Assessment and Quantification of Water Treatment Systems to Meet West Virginia Water Quality Standards

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Background

- August 2011, US District Court ruled that the WVDEP was required to obtain NPDES permits for approximately 171 sites
- These sites are required to meet prevailing water quality standards

Background (con't)

- In August of 2011 the WVDEP contacted the WVWRI and asked for assistance in meeting the compliance order
- A meeting was held shortly thereafter and resulted in the following objectives for the WVWRI:

Objectives

- A priority ranking of the 171 Bond Forfeiture sites
- Capital cost estimates to get the sites within compliance
- Annual cost estimates to keep the sites within compliance

* To be as accurate as possible with costs and treatments given the short time constraints (< 5 months)

Bond Forfeiture Sites

- Of the 171 total sites
  - 89 sites were located in the Northern District
  - 82 sites were located in the Southern District
- There were 33 sites not included in this project as they were already evaluated by the WVDEP

Objective 1

Priority Ranking of Sites

Priority Ranking of Sites

- Obtain Bond Forfeiture database from DEP
  - There were over 60,000 records in the database that needed sorted and arranged
- Data came from the northern, central, and southern West Virginia DEP offices
- Data was contained in Microsoft Access and Excel files

Priority Ranking (con't)

- Before data could be fully organized WVWRI needed to determine which samples within the database would be needed for prioritization
- Worked closely with DEP personnel to determine which sample locations were needed
- WVDEP sent text descriptions and PDF maps of the sites to accompany the data files

Priority Ranking (con't)

- Once the pertinent sample sites were identified the data was pulled
- The data consisted of lab and field parameters such as pH, flow, Acidity, Alkalinity, Metals, and Loadings
- Ranking was based on acid load from highest to lowest

Rank	Company	Permit #	Iron Load (tpy)	Manganese Load (tpy)	Aluminum Load (tpy)	Acid Load (tpy)
1	FREEPORT MINING CORPORATION	S-1005-95	50.57	9.24	41.59	652.93
2	B					
3	E					
4	L					
5	G					
6	C					
7	R					
8	D					
9	C					
10	D					
11	M					
12	S					
13	K					
14	P					
15	R					
16	IN					
17	M					
18	C					
19	TI					
20	B					
21	C					
22	R					
23	S					

Rank	Company	Permit #	Iron Load (tpy)	Manganese Load (tpy)	Aluminum Load (tpy)	Acid Load (tpy)
35	BUFFALO COAL COMPANY, INC.	S-2001-86	0.01	1.34	0.35	4.96
36	MA					
37	B &					
38	SUI					
39	JON					
40	THE COI					
41	B &					
42	M &					
43	ROY					
44	A S					
45	VAL					
46	BEL					
47	X W					
48	LOD					
49	BAF					
50	SAN					
51	C. C					

Rank	Company	Permit #	Iron Load (tpy)	Manganese Load (tpy)	Aluminum Load (tpy)	Acid (tpy)
66	LEVEL LAND MINING CORPORATION	S-3031-90	0.17	0.09	0.08	
67	CHAFIN COAL CO.	O-69-82	0.01	0.12	0.13	
68	ROYAL SCOT MINERALS, INC.	R-3078-86	0.07	0.27	0.06	
69	LODESTAR ENERGY, INC.	S-19-85	0.08	0.19	0.07	
70	INTER-STATE LUMBER CO.	176-77	0.01	0.17	0.11	
71	J.A.L. COAL CO., INC.	S-23-82	0.05	0.19	0.04	
72	ROYAL SCOT MINERALS, INC.	D-32-81	0.24	0.06	0.02	
73	ROYAL SCOT MINERALS, INC.	U-40-85	0.16	0.09	0.04	
74	LAKEVIEW COAL COMPANY	S-55-84	0.01	0.12	0.10	
75	TRIPLE A COALS, INC.	U-3046-87	0.13	0.20	0.01	
76	FARKAS COAL CO.	34-81	0.08	0.15	0.03	
77	DUSTY COALS., INC.	S-119-85	0.13	0.07	0.04	
78	JINKS MINING COMPANY	U-3031-93	0.14	0.10	0.01	

