Evaluation of the Morrison Passive Treatment System, Clarion County Park

Technical Assistance Provided to Clarion County Conservation District through the Trout Unlimited AMD Technical Assistance Program
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Background

The Clarion County Conservation District (CCCD) requested assistance on evaluating the Morrison passive mine water treatment system which is located at Clarion County Park near Shippenville PA. The Clarion County Park is on a reclaimed site that was mined in the 1970s and 1980s by Glacial Minerals. Acid mine drainage with high concentrations of Fe and Mn occurred at the site and was treated chemically until the company's bankruptcy. A passive treatment system was installed by the bonding company in 1991, but it has been abandoned for the last 20 years. The system's performance has declined substantially because of neglect. This project evaluated the condition of the treatment system and provides recommendations about its rehabilitation.

Morrison Passive Treatment System

The passive treatment system consists of an anoxic limestone drain (ALD), wetland channel, vertical flow pond (VFP), polishing pond, and constructed wetland (Figure 1). The ALD contains approximately 500 tons of limestone and discharges via two pipes to a wetland channel that flows on contour 225 ft to the northeast, drops down about 8 ft, and continues 475 ft to the southwest to a 4,000 ft^2 vertical flow pond. The VFP discharges to a 2,000 ft^2 settling pond that discharges to a 4,000 ft^2 constructed wetland. The final discharge is to an unnamed tributary to the Clarion River that enters the Clarion River Reservoir 900 ft upstream of the Piney Dam. The April 2014 Google Earth image shows Fe discoloring extending about 100 ft from mouth of the UNT into the Clarion River Reservoir.

The accumulation of iron sludge in the system has been a problem since its construction. Within two years of construction the VFP became plugged due to heavy accumulation of iron sludge on the compost surface. Sometime in the early 2000's the accumulation of vegetation and iron sludge in the channel below the ALD caused a breach where the channel drops to the lower contour. Most of the mine water now flows through this breach into woods (where a kill zone has developed) and eventually into the UNT.

Table 1 shows the results of system sampling. The ALD discharges through two pipes that have similar chemistry. The ALD effluent contains 170-185 mg/L Fe, 40 mg/L Mn, and 1 mg/L Al. The alkalinity is approximately 100 mg/L which is insufficient to neutralize the acidity produced from Fe removal by the reactions shown below.

Fe oxidation and acid production $Fe^{2+} + \frac{1}{4} O_2 + 5/2\, H_2O \rightarrow Fe(OH)_3\,(solid) + 2H^+$
Acid neutralization by alkalinity $H^+ + HCO_3^- \rightarrow H_2O + CO_2$

The neutralization of 1.0 mg/L of Fe in the water requires 1.8 mg/L alkalinity (as $CaCO_3$). If there is sufficient alkalinity, Fe will precipitate, and the final pH will be about 7. If there is insufficient alkalinity, Fe will precipitate but the pH will decrease. The goal of the ALD is to generate enough alkalinity to neutralize the acidity contained in the raw water. At 180 mg/L Fe^{2+}, the alkalinity requirement for full neutralization is 322 mg/L. The ALD is only producing 100 mg/L alkalinity so the ALD effluent is net acidic. The net acidic character of the water is apparent from sampling of the final wetland discharge. The flow that reaches this point has much lower Fe, but the pH is 2.7 and the acidity is not decreased (Table 1)

Most ALDs discharge 150-300 mg/L alkalinity. The Morrison ALD, at 100 mg/L alkalinity, is not performing optimally. A potential alkalinity generation measurement was made by incubating the ALD effluent with limestone aggregate for 10 hours. The alkalinity increased to 325 mg/L. Incubation results are generally within 10% of the alkalinity that will be discharged from a properly sized and constructed ALD. The result indicates that a functional ALD could produce enough alkalinity to neutralize all or most of the Fe.

The sampling on Aug 8 included the wetland blowout. Most of the flow was following the breach down into the woods. There was no removal of Fe in the channel between the ALD effluent pipes and the breach.

Table 1. Sampling results from the Clarion County Park passive treatment system.

