UTILIZATION OF STEEL SLAG TO REMEDIATE ACID MINE DRAINAGE

Presented By

National Slag Association

Acid Mine Drainage "AMD"

Acid mine drainage is as old and pervasive as mining itself. In the United States alone, there are some 500,000 abandoned mines, many of them in the western states. In addition, Eastern states such as Pennsylvania, West Virginia, and Kentucky are the heart of the coal mining industry.

Source: U.S. Environmental Protection Agency (EPA).

AMD & You!!

- Many regard clean water as one of the most fundamental of human rights!
- The EPA estimates that mining has polluted more than 40 percent of U.S. western watersheds.
- Mines abandoned hundreds of years ago still release AMD into countless thousands of miles of public waterways.

What is Acid Mine Drainage? "AMD"

"Acid mine drainage" (AMD) is a byproduct of the mining process and poses a serious threat to groundwater, streams, aquatic life and, ultimately, humans. AMD forms during metal or coal mining when sulfur-bearing minerals are exposed to water and air, forming sulfuric acid. Heavy metals leached from rocks can combine with the acid and dissolve, creating highly toxic runoff."

AMD . . .

An Environmental Time Bomb !!

Carried in water, AMD disrupts growth and reproduction of aquatic life, pollutes drinking water, degrades outdoor recreation and corrodes wastewater pipes and other infrastructure.

What is Acid Mine Drainage? (AMD)

- AMD can come from strip mining, but most acidic drainage occurs during sub-surface mining for gold, copper, silver, coal and other metals found in sulfide mineral-bearing rock.

- AMD is released from any place where iron sulfides, such as pyrite, are exposed to air and water, including open pits, underground tunnels and waste rock piles.

What is Acid Mine Drainage? (AMD)

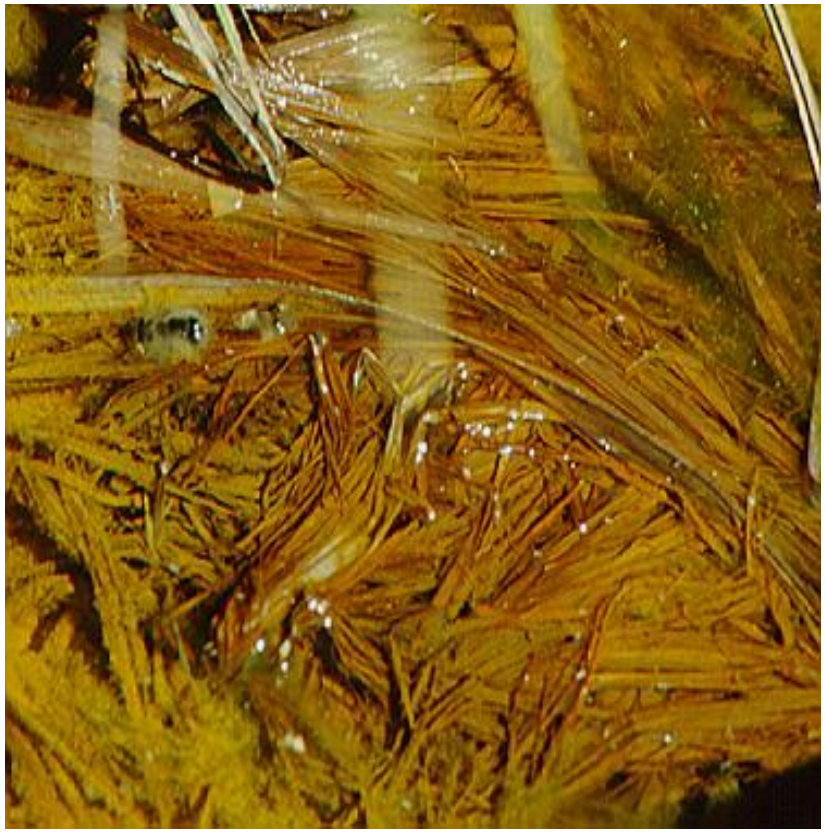
- Results When the Mineral Pyrite (FeS_2) Is Exposed to Air and Water
- $FeS_2 + 3.75\ O_2 + H_2O \Rightarrow Fe(OH)_2 + 2\ H_2SO_4$
- Pyrite is Commonly Present in Coal Seams
- Products of AMD Formation-- Acidity and Iron
- Lowering the pH and Coating Stream Bottoms with Iron Hydroxide (YELLOW BOY)

