and tall shrubs, but nearby habitats and land uses are also important. Migrations set the vernal monthly trends. Bird data were summarized over 1.5 decades for four five-mile subareas, which are sets of habitats, not replicates. Sampling followed the Region 1 Forest Service monitoring procedure with fewer environmental descriptors. Twenty stations per subarea were sampled from March-June, which took about four hours per session starting just after dawn. Data analysis focused on bird abundance and diversity,

- March bird use is indicative of winter residents. Migratory birds swell the April census, which roughly doubles in May and June.
- Species compositions within subareas are weakly similar even for proximate years. This presages weak temporal trends.
- Birds quickly colonize fresh revegetation with no convincing trend in bird counting during the ensuing decade. Assigning birds to trophic levels likewise evidenced no decade-scale temporal trends.
- Analyzing bird use in the two main habitats, fluvial tall shrubs and wetlands, bird counts again revealed no temporal trends. In conjunction with low similarities, this indicates relatively steady abundance with variable composition.
- Species diversity (richness and evenness of relative abundance) increased over time beginning at about six years in wetlands and eight years in the fluvial-tall- shrub type. Time keys for vegetational development.
- While most species' needs can be met by numerous habitat combinations, habitat specialists demonstrate convincing temporal trends in relation to specific vegetational development. The willow flycatcher and marsh wren require mid-seral to mature vegetation. Spotted sandpipers decline as gravelly shorelines fill with plants.[3]

Key Words: Restored bird habitats, temporal trends, species diversity, trophic levels, revegetation, vegetational development, habitat specialists.

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1. Oral presentation at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome back to Montana: The Land of Reclamation Pioneers, June 3-7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.
2. Richard A. Prodgers, plant ecologist, and Nate Kohler, ornithologist, Bighorn Environmental Sciences, Deer Lodge, MT 59722.
3. This work was conducted near 46º0'23" N, 112º 42'48" W.

Remediation of Tar Creek: Shifts in Bird Community Composition over Time[1]

Christine C. Rega-Brodsky*, Summer R. King, and Kelly Mallatt[2]

Abstract: The Tar Creek Superfund Site in Picher, Oklahoma was once the world's largest lead and zinc mining areas. Since being declared a Superfund site in 1983, large-scale remediation efforts have occurred throughout the landscape, such as cleaning up mining waste (chat), soil replacement, and planting native grass mixtures. In this study, we asked how habitat remediation of a heavy-metal contaminated area influences wildlife habitat and bird community composition over time. In 2017 and 2018, we surveyed 24 locations at the Tar Creek Superfund site in various stages of remediation, from no remediation to 5-years post-completion. We sampled each location's bird communities in May – July through three, 5-minute point count surveys, and analyzed community data through Bray-Curtis ordination plots, and a series of regression and ANOVA analyses. We evaluated habitat resources by measuring ground vegetation cover and composition, canopy cover, and shrub and tree species composition. We observed 69 bird species across the mined area, with an average of 15.8 species per site. The remediated locations were composed of grasses and forbs, in contrast to the un-remediated locations dominated by chat and/or trees and shrubs. Remediation efforts attracted significantly more bird species to the sites, particularly for sites with more grass and forb cover; however, some sites without remediation provided adequate habitat resources and hosted diverse bird communities. Sites in construction or sites with bare ground had the least amount of bird activity, highlighting the importance of leaving the ground bare for as little time as possible throughout remediation efforts, especially during the breeding season. Species composition differed across remediation category, with a shift from forest to grassland bird species throughout remediation efforts. Field data collection is ongoing for the 2019 summer breeding season and future efforts include abundance modeling for key species impacted by remediation efforts.[3]

Additional key words: ecology, plants, habitat

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.
2. Dr. Christine Rega-Brodsky (* presenter), assistant professor, Department of Biology, Pittsburg State University, Pittsburg, KS 66762; Summer R. King, environmental scientist and Master of Science, Quapaw Nation, Quapaw OK 74363; Kelly Mallatt, undergraduate student, Pittsburg State University, Pittsburg, KS 66762.
3. Work reported here was conducted near 36°58′32″N, 94°50′17″W.

Trout Unlimited - A Nonprofit Approach to Mine Reclamation[1]

Rob Roberts[2]

Abstract: Trout Unlimited has been working with state, federal, and private partners since 2004 to tackle the challenging issue of abandoned mine reclamation. Since that time, TU has expanded our reach into six different western states; completed 25 successful abandoned mine restoration projects, and restored habitat and water quality in 150 stream miles. While the body of our successful project and policy work grows, the underlying framework and objectives for our Western Abandoned Mine Restoration Program remain the same: (1) implement high-priority watershed-scale mine restoration projects that achieve ecological benefits for fish and rivers across the West, (2) organize and build the capacity of local stakeholder groups to continue long-term restoration and conservation projects in western communities, and (3) drive the development of dedicated funding sources and legislative and/or policy changes. To provide a better understanding of how TU works the following presentation will provide an in-depth look at specific projects ranging from large-scale placer mine reclamation to environmental remediation of mine waste. By the end of the presentation, we hope to not only inform the industry of the vital role non-profits can play in reclamation, but also provide an example of how a collaborative approach will be essential in future reclamation plans[3].

Additional Key Words: abandoned mine, restoration, habitat, water quality, stakeholders

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana, The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.
2. Rob Roberts, Abandoned Mine Reclamation Coordinator, Trout Unlimited, 312 N. Higgins Ave., Suite 200, Missoula, Montana 59802.
3. Work reported here was conducted near 46.872427N, -113.993568W.

Geocoding American Society of Mining and Reclamation Proceedings to Preserve and Easily Access Reclamation Research[1]

Ashley Rovder*, Staci Wolfe, Kari Lagan, Lily Currie, William Strosnider, Peter Smyntek[2]

Abstract: The Saint Francis University Center for Watershed Research & Service worked in conjunction with Saint Vincent College to find and geocode the locations of research conducted in the American Society of Mining and Reclamation conference proceedings from 1998 to 2012 as well as the articles in the Journal of the American Society of Mining and Reclamation from 2011 to 2016. In support of Saint Francis University's Research-Learning structure, a group of four undergraduate students conducted the bulk of the investigation with oversight from professor and postdoc mentors to allow for maximum learning opportunities throughout the project. The team members utilized Google Earth and Earth Point to visually search for the coordinates of each site and then code each pair of coordinates into a collective and interactive map. Future research can be recorded and uploaded in the same way in order to keep the database up to date. This database will be easily accessible to members of the American Society of Mining and Reclamation for finding previous research studies, where trends between location and technical divisions (from water management to ecology) can be analyzed. It offers a tool for locating follow-on research topics such as long term successional or passive treatment performance studies and noting where updates are necessary, as well as a unique way to potentially connect with other American Society of Mining and Reclamation members.

Additional Key Words: geolocation Google Earth.

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2. Kari Lagan, Lily Currie, Ashley Rovder, Staci Wolfe, Undergraduate Environmental Engineering Students, Saint Francis University, Loretto, PA; William Strosnider, Faculty, Saint Francis University Engineering Department, Center for Watershed Research & Service. Loretto, PA; Peter Smyntek, Faculty, Saint Vincent College, Latrobe, PA.

An Evaluation of Biological and Chemical Improvements at Various Spatial Scales in the West Branch Susquehanna River Watershed, Pennsylvania[1]

S.M. Rummel*, A. Wolfe, R. Kester, K. Lavelle, and A. Lutz[2]

Abstract: The West Branch Susquehanna River watershed in northcentral Pennsylvania drains approximately 18,130 km^2 of mostly forested land. Although the watershed contains some of the most pristine coldwater habitat in Pennsylvania, historic coal mining operations left a legacy of approximately 1,900 km of streams impaired by abandoned mine drainage. Over the past 14 years, numerous abandoned mine drainage restoration projects have been completed. In 2017 and 2018, Trout Unlimited completed a watershed-wide assessment of water chemistry, benthic macroinvertebrate communities, and fishery communities to document water quality and biological changes associated with restoration efforts. This study replicates and expands a 2009 study and included 80 replicated sample sites in AMD impaired tributaries and main-stem river sites within the West Branch Susquehanna River watershed and included 30 reference sample sites with no known water quality impairments and supporting a Class A trout fishery. Preliminary results suggest that water quality improvements have continued throughout the watershed since the 2009 study, particularly increases in pH and reductions in heavy metal concentrations at sites downstream of completed AMD restoration projects. Biological improvements have also continued throughout the watershed. Restoration projects on small tributaries within the watershed have led to significant improvements in the mainstem of the West Branch Susquehanna River. This study demonstrates the importance of monitoring to evaluate project effectiveness. It also provides a case study on water quality and biological improvements at several spatial scales, ranging from individual stream restoration to the cumulative downstream impact of numerous AMD restoration projects at the sub-basin scale. The results of this study will provide insight into the prioritization of AMD restoration projects for large-scale remediation of water quality and biological communities.

Additional key words: effectiveness monitoring, benthic macroinvertebrate communities, water quality, cold-water fisheries

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Shawn M. Rummel, Ph.D. (* presenter), Lead Science Advisor, Trout Unlimited, Northeast Coldwater Habitat Restoration Program, Lock Haven, PA 17745; Amy Wolfe, Director, Trout Unlimited, Northeast Coldwater Habitat Restoration Program; Rachel Kester, Project Coordinator, Trout Unlimited, Pennsylvania Coldwater Habitat Restoration Program; Kathleen Lavelle, Field Coordinator, Trout Unlimited, Pennsylvania Coldwater Habitat Restoration Program; and Allison Lutz, Field Crew Leader, Trout Unlimited, Pennsylvania Coldwater Habitat Restoration Program.

Finite Element Water Balance Modeling in a Coal Refuse Pile Cap and Cover Reclamation[1]

I. Lira Santos*, L.J. Cyphers, J.D. Quaranta, and L.C. Hopkinson[2]

Abstract: A novel combination of reclamation techniques, geomorphic landforming and paper mill residuals used as a soil amendment, has the potential to be applied to abandoned mine land reclamation in Appalachia and the United States. The geomorphic approach attempts to approximate the long-term, steady state landform condition, leading to reduced erosional adjustment compared to standard engineered fill designs. Use of paper mill residuals utilizes waste products near their source as part of a manufactured soil. This study evaluated this approach by analyzing regraded coal mine refuse slopes for safety and erosion sustainability. A cap and cover system was designed for the Royal Scot refuse pile near Rupert, WV[3] and was applied to geomorphic slopes. The cap and cover system was composed of two layers: a 60 cm compacted low permeability layer (hydraulic barrier) composed of refuse, and a 30 cm vegetative growth layer composed of refuse (80%) and paper mill residuals (20%). Three-dimensional finite element modeling was performed to assess ground surface terrain profiles, considering weather and material strength impacted by a 100-year storm event. The focus of the analysis was the effectiveness of the hydraulic barrier layer and the final slope stability of the system. To assess the effectiveness of the design, two models were performed: with the cap and cover system on the surface and with the refuse as a surface. Results from the modeling indicate that the steepest slopes (2H:1V) of the cap and cover reclamation remain stable with a factor of safety of 2.3. Implementation of the cap and cover reduced 42% of infiltration volume into the refuse, with most of the precipitation retained on the growth layer. The model shows the water volume within the pile returning to the initial volume after 56 days due to evapotranspiration and seepage.[3]

Additional Key Words: Coal Refuse, Mine Waste Reclamation, Finite Element Modeling.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.

2. Iuri Lira Santos (* presenter), Student; Levi J. Cyphers, Student; John D. Quaranta, Professor; and Leslie C. Hopkinson, Professor, Civil and Environmental Engineering, West Virginia University, Morgantown, WV 26506.

3. Work reported here was conducted near 38°00'55.3"N 80°36'16.5"W.

NEW GENERATION COAL-FIRED POWER PLANTS: INNOVATION AT THE DRY FORK STATION, GILLETTE, WYOMING[1]

Brenda K. Schladweiler and Dalyn Hugo[2]

Abstract: Coal-fired power generation provided 30% in 2017 of the electrical demand for the United States (U.S.). Twenty-seven gigawatts from a total of 175 gigawatts produced by coal-fired power plants were retired between 2012 and 2016 due to challenges meeting current emission standards, power generation efficiency, and competition from natural gas. New technology in coal-fired power plant construction addresses two of these three challenges, i.e., emissions and efficiency. Basin Electric's Dry Fork Station near Gillette Wyoming went commercial in 2011, one of few coal-fired power plants built in the U.S. since 2010. This power plant is part of a rural cooperative rather than a "for profit" generator. At the Dry Fork Station, a public-private partnership is working to promote innovation in coal-fired electrical generation to develop commercially viable uses for carbon dioxide emissions. In 2014, the Wyoming State Legislature allocated $15 million for the design, construction, and operation of the Innovative Test Center (ITC) at Dry Fork Station. An NRG COSIA Carbon XPRIZE sponsored a $20 million prize to a commercially viable technology developed from this effort. Dry Fork Station receives its coal from the nearby Dry Fork Mine. Reclamation of ash associated with power generation is handled onsite. Information will be presented on: the status of coal-fired power generation in the U.S., and how the Dry Fork Station is unique in that effort; status of the ITC; and reclamation of ash.[3]

Additional Key Words: CO_2 reduction, collaboration, ash reclamation.

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1. To be presented orally at the 36th National Meeting of the American Society for Mining and Reclamation, June 3-7, in Big Sky, Montana.
2. Brenda K. Schladweiler, President, BKS Environmental Associates, Gillette, WY 82717; Dalyn Hugo, Environmental Coordinator, Basin Electric Power Cooperative, Gillette, WY 92716.
3. Work reported here was near 44 23 17.415 - 105 27 37.4106.