Point	**Date**	**Flow gpm**	**pH**	**Alk field**	**Acid mg/L**	**Fe mg/L**	**Mn mg/L**	**Al mg/L**	**SO4 mg/L**
ALD out -E	6/14/17	25	na	na	302	172	38	1.0	1086
Right out-W	6/14/17	13	5.6	na	270	186	39	1.0	1221
ALD out-E	8/8/17	21	5.4	95	263	na	40	0.7	1044
ALD out-W	8/8/17	2	5.4	109	259	187	40	0.8	1262
Wetland Blowout	8/8/17	23	4.4	52	373	193	43	1.3	1245
Final Wetland	8/8/17	7	2.7	0	291	23	37	1.9	1274
ALD out-E	8/25/17		5.4	92	249	175	38	0.9	1189

"na" indicates that sampling results are not available.

June 14 Site Meeting

County Commissioner Ted Tharan and Clarion County Watershed Specialist Tricia McIntire requested a verbal report about the AMD and passive treatment system. A site meeting occurred June 14 that was attended by Ted Tharan, Tricia McIntire, Mark Benson (Knox DMO), Ted Weaver (HE) and Bob Hedin (HE). Mark Benson provided background information regarding bond forfeitures. The DEP has a list of forfeiture sites that are eligible for treatment funding through the ABS Legacy program. The Clarion County Park treatment system is not on the list and does not qualify for ABS funding. The site was mined after 1977 and is ineligible for Title IV AML funding. (This if funding that is used by the Bureau of Abandoned Mine Reclamation to reclaim sites and occasionally support water treatment.) Rehabilitation to the system could be funded through the Growing Greener program or through the Act 13 funding provided from shale gas fees.

System Rehabilitation

The system needs a major overhaul because the ALD is not functioning optimally and iron sludge has compromised channels and ponds. Table 2 provides calculations for the recommended changes.

The ALD should be rebuilt. To assure that the maximum alkalinity is generated and that the ALD will function for 20+ years, the ALD should contain at least 30 tons of high calcite limestone per gpm of flow. Assuming an average flow of 40 gpm (June 2018 flow rate was 38 gpm), then the rebuilt ALD should contain approximately 1,200 tons of limestone.
Water discharging from the ALD will be alkaline and should be directed through settling basins so that the Fe will oxidize and precipitate in a controlled manner. The existing channel is too small and shallow to provide good capture of Fe solids. A series of at 2-3 ponds should be installed. The size of the ponds is determined from the Fe loading and the expected Fe removal rate. Assuming 162 mg/L Fe (90% of 180 mg/L), 40 gpm of flow, and a removal rate of 20 gFe per m^2 of pond per day, then the total surface area of the ponds should be about 19,000 ft^2. Three 7,000 ft^2 ponds are recommended. Because of the large Fe load, aeration will be important. Arranging the ponds in series with aeration structures between the ponds would be beneficial

The water discharging from the ponds will be turbid and contain ~18 mg/L Fe. Wetlands are effective for filtering suspended Fe solids. Assuming a Fe removal rate of 5 $gFe/m^2/day$ then the wetland should be about 8,500 ft^2.

If the ALD has generated sufficient alkalinity the discharge from the wetland should be neutral pH with low Fe and 30-40 mg/L Mn. This chemistry is often suitable for discharge because it will support insects and fish in the receiving stream. If Mn removal is necessary, the wetland effluent should be directed through an oxic (open to the atmosphere) bed of limestone aggregate. The calculated tonnage is ~3,000 tons. This very large tonnage reflects the slow removal of Mn in passive systems.

Table 2. Passive treatment units and sizing calculations			
Treatment unit	**Purpose**	**Sizing basis**	**Size**
ALD	Generate alkalinity	40 gpm at 30-ton LS/gpm	1,200 tons (6,000 ft^2)
Settling ponds (2-3)	Oxidize and settle 90% of Fe	40 gpm at 162 mg/L Fe removed at 20 $gFe/m^2/day$	18,900 ft^2
Constructed wetland	Remove residual Fe	40 gpm at 18 mg/L Fe removed at 5 $gFe/m^{2/}day$	8,400 ft^2
Oxic limestone bed	Remove Mn	40 gpm at 40 mg/L Mn removed at 3 gMn/ton/day	2,900 tons (14,500 ft^2)

The surface areas shown in Table 2 do not account for berms, roads, etc. If the footprint of the system is twice the summed treatment area, then the ALD, ponds and wetland require about 1.5 acres. The current treatment system layout is not large enough to support this system. (The undersized system is one reason for its quick failure.) Alternative treatment locations should be explored. Suitable area appears available southeast of the system, however, this area is outside the apparent property boundaries of the County Park.