Objective 2

Capital Cost Estimate Reports

Capital Cost Estimate Reporting

- Upon completion of the prioritization, development of capital cost expenditures were needed
- Before capital costs could be calculated, WVWRI needed to determine what type of construction would be done at each of the sites to achieve compliance
- Characterization of each of the sites was needed

Site Characterization

- 5 Categories
  - Partial retrofit within permit boundaries
  - Complete retrofit within permit boundaries
  - Partial retrofit outside of permit boundaries
  - Complete retrofit outside of permit boundaries
  - Baffle only sites

Site Characterization (con't)

- For sites that required a partial retrofit the system outlet data was used as the retrofits were anticipated to be added on at the end of the current systems
- For sites that required a complete retrofit the source samples were used due to the construction of a new site
- The baffle only sites used the lowest samples in the system before the ponds that were expected to get the baffles, where applicable

Capital Cost Estimate Reporting (Con't)

- Based on site characterization by DEP/WRI, all pertinent points were uploaded into an excel model
- A weighted average was calculated for each source sample points to represent the water quality
- The weighted average value was then loaded into AMDZine

AMDZine

- Developed by Bruce Leavitt and Paul Ziemkiewicz
- AMD is treated in series by separate technologies
- AMDzine evaluates how those technologies are assembled to meet
  - a specific WQ standard
  - at a particular site
- Capital costs and operation costs are generated separately

AMDZine (con't)

- Requires the user to be familiar with treatment technologies (ie… what will work/wont work)
- Outputs from model may need to be "fitted" to work on-site
- Can quickly and easily be used to compare several treatment scenarios

AMDZine Inputs

Site Name	A1
Discharge Standards	
pH	
min	6.00
max	9.00
Iron (mg/L)	1.42
Aluminum (mg/L)	0.43
Manganese (mg/L)	1

Raw Water Data	
Flow (gpm)	
min	1.00
max	300.00
Average	25.00
pH average	2.50
Acidity (hot) (mg/L)	50.00
Alkalinity	3.00
Fe Total (mg/L)	300.00
Fe Dissolved (mg/L)	100.00
Fe Ferrous (mg/L)	100.00
Al (mg/L)	80.00
Mn (mg/L)	5.00
Sulfate (mg/L)	2500.00
Calcium (mg/L)	300.00
Magnesium (mg/L)	65.00
DO (mg/L)	0.50
1 hr. Aeration Test	
Initial pH	2.50
Ending pH	3.00

Calculated Data	
Iron Load (Ferrous)	lbs/day
min	1.202
max	360.479
average	30.040
	mg/L
Al acidity	444.77
Fe ++ acidity	
Fe +++ acidity	268.62
Mn Acidity	9.10
pH Acidity	158.11
Total Acidity	880.61
Sludge injection head	0
Carbon Dioxide Acidity	108.11

Site data	
Height of discharge above stream (ft)	1
Is this a pumped discharge (Y/N)	N
Area of land below discharge elevation with slope less than 10% within 1000 feet of discharge (acres)	2
Single Phase Power	N
Three phase power	N
Distance to 3 phase power	1000
Elevation of Sludge Discharge	1000
elevation of sludge pump	1000
Length of sludge pipe	250
Surface area	2.2
Fresh water available (gpm) up slope	10

