Laurel Run Headwaters Restoration Project

Blacklick Creek Watershed

Stream Restoration Incorporated

A Public Private Partnership Effort

Brushvalley and Center Townships, Indiana County, PA

Stream Restoration Incorporated
A PA Non-Profit Organization 501(c)(3)
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Date: June 30, 2002

To: Bureau of District Mining Operations (Cambria Office)
PA Department of Environmental Protection
286 Industrial Park Road
Ebensburg, PA 15931-4119

Attn: Joseph L. Allison, Project Advisor

Re: Final Report
Laurel Run Headwaters Restoration
Project# WR23; ME# 350803; 351179
Brushvalley and Center Townships, Indiana County, PA
500205/FR-trans

Enclosed is the final report for the above noted project.

This report represents only a portion of the "success stories" associated with this reclamation site. The public-private partnership effort and the "hands-on" educational opportunities with Indiana University of PA and other volunteers will hopefully spur additional worthwhile projects in the restoration of this and other watersheds in the region. We hope that the report will meaningfully acknowledge the importance of this project and the funding received through the PA Department of Environmental Protection Watershed Restoration and Partnership Program.

In addition to successfully treating the discharge and substantially improving Laurel Run for at least 2 miles, the project was used as the model in the development of an educational guide, Construct Your Own Passive Treatment System Simulation, which was presented in a workshop at the 2002 National Conference of the American Society of Mining and Reclamation. (An abbreviated copy is included.) This was well received by the mine reclamation community and Dr. Peter Beckett, Laurantian University (Canada) is intending to revise the guide for use in his introductory classes.

Our appreciation can not be expressed adequately for providing this worthwhile opportunity in watershed restoration.

Please review and comment. The submission of a good quality work product is important to all of us. If there are any questions, please do not hesitate to contact any of the participants.

From: Stream Restoration Incorporated

Margaret Dunn, PG; Tim Danehy, EPI; Shaun Busler, Bio.; Cliff Denholm, Env. Sci.; Deanna Treter, Office Mgr.

Sent: Express Mail

LAUREL RUN HEADWATERS RESTORATION

Blacklick Creek Watershed, Brushvalley & Center Townships, Indiana County, PA

"Making It Happen" through a Public-Private Partnership Effort

A Pennsylvania Watershed Restoration and Partnership Act Project

Brief Description of Project Work through Grant and Partnership Contributions

- Completed applications and received permits and approvals. Installed approved Erosion and Sediment Pollution Controls.

- Designed passive system complex (25-year design life) for an acidic metal-laden abandoned underground mine gravity drain. Design basis from "worst case" raw water monitoring: 210 gpm flow, 3 pH, no alkalinity, 180 mg/l acidity, 12 mg/l dissolved iron, 1 mg/l dissolved manganese, and 22 mg/l aluminum.

- Installed components in series: collection system, two Vertical Flow Ponds [in parallel with two-tier underdrain system (total piping: ~2 miles, 4-in., Sch. 40 PVC with perforated laterals and solid mains) containing combined total of 6000 tons, AASHTO #1, 90% $CaCO_3$, limestone aggregate overlain by ½ -foot spent mushroom compost; Flush Pond (17,000 CF); Constructed Wetland (25,000 SF).

- Provided Quality Assurance/Quality Control through Eppley Technical Services.

- Constructed naturally-functioning wetlands which were planted with 12 species of hydrophytes. Plants harvested and transplanted by Indiana University of PA volunteers and other participants in the public-private partnership effort.

- Conducted and published stream assessment as part of the partnership effort --- Alexander, Scott, Shaun L. Busler, Cliff Denholm, Timothy Danehy, and Margaret Dunn, 2002, A Preliminary Stream Assessment for Watershed Restoration: *in* Proceedings of the 2002 National Meeting of the American Society of Mining and Reclamation.

- Developed and presented educational guide, <u>Construct Your Own Passive Treatment System</u>, in a workshop at the 2002 American Soc. of Mining & Rec. national conference.

- Kept photographic log; submitted electronic updates, quarterly status reports, and final report; administered contract.

Ecosystem Benefits

- Treated mine drainage to be net alkaline with low metals, neutralizing over 90,000 lbs/yr acidity and removing over 7,000 lbs/yr metals. Effluent complies with mine permit limits and characteristically does not exceed instream criteria.

- Improved about two miles of Laurel Run by diverting and passively treating the abandoned mine drainage.

- Created wetland wildlife habitat.

<u>Grant Program and Funding:</u> Watershed Restoration and Partnership Act - $451,286

<u>In-Kind/Matching:</u> Amerikohl Mining, Inc.; Aquascape; BioMost, Inc.; WOPEC; Stream Restoration Inc. [non-profit]

PUBLIC-PRIVATE PARTNERSHIP

Water Monitoring, Construction Inspection
PA Department of Environmental Protection, District Mining Operations,
286 Industrial Park Rd., Ebensburg, PA 15931
CHAKOT, George, MCI; ALLISON, Joseph, Compliance Specialist (814) 472-1900

Water Monitoring, Stream Assessment
PA Department of Environmental Protection, Bureau of Mining & Reclamation,
Rachel Carson State Office Building, PO Box 8461, Harrisburg, PA 17105-8461
ALEXANDER, Scott, Water Pollution Biologist (717) 783-9579

Landowner
KRESHO, Peter, 1306 Altimus Road, Homer City, PA 15748

PA Game Commission, PA Game Lands No. 276, PO Box A, Ligonier, PA 15658
HAMLEY, Art, Land Manager

Wetland Plantings, Environmental Assessment
Aquascape, 147 S. Broad Street, Grove City, PA 16127
BERAN, Robert, Wetland Specialist; REIDENBAUGH, Jeff, Env. Eng.; SPENCER, Laura, Biologist (724) 458-6610

Passive Treatment System Design, Water Monitoring, Operation & Maintenance
BioMost, Inc., 3016 Unionville Rd., Cranberry Twp., PA 16066
DANEHY, Timothy, EPI; DUNN, Margaret, PG; BUSTLER, Shaun, Biologist; DENHOLM, Clifford, Env. Scientist; TRETER, Deanna, Office Manager (724) 776-0161

WOPEC, Rt 2, Box 294B, Lewisburg, WV 24901
HILTON, Tiff, Mining Engineer (304) 645-7633

Passive Treatment System Construction
Amerikohl Mining, Inc., 202 Sunset Drive, Butler, PA 16001
STILLEY, John, President; JOHNSON, Fred, Reclamation Manager. (724) 282-2339

Quality Assurance/Quality Control and Project Oversight
Eppley Technical Services, 52 Oakland Ave., Homer City, PA 15748
EPPLEY, Robert, PhD, President (724) 479-0672

Wetland Planting Student Volunteers
Indiana University of Pennsylvania, Indiana, PA, 15705
OKEY, Brian, PhD, Professor

Grant Administration, Education and Public Outreach, Volunteer Effort
Stream Restoration Incorporated, 3016 Unionville Rd., Cranberry Twp., 16066
DANEHY, Tim, EPI; DUNN, Margaret, PG; BUSTLER, Shaun, Biol.; DENHOLM, Clifford, Env. Sci.; TRETER, Deanna, Office Mgr.; TRETER, Chris, OSM Intern (724) 776-0161

LAUREL RUN HEADWATERS RESTORATION EFFORT
BRUSHVALLEY AND CENTER TOWNSHIPS, INDIANA COUNTY, PA

A BLACKLICK CREEK MINE DRAINAGE ABATEMENT PROJECT

FINAL REPORT

submitted to

Pennsylvania Department of Environmental Protection

EXECUTIVE SUMMARY

Stream Restoration Incorporated, a Pennsylvania 501(c)(3) non-profit organization, received funding from the Pennsylvania Department of Environmental Protection through the Watershed Restoration and Partnership Act (WRPA). The primary project goals were to improve Laurel Run (Blacklick Creek headwaters) by passively treating an acidic, metal-laden, abandoned underground mine discharge, to create wildlife habitat, and to provide education and outreach opportunities.

Within a period of five months, permits/approvals had been received and the passive system had been designed and online. The result: the abandoned mine discharge and a 2-mile section of Laurel Run, were remarkedly improved, clearly illustrating the value of Public-Private Partnership efforts with state agencies, private industry, nonprofits, and volunteers to form a determined team to efficiently and economically complete successful water restoration projects.

The four-component passive treatment system included a collection system, Vertical Flow Ponds (two in parallel), a Flush Pond, and a Wetland.

The Vertical Flow Pond design utilized a “state-of-the-art” extensive, two-tier, underdrain, with about 2 miles of perforated, Schedule 40, PVC piping with valved, adjustable outlets to encourage even flow distribution and to provide more thorough flushing of accumulated metal precipitates. (Flushing is intended to decrease plugging potential and maintain effective hydraulic conductivity.)

To provide for educational, “hands-on”, opportunities and to provide the optimal value of the wetland as wildlife habitat, students and faculty of Indiana University of PA along with Aquascape and other team members, planted the wetland using 13 species of hydrophytes harvested from areas with similar water chemistry.

Currently, the passive treatment system is neutralizing about 257 lbs/day of acidity and preventing about 21 lbs/day of metals from entering the receiving stream. The pre- and post-construction passive system discharge characteristics are (raw/treated) 3/7 pH, 0/100+ mg/l alkalinity, 140/0 mg/l acidity, 10/<2 mg/l iron, and 10/1 mg/l aluminum.

Based on recent and historical monitoring and continued functioning of the system, an estimated average of 47 tons/yr of acidity and 4 tons/yr of metals are expected to be eliminated from Laurel Run.

The effect of this single innovative passive treatment system has already positively impacted Laurel Run, substantially improving a 2-mile segment. This was demonstrated by conducting pre- and post-installation stream assessments. As this is of national interest to the mine reclamation community, a peer-reviewed, professional paper was presented at the 2002 national meeting of the American Society of Mining and Reclamation.

As part of the continuing emphasis on public outreach, Stream Restoration Inc. conducted a workshop on the application of passive treatment technology at the above noted conference. The Laurel Run passive system was used as the model in the development of the well-received, <u>Construct Your Own Passive Treatment System Simulation</u>.

In order to more fully evaluate the continued effectiveness of the system and the degree of success in improving Laurel Run on a long-term basis, PA Dept. of Environmental Protection personnel, and other participants are intending to continue monitoring efforts.

Comprehensive Timeline

Date	Description
05/31/00	Water sampling
06/27/00	Water sampling
07/21/00	Water sampling
03/09/01	Grant submission
04/13/01	Grant agreement issued
04/19/01	PA One Call
05/02/01	Water sampling & site investigation
05/03/01	Site investigation & field meeting
05/08/01	GP-7 permit submitted
05/14/01	Field meeting with State Gameland Manager to review design, discuss site plan, & decide upon brush placement
05/22/01	GP-4, GP-5, and GP-8 permit submitted
05/29/01	Field meeting to review construction plans
06/12/01	Water sampling
06/18/01	Grant fully executed
06/2/01	Field meeting & site inspection; Old access road upgraded; Stream crossing installed; Construction area cleared and grubbed; Brush placed in wind-rows
06/29/01	Water sampling; Field meeting with Joe Allison & Scott Alexander
07/11/01	Laurel Run stream assessment
07/12/01	Laurel Run stream assessment
08/08/01	Water sampling & field investigation
09/19/01	Passive Treatment System Online
10/15/01	Water sampling
11/01/01	Site inspection & Field meeting
12/18/01	Water sampling, site investigation, balance flows
04/18/02	Water sampling; preparation for wetland planting; work on flush pond outlet; regraded western hillside
04/23/02	Harvested wetland plants
04/24/02	Planted wetlands with Indiana University Students
06/17/02	Water sampling

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PROJECT DESCRIPTION

INTRODUCTION

In western Pennsylvania, coal mining has been conducted for over 150 years. Mining towns which were once bustling communities are now either abandoned or in decline leaving only polluted streams, coal refuse, spoil, and highwalls. One of the most significantly impacted watersheds within the state is the Blacklick Creek Watershed. The “Cooperative Mine Drainage Survey, Kiskiminetas River Basin” (EPA 1972) indicated that 335 discharges and over 1,675 acres of abandoned surface minelands were affecting the Blacklick Creek Watershed, contributing about 310,000 lbs/day of acidity. At the time of the study, eighteen major discharges constituted 46% of the net acid loading in Blacklick Creek.

