Reclaiming Western Maryland Abandoned Mines Using Coal Combustion By-Products

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Abstract:

Maryland coal-fired power plants produce about 2 million tons of fly ash annually. Approximately half is sold to the concrete industry, leaving 1 millions tons each year for which a beneficial use is needed. One beneficial use for coal combustion by-products is to create a mine reclamation industry to prevent subsidence and mitigate acid mine drainage (AMD.) Western Maryland is home to both one of the most intensely mined coal basins in the nation and to AES Warrior Run coal-fired power plant, making it a prime site for this industrial development. Georges Creek has been mined since at least 1751 (Fry and Jefferson map, 1752), with much of the coal production predating regulation and modern mining techniques. For this reason, many legacy issues remain involving subsidence and AMD. The AES Warrior Run power plant produces a self-cementing fly ash that could be utilized as a grout to treat the subsidence and AMD issues in Georges Creek.

Using GIS and GPS allow for accurate mapping of mines prior to grouting. A review of production records was completed to calculate the minimum amount of coal removed from mines to estimate total void space for the basin. This total was compared with available ash streams from Maryland and the Warrior Run plant alone. Interviews with local residents were conducted to learn about unique characteristics of the mines that would be useful in designing the grouting project. Building on the success of the Winding Ridge demonstration project, this application of coal ash shows potential for grouting Western Maryland mines.

Introduction:

Coal is the most plentiful fossil fuel in the United States, therefore the majority of power plants burn coal to produce electricity. Because the inorganic components are left behind when coal is burned and residues are captured with improving emission control technologies, industry and regulatory agencies are faced with the challenge of finding disposal sites or uses for the resultant coal combustion by-products (CCBs). In the United States, more than 125 million tons of CCBs were produced in 2007 (American Coal Ash Association, 2008). This large stream of CCBs is handled either by disposing of the material in impoundments and landfills or through beneficial use projects.

Established beneficial uses of CCBs include recycling them for use in engineering applications and incorporating them in products such as cement and wallboard. Research suggests that another beneficial use for CCBs involves stabilization and placement in coal mines. Placement of CCBs in mines is the least common of beneficial use projects, but use in mine reclamation has been increasing. With mine placement becoming more common, Congress directed EPA to commission a study to examine CCB mine placement. The resulting committee provided critical review of potential impacts to groundwater and soil and provided guidelines for achieving responsible mine placement. Some states, including Maryland have taken steps to establish regulations for the disposal and use of CCBs due to concerns about its long-term effects on the environment, however, considering mine placement, the EPA has never found a case in which water quality standards were not met as a direct result of the CCBs (National Research Council, 2006). CCB placement benefits abandoned mines by coating pyritic surfaces that have potential to produce acid mine drainage (AMD). When properly stabilized in place, they have little potential for leaching the metals that are concentrated in fly ash when coal is burned. Unlike in a landfill or surface mine application, CCB stabilization in a deep mine can permanently lock metals in place.

In Maryland, coal-fired power plants produce about 2 million tons of Class F fly ash annually. Class F fly ash is produced by plants burning bituminous coals from the eastern United States, and tends to be low in calcium compared to fly ash of western coals. About half of the ash from Maryland is sold to the concrete industry, however, in 2006, 46% was disposed in landfills due to a lack of beneficial use applications. The AES Warrior Run power plant near Cumberland, Maryland boasts the largest beneficial use record, with all 378,034 tons of fly ash produced in 2008 utilized in surface mine reclamation projects (AES Warrior Run, 2009). Similar to placement of CCBs in landfills, this application can lead to long-term water and soil impacts such as leaching of metals due to the interaction of infiltrating water with unstabilized CCBs. Stabilized placement of the ash would reduce the potential for leaching.