Development of Mine Soils in a Chronosequence of FRA-Reclaimed Sites in Eastern Kentucky[1]

K.L. Sena*, K. Yeager, J. Lhotka, and C. Barton[2]

Abstract: Adoption of the Forestry Reclamation Approach (FRA) on surface mines in Appalachia has led to excellent survival and growth of planted native trees, and also favors natural colonization of native trees and other plant species. In addition, FRA sites exhibit rapid soil development, especially including accumulation of organic matter. The current study was conducted to characterize soil development over a series of sites representing a chronosequence of time since reclamation using the FRA (from 0 years to 20 years since reclamation). Soils were sampled at increments from 0 – 50 cm and analyzed for a number of physical and chemical parameters. Aluminum generally increased with depth and time and was positively correlated with clay. While manganese and iron did not exhibit consistent relationships with depth, they increased over time and were also positively correlated with clay. Aluminum and iron were also both negatively associated with sand. In contrast, calcium and sodium were negatively correlated with clay and exhibited complex relationships with time, increasing to maximums by 10-18 years after reclamation, and decreasing to minimums in unmined forest. While $\delta^{13}C$ exhibited complex relationships with time since reclamation ($\delta^{13}C$ was most depleted in the 10-year site and least depleted in the 18-year site), it was less depleted with depth. Organic carbon increased over time since reclamation and decreased with depth. Sand decreased over time, while silt and clay increased over time. This study provides insight into soil development patterns over time and depth in FRA-reclaimed soils in Appalachia, and provides further support for use of FRA in reclamation of surface mined land.[3]

Additional Keywords: pedogenesis, reforestation, Appalachia, radiochemistry, carbon sequestration.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3-7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.

2. Kenton L. Sena (* presenter), Lecturer, restoration ecology, Lewis Honors College, University of Kentucky, Lexington, KY, 40526; Kevin Yeager, Associate Professor, Earth and Environmental Sciences, University of Kentucky, Lexington, KY 40546; John Lhotka, Associate Professor, Forestry and Natural Resources, University of Kentucky, Lexington, KY 40546; Chris Barton, Professor, Forestry and Natural Resources, University of Kentucky, Lexington, KY 40546.

3. Location where work conducted was near 37.460490° N - 83.158137° W.

Biodiversity Development and Soil Carbon Sequestration Efficiency of Certain Indigenous and Exotic Woody Species Planted on Coal Mine Habitats in a Dry Tropical Environment, India: A Case Study[1]

A. N. Singh[*] and Rupinder Kaur[2]

Abstract: Accumulation of significant C stock in redeveloping soils of mine spoil depends upon the quality and rapidity of biodiversity reconstruction in a short span of time. Developing young forests on any degraded ecosystems can play a significant role in mitigating the effect of global climate change. Present study was conducted on a degraded ecosystem in a dry tropical region of India where mining is one of the serious problems. We selected sixteen plantation sites as a total in different ecological models (mono- and mixed culture) for assessing plant diversity and efficiency of soil carbon sequestration on coal mine spoil for this study. Twelve plantation stands selected as mono-cultured and four (*1: Albizia lebbeck + Acacia catechu, 2: Azadirachta indica + Phyllanthes emblica, 3: Dalbergia sissoo + Tectona grandis,* and *4: Dendrocalamus strictus + Tectona grandis)* were selected as mixed cultured. Of which, eight woody species were indigenous, and in which, four of them (*Albizia lebbeck, Pongamia pinnata, Dalbergia sissoo,* and *Albizia procera*) were leguminous tree and short stature in size; and four (*Azadirachta indica*, *Tectona grandis, Dendrocalamus strictus,* and *Shorea robusta*) were non-leguminous. While remaining four woody species (*Acacia auriculiformis*, *Casuarina equisetifolia*, *Eucalyptus hybrid* and *Gravillea pteridifolia*) were exotic in nature. Results indicated that influence of planted species under both models were significantly varied for accumulation of soil organic C and their sequestration in belowground component with increasing plantation age. However, recruitment of biodiversity development among plantation stands was not so effective due to plantation age, origin and combination; because, canopy cover of planted woody species and one invasive species *(Hyptis suaveolens)* invaded under planted stands significantly affected recruitment rates of plant reconstruction and C sequestration. However, in comparison to mono-culture plantation stands, mixed culture either legume or non-legume combination showed a strong tendency in soil carbon sequestration and plant diversity development beneath plantations with age confirming accretion and cycling of carbon in soil which may in turn more strong enhancement of biological fertility that will make a fertile ecosystem in a short range of time.

Additional Key Words: Ecological restoration; Species recruitment; Native; Carbon, Soil development

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.
2. A.N. Singh (* presenter), Assistant Professor, Department of Botany, Panjab University, Chandigarh-160014, Email: dranand1212@gmail.com; ansingh@pu.ac.in; Rupinder Kaur, PhD Scholar, Department of Botany, Panjab University Chandigarh-160014, India.
3. Work reported here was conducted at site located at the North-eastern part of Singrauli coalfield in the district of Sidhi (Madhya Pradesh, India) between latitudes 24° 6’ 45”-24°11’15”N and longitudes 82° 36’ 40”-82°41’15”E and 40° 06’ 07” N; 88° 14’ 59” W.

Usibelli Coal Mine: Concurrent Reclamation is Yielding Success[1]

R.C. Sivils[2]

Usibelli Coal Mine Inc. (UCM) has been operating for the past 75 years near Healy, Alaska. Today UCM has active mining claims, which supply between 1-2 million tons of coal annually to domestic and overseas customers while maintaining a robust environmental program. Concurrent reclamation activities have proven successful in restoring previously mined lands to productive landscapes that are in various stages of bond release. The transition between mining areas will be showcased along with opportunities to enhance environmental stewardship in future mine areas with the continuing goal of final bond release. Recently UCM has begun to transition operations to the Jumbo Dome Mine (JDM), which required a 5.5-mile road construction project. Road ditches, culverts, and slopes were constructed to provide successful drainage control over the road corridor length and three wetland areas were successfully crossed along its route. Marguerite Creek flows through the area as well, which required a large culvert installation to cross the creek and to allow icing conditions, which occur 6-8 months out of any given year. UCM has been developing the JDM property and is advancing the boxcut while establishing a permanent out of pit spoil dump and beginning to establish reclamation slopes on the final outslope. The existing mine areas that UCM operate near Healy are the Gold Run Pass (GRP) Mine, Poker Flats (PF) Mine and Two Bull Ridge (TBR) Mine and reclamation efforts will be showcased.[3]

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3–7, 2019. Published by ASMR, 1305 Weathervane Dr., Champaign, IL 61821.

2. Richard C. Sivils EIT, Reclamation Engineer, Usibelli Coal Mine, Healy Alaska 99743.

3. Work reported here was conducted near 63°53’07”N, 148°57’30”W.

Early Tree Growth in Brown and Gray Mine Soils Compared to Growth in Native Forest Soils[1]

K. Dallaire and J. Skousen[*2]

Abstract: Surface coal mining in Appalachia disturbs hundreds of hectares of land every year thereby removing valuable and ecologically diverse eastern deciduous forests. Reforestation of these areas after mining is an important step to helping restore ecosystem functions and land value. During reclamation, brown and gray sandstone materials were often placed on the surface as topsoil substitutes rather than native topsoil. Studies show brown sandstone substitute materials (mine soils) promote better tree growth because of lower pH, higher percent fines, and higher available nutrients than gray sandstone, but few field studies have compared tree growth on brown and gray mine soils to undisturbed forest soils. This study evaluated the height growth of red oak (*Q. rubra* L.), white oak (*Quercus alba* L.), and tulip poplar (*Liriodendron tulipifera* L.) on two mine soil types compared to the height growth on native soils from clear-cut areas at the Fernow Forest, WV, and from heights based on site indices (SI) of native soils prior to mining. At both mine sites, brown sandstone and gray sandstone plots (with a mulch treatment) were constructed and 12 tree species were planted and measured for growth annually for 11 yrs. Soil properties were also determined. The pH of brown sandstone was 5.2 to 5.4, gray sandstone was 6.5 to 6.8, mulch treatments were 7.0, and native soils were 4.1 to 5.2. Percent fine soil particles ranged from 42 to 60% on mine soils and mulch-treated mine soils had higher levels of Ca (197 $cmol_c\ kg^{-1}$), K (12 $cmol_c\ kg^{-1}$), and Mg (12 $cmol_c\ kg^{-1}$) compared to other soils. After 11 yrs., tree heights on gray sandstone were significantly lower (0.5 to 0.9 m) than tree heights in brown sandstone (2.8 to 3.6 m) for all three species. Trees on mulched mine soils were up to 0.7 m taller than trees on un-mulched brown mine soils. Red oak grew an average of 0.43 m per yr. on native soils in the Fernow Forest compared to 0.27 to 0.32 m per yr. in brown and mulched mine soils. Tulip poplar grew between 0.5 and 0.85 m per yr. in the Fernow compared to 0.24 to 0.44 m per yr. on brown mine soils. For oaks, average annual tree growth in mine soils was about 30-50% of that calculated from pre-mining native soils and about 70% of that from tree height in Fernow clear-cut areas. Tulip poplar on brown mine soils was only 30% the height compared to pre-mining native soils and 50% the height of trees in the Fernow Forest. In gray mine soils; trees were not growing at all. While the trees in brown mine soils are growing, tree growth has not yet reached levels of tree growth in native soils the first 11 yrs. after planting. Evolving mine soils may develop properties over time that are similar to native soils and, with the increased rooting depth, may provide conditions where increased growth rates and SI may be attained.[3]

Additional Key Words: land reclamation, red oak, reforestation, soil compaction, tulip poplar, white oak

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Kara Dallaire, Paragon Soil & Environmental Consulting, Edmonton, Alberta, CA; Jeff Skousen, (* presenter). West Virginia University, Morgantown, WV, USA jskousen@wvu.edu, 304-293-2667.

3. Work reported here was done at Catenary Coal 38°5'28" N, 81°26'37" W, and at Arch Coal 38°25'31.74" N, 80°36'39.74" W.

Life Cycle of a Successful Reclamation Program[1]

Richard E. Spang[2]

Abstract: Westmoreland Coal Company – Rosebud Mine is located near Colstrip, Montana. The 25,000-acre surface coal mine consists of five separate mining permits. Of the two mined-out areas, one permit area is slated for final bond release and the other is nearly reclaimed. The Rosebud Mine produces sub-bituminous coal and supplies the Colstrip steam-electric power station. Reclamation has always been an integral part of the mining operation at the Rosebud Mine and is committed to reclaiming all mining-related disturbances to a use equal to or better than what existed prior to mining. Since the Surface Mining Control and Reclamation Act of 1977, a lot has been learned over the past 42 years in the realm of a successful reclamation program. Reclamation tasks include soil material salvage/redistribution, pit backfilling, regrading/ contouring, drainage construction, revegetation, environmental monitoring, and post-mine land use. This presentation will discuss reclamation activities for an area near final bond release and what has been learned from the life cycle of award-winning reclamation at the Rosebud Coal Mine.

Additional Key Words: Listing of those not in the title.

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1. Oral presentation at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.
2. Richard E. Spang, Senior Scientific Specialist, Westmoreland Coal Company – Rosebud Mine, Colstrip MT 59323. B.S. Forest Resource Management, University of Montana. Farm/Ranch operator 2007 to present.
3. Work reported here was conducted near 45° 52’ 30” N; 106° 46’ 36” W.

Fred Burr Creek Historic Tailings Characterization[1]

Ed Spotts* and Caleb Lucy[2]

Abstract: Fred Burr Creek, a tributary of Flint Creek, is located near Philipsburg, Montana and is a primary contributor of mercury to the Clark Fork River. Historic silver milling operations at the Rumsey Mill in the upper Fred Burr Creek (FBC) watershed between 1889 and the early 1900's have resulted in mercury and metal contamination of water, stream sediments and soils by tailings, as documented in previous investigations. The characterization of impacted soils has been limited to the area in proximity to the mill site. A combination of natural and anthropogenic processes in the upper FBC floodplain have affected the distribution of materials in the floodplain. These actions, in conjunction with the low gradient, depositional nature of upper FBC, prompted an investigation of potential soil impacts downstream of the mill site. A field investigation was performed in July 2018 to evaluate the nature and extent of impacts to floodplain soils in the approximately 1.5 mile long portion of floodplain below the former Rumsey Mill site. A total of 147 samples from discrete intervals within 49 soil pits were collected and analyzed for mercury, arsenic, and lead using a portable X-Ray Fluorescence (XRF) unit optimized for mercury analysis. The presence of tailings/impacted soils was confirmed and appeared to be limited to the riparian corridor. Depths of tailings/impacted soils ranged between 0 and 25 inches below ground surface (BGS), with most impacts observed within the upper 12 inches of this interval. Concentrations dropped approximately two (2) orders of magnitude in underlying alluvial sands and silts and mean depth to groundwater was 42 inches BGS. Mercury, arsenic and lead concentrations (mg/kg) at 37 floodplain sample locations (117 samples) ranged between 1.4 and 318, 1.0 and 10,253, and 4.6 and 3,677, respectively. The wide range likely reflects the degree of fluvial mixing of tailings and background floodplain materials over time with lower concentrations representing samples of the relatively unimpacted underlying alluvial sands/silts. Median mercury, arsenic, and lead concentrations (mg/kg) were 22.7, 661, and 243, respectively. Thirty-two percent (32%) of floodplain samples had mercury concentrations of >100 mg/kg. Future work will focus on quantifying impacts to floodplain resources, evaluating risks to potential receptors, and developing remediation alternatives.[3]

Additional Key Words: historic mining, tailings, Fred Burr Creek, mercury, arsenic.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana, The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.
2. Ed Spotts (* presenter), Senior Scientist and Project Manager, KC Harvey Environmental, 376 Gallatin Park Drive, Bozeman, Montana 59715.
3. Work reported here was conducted near 46.28858N, -113.27524W.

Helping Students of Natural Resource Management Develop a Land Ethic[1]

P.D. Stahl[2]

Abstract: A well-developed Land Ethic may be the most important tool, or skill set, or moral code a land manager must possess. In my opinion, just adequately defining the term Land Ethic and all it encompasses is a difficult task. Students in my Land Reclamation Class sure have a hard time explaining this concept. Aldo Leopold introduced his concept of a Land Ethic as values developing naturally from his outdoor experiences throughout his life. Certainly, a large amount of critical thought also went into the development of Leopold's ideas. Can a Land Ethic be taught in the classroom? Or, can this be obtained only through working, playing, spending time, and seriously thinking about the Land and the outdoors? Because all individuals participate in different activities on the Land and have very different kinds of experiences, it seems logical that we develop different Land Ethics. The objective of this talk is to get attendees to think critically about how to help students in the fields of natural resource management better understand what a Land Ethic is and how to develop a strong one.

Additional Key Words: Reclamation, Restoration, Education, Community.

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2. Peter D. Stahl, Professor, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071.