The Blacklick Creek Watershed Association has made great strides in the remediation of abandoned mine drainage within the watershed. Large-scale passive treatment systems have been successfully installed with the result of providing measurable improvement to the receiving streams. In the Laurel Run Watershed, limited restoration activities have been previously conducted.

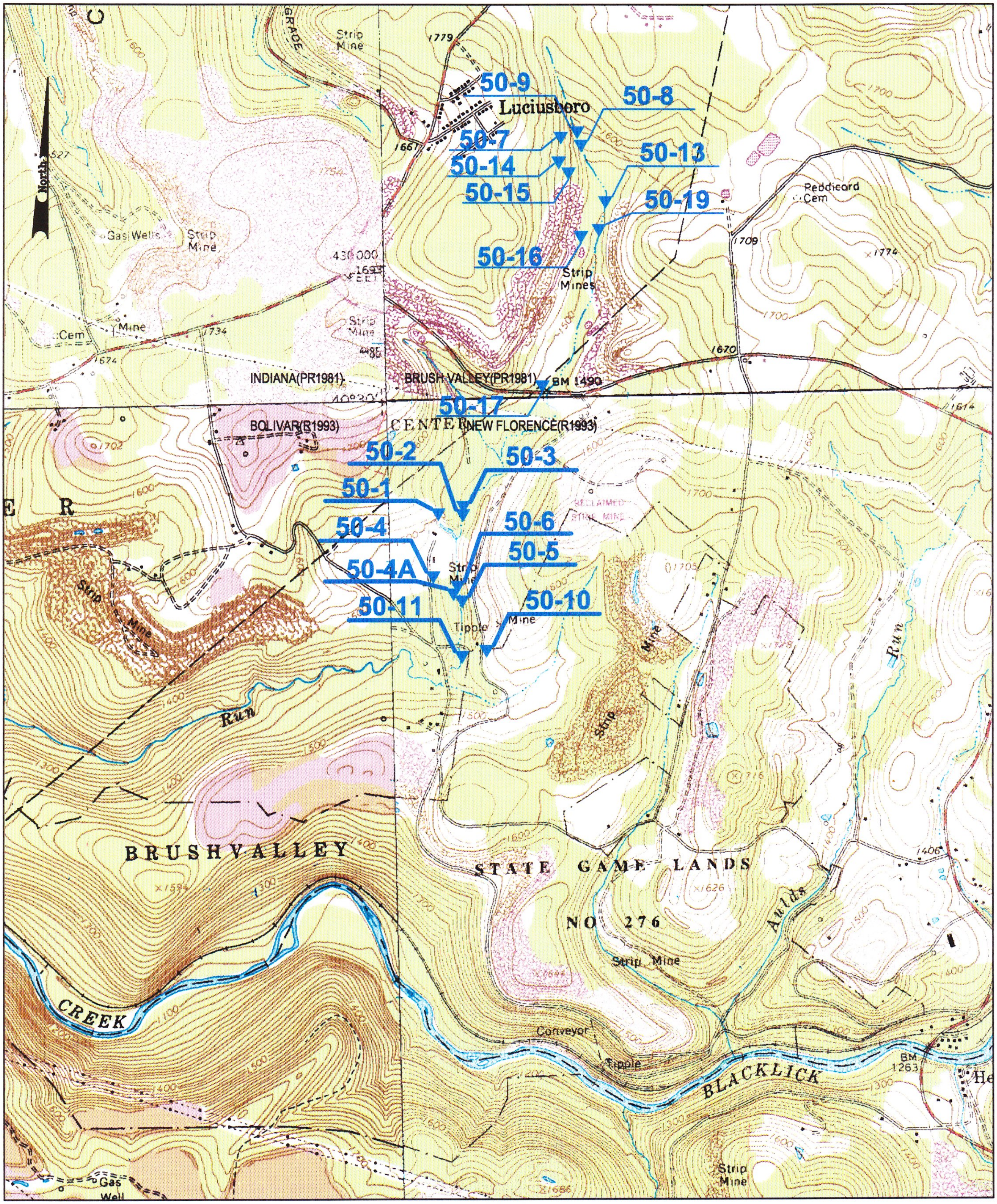
Pollution associated with a century-old abandoned underground mine on the Upper Freeport coalbed near the community of Luciusboro, PA is the sole source of pollution and major contributor of flow in the headwaters of Laurel Run. A portion of an untitled, undated map showing the extensive mine workings indicates that this discreet discharge issues from a single drainage heading. Above the discharge, Laurel Run with an average flow of 40 gpm is a very good quality stream with low alkaline buffering capacity and low metals. Below the confluence with the 130-gpm mine discharge (3 pH, 140 mg/L, 9 mg/L iron, and 13 mg/L aluminum), Laurel Run is acidic (3 pH, 120 mg/L acidity, 9 mg/L iron, and 8 mg/L aluminum). Based on a recent stream assessment, prior to receiving the degraded abandoned mine discharge, Laurel Run contained a myriad of vertebrate and macroinvertebrate life. Crayfish and immature mayfly, stonefly, and caddisfly were identified inhabiting the stream. Similar examinations conducted below the pollutive discharge failed to identify any macro-organisms inhabiting Laurel Run.

This final report addresses the restoration effort associated with the discharge. The funding through the Commonwealth’s Watershed Restoration and Partnership Act was used to implement passive treatment for the mine drainage.

A public-private partnership effort was formed with state agencies, the local watershed group, a surface mining company, and environmental professionals to effectively, efficiently, and economically address this pollution. In order to provide for long-term, low-maintenance, environmentally-friendly treatment, a passive treatment system was constructed consisting of a Discharge Collection System, Vertical Flow Ponds (two in series with two-tiered, extensive underdrain systems), a Flush Pond, and a Constructed Wetland, planted with native species for wildlife habitat.

Site Location

The project is located in Brushvalley and Center Townships, Indiana County. The discharge is located on the Peter Kresho property while the passive treatment system was constructed on PA Game Lands No. 276. The site is located on the 7 ½ ' USGS Brush Valley topographic map (PR1981) at latitude 40° 50' 00" and longitude 79° 11' 00".



WATER SAMPLE LOCATIONS - USGS 7.5' Brush Valley, PA (PR1981)

LAUREL RUN RESTORATION AREA - PHASE I

▼ WATER SAMPLING POINT

Approximate Center of Project (deg-min-sec)
40-50-00 latitude 79-11-00 longitude

Blacklick Creek Watershed
Brushvalley & Center Twps., Indiana County, PA
Stream Restoration Incorporated
6/2002, Scale 1" = 2000'

Additional Topographic Maps:
USGS 7.5' New Florence (R1993)
USGS 7.5' Indiana (PR1981)
USGS 7.5' Bolivar (R1993)

1000 0 1000 2000

Laurel Run Locacation Map Rev

PRE-EXISTING CONDITIONS

A pre-act (1977 SMCRA) abandoned underground mining operation on the Upper Freeport coalbed near the community of Luciusboro severely impacted the headwaters of Laurel Run. The highly acidic, metal-laden, pollutive mine discharge, which emanates from a gravity drainage heading, flows directly into and is the major contributing source of flow to the headwaters of Laurel Run.

Although thriving in Laurel Run above the mine drainage, below the discharge benthic organisms were not observed, due to poor water quality and metal precipitates coating the substrate.

Pre-Existing Stream and Drainage Characteristics

The following table depicts the impact of the site drainage on the stream quality prior to installation of the passive treatment system:

Pre-Existing Average/"Worst Case" Stream and Drainage Characteristics

Point	Flow	pH	Alkalinity	Acidity	Fe	Mn	Al
Upstream	36/72	5.7/5.4	4/2	6/8	<1/<1	<1/<1	<1/<1
Discharge	133/210	3.1/3.0	0/0	140/180	9/12	1/1	13/22
Downstream	111/142	3.2/3.0	0/0	122/181	9/14	1/1	8/12

flow in gpm; alkalinity, acidity, and total metals expressed in mg/L; pH not averaged from H ion concentrations; (Note the maximum flows do not necessarily correspond to maximum concentrations. See attached data.)

PASSIVE TREATMENT SYSTEM INSTALLATION

Site Preparation

A PA Natural Diversity Inventory Search was conducted with results reported as "no potential conflicts". Road bonds and permits were handled by Amerikohl Mining, Inc. Passive system design plans were completed by BioMost Inc. and reviewed by the PA DEP, Cambria District Mining Office. PA One Call relating to underground utilities was contacted and the response was "no involvement". An existing haul road was upgraded and a stream crossing was constructed following approval of GP-7. Erosion and Sediment Pollution Controls were installed after plan approval by the Indiana County Conservation District. The site of the passive treatment system was cleared and grubbed.

Installation

The passive treatment system installed in the Laurel Run headwaters consists of the following four components in series **(See plans drawings and photo section.)**:

1. **Discharge Collection System**
2. **Vertical Flow Ponds** (two in parallel with two-tier underdrain system)
3. **Flush Pond**
4. **Settling Pond/Wetland**

Bulk Materials: Spent mushroom compost was used in the Wetlands and in the Vertical Flow Ponds overlying the limestone aggregate. Limestone aggregate(90% $CaCO_3$) was placed in spillways and Vertical Flow Ponds.

Discharge Collection System: The discharge, which emanates from the gravity drainage heading was located on private property. The landowner agreed to a collection system, but would not allow any ponds or wetlands to be constructed on his property. The collection system, therefore, not only had to collect the drainage, but also had to convey the water roughly 300 feet to the construction area. The collection system consisted of six, 6-inch, Schedule 40, PVC laterals with five, 1-inch, perforations spaced around the diameter of pipe every 0.5' along the length of the pipe. Each lateral is connected to a single 10-inch perforated header plumbed onto 10-inch, solid, Schedule 40, PVC pipe with a 10-inch slide-type gate valve. This pipe then conveys the discharge approximately 300 feet to the passive treatment system. Cleanouts were installed approximately every 100 feet. In order to "cross" the two good quality springs/streams a GP-5 (utility crossing) and GP-8 (temporary road crossing) were obtained for each stream. The permits allowed for the pipe to be placed beneath the low flow streams. The collection system was installed to maintain the existing hydrology of the underground mine pool. A by-pass was constructed for flows in excess of the design flow to be conveyed to an existing channel.

Vertical Flow Ponds: The primary purpose of the Vertical Flow Ponds is to neutralize acidity while generating alkalinity. Aluminum solids are also precipitated. The system utilizes two Vertical Flow Ponds built to operate in parallel. The ponds are designated Vertical Flow Pond East and Vertical Flow Pond West. The parallel configuration allows for the continual treatment of the discharge by one pond when maintenance activities are performed on the other pond. Geotextile was used to line the bottom and sides of the pond to the approximate elevation of the top of the limestone. Bedding stone (1/2 foot in thickness) was placed on the geotextile and the lower underdrain piping system was installed. Two feet of AASHTO #1 $CaCO_3$ limestone aggregate was then placed on top of the lower tier of pipes. A second (upper) underdrain similar to the first was installed and covered by a second two-foot layer of limestone. About a ½ foot of spent mushroom compost was then spread directly over the limestone.

The underdrain system was developed in order to optimize flow distribution and flushing of accumulated metal solids. Each of the 2 tiers of underdrain piping is divided into 4 quadrants or cells giving a total of 16 cells in the two ponds. Each cell outlets through individual discharge pipes. The underdrain was constructed of 4-inch, Schedule 40, PVC pipe. Perforated laterals were placed on 4.5-foot centers and connected to a solid header with a sanitary-type tee. Perforations were hand-drilled with two, 0.5-inch perforations approximately 30° from the top of the pipe. The perforation spacing was equal to the lateral spacing (4.5 feet). Four separate header pipes were used for each underdrain thus dividing the surface area into approximately equal quadrants. Each header pipe extends from the treatment media through the breastwork to an individual 4-inch, slide-type, gate valve. Prior to the gate valve, a tee was installed about midway through the breastwork to create a riser, which leads to the primary outlet for that cell. Each outlet included a 4-inch by 3-inch rubber reducer into which a 3-inch riser (1.5 foot section with 3-inch 90° elbow) was inserted. The reducer was equipped with two stainless steel hose clamps. The 4-inch hose clamp fastens the reducer to the 4-inch riser pipe. The 3-inch clamp was used to vertically adjust the 3-inch riser that can be used to control the flow rates within each cell.

