SUCCESS AND PROBLEMS AT ACID MINE DRAINAGE ABATEMENT PROJECT COLD STREAM SITE A CONTRACT NO. AMD 14(0850)101.1 RUSH TOWNSHIP, CENTRE COUNTY[1]

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Abstract. A series of sedimentation basins and vertical flow wetlands (VFWs) were constructed on approximately 1.6 hectares (4 acres) of ground at a cost of $239,000 in the fall of 1998. The sedimentation basins remove metals precipitates and the VFWs neutralize acidity through neutralization (limestone) and sulfate reduction (spent mushroom compost). The system was designed to handle flows of about 450 L/minute (120 GPM) of highly acidic water (pH 2.6, 70 mg/L of iron, and an acidity of 900 mg/L) but has experienced flows ranging from 0 to 5300 L/minute (1400 GPM). The treated water has averaged pH 7.0, iron concentrations less than 1 mg/L, and no net acidity. There have been problems with aesthetics and odor complaints, and these have been dealt with. Based on our experience at this and other sites, some pre-and post-construction recommendations are provided.

Additional Key Words: passive treatment, vertical flow wetlands.

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[1] Paper was presented at the 2004 National Meeting of the American Society of Mining and Reclamation and the 25th West Virginia Surface Mine Drainage Task Force, April 18-24, 2004. Published by ASMR, 3134 Montavesta Rd., Lexington KY 40502.

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Proceedings America Society of Mining and Reclamation, 2004 pp 1663-1671
DOI: 10.21000/JASMR04011663
https://doi.org/10.21000/JASMR04011663

Introduction

The Pennsylvania Department of Mines and Mineral Industries first documented the discharge of mine drainage into Cold Stream in 1969 under Operation Scarlift. Further investigations by different agencies revealed that mine drainage was discharging into an unnamed tributary in the Glass City area from several different locations. Cold Stream supports a reproducing brook trout population upstream of the Glass City tributary, and supports stocked trout upstream and downstream of the tributary. In 1996, the PA Bureau of Abandoned Mine Reclamation (BAMR) decided to design and construct passive treatment systems to treat these discharges in this watershed.

Cold Stream system A is one of several systems constructed in 1998. The project site is located on the east side of and adjacent to State Route (SR) 0350, south of the Borough of Philipsburg, in Rush Township, Centre County (Fig. 1), on the Sandy Ridge USGS 7.5' Quadrangle at north latitude 40° 51' 48" and west longitude 78° 13' 24". A vertical flow wetland (VFW) was constructed by BAMR to treat the highly acidic, high metal discharges of AMD from an underground mine complex. The system is designed to handle about 450 L/minute (120 GPM) flow. However, during the last four years, we have documented flows ranging from 0 to 5300 l/minute (1400 GPM). Despite this, the system has operated very effectively. Since completion of the construction, the mine water discharge that is being treated has averaged a pH of 2.6, 70 mg/L of Fe, and 900 mg/L of acidity (as $CaCO_3$). The treated water coming out of the system has an average pH of 7.0, Fe less than 1 mg/L, and no net acidity.

Success of the System

Cold Stream System A is made up of two VFWs, an AMD collection pond, a settling pond, an aerobic wetland, and a collection channel. The ponds total about 1.6 hectares (4 acres) in area. Woodduck Chapter Trout Unlimited of Phillipsburg is actively involved in monitoring this watershed and is monitoring the quality of treated discharge at this site. Since the completion of this system, Mr. Merlin Bock, a dedicated member of this group, has collected water samples on a regular basis. The PA Department of Environmental Protection (DEP) analyzed these samples and tabulated them (Table 1). Table 2 shows the amount of metals removed.