Reestablishment of Wyoming Big Sagebrush in Eastern Wyoming for Sage Grouse Habitat Restoration[1]

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

Abstract: Reestablishing Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) following a wildfire has proven difficult in many areas of the western United States especially in areas where competition from grasses is problematic. This study attempts to develop an effective method for restoring Wyoming big sagebrush in a Sage Grouse Conservation area where sagebrush was previously decimated by wildfire and the current plant community is dominated by relatively heavy native grass cover. Different methods were used to grow seedlings propagated from locally adapted seed that will maximize the amount of soil moisture available to them through snow catchment fencing, fabric mulch and seedling planting density. Sagebrush seedlings were planted in the spring of 2014 onto a 2-year-old burn site using a randomized complete block design. 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 2015 (18 months post planting), survival for seedlings with and without fabric mulch was 49.9% and 30.3% respectively, with a 137% increase in height and 270% increase in width for seedlings planted with the fabric mulch treatment. Growth differences continued to increase through October 2016 when fabric mulch was removed. Drawbacks to use of fabric mulch included attraction of rodents during winter and the degree of difficulty of removal after 3 years in place. Management implications for this method, including planting of shrub islands and recruitment of new sagebrush plants from those we planted will be discussed.

Additional Key Words: competition, soil moisture, fire, threatened species

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2. Peter D. Stahl (* presenter), Professor, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY, 82071: David Casey Balthrop, Environmental Planner/Biologist, Logan Simpson, Fort Collins, CO 80524.

3. Work reported here was conducted near 43 75’97” N, 105 38’22” W.

Integrating Reclamation Oriented Water Management Within Regulation[1]

J.E. Staldine*, C. Yde[2]

Abstract: Large scale projects like coal mines are typically regulated by several permits, often within a single agency with overarching goals and directives. Despite common interests, regulation from separate permits may unintentionally compete or conflict resulting in stalled progress or performance within these goals. A need was identified to integrate permitting requirements for coal mining and reclamation with point source discharge regulation in a manner that protected natural resources and promoted the progression from coal mine to post-mine land use. Through integrating existing regulations for coal mine reclamation, the Western Alkaline Coal Mining effluent limit guidelines, demonstrating science-based rationale, and working to build awareness across programs and decision-makers, policy guidance was developed to transition outfalls to promote reclamation rather than hinder progress. Implementing this policy is a matter of consistently integrating performance benchmarked goals within permitting actions, with the net effect of incentivizing mine operators to pursue drainage basin oriented reclamation.

Additional Key Words: NPDES, Western Alkaline, Coal Mine, Reclamation.

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2. Jonathan E. Staldine (* presenter), MPDES permit coordinator, Coal and Opencut Mining Bureau, Montana Department of Environmental Quality, Helena, MT 59601; Chris A. Yde, coal section supervisor, Montana Department of Environmental Quality, Helena, MT 59601.

Unconventional Seismic Studies at a Coal Mine Fire Before and After Reclamation Efforts[1]

L. Steele*, D. O'Connell, J. Nuttall, T. Tafi, and J. Turner[2]

Abstract: In the 1980s, the state of Colorado Division of Reclamation and Mine Safety developed the statewide Mine Fire Program to observe and evaluate ~36 actively burning underground coal mine fires in CO. Reclamation of these sites, in particular the South Canyon East coal seam fire site near Glenwood Springs, CO is a logistically difficult objective, as the burning coal seams are steeply dipping (~50º) beds along the Grand Hogback monocline. Temperature measurements from vents at the site range between ~100° and > 300° F at the surface, leading to potential for wildfires. We designed a monitoring program to evaluate risk in effort to prevent such hazards by continuously monitoring and evaluating these sites through new quantitative methods. Seismic approaches can be used in a wide variety of geotechnical applications, but the exact needs of any specific project or site require the adaptation and customization of multiple methodologies. With a bit of creativity, however, a diverse array of applications can be realized. Here we present an example of innovative use of seismic data in anthropogenic environments. In a pilot study, we deployed a passive seismometer overnight at this very active coal seam fire near Glenwood Springs, CO. In addition to migrating elk, the instrument recorded intermittent, repeating impulsive events and distinct, unfamiliar long-period signals. We hypothesize that these signals are spalling of roof material or propagation of roof-subsidence fractures and air intake or slow flexure of the roof material, respectively. To test these hypotheses and to assess the utility of passive seismic monitoring of abandoned coal mine fires, a small array of six instruments was deployed for a one-month background monitoring period and additionally recorded data during site reclamation efforts. We will discuss the monitoring results before any reclamation efforts took place and the seismic results during and after attempts to extinguish the subsurface coal seam fire.

Additional Key Words: seismic monitoring, site characterization, construction design inputs, geohazards, coalmine, abandoned mine.

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1. Oral presentation to be given at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT.
2. Lincoln Steele (* presenter), Project Geophysicist Tetra Tech Inc., Golden, CO 80401; Dan O'Connell PhD, Principal Geophysicist Tetra Tech Inc., Golden, CO 80401; Jeff Nuttall P.G., Sr Geologist/Manager Tetra Tech Inc., Golden, CO 80401; Tara Tafi, Sr Project Manager Colorado DRMS-IMRP Crested Butte, CO 81224; Jamey Turner P.G., Sr Geologist/Geophysicist Tetra Tech Inc., Golden, CO 8041.
3. Work reported here was conducted near Glenwood Springs, CO; 39.533415N - 107.415357W.

Abatement of Abandoned Coal Mine Hazards Beneath a Rural Road[1]

C. Stock*, J. Nuttall, and M. Bautz[2]

Abstract: On March 22, 2018, the State of Wyoming was contacted by a resident about several subsidences emerging on Terry Road, which serves as an access to a private residence as well as other commercial ventures. Underground coal mining at the site may have begun as early as the 1880s and ceased in 1940 with no mapping available and no potentially responsible party identified. Tetra Tech visited the site on March 27 and identified two subsidences directly impacting Terry Road as well as other subsidence features in adjacent pastureland. An investigation work plan was approved by the Wyoming Department of Environmental Quality, Abandoned Mine Lands Division (AML). The subsurface investigation was completed in April and May. Eighty-one boreholes were drilled across the site accompanied by downhole laser scanning to develop a three-dimensional model of the underground workings. The mine workings included two primary tunnel alignments with dimensions approximately 6 meters wide and 3 meters high as well as several spurs in every direction. Remediation options were presented to AML and excavation and backfill was selected as the remedy. Earthwork construction began on October 22 and included excavations up to 18 meters deep. Over 23,000 cubic meters of soil and rock were excavated and replaced in compacted lifts. Tetra Tech provided construction oversight during construction which terminated January 4, 2019. Additional support included periodic unmanned aerial vehicle (drone) surveying and imagery plus RTK surveying at the conclusion of the project to reestablish roads and fence lines.

Additional Key Words: downhole laser scanning, underground 3D mapping, subsurface investigation, drone, remediation construction.

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1. Oral presentation to be given at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT.
2. Caleb Stock, P.E. (* presenter), Project Geotechnical Engineer, Tetra Tech Inc., Fort Collins, CO 80525; Jeff Nuttall P.G., Sr Geologist/Manager Tetra Tech Inc., Golden, CO 80401; Melissa Bautz P.G., Project Manager, Wyoming Department of Environmental Quality, Abandoned Mine Lands Division, Lander, WY 82520.
3. Work reported here was conducted near Sheridan, WY.

Applying UAV Imagery to Minimize Impacts to Surface Water from Oil and Gas Well Pad Development[1]

M. P. Strager*, P. Kinder, S. Grushecky, J. M. Strager[2]

Abstract: Unmanned Aerial Vehicles (UAVs) have matured from recreational use by hobbyists to an essential geospatial and modeling tool for natural resource managers. UAVs now have improved flight planning software and can manage higher payloads to incorporate advanced sensors such as LiDAR for high-resolution elevation modeling. Extractive industry sites such as oil and gas well pads can be evaluated using UAV imagery and LiDAR data. These tools have the potential to provide high-resolution aerial imagery and remote sensing data. This information can assist inspectors in performing focused and strategic site inspections of erosion and sediment control practices in an efficient and effective manner. With increasingly stringent construction storm water regulations, inspections have become an integral component in ensuring adequate protection of our nation's waterbodies. In this study, we applied UAV aerial imagery and LiDAR data to map and track overland runoff at a gas well pad in West Virginia. A maximum likelihood classifier was used to classify the imagery and highlight disturbed areas of runoff. Next, we incorporated a landscape-based runoff model for total suspended solid (TSS) estimates to help identify sediment management locations. We found this technology provided very site-specific high-resolution information in a timely manner to effectively identify runoff sources, extent, and water quality from the well pad. The predicted TSS estimates indicated a potential risk to downstream biological conditions highlighting the importance and utility of this approach to monitoring such pad sites for this industry.[3]

Additional Key Words: landscape-based runoff modeling, sediment management, planning.

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2. Michael P. Strager (* presenter), Professor of Spatial Analysis; Paul Kinder, Director, Natural Resource Analysis Center; Shawn Grushecky, Assistant Professor Energy Land Management; Jacquelyn M. Strager, Research Coordinator, Natural Resource Analysis Center, West Virginia University, Morgantown, WV 26506.
3. Work reported her was conducted near 39º 37' 17.76" N, 80º 16' 42.96" W.

Mine Water Reclamation in Appalachia Facilitated by Student Support and Technical Assistance from Academia[1]

Travis Tasker*, James Eckenrode, and William Strosnider[2]

Abstract: Acid mine drainage (AMD) is one of the most persistent and expansive sources of water quality degradation in Appalachia, impacting over 4,000 miles of stream throughout the state of Pennsylvania alone. The Center for Watershed Research and Service (CWRS) at Saint Francis University in Loretto, Pennsylvania was developed in 2012 with the mission to provide support for local and international watershed protection. Due to the mining impacts surrounding the University, the CWRS has assisted in the monitoring, design, research, and maintenance of AMD treatment facilities throughout Pennsylvania. Many of these projects are facilitated by collaboration with local consultants, watershed districts, and the Department of Environmental Protection. Work is completed through volunteer efforts by students, faculty/staff of the CWRS, student class projects, or fee for service opportunities with clients. While assisting in AMD remediation, the CWRS provides unique opportunities for students at Saint Francis University to use their skills to solve real world problems and promote environmental stewardship. The success of the CWRS has helped reduce AMD water quality degradation in Pennsylvania while developing the next generation of environmental stewards. Similar models could be applied at other academic institutions to support student learning while solving environmental issues.

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2. Travis Tasker (* presenter), Postdoc Fellow; James Eckenrode, and William Strosnider, Environmental Engineering, Saint Francis University, Loretto, PA 15940.

Innovative Methods for Cost Effective Rehabilitation of Challenging Mining and Energy Sites[1]

M. S. Theisen and A. Jung[2]

Abstract: Rehabilitation of severely disturbed sites may require unique and out of the box approaches, particularly when sustainable soil sources are lacking, coupled with high erosion control potential. Mining and energy projects situated in remote and/or difficult to access areas pose additional challenges beyond the universal difficulties encountered in rehabilitating severely disturbed sites. From the ground up, sources of suitable onsite, imported or manufactured "topsoil" may be difficult and costly to obtain with massive hauling and placement costs. In absence of adequate sources of topsoil, new techniques have been developed to treat and revive depleted soils to render them more capable of accelerating and sustaining vegetative growth. Essentially, on-site soils can be "engineered" to improve their chemical and biological properties. The meticulous introduction of organic matter, agronomic amendments, plant biostimulants, and soil building components can effectively turn marginal soils into productive and sustainable growth media. Biotic Soil Technology (BST) is a generic term to describe the emerging field of manufactured growth media containing biodegradable fibers, biostimulants, biological inoculants, and other components engineered to cost-effectively increase organic content, accelerate sustainable vegetative establishment and promote regeneration of denuded soils. Next, erosion and sediment control can become quite challenging when dynamics such as poor soil structure, severe slope gradients, high intensity rainfall, and channelized flow events can occur. There is a growing toolbox of highly and cost effective erosion control techniques, but how can they be easily selected and installed in remote and/or difficult to access areas? This presentation will offer case studies of energy and mining projects in diverse ecosystems where deployment and installation of topsoil alternatives and erosion control materials were confronted with supply and access challenges. Examples include secluded sites where unique land and aerial application techniques were the only options to successfully rehabilitate challenging sites.[3]

Additional Key Words: erosion control, topsoil, energy, mining, pipelines, fires.

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2. Marc S. Theisen, Vice President – Technical Services, Profile Products LLC, Signal Mountain, TN 37377; Andrew Jung, President – Western GeoSystems, Golden, CO 80401
3. Work reported here was conducted was conducted at various sites in North America, China, Australia and Papua/New Guinea.

Subsurface Mine Void and Karst Imaging Using 3D Seismic Methods; Adapting Oil and Gas Seismic Advancements to Develop 3D Integrated Site Characterization Models[1]

J. Turner, L. Steele, D. O'Connell, J. Nuttall, W. Levandowski, and M. Isaacson [2]

Abstract: Subsurface voids (both karst and mining related) pose significant risk to human health, the environment, infrastructure, and mining operations worldwide. Innovations in 3D seismic acquisition and processing have provided technological advancements in site characterization applications. Detailed void network imaging and mapping of void networks can be accomplished using shallow high-resolution dense sourcing and receivers acquisition specifications with customized processing workflows. Multi-component seismic acquisition with swept-frequency active sourcing provides full 3D azimuthal coverage to successfully delineate water- and air-filled subsurface voids from 3 to 3000-foot depths using 3D seismic acoustic velocity structure, signal attenuation, and resonance constraints. These data provide enough resolution of subsurface characteristics to: guide targeted drilling investigations, monitor real-time mining and drilling, map karst systems and aquifer flow paths, identify potential sinkhole locations, and manage risk during placement of critical infrastructure such as stacks, mining equipment, pipelines, flowlines, horizontal directional drill paths, tanks, bridge foundations, dams, and tailings. These data are applicable to accurately mapping unknown historic hard rock and soft rock mine workings and are most valuable when tied to empirical borehole data and provide continuous data for interpolation between borings. 2D seismic methods do not work for these applications, and 3D multicomponent sensors and processing continue to become more affordable, and much more effective for sufficient data resolution.

Additional Key Words: Geohazard, subsidence, modeling, engineering inputs, construction design.

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1. Oral presentation to be given at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT.

2. Jamey Turner P.G., Sr. Geologist/Geophysicist; Lincoln Steele, Project Geophysicist; Dan O'Connell PhD, Principal Geophysicist; Jeff Nuttall P.G., Sr. Geologist/Manager; Will Levandowski PhD, Sr. Geophysicist; and Mitch Isaacson, Hydrogeologist, Tetra Tech Inc., Golden, CO 80401.