<u>Flush Pond:</u> The purpose of the Flush Pond is to provide holding capacity during flushing events of the Vertical Flow Ponds. The Flush pond was designed to retain the water for settling and accumulation of solids prior to discharge.

<u>Wetland:</u> The Wetland provides multiple functions including oxidation and settling of metal solids and wildlife habitat. Other natural functions include uptake, storage, and conversion of various pollutants for additional water purification. All of these functions are accomplished and enhanced through the use of microtopographic relief, directional earthen baffles, and vegetation with high species diversity and density.

The wetland was planted with hydrophytic species by Indiana University of Pennsylvania students through professor Brian Okey's class on April 24, 2002. Prior to the wetland planting, the students were given a tour of the site and were instructed on the types of plants, their function, and planting procedures. These activities were led by Jeff Reidenbaugh of Aquascape and Shaun Busler of Stream Restoration Incorporated.

The topographic variation throughout the constructed wetland and predictable flows will promote the establishment of a diverse community of wetland plants. The table that follows indentifies the species transplanted into the wetlands. Species were selected based upon observations of successful establishment in previously constructed treatment wetlands. The transplanted species chosen for this system were obtained from wetlands with similar water chemistry thus promoting a higher success rate. Permission was obtained from the PA Game Commission for those plants removed from State Game Lands No. 95. Species were also obtained from property owned by Robert Beran of Boyers, PA. Volunteer plants will contribute to the wetland diversity and function.

Wetland Species Planted 4/24/02

Common Name	Scientific Name	Life Stage	Hydrologic Level/Zone
Broad-leaved cattail	*Typha latifolia*	Plant	C&D
Button bush	*Cephalanthus occidentalis*	Cuttings	D
Rice Cut-Grass	*Leersia oryzoides*	Plant	C
Sedges (unknown)	*Carex spp*.	Plant	B&C
Silky Dogwood	*Cornus amomum*	Cuttings	B
Skunk Cabbage	*Symplocarpus foetidus*	Plant	B&C
Soft rush	*Juncus effuses*	Plant	B&C
Spatterdock	*Nuphar luteum*	Rhizome/Plant	D
Sphagnum	*Sphagnum spp*	Plant	B&C
Swamp milkweed	*Asclepias incarnata*	Plant	B&C
Three-way sedge	*Dulichium arundinaceum*	Plant	C&D
Tussock sedge	*Carex stricta*	Plant	B
Wool grass	*Scirpus cyperinus*	Plant	B&C

Zones: A>6” above water level; B= 0” to 6” above water level; C = 0” to 6” below water level; D >6” below water level

PASSIVE TREATMENT SYSTEM PERFORMANCE

The passive treatment system at Laurel Run has been online and functional since 9/19/01. Although sampling events indicate that the system is working well, results must be considered initial when considering the 25-year design life. The following table identifies and presents initial water quality characteristics through each component of the system from influent to effluent:

Comparison of Water Quality Through the LAUREL RUN PASSIVE TREATMENT SYSTEM

Component	Flow	Lab pH	Alkalinity	Acidity	Fe	Mn	Al
Raw	249	3.3	0	147	11	1	7
VFPE	115	7.2	229	0	3	1	1
VFPW	134	7.0	77	0	1	1	1
Wetland	249	7.4	183	0	1	1	1

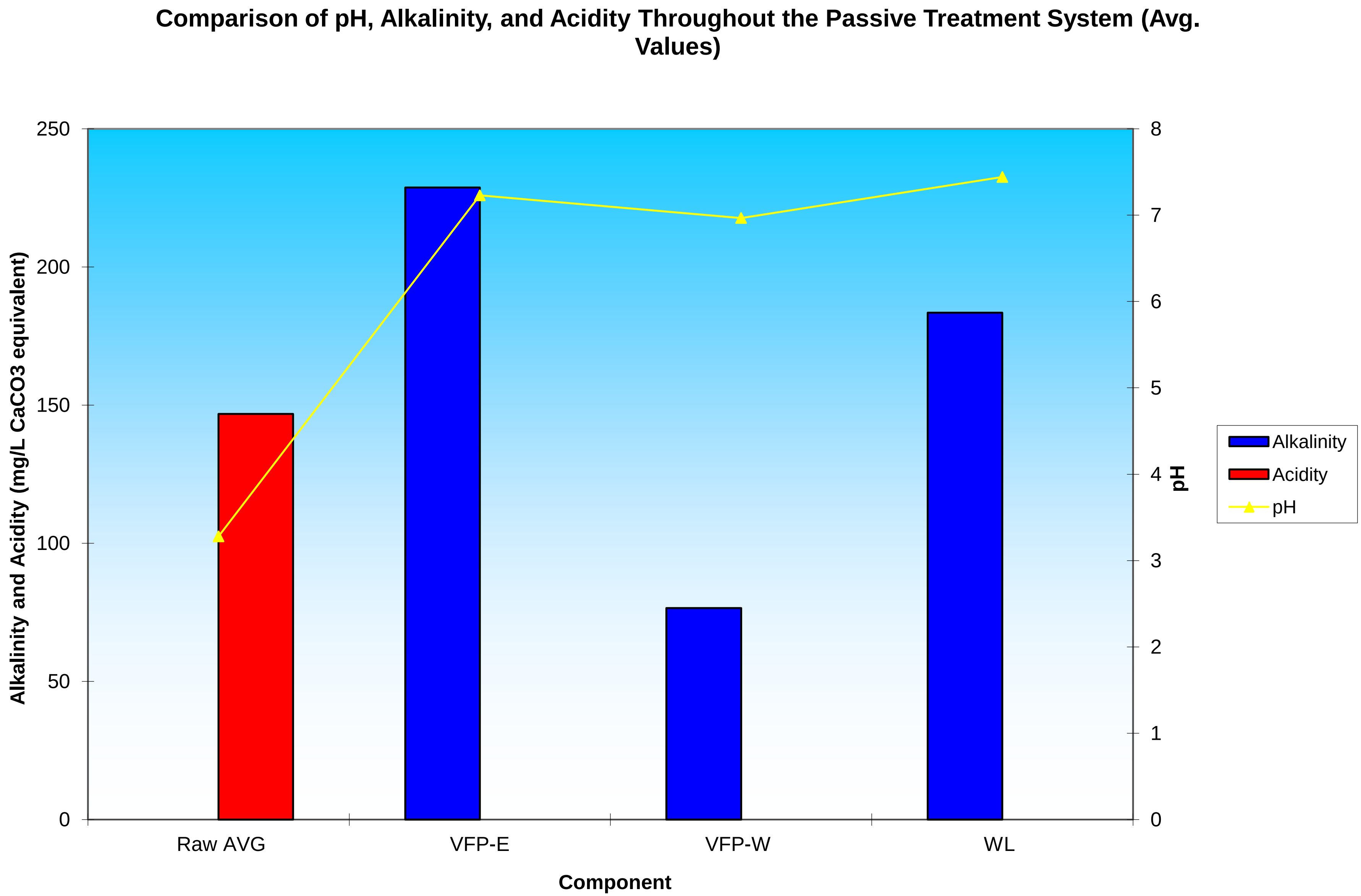
Average values; flow in gpm; alkalinity, acidity, and total metals expressed in mg/L; pH not averaged from H-ion concentrations

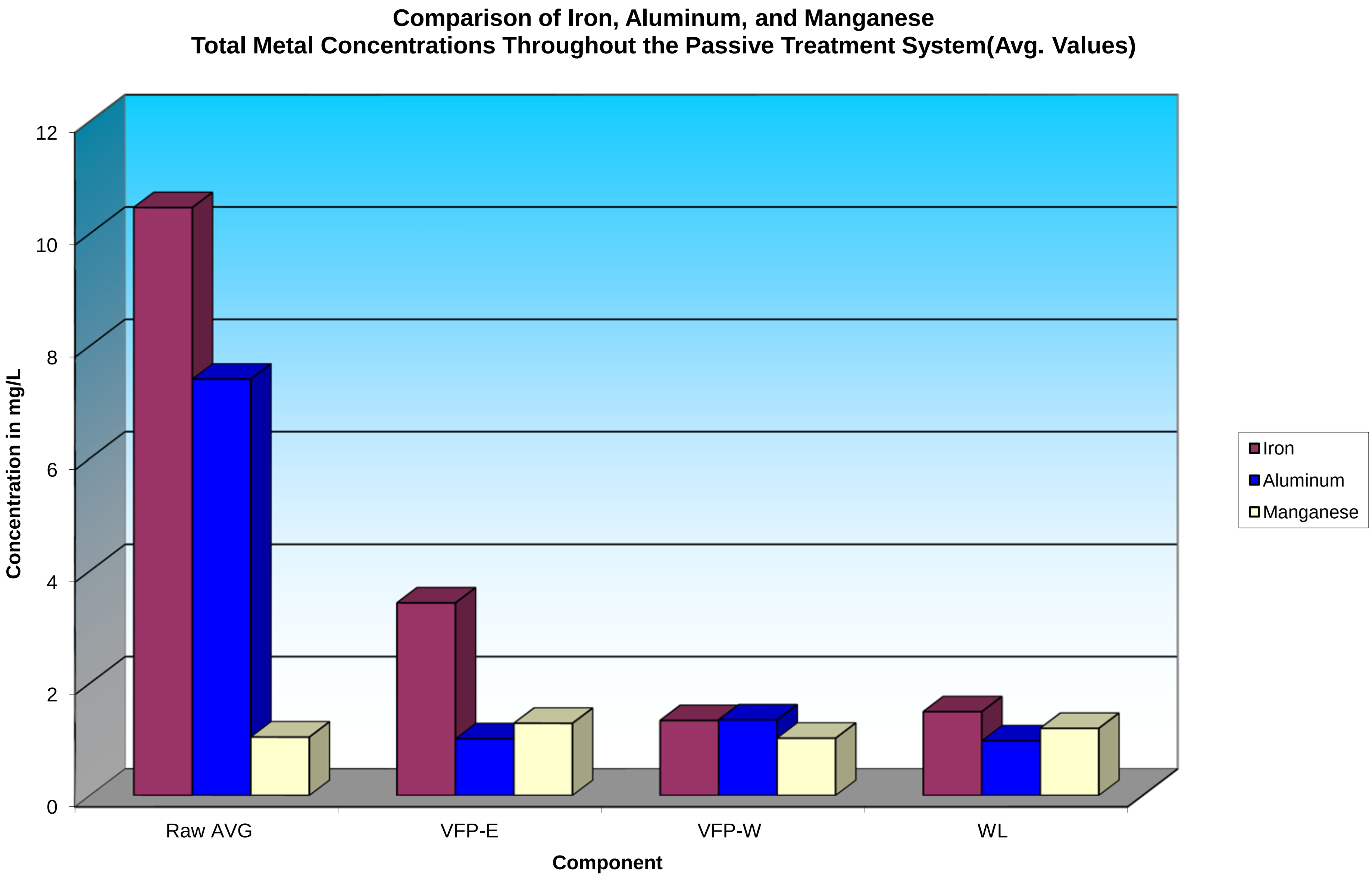
Discharge Collection System: The system collecting and conveying the abandoned mine discharge emanating from the gravity drain heading to the Vertical Flow Ponds is continuing to function well, even during high flow. During extremely high flows, the overflow spillway allows for a portion of the drainage to bypass so as not to overwhelm the system. (The mine water appears to be diluted during high flows.)

