The Indiana Department of Natural Resources
Division of Reclamation

Submits

AML Site 2052
Minnehaha Slurry
Sullivan County, Indiana

For the

2015 Abandoned Mine Land Reclamation Award

Submitted By

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Project Information

Construction Start Date: May 23, 2012
Construction Completion Date: May 15, 2013
Construction Costs: $6,589,864.32

Organizations Responsible for Reclamation

Indiana Division of Reclamation
Aigner Construction, Inc.

with cooperation from

Peabody Midwest Mining, LLC
Indiana Division of Fish & Wildlife
Minnehaha Fish & Wildlife Area

Date Submitted

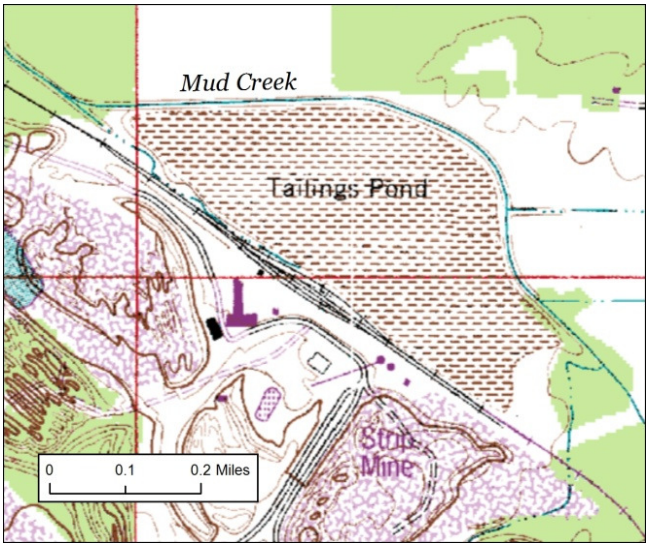
April 23, 2015

Indiana AML Site 2052, Minnehaha Slurry

This project addressed the urgent safety and environmental dangers posed by a weakened levee holding back an abandoned slurry pond in Sullivan County, Indiana. AML engineers pushed the limits of landform design in order to accommodate a large sulfate-reducing bioreactor, which has significantly improved water quality leaving the site. Managers utilized an adjacent completed project and cooperated with a neighboring active mine to increase efficiency and achieve superior landscape-wide reclamation.

A Dangerous Situation

A 60-acre slurry impoundment was located directly adjacent to Mud Creek, a tributary of the Wabash River. In fact, Mud Creek was relocated by a mining company during the mid-1900s to construct the tailings pond. The initial levee was built using the excavated material, and then gob and slurry were added on top. The structural integrity of the levee was inadequate due to its poor construction, and complete structural failure was a possibility.



Topographic map of the tailings pond.

In addition to the coal slurry in the tailings pond, exposed gob material was situated along its southern border. Acid mine drainage from the gob and slurry impaired water quality in Mud Creek, entering the creek through numerous seep zones along the retaining levee.

Highly acidic water constantly penetrating the levee further undermined its stability and threatened to breach the retaining structure. A sudden failure would have caused a massive discharge of water and slurry downstream, damaging property and potentially injuring or killing people.

Coal refuse in the levee allowed numerous acid seeps to penetrate, undermining its structural integrity.

An Innovative Design

The project goals were three-fold: repair the levee, reclaim the coal refuse, and remediate the acid mine drainage. While the cramped layout of the site presented logistical challenges, it ultimately helped inspire a design that integrated all three goals. Although it had never been attempted before, engineers proposed to stack the slurry from the east side of the tailings pond onto the west side. Because the east side levee contained the worst seep zone for Mud Creek, slurry excavation was necessary for its repair. Finally, removing the slurry provided space to construct a large sulfate-reducing bioreactor on the east side of the former tailings pond.

To facilitate slurry excavation and safely repair the levee, impounded water had to be removed. Acid water was pumped from the slurry impoundment into a holding pond, where it was treated with sodium hydroxide before being released into Mud Creek. The holding pond capacity was estimated at one million gallons, and it was filled and emptied six times. The total amount of sodium hydroxide used was 6,960 gallons.

The surface of the vast slurry pond had been sculpted by flowing and impounded water.

A total of 595,000 cubic yards of slurry was excavated and stacked onto existing slurry. The combined slurry was then covered with two feet of soil and revegetated. Geomorphic design principles were used to create variable topography and minimize the potential for erosion gullies. Natural stream design techniques were also utilized to create a sinuous waterway through the new landscape.

A meandering stream and gentle hills exhibit geomorphic design.

Willow mats stabilize the repaired levee along Mud Creek.