The Influence of Bacteria on Passive Remediation Systems[1]

Michelle M. Valkanas* and Nancy J. Trun[2]

Abstract: Passive remediation systems are increasingly becoming a cost-effective choice for treatment of abandoned mine drainage. Their ability to remediate both acidic and circum-neutral discharge has proven to be successful. Currently, these systems are designed based on geochemical processes, with minimal regard to the naturally forming microbial communities. We aim to identify the roles microbial communities, specifically bacteria, play in passive remediation systems. We designed an in vitro system to determine the influence bacteria have on soluble iron, manganese, and sulfate levels in two passive remediation systems in Pennsylvania that treat acidic mine drainage (Boyce and Middle Branch). Slurries were taken from settling ponds throughout the remediation systems, sterilized and reinoculated with bacteria from different points in the systems. Enrichment studies were also performed to identify the potential for mine drainage constitutes to shape bacterial communities. We found that bacteria have the ability to both negatively and positively influence the removal of contaminants from the passive remediation systems. Biologically-driven iron-oxidation that resulted in iron precipitation was observed in both systems, while Middle Branch also had manganese-reduction that led to resolubilization. Our findings suggest that the microbial communities in remediation systems can have both positive and negative effects on contaminant removal. Further understanding of the microbial communities present in passive remediation systems could help to improve system performance and longevity.[3]

Additional Key Words: Abandoned Mine Drainage, Microbial Communities, Bioremediation.

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2. Michelle M. Valkanas (* presenter), PhD Candidate, Biological Sciences, Duquesne University, Pittsburgh, PA 15282; Nancy J. Trun, Associate Professor, Biological Sciences, Duquesne University, Pittsburgh, PA 15282.

3. Work reported here was conducted at Boyce Park AMD Passive Remediation System (40.463740, -79.748558) and Middle Branch Passive Remediation System (41.344826, -77.867146).

Monitoring and Assessment: Evaluating Reclamation Success of Surface Coal Mine Reconstructed Rangelands[1]

E.A. Vasquez[2]

Abstract: Evaluation of surface coal mine reclamation is ultimately based on the specific requirements of the reclamation plan and the functional requirements of the post-mining land use. The scope of this discussion focuses on monitoring and evaluating the successes of reclamation following surface coal mine disturbances. The Surface Mining Control Reclamation Act of 1977 regulations require bonding by the operator prior to mining activities. An assessment of reclamation is conducted by the regulatory agency prior to bond release for three Phases of reclamation. For Phase I, the performance of the reconstructed landform topography is evaluated; Phase II assesses attributes such as topsoil depth, vegetative cover, soil/site stability, and hydrologic function. Final bond release for Phase III requires the reclaimed plant community(s) meet specified criteria indicative of diverse, effective, and permanent plant communities for their intended post-mine land use. Vegetation success standards for Phase III bond release having a post-mine land use of rangelands are largely based on indicators such as foliar and ground cover, shrub density, plant diversity, and biomass production compared to either a reference area(s) or technical standard. Reclaimed rangeland watersheds should capture, store and release water effectively into re-constructed watersheds. Indicators such as vegetative cover and composition may suggest successful reclamation. Process-based indicators such as water-flow patterns, rills, soil compaction, and plant community composition and distribution relative to water infiltration and runoff may help to identify ecological processes in need of repair. The graded spoil in all reclaimed mining areas should be systematically sampled to identify the extent, nature, and location of unsuitable materials for plant growth. Further research focused on effectively linking remotely sensed data with site-based data is warranted and can help to address ecological questions concerning reclamation across a gradient of spatial scales. Monitoring program design should be an integral part of the reclamation planning phase and indicators reflecting landscape-scale processes can be adapted to monitor reclamation success over the long-term.

Additional Key Words: Restoration, Revegetation, Invasive Species, Geomorphic Reclamation, Non-parametric Statistics.

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2. Edward A. Vasquez, Ph.D., Ecologist, USDI – Office of Surface Mining Reclamation and Enforcement, 1999 Broadway, Denver, CO, 80202.

How do We Know That the Land Has Been Reclaimed – Regulatory Approach for a Surface Coal Mine (WY, USA)[1]

A. Krzyszowska Waitkus[2]

Abstract: Before a company can begin mining in the U.S., it must secure a mining permit and comply with regulations and performance standards of the USA Federal Surface Mining Control and Reclamation Act (SMCRA) of 1977, state programs and other federal environmental acts. The Wyoming Department of Environmental Quality (WDEQ)/Land Quality Division (LQD) administers Wyoming's coal regulatory program and approves a surface coal mine permit application. Process of approving a surface coal mine permit application includes obtaining a coal lease from the federal Bureau of Land Management, completeness and technical reviews and approval by the LQD and public involvement. Before a mine permit is issued, a permittee must also submit a reclamation bond to secure the performance of reclamation obligations. After approval of the permit, any major revisions, amendments must be approved by the WDEQ/LQD and public hearings are required. According to WDEQ/LQD Coal Rules and Regulations, the goal of surface coal mine reclamation is to restore the land to a condition equal to or greater than the highest previous use. The coal mine permit application consists of four major portions: adjudication section, supporting data (baseline information), mine plan, and reclamation plan. For example, in the North Antelope Rochelle Mine permit more than 60% of the information concerns premining baseline data. The permit application, once approved, constitutes the enforcement contractual document (permit) with the WDEQ/LQD that is used during monthly compliance inspections of mining operations. Any discrepancy from the permit commitment and WDEQ/LQD Coal Rules and Regulations found during inspections or through a regulatory review of annual reports (submitted by the operator) could result in a violation with associated penalties. For the state of Wyoming, a system of reclamation criteria and performance standards has been established to indicate completion of successful reclamation phases. The reclamation status and the completion of various reclamation phases are verified through the bond release process. Representatives from the state, federal agencies, and land owners are joined together for the field inspections of the bond release phases. In Wyoming, four bond release phases for surface coal mines indicate the achievement of various reclamation processes.

Additional Key Words: Permitting, Inspections, Annual Report, Bond Release.

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2. Anna Krzyszowska Waitkus, Environmental Consulting, 80 Eagle Nest, Laramie, WY 82070, enviro@wyoming.com.

A Permeable Reactive Barrier (PRB) for the Immobilization of Selenium in Seep Water and Shallow Groundwater at a Phosphate Mine an Southern Idaho: Results of Bench Scale Testing[1]

William J Walker*, David Tooke, Matthew Wright, Jeffrey Hamilton, Cindy Schreier, and Jonathon Peterson[2]

Abstract: A bench study designed to determine the efficacy of a permeable reactive barrier (PRB) for removing elevated Se in groundwater and seep water at the toe of overburden storage area at a phosphate mine in Idaho. The bench testing was considered a first step in the pre-design considerations for developing an engineering and geochemical strategy for long-term water treatment options at the site. The study consisted of three main parts: (1) characterization work designed to determine the basic chemistry of the site-water under consideration and the components of the PRB, (2) batch leaching studies designed to assess the chemistry changes that each media component is expected to contribute to the overall effluent water chemistry, and (3) column studies in which mine seep or groundwater were delivered up-flow to columns packed with the PRB components. The column influent flow rate was set to establish a hydraulic residence times of 12 and 24 hours. The results of the studies indicated that the media components of the PRB caused no chemical changes of concern to effluent water quality. Column testing results indicated Se was rapidly reduced to elemental Se. The initial Se concentration in seep water was 9 mg/L and was reduced to about 0.2 mg/L after 25 pore volumes and 0.1mg/L after 50 pore volumes. Increasing the hydraulic residence time to 24 hr., decreased Se to 0.07 mg/L or just above the 0.05 mg/L water quality goal. The initial Se concentration in groundwater was about 1 mg/L and was reduced to less than 0.02 in the first 3 hours of column contact time, well below the 0.05 mg/L water quality goal. The presentation will provide details of the testing including Se reduction, the fate and stability of Se in the PRB and the initial design and performance of the field pilot constructed in September 2018[3].

Additional Key Words: column and batch leaching, selenium reduction, selenium speciation, seep water, overburden, microbial reduction.

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2. William J Walker (* presenter), PhD, Senior Geochemist; David Tooke, PhD, Associate Geochemist; Matthew Wright, PE, Associate Engineer; and Jonathon Peterson, Project Geologist, NewFields Companies, Mining and Energy Services, Missoula, MT; Jeffrey Hamilton, Senior Environmental Engineering Manager, J.R. Simplot Corporation, Pocatello, ID; Cindy G. Schreier, PhD, Chief Scientist, Prima Environmental, Sacramento, CA.

3. Work reported here was conducted near 42° 44’ 56” N; 111° 30’ 23” W.

Spatial Distribution of Reconstructed Soil Volume Density in Loess Open-pit Mining Area Based on IDW Interpolation[1]

Shu-fei Wang, Yin-gui Cao, and Zhong-ke Bai[2]

Abstract: We examine the southern dump of Pingshuo antaibao open-pit coal mine in China with the field sampling data, DEM and high-definition images, and aim at analyzing the variation of soil bulk density in the research area and the effect of slope and vegetation configuration mode on the variation of soil bulk density. Typical profile sampling, indoor testing, geostatistics method, IDW and overlay analysis are used in the research. Results show that: (1) soil bulk density value increases with the increase of soil depth, and it is of moderately variation of each layer. (2) The amplitude of soil bulk density of 0-20cm in both the east-west and south-north directions is small and similar. In the four layers of 20-60cm, the variation of soil bulk density in the east-west direction is far greater than that in the south-north direction. (3) Soil bulk density of 0-30cm medium slope is the largest, in the 30-60cm soil layer, the bulk density of soil in large slope topography is larger than that in small slope topography. (4) From the perspective of vegetation allocation model, the order of soil bulk density in 0-20cm and 20-60cm layers is different. As a whole, the bulk density of soil in the area with Caragana korshinskii is smaller, while that in the area with mixed vegetation is moderate, and that in the area without vegetation or only Robinia pseudoacacia is larger. The following conclusions can be drawn. Spatial differentiation of soil bulk density in 0-20cm soil layer is affected by herbaceous root system, while it is affected by vegetation allocation mode in 20-60cm soil layer. On the whole, soil bulk density decreases with increasing slope, but when the slope is between 0 to 21°, it has a special law of change. The mixed mode of "grass-irrigation-joe" or "irrigation-joe" has the best effect in regulating soil bulk density. These results can improve the basic principle of land reclamation in mining areas in theory and provide basis for further optimizing land reclamation technology in practice.

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1. Oral paper presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana: The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Shu-fei Wang, Yin-gui Cao, and Zhong-ke Bai, School of Land Science and Technology, China University of Geosciences, Beijing 100083, China; Yin-gui Cao is also with the. Key Lab of Land Consolidation, Ministry of Land and Resources of the PRC, Beijing 100035, China.

Implementation of the 2018 AML Pilot Program in Pennsylvania – AML Reclamation as an Economic Catalyst[1]

P. M. Webb[2]

Abstract: The Consolidated Appropriations Act of 2018, (Public Law 115-141), authorized the federal Office of Surface Mining Reclamation and Enforcement (OSMRE) to provide funding for Fiscal Year (FY) 2018 for the Abandoned Mine Land (AML) Reclamation Economic Development Pilot Program (AML Pilot Program). For FY2018, the AML Pilot Program is providing grants to the six Appalachian states with the highest amount of unfunded high-Priority coal AML problems based on OSMRE's AML inventory data as of September 30, 2017 and grants to the three Tribes with an approved AML Reclamation Program. Kentucky, Pennsylvania (PA), and West Virginia are each receiving $25 million; Alabama, Ohio, and Virginia are each receiving $10 million; and, the Hopi Tribe, Crow Tribe, and Navajo Nation are each receiving $3.33 million. The purpose of the funding is to accelerate the remediation of AML sites with economic and community development end uses, with the intent of exploring and implementing strategies to return legacy coal sites to productive uses. This is the third year that AML Pilot Program funding has been authorized by Congress; PA received $30 million in FY 2016 and $25 million in FY 2017. Like the first 2 years, the AML Pilot Program requires the AML program to consult with state and local economic and community development authorities to identify AML projects with an economic and community development nexus. PA is targeting 15 AML Pilot sites, from over two dozen proposals received and evaluated, that encompass a wide variety of projects types and a broad range of economic or community development benefits and partners. PA is allocating the majority of the AML Pilot Program funds for the construction of SMCRA Title IV eligible AML and AMD problems. The project partners will then work to fund and complete non-AML economic development aspects of the projects. PA's 2018 AML Pilot Grant was approved on December 1, 2018 and has a three-year period of performance. This presentation will discuss the planned reclamation and anticipated benefits for each of the 15 AML Pilot Projects as well as the status of each including any issues, which could impact their successful implementation.

Additional Key Words: Abandoned Mine Lands (AML), Economic Development.

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2. Patrick M. Webb, P.E., Mining Engineer Manager, Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation, Ebensburg, PA 15931.

Restoration of Wyoming big sagebrush to intact rangelands within a Greater Sage-grouse Core Population Area, Converse County, Wyoming[1]

Jana White[2]

Abstract: Natural recolonization and regeneration of Wyoming big sagebrush (*Artemisia tridentata ssp. Wyomingensis*) within wildfire-impacted landscapes of eastern Wyoming can take decades or even centuries. For this reason, active efforts to preserve and restore the sagebrush ecosystem are integral to conservation efforts for Greater Sage-grouse (*Centrocercus urophasianus*) and other sagebrush-obligate species in this area. In 2014, the Douglas Core Area Restoration Team (Team) began to investigate strategies for restoring sagebrush to post-wildfire sites within a Greater sage-grouse core population area in eastern Wyoming. Projects have consisted of outplanting 100,000+ greenhouse-grown sagebrush seedlings across 5000+ acres. Results from annual project monitoring highlight the importance of using locally collected seed to grow sagebrush seedlings, and directly confronting environmental challenges such as competition, soil moisture constraints, and herbivory in project design and implementation. We will present results on seedling survival, growth, and reproduction during the initial years following project implementation. In addition, we will describe ongoing research into the longer-term persistence of sagebrush seedlings after project infrastructure is removed and seedlings are exposed to ambient environmental conditions and land management practices.