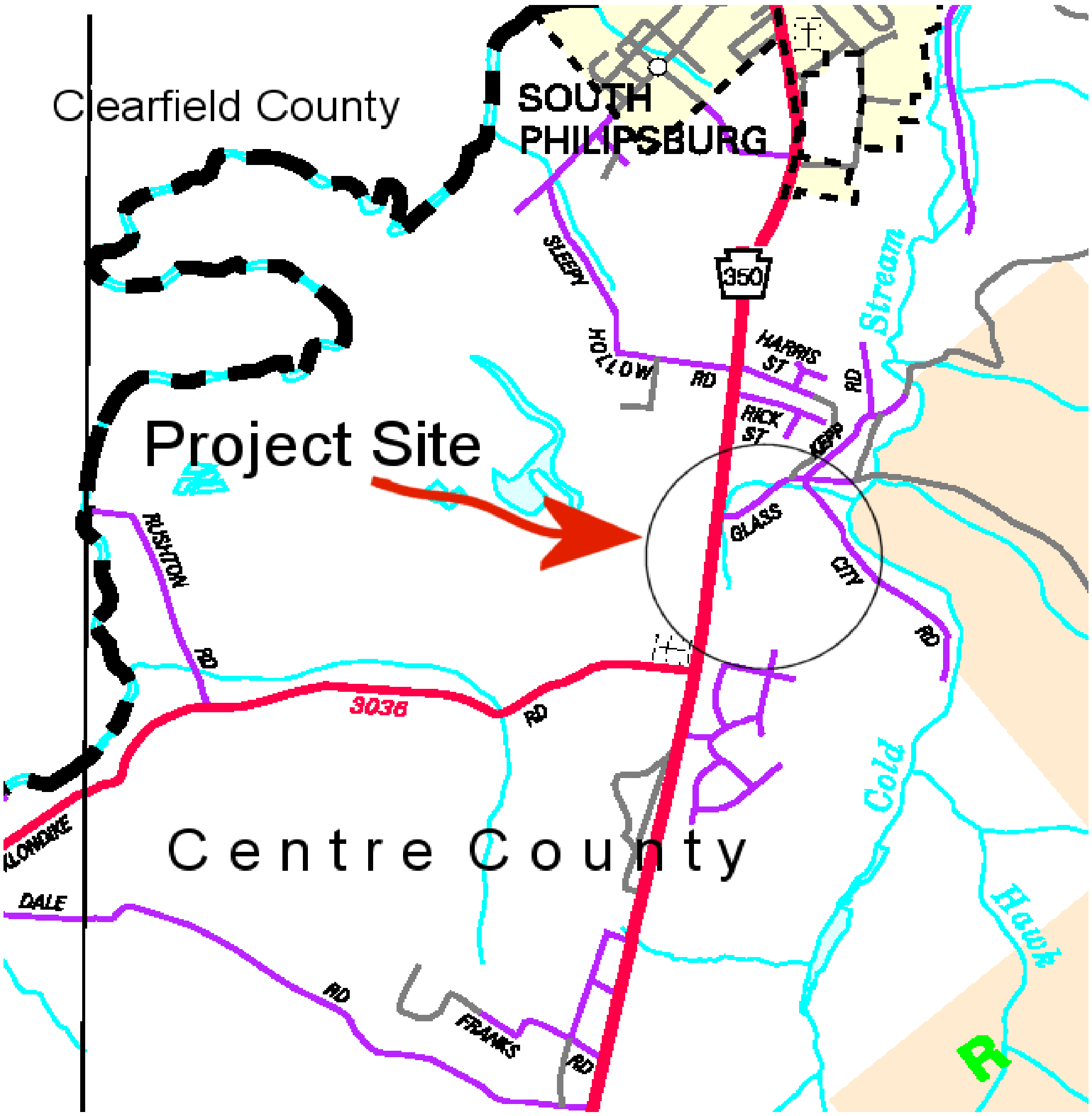

Fig. 1 Project location map

The local partnership has greatly benefited everyone. Benefits of this passive treatment system have already been observed in Cold Stream near the Glass City area. A biologic survey of Cold Stream done by BAMR personnel, in May 2000 and June 2002, compared to a survey done in 1995 show considerable improvements in the biologic health of the stream (Table 3). Although Station 1 has not improved since 1995, Stations 2-4 have improved. The total numbers of taxa, the numbers of mayflies, and the EPT index (Ephemeroptera, Trichoptera, and Plecoptera) have all increased at Stations 2-4.

Table 1. Water Quality Monitoring Report; Flow data on this spreadsheet are estimated.

