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FINAL REPORT

FOR PADEP

GROWING GREENER

GRANT ME#

BREWSTER HOLLOW – SX8-D1

AMD REMEDIATION PROJECT

AUGUST 2016

TECHNICAL REPORT

The Brewster Hollow watershed is located in Broad Top Township in the northeastern corner of Bedford County. From its headwaters to its confluence with the mainstem of Six Mile Run in the village of Defiance, the watershed is primarily forested with several residences near the mouth. Six Mile Run watershed, the mainstem of which enters the Raystown Branch of the Juniata River (HUC = 02050303) approximately two miles downstream at Riddlesburg, PA, is classified as a warm water fishery (WWF).

The impacts of abandoned underground and surface coal mines have severely impaired the water quality and aquatic life communities in the Six Mile Run watershed. Old mining operations have resulted in at least 20 different identified abandoned mine drainage (AMD) sites in the Six Mile Run watershed including at least three in the Brewster Hollow subwatershed. The AMD discharges in the watershed lower the naturally low pH and produce elevated dissolved metals concentrations in Brewster Hollow and ultimately Six Mile Run. The entire 6.16-mile mainstem of Six Mile Run from the headwaters to the confluence with the Raystown Branch of the Juniata River is listed as impaired on Pennsylvania Department of Environmental Protection's (PA DEP) 303(d) list for both pH and metals as a result of the AMD discharges. The SX8-D1 AMD discharge was identified in the 2001 AMD Assessment and Remediation Plan as a significantly influential discharge to Brewster Hollow as well as to the mainstem of Six Mile Run. In that report, the SX8-D1 discharge was identified as a priority for remediation. The SX8-D1 AMD discharge is net acidic, with high iron and low aluminum concentrations. This AMD discharge contributes approximately 0.6 tons of aluminum, 7.9 tons of iron, and 33.4 tons of acidity annually to Brewster Hollow and Six Mile Run. The SX8-D1 AMD discharge was targeted for passive treatment to increase pH and to provide adequate alkalinity to neutralize the acidity and reduce metals loading, specifically iron and aluminum. The SX8-D1 AMD remediation project is one of the priority steps in working downstream from the headwaters to help restore Six Mile Run from the historic AMD pollution.

Broad Top Township received PA DEP Section 319 Grant funding for the construction of a passive treatment system for this priority AMD discharge. Broad Top Township selected Skelly and Loy, Inc. to prepare the final engineering design and permitting of the passive treatment system with an estimated 20 to 25-year lifespan. The treatment system engineering design was completed in 2013 and construction was completed in the summer of 2014, following receipt of all the necessary permitting approvals. Using information from the 2001 AMD Assessment and Remediation Plan, LIDAR topographic mapping, and an in-field survey performed by Skelly and Loy personnel, the project team evaluated alternatives for capture and

treatment of the AMD discharge. The goal was to intercept the mine water further away from the stream than where it was discharging. Exploratory excavation work by Township personnel showed that the mine water could be intercepted further north of the stream and kept from discharging along the bank of Brewster Hollow. The area between the hillside and Brewster Hollow provided a suitable area for a large passive treatment system, but required considerable excavation. The final plans even show a portion of the flushable limestone pond covered with backfill material so as to achieve the desired grade in the cut back slope.

The SX8-D1 AMD source, which discharges from an old, buried, underground mine entry along the north bank of Brewster Hollow in the village of Defiance, had severe impacts and at times was the only source of water in the downstream segment of the stream. Upon determining that the AMD could be intercepted at a point further away from the stream, the plan was developed to treat the water on site using a large flushable limestone bed (FLB) based passive treatment system. The final treatment system design involved installation of a mine seal that forced the water from the buried mine tunnel up into the system above it on the site. Concrete and clay were used to prevent the AMD from leaking into Brewster Hollow from the source.

Detailed topographic surveys were not performed during construction and "red line" survey drawings were not developed, but observation made during visual surveys determined that the design plans were followed, with no significant deviations.

The AMD enters the upstream end of the FLB directly from the underground mine workings. The FLB consists of a five foot layer of limestone containing approximately 3,000 tons of high calcium carbonate (greater than 80% $CaCO_3$) limestone. After flowing through the long and narrow limestone layer of the FLB, the water flows into a large settling pond to provide aeration and to help oxidize and precipitate the iron and aluminum. Following the settling pond, the AMD is directed into a polishing/aerobic wetland segregated by concrete structure baffles to reduce incoming velocities and to lengthen the flow path of the water before the final outfall. The polishing/aerobic wetland contains a 0.5-foot mixed layer of spent mushroom compost and limestone fines with wetland plantings. The aerobic wetland is the final polishing step in the passive treatment process to remove any remaining metals before finally discharging into Six Mile Run just below the confluence with Brewster Hollow.