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2. Jana White, Trihydro Corporation, 1252 Commerce Dr. Laramie, WY 82070

Proposed Skill Sets for Effective Natural Resource Managers of the Future[1]

Stephen E. Williams* and Stanley E. Bellgard[2]

Abstract: The sequence of finding mineable minerals, securing license to extract, extracting and restoring land to a sound ecologically functioning condition is the ultimate challenge to natural resource managers. Whether managers are regulators, practitioners or end users, objectives for the extractive and resources industry are to profitably provide the extracted product while maintaining environmental conditions, within a framework of cultural and social sensitivity, before, during and the after the operation. Thus, the educational and experiential transformation of persons to fully engaged, natural resource managers whom can successfully negotiate the mining life cycle and secure the industry objectives is increasingly multidimensional. Therefore, a rigid successional education model is functionally being replaced by more of an agile educational model for natural resource managers. In this model, trainees may follow a diversity of educational pathway as they become versed in a diversity of sciences, arts, engineering, legal, social, cultural, ethical, and environmental to provide a more "global" context applied to meet the industry objectives. Ultimately, the quality of these skill sets become tested in decision-making. Three tenets habits of effective decision-making are: use the best information available, understand the laws that apply, and take into account the immediate, short-, medium-, and long-term public interest in the decision. Support for these tenets overlap with one another but include multi-disciplinary scientific studies, economic imperatives, knowledge of legal risks, aesthetics, ethics, and socio-cultural values. There have been shifts in societal values especially as the newest generation has developed deep relationships with technologies. They are re-creating our world, and demand co-created educational frameworks. Several case studies will highlight the use and misuse of these precepts in the decision-making process. The tensions that challenge the integrity of the process will be highlighted using an example of a mine-land reclamation course conducted in a country (Mongolia) that is struggling with disturbed land reclamation issues. The presentation will conclude with a listing of a proposed skill set needed by natural resource managers of the future.

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2. Stephen E. Williams (* presenter), Professor Emeritus, Ecosystem Science and Management Department, University of Wyoming, Laramie. USA 82072 sewms@uwyo.edu and S. E. Williams & Associates, LLC. sewmsllc@gmail.com and Stanley E. Bellgard, Research Scientist, Manaaka Whenua Landcare Research, Auckland, New Zealand. BellgardS@landcareresearch.co.nz

SMCRA Fee Collection Reauthorization: Ensuring the Future of Abandoned Coal Mine Reclamation[1]

A.G. Wolfe and A. McAllister[2]

The Surface Mining Control and Reclamation Act (SMCRA) is federal legislation that regulates coal mining in the United States. Prior to its original passage in 1977, the coal mining industry was largely unregulated, particularly with regard to environmental impacts. Mining that occurred before the enactment of SMCRA took a large toll on the surrounding land and water. More than 10,000 miles of streams and rivers are polluted with abandoned mine drainage between Pennsylvania and West Virginia alone, and hundreds of thousands of acres of scarred mine lands still remain throughout the nation's coal regions. Thousands of abandoned mines still exist that pose health and safety hazards to communities, and new mine fires and subsidences routinely develop that create an ever-evolving inventory of sites to address. Title IV is the section of SMCRA that contains the funding mechanism – which is derived from a fee on every ton of coal mined in the nation – to address dangerous abandoned mine sites and reclaim land and water degraded by mining conducted prior to the passage of SMCRA. Those fees are placed into an account known as the Abandoned Mine Reclamation Fund. At this time, the collection of reclamation fees is set to expire in 2021. Much progress has been made over the years to restore our nation's waterways and land by a multitude of entities including non-government organizations and government agencies alike. Nevertheless, a lot of work remains to be done. Public health and welfare, as well as restoration of our nation's land and water resources, requires congressional action to reauthorize the fee collection until the year 2036. Failure to act continues a cycle of depressed economies and unemployment while exposing our communities and families to health and safety hazards and environmental degradation. With only two years left until the expiration of the current reclamation fee collection, time is of the essence to begin working on reauthorization of the fee. This presentation will provide an overview of SMCRA's Abandoned Mine Reclamation Fund and what is needed from the reclamation community to ensure the continued reclamation of dangerous mine-scarred lands and polluted waters.

Additional Key Words: Abandoned Mine Reclamation Fund, SMCRA policy, abandoned coal mine reclamation funding

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2. Amy G. Wolfe (co-presenter), Director of Northeast Coldwater Habitat Program, Trout Unlimited, Lock Haven, PA 17745; Andy McAllister (co-presenter), Director, Western Pennsylvania Coalition for Abandoned Mine Reclamation, Luxor, Pennsylvania 15662.

Coal Mining Subsidence and its Effects on Agricultural Land: a UAV-Based Investigation in Eastern China[1]

Wu Xiao*, Zhenqi Hu, and Jiale Chen[2]

Abstract: China produces and consumes nearly half of the global coal production, of which more than 85% comes from underground mining. The exploitation of coal reserves brings lot of negative impact and land and environment, mining induced subsidence were the most serious issues in China. To investigate the impacts of mining subsidence on agricultural land in eastern China, a high ground water table plain, a field survey covers soil and maize biochemical vegetation parameters are carried out, which includes soil moisture N, P, K content, maize chlorophyll, leaf area index (LAI), and biomass. Furthermore, multi-spectral and visible sensors are mounted on an unmanned aerial vehicle (UAV) based platform to monitoring geomorphology and maize biochemical vegetation parameters. Inversion models were constructed using empirical modelling methods; the remote sensing inversion models of chlorophyll, LAI, and biomass were built, validated, and compared. Finally, the spatial distribution of those indicators was analyzed to delineate the boundary of mining subsidence on agricultural land. The chlorophyll, LAI, and biomass content gradually decreased from the edge of the subsidence basin to the center, which indicated a significant impact of mining induced terrain alternation and effects on agricultural land. The proposed method provides highly efficient, immediate, and accurate references for mining damage assessment, and could guide subsequent subsided land reclamation and ecological restoration[3].

Additional Key Words: High ground water table; multi-spectral; remote sensing

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2. Wu Xiao (* presenter), professor, land management/ survey and mapping, Zhejiang University, Hangzhou, 310058; Zhenqi Hu, Professor, land reclamation, China University of Mining and Technology, Beijing, 100083; Jiale Chen, graduate student, survey and mapping, China University of Mining and Technology, Beijing, 100083;
3. Work reported here was conducted near 35°29'55" N, 116°55' 03" E.

Stream Restoration Techniques to Mitigate the Yellowstone Hydroelectric Decommissioning Project in Duchesne County, Utah[1]

Crystal Young and Lee Forbes[2]

Abstract: Moon Lake Electric Association, Inc. (Moon Lake) is applying to the Federal Energy Regulatory Commission for a surrender of license for the Yellowstone Hydroelectric Project. The Yellowstone Hydroelectric Project is located on the Yellowstone River in Duchesne County, Utah. Originally licensed in 1943, the Yellowstone Hydroelectric Project consists of a 4.6 meter-high, 113-meter long timber, rock, and steel composite dam that impounds a reservoir, a 4,307-meter long penstock pipeline, and a powerhouse with a capacity of 900 kilowatts. Based on findings during the relicensing process, a determination was made that the costs to operate and repair infrastructure, in addition to the low power generation, it is in the best interest of Moon Lake to decommission the project and to satisfy their customers from other sources of power. The project area is on lands managed by the U.S. Forest Service (USFS) in the Ashley National Forest (ANF) Duchesne Ranger District and on private land owned by Moon Lake. This project created a unique opportunity to restore the historic multi-thread channel configuration and mitigate impacts for the removal of the facilities. This presentation focuses on the stream restoration components of the project. Reference reaches were identified and surveyed to define design parameters. The stream restoration design restores the historic valley floor by re-establishing a main channel, side channel, and riparian and wetland floodplain habitats. The design optimizes the geomorphic and hydrologic processes to maintain existing hyporheic conditions of the spring feed channels and wetland habitats at the head of the reservoir. Natural analog in-stream structures are planned to maintain vertical and horizontal stability utilizing local natural materials and maximizing transplanting to provide a cost-effective design. In-channel structures include toe wood, log j-hooks, sod mats, log-boulder riffles, and boulder grade control structures.

Additional Key Words: FERC, Natural Channel Design, Ecosystem Function.

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2. Crystal Young, Hydrologist-Fluvial Geomorphologist and Lee Forbes, P.E. Senior Ecosystem Restoration Engineer, SWCA Environmental Consultants 141 Discovery Drive, Suite 118, Bozeman, MT 59718.

Application of Coupled Surface and Subsurface Hydrological Modeling in Hydrology-Based Reclamation Technique of Mine Lands[1]

Teklu K Tesfa, Chang Liao, and Z. Fred Zhang[2]

Abstract: Both surface and groundwater flow provide significant seepage pathways for contaminant transport from abandoned mine lands to the surrounding environment playing major role in environmental pollution. Thus, effective reclamation technique of mine lands must incorporate detailed understanding of the hydrological characteristics of both surface and subsurface water including the interactions between them at the watershed, where the mine lands are located. Despite of the significance of the interactions between surface and subsurface water for contaminant transport, traditionally, hydrological studies are performed for surface and subsurface water independently and the effect of the interactions between them is assumed to be insignificant. In this study, as part of a hydrology-based design of geomorphic evapotranspiration (GET) covers for the reclamation of mine lands, we applied a coupled surface and groundwater hydrological modeling to understand the hydrological characteristics of the Tin Pan mine site, located in the northern region of New Mexico, United States. For this purpose, the Soil and Water Assessment Tools (SWAT) and the Modular Three-dimensional Finite Difference Groundwater Flow Model (MODFLOW) were coupled to simulate surface and subsurface hydrology of the watershed, where Tin Pan mine site is located. Due to lack of meteorological data at the Tin Pan watershed, the coupled hydrological models were first calibrated using the Purgatoire watershed, which is climatically and topographically similar to the Tin Pan watershed, located in the southern region of Colorado, United States. In this presentation, we show results of the coupled surface and subsurface water simulation at the Tin Pan watershed that are relevant to the hydrology-based design of GET covers for reclamation of mine lands.[3]

Additional Key Words: Abandoned Mine Waste; Water Management; Geomorphic Reclamation; Evapotranspiration Cover.

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2. Teklu Tesfa, Scientist; Z. Fred Zhang, Environment Engineer; Energy and Environment Directorate, Pacific Northwest National Laboratory, Richland, WA 99352. Chang Liao, Post Doctorate, Earth & Biological Sciences Directorate, Pacific Northwest National Laboratory, Richland, WA 99352.

3. Work reported here was conducted near 36°56'30.47" N, 104°32'16.51" W.

Modeling Water Balance of Geomorphic Evapotranspiration Covers for Reclamation of Mine Land[1]

Z. Fred Zhang[2], Yilin Fang, Nicholas Bugosh, Teklu Tesfa[2]

Abstract: Surface mining imposes severe ecological effects on the land because it not only alters the vegetation, soils, bedrock, and landforms, but also changes the surface hydrology, groundwater, and flow paths that ultimately result in degraded ecology and water quality. The combination of two relatively new methodologies, fluvial geomorphic landform design and evapotranspiration (ET) covers, as the geomorphic ET (GET) covers, offer solutions to reclaim abandoned mine land for long term. The GET cover can be evaluated for optimized design, e.g., by predicting the water and contaminant balance using a numerical simulator. An ET module is being developed for the existing eSTOMP simulator. Soil water stress is quantified with a water stress function, which is the product of plant wilting factor and the fraction of roots. The plant-wilting factor is a function of soil water matric head. When the plant is not stressed (water stress function = 1), actual transpiration (T_a) is the same as the potential evapotranspiration (PET). When the plant is stressed (water stress function < 1), T_a is the reduced PET by a factor of the water stress function. The ET module provides an additional capability to the eSTOMP simulator to predict actual ET for different plant types. Different types of vegetation can be mixed. Different micro-climate condition (as indicated by the PET) can be applied to as desired (e.g., in the north and south slopes of a hill). This simulation capability is demonstrated for different GET cover designs.

Additional Key Words: Abandoned Mine Waste; Water Management; Contaminants; Vegetation.

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2. Z. Fred Zhang, Environment Engineer; Yilin Fang, Teklu Tesfa, Earth Scientists; Energy and Environment Directorate, Pacific Northwest National Laboratory, Richland, WA 99352. Nicholas Bugosh, GeoFluv, Inc., Parma, Ohio 44134.

Abatement of AMD at the Germantown AML Site in West Central Missouri[1]

D. P. Wedemeyer*, P.T. Behum, and M. Meuller[2]

Abstract: Between 2015 and 2018 Missouri Department of Natural Resources, Land Reclamation Program (LRP) completed a two-phase acid-mine drainage (AMD) abatement project at the Germantown abandoned mine land (AML) site in west central Missouri. This poster paper will overview the case history and performance of these AMD abatement efforts. The 971-hectare Germantown AML site was formerly the location of the Peabody Coal Company Power Mine, which extracted the Tebo and Wheeler-Pittsburg coal seams. Starting in 1967 Peabody reclaimed by1987 about 30% of this historic mine area. An initial abandoned mine lands (AML) reclamation effort by LRP was conducted in 1988 which attempted to address part of the 486 acres of barren spoil that remained as reported in a 1984-1986 US Geological Survey (USGS) study. This area-type surface operation mined though most of the former receiving stream, Horn Branch of Deepwater Creek leaving about 100 impoundments of which 1/2 were reported by the USGS to have a pH < 4.0. More recent LRP effort included the L-Pit Reclamation Project, conducted 2015-2016 followed by the Duck Pond Reclamation Project in 2016-2018. The L-Pit project centered on 127.4 acres of land reclamation. However, two small passive treatments systems were constructed: a surface flow wetland treating a net alkaline discharge, and a variation of a limestone-buffered, sulfate-reducing bioreactor and associated oxidation cells. This bioreactor, termed organic, limestone and aglime (OLA) cell, treats a low-flow highly acidic seep. Three additional passive treatment systems based on OLA-type bioreactors were installed at the Duck Pond Project in 2017.

Additional Key Words: organics limestone and aglime cells, sulfate-reducing bioreactor.

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2. Daniel P. Wedemeyer (*presenter), Environmental Specialist III, and Michael Mueller, Reclamation Specialist, Missouri Department of Natural Resources, Land Reclamation Program, Jefferson City, MO, 65102; Paul T. Behum, Ph.D., Sr. Hydrologist, Office of Surface Mining and Reclamation, Mid-Continent Region, Alton, IL 62002.
3. Work reported here was conducted near 38° 17’ 22” N; 94° 01’ 00” W.