After the slurry was excavated, the levee could be repaired. Coarse material was removed from the levee and replaced with borrow material. An additional 1,000 cubic yards of material was excavated in the seep zone, well below the elevation of the seeps. These actions were designed to reinforce the levee and prevent further seepage. Willow mats were also installed to promote tree growth and reduce erosion.

A Lasting Impact

A passive treatment bioreactor was constructed to provide continuous remediation of acid mine drainage from both the slurry pond and from outside the site. In a bioreactor system, bacteria convert sulfate ions in acid mine drainage into sulfide while organic material is metabolized to bicarbonate. The sulfide causes metals to precipitate out of the water, while the bicarbonate neutralizes the acidity. At this site, compost provided the sulfate-reducing bacteria and hay, straw, and wood chips supplied the organic material. Agricultural lime was also added for additional alkalinity production.

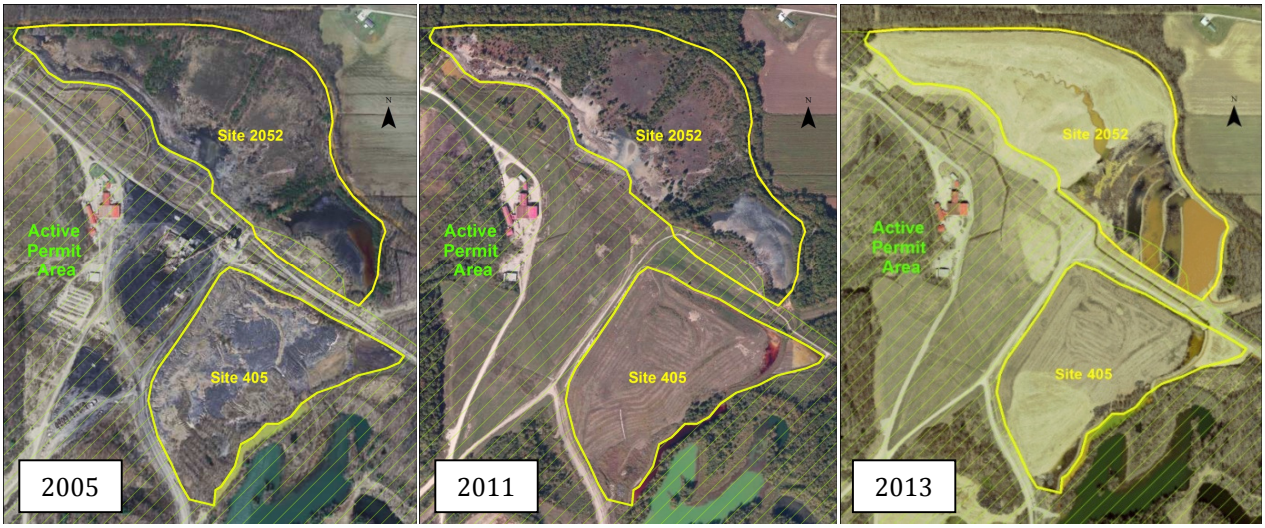
This oblique view of the site shows the stacked slurry on the left and bioreactor on the right.

The volume of substrate used in the bioreactor was 72,400 cubic yards. This included 17,500 tons of ag lime, 2,400 tons of compost, 4,000 tons of wood chips, and 5,000 tons of a hay/straw mix. The materials were mixed thoroughly with water to ensure homogeneity and prevent differential settlement. The substrate was placed around four large earthen berms that control water flow through the system and prolong the water-substrate interaction. A settling pond for metals was built at the eastern end before the outfall.

The bioreactor takes in water from the newly-constructed stream that drains the capped slurry, and also from a reclaimed gob pile to the south. A ditch was built to convey this outside water to the intake of the passive treatment system. The water has a pH of 2.8, and after flowing through the system the pH has improved to 7.5-7.7. With increased pH, concentrations of iron and manganese are reduced significantly. The bioreactor is operating to substantially improve water quality, and it will be monitored in the future to ensure continued function.

The riprap-lined ditch conveys acid water from outside the site into the bioreactor.

These aerial photos show the layout of the site and its neighbors. Site 405 and parts of the hatched active permit area were reclaimed before 2011, while Site 2052 and the orange lake on its western border were reclaimed by 2013. The southwest part of Site 405 that was re-impacted is recognizable from its lighter color.



