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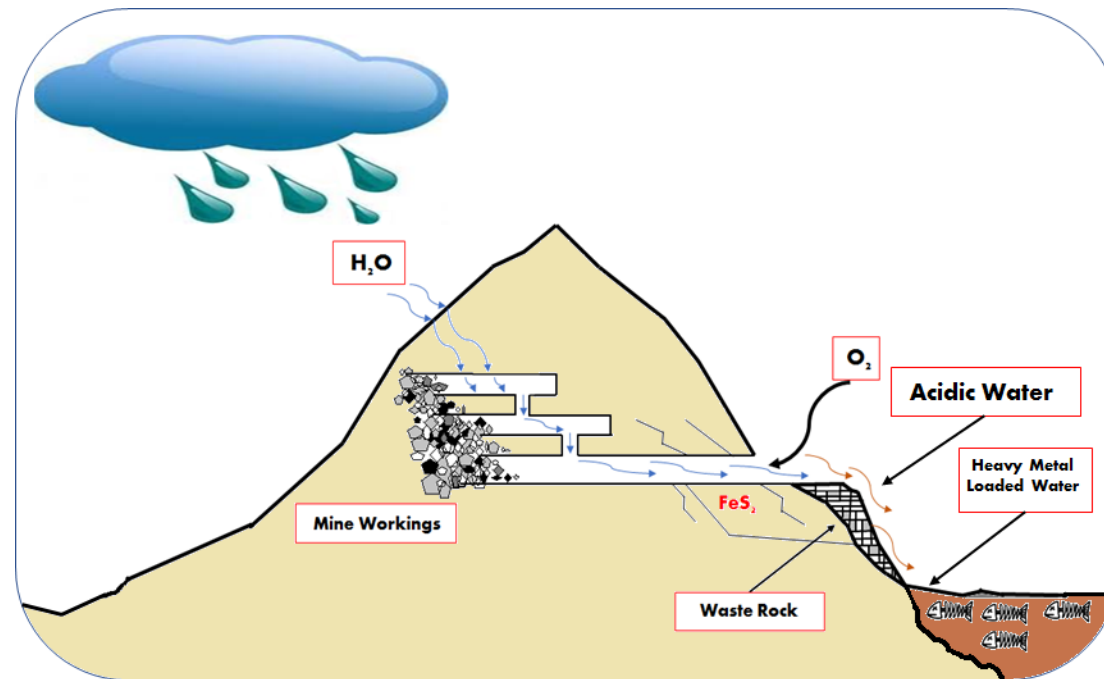
February 11-14, 2019 | New Orleans, Louisiana
battelle.org/sedimentscon | #BattelleSediments19



Recovery of Rare Earth Elements from Acid Mine Drainage Using Geotextile Tubes Containment and Dewatering Technology

Tom Stephens
TenCate Geosynthetics

What is Acid Mine Drainage?



Acid Mine Drainage (AMD) occurs when ground water passes thru a layer of sulfide minerals and becomes acidic forming a low pH sulfuric acid solution. This AMD leaches heavy metals into a solution and oxidizes when coming in contact with air. This acidic water drains from the surface and underground mines into the open environment polluting surface water with ochre, which are red, orange or yellow precipitate sediments.

