Klondike Passive Treatment System Investigation
Babb Creek Watershed, Tioga County

Technical Report Provided by Hedin Environmental through the Trout Unlimited AMD Technical Assistance Program

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Background

The Klondike Passive Treatment System treats an acidic deep mine discharge to Lick Creek which is a tributary to Babb Creek. The treatment system was designed and constructed in 1997 by DEP and DCNR. Originally the system consisted only of a vertical flow pond (VFP), but a settling pond was added in 2005 to retain metals. In response to performance problems the compost was replaced in 2007. Treatment effectiveness appears to have declined sharply in March of 2009. The compost was mixed in May of 2009 in an attempt to restore performance. This report provides recommendations for treatment system rehabilitation.

Figure 1 shows the layout of the system. The VFP has a water surface area of 2,600 m^2. The settling pond is visible in the topographic contours, but not in the aerial photography because the pond was constructed between the acquisition of photography and elevation data.

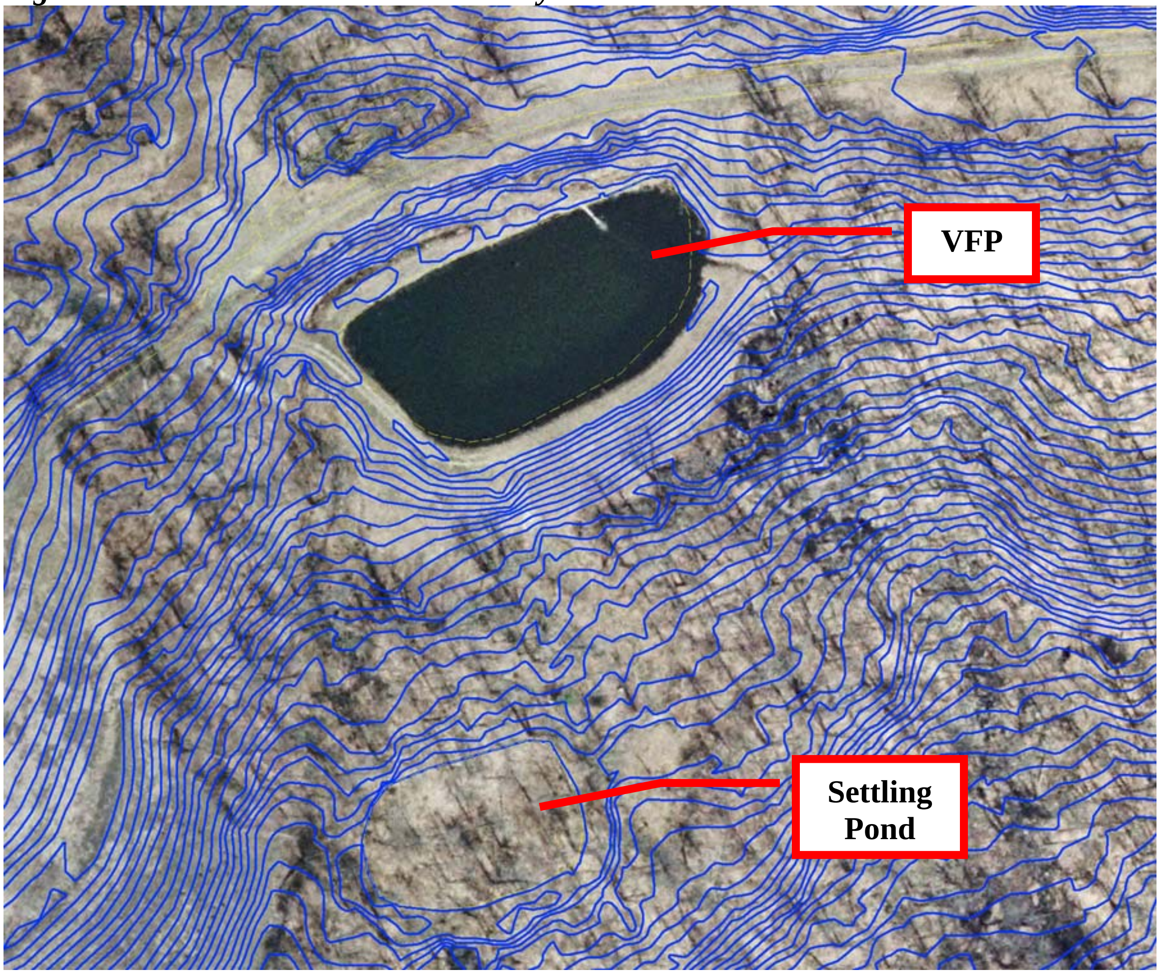
Based on construction photos and discussions with BCWA it is apparent that neither the VFP bottom nor VFP substrate (limestone, compost) were installed level. In fact the bottom of the VFP appears to be sloping in the opposite direction from the top of the substrate. It is very likely that the thickness of treatment substrate varies widely and, as a result, creates zones of preferential flow through the thinner areas.