Modern Surface Mining

Sub-Surface Mining

EFFECTS OF ACID MINE DRAINAGE

EFFECTS OF AMD ON THE ENVIRONMENT



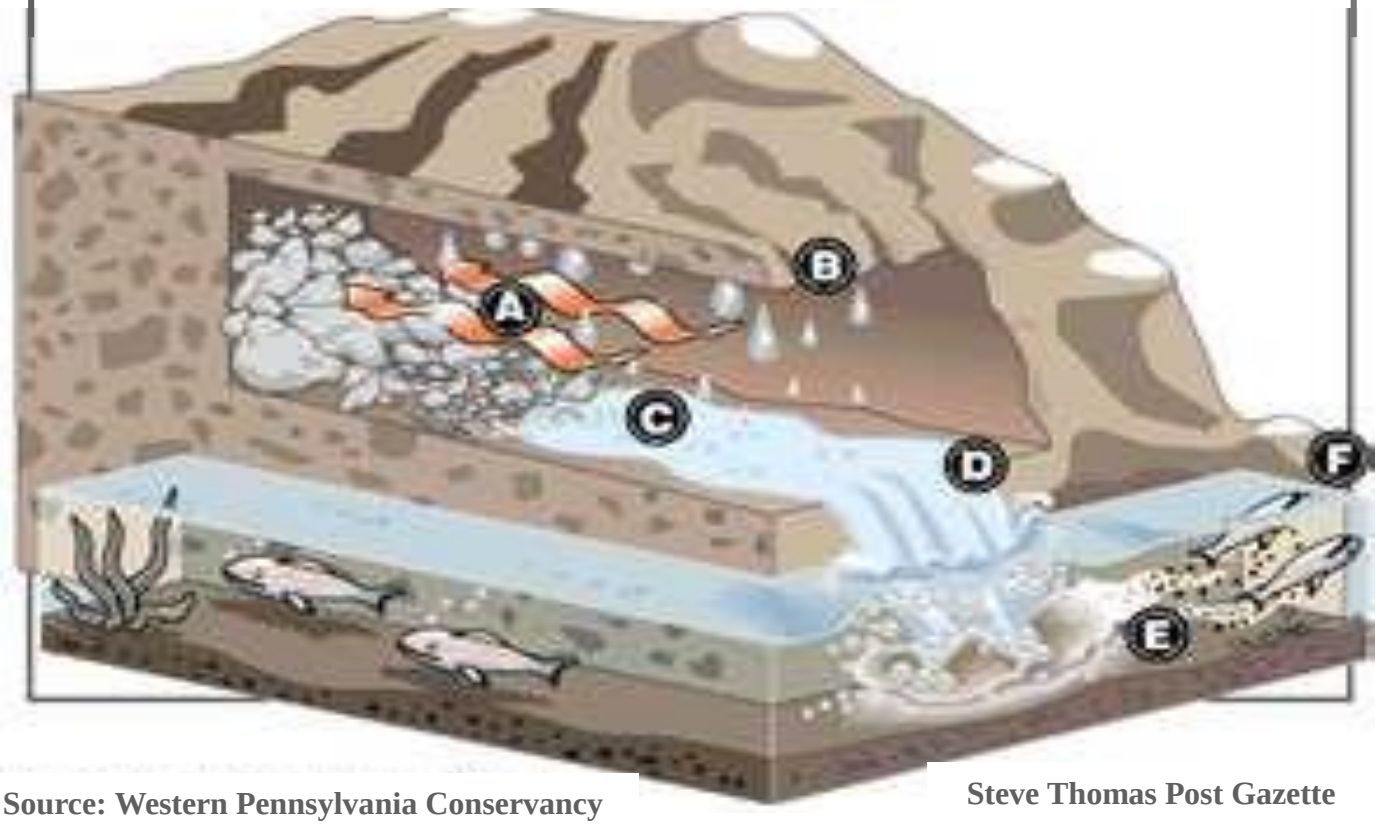
- Smothers aquatic plants and animals
- Acidic Water--lower pH
- Coats Streams with Orange Color Sludge
- "Yellow Boy"

“YELLOW BOY”

Acid Mine Drainage

Here's a look at what AMD is and how it affects the surrounding environment.