The AES Warrior Run power plant is located in proximity to the George’s Creek coal basin, which has been referred to as the most intensely mined basin in the nation. With mining dating at least as early as 1751 (Fry and Jefferson map, 1752) and most hillsides contains multiple levels of mine voids, this area suffers from long-term impacts of coal mining such as AMD, stream loss and subsidence issues. A review of coal production for commercial mines producing a minimum of 5000 tons revealed that well over 101 million tons of coal was extracted from this small basin in western Maryland. During the height of mining from 1900 to 1910, about 5000 miners worked in George’s Creek, while only a few hundred remain today (Annual Reports of the Mine Inspector for Allegany and Garrett Counties, Maryland, 1876-1976).

A solution for the environmental, economic and social woes experienced due to the decline of the coal industry in George's Creek involves development of a mine reclamation industry to recreate lost jobs while mitigating the impact of mining on the local environment and stimulating local business. Use of CCBs to fill abandoned mines would benefit local power plants such as Warrior Run by stabilizing the ash back in mines from which coal was historically extracted, while reducing production of AMD and potential for subsidence. Jobs would be created in order to design intelligent mine placement projects, store and transport the ash, place it in the mines, and monitor soil and water quality afterward.

Methods:

To begin the project, a literature review was conducted in order to gather information on CCB generation in Maryland and state regulation of ash, methods of disposal and use, and historic data on George's Creek abandoned mines. A list of mines to be included in the study was compiled based on location and historic production data. Only commercial mines reporting a minimum of about 5,000 tons total production were included. Although truck mines and smaller commercial mines would be appropriate for demonstration mine placement projects, a lack of information on smaller mines exists. Larger mines also allow for greater potential to drive the industry and the cost of mine placement is greatly reduced when larger void spaces are filled. A spreadsheet of focus mines was created detailing alternate names for each mine, total production (for all coal seams mined), and notable characteristics such as reported mine fires, subsidence events, and previous reclamation work (See Appendix A). Some mines of the Upper Potomac coal basin were also included due to their proximity to George's Creek. The mine spreadsheet was used to calculate total production for George's Creek mines, which was then used to estimate void space with the potential for stabilized CCB placement. To establish an estimate of void space, the density of coal was considered when converting from tons of production to volume of void space. A subset table showing examples of typical George's Creek mines was created for the poster to show the range of production. A map showing point locations for primary mine locations in George's Creek is under construction at WMRGIS Center at FSU. The map is depicted in Appendix B to indicate the intensity of mining in George's Creek, however it is still a work in progress; additional mine locations will be added as research continues.

Using the 2008 Maryland CCB Annual Generator Tonnage Report for AES Warrior Run, ash production totals were obtained for the past five years. This data was averaged to estimate the potential yearly ash stream that could be utilized in George's Creek, and adjusted to consider the volume of water that would be added in grout preparation. The available yearly ash stream was compared to the total estimated void space volume in order to give a minimum number of years the proposed industry could be supported locally, assuming that AES Warrior Run continues to burn coal at the current rate.

Results:

The spreadsheet summarizing production for George's Creek abandoned mines producing a minimum of about 5,000 tons found that a total of 101,058,780 tons of coal were extracted. An average ash production of 354,095 tons was calculated using the past five years of ash reports for AES Warrior Run (AES Warrior Run, 2009). Considering the density of coal, the total coal production of 101,058,780 was converted to an estimate of 2,455,728,354 cubic ft of void space available for CCB placement. Because CCB grout mixes are generally measured in cubic yards, the figure for void space was converted to 90,952,902 cubic yards. Assuming that one ton of CCBs typically results in one cubic yard of flowable fill grout once water is added, the average annual grout volume that could be produced with Warrior Run ash was compared to available void space to give an estimate of the length of time that the ash could be utilized to fill all mines in the study. The data suggested that assuming a constant ash stream from Warrior Run, the mine reclamation industry could be supported for 256.8 years.

Discussion:

Several assumptions were made to create the estimated life of the mine reclamation industry using AES Warrior Run CCBs. In calculating the coal production to estimate void space, one variable that could not be accounted for was the amount of gob or coal waste removed at each mine. This material was removed with the coal and piled near mine entrances, but was never recorded. Therefore, additional void space exists at each mine due to the removal of gob and it would be difficult to make a reliable estimate. This suggests that there is more void space than can be accounted for with coal production totals alone.