Results of Acid Mine Drainage



1997 USGS Fact Sheet Reported by WVDEP: 484 Streams totaling 4,563 km (2,852 miles)

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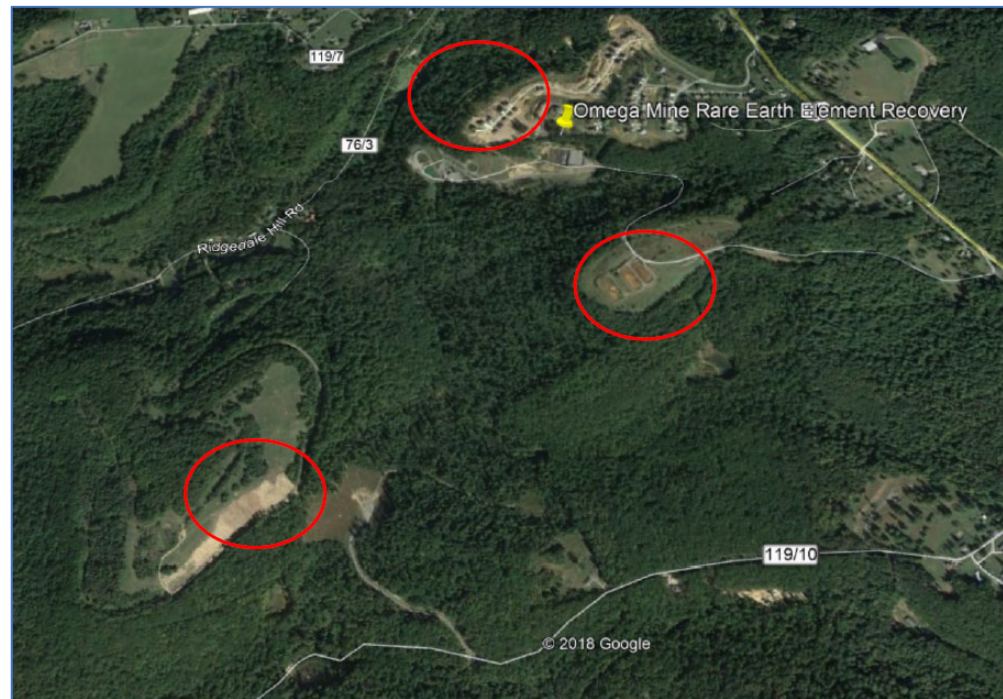
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Omega Mine AMD Treatment Plant With Geotextile Tube Dewatering and Containment Opened in 2016



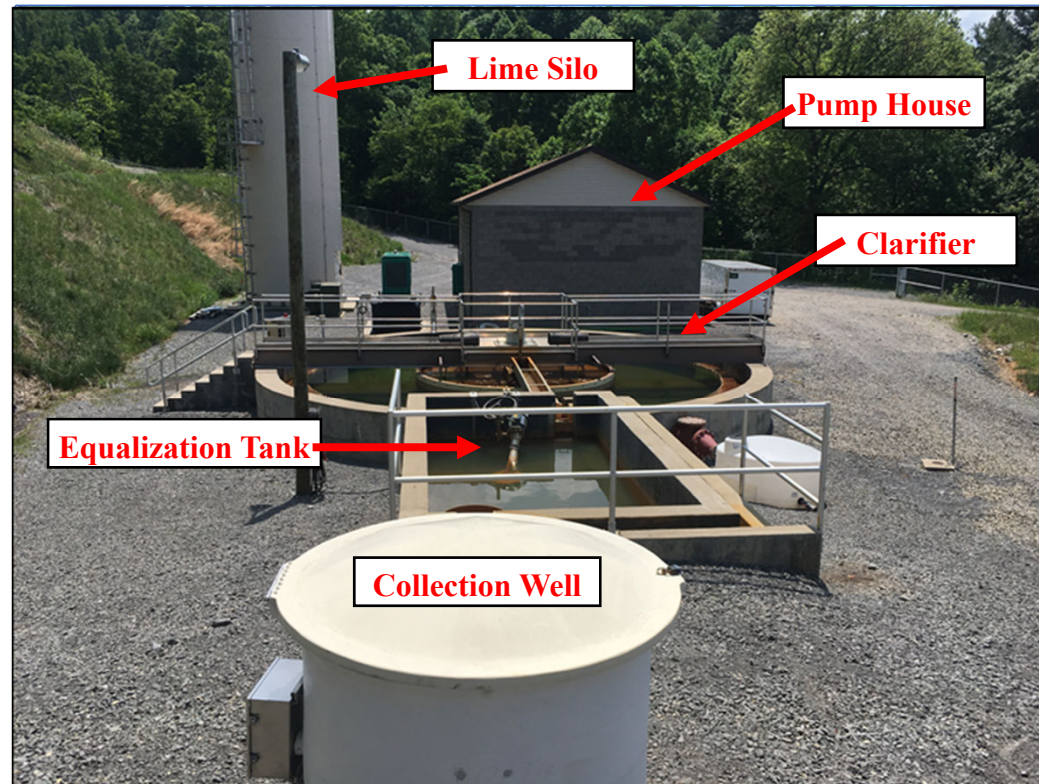
Designed and Operated by West Virginia DEP