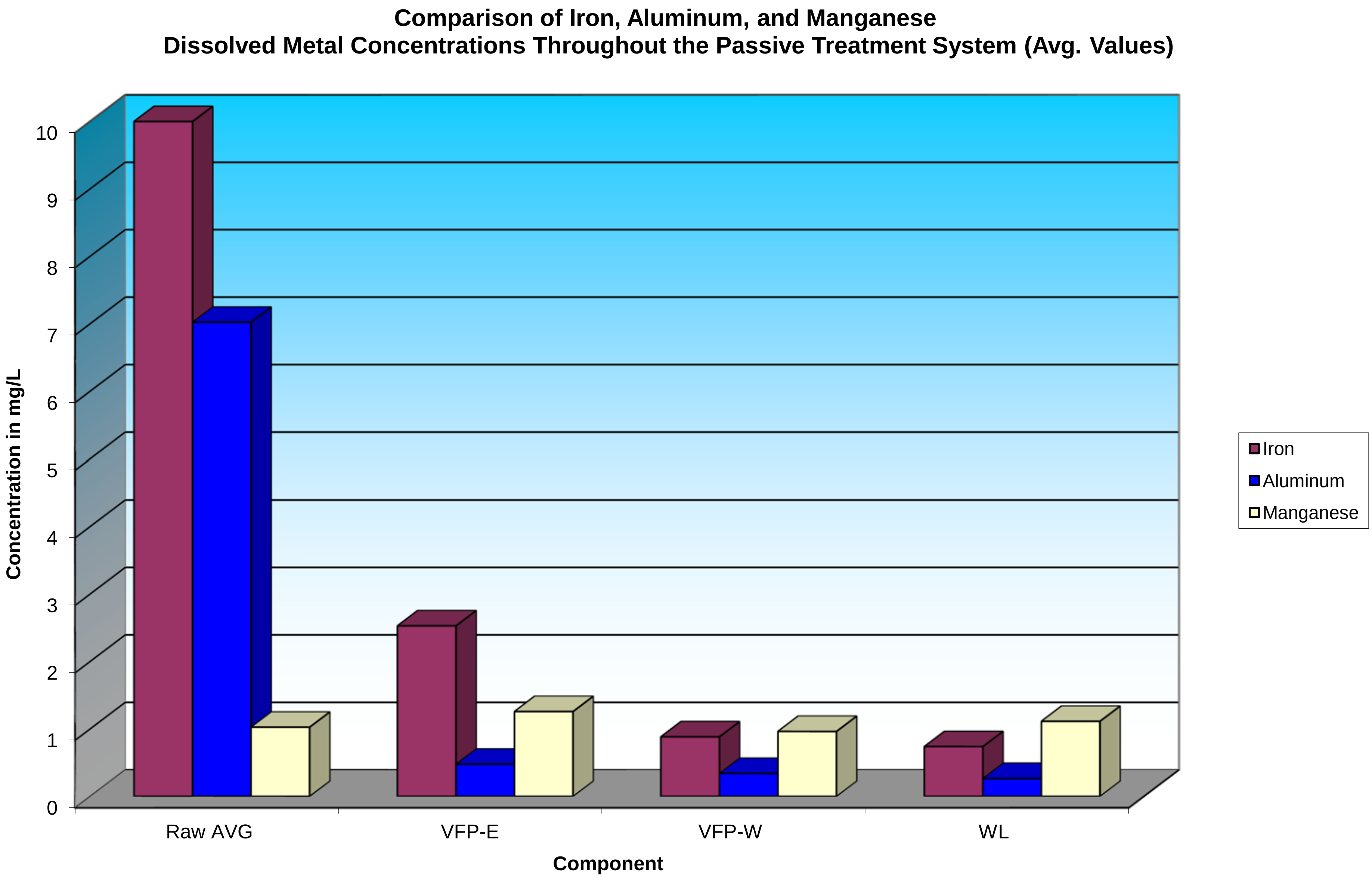
Vertical Flow Ponds: The Vertical Flow Ponds (VFPE & VFPW) are successfully functioning. Influent to the Vertical Flow Ponds can be described as an acidic, low pH, iron- and aluminum-bearing discharge while the effluent can be described as net alkaline with a circum-neutral pH and low metal concentrations. The Vertical Flow Ponds are neutralizing about 100% of the acidity, an average of over 257 lbs/day. In addition, over 21 lbs/day of metals are being retained within the system. This corresponds to a decrease in the average iron and aluminum loadings by approximately 75%, ranging from 62% during extremely high flow events to over 90% during lower flow conditions. The higher flow rates for VFPW in relation to those of VFPE are thought to contribute to the lower alkalinity and pH measurements. (See attached monitoring.)

Flush Pond: Because of the metal solids accumulation within the Vertical Flow Ponds, the ability to flush as much of this material as practical is important to maintain sufficient hydraulic conductivity. A valved, draw-down device (10 inches in diameter) was added to the Flush Pond in order to have the capability to control the water level. The facility was designed to retain a flush for settling and accumulation of solids.

Wetland: In addition to providing wildlife habitat, the wetland is “polishing” the effluent and allowing for further formation and accumulation of metal solids. The effluent from the wetland, which then enters Laurel Run via a rip-rap lined spillway, is characterized as net alkaline, circum-neutral, water with low concentrations of iron, aluminum and manganese (each averaging about 1 mg/l or less).


Comparison of pH, Alkalinity, and Acidity Throughout the Passive Treatment System (Avg. Values)
Alkalinity and Acidity (mg/L CaCO3 equivalent)
250
200
150
100
50
0
pH
8
7
6
5
4
3
2
1
0
Raw AVG
VFP-E
VFP-W
WL
Component
Alkalinity
Acidity
pH


Comparison of Iron, Aluminum, and Manganese
Total Metal Concentrations Throughout the Passive Treatment System(Avg. Values)
Concentration in mg/L
0
2
4
6
8
10
12
Raw AVG
VFP-E
VFP-W
WL
Component
Iron
Aluminum
Manganese


Comparison of Iron, Aluminum, and Manganese
Dissolved Metal Concentrations Throughout the Passive Treatment System (Avg. Values)
Concentration in mg/L
0
1
2
3
4
5
6
7
8
9
10
Raw AVG
VFP-E
VFP-W
WL
Component
Iron
Aluminum
Manganese

MEASURABLE ENVIRONMENTAL RESULTS

Based on limited, short-term sampling by project partners, the Laurel Run passive treatment system is successfully treating the abandoned mine drainage at the site. The system came online September 19, 2001. Water samples, first taken on 10/15/01, included the raw untreated water, passive treatment components, and stream samples. Measurable environmental results to the receiving stream, Laurel Run, were immediate.

Impact to Discharge: With the installation of the passive treatment system, the final effluent now meets the standard permit effluent limits for coal mining activities. In addition, average values reported instream criteria (Title 25, Chapter 93) are also characteristically met. On average, the system is neutralizing about 257 lbs/day (47 tons/year) of acidity and preventing about 21 lbs/day (4 tons/year) of metals from entering Laurel Run.

Comparison of the Raw and Final Effluent
(range: minimum – maximum)

Sampling Point	Flow	pH	Alk.	Acidity	Fe	Mn	Al
Raw	35 - 525	3.0 - 3.7	0	41 - 286	3 - 23	1 - 2	<1 - 20
Final effluent		7.1 - 7.7	71 - 487	0	<1 - 3	<1 - 2	<1 - 1

flow in gpm; alkalinity, acidity, and total metal concentration in mg/L; pH not calculated from average H-ion concentrations;

In addition to improvements in water quality, about a half-acre of naturally-functioning wetlands has been created using more than 12 hydrophytic species which provide wildlife habitat in addition to water treatment. In similar wetlands constructed as part of a passive treatment system, additional hydrophytic species have been observed to volunteer and create an even more diverse ecosystem.

Impact to Laurel Run: The effect upon the water quality of Laurel Run has been quite remarkable. (See accompanying graphs at the end of this section.)

Laurel Run: Segment from Diverted Discharge to System Confluence
(average values: before/after)

Stream Segment	pH	Alkalinity	Acidity	Fe	Mn	Al
Above PTS (50-13)	4.8/7.6	0/17	75/0	5/<1	1/<1	6/<1

flow in gpm; alkalinity, acidity, and total metal concentration in mg/L; pH not calculated from average H-ion concentrations;

The water quality of about ¾ of a mile of Laurel Run has been restored to probable pre-mining conditions. This was accomplished by capturing and diverting the underground mine drainage to flow through the passive system. This enabled the good quality (50-9) in the uppermost headwaters to be the main source of flow in Laurel Run until the confluence with the passive treatment system effluent.

Laurel Run: Downstream of System
(average values: before/after)

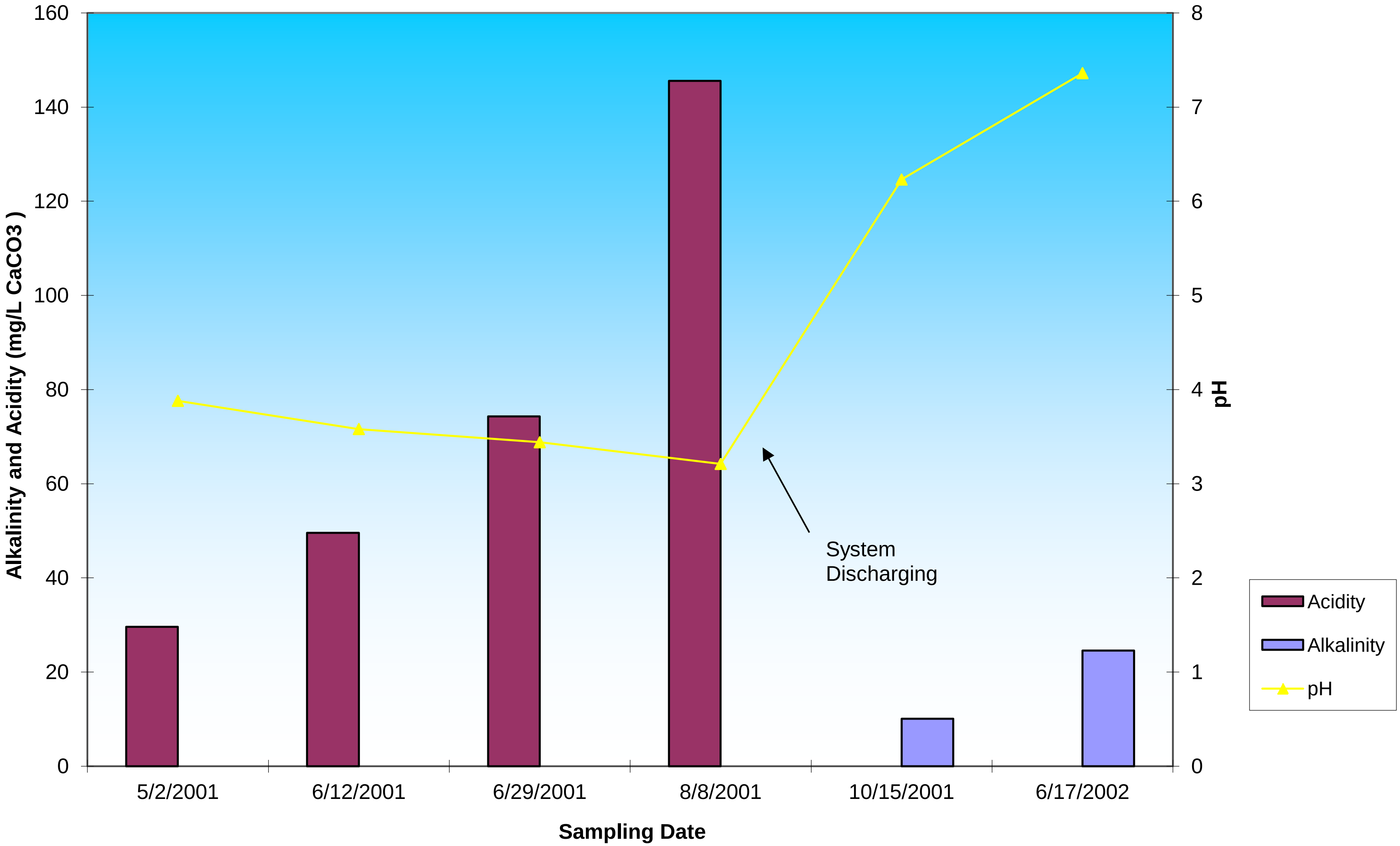
Downstream	pH	Alkalinity	Acidity	Fe	Mn	Al
Below PTS (50-8/19)	3.1/7.3	0/136	133/0	10/2	1/<1	9/<1
½ mile (50-17)	4.8/7.6	3/159	28/0	1 / 4	1/2	4/<1
1 ½ miles (50-11)	5.1/6.5	4/8	48/0	11/2	3/2	1/<1

flow in gpm; alkalinity, acidity, and total metal concentration in mg/L; pH not calculated from average H-ion concentrations; Note: Before construction, the Laurel Run downstream monitoring point was 50-8 and after construction the point was moved to below the confluence of the passive system to 50-19. (See location map and water monitoring data.)