**Water Monitoring Report, Cold Stream AMD Treatment System Site A
Rush Township, Centre County**

Date	Location	sample ID	pH	Fe, mg/L	Mn, mg/L	Acidity, mg/L	Al, mg/L	T Alk mg/L $CaCO_3$	SO_4 mg/L	Ca^{2+}	T HARD mg/L $CaCO_3$	TSS mg/L	Mg mg/L
07/10/98	SAP2 seep	7442234	2.6	77.1	2.8	564	42.3	0	481	20.3			14.9
04/19/99	influent	7442013	2.6	58.8	0.997	274	21	0	206	6.79	44.2906	22	6.63
	effluent	7442014	7.3	0.487	0.595	0	0.1	170	650	217	605.948	10	15.4
05/20/99	influent	7442016	2.6	77.6	1.77	338	31.7	0	315	11	64.1268	10	8.89
	effluent	7442015	7.6	0.293	0.494	0	0.1	402	326	219	615.068	16	16.4
06/16/99	influent	7442020	2.6	92.9	2.18	618	43.8	0	572	15.3	89.75	20	12.5
	effluent	7442021	8.2	0.19	0.36	0	0.1	634	142	248	709.4	86	21.7
10/06/99	influent	4341030	2.5	195	4.51	458	92.8	0	na	28.3	175.81	16	25.5
`	effluent	4341035	6.8	1.14	0.695	0	0.262	936	24	359	1046.232	24	36.1
10/19/99	influent	7442001	2.4	209	4.35	694	98.8	0	380	29.1	174.102	16	24.6
	effluent	7442002	7	0.135	0.816	0	0.1	928	304	394	1134.556	24	0.816
11/18/99	influent	7442039	2.5	192	4.72	670	102	0	715	28.7	173.102	10	24.6
	effluent	7442038	7.1	2.52	1.21	0	0.619	816	99	344	994.724	154	32.7
12/17/99	influent	7442053	2.5	156	2.1	856	53.4	0	605	14.6	98.712	16	15.1
	effluent	7442056	6.9	8.41	0.696	0	3.12	144	551	191	605.6	64	31.1
01/14/00	influent	7442065	2.5	150	2.38	854	57.7	0	453	14.2	92.356	40	13.8
	effluent	7442068	7.0	2.08	1.07	0	0.655	86	631	205	620.444	170	26.2
03/17/00	influent	7442089	2.6	68.9	1.42	458	25.7	0	189	9.26	58.7468	<2	8.64
	effluent	7442090	6.8	1.36	1.87	0	0.1	120	530	224	623.036	4	15.3
04/19/00	influent	7442093	2.6	67.4	1.19	456	23.1	0	268	8.56	54.154	<2	9.95
	effluent	7442094	6.9	0.466	1.05	0	0.255	134	449	201	567.596	<2	15.8
05/18/00	influent	7442097	2.6	66.9	1.5	532	29.5	0	439	9.79	62.3378	6	9.19
	effluent	7442098	6.5	0.886	1.34	0	2.46	62	503	163	457.352	8	12.1
06/19/00	influent	7442101	2.6	80.5	1.37	534	28.8	0	217	9.77	63.1118	<2	9.39
	effluent	7442102	6.8	1.93	0.641	0	0.344	88	556	173	490.18	12	14
07/17/00	influent	7442105	2.5	99.3	2.12	676	41.6	0	471	13.5	91.43	<2	14
	effluent	7442106	6.6	13.6	1.55	0	0.891	116	529	199	572.072	22	18.1
09/21/00	influent	7442117	2.4	83.7	3.84	424	68	0	352	21.3	139.77	16	21
	effluent	7442118	7	282	7.66	0	33.4	94	588	170	485.564	1080	14.7
11/16/00	influent	7442125	2.7	66.5	1.95	426	35.2	0	216	14.9	84.63	138	11.5
	effluent	7442126	6.6	7.27	0.732	0	1.8	38	77	46.3	153.7364	138	9.22
12/18/00	influent	7442129	2.5	174	3.3	1140	74.3	0	173	21.2	130.868	20	18.9
	effluent	7442130	7.1	6.3	0.842	0	0.702	180	617	239	683.196	40	20.8
03/19/01	influent	7442137	2.5	67.9	1.1	336	21.7	0	242	8.05	52.1374	<2	7.77
	effluent	7442138	7.1	0.842	0.415	0	0.1	144	683	203	565.18	<2	14
05/22/01	influent	4341001	6.4	459	1.38	0	233	266	612.2	256	685.732	45748	11.1
	effluent	4341002	6.3	131	1.21	0	32.8	136	557.9	207	563.232	320	11.1
06/18/01	influent	7442141	2.4	126	2.69	869.2	53	0	607.2	16.1	108.23	12	16.5
	effluent	7442142	6.9	6.4	2.86	0	0.1	104	457	196	554.684	28	15.7
9/26/2001	influent	4341005	2.6	75.4	5.6	787.2	75.4	0	203	24.3	150.56	<2	21.8
	effluent	4341006	6.7	30.3	5.14	0	4.13	70	435	219	631.96	30	20.5
1/28/2002	influent	4341009	2.5	183	2.81	954.4	68.3	0	728	19.9	120	1	17.1
	effluent	4341010	7.1	2.03	2.08	0	0.1	130	520	222	646	1	22.2
5/1/2002	influent	4341013	2.5	88.6	1.38	383	32.3	0	582	9.41	61	1	9.1
	effluent	4341014	7.2	0.518	0.282	0	0.1	66	478	201	564	1	15
6/24/2003	influent	4341901	2.6	35.5	0.883	306.2	16.2	-	255.9	6.97	43	<2	6.2
	effluent	4341906	7	0.192	0.157	0	< .2	86.6	321.5	155	433	6	11
7/31/2003	influent	4341001	2.6	39.5	1.0	359.4	17.9	0	357.7	7.4	46	<2	6.6
	effluent	4341006	7.3	0.47	0.471	0	< .2	65.2	364.8	145	409	4	11.68