Recommendations

The samples collected in this report reliably characterize the current chemistry of the AMD. Flow information is needed. A monitoring station should be installed near the ALD pipe discharges and flow rates should be measured monthly.

Potential treatment areas downhill from the ALD pipe discharges should be investigated for constructability and property ownership. Contact should be made with property owners to determine if easements can be obtained for siting a reconstructed treatment system. Alternatively, the property could be purchased (or donated) and incorporated into the Clarion County Park.

Funding options for the development of construction plans and permits should be explored. Growing Greener and DCED Act 13 funds are possible sources of state funding. The Foundation for Pennsylvania Watersheds can provide grants of $10,000 - $20,000. The first phase is a project to develop the construction plan, construction drawings (90% complete), permit packages, and a detailed construction cost estimate. The cost for this effort is typically $30,000 - $40,000. These deliverables would be the basis for preparation and submittal of a second grant proposal that would cover permitting and construction.

The proximity of the treatment system to the County Park provide educational opportunities. Most passive treatment systems in Clarion County are in remote locations. If a functional system was reconstructed at the Clarion Park Site, it could be used to educate the community about water quality and water treatment.

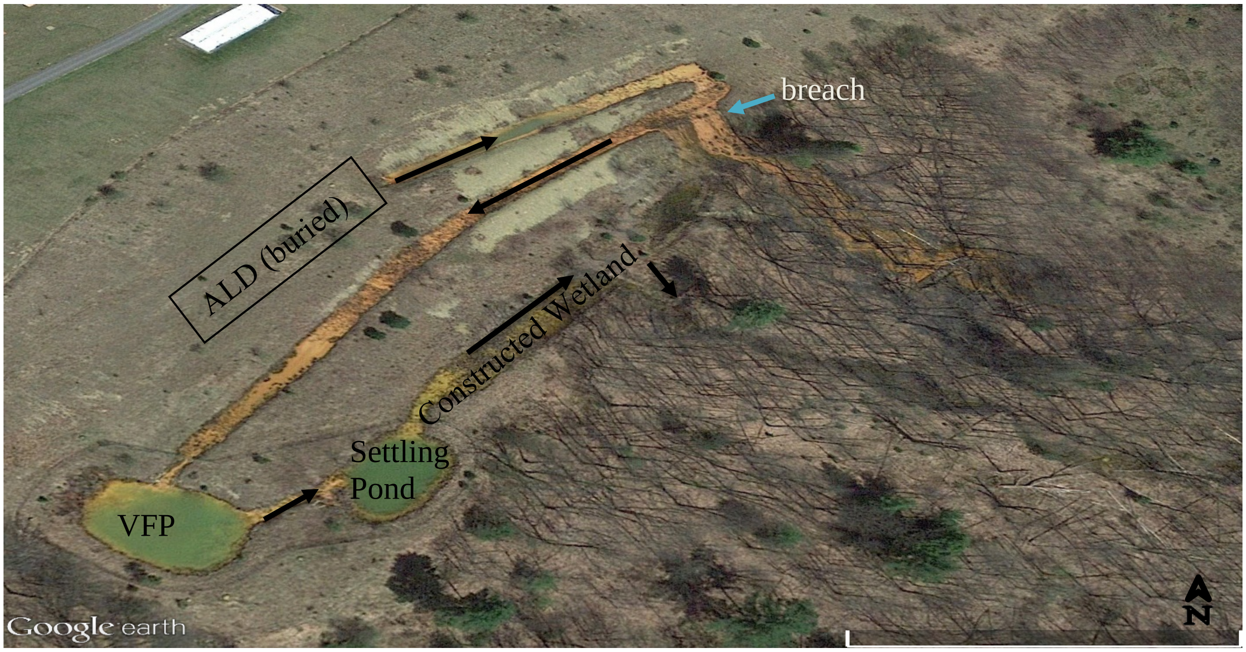

Figure 1. Layout of the Morrison Clarion County Park passive treatment system