Do Weeds Hinder the Development of Native Plants on a Reclaimed Boreal Mine Site?[1]

Brea Burton,* Kaitlyn Trepanier, and Brad Pinno[2]

Abstract: Weedy non-native plants can be a major impediment to the establishment, growth and survival of native plant communities on mine reclamation sites. For oil sands mines in the boreal forest of northern Alberta, one of the main reclamation targets is to have a natural plant community similar to the surrounding forests. In this region, the weedy plants are almost exclusively short-lived non-native forbs common in agricultural areas such as sow-thistle (*Sonchus arvensis*), scentless chamomile (*Matricaria perforata*), and sweetclover (*Melilotus officinalis*); weedy shrub and tree species are not present. The goal of this project is to better understand the role of weeds on reclaimed oil sands mine sites and determine if weeds hinder the establishment of native plants or if they are simply utilizing available resources with no long-term impacts on plant community development. Past work has shown contrasting results as to the impact of weeds. For example, reclamation practices that increase weeds, such as fertilization, decrease native tree establishment, while actively controlling weeds increases highly competitive grasses but not native forbs. For this study, we will examine the impact of weeds on native plant communities on two different reclamation soil types after one and four growing seasons. The reclamation soils are forest floor mineral mix, an upland forest based soil rich in native plant propagules, and peat mineral mix, a lowland based soil high in organic matter but low in native uplands plant propagules.[3]

Keywords: oil sands, mine reclamation, boreal forest, non-native plants, native forbs.

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2. Brea Burton (* presenter), Undergraduate student, Kaitlyn Trepanier, Graduate student, Brad Pinno, Assistant Professor – Silviculture, Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada

3. This work took place in the mineable oil sands region of northern Alberta near 57.2˚N 111.6˚W.

Prediction of Sludge Generation in Mine Drainage Treatment Plan with Lime Dosing[1]

Young-Wook Cheong*, Choonoh Lee, Gil-Jae Yim, Joon-Hak Lee, Dong-Kwan Kim, Duk-Min Kim, and Jae E. Yang[2]

Abstract: In Korea, some acid mine drainages are treated with semi-active treatment. The semi-active treatment facilities consist of a neutralizing reaction tank, a rectangular concrete settling pond, and an aerobic wetland. The size of the rectangular pond is designed large enough to settle the sludge for as long as possible. The size of the pond is determined by the prediction of the amount of sludge and the theoretical formula is usually used. However, earlier than expected, the sludge fills the settling ponds and is released to the waterways. This study was carried out to understand why sludge fills up faster than expected. In this study, sludge generation was calculated using the existing USEPA (1983) and MIRECO (2017) formulas and the sludge generation calculated was compared with sludge amount from an experimental result. Two theoretical formulas showed similar sludge generation to 966g and 981g, respectively, when neutralizing the $1m^3$ of mine drainage. When converted into volume, there was a five-fold difference in sludge volume, assuming the moisture content was 95 % and 99 %. After neutralizing $1m^3$ with 20% lime slurry, the amount of sludge was similar to the volume, assuming 99%. When calculating the sludge volume, the moisture content was shown as a very important variable. One of the reasons why the settling pond's life has been reduced was that it has been assumed that water content in sludge is low when calculating the volume of sludge.

Additional Key Words: Semi-active treatment, settling pond, sludge, water content

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2. Young-Wook Cheong (* presenter), Principal Researcher, Geologic Environment Division, Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon, Korea; Choonoh Lee, Gil-Jae Yim, Joon-Hak Lee, Dong-Kwan Kim[3] and Duk-Min Kim, Mine Reclamation Corporation (MIRECO), Wonju, Korea; Jae E. Yang, Professor, Department of Biological Environment, Kangwon National University, Chunchon, Korea.

3. Work reported here was conducted near 35˚30’91”N, 129˚22’41”W.

One Steppe: Efforts from Multiple Stakeholders in Wyoming to Streamline Disturbance, Reclamation, and Conservation Efforts[1]

Michael Curran*, Nicholas Graf, Teal Wyckoff, and Pete Stahl[2]

Abstract: Researchers at University of Wyoming have collaborated to develop a suite of digital tools to improve land management throughout the state. Existing systems which were in existence included Wyoming Geographic Information Science Center's Density Disturbance Calculation Tool (DDCT) which maps land surface disturbance in critical sage-grouse habitat throughout Wyoming as well as the Wyoming Reclamation and Restoration Center's Oil and Gas Reclamation Database which tracks reclamation efforts and vegetation monitoring for over 20 oil and gas operators in Wyoming. The integration of these tools along with other spatial layers, including sage-grouse lek area data, has been developed into the Surface Mapping and Reclamation Tracking (SMaRT) Tool. While initial efforts to develop SMaRT highlighted areas where oil and gas reclamation has been occurring with various success levels throughout Wyoming, the tool lacked input from other industries affiliated with the Wyoming Mining Association and also lacked a central way to report data into the system. Reclamation upload templates have been developed for various industries to streamline disturbance and reclamation reporting and other areas where conservation efforts have occurred are being tracked through the Wyoming Conservation Efforts Database. The aforementioned tools have been developed into an integrated system, One Steppe, as an effort to paint a detailed picture of Wyoming's sagebrush-steppe ecosystem. Various aspect of One Steppe will be demonstrated and future research opportunities will be discussed.

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2. Michael Curran (* presenter), PhD student, Program in Ecology, University of Wyoming, Laramie; Nicholas Graf, Academic Research Professional, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY, USA; Teal Wyckoff, Academic Research Professional, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY, USA; Pete Stahl, professor and director, Wyoming Reclamation and Restoration Center, University of Wyoming, Laramie, WY, USA.

The Role of Solar-Powered Float-Mix Aerators on Iron Oxidation Rates in Passive Treatment Oxidation Ponds[1]

D.M. Dorman* and R.W. Nairn[2]

Abstract: In the passive treatment of net-alkaline mine drainage, oxidation ponds are typically the primary cell for iron retention. Oxidation ponds are designed to promote iron oxidation, hydrolysis, and precipitation, which may also increase trace metal removal via sorption. Iron oxidation kinetics may be accelerated by supplemental aeration techniques including dissipation of energy from hydraulic head and use of diffusers and floating aerators. The purpose of this study was to investigate the effectiveness of two custom-designed, float-mix aerators with regard to ferrous iron oxidation rates in a passive treatment system oxidation pond. The study site was the Southeast Commerce passive treatment system at the Tar Creek Superfund Site, the Oklahoma portion of the abandoned Tri-State Lead-Zinc Mining District. This study examined oxygenation of the water column and resulting iron oxidation, hydrolysis and precipitation from multiple perspectives: (i) with respect to depth, (ii) spatially with respect to the aerator and (iii) spatially within the entire pond. It was hypothesized that more oxygen would be driven into the water column nearer to the water surface and closer to the aerators resulting in greater iron removal from the water column. In-situ measurements, including dissolved oxygen, pH, specific conductance, and oxidation-reduction potential, were taken every 15 minutes throughout the multi-day study periods. Water samples were collected at the beginning, middle, and end of each study at specified depths and locations. Samples were returned to the laboratory and analyzed for total and dissolved metals (EPA methods 3015 and 6010) and total suspended solids (EPA method 160.2) concentrations. Each study was performed both with the aerators on and off to examine the overall performance of the aerators. Future studies will further examine the roles of aeration on ferrous iron oxidation, ferric oxyhydroxide precipitation, solids settling, carbon dioxide exsolution, and resultant bulk water quality changes.

Additional Key Words: net alkaline water, acid mine drainage, passive treatment systems

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2. Dayton M. Dorman (* presenter), Graduate Research Assistant, and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.
3. Work reported here was conducted near 36°55’34.04”, 94°52’30.98”.

Flow Visualization Utilizing Airborne Thermography[1]

John Gaughan[*], Blake Furman, Br. Marius Strom[2]

Abstract: In this study, an airborne thermography system was successfully developed and used to characterize short-circuiting and estimate the mean surface velocity of water from an AMD seep. The system's first test was conducted at Squatter Falls passive treatment system in Western Blair County, PA where high contrast thermal imagery was collected from an unmanned aerial system (UAS) allowing for rapid visual assessment of short-circuiting occurring near the seep. This revealed temperature discrepancies on the Northern bank of the first treatment cell indicated that a small amount of water from the seep was not receiving treatment. The next test of the system was a thermal tracer experiment conducted at the discharge of the first treatment cell into the second, which demonstrated the viability of utilizing heated water as a low-impact tracer. To evaluate the use of this tracer in other applications, a velocimetry study was conducted at Brubaker run near Dean, PA. The thermal imagery from the study was run through an automated image analysis program, which estimated flow rates by tracking the plume's centroid with respect to a ground reference point. Quality Assurance of the program was done by comparing the velocity measurement from a weir just downstream, yielding a 6% difference between the two measurements.

Addition Key Words: UAS, thermography, remote sensing, passive treatment

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2. John Gaughan (* presenter), Senior Environmental Engineering Undergraduate, Saint Francis University, Loretto, PA 15940; Br. Marius Strom (advisor), Engineering Laboratory Instructor, Saint Francis University, Loretto, PA.
3. Work reported here was conducted near 40.5164° N, 78.5164° W.

Interlayered Soil Profile Reconstruction in Reclaiming Subsided Land With Coal Gangue[1]

Yuling Gong[*], Zhenqi Hu, and Kevin McSweeney[2]

Abstract: Rehabilitation of areas impacted by subsidence following coal mining is a pressing need in eastern China, especially where availability of suitable soil material is limited. A field experiment was established to evaluate performance of varying layered combinations of soil and gangue materials as measured by maize (Zea mays L.) growth and yield. Two control treatments and eight experimental treatments were constructed. All treatments had a 30 cm surface layer of topsoil. CK1 consisted of native soil material. CK2 consisted of 50 cm coal gangue covered by topsoil and 40 cm subsoil. Group1 treatments (T1-T3) had a 15 cm layer of subsoil immediately below the topsoil, underlain respectively by progressively thicker gangue layers (20, 30, 40 cm) overlying another 15cm subsoil layer, in turn underlain by gangue. Group 2 (T4-T5) followed the same pattern as Group1 except that the lower subsoil layer was 25 cm thick. Group 3 (T6-T7) differed from Groups 1 and 2 by having a 25 cm upper and 15 cm lower subsoil layer between different thicknesses of gangue. T8 consisted of three 10cm layers of subsoil separating 2 gangue layers and a gangue layer below. Key plant performance indicators, biomass and yield, were significantly better under CK1-2 than in the other treatments (T1-T8). Below the topsoil Eh, pH and total salt content were higher and water content less in T1-T8 than in the CK1-2, reflecting the influence of gangue in the 30-70 cm zone in these treatments. Results indicate that minimizing the adverse impacts of gangue requires a combined top-subsoil cover of at least 70 cm.

Additional Key Words: coal mining subsidence; land reclamation; maize.

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2. Yuling Gong (* presenter), Ph.D. Candidate, Zhenqi Hu, Professor, Institute of Land Reclamation and Ecological Restoration, China University of Mining and Technology (Beijing), Beijing 100083, China; Kevin McSweeney, Professor, University of Illinois Department of Natural Resources and Environmental Sciences, University of Illinois-Urbana, Il 61801.

Sulfate Removal by Selected Organic Substrates in Continuous Flow-Through Columns[1]

J.D. Ingendorf* and Robert W. Nairn[2]

Abstract: Sulfate-reducing bioreactors are common process units in metals-contaminated mine water passive treatment systems (PTS). Although their effectiveness has been demonstrated for both alkalinity generation and retention of trace metals as sulfides, sulfate removal has been generally inconsequential. Given the recent emphasis on abatement of total dissolved solids (TDS) and specific conductance, and the contribution of sulfate to both parameters, effective sulfate removal has become paramount. In this study[3], a laboratory bench-scale continuous flow-through column study was conducted to evaluate sulfate removal using three different locally available organic substrates (Norman Aged Compost (NAC), Murphy Compost (MC), and Spent Mushroom Compost (SMC)) for use in future PTS designs. These substrates were chosen following the conclusion of a batch study of seven locally available substrates, which identified the chosen materials as having the greatest sulfate removal capability and sulfate reducing bacteria (SRB) populations. In the column study, each organic substrate was tested in triplicate, with each column filled with a 2:1 mix of organic substrate to washed river rock and was inoculated with 50 mL of an active known SRB solution from the batch study. A solution of magnesium sulfate [1000 mg L^{-1} $\pm$ 10%] was passed through the column at a flow rate of 0.5 mL day^{-1} resulting in an estimated detention time of eight days. The effluent of each column was analyzed for total and dissolved sulfate, total sulfide, pH, ORP, and temperature. Sulfate concentrations in all flow through columns initially decreased dramatically to below 200 mg L^{-1} after the initial 10 days but rose to near 500 mg L^{-1} after 50 days in both MC and NAC treatments. The effluent of the SMC columns remained at or below 200 mg L^{-1} for the duration of the study. For all columns, pH remained circumneutral, and ORP was between -140 mV and -375 mV. Mean sulfide concentrations on day 75 of the study were 32.5 mg L^{-1} for NAC, 65.2 mg L^{-1} for MC, and 146.9 mg L^{-1} for SMC. Use of specific organic substrates under controlled conditions may allow sulfate-reducing bioreactors to help address elevated sulfate concentrations.

Additional Key Words: Vertical-flow bioreactor, sulfate reduction, retention time.

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2. J.D. Ingendorf (* presenter), Graduate Research Assistant, and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, OK 73072.

3. The study was conducted in Norman, OK at the University of Oklahoma and organic substrates were collected near N 35.2226° N, W 97.4395°.

Optimization of Drainable Limestone Beds for Treatment of Acid Mine Drainage[1]

Kari Lagan*, Travis Tasker, Joel Bandstra, and William Strosnider[2]

Abstract: Acid mine drainage (AMD) generated from mining activities can influence water chemistry in surrounding rivers and streams. The mining exposes iron sulfide minerals (i.e., pyrite) to oxidation reactions that generate a low pH and metal rich solution known as AMD. Drainable limestone beds (DLBs) can be used to treat AMD with a wide variety of solution chemistries by increasing solution pH and precipitating oxyhydroxides within the limestone bed. Over time, these oxyhydroxides can clog the limestone and reduce alkalinity generation. Therefore, DLBs are equipped with effluent valves that can be programmed to empty the system quickly, facilitating high scour velocities that can remove the precipitated iron and aluminum oxides. There are few studies that explore how AMD drainage chemistry and scour velocity during flushing events influences the long-term treatment performance of DLBs. We hypothesize that the concentration and ratio of iron to aluminum in AMD can influence the performance of DLBs and the flushability of precipitated ox-hydroxides from these systems. Therefore, lab-scale DLBs were constructed to evaluate how the flushing velocity and concentrations/ratios of iron and aluminum influence the performance of DLBs. Results will be used to understand and optimize DLBs for treating AMD.