- **A** During Mining, pyrite is exposed to oxygen.
- **B** Ground water seeps into the mine.
- **C** Oxygen, water and pyrite react to form sulfuric acid and in turn dissolve metals from the rocks.
- **D** Water drains out of the mine.
- **E** Dissolved metals react with oxygen and fall out of solution into the stream water, turning a bright color.
- **F** Aquatic animals and plants are killed by the drainage.



Source: Western Pennsylvania Conservancy

Steve Thomas Post Gazette

Typical Mine Drainage Composition

Composition Metals (mg/L)	Coal Mines	Cu-Pb-Zn Sulphide mines	Industrial Effluent Limits
pH	2.6-6.3	2.0-7.9	6-9
Fe	1-473	8.5-3200	3.5
Zn			
Al	1-58		
Mn	1-130	0.4	2
Cu		0.005-76	0.05
Pb		0.02-90	0.2

Current Treatment Approaches to AMD

- **Active Treatment-Neutralization by Addition of Lime/Limestone**
- **Install Treatment Plant (High Cost)**
- **Passive Treatment - Utilize Naturally Occurring Biological and Geo-chemical Processes**

Why Utilize Steel Slag?

- High Calcium Content
- Slag's pH is very high (>11%)
- Produces a High Alkaline Environment to Balance the acidic drainage. (pH > 7)
- Abundant Sources Available
- Low Cost ($10-15 Per Ton)

AMD Case Study #1

UTILIZATION OF STEEL SLAG TO REMEDIATE ACID MINE DRAINAGE

Charles Ochola, PhD., PE

Tube City IMS

Tube City IMS
We Create Value

AMD Case Study #1

ABANDONED MINE IN PA

- Mine Opening in Eastern Pennsylvania Abandoned Early 1900's
- Today a large quantity of acid mine drainage flows from the open portal polluting rivers many miles downstream

PROBLEM

- PENNSYLVANIA LEADING PRODUCER OF COAL SINCE 1800'S
- ABANDONED MINES MAJOR PROBLEM IN 45 OF 67 PENNSYLVANIA COUNTIES
- 2,500 MILES OF POLLUTED STREAMS
- 250,000 ACRES OF UNRECLAIMED SURFACE MINES
- 100 MILLION FT^3 OF BURNING COAL REFUSE