System Performance

Table 1 summarizes sampling of the system. The discharge flow averages 187 gpm with a maximum observed flow of 300 gpm. The water quality of the raw discharge is not severe with 90 mg/L acidity, 3.3 mg/L iron, 2.2 mg/L manganese and 6.5 mg/L aluminum on average. At the observed maximum flow and average acidity concentration the VFP receives 57 $(g/m^2)/d$ acidity. This is 41% higher than the recommended 40 $(g/m^2)/d$ that is typically recommended. At average flow the loading rate is 35 $(g/m^2)/d$, which was likely the design rate.

The system has been regularly monitored since 2004. Effluent quality has been generally good with average pH of 6.8 and 61 mg/L net alkalinity. However, permeability has been a persistent problem and as a result untreated water is often discharged through the VFP emergency spillway. In an attempt to address the permeability problem the compost was replaced in 2007. Since the compost was replaced the permeability has improved but performance appears to have declined. To improve effluent quality the water level in the VFP was raised so that a majority of the flow bypasses the system through the emergency spillway.

Figure 1. Klondike Passive Treatment System



Note: Imagery and topography source is the PA DCNR PAMAP program. Contour interval is 2 feet.

Table 1. Average treatment system performance before and after compost replacement

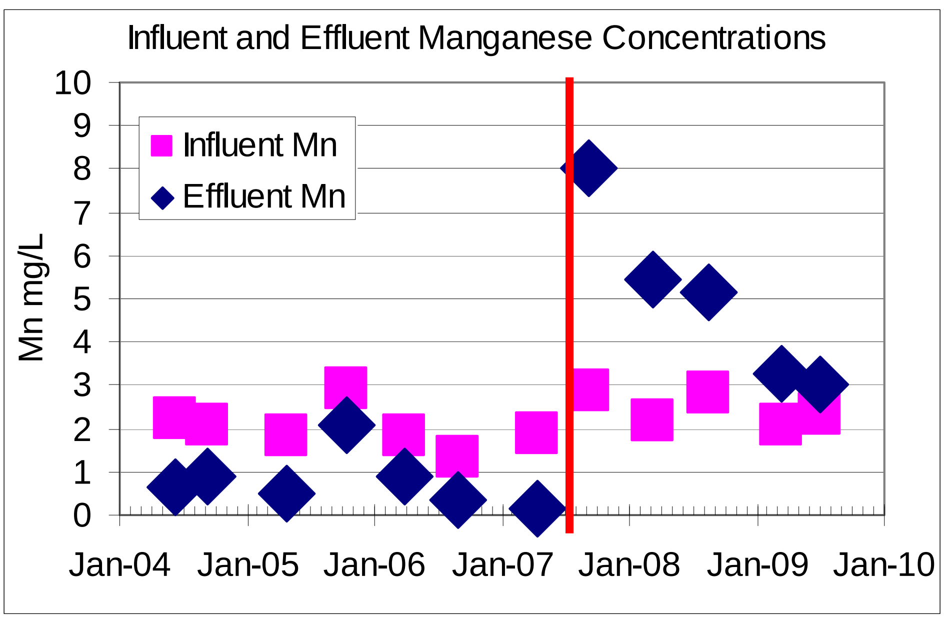
	Count	**pH**	**Acid (mg/L)**	**Fe (mg/L)**	**Mn (mg/L)**	**Al (mg/L)**
Raw 2004-2009	12	3.3	90	3.3	2.2	6.5
Effluent 2004-2009	12	6.8	-61	2.0	2.5	1.6
Raw before compost replacement	7	3.3	91	2.9	2.0	6.2
Effluent before compost replacement	7	6.9	-62	0.5	0.8	1.4
Raw after compost replacement	5	3.3	89	3.7	2.4	6.9
Effluent after compost replacement	5	6.7	-60	4.0	5.0	1.8

Following the replacement of the compost the system became a source of iron and manganese. That is, they released more of these metals than they received from the discharge. Originally the system contained a compost layer that was heavily amended with limestone. By the time the compost layer was replaced in 2007 very little organic material remained. Such a system would not have sufficient organic material to create reducing conditions so the VFP was operating essentially as an oxic limestone bed. When the compost layer was replaced with a layer of spent mushroom compost with no limestone amendment (i.e. 100% organic material) the conditions in the limestone layer were switched from oxic to reducing.

Many of the metals solids that formed in the limestone layer under oxic conditions are soluble under reducing conditions. As a result, metals solids are going back into solution causing the system to discharge water having higher manganese concentrations than what is entering the system. Iron now passes through the system due to the reducing conditions. Since the system is no longer removing manganese and iron (and their associated acidity) the acidity removal rate is lower.

