**Passive Treatment in Pennsylvania Watersheds:
Erico Bridge Restoration Area – A Case Study[1]**

Slippery Rock Watershed Coalition[2]

Abstract

For two years, a passive treatment complex at the Erico Bridge Restoration Area, Venango Twp., Butler Co., PA, has successfully removed essentially 100% of the acidity, 97% of the iron, and 81% of the manganese from ~500 gpm of abandoned mine drainage. The ~24-acre site was formerly the largest contributor of acidity and iron to Seaton Creek, the most heavily impacted major tributary in the Slippery Rock Creek Watershed (Ohio River Basin). [1998 *Comprehensive Mine Reclamation Strategy,* PA Dept. of Environmental Protection, Knox District Mining Office] Through a public-private partnership effort representing more than 25 groups, the system was installed in less than two construction seasons. By neutralizing ~900 lbs/day of acidity and capturing ~500 lbs/day of metals, the implementation of this complex has enabled fish not only to return but also to spawn in the formerly dead Seaton Creek.

Introduction

With broad-based public and private support (including >150 local residents through support letters), Slippery Rock Watershed Coalition participants received funding through the PADEP Growing Greener program to install a passive system to treat five, net acid, metal-bearing, discharges, to remove coal refuse, and to enhance existing streambank wetlands. With funding from the Butler County Commissioners, Western PA Watershed Program, and generous donations and in-kind contributions from numerous partners, sixteen passive components were installed instead of the four proposed.

Including federal, state, and local permitting, site characterization addressing the abandoned underground mine pool, innovative passive system design (largest known Anoxic Limestone Drain within PA), and system installation utilizing innovative techniques, the project was completed without an increase in the original contract costs. This economic, efficient, and effective implementation was made possible by a coordinated team approach developed prior to submission of funding requests. This public-private partnership effort included government agencies, private industry, nonprofits, a local college, and volunteers.

Brief Description of Passive Treatment Complex

The 16-component passive treatment complex includes 3 Anoxic Collection Systems, 3 Anoxic Limestone Drains, 2 Plunge Pools, 5 Settling Ponds, 2 Aerobic Wetlands with fabricated substrate, and a Horizontal Flow Limestone Bed (Table 1). The main passive

---

[1] Paper presented at the West Virginia Surface Mine Drainage Task Force Symposium, 4/20/05, Morgantown, WV.

[2] Slippery Rock Watershed Coalition, c/o Stream Restoration Inc., 3016 Unionville Rd., Cranberry Twp., PA 16066, sri@streamrestorationinc.org, www.srwc.org

treatment complex was completed in June 2003. (Components for a small discharge were completed in May 2004.) Based on available monitoring data, the complex is neutralizing ~900 lbs/day of acidity and preventing ~500 lbs/day of metals from entering Seaton Creek. Pre-construction raw water averaged ~320 gpm with a 5.7 pH, 50 mg/l alkalinity, 62 mg/l total Fe, and 31 mg/l total Mn. With a post-construction average flow of ~500 gpm, the effluent quality averages 7.0 pH, 111 mg/l alkalinity, 2 mg/l total Fe, and 3 mg/l total Mn (See Tables 2-3 for additional water quality data).

Table 1: Passive Treatment System Components at the Erico Bridge Restoration Area

Component	Description
ACS1	Anoxic collection system for discharge 63E
ALD1	8,300 Tons, AASHTO #1, 90% $CaCO_3$, Vanport limestone
SP1	25,000 SF Settling Pond with 3 directional baffle curtains
SP2	32,000 SF Settling Pond
WL1	16,000 SF naturally-functioning aerobic wetland
SP3	11,000 SF Settling Pond
PP1	4,000 SF Plunge Pond energy dissipater from SP3 into WL2
ACS2	Anoxic collection system for discharges 63A (portion), 63B, and 63C
ALD2	3,300 Tons, AASHTO #1, 90% $CaCO_3$, Vanport limestone
SP4	18,000 SF Settling Pond
WL2	118,000 SF naturally-functioning aerobic wetland
PP2	5,000 SF Plunge Pond energy dissipater from WL2 into HFLB
HFLB	9,000 Tons, AASHTO #1, 90% $CaCO_3$, Vanport limestone
ACS3	Anoxic collection system for discharge 63A-1
ALD3	400 Tons, AASHTO #1, 90% $CaCO_3$, Vanport limestone for discharge 63A (portion)
WL3	17,000 SF “in-situ” wetland reconfigured to enhance treatment

