Evaluation of the C&K Coal Pit 431 Passive Treatment System, Glasgow, Cambria County

Technical report provided by Hedin Environmental through the Trout Unlimited AMD Technical Assistance Program TUTAG-09

February 20, 2006

Background The information contained in this report was obtained from PADEP sampling records, Art Rose (Clearfield Creek Watershed Association) and Hedin Environmental (HE) files. HE provided the original design to C&K Coal for the Pit 432 passive treatment system and was involved in early monitoring. HE's knowledge of the design of the system is limited to the vertical flow ponds and constructed wetlands. The pyrolusite bed was designed and constructed by Allegheny Mineral, working directly with C&K Coal Company.

The system treats very severe AMD from a reclaimed surface mine near Glasgow (Cambria County). Recent analyses of the primary discharge indicate that it contains 800-1000 mg/L acidity, 150-200 mg/L Fe, 125-150 mg/L Mn, and 50-80 mg/L Al. At the time that the passive treatment system was designed, the discharge has similar acidity, but contained higher Fe and lower Al than is currently observed. Previous to construction of the passive system, the company was reportedly using 2000 gallons of NaOH per week for treatment. Recognizing that the chemistry was beyond the accepted limits of passive treatment, the company still proceeded with the design and installation of a SAPS passive system. The system was designed with two vertical flow ponds, each followed by a constructed wetland. The goal was to generate alkalinity in the VFPs and precipitate Fe in the wetlands. The discharge from the final wetland was directed into a pyrolusite bed for Mn removal.

The VFPs were designed with 1.5 feet of limestone aggregate overlain with 1.5 ft of compost that was amended with limestone sand to increase its neutralization capacity. The underflow system, that collects the mine drainage from beneath the limestone aggregate, was designed with flushing capabilities. However, the underdrain pipes were not sized to maximize flush velocities, and during construction the size of the underdrain pipes may have been decreased to lower costs.

The VFPs were designed for 51 gpm of flow containing 861 mg/L acidity with an assumed acidity removal rate of 40 g $m^{-2}day^{-1}$. The first VFP is 26,000 ft^2 and contains ~1,000 tons of limestone aggregate. The second VFP is 20,000 ft^2 and contains ~750 tons of limestone aggregate. The wetlands were constructed with 1-2 feet of spent mushroom compost substrate. (Wetland specifications were not provided because C&K

Coal had a standard wetland construction procedure.) The first wetland is ~24,000 ft^2 and the second wetland is ~20,000 ft^2.

Hedin Environmental was not involved in the design or construction of the pyrolusite bed. Discussions with C&K indicated that it was designed with ~2,500 tons limestone. The excavation was lined with a synthetic liner and contained several internal berms intended to prevent preferential flow. The pyrolusite system was not constructed until the summer of 1997. In the interim period, discharge of the passive system was treated with NaOH to remove Mn.

The system was predicted to removal 100% of the Al, 85% of the Fe, and none of the Mn. The subsequent pyrolusite system, designed by Allegheny Mineral, Inc., was intended to remove the residual Fe and the Mn.

The system was constructed in the fall of 1996. Table 1 shows early results. As noted above, the discharge contained more Fe and less Al in the late 1990's than recent analyses indicate. The system initially functioned as planned. The July 1997 data are representation of the SAPS concept. The first VFP discharged an alkaline Fe-contaminated flow. As this water passed through the first wetland it was aerated and iron precipitated, causing consumption of alkalinity and, eventually, a large decrease in pH. Flow through the 2nd VFP replaced the alkalinity. This time, there was sufficient alkalinity to neutralize the removal of residual Fe. The final discharge had pH 6 and contained only 9 mg/L Fe.

Accompanying the good results, however, was high accumulation of Fe in the VFPs. Eventually the accumulation of Fe in the 1st VFP caused a permeability problem and water began to discharge through the overflow channel, avoiding contact with the limestone. The Company subsequently excavated the 1st VFP and discovered that the compost was covered with a thick iron layer and that only the top couple inches of the limestone contained any metal precipitates. The spoiled limestone was replaced and the contractor tried to increase the amount of limestone. The underdrain system was renovated to improve flushing abilities. There was discussion about installing a separate flushing system in the top half of the limestone aggregate, but HE was not informed whether this occurred. The surface area of the VFP was not substantially changed because the size of the pond was limited by the elevation of the discharge, the access road, and the existing constructed wetland.