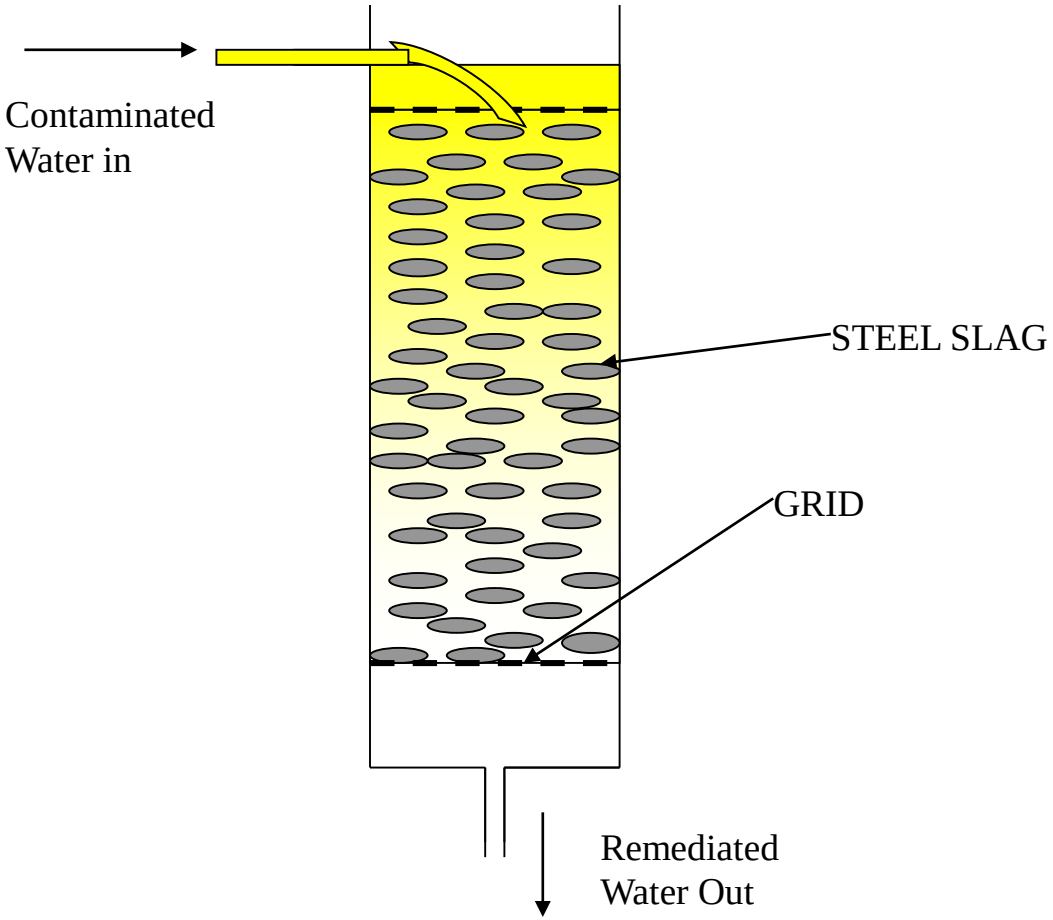
OBJECTIVE

- Determine The Effectiveness Of Steel Slag As A Passive Treatment Method For The Remediation Of Acid Mine Drainage
- Develop Guidelines For Implementation Of Steel Slag Into The Field

METHODS

- Characterization (Mineralogy, Chemistry Of Pore Water)
- Batch Equilibrium Testing
- One Dimensional Column Studies
- Neutralization Experiments
- Laboratory Pilot Scale Investigation
- Field Demonstration Project

ONE DIMENSIONAL COLUMN SETUP



RESULTS OF BATCH AND NEUTRALIZATION TESTS

Metal	Initial Concentration Range (mg/L)	Final Concentration Range (mg/L)	Initial pH Range	Final pH Range	Removal Efficiency (%)
Fe	0.5-200	0.001-0.009	2.66-4.75	10.27-11.26	99.50-99.99
Zn	0.5-200	0.000-0.250	2.96-7.00	10.61-11.31	99.86-100.00
Al	0.5-200	0.002-0.087	2.12-5.88	10.02-11.34	83.80-99.99
Cu	0.5-200	0.010-0.060	2.09-6.09	10.67-11.41	96.00-99.99
Pb	0.5-200	0.001-0.003	3.15-6.98	10.83-11.47	99.50-99.99

POTENTIAL BENEFITS TO PA

- Save PA In the Cost Of Remediating AMD
- Slag Cost $10-15 Per Ton
- Lime-limestone $35 Per Ton
- Produces Less Sludge Which Has High Disposal Cost
- In Wetlands Environment-allow Natural Processes For Remediation