This study intends to provide a rough estimate of space that could be filled with stabilized AES Warrior Run ash and to show that this reclamation industry could be supported for about the same amount of time that coal mining has been conducted in George's Creek. If the industry was established, work would begin with characterization of the CCBs to be used in order to establish the correct method required to stabilize the ash and the best way to minimize interaction of groundwater with the CCBs once placed. The Warrior Run ash has been studied for leaching potential, cementitious properties, strength, compaction and permeability. Thorough site characterizations would also be necessary to understand the hydrogeologic setting, soil and overburden, mine geometry and current and future land use for each site. An estimate of gob or coal waste removed would help to account for additional void space. Many George's Creek mines still have gob near their openings and gob piles are identified on most mine maps; however it would be tough to estimate the additional void space at many sites. There would be many variables from site to site, so each would require detailed study to establish a plan for responsible mine placement prior to grouting. Following mine placement of the CCBs, soil and water monitoring would continue to identify any potential for long-term impacts.

Although several assumptions were made, they allowed for a rough estimate to show the potential for creation of this industry and positive impact to the mine-scarred landscape. The loss of jobs in the declining coal industry could be replaced by using local labor, supplies, scientists, and engineers to carry out reclamation and monitor soils and water after placement. Since George's Creek has been called the most intensively mined basin in the nation, resulting issues such as AMD and subsidence are prevalent and could be addressed with the use of CCBs. The dual purpose of improving environmental conditions while using local ash beneficially has great potential in George's Creek due to the extent of mining and proximity to an ash source. Additional study is needed to encourage the formation of a mine reclamation industry using CCBs to provide jobs and repair the impact of mining to George's Creek.

Although placement of CCBs in mines has proved to be beneficial in reducing AMD and preventing subsidence potential, more research is needed to establish the practice as a beneficial use in Maryland and nationwide. Current regulation of fly ash varies widely, so states are encouraged to provide guidelines for responsible use of CCBs such as mine placement that will reduce landfilling and mitigate the impacts of historic coal mining on the environment.

Works Cited

AES Warrior Run. (2009). 2008 CCB Annual Generator Tonnage Report to Maryland Department of the Environment. Baltimore, MD.

American Coal Ash Association Web site. 2008. American Coal Ash Association. April 25, 2009. [http://www.acaa-usa.org/].

Fry, Joshua and Jefferson, Peter. *A map of the most inhabited parts of Virginia, containing the whole province of Maryland with part of Pennsylvania, New Jersey and North Carolina* [map]. 1752. <http://www.monticello.org/jefferson/lewisandclark/Fry-JeffersonMap.html> (May 2007).

Maryland Bureau of Mines. *Annual Reports of the Mine Inspector for Allegany and Garrett Counties, Maryland, 1876-1976*. <http://www.frostburg.edu/minemapping/annual_reports.htm> (2008).

National Research Council. (2006). Managing Coal Combustion Residues in Mines. The National Academies Press. Washington, D.C.

<u>Appendix A:</u> Spreadsheet of Mines in the Study*
(* The notes column containing specific site information has been omitted)

Void Space in the George's Creek coal basin

(by minimum estimate based on production from commercial mines reporting over 5,000 tons)

