Topic PT-5

White Paper Topic: Coal Refuse Reclamation: Capping/Barriers and Improved Methods

Development Team: Paul T. Behum (team leader), Jeff Skousen

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Problem Identification:

Background:

In a typical non-acid and non-toxic cover for a coal refuse facility using the "high and dry" scenario, the purpose of the refuse cap is twofold. First, the soil cap provides a rooting medium for initial establishment and the long-term maintenance of a vegetative cover (Daniels and others, 1997; Daniels, 2005). This vegetative cover is intended to support an appropriate land use such as hay and pasture and prevent erosion. Second, the soil cap should restrict recharge into the refuse pile for the purposed of minimize AMD generation. Addition of alkaline amendments is commonly used supplement acid neutralizing potential of this cover/barrier. This material, typically agricultural limestone or some type of alkaline waste/byproduct is applied and incorporated at both the re-graded refuse surface and the non-compacted soil layer of the cover. Refuse piles under Surface Mining Control and Reclamation Act (SMCRA) of 1977 Title V are also typically compact the refuse to reduce the hydraulic conductivity. In order to get alkaline materials in direct contact with refuse, limestone or other lime product (such as cement kiln dust or alkaline coal combustion byproducts) can be metered directly onto the coarse refuse material as it emerges from the coal processing facility. However, compaction and bulk alkaline treatment of coarse refuse is not a common practice at prelaw AML sites. Sites reclaimed under the AML program typically only reshape the refuse piles to improve stability and increase runoff by creating a crown on previously flat-toped piles, apply an alkaline amendment to the refuse surface, and cover the pile with the best available material. For fine coal refuse (slurry) inundation and/or construction of an anaerobic wetland cover may, in some cases, create an environment for long-term AMD prevention (Nawrot, J.R., 2004).

A number of pre-SMCRA coal refuse facilities and some post-SMCRA sites have been the source of long-term acidic mine drainage. These sites may also discharge elevated levels of toxic metals such as zinc, nickel and cobalt. In theory, the "high and dry" cap/barrier approach (with the lime amendments) will prevent AMD generation and long-term AMD problems. However, in practice, the results have been mixed and AMD problems continue.

Discussion:

A number of sites incorporate improved design features as listed below. Most of these have developed, as practice, by individual companies and AML programs. However, there is a lack of comprehensive guidelines to aid the reclamation designer. Although not universal, some problems with the refuse caps are listed below:

1. Based on field surveys of pre-law sites, some caps installed on highly acidic refuse (>>30 tons CCE of acid producing potential/1,000 tons of material) may have been installed too thin (1.5- to 2-foot thick or less) and or constructed of a material that will provide an inadequate protection from excessive recharge into the coarse refuse. While thin covers may provide adequate rooting medium for establishment of vegetation (Daniels, 2005), they may be inadequate to provide long-term prevention of AMD (note: site conditions, cap-design, and cap composition, alkaline material placement will also determine the cover success for long-term AMD prevention). For example, glacial-fluvial sand and gravel was used to cover the pre-law Green Valley site in Indiana. Although vegetation is well established the site remained a major AMD problem site (reference to be added).