Table 2. Average metal removed in tons/year at Cold Stream System A.

Assumed average flow is 60 GPM				
Year	**Average metal removal in tons/year**			
	Acidity	**Fe**	**Al**	**Mn**
1998	40.28	7.49	3.16	0.11
1999	53.71	17.06	4.21	0.15
2000	81.09	8.06	5.06	0.04
2001	71.68	7.16	5.38	0.03
2002	87.64	17.65	6.59	0.12
TOTAL	**334.40**	**57.44**	**24.39**	**0.46**

Table 3. Insect Summary of Cold Stream from 1995-2002.

	1995	2000	2002
Total taxa			
Station 1	19	14	15
Station 2	12	21	16
Station 3	10	15	22
Station 4	4	22	27
Total no. of mayflies			
Station 1	8	2	5
Station 2	4	5	4
Station 3	2	2	6
Station 4	0	5	6
EPT index (the no. of mayfly, stonefly, and caddisfly taxa)			
Station 1	15	6	9
Station 2	7	10	8
Station 3	7	8	12
Station 4	2	13	10

Problems Experienced and Lessons Learned at System A

During construction, test pits were excavated and indicated pervious soil characteristics. Therefore, metal retention ponds were lined with 40 mil plastic, and other ponds were lined with on-site dense clay. A new discharge was found (0-112 L/minute, 0-30 GPM) and was routed to the constructed aerobic wetland for pre-treatment and to the VFP for final treatment. The entire project area was fenced because of its proximity to a residential area, which increased the cost of the project.

After the completion of this system in the fall of 1998, DEP-BAMR received numerous aesthetic and odor complaints from surrounding residents and their legislator. Although, this VFW passive treatment system has worked very well in removing the acidity and metals from the discharge, it is not without problems. The problems at the site have been related to aesthetic and odor complaints from surrounding residents. Flow into this system has been intermittent due to drought conditions experienced after the completion of the system. There was no flow through the system for periods of time in the late summer and early fall of 1999, resulting in stagnant conditions within the system. When flows increased significantly due to rainfall in late fall and early winter, the resulting discharge caused severe odor problems from hydrogen sulfide gas. The topography of the area and its close proximity to many residents exacerbated the problem. In order to address the situation, the system effluent was buried under limestone by constructing a small limestone dam at the discharge point. This seemed to at least temporarily correct the problem. Additionally, it as determined that the 1st VFW was removing most of the metals and acidity entering the system and that the partially treated influent entering the 2nd VFW is free of metals. So, compost was removed from the last VFW in an effort to remove a source of the sulfate reduction reaction. The excavated compost was used at another system in a more remote area of the watershed.

