Report for 2003PA16B: Development of Passive Treatment System Monitoring and Research Program

There are no reported publications resulting from this project.

Report Follows

Abstract:

Stream Restoration Inc. and Grove City College propose to develop a training program to monitor passive treatment systems and receiving streams in the headwaters of Slippery Rock Creek. Since 1995, a public-private partnership effort consisting of non-profit corporations, colleges and universities, private industries, and governmental agencies have cooperated in the restoration of the 27-sq. mi. headwater area of the Slippery Rock Creek Watershed. The quality of the headwaters was documented in 1970 by Operation Scarlift to be heavily impacted by abandoned mine drainage. To date, 15 passive treatment systems have been constructed within the project area including every major type of component, such as vertical flow ponds, aerobic wetlands, anoxic limestone drains, open limestone channels, and horizontal flow limestone beds. Even though the passive systems are low maintenance, periodic inspection and monitoring will help insure the timely resolution of minor maintenance issues before larger problems develop. In addition, decreasing effectiveness in water treatment will also be documented in order to improve the design of future passive systems. This program will continue the extremely important outreach and educational opportunities to students and interns, vital not only to the professional growth of individual students but also to sustaining the watershed restoration concept.

Statement of Critical Water Problem:

Problems associated with abandoned minelands are so extensive that alone neither federal, state, or local governments nor the mining industry nor watershed groups can adequately address the impacts. In Pennsylvania, $2{,}500^{+}$ miles of streams are impacted (equal to the distance from Pittsburgh, PA to Los Angeles, CA) and $250{,}000^{+}$ acres are unreclaimed. In northern Butler County, western Pennsylvania, coal mining was conducted in a 27-sq. mi. area of the Slippery Rock Creek headwaters for over 100 years. Mining communities which once flourished are now abandoned and what remains are polluted streams, coal refuse, and spoil. The residents that stayed called Slippery Rock Creek, “Sulfur Creek”, due to the affects of mine drainage. In 1970 during the Commonwealth’s Operation Scarlift, the quality of the headwaters was documented to be “the most severe condition of coal mine drainage... Indeed, very little drainage from this region is produced exclusive of contact with, or issuance from mine workings.” (About 4000 acres are underlain by mine workings and 8000 acres were included in surface mine permits.) Within the 410 square miles of the Slippery Rock Watershed, streambed sediments in the headwaters have the highest heavy metal concentration.

Since 1995, a public-private partnership consisting of non-profit corporations, colleges and universities, private industries, and governmental agencies have cooperated in the restoration of the 27-sq. mi. headwater area of the Slippery Rock Creek Watershed. To date, 15 passive treatment systems have been constructed within the project area including every major type of component, such as vertical flow ponds, aerobic wetlands, anoxic limestone drains, open limestone channels, and horizontal flow limestone beds. These systems remove 30% of the acid loading and contribute 193 kg/day of alkalinity to Slippery Rock Creek and its tributaries along with removing over 27% of the iron and aluminum loading. Without proper monitoring and maintenance, the effectiveness of these systems is not certain.

Objectives:

Since these passive systems include all technologies currently available for the treatment of acid mine drainage, they provide a unique opportunity for the development of educational training programs for undergraduate students. These students will be given "hands-on" experience and training from professionals in the field of passive treatment.

Specifically, students will:

- Conduct monitoring and maintenance of 15 passive treatment systems and their receiving streams in the headwaters of Slippery Rock Creek
- Conduct field and lab analysis of the passive systems and receiving streams
- Upload data to a website for investigators and others to view
- Evaluate the performance of the passive systems

Timeline of Activities

Milestones Project Tasks	**Responsible Parties**	**Start Date**	**End Date**
Grant Administration	SRI	03/2003	04/2004
Project Development Compile or complete O&M Plan for each of 15 passive treatment systems Develop website in order to download blank inspection forms and enter site data collected Develop inspection sheet w/site schematic for each site Purchase field test labs(2) and digital cameras(1)	BMI, GCC, SRI, 241	03/2003	04/2003
Site Monitoring Monthly-passive systems Annually-land reclamation sites (growing season to Sept.) Annual wetland monitoring	BMI, GCC, SRI	04/2003	04/2004
Aquatic Survey (Fish and macroinvertebrates) Annual "fish-shocking" of six stream stations	GCC, SRI	07/2003	07/2003