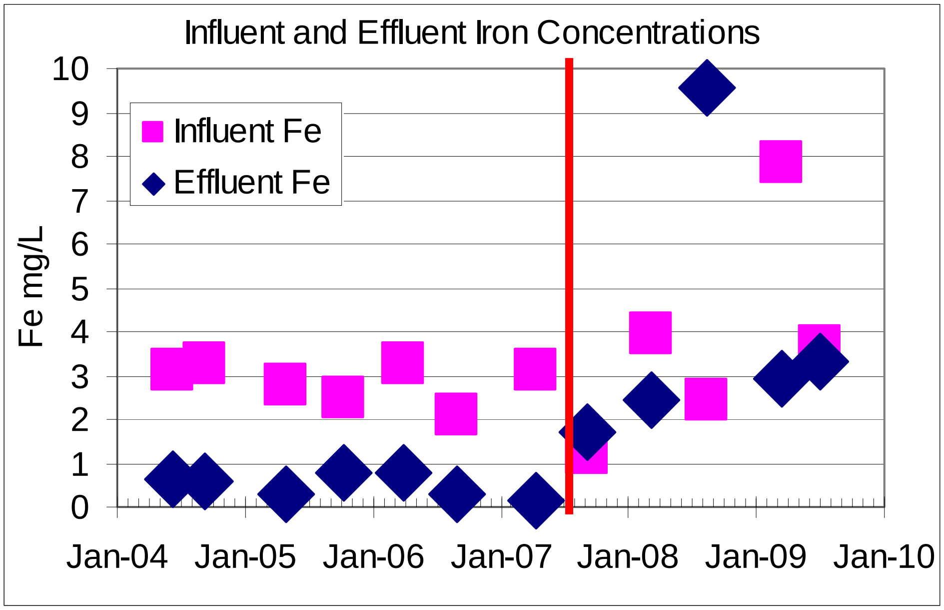
Figures 2 and 3 show the influent and effluent iron and manganese over time. The system appears to be stabilizing in terms of manganese release. Nonetheless, it is evident that even once stabilized the system will suffer from short-circuiting problems.

Figure 2. Manganese concentrations before and after compost replacement



The red line indicates the approximate date of compost replacement.

Figure 3. Iron concentrations before and after compost replacement



The red line indicates the approximate date of compost replacement.

Clearly the replacement of the compost layer changed the chemical performance of the system. However, there is some indication that the physical function of the system was altered as well. The effluent water is turbid with orange suspended solids. One potential cause of this could be a hydraulic short-circuit. Acidic, aerobic water is reaching the underdrain plumbing where it mingles with alkaline treated flow. Once mixed, iron precipitates from the solution forming the visible solids in the effluent.

<u>Recommendations</u>

Both the chemical and physical function of the system appear to be compromised. Two options have been devised to restore system performance. The first option, which involves simply adding limestone to the compost layer, is less intrusive and thus carries a lower cost. In contrast, the higher cost second option, which is a complete rebuild of the VFP, also has a higher likelihood of success. These options could also be implemented in phases rather than separate strategies. The compost could be amended with limestone and if monitoring reveals that the system is still not performing as desired, the VFP could be rebuilt and the amended compost reused. Since the compost would be amended for the rebuild anyway, the only additional cost of implementing the first phase is machine time for mixing.

<u>Option 1 - Amend Compost</u>

The compost is not amended with limestone. Amending the compost with fine limestone will improve system performance and make the system more resilient to loading fluctuations. The compost should be amended at a rate of one part limestone to three parts compost by volume. This is the rate of compost amendment used at the Anna S passive treatment system which has successfully treated more acidic mine drainage for nearly six years. The existing system contains about 1,000 yd^3 of compost. At 1.35 $tons/yd^3$, 340 tons of limestone will be required.

The addition of limestone to the compost should be used as an opportunity to redistribute the compost uniformly. Variations in compost thickness or density should be avoided.

<u>Option 2 - Rebuild</u>
The installation of new treatment substrate will allow for the problems associated with construction errors to be corrected and also for the system capacity to be restored and even increased. The following is a description of the rebuild process.

The existing compost will be removed and stockpiled for reuse. The existing limestone will remain within the system but will be leveled. The surface of the existing limestone will serve as the new base of the pond. New underdrain plumbing, placed directly on top of the existing limestone will be connected to the existing header and outlet plumbing. Two feet of AASHTO #3 limestone (2,300 tons) will then be placed over the existing limestone and new underdrain plumbing. The existing 1,000 yd^3 of compost plus an additional 900 yd^3 of new compost will be amended with 640 tons of limestone fines. The total thickness of the compost layer is estimated to be 2 feet. Table 2 summarizes the required quantities.

Table 2. Quantities for system rebuild

Item	**Quantity***
AASHTO #3 limestone	2,300 Tons
Limestone fines	640 Tons
New compost	900 yd^3
Existing compost	1,000 yd^3
Total compost to be handled	1,900 yd^3
4” sch. 40 PVC pipe (9 - 180’ laterals, 10’ spacing)	1,620 ft

** These quantities are based on measurements taken from aerial photographs and assumed side slopes, the volume available to receive these quantities should be verified in the field.*