To HE's knowledge, no changes were made to the 2nd VFP or the constructed wetlands. Also at this time, a flow control device was installed that diverted flows exceeding ~50 gpm away from the passive system and to a chemical treatment system. The idea was to rely on passive treatment during base flow conditions and a combination of passive and chemical treatment during higher flow conditions.

Table 1. Sampling Results for the complete passive system in its first year. Flow is gpm; other parameters are mg/L. Data do not include the pyrolusite system, which was not on line.

Point	**Date**	**Flow**	**pH**	**Alk**	**Acid**	**Fe**	**Mn**	**Al**	**SO4**
DER-1 (VFP1-in)	1/17/97	72	4.0	0	839	349	140	28	2800
VFP1-out	1/17/97		6.0	94	433	238	129	<1	2600
Lower wetland out	1/17/97		6.0	80	209	39	91	<1	2100
DER-1 (VFP1-in)	3/21/97		4.1	0	939	346	144	31	
VFP1-out	3/21/97	101	6.0	82	592	261	141	2	
VFP2 –underflow	3/21/97		6.2	84	300	137	110	<1	
DER-2	3/21/97	10	3.4	0	417	53	131	26	
Lower wetland out	3/21/97		6.0	51	314	121	110	<1	
DER-1 (VFP1-in)	7/1/97	25.1	4.1	0	1062	366	145	34	3086
VFP1-out	7/1/97	23.6	6.0	175	341	176	123	<1	2555
VFP2-in	7/1/97		3.1	0	281	25	93	<1	2078
VFP2 –underflow	7/1/97	30.1	6.2	141	146	78	84	<1	1909
Lower wetland out	7/1/97		6.3	9	131	10	77	1	1868
DER-2	7/1/97	8.5	3.2	0	535	17	179	10	2288
Final effluent (Pre-NaOH)	7/1/97		6.2	9	180	<1	94	<1	1925

Hedin Environmental had no involvement in the system after 1997. The water quality records show that the company relied on chemical treatment to remove Mn. The records suggest that chemical treatment ceased in the summer of 2003 when the pH of the final effluent decreased from 9 to 6, and Mn concentrations increased from <1 mg/L to 40 mg/L. Since 2003, the system appears to be operating in completely passive mode.

Current Treatment Table 2 shows the average chemistry and acidity loading of the two influents and the final discharge since June 2003. As noted above, the influent chemistry has changed somewhat. Iron concentrations are about one-half and Al concentration are double the 1997 levels Except under extremely low flow conditions (< 5 gpm), the acidity concentrations are similar in both periods. The alkaline flows that occur during very low flow may reflect remnant treatment by an ALD that was installed at the site before construction of the SAPS system.

Table 2. Average chemistry and acidity loading since June 2003

Point	Flow gpm	pH	Acid mg/L	Fe mg/L	Al mg/L	Mn mg/L	Acid, lb/day
DER1	34	3.9	666	175	66	139	370
DER2	12	4.8	369	40	22	125	51
Total in*	*46*		*588*	*140*	*56*	*135*	*421*
1T (final)	40	4.6	255	7	17	76	123

**"total in" values are flow-weighted averages of the two influents*

The system continues to effectively remove Fe, which is 95% lower at the effluent. Al concentrations are lowered by 70%, acidity concentrations are lowered by 55%, and Mn is lowered by 45%.

The changes appear to be largely due to neutralization and removal within the system, not simply dilution. On two recent sampling days, when inflows of surface water were minimal (flows in and out balanced), the systems provided significant treatment. Table 3 shows the results of these sampling efforts.

Table 3. Sampling Results for the complete passive system in December 2005 and January 2006..