Omega Mine AMD Treatment Plant With AMD Source Location



Designed and Operated by West Virginia DEP

AMD Treatment Stages



AMD Collection Well

pH	Al	Ca	Cl	Fe	Mg	Mn	Na	SO ₄	Si
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
method	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7
MDL	0.021	0.01	0.035	0.013	0.01	0.017	0.03	0.047	0.1
2.9	81.8	113.4	22.7	179.9	36.7	1.5	17.7	1501.1	33.8

AMD Incoming Flow

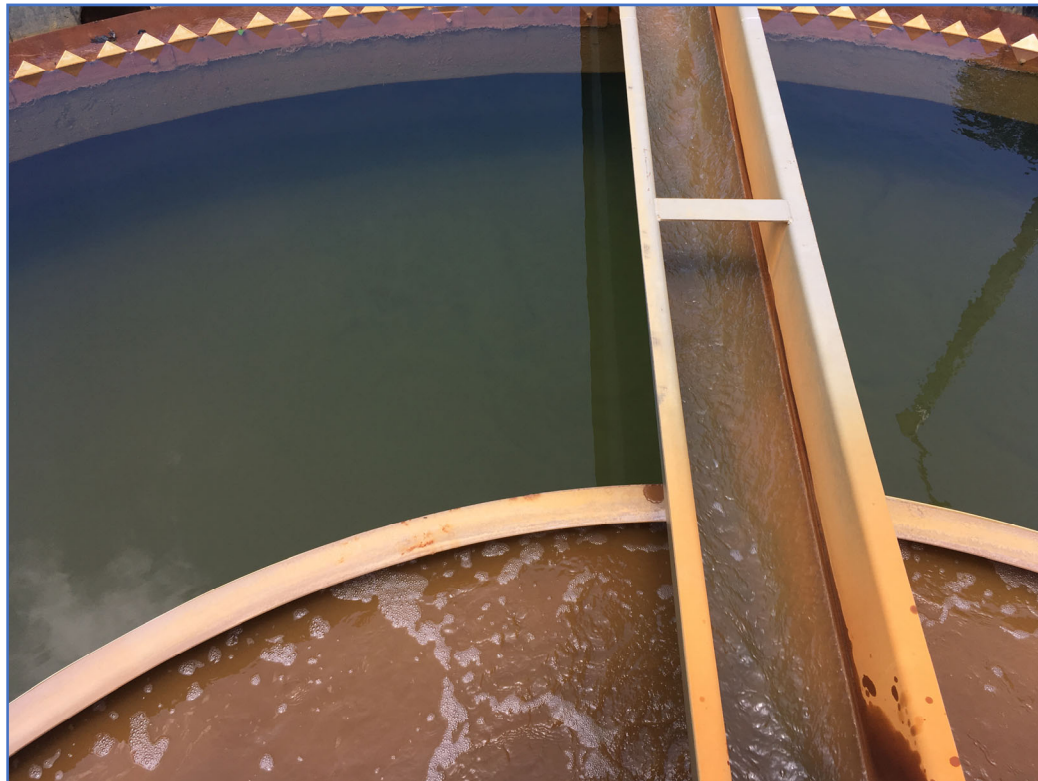
2018 Average of 16 Data Point Measurements of Each Category