Mine Name	**Total Reported Production (in tons) (deep mining only)**
Barnard's Mine aka Barnard Mines	11,139
Bennett Mine	11,181
Consol No. 4 aka Eckhart Slope or Maryland Mine	2,080,553
Consol No. 10 aka Eckhart No. 10	5,634,115
Conway Mine	71,661
Engle Mine	16,474
Consol No. 3 aka Hoffman Mine	5,640,228
Lancaster Mine aka Porter & Rephann No. 1	5,579
Earl & Joseph Michaels Mine	9,107
Porter Mine	60,334
Sullivan's Mine aka Sullivan Brothers Fuel Mine	488,996
Washington Mine No.1 aka Washington Hollow Mine	309,732
Washington Mine No.2 aka Old Aetna Mine or Slope	1,321,733
Big Savage Mine	6,669
Darby Brady Mine	4,918
Andrew Brode Mine aka Brodie mine	4,280
Sol Brode Mine aka Brode's Fuel Mine or Brode Mine	15,249
Consol No. 13	334,557
Frostburg Fuel Company	14,207
Maryland Fuel Company	105,257
McNitt No. 3 aka Brady Mine	73,208
Ocean No. 2 aka Old Consolidation Mine- later Consol 13	11,478
Roaring Ben Mine	6,452
Rosebud Mine	11,526
Spates Mine No. 1	51,918
Tollgate Mine aka Savage Mountain Mine	5,011
Tri-State No. 1	61,031
Workman Mine	99,409
Barnes Mine aka Mines	40,354
Blaen Avon Mine aka McCulloh Mine	263,289

Borden Shaft aka Consol No. 12	3,434,095
Bowery Mine	56,630
Bowery Furnace Mine No. 1	29,096
Bowery Furnace Mine No. 2 aka Midlothian or GC No. 1	1,075,384
Bowery Tyson Mine aka No. 2	158,311
Consol No. 11 aka Pumping Shaft or New Shaft	589,796
Filer Fuel Mine aka Ben Filer mine	15,550
McNitt No. 2	1,042,198
Midlothian Mine aka Old Midlothian Mine	41,543
Samuel Smith Mine aka Smith's Fuel Mines	27,172
Winters & Brode aka Winters & Brodie	7,902
Carlos Drift aka Carlos Mine, Carlos No. 1	1,100,000
Carlos Slope aka Carlos Mine	2,395,000
Consol No. 2 aka Consol Tyson No. 2 or 10	113,877
Consol No. 6	318,714
Consol No. 7 aka Klondike Mine	9,462,330
Consol No. 17	1,517,231
Hill Mine aka New Mine, Carlos No. 2	275,000
Sullivan No. 2	271,377
Wolford Mine	17,637
Woodland Mine aka Strawberry Mine	17,887
Campbell Mine aka MJ Campbell or McGregor's Mine	5,583
Central Sand & Gravel Co. Mines	27,607
Consol No. 8 aka Outcrop Mine	1,122,284
Consol No. 15- Astor, Pompey and Hoffman Drift mines	14,654
Consol No.16 aka Shaw No. 1	301,735
Davis Brothers Mine aka Stapleton & Storey Mine	6,888
Enterprise Mine	256,372
Gray Mine aka Bluebird Mine	5,059
J. R. & H. No. 1	4,682
Macaneck Coal Co. Mines	68,340
Midland Mine aka Eagan or GC Coal & Iron Co. 9, 10 & 12	431,148
Miller Mine aka Neff Run Mine, Medicine Mine	484,053
Ocean No. 1 aka Consol No. 1	8,716,666
Ocean No. 1-B aka Ocean No. 18	25,432
Vale Summit Big Vein Mine aka Alex Davis Mine	19,469
Margaret Williams Mine	6,329
American Coal Co. Jackson Tyson Mine	68,444
Anderson Mine	4,699
Beechwood No. 1 Mine	34,218
Bivecol Mines aka Charlestown No. 1	225,082
Castle G Mines	218,151
Castle Mine aka Castle Run, A or No. 1 Mine	1,390,696
Coramandel Mine aka Big Vein Mine Nos. 1 & 2	83,707
Dug Hill Mine aka Old Coney & Cutter Mines	690,327
Foot Mine aka Foote Mine	22,779
Georges Creek Mining Co. No. 2 aka Waynesburg Mine	20,296
Georges Creek No. 3 aka Roaring Ben Waynesburg No. 3	1,252,109
Georges Creek No. 4 aka Roaring Ben Tyson No. 1	974,784