Point	Date	Flow	pH	Alk	Acid	Fe	Mn	Al	SO4
DER-1 (VFP1-in)	12/20/05	20	3.9	0	705	162	142	64	3334
VFP1-out	12/20/05	18	5.2	7	316	62	102	42	2625
VFP2 –underflow	12/20/05		6.0	66	123	12	101	2	2056
VFP2-overflow	12/20/05		3.6	0	144	4	44	8	1260
DER-2	12/20/05	8	5.7	8	364	50	137	20	2625
Woods outflow	12/20/05	11	3.8	0	173	<1	72	5	1406
Lower Ditch overflow	12/20/05	11	4.2	3.7	180	5	76	7	1487
DER-1 (VFP1-in)	1/13/05	88	3.6		1030	175	149	73	3033
VFP1-out	1/13/05	93	4.1		439	76	114	49	2358
DER-2	1/13/05	9	4.6		439	40	127	20	2004
Woods outflow	1/13/05	38	3.9		270				
Lower Ditch overflow	1/13/05	63	3.8		280				

While the system is improving water chemistry, it is not functioning as intended. The 2nd VFP discharges more water through the overflow channel than through the underdrain system. However, as shown in the December 2005 sampling data, the chemistry of the two flows do not differ substantially and the overflow sample actually has some superior attributes (less Fe, less Mn).

Recommendations While the treatment system is not functioning in the manner originally envisioned, it is still lessening contaminant inflow to Muddy Run. In December and January, the system discharged water with about 75% less acidity than was contained in the raw discharges. Most of the acidity being discharged is tied up in Mn, which is considerably less toxic to stream organisms than Al and Fe.

<u>Routine O&M</u> In order to maintain or improve the treatment system's performance, routine O&M is necessary. The primary operational item is the flushing of the VFPs to improve flow through the limestone substrate. The Clearfield Creek Watershed Association recently flushed both VFPs. The 1st VFP has two sets of flushing pipes which likely represent the original pipes (which were never effective) and a second set installed during the renovations. The CCWA reports that the flushing produced a

good flow and solids. Continued flushing is appropriate. The CCWA reported that flushing of the 2nd VFP did not produce a good flow and efforts to manually dislodge blockage in the pipes did not improve the flushing flow.

The performance of the treatment system should continue to be monitored so that the CCWA can respond to developing problems. The Cambria DMO is currently monitoring the site through the collection of samples from the two discharges and the final discharge. The CCWA could request that the Cambria DMO expand its monitoring to include the discharge of the 1st VFP, the mixed flow immediately below the 2nd VFP, and both system discharge points. Alternatively, the CCWA could collect samples and submit them to the State Laboratory for analysis.

<u>Major Maintenance</u> Major maintenance activities are non-routine actions that generally require special planning, heavy equipment and external funding. The 2nd VFP is plugged. The cause of the plugging should be investigated, with the hope that a corrective action is identified that is less expensive than rebuilding the VFP. It is possible that the permeability problem is related to the precipitation of iron solids on the top of the compost. If this is the case, removal of the iron and replacement of the compost may provide renewed treatment. The VFP should be drained by diverting the current flow around the 2nd VFP. The pond should be excavated in several locations so that the vertical cross-sections can be inspected. If the limestone is not fouled, then the problem is likely associated with the compost (and iron deposition). A section of the compost should be removed and replaced with fresh substrate. If, when the water is cut back into the system, the VFP operates in a downflow mode without substantial head loss, then it can be concluded that the substrate is the problem. Plans to repeat to exercise, with complete replacement of the compost, could be considered. If the excavations reveal that the limestone aggregate is plugged, then the system can not be repaired without complete reconstruction.

<u>New Construction</u> If the 2nd VFP cannot be renovated through maintenance, then the construction of a new VFP should be considered. Two options are to rebuild the 2nd VFP or construct a new VFP in the area where the pyrolusite bed is located. The less expensive option may be to build in the pyrolusite system. The bed's 2,500 tons of limestone could be used to create a 22,000 ft^2 VFP (water surface area) containing 2 ft of water overlaying 1 ft of organic substrate overlying 3 ft of limestone aggregate. This system would treat 75 gpm of flow, assuming the removal of 100 mg/L acidity (the current acidity associated with Fe and Al at 1T), the generation of 100 mg/L excess alkalinity, and a net alkalinity generation rate of 40 g $m^{-2}day^{-1}$. The average flow since June 2003 has been 40 gpm with flows ranging to 100 gpm. Enough vertical relief exists to provide at least 8 ft of head. It appears that outslopes of the existing bed could be raised without encroaching into wetlands or the riparian zone. The condition of the limestone in the bed is not known and should be investigated. If it is not fouled, then the use of the limestone could decrease construction costs by about $30,000. Excavation costs would be minor. The construction costs, using the existing space and existing limestone aggregate, would likely be less than $75,000.