AMDZine Decision Tree

	Passive pH adjustment	Unit Appropriate
0	Anoxic Limestone Drain	FALSE
0	Open Limestone Channel	FALSE
0	Vertical flow pond (reducing)	FALSE
0	Vertical flow pond (auto siphon)	FALSE
0	limestone leach bed "D"	FALSE
0	limestone leach bed "M"	FALSE
0	Aerobic wetland	FALSE
0	Anaerobic wetland	FALSE
0	Steel slag bed	TRUE
0	Pre Aeration needed O_2 lbs/hr	
0	Stair step pre-aerator	TRUE
0	Sluce pre-aerator	TRUE
1	Trompe pre-aerator	TRUE
0	Diffusion pre-aeration	TRUE
0	Mechanical pre-aeration	TRUE
0	Post Aeration needed O_2 lbs/hr	
0	Stair step aerator	TRUE
0	Sluce aerator	TRUE
0	Trompe aeration	TRUE
0	Hydrogen peroxide (lbs / month)	FALSE
0	Diffusion aeration	TRUE
0	Mechanical aeration	TRUE
0	Settling pond (detention time hr)	FALSE
0	Clarifier	FALSE
0	Semiactive pH adjustment	
0	Doser (quick lime)	FALSE
0	Doser (hydrated lime)	FALSE
0	Sodium Hydroxide	FALSE
0	Active pH adjustment	
0	Hydrated lime (std)	FALSE
0	Hydrated Lime (high density)	FALSE

AMDZine Outputs

	Q max (gpm)	Installed	Area Used	Raw WQ				
				pH	Acidity	Fe	Mn	Al
	300	Cost	ft2	6.5	17.2	3.0	5.0	4.0
Unit 1	Stair step pre-aerator	$ 110	135	7.0	17.2	3.0	5.0	4.00
Unit 2	Vertical flow pond (reducing)	$ 276,370	48,036	7.1	14.5	3.0	5.0	0.48
Unit 3	Trompe aeration	$ 1,113	36	7.1	14.5	3.0	5.0	0.48
Unit 4	Settling pond	$ 11,770	1,400	7.1	14.5	0.9	1.0	0.48
Unit 5	limestone leach bed "M"	$ 105,330	23,528	7.1	0	0.1	0.4	0
Unit 6								
Final WQ				7.10		0.90	1.00	0.00
Target WQ				6.00		1.42	1.00	0.43
	TOTAL	$ 394,693	73,136					
	Acres		1.68					

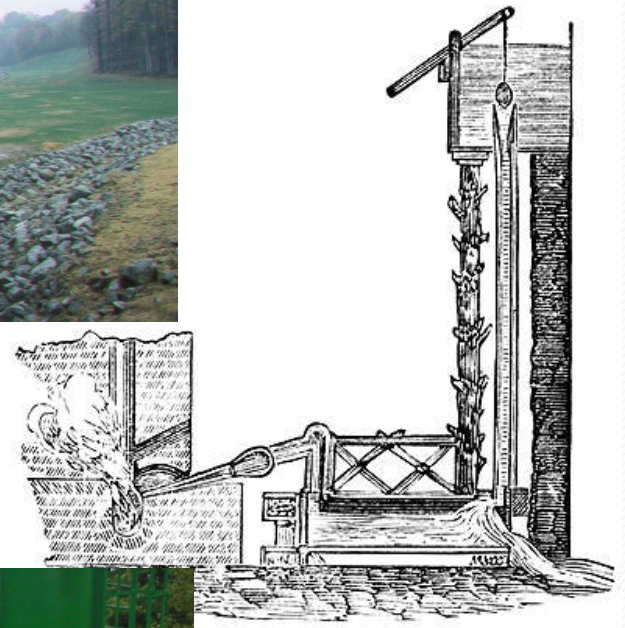
		Installed	Area Used	Raw WQ				
				pH	Acidity	Fe	Mn	Al
		Cost	ft2	6.0	14.5	3.0	5.0	4.0
Unit 1	Trompe pre-aerator	$ 27,165	889	5.5	13.1	3.0	5.0	4.00
Unit 2	Doser (hydrated lime)	$ 116,722	1,800	7.5	0.0	3.0	5.0	4.00
Unit 3	Settling pond	$ 11,770	1,400	7.5	0.0	0.9	1.0	0.48
Unit 4	Settling pond	$ 11,770	1,400	7.5	0.0	0.9	1.0	0.48
Unit 5	Settling pond	$ 11,770	1,400	7.5	0.0	0.9	1.0	0.48
Unit 6								
Final WQ				7.50		0.90	1.00	0.48
Target WQ				6.00		1.42	1.00	0.43
	TOTAL	$ 179,198	6,889					
	Acres		0.16					

AMDZine Outputs (con't)

