Monday Creek Restoration, Snow Fork Dosers

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Introduction

The Monday Creek Restoration Project is a program of Rural Action, a non-profit organization committed to improving watershed health in Appalachian Ohio. Monday Creek is a stream impaired by acid mine drainage (AMD) and other pollutants. Previous studies have identified Snow Fork as the tributary with the greatest AMD contribution to Monday Creek, therefore the Snow Fork Dosers project was proposed for design and eventual construction with project oversite provided by Ohio Department of Natural Resources, Division of Mineral Resources Management, with funding from Ascent Resources. Although the proposed dosers are not yet under construction, the Snow Fork project design demonstrates the potential for stream restoration using active treatment with lime dosing, and the effectiveness of collaboration and perseverance in moving stream restoration projects toward completion.

Site Selection

The project included evaluation of five potential doser sites pre-selected by ODNR and initially designated as Sites 1–5. Site 2 and Site 4 were ultimately selected as the preferred dosing locations and renamed as the "Brush Fork" and "State Route 78" sites respectively. Site selection was based on comparison of factors including water quality, flooding potential, environmental sensitivity, availability of utilities, site topography, site access, and property ownership. These factors were each given a value from one (worst) to three (best) with the water quality values tripled to reflect their importance in site selection. The factors were tabulated in a spreadsheet and total values determined for each site. The two top ranked sites, Brush Fork and State Route 78, were thus selected for detailed design.

Potential sites located downstream of the major AMD sources were preferred in order to reduce uncertainty regarding the quality of the water to be treated, as was reflected in the site ranking. The Brush Fork Site located along Snow Fork and downstream of the Brush Fork tributary discharge was therefore preferred over a nearby potential site that was located upstream and along the Brush Fork tributary. Although Brush Fork is the largest contributor of AMD to Snow Fork, examination of data from "watersheddata.com" indicated the acid concentrations are generally highest in Snow Fork at this location as they reflect AMD from both Brush Fork and the upstream reaches of Snow fork. This site is also near sampling location SF00630, for which several years of water quality data was collected by Rural Action. The State Route 78 Site is also located downstream of the discharge of Brush Fork, as were two other potential treatment sites under consideration. The State Route 78 site was also selected for detailed design due to a variety of factors, but primarily due to its location being downstream of other tributaries and AMD sources while not being too close to the confluence with Monday Creek.

Treatment Strategies

Potential lime treatment strategies to be considered for the proposed doser sites included using Calcium Oxide (Quicklime), dry Hydrated Lime, or Hydrated Lime Slurry. Water quality data indicates elevated concentrations of Aluminum and hardness are present in the waters of Snow Fork. Aluminum solubility is pH dependent, being relatively insoluble in the circumneutral pH Range (pH of 6.0 to 7.5) but becoming more soluble under acidic (pH < 6) and alkaline (pH > 8) conditions. It is therefore necessary for the selected treatment system to be capable of reliably maintaining circumneutral pH levels in Snow Fork to prevent Aluminum

from remaining in solution or redissolving after treatment and potentially discharging into Monday Creek.

A Calcium Oxide doser can be difficult to regulate and reacts more slowly compared to a hydrated lime system, increasing the chances that Aluminum precipitates may redissolve due to overestimating or underestimating the required treatment dosages. Due to the observed hardness of the waters of Snow Fork, secondary treatment from residual lime deposits may (or may not) occur, increasing the difficulty of setting effective treatment doses and potentially wasting lime. Therefore the use of Calcium Oxide is not recommended for the Snow Fork Doser projects.

Dry Hydrated Lime (Calcium Hydroxide) treatment is expected to be more reactive and thus more responsive to dosage adjustments compared to treatment with Calcium Oxide. Redissolving of Aluminum would still be a possibility with a dry hydrated lime treatment system though presumably not as problematic as with a Calcium Oxide based treatment system. A Hydrated lime system would require less lime to achieve the same level of treatment as a Calcium Oxide lime system, but both systems would be operated in much the same way, which is an advantage as ODNR has experience operating such systems.

Hydrate Lime Slurry would be the most reactive and thus most responsive to dosage adjustments, making it efficient and adjustable but requiring a clean water supply for creation of the wet lime slurry. Due to several factors including anticipated higher capital and operational costs and the difficulty in obtaining suitable water supplies to the sites in an economic or timely manner, a dry hydrated lime feed system was recommenced as the preferred system for the Brush Fork and State Route 78 Dosers.

Anticipated Lime Requirements

Treatment of the water in Snow Fork will require sufficient hydrated lime for neutralization of the acid loadings which vary based on fluctuations in flow rate and acid concentration. Assessment of long and short term treatment requirements were based on available flow data, historic and recent water quality data, and a calculated curve describing the relationship between flow in Snow Fork and acid concentration. The design investigations including modeling with AMDTreat to confirm the decision to design dosers utilizing hydrated lime and excel spreadsheets to analyze the large amounts of available flow and water chemistry data.

Steam flow measurements and acid concentration data points obtained from "watersheddata.com" for Site 00630 and supplemented with more recent data obtained by Rural Action as part of the Snow Fork Doser Project are shown in Table 1.

The data in Table 1 was inserted into an Excel spreadsheet and analyzed to generate a power curve as shown in Fig. 1. The curve equation generated from the data describes the calculated relationship between flow and acid concentration in Snow Fork. This equation could then be used for estimating acid concentrations in Snow Fork at any rate of flow. Fortunately, historical daily mean flow values for Snow Fork were available from USGS records of former monitoring Station 00060, located very close to the State Route 78 site. Snow fork flow data available for the period of 10/01/1980 to 9/30/2002 was applied to the equation and the minimum, median, and peak daily anticipated acid loads in Snow Fork were estimated and used to calculate the corresponding requirements for Hydrated Lime. Consideration was also given to the total drainage area at the Brush Fork doser site being only 79% of the total drainage area at the former USGS station site.