The AMD discharge, from the sealed underground mine tunnel, enters the upstream end of the FLB, and passes through the high calcium carbonate limestone material generating alkalinity sufficient to neutralize the acidity and begin the process of precipitating the iron and

aluminum. The net alkaline water from the FLB is then routed to a long and narrow settling or retention pond for precipitation and/or oxidation of the metals, primarily iron. Skelly and Loy designed passive flushing systems to aid in the removal of any aluminum and iron precipitates from the void spaces in the limestone layer of the FLB.

Before treatment the AMD discharge was characterized as follows:

SX8-D1 Raw AMD Discharge Characterization

FLOW (gpm)	Field pH (SU)	ALKALINITY (mg/L)	ACIDITY (mg/L)	TOTAL IRON (mg/L)	FERROUS IRON (mg/L)	TOTAL ALUMINUM (mg/L)	TOTAL MANGANESE (mg/L)
120	3.50	0	127	30.0	16.5	2.3	1.6

SX8-D1

The source of this discharge is an abandoned underground mine entry located on the north side of Brewster Hollow. This AMD discharge is characterized as fairly consistent with respect to flow rate and has historically ranged from 60 to greater than 250 gallons per minute (gpm).

The engineering design was determined through evaluation of water quality and discussions with the project team members. A passive treatment system consisting of a large FLB, containing approximately 3,000 tons of limestone was chosen. The FLB consists of a five feet deep layer of AASHTO #3, with a perforated header pipe near the bottom downstream end of the limestone layer and attached to an automatic inline structure. Based on historic water chemistry data and a maximum design flow of approximately 150 gpm (75^{th} percentile of measured flows) the system provides the AMD a minimum of 20 hours contact time. Calculations indicate that amount of limestone in the FLB will produce enough alkalinity to raise the pH and precipitate the dissolved aluminum and iron from the SX8-D1 discharge for a minimum of 20 years. A perforated header pipe is installed near the bottom downstream end of the limestone layer and is attached to an automatic inline water level control structure, which controls both normal outflow and scheduled flushes. The water then discharges out of the FLB and into a settling pond with a floating baffle where the iron is oxidized and metal precipitates are settled and retained. A rock-lined principal spillway was installed in the settling pond to control the water level and to discharge the water in a diffuse manner into the polishing/aerobic wetland. Additionally, a piping system with a manual control valve was installed from the settling pond into the wetland to provide a means of draining the pond for any necessary

maintenance. The final component of the passive treatment system is a polishing/aerobic wetland, which provides additional retention and capacity to settle and retain any remaining aluminum and iron precipitates. An inlet water level control structure with a stone walkway was installed in the aerobic wetland to control the water level and provide a means of draining the pond for any necessary maintenance.

The automatic inline water level control structure and associated perforated piping are used to set the water level in the FLB and to automatically flush the aluminum and iron precipitates from the void spaces in the limestone layer to the adjacent settling pond on a preset schedule (normally once or twice a week). The FLB outlets directly into the settling pond that was designed for the purpose of iron oxidation and metal precipitates removal using detention time and settling mechanisms. A baffle was constructed on-site using cable and PVC/HDPE liner material with window flaps cut into the material roughly one foot below the water surface. The baffle was installed perpendicular to the flow path to reduce velocities of the incoming water and to encourage settling of the metal precipitates. A rock-lined principal spillway was installed in the settling pond to control the water level and outfall the water in a diffuse manner into the polishing/aerobic wetland. Additionally, a piping system with a manual control valve was installed from the settling pond into the wetland to provide a means of draining the pond for any necessary maintenance. An inlet water level control structure was designed in the polishing/aerobic wetland to allow for adjustment of the water elevation for adequate retention in the pond in response to sediment and/or metals accumulation. The inlet structure also allows for dewatering of the pond for maintenance purposes (e.g., sludge removal). The outfall from the aerobic wetland inlet structure serves as the final discharge of the treatment system and discharges directly into a constructed stormwater diversion channel near the confluence of the treatment system with the mainstem of Six Mile Run.

PROJECT RESULTS

The AMD discharge treated at this project was historically a significant loading source of acidity and iron to the mainstems of Brewster Hollow and Six Mile Run. Field pH and flow measurements have been collected on the final system outfall since construction was completed in 2014. pH levels have been above 6.0 in the final system outfall. During one sampling event in August 2014, water chemistry measurements and flow rates were collected for the raw AMD and final outfall. System performance was evaluated by comparing pH, acidity, alkalinity and metal concentrations of the raw AMD with the final discharge from the constructed passive treatment system.