Paul Ziemkiewicz PhD Director - WVU Water Research Institute

First Stage of Treatment



pH Adjusted AMD
Solids Precipitate and Sink To
Bottom of Clarifier as a Sludge



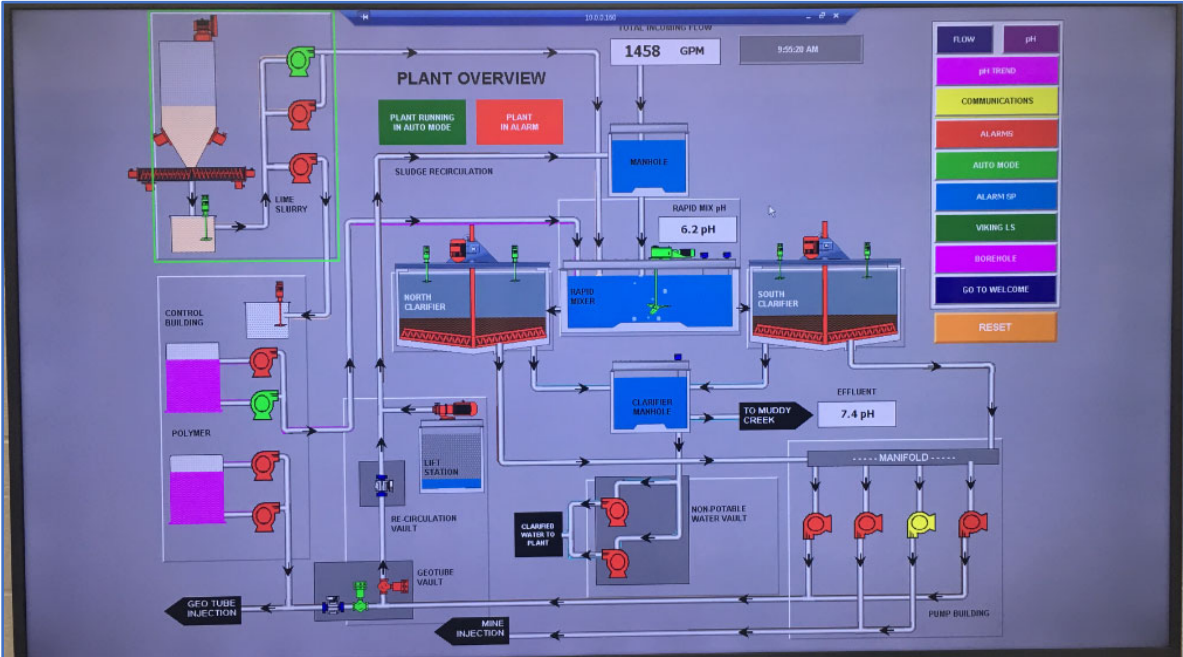
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AMD Sludge Is Pumped Into Pump House
Where Polymer Is Injected and Slurry Is
Pumped To Geotextile Tube Dewatering Cell