Georges Creek No. 5 aka Roaring Ben Waynesburg No. 5	777,382
Georges Creek No. 12	145,278
Georges Creek No. 13	30,999
Georges Creek Nos. 16 & 17 aka GC No. 1	566,730
Georges Creek Tyson No. 2 aka Hartman Coal Co. Ty 2	188,005
Alvey Green's Mine aka Green Coal Co. Tyson No. 2	9,428
Jackson Mine aka Sonny Mine	2,264,218
Kirkwood Mine	10,170
Koontz No. 1 aka Koontz or McKee No. 1 Mine	2,266,877
Koontz No. 2 aka New Central Tyson No. 2	786,391
Appleton Mine- Maryland Coal Co.	1,292,707
Kingsland Mine- Maryland Coal Co.	1,574,163
Patton Mine- Maryland Coal Co.	1,000,000
Tyson Nos. 1 & 2- Maryland Coal Co.	342,576
Waynesburg No. 1- Maryland Coal Co.	140,699
Meadow Mine	9,028
Miller's Mine aka Miller Mines	28,269
Buck Hill Mine	1,000,000
Pine Hill Mine- GC Coal & Iron Company	358,023
George's Creek No. 2- GC Coal & Iron Company	439,031
Russell Mine	24,420
Shamrock Mine- Lonaconing Coal Co.	114,123
Douglas Waddell Mine	155,160
Ajax Mines 2-4	55,082
Bakerstown Coal Co. No. 1	6,116
Bakerstown Coal Co. Nos. 3 & 4	14,529
Barton & George's Creek Coal No. 2	36,259
Brashear Mines	24,743
Caledonia Mine- American Coal Co.	2,223,237
Clark No. 1 (was Moscow No. 1) and No. 2	60,041
Colmer No. 1	10,583
Ajax No. 1 aka DeShong No. 1	115,014
E & K No. 1	17,599
Elkheart Mine aka Potomac Bakerstown Mine	49,857
Fern Rock Mine aka Fazenbaker Mine	7,601
Frenzel Mines	20,711
Gary Mines	113,236
J.O.J. Greene Mines	86,961
Kyle Mine	14,541
Langham Mine	46,214
MacDonald & MacDonald No. 1	11,833
McDonald Mine aka Arcadia Mine, W&W Nos. 1 & 2	286,292
Metz Mine	104,119
Tom Metz Mine	11,025
Michaels No. 2 aka Ezra Michaels Mine, No. 1 or 2	75,228
Miller Mine aka E.L. Miller No. 2	21,816
Alvey Moore Mine aka Wilma Mine	35,972
Moscow Mine- Piedmont Mining Co.	93,560
Moscow No. 1- Moscow-George's Creek Coal Co.	48,669
Moscow No. 2- Moscow-George's Creek Coal Co.	208,359