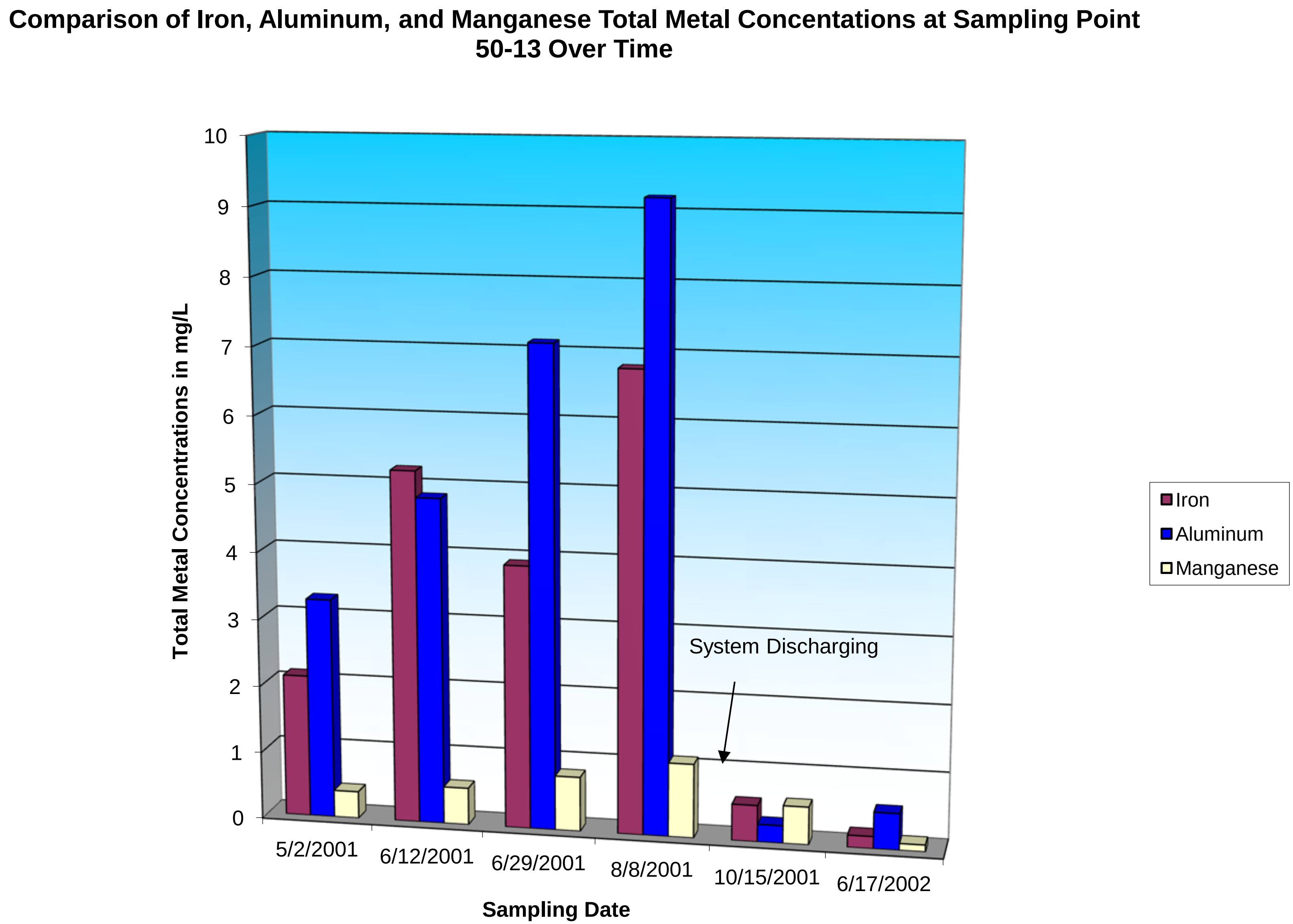
At sample point 50-17, located approximately ½ mile downstream from the passive treatment system, the pH has increased from an average value of 4.8 to 7.6. Laurel Run has changed from a net-acidic stream (average acidity = 28 mg/L $CaCO_3$) to a net-alkaline stream (average alkalinity = 159 mg/L $CaCO_3$). Although the high alkalinity values will probably not persist after limestone fines within the system have been consumed, the system will continue to produce excess alkalinity that will aid in neutralizing acidity from other abandoned mine discharges that enter downstream. An example is noted at sample point 50-11, which is located approximately 1 mile downstream from 50-17. Although Laurel Run at this sampling point has improved from a 5.1 pH, net-acidic stream to a 6.5 pH, net-alkaline stream, much of the excess alkalinity present at 50-17 has been consumed/diluted within that one-mile section of stream. This is due to several other discharges such as 50-1, 50-4, 50-4a, and 50-10 that enter Laurel Run between these two points. (See attached map with water sample locations.)

Water monitoring of the system and Laurel Run will hopefully continue in order to document the long-term effectiveness of passive treatment technology to abate abandoned mine discharges. In time, Laurel Run has an excellent chance of recovering to a functioning ecosystem with the long-term improvement of water quality provided by the passive treatment system. The main obstacle to recovery is now the iron and aluminum covered substrate and additional discharges which enter downstream. (See the professional paper attached to this report.)

Comparison of pH, Alkalinity, and Acidity of Sampling Point 50-13 Over Time

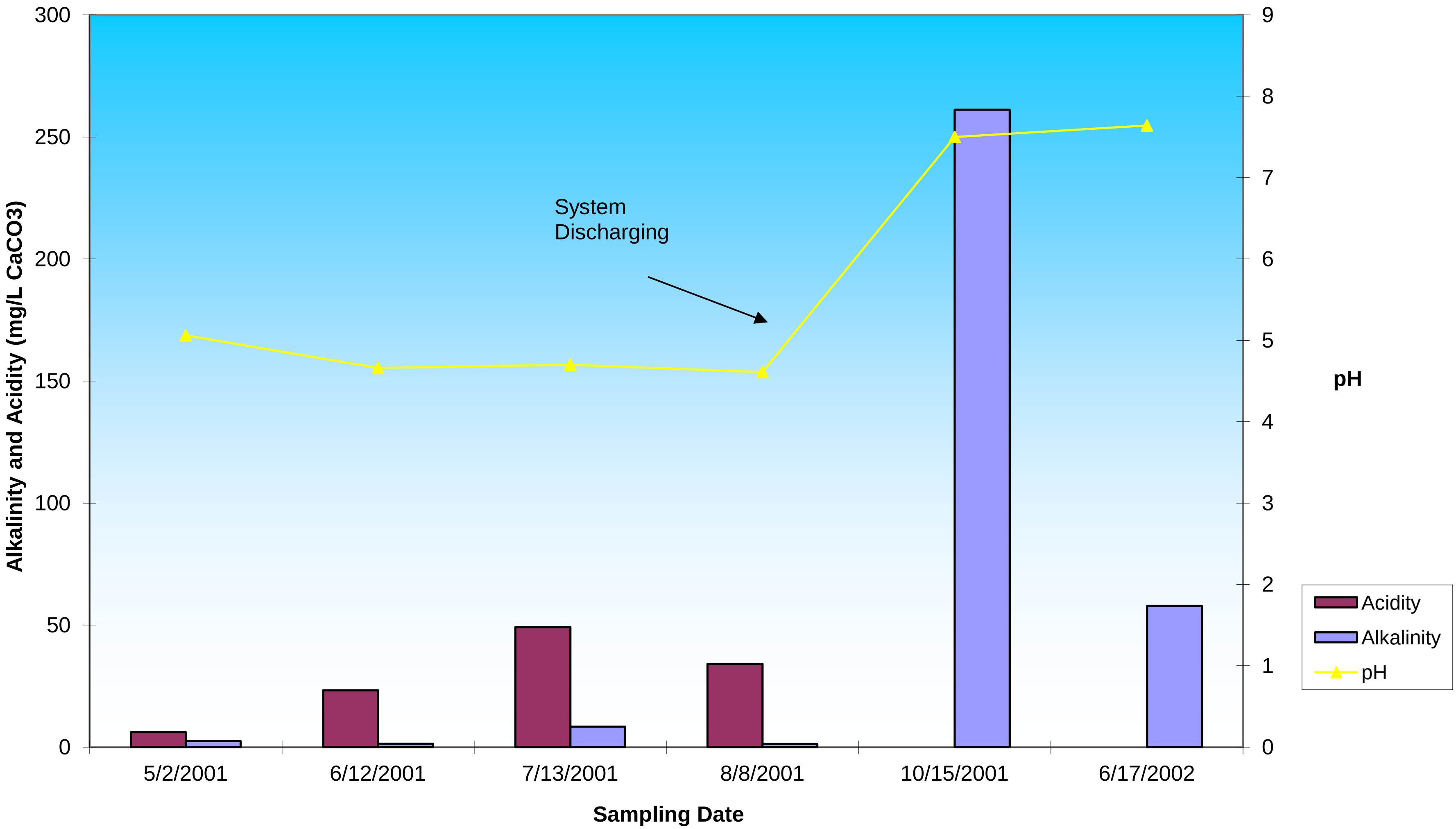


50-13 illustrates a 3/4-mile improvement to Laurel Run simply by removing the discharge's original point of entry into the stream.



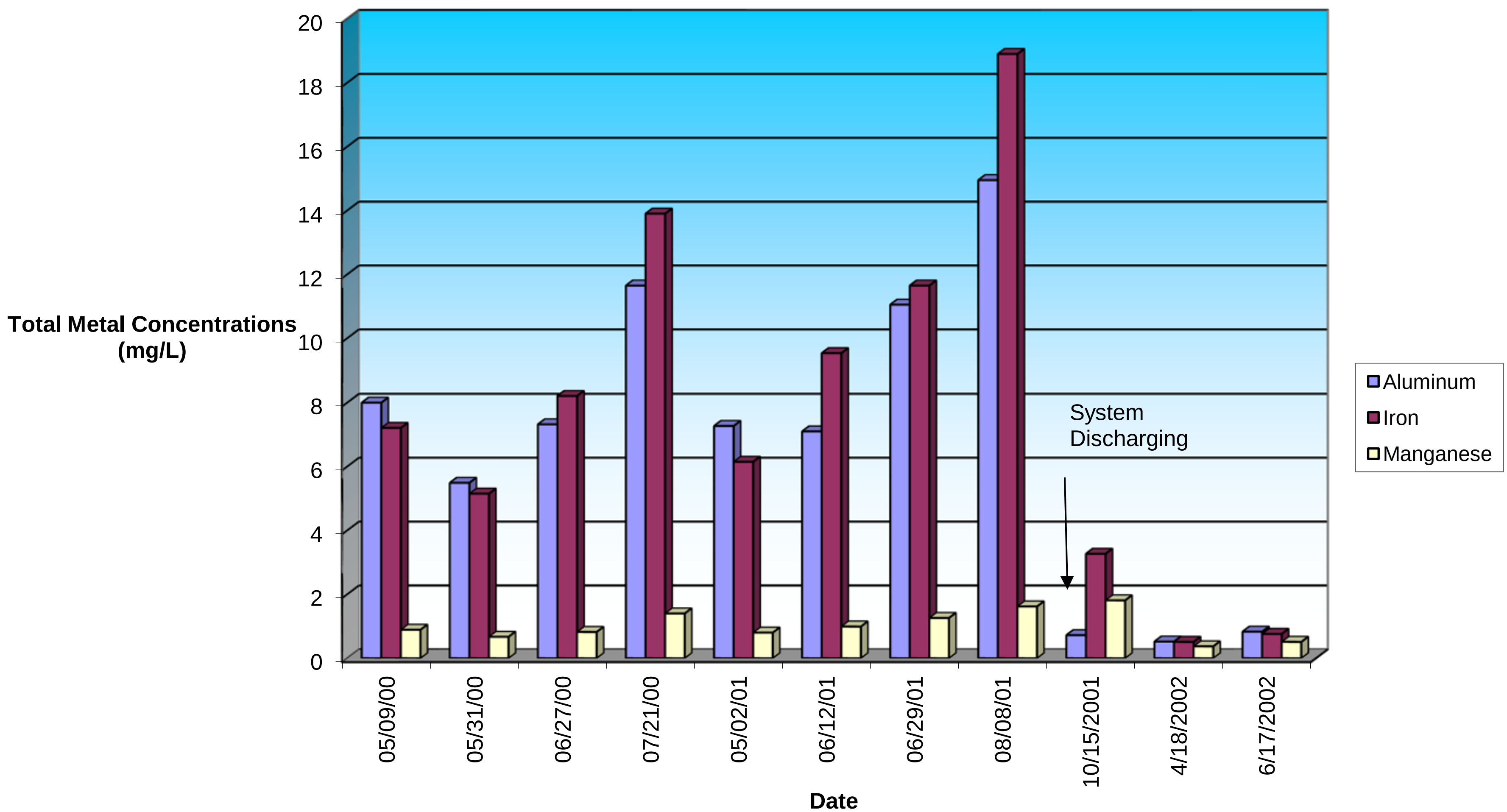
50-13 illustrates a 3/4-mile improvement to Laurel Run simply by removing the discharge's original point of entry into the stream.