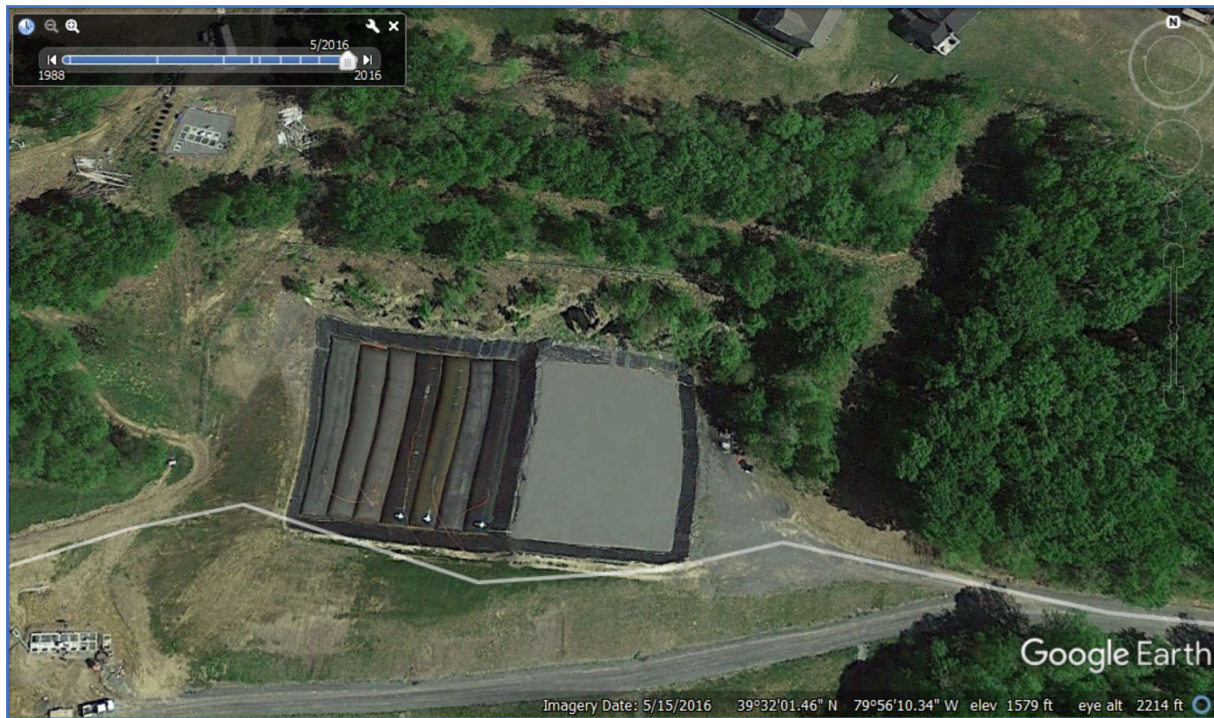
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Automated Controls



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Omega Mine AMD Geotextile Tube Dewatering Cell



160' x 340' Geotextile Tube Dewatering Cell

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Geotextile Tube Dewatering Cell Expansion Area



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Third Geotextile Tube Layer Added in 2018



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System Operated 24/7
365 Days Per Year



Clear Effluent From Treated and Geotextile Tube Dewatered AMD Returned To Native Stream



Omega Coal Mine Acid Mine Drainage Treatment Plant and Geotube® Dewatering Operation and Efficiency

- Incoming Flow Rate — 200 gpm (46 m³/hr)
- pH Range — 2.3 to 2.9
- Lime Adjustment pH — 6.5 to 7.0
- Heavy Metals and Sulphate ppm — 1,985
- Allowable Discharge Upper Limit ppm — 3.73
- General Operating Discharge — >1.0
- Since opening in 2016, there have no discharge violations.

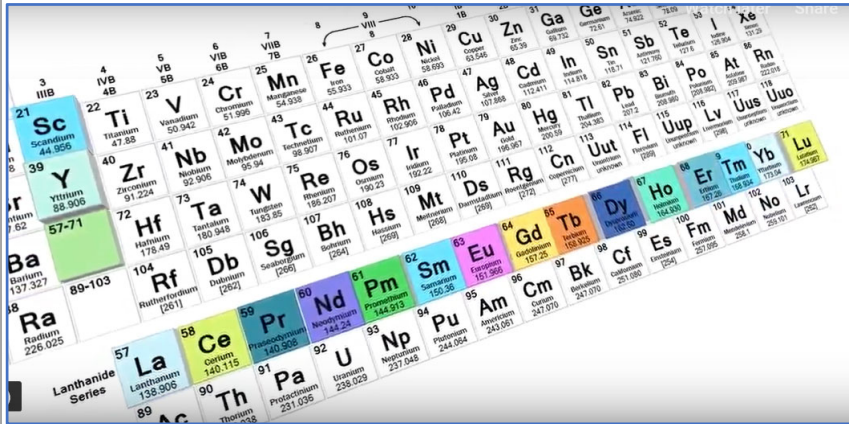
WV DEP Operations Manager – Mark Dickey

Before and After



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What are Rare Earth Elements And Why Are They Important?