Moscow No. 3- Moscow-George's Creek Coal Co.	196,032
Old Colony Mine aka Shaw No. 4	36,229
P & R No. 4	37,556
Pekin/Nikep Mine aka Hoffa No. 4, Atlantic Mine	1,273,012
Potomac Mines aka Hoffa Mines, Barton Mine	982,483
Potomac Hollow Mine	7,801
Pynhed Mine aka Moore Mine	36,500
Ross Mine	6,486
Shaw Mine aka Hope Mine, Old Mill Mine	19,667
Speir Mine aka Spears Mine	26,112
Stationary Mine	7,758
Supply No. 1 aka P. Gallagher - G. Frenzel No. 1	8,002
Swanton Mines (all 3 mines)	1,418,199
W & W No. 5	51,480
W & W No. 6	472,616
Aden Mine aka Brashear Mine	78,628
Buxton Mine	1,152,369
Devon Nos. 1 & 2	629,478
Excelsior Mine	64,100
Fahey's Mine aka Franklin Mine No. 10	15,930
Franklin Hill Mines aka Buckhorn Mine	1,099,991
Grove Mine aka Grove No. 1	15,360
Hampshire Mine aka Washington No. 4	652,430
Hampshire Mine No. 2 aka Hampshire Hill Mine	1,305,063
Hampshire Mine No. 3 aka Hampshire Freeport Mine	35,977
Kern Mine aka Mayberry or Howard & Maybury Nos 1&2	20,569
Mack Mine aka Little Ben No. 2	6,886
Mine No. 52, Davis Coke & Coal	9,446
Mine No. 627, Wilbert Gordon	5,186
Michaels Mine aka Michaels No. 1- Arch Michaels Coal	64,821
Mill Run Mine	80,896
Mill Run Nos. 1 & 2	120,548
Morrisons Mine aka Ginseng or Masco Mine	37,864
Mud Mine	5,170
Penn Mine aka Burtner Mine	459,099
Phoenix Mines aka Elkhart Mine, Donald Mines	1,357,950
Reynolds Mine	42,452
Ross Mines aka Frog Hollow Mine	1,045,097
Smith's Mine	7,449
Tacoma Nos. 4 & 5 aka Roberts Mine	68,966
Washington Mine No. 3 aka Tacoma Mine Nos. 1 & 2	819,497
Washington No. 5 aka Washington No. 3	995,830
Washington No. 6 aka Washington No. 3	269,353
Washington Mine No. 1	371,930
Westernport Coal Co. Mines aka Dailey Coal Nos. 1 & 2	221,508
Wilson Mine	11,019
Ayers-Parker Mine	9,522
Clites Mines aka Parker Nos. 1, 2 & 3	49,015
Parker Mine aka Bond or Parker No. 1	434,566
Sunnyside No. 1 Mine aka McMullen or Trotter Run No. 1	464,673

Sunnyside No. 2 aka Billycliff Mine	12,056
Trotter Run No. 2 aka McMullen Mine	11,200
Bald Knob Mine aka Brailer Mine	271,746
Brickyard Mine	18,601
Casanave Nos. 1-4 aka Mullaney Mine No. 2	46,975
Independent Mine	11,742
Liberty No. 1	250,362
Liberty Nos. 3 & 4 aka Maryland Union No. 1 or 1718	176,675
McKenzie Mine aka Savage No. 1	9,050
Mountain Mine	7,236
Mt. Union Mine aka Liberty or Liberty Fuel Mine	25,441
Mutts Mine	24,811
Newton Mine aka Newtown Mine	126,541
Pioneer Mine	29,376
Trimble Mine aka DuWell or Jesse Trimble Little Pitt. Mine	57,419
Union No. 4 aka Black Hills Mine	161,143
United Big Vein Mine aka Liberty No. 2	127,492
Watkins Mine aka Jenkins No. 2	7,602
Benson Mine	49,876
Blackberry Mine	66,332
Borden Mine aka Borden Hill No. 2, Evans No. 1, Schiver's	294,746
Borden Hill Mine	39,288
Clifton Mine aka Clifton Big Vein or No. 1	294,746
Clifton No. 1 aka J. Sullivan Mine	45,026
Consol No. 9	2,421,091
Consol No. 14 aka Old Allegany Mine	662,145
Frost mine aka Ocean No. 6	22,015
Griffith Mines aka Borden Mine or Stewart & Griffith	25,468
Hanna Mine aka Allegany Big Vein Coal Co. Nos. 1-4	50,968
Harden Mines	19,069
Liberty No. 4	11,628
New Hope Mine aka New Hope Slope, Ocean No. 4	1,242,509
Union No. 1 aka No. 4 or 10 aka Withers Mine	1,085,020
Union No. 2 aka Allegany Big Vein Coal Co. No. 1	3,450,275
Gunstan Mine	52,433
Mertens No. 2	8,636
Michaels No. 1 Clarysville Mine	19,926
Montell Mine aka Mertens No. 1	278,145
Piney Mountain Mine	14,917
Stanton Mine aka Short Gap Mine	81,842
Sullivan No. 3 Mine	297,798
TOTAL PRODUCTION	101,058,780

Appendix B: The George's Creek Abandoned Mine Location Map