- All parameters were adjusted based on site dimensions provided by the WVDEP(total head, pumping, acreage, etc.)
- Each unit was selected based on the water chemistry and "best-fit" suggestions from DEP
- Final treatment system with sequence and cost were displayed on final results page

AMDZine

- Some of the most common treatment technologies selected for these systems:
  - Dosers
  - Trompe (method of aeration)
  - Open Limestone Channels
  - Limestone Leach Beds
  - Settling Ponds/Wetlands
  - Steel Slag Leach Beds



Baffle Calculator

- It was determined that certain sites only needed additional retention time
- Additional retention time could be gained from installing baffles in existing ponds
- WVWRI researched how we could develop a methodology for costing out baffles and found a study done by the Institute of Technology and Engineering from Massey University in New Zealand

Baffle Calculator (Con't)

- The results of the study:
  - Found that a minimum of two baffles is recommended and that four baffles produced the best results but any more than four was not recommended
  - Long evenly spaced baffles improved pond efficiency and baffles with a width of 70% gave superior performance compared to 50 and 90%.

- WVWRI used this information to develop 2 baffle calculators (one when length and width is known, one when volume is known)

Calculator (Length and Area)

Baffle Calculator - When length and area is known

INPUT					
Width of Pond	40	ft.	Number of Baffles	4	*
Length of Pond	200	ft.	Baffle Cost	20.00	$/LF

OUTPUT					
Baffle Footage**	112	ft.	Baffle Cost	2,240.00	$
Bfl Offset from edge	5	ft.	Baffle Centers	10	ft.

Notes (Based on a study performed by the Institute of Technology and Engineering from Massey University, New Zealand)

* A minimum of 2 baffles is recommended.

A further improvement was achieved using 4 baffles and this extra cost may be warranted in some cases.

Based on the results of this study, the use of more than 4 baffles would not be recommended.

**Long, evenly spaced baffles improve pond efficiency.

Baffles of 70% width gave superior performance compared to 50% and 90% baffle widths.

Assume pond depth is 8' with 2 feet of freeboard

Calculator (Volumetric)

Baffle Calculator - When only volume is known

INPUT					
Volume of Pond	10000	ft^3	Number of Baffles	4	*
Depth of Pond	8	ft.	Baffle Cost	20.00	$/LF
RATIOS					
Length	4		Width	3	
OUTPUT					
length of pond	47		width of pond	27	
pond ft^2	1250				
Baffle Footage**	74	ft.	Baffle Cost	1,484.92	$

Notes (Based on a study performed by the Institute of Technology and Engineering from Massey University, New Zealand)
* A minimum of 2 baffles is recommended.
A further improvement was achieved using 4 baffles and this extra cost may be warranted in some cases.
Based on the results of this study, the use of more than 4 baffles would not be recommended.

**Long, evenly spaced baffles improve pond efficiency.
Baffles of 70% width gave superior performance compared to 50% and 90% baffle widths.

Assume pond depth is 8' with 2 feet of freeboard

Ancillary (Other) Costs

- In order to get an accurate capital cost, ancillary costs were also taken into consideration, such as:
  - Roads
  - Access/Land Issues
  - Additional Ditching
  - Additional Ponds
- These factors were considered by using cost multipliers for each of the five categories
- The multipliers came from DEP based on previous project implementation

Ancillary Cost Multipliers

- Partial retrofit within permit boundaries (0.43)
- Complete retrofit within permit boundaries (.33)
- Partial retrofit outside of permit boundaries (1.5)
- Complete retrofit outside of permit boundaries (1.0)
- Baffle only sites (.43)

Capital Cost Generation

- As part of the consent order, WVDEP was required to submit AMD treat runs
- The treatment technology generated from AMDzine was then entered into AMD Treat
- The same cost inputs were used for both AMDzine and AMD Treat

Total Capital Cost Generation

- Capital cost taken from AMDZine (AMD Treat) + Cost multipliers for each of the respective categories = total capital costs
- The final capital cost was entered onto the final cost spreadsheet