Coordinated Land Reclamation

About 40,000 CY of abandoned coal refuse were removed, transported, mixed with alkaline coal ash from a circulating, fluidized-bed, power plant and placed within a nearby abandoned strip cut, reclaiming two sites (“2-for-1”) concurrently without additional costs to the Commonwealth. This would not have been possible without project partners Quality Aggregates and Scrubgrass Generating. Within the gob pile footprint, created wetlands were planted with over 40 species for ecological function and high-value wildlife habitat. With approval from the US Army Corps of Engineers, an innovative in-stream water elevation control structure was installed across Seaton Creek to establish the necessary hydrology for a 1-acre wetland and to enable >3.5 acres of severely-impacted wetlands along the banks of Seaton Creek to receive good quality water from the passive system.

Education and Outreach Opportunities

This site has been widely used for education and outreach activities including numerous tours, presentations, and newspaper, magazine and website articles. In addition, church youth groups, homeschool students, boy scouts, children at-risk, and adjudicated youth participated in the project by planting wetlands and uplands, and building and installing wildlife habitat structures such as bluebird, kestrel, and wood duck boxes, and osprey nesting platforms. Encouraged by local residents, site history was also compiled. Assisted by an online management tool, “Datashed”, to readily access information, volunteer monitoring will help to evaluate long-term performance.

Aquatic Habitat Returning

Complementing the recent De Sale, Goff Station, and Chernicky restoration efforts located upstream of Erico, the entire length (~5 miles) of Seaton Creek has been dramatically improved, resulting in Seaton Creek, probably devoid of fish for a century, supporting a reproducing fish population (spawning beds observed). Under the direction of Dr. Fred Brenner, Grove City College, electrofishing and macroinvertebrate monitoring will assist in evaluating the sustainability of stream restoration.

Brief Outline of Work Effort

- Completed applications/notifications and received permits/approvals necessary for the **~24-acre restoration site** from US Army Corps of Engineers, US Fish & Wildlife Service, Venango Twp. Supervisors, PA Historical & Museum Commission, PA Fish & Boat Comm., PA Dept. of Environmental Protection, Butler Co. Conservation District, PA One Call;

- Identified underground utilities and installed approved Erosion & Sediment Controls;

- Designed passive system complex (25-year design life) for **five abandoned mine discharges** (63A, 63B, 63C, 63D, 63E) significantly impacting Seaton Creek, a major tributary to Slippery Rock Creek. Design basis (raw water monitoring by PA DEP and other project partners): >300 gpm avg. (>700 gpm max.), 5.7 pH, 62 mg/l (total/dissolved 166 mg/l max.) iron, and **31 mg/l manganese**; [post-construction **average flow rates ~500 gpm** and **avg. iron ~70 mg/l**];

- Installed **17 piezometers** (22 exploratory boreholes) to monitor potentiometric surface of confined water-bearing zones associated with underground mine in Brookville coalbed and with surficial material replacing Brookville coalbed (subcrop); monitored water levels and quality;

- Developed interpretive geologic maps and cross-sections including isopach maps, potentiometric maps, bed map, etc.;

- Developed and implemented plan addressing underground mine pool prior to construction of passive system;

- Expanded proposed 4-component system to a **16-component passive treatment complex** consisting of Anoxic Collection Systems (3); Anoxic Limestone Drains (3) (12,000 tons limestone aggregate); Plunge Pools (2); Settling Ponds (5); **Created Wetlands with wildlife habitat enhancements (2) (>2½ acres total)**; Horizontal Flow Limestone Bed (1) (9,000 tons limestone aggregate);

- **Analyzed (Acid-Base Accounting) abandoned coal refuse** to identify potential acidity production and neutralization required;

- Removed **~40,000 cubic yards of abandoned coal refuse** (Scarlift pre-construction estimate 15,000 CY) neutralized material with alkaline, circulating fluidized-bed coal ash from Scrubgrass Generating Plant (Kennerdell, PA) and placed coal refuse within the backfill to **assist in the reclamation of** the nearby (<1 mile from site) Tiche **abandoned surface mine pit** on the Brookville coalbed;