Comparison of pH, Alkalinity, and Acidity of Sampling Point 50-17 Over Time



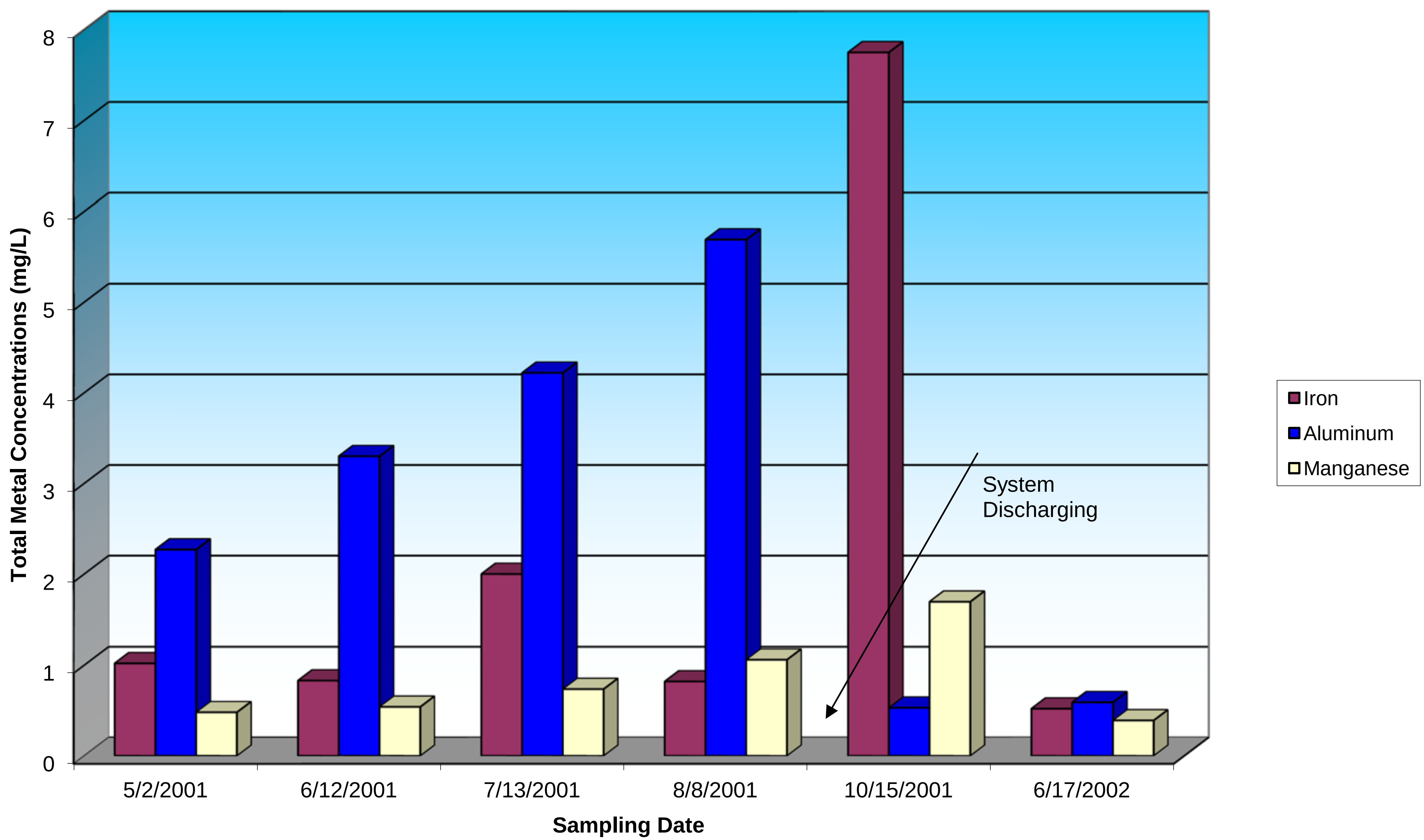
50-17 is located on Laurel Run approximately 1/2 mile downstream of the passive treatment system.

Comparison of Iron, Aluminum, and Manganse Total Metal Concentrations of Laurel Run Over Time at Sampling Point 50-8 (Pre-Construction) and 50-19 (Post-Construction)



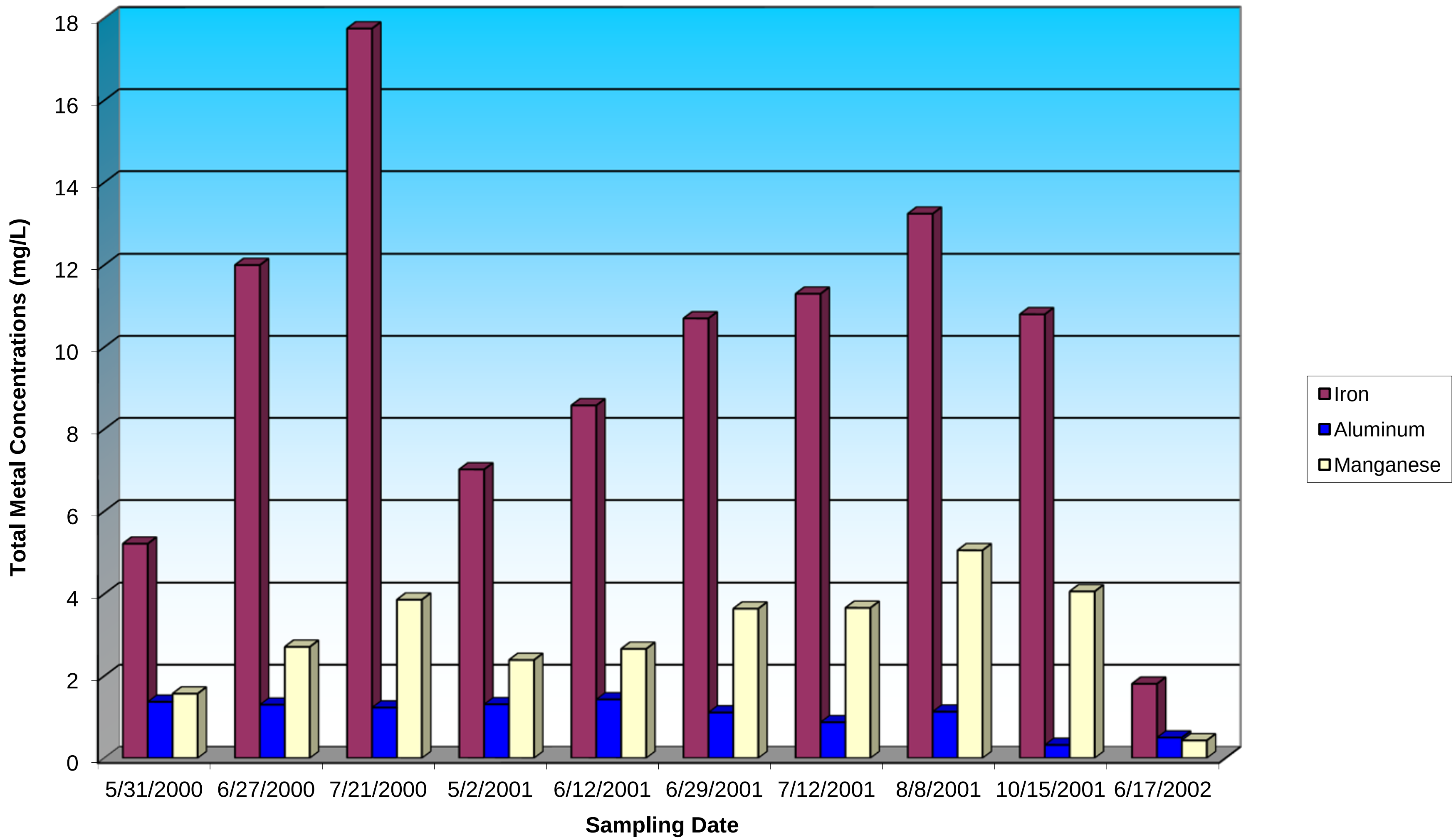
Post-Construction sampling point 50-19 is located on Laurel Run immediately downstream of the passive treatment discharge

Comparison of Iron, Aluminum, and Manganese Total Metal Conentrations at Sampling Point 50-17 Over Time