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2. Kari A. Lagan (* presenter), undergraduate, Environmental Engineering and Chemistry; and Travis Tasker, Joel Bandstra, and William Strosnider, Faculty in Environmental Engineering, Saint Francis University, Loretto, PA 15940.

Succession After Reclamation: Identifying and Assessing Ecological Indicators ff Forest Recovery on Reclaimed Oil and Natural Gas Well Pads[1]

Randi C. Lupardus*, Anne C.S. McIntosh, Arnold Janz, and Dan Farr[2]

Abstract: To address a lack of understanding of long-term successional trajectories of reclaimed oil and natural gas sites, we sampled 30 reclaimed and adjacent reference sites in Alberta's boreal forest ranging from 7-48 years post-disturbance. The objectives of this study were to: i) measure above- and below-ground ecological properties to determine if certified reclaimed wellsites were on a positive successional trajectory for recovery, and ii) determine which properties were significantly influenced post wellsite reclamation and were thus good ecological indicators for recovery. Multi-response permutation procedures and non-metric multidimensional scaling illustrated separation between reclaimed and reference sites plant community compositions. When accounting for forest type, seral stage, and time since last disturbance, there was further separation of sites, with only two sites (7%) resembling community structure of reference sites, and 18 sites (60%) resembling treeless grasslands, two of which were >35 years post disturbance, indicating an arrested recovery trajectory. The remaining 30% of sites are likely on a positive trajectory towards recovery. We used a joint generalized estimating equation (JGEE) to determine reclamation had a significant effect on soil bulk density and pH, noxious plant cover, canopy cover, grass cover, woody debris, LFH, introduced plant richness, and live tree basal area. Our data indicate impacts can be long lasting and may remain for half a century or more post reclamation, potentially flat lining the recovery trajectory.

Additional Key Words: ecological recovery; boreal forest; multivariate statistics

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2. Randi Lupardus (* presenter), joint postdoctoral fellow with Alberta Environment and Parks, Environmental Monitoring & Science Division, and the Augustana Campus-University of Alberta, Camrose, AB, T4V 2R3; Anne C.S. McIntosh, Assistant Professor, Biology, Augustana Campus-University of Alberta, Camrose, AB, T4V 2R3. Arnold Janz, Land Scientist, Alberta Environment and Parks Environmental Monitoring & Science Division, Edmonton, AB, T5J 5C6; Dan Farr, Director of Biodiversity and Ecosystem Health, Alberta Environment and Parks Environmental Monitoring & Science Division, Edmonton, AB, T5J 5C6.

3. Work reported here was conducted in the Boreal Forest of Alberta, Canada.

The Ecological and Economic Efficacy of Hillslope Erosion Control Features in Forest Lands after Severe Wildfire[1]

Patrick T McGunagle*[2]

Abstract: Ecological restoration after natural disturbance, such as large wildfires, may be an exercise of preserving environmental form at the expense of ecosystem function. Fire behavior models consider slope, aspect, elevation, fuels loading, fuels condition, climate, weather, and regional trends when predicting large wildfire behavior and effects. Wildland Urban Interface (WUI) expands as communities spill into forested areas; fire behavior models now include structures and vehicles as fuels inputs in predicting fire spread. Similar modelling inputs may be useful in predicting hillslope erosion due to fire severity and topography. Protection of the built environment "at all costs" during natural disturbance limits the preservation of resiliency within the ecosystem; subsequent ecosystem disturbance response occurs at higher magnitude and frequency. The effect of a century of fire suppression is more frequent and severe wildfires today; erosion and debris flow response to wildfire at the watershed scale may be similarly changing. The California Fires of 2017 saw more fatalities due to flooding and debris flow effects than the actual fires themselves. This presentation summarizes data and experiments from more than fifty years of USDA Forest Service and DOI Bureau of Land Management studies on ecosystem response to wildfire across a variety of spatial and temporal scales and regional characteristics[3]. Post-fire treatments are investigated for meeting targets in budget, ecosystem response, erosion prevention, resource benefit, scaling feasibility and aesthetics. Current Best Management Practices may not recognize appropriate ecological timescales or drivers for ecosystem function; the ecological context of human response to natural disturbance within the built environment may not be appropriately internalized within management plans and emergency response. This summary is provided to promote designing ecological resilience into contingency management plans, especially in areas of the built environment at risk for repeated exposure to disturbance scenarios. Conclusions on response validity are drawn from limited economic data.

Additional Key Words: Wildland urban interface, post-fire erosion, erosion control treatments, water quality, erosion mitigation, debris flow, sediment yield, historical fire regime, resilience, ecological form, ecological function, overland flow, hydrologic modeling, hydrologic regime, succession, values at risk, timescale consideration, natural disaster economics, operational safety and emergency response, best management practice, viewshed preservation.

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2. Patrick T McGunagle (* presenter), Graduate Student, Land Resources and Environmental Sciences, Montana State University, Bozeman, MT 59715.

Wool Erosion Control Blankets: A New Roadside Reclamation Tool[1]

K. O'Neill*, R. Ament, and A. Salmore[2]

Abstract: Road construction projects can significantly disturb existing soil profile and obliterate roadside plant communities, making successful revegetation and restabilization of slopes extremely difficult. A new erosion control product manufactured with regionally-produced waste wool is currently being evaluated in an active 2018-2020 field project[3]. The erosion control blankets (ECBs) will be evaluated for growth and establishment of desirable planted species and weedy species on harsh roadside sites with steep slopes (~3:1) and invasive cheatgrass competition. 3-4 different compositions of these wool erosion control blankets (WECBs) (100% wool, 70% wool-30% straw, 50% wool-50% straw, and 30% wool-70% straw) are being evaluated against conventional coconut-coir ECBs. Wool becomes saturated at 33% of it's moisture-free weight (D'Arcy 1990), but can store up to 400% of its weight in water (Upton 2003), leaving a large amount available for plant uptake. Sheep wool also contains 15 – 17% nitrogen, which can act as a slow release fertilizer for plant growth and development. Prototype WECBs were recently field tested against traditional coconut-coir ECBs in Montana. In general the WECB prototypes outperformed the coconut-coir in two significant areas: they allowed for higher levels of plant canopy over seeded perennial grasses and reduced plant canopy cover of weedy species (Ament et al. 2017). This project has great relevance to the Land Use Planning and Design, Soils and Overburden, and Revegetation technical sessions.

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2. Rob Ament, Road Ecology Program Manager, Western Transportation Institute, Montana State University, Bozeman MT 59717; Alissa Salmore, Environmental Planner, Idaho Transportation Department, Pocatello, ID 83204; and Kristen O'Neill (* presenter), Master's Student, Land Resources and Environmental Sciences, Montana State University, Bozeman MT 59717.

Super Absorbent Polymer effects on Soil Physical Properties as Functions of Application Rate and Soil Texture[1]

Megan Ostrand*, Thomas DeSutter, and Aaron Daigh[2]

Abstract: Super absorbent polymers (SAPs) are materials that can absorb significantly more water or aqueous solution than their mass. The nature and properties of SAPs make them a widely utilized material across many disciplines. The objectives of this study were to determine the physical effects of SAP application rates across five soil textures, namely water retention and liquid limits. To each texture, SAP application rates were 0, 0.4%, 0.8% and 2% by soil mass. For water retention, matric potentials of -0.1, -0.3, and -15 bar were used and to determine the liquid limits the fall-cone method was used. Gravimetric water content increased with application rate across all soil textures with the increase being greatest in soils with higher sand concentrations. For example, there was a 218% increase in water content for the Williams soil (Fine-loamy), and a 114% increase for the Fargo soil (Clay). Liquid limit results suggest that SAP application increases the water content at the liquid limit and preliminary analysis indicates that the application rate of SAP is significant ($p<0.05$). Understanding the physical properties and SAP behavior will give us insight into potential field applications, such as reducing soil compaction and allowing for extended periods of plant-available soil water.

Additional key words: Gravimetric, water retention, liquid limit

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2. Megan S. Ostrand (* presenter), graduate student; Thomas DeSutter, Professor and Program Leader; and Aaron Daigh, Assistant Professor, Dept. of Soil Science, North Dakota State University, Fargo, ND 58108.

Geocoding American Society of Mining and Reclamation Proceedings to Preserve and Easily Access Reclamation Research[1]

Ashley Rovder*, Staci Wolfe, Kari Lagan, Lily Currie, William Strosnider, Peter Smyntek[2]

Abstract: The Saint Francis University Center for Watershed Research & Service worked in conjunction with Saint Vincent College to find and geocode the locations of research conducted in the American Society of Mining and Reclamation conference proceedings from 1998 to 2012 as well as the articles in the Journal of the American Society of Mining and Reclamation from 2011 to 2016. In support of Saint Francis University's Research-Learning structure, a group of four undergraduate students conducted the bulk of the investigation with oversight from professor and postdoc mentors to allow for maximum learning opportunities throughout the project. The team members utilized Google Earth and Earth Point to visually search for the coordinates of each site and then code each pair of coordinates into a collective and interactive map. Future research can be recorded and uploaded in the same way in order to keep the database up to date. This database will be easily accessible to members of the American Society of Mining and Reclamation for finding previous research studies, where trends between location and technical divisions (from water management to ecology) can be analyzed. It offers a tool for locating follow-on research topics such as long term successional or passive treatment performance studies and noting where updates are necessary, as well as a unique way to potentially connect with other American Society of Mining and Reclamation members.

Additional Key Words: geolocation Google Earth.

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2. Kari Lagan, Lily Currie, Ashley Rovder, Staci Wolfe, Undergraduate Environmental Engineering Students, Saint Francis University, Loretto, PA; William Strosnider, Faculty, Saint Francis University Engineering Department, Center for Watershed Research & Service. Loretto, PA; Peter Smyntek, Faculty, Saint Vincent College, Latrobe, PA.

Locating and Characterizing Mine Drainage Sources in a Topographically Challenging Location at the Tar Creek Superfund Site, Oklahoma[1]

N.L. Shepherd[*] and R.W. Nairn[2]

Abstract: Mining in the Tri-State Lead-Zinc Mining District of Oklahoma, Kansas and Missouri in the 19th and 20th centuries resulted in substantial land disturbance, water quality degradation and the resultant designation of four U.S. Environmental Protection Agency Superfund Sites. In the Tar Creek watershed, considerable artesian-flowing mine pool upwellings degrade stream water quality, biological integrity and habitat. This study focused on locating and evaluating abandoned artesian-flowing mine drainage sources in the central portion of the Tar Creek Superfund Site, near the abandoned town of Douthat, OK. The focused study area was mined from the 1930s to the 1950s, leaving behind numerous mineshafts, collapse features, and boreholes. Many of these mining features remain hydraulically connected to the mine pool and provide relief when the water table exceeds the land surface elevation. The surface topography and mine pool piezometric surface at the site maintain similar elevations, resulting in numerous mine drainage sources that fluctuate seasonally with the mine pool, which may become storm-driven discharges. Given the limited topographic relief and near surface proximity of the mine pool piezometric surface, discharge rates vary between zero and several hundred gallons per minute. In this study, artesian-flowing discharges were located using historic mining maps, published literature containing potential mine drainage locations, and extensive field investigations. Once located, water quality (physical parameters, total and dissolved metals and major anions), volumetric discharge rates, and temporal persistence of the discharges were evaluated. One of the largest contributing discharges was selected to determine the impact of storm events on metal mass loading from the discharge to the receiving stream. These mine drainage discharges combined account for approximately 80% of the mine drainage within the Tar Creek Superfund Site. Therefore, locating and characterizing these discharges is the first step in the process of designing treatment systems capable of addressing the majority of the artesian-flowing mine drainage at the site.[3]

Additional Key Words: Weirs, Capturing Flow, Borehole Discharge

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2. Nicholas L. Shepherd (* presenter), Graduate Student, and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

3. Work reported here was conducted near 37°57’30” N, 94°50’ 42” W.

Modeling the Effects of Improved Stormwater Management at a Large Open-Pit Mine[1]

S. Shoemaker, J. Hugo, J. Bandstra, and W. Strosnider[2]

Abstract: An open pit mine is currently generating elevated levels of total suspended solids (TSS) and total dissolved solids (TDS) in runoff. These elevated levels are above the permit concentrations and therefore, remediation at the site is necessary. Three general approaches were modeled; source reduction, improvements to the conveyance system, and treatment systems within and at the end of the conveyance system. A conceptual design of an integrated stormwater treatment system was developed. This design included improvements of the tailings pile, restructuring of the canals, and construction of a wet detention basin just above the discharge point. Individual model components were pulled together into an integrated model for the entire stormwater management system at the mine. The model is focused on the impact of the improvements on TSS and TDS levels as well as the quantity of water that the system receives in certain storm events. Results indicate substantial water quality improvements are possible with an integrated stormwater management approach.

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2. Staci Shoemaker (* presenter), student, environmental engineering, Saint Francis University, Loretto, PA 15940; Justin Hugo, student, environmental engineering, Saint Francis University, Loretto, PA 15940; Joel Bandstra, associate professor, environmental engineering, Saint Francis University, Loretto, PA 15940; and William Strosnider, associate professor, environmental engineering, Saint Francis University, Loretto, PA 15940.

Treating Acid Mine Drainage with Ferrate (Fe VI): A Preliminary Assessment[1]

D. Slovikosky*, W.H.J. Strosnider, J.A. LaBar, and J.E. Goodwill[2]

Abstract: Ferrate (Fe (VI)) has been earning attention in water treatment applications due to its alkaline properties and strong oxidation potential, but has not been tested as an acid mine drainage treatment option. Our experiment focused on the viability of ferrate as an option for treating net-acid acid mine drainage from a coal mine in western Pennsylvania. We focused on the oxidation of Fe and Mn as well as the removal of Fe, Al, and Mn through sedimentation. The acid mine drainage was dosed with two different treatments: Fe (VI) only or with sodium hydroxide (NaOH) simultaneously. Various dosing levels were tested with standard jar testing procedures and even at stoichiometrically excessive amounts, Fe (VI) alone did not complete the oxidation of Fe and Mn. With the co-addition of NaOH and a Fe (VI) dose of 25 µM over ninety percent oxidative precipitation of iron and manganese was achieved. The formation of Mn (VII) was noted at Fe (VI) dosages above the stoichiometric requirement. This could be problematic in full-scale systems if they are not properly monitored. The resultant Al (III) and Fe (III) particles were relatively large which suggests that these particles could be removed via subsequent clarification. The resulting Mn (IV) particles were relatively small and did not fully settle which suggests destabilization and aggregation may be required to meet effluent standards. Fe (VI) seems viable for the treatment of acid mine drainage especially with the co-addition of NaOH. However, more research is required to gain a full understanding of potential application questions and the fundamental mechanisms.[3]

Additional Key Words: oxidants, chemical addition, dosing.