Abbreviations: BioMost, Inc. (BMI); Grove City College students (GCC); Stream Restoration Inc. (SRI); 241 Computer Services (241)

Methods:

Students will begin by creating site-specific monitoring and maintenance plans based on an existing template of a passive treatment system. The plan would consist of a site inspection schedule and field and laboratory testing of selected intermediate points between passive components in order to document the effectiveness of each and to determine if maintenance or retrofitting is necessary. Field and laboratory testing (including flow measurements) and inspection are to be conducted monthly. Both total and dissolved metals will be analyzed

according to Standard Method procedures. During inspections digital photos would be taken of selective features in order to assist in determining the need for maintenance. Simple maintenance tasks, such as removal of excessive vegetation from inlet or outlet structures, will be performed in the field at the time of the evaluation. Inspection of passive treatment systems may take up to an hour or more while inspection of land reclamation sites may require only a few minutes to photograph the site. Passive treatment experts will assist the students with the creation of the monitoring and maintenance plan and during the first monitoring event.

Wetlands will be monitored annually for functionality and diversity. Success of vegetative establishment will be documented by estimating percent coverage of plant species. Survival rates will be estimated using species counts that are correlated to the original species planted. Vegetative densities and survival rates will be used to document successful establishment of the wetland or identify problems requiring corrective measures. Invasive species will be identified, monitored closely, and removed as determined to be necessary. Extremely aggressive invasive species, such as Phragmites or purple loosestrife, will be removed immediately upon identification.

An aquatic survey will be conducted annually. Last year, Dr. Fred Brenner, Grove City College biology professor, documented the return of fish in the upper portion of Seaton Creek, which just the year before had a 4.5 pH and now has a 6.5 pH. Documenting the return of fish in other portions of Seaton Creek and the main branch of Slippery Rock Creek would be invaluable in the determination of the success/failure of the entire headwaters restoration effort.

All plans created and information obtained through this program will be placed in an online database to document the performance of the passive systems. The online database will provide three basic functions (1) to download site-specific monitoring and maintenance plans, (2) to upload information gathered in the field or from laboratory reports, and (3) to provide meaningful, accessible reports on demand. The database will be MySQL format, stored on a server (600MB of space) and accessed via the world wide web. Data will be uploaded in comma delimited format. The data will automatically be inserted into the database and will be immediately accessible. The data will be able to contain objective measurements as well as subjective comments and photographs. Reports specified by Stream Restoration Inc. and Grove City College will be generated on demand from the latest data available. The reports will be available in a printable format or for download as comma delimited text files. Professionals will assist the students in the creation of this database.

The Slippery Rock Watershed Coalition has a unique opportunity to research a variety of passive treatment systems and land reclamation techniques in the headwaters of Slippery Rock Creek. Coalition participants, having been involved in the restoration effort, are extremely familiar with the design of these systems. The following innovative passive systems have been successfully implemented (See also attached map):

Site	Year	Restoration Effort	Special Challenge	Innovative Solution	Comments
SR114	1995	1450 T ALD	125-gpm upwelling	vertical collection	largest ALD in PA (1995)
Bertha	1996	900 T ALD	lake proximity	ALD encapsulation	Bald Eagle use of lake
Tipple	1996	alkaline addition	100,000 T gob	175,000 T coalash	21-ac floodplain
Ferris	1997	four VFP	5 flows(170 gpm)	compost/LS & LS-only	1st two-step VFP in PA
Able	1998	land reclamation	acidic spoil	90,000 T coalash	56-ac "no-cost" project
SR109	1998	VFP	limited space	decreasing depth pond	diverse wetland T
SR101A	1998	900 T ALD	sloughing soils	piezometers-head data	old railroad grade used
Brookville	2001	alkaline addition	gob piles in stream	gob neutralization	22 ac reclaimed
DeSale I	2000	3000 T VFP(2)	high dissolved Al	VFP in parallel	1st two-tier piping in PA
DeSale II	2001	4400 T VFP (2)	treat entire stream	controlled intake	1 acre wetland
Goff	2001	8200 T VFP (4)	5 flows (400 gpm)	2 VFP in parallel	bat hibernaculum
SR96	2002	700 OLD	oxygen in AMD	Flushing option	1st known in W. PA
SR81	2002	1300 T ALD	relocated discharge	in-situ collection	add. land reclamation
DeSaleIII	2002	1700 VFP (2)	high acidity	3 alk gen. in series	use existing facilities
Erico	2002	12,000 T ALD (3)	Mine pool	Built over coal seam	largest known ALD (2002)