A Landscape-Wide Approach

This project both utilized and improved neighboring lands to conserve resources and increase the project's impact in the region. AML Site 405 is a reclaimed gob pile southeast of the project area. In addition to directing its acid drainage to the new bioreactor, the site was also used to bury gob material found on the slurry pond. Approximately 212,600 cubic yards of course refuse was excavated from Site 2052 and buried at the southern end of Site 405. Although it did involve stripping off cover material prior to gob burial and revegetation, utilizing this neighboring AML site as a disposal area prevented other lands in a later successional stage from being affected.

Another neighbor impacted was Peabody Midwest Mining, who was operating an active surface mine to the southwest. AML staff reached an agreement with Peabody to use permitted land to store materials during the construction process. Materials storage was not a trivial issue due to the large volumes of substrate used in the bioreactor, and this arrangement helped restrict the project footprint and preserve unimpacted lands.

Hay and straw for the bioreactor formed impressive stacks.

The AML project also facilitated reclamation work on Peabody's site. The permitted area contained an acidic retaining basin at its outfall, which is adjacent to Site 2052. With the AML work in progress, the company developed a reclamation plan in coordination with the Title V Regulatory Section. Peabody hired AML's contractor Aigner Inc. to perform the work, so they saved on mobilization costs. A 3.3-acre area was regraded and covered with 174 tons of lime and 2 feet of soil. The retaining basin was removed, and subsequent monitoring of the drainage has found good water quality.

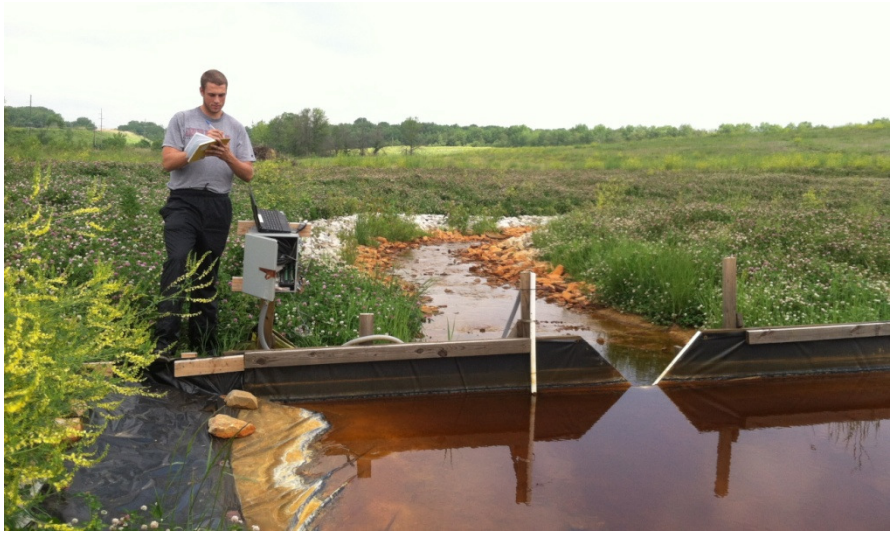
Surface Mining Control and Reclamation Act

The Minnehaha Slurry reclamation project was one of the most expensive in cost and extensive in scope that the state of Indiana has ever attempted. Indiana contractor Aigner, Inc. submitted the low bid of $6,199,995 and was awarded the contract. Three other contractors bid over $9.5 million each, which shows how the competitive bidding process saves money and helps the AML budget stretch further. The amount paid was increased to $6,589,864.32 to account for additional unanticipated acid water treatment.

A project of this scale would not have been possible without the dedicated funding source provided by the Surface Mining Control and Reclamation Act. The Act was designed to protect public safety and the environment from the adverse impacts of past coal mining, and this project definitely qualifies. In addition to remediating the acid mine drainage into Mud Creek, it eliminated the danger of levee failure and the severe environmental and property damage that it would have caused.

The Minnehaha project will also augment knowledge on reclamation technology due to the innovative techniques used at the site. Both the geomorphic slurry landform design and the bioreactor function are being studied by scientists from the Indiana Geological Survey, along with graduate and undergraduate students. Groundwater levels, surface flow, and water chemistry are being monitored in order to develop a water balance model, analyze slope and levee stability, and document the improvement in discharge water quality. Bioreactor construction is a developing methodology with

Two undergraduates install a monitoring port in the bioreactor.



A graduate student records flow data at a weir feeding into the bioreactor.

important potential to provide ongoing and self-sustaining acid water treatment, and analysis of the Minnehaha system will enhance our understanding of this complex and state-of-the-art technology.

Project highlights:

- 595,500 cubic yards of slurry buried
- 212,600 cubic yards of gob buried
- 1,000 feet of levee stabilized
- 28,900 tons of bioreactor substrate used
- improvement in pH from 2.8 to 7.6