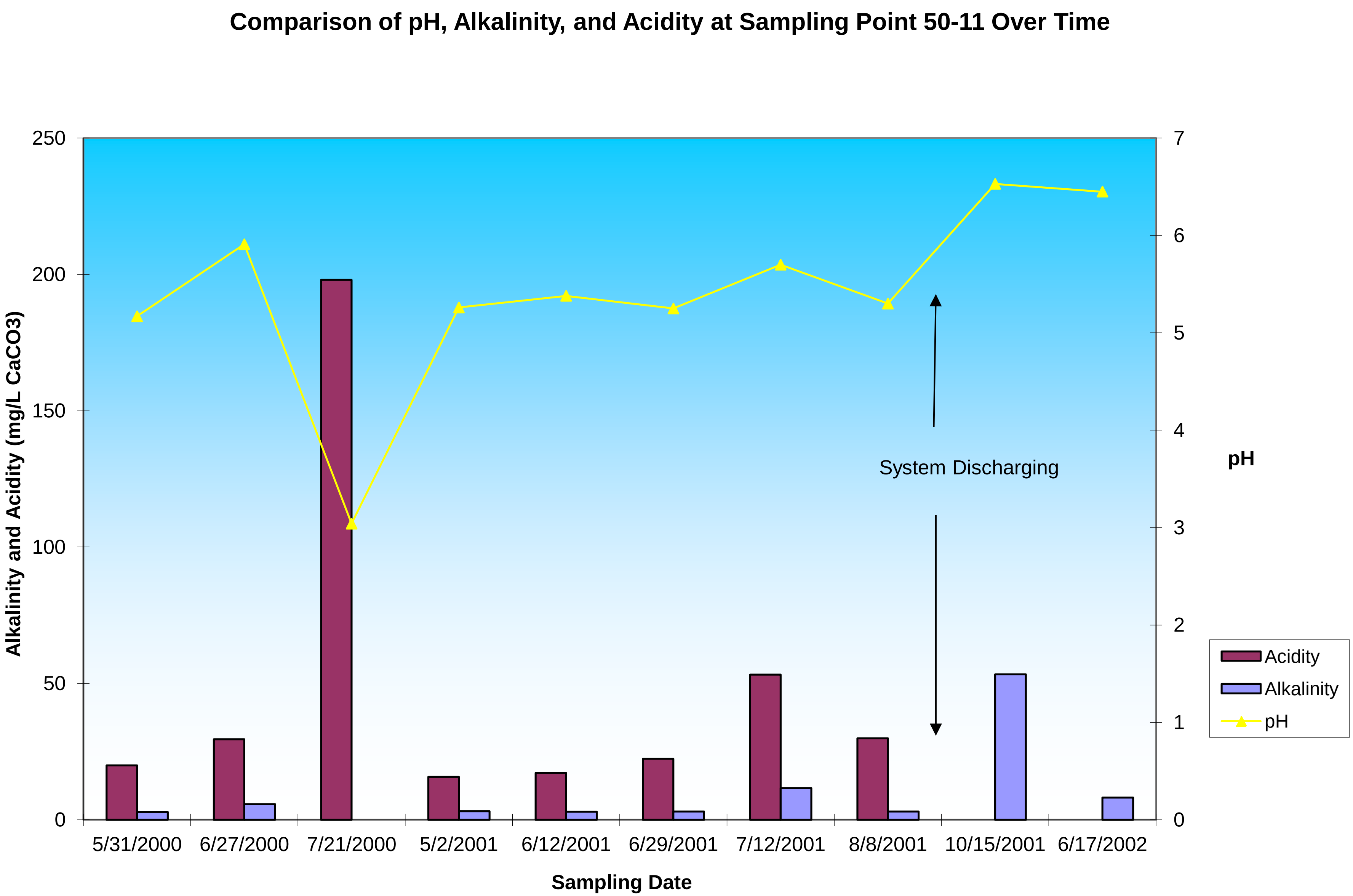


50-17 is located on Laurel Run approximately 1/2 mile downstream of the passive treatment system.

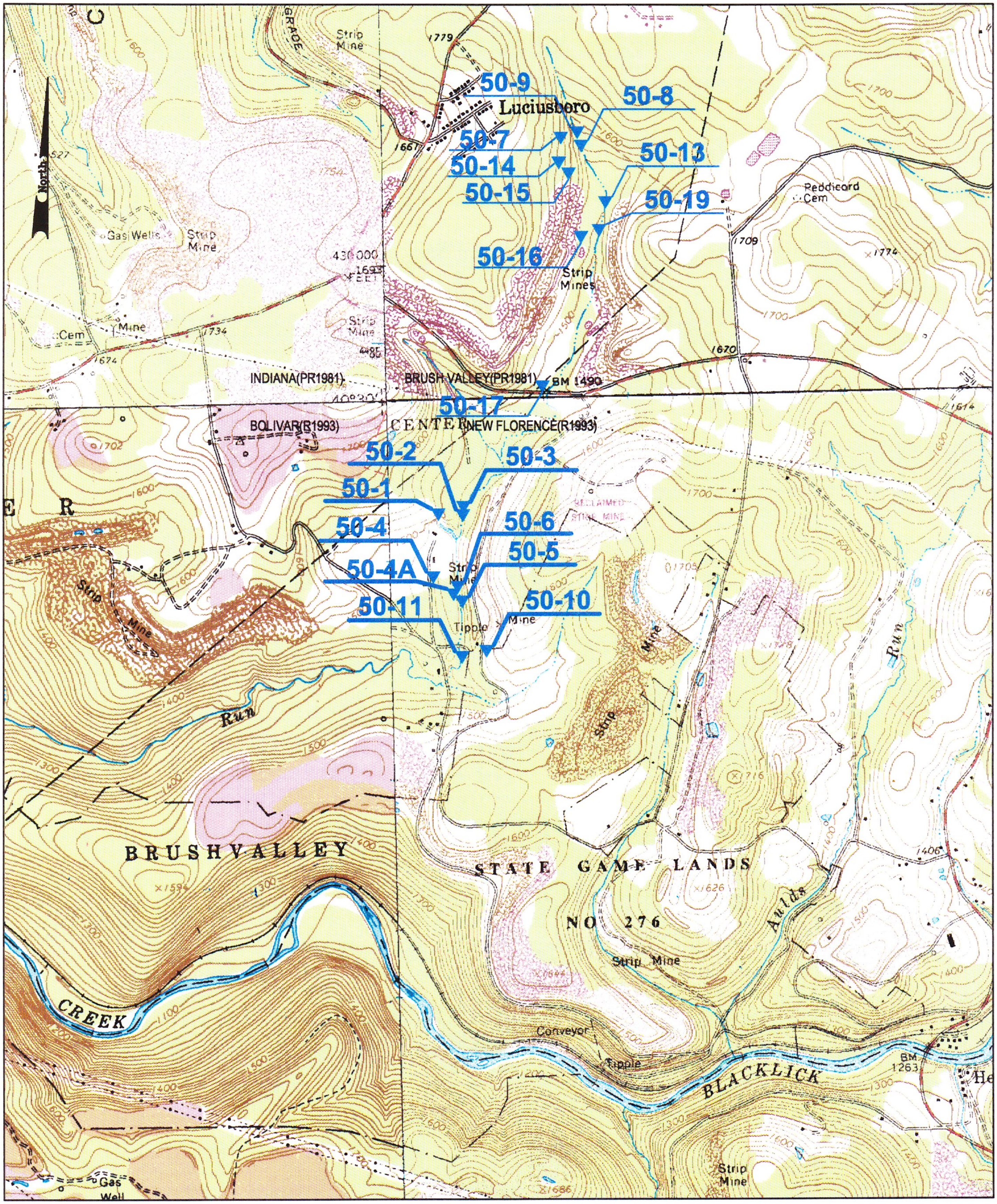
Comparison of Iron, Aluminum, and Manganese Total Metal Concentrations at Sampling Point 50-11 Over Time



50-11 is located on Laurel Run approximately 1 1/2 miles downstream of the passive treatment system.



50-11 is located on Laurel Run approximately 1 1/2 miles downstream of the passive treatment system.



WATER SAMPLE LOCATIONS - USGS 7.5' Brush Valley, PA (PR1981)

LAUREL RUN RESTORATION AREA - PHASE I

Blacklick Creek Watershed

Brushvalley & Center Twps., Indiana County, PA

Stream Restoration Incorporated

6/2002, Scale 1" = 2000'

▼ **WATER SAMPLING POINT**

Approximate Center of Project (deg-min-sec)
40-50-00 latitude 79-11-00 longitude

Additional Topographic Maps:
USGS 7.5' New Florence (R1993)
USGS 7.5' Indiana (PR1981)
USGS 7.5' Bolivar (R1993)

1000 0 1000 2000

Laurel Run Locacation Map Rev

An acidic, iron-laden, aluminum bearing abandoned mine discharge emanates from this century old underground mine gravity drain.

Flow rates from the discharge, which was the primary contributor to flow in the headwaters of Laurel Run ranged from 35 to 525 gallons per minute.

View of the abandoned mine drainage (right) entering Laurel Run (left).

Laurel Run downstream of where the abandoned mine discharge enters the stream. Note the heavy iron staining.

Water sampling conducted by Cliff Denholm, BioMost, Inc., along Laurel Run to document the impact of the abandoned discharge before construction of the passive treatment system.

A stream crossing with culvert pipe had to be installed in order to gain access to the construction site for the passive treatment system.

Clearing and grubbing must be completed as part of the site preparation before construction begins.

View of the compactor that was used at the site.

Tim Danehy, BioMost, Inc., and John Stilley, President of Amerikohl Mining Inc., discussing the construction drawings of the passive treatment system.

Cliff Denholm and Tim Danehy (standing left to right) at a construction meeting with Joe Allison and Scott Alexander (sitting left to right) from the Pa DEP Ebensburg office.

Construction of the Vertical Flow Ponds at the Laurel Run North Passive Treatment System by Amerikohl Mining Inc.

Construction of the passive treatment system required meeting many challenges due to difficult site conditions.

Vertical Flow Pond under construction. Note the underdrain piping system and a portion of the second layer of limestone put in place.

Peripipe discharge pipes for the Vertical Flow Ponds allow for easy balancing, control, and adjustments to flow rates within the ponds.

Former location of mine drain, which is now utilized as part of the collection system and covered with limestone.

Flush Pond in the forground is used as a holding pond during flushing events of the Vertical Flow Ponds behind it.

Top: Pictured from left to right are Chris Treter, OSM Intern to Stream Restoration; Melissa Busler, volunteer; Shaun Busler, BioMost, Inc.; Scott Alexander, PA DEP BMR; Lyle Alexander, volunteer; and Misty Migyanka, PA DEP intern; assembled to complete a stream assessment of Laurel Run before the completion of the passive treatment system as a baseline to document the recovery of the stream. The rapid assessment survey (below) included water sampling, flow measurements, and macroinvertebrate sampling.

Views of the unplanted wetland, which the effluent of the Vertical Flow Ponds enters for further oxidation and precipitation of metals.

Flush pond and valve boxes for the flush pipes of the Vertical Flow Ponds.

A flushing event only a couple of months after the passive treatment system was placed on line.

Final effluent from the passive treatment cascading down the rip-rap lined spillway to enter Laurel Run.

Shaun Busler, BioMost, Inc (left) with volunteer Terry Frombach (right) “burp” the system and balance flows from a Vertical Flow Pond while PA DEP interns look on from behind.

Two PA DEP interns assisting with monitoring the site by taking water samples. The interns and other volunteers were given a tour of the site and an overview of how the passive treatment system works.

Employees of Aquascape Wetland & Environmental Services harvesting wetland plants to transplant them into the treatment wetland.

Dr. Brian Okey's Students from Indiana University of Pennsylvania volunteer with Aquascape, BioMost Inc., and Stream Restoration Inc. to plant the naturally-functioning treatment wetland. The students were given a tour of the site with a brief explanation of passive treatment systems and wetland plants prior to the planting.

A Preliminary Stream Assessment for Watershed Restoration[1]

Scott Alexander, Shaun L. Busler, Cliff Denholm, Timothy Danehy, and Margaret Dunn[2]

Abstract. An assessment of Laurel Run, Indiana County, was conducted in the summer of 2001 through a partnership effort between the Pennsylvania Department of Environmental Protection and Stream Restoration Inc. The purpose of the assessment was to evaluate the potential recoverability of a stream affected by abandoned mine drainage (AMD) before construction of a passive treatment system in the headwaters of Laurel Run. Several major discharges have severely degraded the stream to the confluence with Blacklick Creek (Ohio River Basin). At the mouth of Laurel Run, the stream has a flow rate exceeding 4,200 L/min (1,100 gpm) with pH 5.5, 42 mg/L acidity, 2.5 mg/L iron, and 2.9 mg/L manganese. In addition, baseline data were collected to examine the overall health of the watershed for future planning and preliminary Total Maximum Daily Load (TMDL) studies. Twenty-one sites were assessed using standard EPA Rapid Bioassessment Protocol sampling methods, examining physical, chemical, and biological characteristics. The number and variety of benthic macroinvertebrate taxa were much lower when compared to a physically similar, healthy stream. The primary contributors of flow to the headwaters are an acidic, abandoned, underground mine discharge with an average flow rate of 379 L/min (100 gpm) and several spring fed tributaries. Two unnamed tributaries located above the AMD were found to contain low tolerant macroinvertebrate taxa, indicative of excellent water quality and a reference for the future potential of Laurel Run. In September 2001, a passive system was placed online to treat the AMD. This system consists of two vertical flow ponds built in parallel, a flush pond, and a ½-acre wetland. Water quality analysis shows that Laurel Run has improved to the confluence with the next major discharge, located approximately one mile downstream. Even though the passive treatment system has dramatically improved the quality of the water, several other discharges are inhibiting the full recovery of the stream.