As an example, the Goff Station Restoration Area is an extremely innovative, 15 component system that includes the creation of wildlife habitat. This system is successfully treating the mine discharges and has further developed passive treatment technology. The first full-scale, side-by-side comparison of limestone-only and limestone/compost Vertical Flow Ponds were constructed at this site. The monitoring of these Vertical Flow Ponds will provide valuable information into the design of future passive systems.

As-built drawings exist for most of the restoration sites. An as-built is a detailed post-construction plan drawn to scale that includes survey elevations. As a result of this information, the performance of these systems can be accurately evaluated and the most productive system identified.

Related Research:

During the last decade, vertical flow pond (VFPs) have been used to treat AMD, but the mechanisms operating within these systems are not completely understood. Based on the initial design or these systems proposed by Kepler and McCleary (1994), VFPs provide net addition through the dissolution of limestone and sulfate reduction, resulting in the precipitation of iron and aluminum in the substrate. Brenner (2001a,b) reported that VFPs are effective in removing over 90% of the iron and aluminum, but they are not as effective in removing manganese. Demchak (1998) indicated that the efficiency of some of these systems began to decline after 18-24 months due to a reduction in limestone and iron accumulation in the substrate and similar results were reported by Brenner (2001a,b) and Brenner *et al.* (2002) for a scale model of these

systems. When a scale model was dissected, iron precipitates had accumulated in the upper third of the substrate and efficiency of the system in both alkaline addition and metal removal had declined in the second year of operation (Brenner 2001a,b). Demchak (1998) also reported the overall effectiveness of the VFPs varied seasonally especially as the systems aged.

The objective of the current study is to evaluate the efficiency of passive systems in the headwaters of Slippery Rock Creek while providing an educational experience for undergraduate students. Only sporadic water quality sampling has occurred to date of these systems. This study will monitor monthly each component and document their performance and effects on the receiving streams. This information can then be compared to similar studies by Demchak and Brenner.

References:

Brenner, F.J. 2001a. Use of constructed wetlands for acid mine drainage abatement and stream restoration. Water Science Technology 44:449-454.

Brenner, F.J. 2001b. Use of constructed wetlands for acid mine drainage abatement on a watershed basis. pp 267-276. *In.* Integrated Surface and Ground Water Management. B.K. Panigrahi (ed). American Society of Civil Engineers. Reston, VA.

Brenner, F.J., K.D. Kosick, S. Busler, C.A. Gardner, and C. Tippie. 2002. Efficiency of a Scale model vertical flow and aerobic wetland system in treating acid mine drainage. American Surface Mining Association. Lexington, KY pp 818-829.

Demchak. J.L. 1998. Analysis of vertical flow wetlands in the treatment of acid mine Drainage. Unpub. M.S. Thesis. Clarion University of Pennsylvania.

Kepler, D.A. and E.C. McCleary. 1994. Successive alkalinity-producing systems (SAPS) for the treatment of acidic mine drainage. Proceedings International Land Reclamation and Mine Drainage Conference and Third International Conference on the Abatement of Acid Drainage. 1:195-204.