AMD Case Study #2

Utilization of Steel Slag to reduce Acid Mine Drainage

National Slag Association Annual Meeting 2006

Presentation on the Utilization of Steel Slag to reduce Acid Mine Drainage

Jim Gue

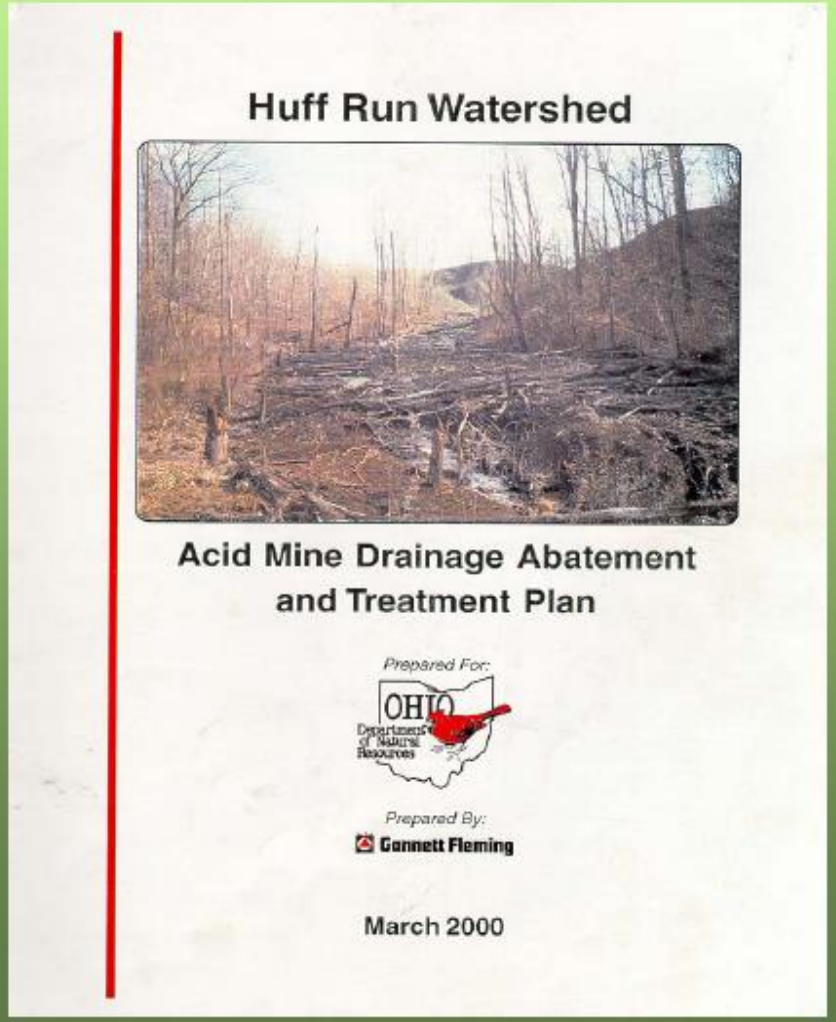
Ohio Department of Natural Resources

"PASSIVE TREATMENT OF ACID MINE DRAINAGE USING STEEL SLAG IN THE HUFF RUN WATERSHED "

Huff Run Watershed

- Muskingum Conservancy District
- Tuscawaras River Basin
- Conotton Creek
- 10 miles length
- 14.1 sq miles

A Primary Huff Run AMDAT Goal:



"Identify and develop AMD abatement Projects in reaches 4 and 5 to buffer downstream episodic low flow pH excursions."

Pre-Construction Water Quality

Project Sample Location	pH	Fe	Mn	Al
Seep at Headwaters	5.8	.648	18.5	.357
Pond 1	2.99	6.94	44.1	21.3
Pond 2	6.64	.258	1.44	<.25
Impoundment 4	4.64	.169	12.3	.987
Impoundment 6	6.28	1.85	5.47	<.25
Wetland Outlet	4.78	.302	15.1	.51
Site Discharge	3.97	.75	18.8	3.33

pH (SU)

Metals (mg/l)

Steel Slag Advantages:

- Steel slags yield several hundred times more alkalinity per equal weight than limestone
- High alkalinity with low contact time
- Low cost ($12.00/ton at Lindentree Project)
- Ease of availability
- Long-term passive treatment