- Installed **innovative in-stream water elevation control structure across Seaton Creek** in accordance with US Dept. of the Army permit to create **~1-acre of wetlands in the footprint of previously existing gob piles** and enhance >3.5 acres of existing, degraded, wetlands with treated effluent from passive complex; planted associated ~1/5-acre upland area;

- **Developed wetland substrate** from mixture of spent mushroom compost, alkaline pond fines (by-product from limestone quarry), and onsite soil material;

- Demonstrated neutralization of **~900 lbs/day of acidity** (~30% higher than 620 lbs/day pre-construction estimate) and retention of **~500 lbs/day of metals** (~30% higher than 340 lbs/day pre-construction estimate) by passive complex and return of fish in Seaton Creek through continued monitoring by project partners;

- **Treated site drainage** (combined final effluents) to **average values of 7.0 pH, 111 mg/l alkalinity, negative acidity, 2 mg/l total iron, and 3 mg/l total manganese; removing ~100% of acidity, 97% of iron, and 81% of manganese**;

- Utilized **"Datashed"** (www.datashed.org) to post Operation & Maintenance Form;

- Conducted **education and outreach activities** including wetland and upland plantings, construction and installation of wildlife habitat structures with service groups and children at-risk, and site tours (visitors from Venezuela, Peru, Korea, Brazil, OK, OH, MT, WV, community groups, watershed education programs, etc.);

- Compiled **mining history** of the site and the region spurred by the interest of nearby residents to encourage expansion of local interest in watershed stewardship;

- Compiled **pictorial log** of site conditions including historical and "before, during, and after" restoration;

- Developed **permanent project sign** and three interpretative signs;

- Received **5-year post-construction warranty by Quality Aggregates Inc.** for site revegetation and structural integrity of the passive system components;

- Submitted electronic updates, quarterly status reports, and a final report; administered contract.

Water Quality through System

The water monitoring data presented in Table 2 depicts the change in drainage quality through the passive system.

General Flow through Components

63E (influent)→ALD1→SP1→SP2→WL1→SP3→PP1----

I→WL2→PP2→HFLB (final effluent)

63B (influent)→ALD2→SP4---------------------------------------

63A1(influent)→ALD3→SP5 (final effluent)

Table 2: Discharge Characteristics Through the Erico Bridge Passive Treatment Complex

Component	Flow	pH (*field*/lab)	Alkalinity (*field*/lab)	Acidity	DFe	DMn	DAI	DO
ALD1	363	*6.5*/6.4	*234*/190	-12	71	27	<1	0
SP1	NM	*6.7*/6.4	*187*/111	-36	46	24	<1	1
SP2	NM	*6.8*/6.6	*147*/104	-45	24	23	<1	6
WL1	NM	*6.9*/6.7	*131*/99	-17	17	24	<1	6
SP3	NM	*7.0*/6.8	*118*/98	-37	11	23	<1	7
ALD2	63	*6.6*/6.5	*256*/213	-41	68	18	<1	0
SP4	NM	*6.7*/6.6	*162*/114	-64	31	17	<1	3
WL2	NM	*6.9*/6.7	*76*/75	-18	6	18	<1	8
HFLB (major final effluent)	479	*7.2*/7.0	*111*/112	-60	1	3	<1	3
ALD3	15	*6.5*/6.4	*220*/148	3	81	16	<1	0
SP5 (minor final effluent)	NM	*6.5*/6.3	*118*/69	-5	26	15	<1	4
Composite Final Effluent (weighted value)	**494**	***7.2*/7.0**	***112*/111**	**-58**	**2**	**3**	**<1**	**3**

Average values; flow in gpm; flow measured at ALD1, ALD2, ALD3, and HFLB outlet pipe; other flows assumed; lab and field pH not averaged from H-ion concentrations; alkalinity, acidity, dissolved metals, and dissolved oxygen expressed in mg/L; Composite Final Effluent for general description only---monitoring events and frequency not coincident; monitoring data available (or to be available) online

Table 2 demonstrates the decrease in dissolved iron concentrations and alkalinity as the mine discharges are conveyed from the alkalinity-generators (ALD1, ALD2, ALD3) through the oxidation and precipitation components (SP1, SP2, WL1, SP3, SP4, SP5). Note that additional degraded, untreated, drainage is encountered by WL1 and WL2. Note also the increase in alkalinity and decrease in dissolved manganese as the drainage flows through the HFLB. Extremely limited space was available for construction of ALD3 and SP5 due to the proximity of Seaton Creek and a public road.