2. Some caps have also been installed to have inadequate compaction of the lower part of the cap to provide the necessary protection from recharge into the coarse refuse (Gentile and others, 1997). Placement of an agricultural lime layer (or equivalent material) on the graded refuse surface prior to soil cap installation may serve as an impermeable layer because a hardpan will typically form.
3. On some piles the top surfaces were not crowned. As a result these sites retained flat-topped slopes (<2% grade), which are inadequate to create runoff and increasing infiltration and recharge. If at all possible terraces should be avoided on side slopes to reduce infiltration. Improved slope shape using a computer-aided design that simulates natural geomorphic terrain in addition to careful construction using GPS-based machine guidance can eliminate the need for terraces.
4. A number of caps have been installed without adequate testing of the acid- forming and/or toxicforming potential. As a result, the cover material itself may contribute to the acid-forming and toxicforming problems or may not provide adequate long-term rooting medium. Consider use of improved ABA methods such as the modified Sobek Method for consideration of siderite mineralization and the Texas AML practice of consideration of soluble sulfate for weathered materials. Consideration of exchangeable aluminum may also be warranted for some sites.
5. In amendments to the cover and, in some cases, refuse, there should be an adequate amount of alkaline material to compensate for differential weathering of the alkaline material in comparison to the rate pf pyrite oxidation (Doolittle and Hossner, 1997; Skousen, 1987, 2005). Inadequate amounts of lime amendments may in some cases have been applied. To account for differential weathering research has suggested that, for materials such as acidic coarse refuse, even an amount that more than125% of the stochiametric amount of lime is necessary to meet provide long-term AMD prevention (Doolittle and Hossner, 1997).
6. Low-cost industrial waste products such as cement kiln dust (CKD) and coal combustion byproducts (CCB's) are commonly used as substitutes for higher-cost lime. These waste products are not subject to the quality control performed by the supplier that is required for a manufactured product such as agricultural lime. If toxic or otherwise deleterious materials are present in this waste material that could be mobilized by the either soil zone leaching or leaching by AMD (sulfuric acid leach), then this material could contribute to the pollution at the site. However, due to natural attenuation of the pollutants from these materials significant off-site impacts have not been observed (Esling and others, 1996). Any toxic or otherwise deleterious materials present in alkaline waste material used as a lime substitute, which are mobilized by either the soil zone leaching or leaching by AMD (sulfuric acid leach, may contribute to the pollution at the site). To avoid this problem repeated, systematic sampling and analyses along with surface and ground water monitoring is recommended. Consideration of the appropriate leach test methodology is critical. For example, waste materials placing in the soil zone may need to be examined by both the Toxicity Characteristic Leach Procedure (TCLP, EPA Method 1311) and the Synthetic Precipitation Leach Procedure (SPLP, EPA Method leach tests. Whereas, it may be appropriate to only use the SPLP test for waste material used as amendments to neutralize AMD within the pile.
7. Tree and/or shrub planting have been conducted, on some coal refuse cover areas, during the reclamation effort or by landowner in an effort to provide an improved wildlife habitat. At other sites tree and/or shrubs have voluntarily spread over the site. Will this vegetation will degrade the compaction layer of the cover and lead to increased AMD generation? There has not been any research related to tree development on refuse piles and there are no known guidelines to aid reclamation specialists.
8. In an effort to prevent stability problems or minimize groundwater impacts, reclamation designers install under drains beneath some coal refuse fills. These under drains will induce a hydraulic gradient within the pile. Under these conditions any water that seeps through the cap would likely infiltrate through the refuse and, unless the refuse (or refuse plus alkaline amendment) will provide a long-term net alkaline acid base account (ABA), then the site will be long-term AMD source.

Course of Action:

We should reconsider the construction refuse covers with an inadequate cover design, which, for the purposes of AMD abatement, have a likelihood of failure. The reclamation community could establish, through workshop(s) and guideline development, a consistent and scientifically sound methodology for placement of coal refuse covers. While several noteworthy studies have provided excellent guidance on constructed covers for the purposes of establishment of vegetation, there is an inadequate understanding and guidance in design features necessary for AMD prevention or diminution. A hydrology-based solution is needed. Because each reclamation site presents unique conditions, we must consider publishing a design guideline that presents technology developed in a National workshop or series of regional workshops.

Cost of Project:

Proposals are preliminary and costs have not yet been developed

1. Sub-team work meetings (travel and per diem): $5,000 (+/-) /ea.
2. Forum/Workshop registration and facilitation assistance $6,000 (+/-)
3. Forum/Workshop Audio Visual Contract: $4,000 (+/-)
4. Forum/Workshop Travel assistance $20,000 (+/-)
5. Forum publishing costs: $10,000 (+/-).
6. Forum publishing costs: $10,000(+/-).
7. Directed research/demonstration site investigations-related expenses $40,000 (+/-)*.

* Assumes demonstration site reclamation is derived from state AML grant funding.

Time Required:

These proposals are preliminary and a timetable must be developed. Anticipate that a forum should be set up in FY2006 or early FY2007. We suggest a Mid-west forum location, possibly St. Louis, due to proximity to field sites. A topic-focused guidance document would require about one year after the forum.

Literature Survey:

- Doolittle, J.J. and L.R. Hossner, Acid-base Properties of a Limed Pyritic Overburden during simulated weathering, 1997, Jour, of Environ. Qual. V. 26, p.1655-1662.
- Hageman P.L., 2004, Use of Short-Term (5-Minute) and Long-Term (18-Hour) Leaching Tests to characterize, Fingerprint, and Rank Mine-Waste Material from Historical Mines in the Deer Creek, Snake River, and Clear Creek Watersheds in and around the Montezuma Mining District, Colorado, U.S. Geological Survey Scientific Investigations Report 2004-510.
- Nawrot, J.R., 2004, Coal Tailings Reclamation practices: Soil Cover Variances – The Ayrshire Alternative, in Proc. 2004 National Meeting of ASMR and W. Va. Surface Mine Drainage Task Force.
- Skousen, J., 1987, Acid soils and liming principles, Green Lands, V. 17, No. 3 p. 33-39.