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2. Debbie Slovikosky (* presenter), undergraduate student, department of environmental engineering, Saint Francis University, Loretto, Pa 15940; William H.J. Strosnider, associate professor, environmental engineering program, Saint Francis University, Loretto, PA 15940; Julie A. LaBar, assistant professor, science department, Centenary University, Hackettstown, NJ 07840; and Joseph E. Goodwill (presenter), assistant professor, department of civil and environmental engineering, University of Rhode Island, Kingston, RI 02881.

3. Work reported here used waters from a mine discharge near 40.367135°, 78.646209°.

Bench Scale Assessment of Acid Mine Drainage Addition to Secondary Municipal Wastewater Treatment Processes for Co-treatment[1]

Charles Spellman Jr.*, Travis Tasker, Joseph Goodwill, William Strosnider[2]

Abstract: Acid mine drainage (AMD) and municipal wastewater (MWW) are two pollutants that pose serious risks to the water environment if left untreated. MWW can cause eutrophication and introduce pathogenic microorganisms into downstream freshwaters while AMD discharges to surface waters can lead to acidification and increased metal loadings that are harmful to aquatic organisms. One of the more novel ideas for AMD treatment is the co-treatment with MWW. This co-treatment can remove metals from low pH AMD while also decreasing BOD and phosphorus in higher pH MWW. The minimal quantity of data on co-treatment leaves many unanswered questions about the feasibility in an existing wastewater treatment facility. The goal of this research was to access the potential of adding AMD to MWW at a conventional wastewater treatment plant in Johnstown, Pennsylvania. Johnstown has a large discharge of AMD located in the city's more urbanized area with a wastewater treatment facility 6 km further upriver from the discharge.[3] This bench-scale batch study examined the impact of adding AMD at various ratios to aeration tank mixed liquor effluent, prior to secondary settling. After mixing & settling, common wastewater treatment laboratory tests were performed on reactor supernatant (secondary effluent) including sludge settleability, BOD5, COD, turbidity, solids, coliforms, and other important water chemistry parameters. All results were then compared to MWW absent of AMD to determine the impact of AMD on the MWW final effluent and the feasibility of incorporating co-treatment at full scale.[3]

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2. Charles Spellman Jr. (Presenter), Graduate Student, & Joseph Goodwill, Assistant Professor, Department of Civil & Environmental Engineering, University of Rhode Island, Kingston, RI 02881; Travis Tasker, Post-Doctoral Fellow, & William Strosnider, Associate Professor, Department of Environmental Engineering, Saint Francis University, Loretto, PA 15940.

3. AMD discharge located near 40° 19' 41" N, 78° 55' 34" W; Wastewater was obtained from the Dornick Point Wastewater Treatment Facility at 241 Asphalt Rd, Johnstown, PA 15906 (near 40° 21' 51" N, 78° 57' 8" W).

Post-Reclamation Long-Term Monitoring and Care at the Shullsburg Mine in the Upper Mississippi Valley Lead-Zinc District[1]

Sage Tanck*, John Zurawski*, Alex Belisle, and Yari Ben Johnson[2]

Abstract: The lead-zinc deposits of the Upper Mississippi Valley had a 300-year history of continuous mining and inspired one of the earliest mineral rushes in the United States. The Shullsburg mine was one of only two mines in the region still in production after state permitting was introduced in the late 1970s. Reclamation to wildlife habitat began on a portion of the tailings pile in 1985 and continued on the remainder of the site into the early 2000s. Most of the 30-hectare site is management as shortgrass prairie and has become home to seven breeding pairs of state-threatened Henslow's Sparrow (*Ammodramus henslowii*), which inhabits open grasslands. The Wisconsin Department of Natural Resources, the regulatory authority, issued the Certificate of Completion in 2014, which initiated the required 20-year long-term monitoring and care period. During this period, annual site visits using a simple rapid assessment method are conduct at ten permanent observation points to identify hazards, limitations or threats, and management recommendations. The rapid assessment method was created by Applied Ecological Services, Inc. The latest site visit in fall 2018, found that more than 70% of the reclaimed tailings pile is revegetated. A few areas with minor erosion and red spots were identified for further remediation. Seven different invasive species with the potential to cause future management problems were identified. Woody vegetation, mostly eastern cottonwood (*Populus deltoides*) is starting to encroach on the top of tailings mound. Almost 5 years into the long-term monitoring, Shullsburg mine reclamation provides a secure, aesthetically compatible, ecologically functional, and stable wildlife habitat area.[3]

Additional Keywords: wildlife, habitat, Wisconsin.

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2. Sage Tanck (* co-presenter), student, Reclamation, Environment & Conservation program, University of Wisconsin-Platteville, Platteville, WI 53818; John Zurawski (* co-presenter), student, Reclamation, Environment & Conservation program, University of Wisconsin-Platteville, Platteville, WI 53818; Alex Belisle, student, Reclamation, Environment & Conservation program, University of Wisconsin-Platteville, Platteville, WI 53818; and Yari Ben Johnson, Assistant Professor and Director, Reclamation, Environment & Conservation program, University of Wisconsin-Platteville, Platteville, WI 53818;

3. Work reported here was conducted near 42°32'32.3"N, 90°14'45.4"W.

The Role of Mixing on Nutrient and Metal Interactions at the Sediment-Water Interface[1]

Zepei Tang* and Robert W. Nairn[2]

Abstract: A greenhouse microcosm study simulated nutrient/metal interactions at the sediment layer-water column interface in a large Oklahoma reservoir. Grand Lake O' the Cherokees (GLOC), downstream of the Tri-State Lead-Zinc Mining District, demonstrates elevated sediment metals concentrations and is eutrophic due to nutrient-rich agricultural and urban run-off. Three different mixing treatments were established in nine 20-L vessels containing lake sediments: control (no mixing), low mixing (200 rpm, Reynold's number (Re) ≈13,500) and high mixing (500 rpm, Re≈33,700), using overhead blade-stirrers. An initial 2-hour mixing period produced significant increases in total suspended solids (TSS), peaking at 204 mg L^{-1} and 19,200 mg L^{-1}, respectively. Over the 7-day settling period, mixing treatment TSS decreased to 10-20 mg L^{-1}, similar to the control. Mixing treatments produced significant initial increases in total phosphorus (P), iron (Fe), manganese (Mn), and zinc (Zn) in the water column, indicating nutrient and trace metal release from sediment due to mixing disturbance. During the settling period, concentrations decreased, indicating metal precipitation and nutrient sorption. Lead (Pb) and nickel (Ni) shared trends for the high mixing treatment. The low mixing treatment demonstrated a continuously decreasing trend for Pb but Ni stayed relatively constant. Cadmium (Cd) concentrations were consistently below the practical quantitation limit (PQL). Sediment Zn and Cd concentrations increased with greater mixing as follows: control (34,800 and 307 mg kg^{-1}) < low mixing (36,400 and 324 mg kg^{-1}) < high mixing (40,300 and 352 mg kg^{-1}), respectively. All treatments had greater concentration then the initial sediment (29,200 and 239 mg kg^{-1}). Sediment Pb concentrations were also greater than the initial concentrations (3,602 mg kg^{-1}) as follows: control (4,923 mg kg^{-1}) > low mixing (4,883 mg kg^{-1}) < high mixing (5,070 mg kg^{-1}), respectively. Resuspension caused by mixing and subsequent settling helps precipitate aqueous trace metals to the sediment layer.[3]

Additional Key Words: phosphorus, trace metals, total suspended solids

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2. Zepei Tang (*presenter), Graduate Research Associate and PhD candidate (student), and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.
3. Work reported here was conducted near 35°11'0.52" N, 97°26'52.27"W.

Reclamation Planning in the Intermountain West[1]

Brad Teson*, Travis Kimsey, and David Marshall[2]

Abstract: Energy projects in the intermountain west are often located in arid environments with limited soil resources. The soil resources that are present developed over tens of thousands of years and are easily degraded during construction activities. Successful reclamation depends on accurate inventory of the available soil resources, proper stripping and stockpiling of these resources, re-spreading of this soil, and tailoring re-vegetation practices to site-specific conditions. For each project, KC Harvey reclamation scientists conduct a detailed pre-disturbance site characterization including assessments of soil resources and vegetation communities. These data are then used to create a custom reclamation plan that outlines soil salvage depths, seedbed preparation procedures, seeding recommendations, a weed management plan, and a monitoring plan to ensure reclamation goals are achieved.[3]

Additional Key Words: soil salvage, reclamation planning, oil & gas, energy, soil, site-specific.

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1. Poster presented at the 2019 National Meeting of the American Society of Mining and Reclamation, Big Sky, MT. Welcome Back to Montana, The Land of Reclamation Pioneers, June 3 - 7, 2019. Published by KC Harvey, Environmental, LLC, 376 Gallatin Park Dr. Bozeman, Montana 59715.

2. Brad Teson (* presenter), Senior Reclamation Ecologist; Travis Kimsey, Senior Range Ecologist; and David Marshall, Principal Scientist, KC Harvey Environmental, LLC, Bozeman, Montana 59715.

3. Work reported here was conducted near 41.659286 N - 108.002519 W.

Vegetation Community Dynamics on Soil Islands in Oil Sands Reclamation.

K.E. Trepanier* and B.D. Pinno

Abstract: The objective of land reclamation following oil sand mining in the boreal forest of northern Alberta, Canada is to re-establish a functioning ecosystem. Re-establishment includes the development of natural vegetation communities. However, there is still information that is lacking about plant community dynamics on reclamation sites. Vegetation community establishment changes substantially during early development years; therefore, it is key to monitor the progression of communities and soil across reclamation areas. Reclamation practices use soil from forest floor-mineral mix (FFMM), which has higher plant diversity, and peat-mineral mix (PMM), which has greater tree regeneration. An attempt to optimize the benefits of both soil types is a reclamation technique known as "Islands" reclamation, based on forest harvesting and natural landscape patterns. This technique integrates islands of FFMM within a matrix of PMM. The islands of FFMM are indented to serve as a "lifeboat" or colonizing centre to native species post-disturbance. Vegetation assessments (species richness and cover classes) will be done within 27 islands of varying size. Species area curves will be developed to determine optimum size establish native vegetation communities. We expect to see higher diversity as area and time increases. To determine vegetation community spatial patterns, transects were placed along the boundary between FFMM and PMM. Surveying was done in 2015 and will be re-measured in 2019. Vegetation communities are expected to be dispersing further into the FFMM-PMM soil boundary compared to 2015. Understanding how reclamation practices can influence vegetation community dynamics is an important step in developing new methods and targets for oil sand reclamation. Island reclamation will help overcome a large obstacle of re-establishing a diverse native vegetation community, while taking advantage of the ecological differences in available reclamation soil.

Keywords: plant community, plant egress, land reclamation, restoration ecology, soil salvage, soil placement, reclamation soils, minable oil sands

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2. Kaitlyn E. Trepanier, M.Sc. student, Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada; Brad D. Pinno, Professor, Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada
3. This study will take place at Canadian Natural Resources Limited's Horizon oil sands, located approximately 75km northwest of Fort McMurray, Alberta, Canada.

Improving Pedotransfer (Ptfs) Functions Using Recursive Feature Elimination and Random Forest for Predicting Soil Saturated Hydraulic Conductivity[1]

Xin Wang[*], Yanling Zhao, Wu Xiao, Huifang Liu, K. McSweeney, and Zhenqi Hu[2]

Abstract: Pedotransfer functions (PTFs) are alternatives to direct methods for acquiring soil hydraulic properties. PTFs are commonly developed using basic soil physical and chemical properties. In some instances, input variables (such as topographic factors) and more advanced algorithms (machine learning) are applied to augment PTF performance. However, there are few studies focused on how to choose optimal variable combination to improve the interpretability of models. In this study, we used 128 saturated soil hydraulic conductivity (Ks) measurements from northern China, to develop a range of PTFs based on different inputs and algorithms (random forest and artificial neural network) to estimate Ks. The recursive feature elimination (RFE) method was used to filter for optimal combination of variables. Variable importance and partial dependence plots based on random forest were used to reveal relationships between Ks and input variables. We evaluated performance of new PTFs using the determination coefficient (R^2), root mean square error (RMSE) and mean prediction error (ME). The results showed that including topographic factors as additional inputs improved performance of PTFs for estimating Ks. Compared to PTFs that used basic soil properties (BD, clay, silt and sand content) as inputs, the R^2 of PTFs, selected by RFE, increased by 9% for random forest (RF) and 12% for artificial neural network (ANN) respectively and RMSE decreased by 9% for RF and 8% for ANN. The PTFs considering all factors (soil basic properties and topographic factors) without feature selection obtained the poorest results. These results illustrate the potential of RFE and RF to improve performance of PTFs in estimating Ks.

Additional Key Words: Random Forest, Recursive Feature Elimination, Partial Dependence Plot, Topographic Factor

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Scale Composition and an Automatic Cleaning Device for pH Electrode used in Mine Drainage Treatment[1]

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Abstract: Since 2010, Korea has been operating semi-active treatments consisting of neutralization reaction tank - settling pond - wetland to neutralize some abandoned mine drainage. In this study, we tried to find out the composition of scale around pH electrodes and solve the frequent cleaning inconvenience. The pH electrode inside the neutralization reactor tank with large pollution load is vulnerable to scale formation. The pH electrode used in the neutralization reaction tank was a glass bulb electrode and the neutralizer was 20% liquid calcium hydroxide and NaOH solution. The most contaminated Ilkwang mine drainage was neutralized to pH 7 with 20% liquid calcium hydroxide and 1M NaOH solution, and pH measurement and scale formation were observed by inserting pH electrode while stirring the neutralized water in beakers. SEM-EDX analysis showed that in the vicinity of the surface of the water in beakers, gypsum was confirmed, and Fe, Al, Cu and Zn constituted scale in the lower part of the water surface. These scales can be easily washable with acid solutions. An automated system has been created to perform a suction-wash-and-preserve procedure to clean the pH electrode. In the laboratory, this cleaning system has successfully washed the pH electrode by operating at least one cycle per minute, depending on the program setting.

Additional Key Words: Semi-active Treatment, pH electrode, Mine Water

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