STATION	FLOW (gpm)	pH	ALKALINITY (mg/L)	NET ACIDITY (mg/L)	TOTAL IRON (mg/L)	TOTAL ALUMINUM (mg/L)
Raw AMD – Historic Avgs	120	3.50	0	127	30.0	2.3
Final Outfall – 8/28/14	70	7.30	128	-124	1.52	<0.05

Based on the recent sampling event the treatment system is performing very well during above average flow conditions. Despite the moderate concentrations of aluminum and high concentrations of iron in the raw AMD, the treatment system works effectively at removing nearly all of those metals as well as imparting considerable excess alkalinity for Six Mile Run. Based on the snapshot sampling event in August 2014, the constructed passive treatment system is achieving the design effluent concentrations by removing more than 95% of the aluminum and iron, and neutralizing acidity at the final outfall. Under normal flow conditions (120 gpm), the alkalinity production rate and metals removal should be sufficient to create a net alkaline effluent with anticipated iron concentrations below 3.0 mg/L and aluminum concentrations below 0.5 mg/L in the passive AMD treatment system final discharge.

From 2011 through 2012, chemical testing was performed in the mainstem of Six Mile Run. Prior to the construction of SXO-D9, data from various sampling locations show that the TMDL pollutants for Six Mile Run are reduced downstream of several functioning AMD passive treatment systems. Since the completion of SX0-D9 and now SX8-D1, further monitoring of the improvements to Six Mile Run should be conducted. Monitoring efforts in Six Mile Run below all of the passive AMD treatment systems in operation would provide more detailed feedback on system effectiveness and the restoration efforts in the Six Mile Run watershed. Water quality in Six Mile Run has improved at the TMDL Station #57 most likely due to the numerous treated AMD sources in the upper watershed. At the downstream TMDL Station #68 aluminum concentrations have decreased from 2.00 mg/L in 2000 to 0.89 mg/L in 2011-2012, iron has decreased slightly from 0.35 mg/L in 2000-2001 to 0.32 mg/L in 2011-2012, manganese has dropped from 0.62 mg/L in 2000-2001 to 0.29 mg/L in 2011-2012, and hot acidity has improved from 23 mg/L to -9.2 mg/L in 2011-2012. Initial data for each parameter was taken directly from the TMDL report for Station #68.

COSTS

The Township was able to use its own employees and equipment to construct this

treatment system keeping the cost as low as possible. The total cost for design and construction of the system was $324,069.

OPERATION & MAINTENANCE

Skelly and Loy has prepared an Operation and Maintenance (O&M) Manual for the passive treatment system constructed with this Section 319 grant funding for the SX8-D1 AMD sources. Broad Top Township has committed to perform the routine O&M required to keep this system functioning during the projected 20 to 25-year life. The Township has currently not obtained the funds that will be required to refurbish this treatment system at the end of its' initial life or to finance basic long term O&M activities on the SX8-D1 passive treatment system in the Six Mile Run watershed.

The general O&M requirements for this system includes quarterly inspections with field testing of flow and pH to ensure it is operating properly, inspection of the regular automatic flushing mechanism of the FLB on a quarterly basis (at a minimum) to ensure proper operation, keeping all channels and pipes clear for both regular and high flows, repairs of any erosion areas, sludge removal from the settling pond as necessary, and potentially stirring of the limestone layer in the FLB to help preserve the open pore space from the accumulation of aluminum and iron. Particular attention should be paid to the area where the water enters the FLB from the mine seal to prevent hydraulic pressure on the water into the mine workings which could result from the accumulation of metal precipitates within the limestone void spaces.

CONCLUSION

The passive treatment system for the SX8-D1 AMD discharge was constructed in 2014 using funding from the PA DEP Section 319 program. Broad Top Township constructed the treatment system as part of a larger effort to restore the Six Mile, Sandy Run, and Longs Run watersheds as identified in the 2001 AMD Assessment and Remediation Plan.

The construction of this passive AMD treatment system has and should continue to significantly reduce acidity and metals concentrations discharging to the mainstems of Brewster Hollow and Six Mile Run as well as continue to provide a significant contaminant load reduction to the lower section of Six Mile Run. This project is complete with the exception of the continued operation and maintenance requirements outlined above, which are projected to continue indefinitely. The combined results of this project along with the constructed AMD

remediation systems for most of the identified AMD sources in Brewster Hollow and Six Mile Run, involving similar components, are anticipated to help achieve the pH and metals reductions required by the TMDL set by PA DEP for Six Mile Run. Natural aquatic life is returning to the middle and lower sections of Six Mile Run and should continue to do so as long as the water quality improvements are maintained.

REFERENCES

1. Six Mile, Sandy and Longs Run Watersheds AMD Assessment and Remediation Plan - 2001
2. Six Mile Run Watershed Final TMDL Report- 2002

APPENDICES

A. PROJECT LOCATION MAPS
B. PROJECT PICTURES