A detailed periodic table of elements, with the lanthanide and actinide series highlighted in various colors to represent rare earth elements. The lanthanide series (elements 57-71) is highlighted in green, and the actinide series (elements 89-103) is highlighted in blue. Other elements are color-coded by groups: alkali metals (yellow), alkaline earth metals (orange), transition metals (various shades of blue and green), and non-metals (various shades of red and pink).




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What are Rare Earth Elements
And Why Are They Important?



+99% of World Supply Comes From China


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Extraction of rare earth elements from acid mine drainage precipitates

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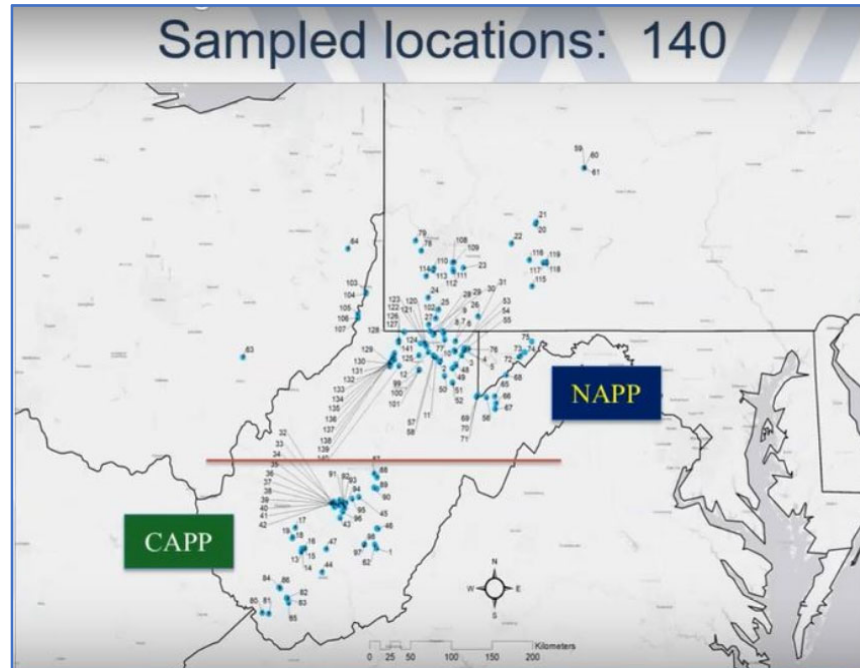
U.S. Energy Association
31 May 2018
Washington DC



The WV Energy Institute | energy.wvu.edu

VIRGINIA TECH

NATIONAL ENERGY TECHNOLOGY LABORATORY



Results of AMD Analysis

Estimated REE production CAPP/NAPP

Sludge cells sampled, this project	76	
Sludge volume (Dry)	482,915	m ³
Sludge mass (Dry)	1,062,413	tons DW
average TREE grade	663	g/t
TREE mass	350	tons
REE Basket Price (MREO)	\$ 237.23	/kg TREE
estimated CV	\$ 79,633,629	



Estimated annual REE production: Appalachian Basin

	low	High
AMD production	1,503,371	6,626,156 gpm
avg. TREE concentration	0.269	0.269 mg/L
Annual TREE production	807	3,555 tons/year
REE Basket Price (MREO)	\$ 237.23	\$ 237.23 /kg
Contained TREE value	\$ 191,362,343	\$ 843,435,793 /yr

Results of AMD Analysis



Conclusion?

- AMD Can Be Effectively Treated and Contained and Dewatered with Geotextile Tube Technology
- Effluent Water From AMD Treatment and Geotextile Tube Dewatering Can Be Discharged Direct Native Streams
- Rare Earth Elements Are Present In High Concentrations in Dewatered AMD Contained in Geotextile Tubes
- Rare Earth Elements Can Be Economically Recovered From Dewatered Ore Retained Inside Geotextile Tubes