Limestone/Steel Slag Channel

Limestone/Slag Treatment Swale

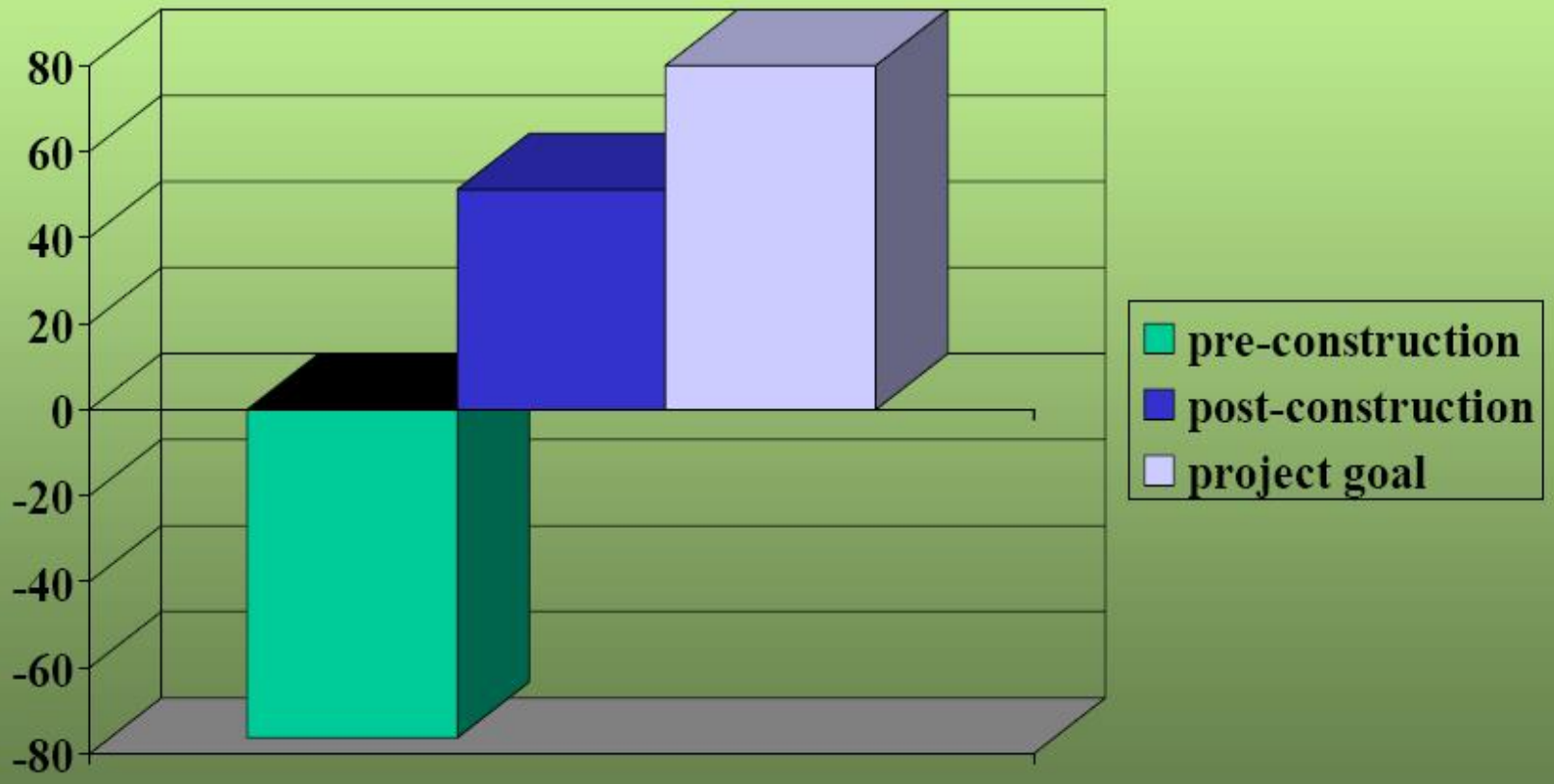
Limestone Rip-Rap Channel

Discharge Analysis (pH)

Site Location	Pre-construction (4-11-02)	Post-construction (11-17-04)
Pond 6 discharge (limestone channel 2)	6.28	6.0
Slag channel 5	6.25, 4.87, 4.64, 6.8	10.5
Pond 1 (slag channel 7)	2.99	11.0
Channel 6	4.5, 6.64	10.0
Bog discharge into slag swale	5.88	7.0
Slag Swale Outlet	---	11.0
Weir outlet	4.78	10.0
Project Outlet Channel, downgrade	3.97	9.0
Brass Road Culvert	3.97	8.0

Acidity/Alkalinity

(mg CaCO3/L)



The Future Challenge !

AMD remains one of mining's most daunting environmental challenges. Preventing toxic drainage from occurring is preferable to performing remedial treatment. In the meantime, the advocacy group Earthworks estimates it will cost taxpayers from $32 billion to $72 billion to clean up AMD and other mine waste.

Dealing with Acid Mine Drainage

Steel Slag offers a cost-effective and proven answer to the Challenge of AMD Remediation !