Flow into this system had been intermittent. There was no flow through the system for a period of time in the late summer and early falls of 1999, due to drought conditions in this area, resulting in stagnant conditions within the system. Mushroom compost in the VFPs was exposed during this time. When flows increased significantly due to rainfall in late fall and early winter, the resulting discharge caused severe odor problems from hydrogen sulfide gas. At sites where water has flowed continuously through the VFWs, the hydrogen sulfide odors have been much less evident.

The aesthetic complaints were partially the result of the chain link fence constructed around the site after some local residents expressed safety concerns. While some of the local residents wanted the fence, others complained about its appearance. There were also complaints that the revegetation of the site was inadequate and that the cells did not blend in well with the surrounding area. Conifers were planted around the site and shrubs were planted on the embankments to improve the aesthetics of the site. In addition, three feet of dirt was removed from the top of the second VFP so that a neighbor could see the pond from his house. (However, one local resident has continued to voice complaints about the site's appearance.) The dirt and compost was donated to the local watershed group. They used the material for another passive treatment system being constructed further downstream.

In January 2002, we tried to flush this system after a few months without flushing, and found the flush pipe clogged with grass and metal oxides. It took considerable effort to unclog this pipe. Since then, we make it a practice to flush this system on a monthly basis.

Recommendations for Improving Passive Treatment Systems

The following recommendations are based on observations made during the maintenance of these systems. Our problems have, for the most part, been related more to hydrologic issues than a failure of the systems to effectively treat water. Considerable adjustments were made after construction for our systems to operate as designed. Also, maintenance needs have been much greater than originally envisioned. However, once the "bugs" were worked out, the systems have been quite successful. Much of what we have learned has been summarized below:

Pre Design Stage.

- Sample collection, lab analyses and flow measurements need to continue for as long as possible, with one year of data collection being the minimum recommended prior to commencement of design. Low flow and high flow data should be included in the design.
- Site evaluations need to include an evaluation of soil material to determine suitability for construction of treatment systems. Contracts should be flexible enough to allow for changes during construction, including the addition of synthetic liners where needed.
- Plan to have staff and funds available for post-construction "tweaking" and long-term operation and maintenance.

Practical Considerations during Design.

- Flow distribution boxes may be needed to divert high flows away from the treatment system.
- System designs should provide post-construction sampling and flow measurement capabilities.
- For uniform distribution of discharges, VFPs should not be too long.
- It is ideal to have separate flush ponds for each VFP. This will save lot of time to make room for flushed water and also will help in metal recovery at some future date.
- VFP systems should be located away from residential areas to avoid odor complaints.

- Roadways leading to all structures and monitoring points need to be constructed.
- A cul-de-sac or turn around should be constructed at the entrance of the system for easy exit.
- Location of level control boxes and valves should be on flat ground for easy operation.
- Tall markers should be constructed around the level control boxes and gate valves so they can be easily located during winter months.
- Corrosion resistant covers and locks should be used.
- VFPs should be leak proof, preferably lined with synthetic material.

Post Construction

- Stop logs used in the level control box can become coated with Fe and Al oxides. They need to be cleaned regularly. Rubber gaskets used on these stop logs to seal the joint between two adjacent stop logs wear out and need to be replaced.
- The outlet of a VFP should be submerged to avoid odor problems.
- Experience has proven that all passive treatment systems need regular maintenance.
- Post-construction monitoring is needed for making performance adjustments to the system. In addition, the data provides an opportunity for feedback to modify and enhance future designs.

While it is apparent that there are many challenges when addressing AMD with passive treatment facilities, these systems are also showing great promise in many watersheds. Biological assessments of these watersheds are documenting substantial improvements.

Acknowledgements

I thank Pam Milavec, Eric Cavazza, P.E; Joe Schueck, P.E; Kay Spyker, Rich Beam, P.G. and Dan Sammarco, P.E. of PADEP, for their assistance in preparation of this presentation. I also want to Thank Mr. Robert Kleinmann of Department of Energy for editing this presentation.

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