Table 3: Loading Analysis for the Erico Bridge Passive Treatment Complex

Component	Alk (field)	Alk (lab)	Acd (net)	TFe	Fe Removal Rate	TMn	Mn Removal Rate
ALD1	1025	620	-105	317		117	
SP1	834	491	-157	242	109	112	Neg
SP2	667	460	-207	182	98	106	Neg
WL1	592	413	-170	140	201	104	Neg
SP3	530	433	-173	105	177	103	Neg
ALD2	194	118	-40	54		14	
SP4	123	86	-48	29	84	13	Neg
WL2	423	373	-164	52	42	95	11
HFLB (final effluent)	594	559	-443	10		23	
ALD3	39	18	-1	15		3	
SP5 (final effluent)	21	11	-3	7	112	3	Neg
Total Final Effluent	**615**	**570**	**-446**	**17**		**26**	

Average effluent loading values in lbs/day; Removal Rate in lbs/ac/day; Fe and Mn loadings calculated from total concentrations; Total Final Effluent sum of HFLB and SP5 loadings; not shown but included in removal rate calculations are loadings for the seep in WL2 of 17 lbs/day Fe and 5 lbs/day Mn

Table 3 presents conservative values relating to the decrease in loadings by the passive complex due to the, previously mentioned, interception of raw abandoned mine seepage especially observed in WL1 and WL2. For instance, the seep encountered in WL2 is estimated to flow at ~25 gpm and limited sampling analyses indicate the seep has a 5.8 pH, 81 mg/l alkalinity, 53 mg/l dissolved iron, and 17 mg/l dissolved manganese. Needless to say, these encountered discharges greatly add to the metals loadings decreased by the passive treatment complex. The passive complex, therefore, is more effective and more efficient in treating the site drainage than indicated by the values in Table 3.

Accepted removal rates for iron and manganese are 90 to 180 lbs/ac/day and 4.5 to 9 lbs/ac/day, respectively, for constructed wetlands (USDA et al, undated, A Handbook of Constructed Wetlands V. 4: Coal Mine Drainage: ISBN 0-16-053002-4, US Gov. Printing Office, 29 pp.). The Aerobic Wetlands and Settling Ponds at the site appear to support the expected removal rates relative to iron loadings, except in the case of WL2. This may be due to the relatively low iron concentrations in the major flow to WL2 or the immaturity of the wetland. With respect to manganese, WL2 greatly exceeds the expected removal rate. Note that the majority of the manganese is being removed by the HFLB.

Acknowledgements

Funding/In-Kind/Matching: PA Dept. of Environmental Protection; Butler County Commissioners; Western PA Watershed Program; Beran Environmental Inc.; Butler Co. Environmental Quality Board; Urban Wetland Institute; Grove City College; Venango Twp. Supervisors; Butler Co. Planning Comm.; Scrubgrass Generating Plant; Jennings Environmental Education Center; Karns City Elementary School; Americorps; Jack & John Foreman; Homeschool students; Church of Jesus Christ of Latterday Saints volunteers; Butler Co. Juvenile Court Services; Butcherine Distributor; Grove City Cub Scout Pack 76; George Jr. Republic; BioMost, Inc.; WOPEC; Quality Aggregates Inc.; PA Game Commission; Environmentally Innovative Solutions, LLC; Northwest Sanitary Landfill; Slippery Rock Watershed Coalition; Stream Restoration Inc.

Legislators/Government: PA Senator Mary Jo White; PA Rep. Dick Stevenson; Butler Co. Comm.: Glenn Anderson, James Kennedy, Joan Chew; Venango Twp. Supervisors: Norman Link, Jim Shaffer, John Wells

Landowners: Bessemer & Lake Erie Railroad Co.; The Flick Family; The Tiche Family

Local Residents: Support letters with over 150 signatures