Objective 3

Annual Maintenance Cost Reports

Annual Maintenance Costs

- Took the treatment scenarios generated from AMDZine (AMD Treat)
- Entered those into the Annual Cost module in AMD Treat
- Used recent cost values provided by Special Reclamation
- Entered on the final cost spreadsheet

Annual Maintenance Costs (con't)

- Annual Maintenance Costs Included:
  - Sampling
  - Labor
  - Maintenance
  - Pumping
  - Chemical Cost
  - Sludge Removal

Final Cost Spreadsheet

Site Name	Permit Number	Newly Estimated Capital Costs	Final Capital Const. Cost	Newly Estimated Annual O&M
A S & K, INC.	S-1011-89	$91,150.00	-$151,850.00	$4,075.41
ALPHAINE CORP.	S-6032-86	$0.00	$0.00	
AMANDA NICOLE FUELS, INC.	S-1018-88	$0.00	$0.00	$48,465.00
B & S Contracting Inc.	U-3055-87	$88,530.00	$88,530.00	$6,721.35
B & S CONTRACTING, INC.	O-3086-87	$0.00	$0.00	
B & S CONTRACTING, INC.	R-668	$3,360.00	$3,360.00	$5,765.60
BARRENSHE COAL CO.	UO-694	$83,782.00	$83,782.00	$9,877.00
BARRETT FUEL CORP.	R-737	$10,200.00	$10,200.00	$4,180.23
BELLE CONTRACTING, INC.	S-6020-87	$116,377.69	$116,377.69	$10,623.00
BENHAM GROUP	120-79	$8,960.00	$8,960.00	$19,826.62
BJORKMAN MINING	S-37-81	$8,960.00	$8,960.00	$4,333.60
BLACK DIAMOND MINING CO.	13-79	$2,800.00	$2,800.00	$3,731.28
BOLINGREEN MINING COMPANY	S-1024-88	$8,990.41	$8,990.41	$6,964.00
BRADY CLINE	EM-97	$506,785.00	$506,785.00	$17,422.51
BRENKEE COAL CO.	UO-435	$424,143.65	$ -	
BUFFALO COAL	S-2003-88	$2,098,037.50	$2,098,037.50	$135,402.00
BUFFALO COAL COMPANY, INC.	S-53-80	$1,190,250.00	$326,412.00	$80,857.00
BUFFALO COAL COMPANY, INC.	S-52-80	$1,375,155.00	$430,661.00	$107,233.00
BUFFALO COAL COMPANY, INC.	S-2006-86	$0.00	$0.00	$57,400.00
BUFFALO COAL COMPANY, INC.	S-2001-86	$1,377,127.50	$975,188.50	$66,769.00
BUFFALO COAL COMPANY, INC.	S-2003-03	$113,052.50	-$464,825.50	$30,728.00
BUFFALO COAL COMPANY, INC.	S-2011-92	$0.00	$0.00	
BUFFALO COAL COMPANY, INC.	S-122-80	$15,400.00	$15,400.00	$25,536.16
C. C. CONLEY & SONS, INC.	S-3046-91	$309,285.00	$309,285.00	$14,010.00
CHAFIN COAL CO.	O-69-82	$0.00	$0.00	$3,595.39
CHESTNUT RIDGE COAL CORP.	S-28-83	$92,001.91	$92,001.91	$61,930.00
CHEYENNE COAL SALES	S-2009-96	$570,725.00	$159,625.00	$67,181.00

Results

- Prioritization of approximately 171 Bond Forfeiture sites
- Total capital cost to get the 171 sites within compliance is approximately $33,952,128
- Operations and Maintenance costs to keep the sites within compliance is approximately $5,547,228/year
- Senate Bill 579, Alternative Bonding System. Increase from 14.4 to 27.9 cents/ton coal to the Special Reclamation Fund.

Special Thanks

- WVDEP Office of Special Reclamation for all of their hard work
  - Northern Office
  - Central Office
  - Southern Office
- The technical staff of the WVWRI that pulled all of this together in a short time frame (August – December)
- Paul Ziemkiewicz and Bruce Leavitt for the development of AMDZine

Questions?