Results:

Fifteen passive treatment systems in the Slippery Rock Watershed were monitored for 12 months beginning in May of 2003 and terminating in May of 2004. Currently, these systems are treating over 700,000,000 gallons of acid mine drainage annually. These combined systems are currently removing 640 tons/yr of acidity and 160 and 30 tons/yr of iron and aluminum, respectively from acidic discharges while providing 70,445 kg/year of alkalinity to Slippery Rock Creek and its tributaries. These systems include every major type of component currently used to treat acid mine drainage such as vertical flow ponds, aerobic wetlands anoxic limestone drains, open limestone drains and horizontal flow limestone beds. Although these systems varied in their efficiency, all systems except SR 109 were effective in treating acid mine drainage. In the remaining 14 systems, the pH increased from <3 to between 6.0 and 7.2 and alkalinity exceeded acidity in the final discharge to receiving streams. The systems comprised of a combination of vertical flow ponds and aerobic wetlands were effective in removing iron and aluminum and the concentrations of these metals were < 4 mg/L in the final discharge even in those systems where iron and aluminum exceeded 50 mg/L in the inflows. But only those systems with horizontal flow limestone beds as the final treatment system were effective in removing manganese from

acidic mine discharges. For the two vertical flow pond/aerobic wetland and horizontal flow limestone bed systems, 27 mg/L of alkalinity (as $CaCO_3$) was added to receiving streams and iron, manganese and aluminum concentrations were reduced by 40 mg/L, 16 mg/L and 27 mg/L respectively. In addition, pH units increased from an average of between 2.87 and 3.80 in the inflows to an average of between 6.8 and 7.2 in the discharges to receiving streams. In order to insure adequate alkaline addition and manganese removal to receiving streams, it is recommended that the inclusion of horizontal flow limestone beds be considered as the final treatment in all passive treatment systems. As a result of the improvement in water quality in receiving streams, macroinvertebrates and fish are beginning to re-colonize the headwaters of Slippery Rock Creek and its two major tributaries, Murrin Run and Seaton Creek. During the last year, caddisflies, mayflies, dragonflies, damselflies, crayfish and three fish species have been collected in both Seaton Creek and Murrin Run below the discharges of these passive treatment systems.

Students Supported:

Jeremy Benjamison, Biology Major, Junior, Grove City College
Emily Coughlin, Biology Major, 2004, Graduate, Grove City College
Ty Coulter, Biology Major, Junior, Grove City College
James F. Dunne, Chemistry Major, Junior, Grove City College
Candace McClure, Biology Major, 2003, Graduate, Grove City College, Graduate School of Public Health, University of Pittsburgh
Natalie Johnson, Biology Major, 2004, Graduate, Grove City College.
Peggy Lo, Biology Major, Junior, Grove City College
Justin Treeter, Molecular Biology Major, Sophomore, Grove City College

Papers Presented:

The efficiency of passive treatment systems and their impact on Seaton Creek. Emily Coughlin, Jeremy Benjamison, Justin Treeter, James Dunne, Candace McClure, Fred J. Brenner and Shaun Busler. Poster. American Society of Mining and Reclamation, Morgantown WV and Sigma XI Grove City College

Evaluation of the efficiency of passive treatment systems on water quality in the headwaters of Slippery Rock Creek. Emily Coughlin, Jeremy Benjamison, Justin Treeter, Terry Coulter, James Dunne, Candace McClure, Fred J. Brenner and Shaun Busler. Poster. American Society of Mining and Reclamation. Morgantown WV.

Watershed approach to acid mine drainage abatement: A historical prospective. Fred J. Brenner. Pennsylvania Academy of Science. Monroeville, PA.

Evaluation of passive treatment system efficiency in the headwaters of Slippery Rock Creek. James Dunne, Emily Coughlin, Candace McClure, Fred J. Brenner and Shaun Busler. Pennsylvania Academy of Science, Monroeville, PA

The efficiency of passive treatment systems and their impact on Seaton Creek. Emily Coughlin, James Dunne, Candace McClure, Nicholas Morgan, Fred J. Brenner and Shaun Busler. Pennsylvania Academy of Science, Monroeville, PA and Slippery Rock Watershed Student Symposium, Slippery Rock University.