The estimated quantity of lime for complete neutralization of the calculated median annual acid load in Snow Fork was estimated at approximately 853 t/a. This represents the total combined amount of lime to be discharged from both the Brush Fork and State Route 78 dosers with a total combined feed rate ranging from a maximum of 953 lb/h to a minimum of 60 lb/h. The monthly quantities of dry lime required for neutralization of the anticipated acid loads are shown in Table 2, with the highest occurring during March and April and lowest in September and October.

Although the Snow Fork Doser alone was theoretically capable of achieving the AMD treatment objectives for Snow Fork and Monday Creek, the reliability on a single doser system could leave the system

Table 1 Snow Fork Water Data at SF00630

Qcfs	Qgpm	Acid Conc. mg/l	Qcfs	Qgpm	Acid Conc. mg/l
1.68	754	130	13.54	6,077	82.7
1.87	839	116	14.5	6,508	113
2.14	960	162	14.63	6,566	53.4
2.17	974	151	15.13	6,790	78.2
2.189	982	99.5	15.13	6,790	78.2
2.22	996	91.84	16.05	7,203	86.6
2.3	1,032	128	17.29	7,760	55.1
2.542	1,141	80.5		0	25
2.542	1,141	81.9	18.291	8,209	30.7
2.7	1,212	87.4	18.6	8,348	115
2.86	1,284	94.9	19.3	8,662	67
2.9	1,302	123	20	8,976	35.5
2.9	1,302	94.2	20	8,976	62
2.96	1,328	107	21.266	9,544	34.2
3	1,346	126	21.452	9,628	62.4
3.982	1,652	99.2		0	16
3.72	1,670	70.4	24.3	10,906	61
3.76	1,687	96	25.45	11,422	61.1
3.762	1,688	72	25.93	11,637	66
4.03	1,809	54.1	29.3	13,150	61.5
5.35	2,401	102	29.53	13,253	41.3
5.7	2,588	73.3	31.158	13,984	84.7
5.35	2,401	102	29.53	13,253	41.3
5.7	2,558	73.3	31.158	13,984	84.7
6.42	2,881	65.6	31.19	13,998	40.7
6.895	3,094	64	32.087	14,401	47.7
9.58	4,300	109	32.428	14,554	93.3
11.1	4,982	57.1	32.66	14,658	50.1
11.63	5,220	69.5	34.19	15,344	37.1
12.779	5,735	73.3			

vulnerable to treatment interruptions due to mechanical failures or interruptions to lime deliveries. Additionally, the frequency of lime deliveries would have been high for a single site. Therefore construction of both the Brush Fork and State Route 78 dosers is planned. The Brush Fork site had the advantage of being immediately downstream of the largest AMD contributors to Snow Fork and is to be constructed before the State Route 78 Doser. Bidding of the Brush Fork Doser is planned for 2024, but construction completion is not anticipated before 2025 due to long lead times for the lime silo and electrical components, which are currently taking about a year for time of order to delivery. The State Route 78 Doser bid date has yet to be determined, but is expected to follow within a year or two.

Table 2 Estimated lime requirements in pounds of dry calcium hydroxide per month (SF00630)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
lbs/month	176,699	199,341	240,541	272,752	232,700	176,672	80,947	88,347	48,329	44,514	55,638	90,088
tons/month	88	100	120	136	116	88	40	44	24	22	28	45
refills/month	1.5	1.7	2.0	2.3	1.9	1.5	0.7	0.7	0.4	0.4	0.5	0.8

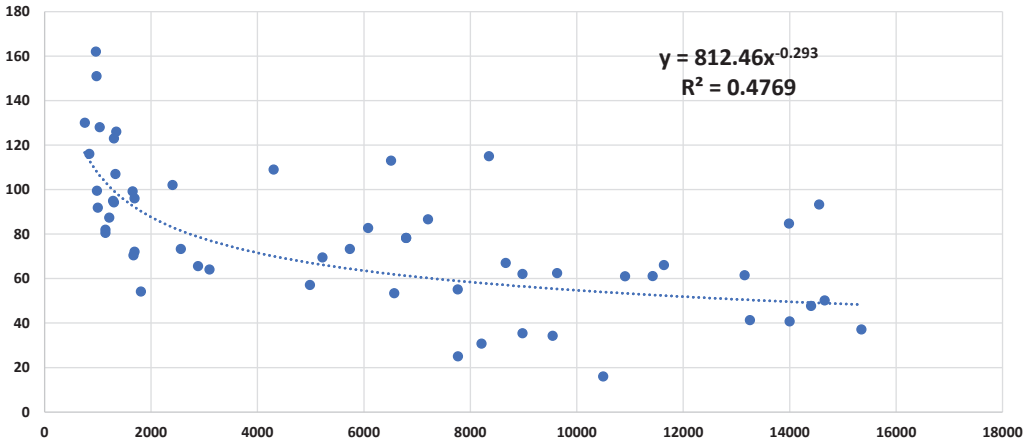

Figure 1 *Q (gpm) vs. Acidity (mg/L) Power Curve Fit*

The cooperation and persistence of the groups involved in moving this project to the bidding phase should serve as motivation to other watershed groups and stream restoration efforts. Although other options are available for AMD treatment, the application of active treatment using lime dispensed directly from "dosers" into affected waters has been successful elsewhere in Appalachia, and as shown in this design, can be successful at Snow Fork and Monday Creek in Ohio.