Additional Key Words: abandoned mine drainage (AMD), benthic macroinvertebrates, passive treatment, Rapid Bioassessment Protocol (RBP), restoration, stream assessment, Total Maximum Daily Load (TMDL)

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Timothy Danehy, EPI,
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Introduction

The initiative for assessing and reclaiming the water resources of the United States has been growing within the last 20 years. The Pennsylvania Department of Environmental Protection, for example, has encouraged the development of public-private partnership efforts in order to tackle the almost 101,172 hectares (250,000 acres) of abandoned mine lands and 3,862 km (2,400 miles) of streams impacted by abandoned mine drainage. On Dec. 15, 1999, Gov. Ridge signed "Growing Greener" into law, marking the largest environmental investment ever by a Pennsylvania governor -- $650 million over five years. Within the first two years of the Growing Greener initiative, over 809 hectares (2,000 acres) of abandoned mine lands have been reclaimed, over 1,700 hectares (4,200 acres) of wetlands have been restored or created, and over 595 km (370 miles) of streams have been significantly improved. The overwhelming support for these projects by the community has been demonstrated through doubling the state funding through in-kind and matching contributions (PA DEP, 2001).

Checking the overall health of waterways is important, especially in a region as deeply affected by mine drainage as in the Appalachian Coal Region. Mine drainage has a negative impact on three major components of a watershed. Past mining practices have adversely changed the physical geology within a watershed, which has altered water chemistry and affected the environment for aquatic plants and organisms (Earle and Callaghan, 1998). Watershed monitoring is necessary to determine not only one parameter or source of pollution, but also the overall health of a watershed's individual streams and their surrounding areas. In addition, the monitoring of pristine waterways is equally important since non-impacted streams serve as a reference to measure the recovery of similar impacted streams (Barbour et al., 1999). This paper will address the benefits of utilizing watershed monitoring as a method for 1) obtaining a foundation of preliminary, baseline data for historical and pre-restoration construction, and 2) future comprehensive planning for individual projects in a consecutive order from the headwaters to the mouth. This case study of the Laurel Run Watershed is presented as an illustration.

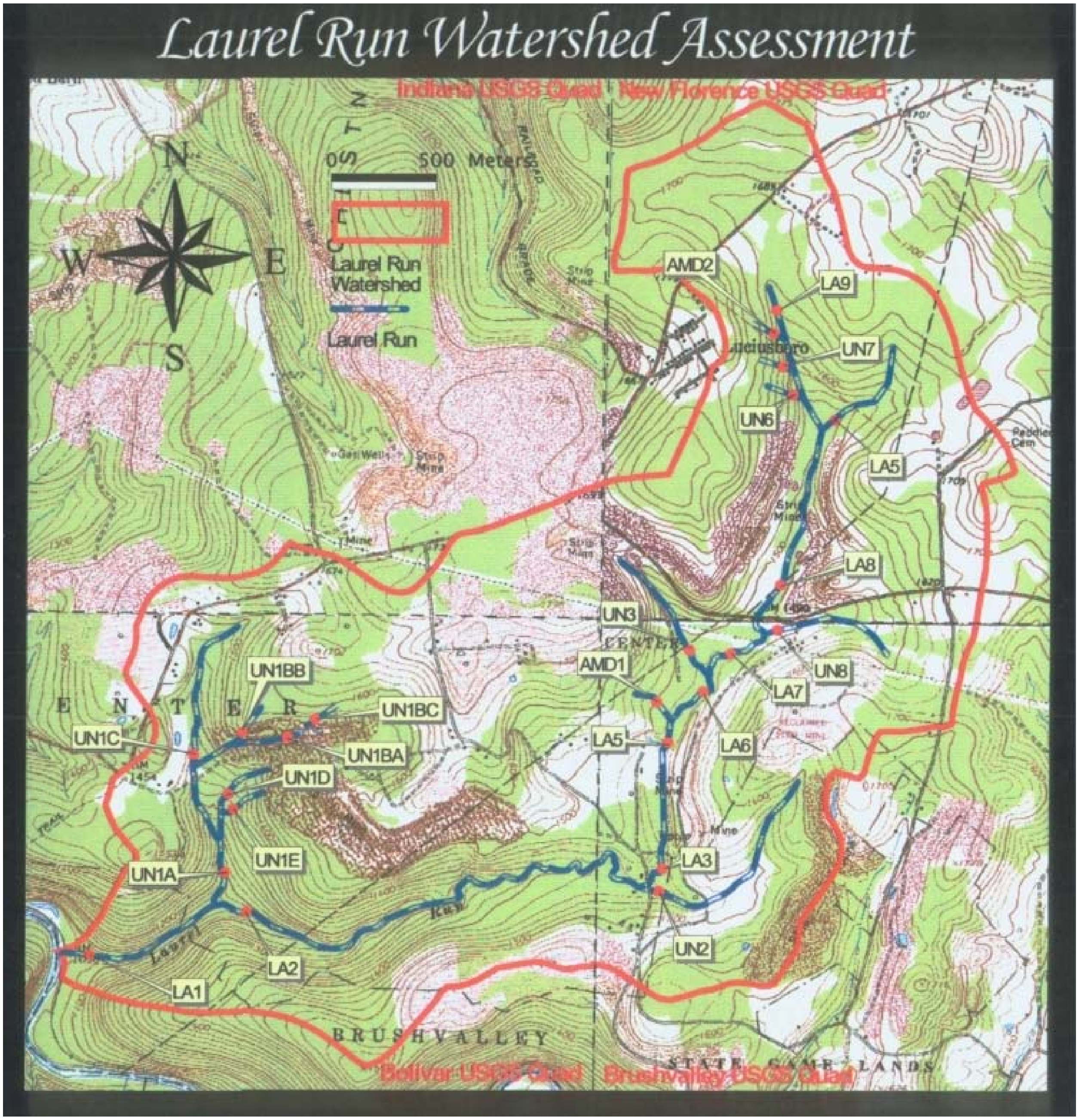

Figure 1. Watershed map of Laurel Run, Center and Brushvalley Townships, Indiana Co., PA.

<u>Laurel Run</u>

Laurel Run is a tributary to Blacklick Creek in the Ohio River Basin (Figure 1). The watershed lies in Center and Brushvalley Townships, Indiana County, PA. The drainage encompasses approximately 10.6 sq. km (4.1 sq. mi.) and flows in a southwesterly direction. The headwaters of Laurel Run are a series of springs and a deep mine discharge traveling approximately 9.8 km (6.1 mi.) into Blacklick Creek. With elevations ranging from 488 to 372 meters (1602 to 1220 feet) traveling downstream, the topography of the watershed is characterized by flat rural and forested lands with gently rolling hills of low relief in the headwaters, as well as high gradient, stream bed relief toward the mouth of Laurel Run.

During July 11-13, 2001, a qualitative watershed assessment was conducted on Laurel Run through a public-private partnership effort. Personnel from Stream Restoration Inc. and the PA Department of Environmental Protection, Bureau of Mining and Reclamation planned and implemented collection of data at twenty-three sites. The sampling stations include the main stem, polluted and non-polluted tributaries, and various mine drainage discharges (Figure 1).

In September 2001, a passive treatment system was placed online through a public-private partnership effort involving Stream Restoration Inc., Amerikohl Mining, Inc., PA Game Commission, private landowners, and the Pennsylvania Department of Environmental Protection. This system consists of two Vertical Flow Ponds built in parallel, a flush pond, and a ½-acre wetland. The vertical flow ponds were built entirely of environmentally-friendly materials (limestone and mushroom compost) and utilized an innovative piping system to flush metal particulates from the ponds (Figure 2, 4, 5).

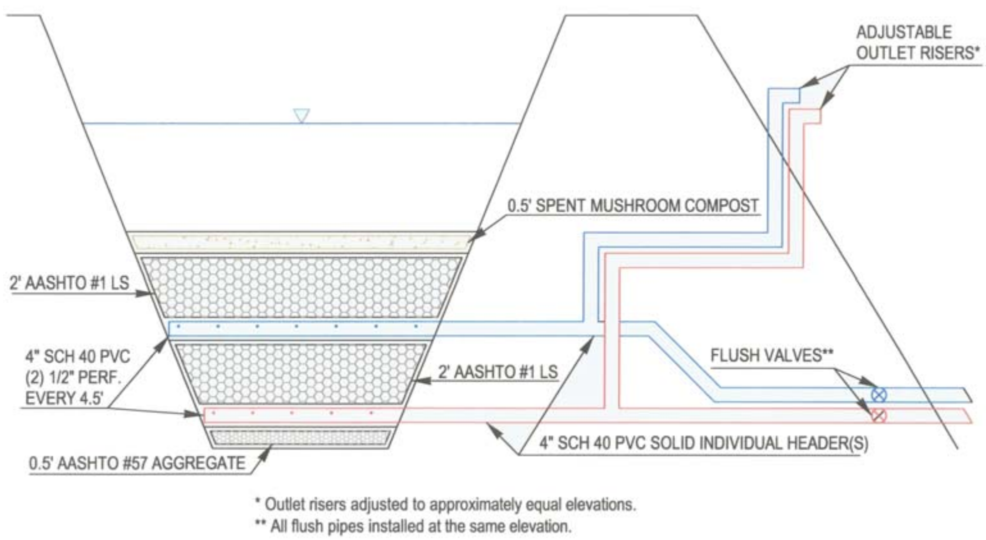

Figure 2: Cross-section of Vertical Flow Pond depicting the type and placement of materials used in construction.

Methods and Materials

A watershed is the region from which surface runoff drains the surrounding land into a stream, river, lake, reservoir, or other body of water. Ideal watershed monitoring should test specific parameters from three general categories: physical, chemical, and biological.

Physical Characteristics

Physical parameters analyzed included a background description of the waterway, various field conditions, benthic habitat and gradient, and a description of the stream banks. The stream was evaluated for depth, width, flow, hydrogeologic origin, water level, and in-stream coloration. Field conditions tested included weather, odors, air temperature, evidence of wildlife presence, and any comments concerning the monitoring station. Adjacent banks were examined for water-saturated soils, upstream land use and potential impacts, bank vegetation disruption, and bank erosion. In-stream habitat conditions were evaluated at each station. The type of benthic environment and bed coating were documented. The habitat evaluation consists of rating twelve habitat parameters to derive a station habitat score (Barbour et al., 1999).

Chemical Characteristics

Chemical parameters evaluated in the field were temperature, pH, dissolved oxygen, and conductivity. Acidity, alkalinity, manganese, iron, aluminum, sulfates, suspended solids, and turbidity were measured in the lab. At each sampling station, water samples were collected by the grab method using a 500 ml bottle and one 125 ml bottle fixed with nitric acid (APHA, 1998). Sampling was conducted from the mouth to the headwaters of Laurel Run in order to collect undisturbed samples. These samples were analyzed using an ICP/Atomic Emission Spectrometry (EPA 200.7) by the Department's laboratory.

Biological Characteristics

The indigenous aquatic community is an excellent indicator of long-term conditions and is used as a measurement of both water quality and ecological significance (Barbour et al., 1999). Benthic macroinvertebrate collections were completed using the EPA Rapid Bioassessment Protocol benthic sampling methodology at the time of water sampling (Barbour et al., 1999). The collected and processed benthic samples serve as a basis for analysis and comparison of tolerance values to generally accepted water quality predictive scoring ranges. Ranging from 1 to 10, low scores are indicative of extremely sensitive organisms and good water quality, while higher scores represent tolerant organisms and poor water quality (Barbour et al., 1999). Due to stream degradation and lack of consistent numbers, the results were limited to a qualitative analysis (family and tolerance index). A fish survey was not conducted as the stream was heavily impacted by AMD.

Results and Discussion

Physical Characteristics

In-stream habitat conditions were evaluated and summarized at each station (Table 1). The range of cumulative habitat score totals for Laurel Run stations were 142 to 213, generally considered to reflect sub-optimal to optimal habitat conditions. Laurel Run received the lowest score under the vegetative protection and grazing/disruptive pressures habitat parameter. Many types of land disturbance will affect a watershed (Earle and Callaghan, 1998). At the time of the assessment, there were several activities that could potentially impact the watershed, including road maintenance, farming, mining, logging, and landfill operations. In addition, multiple sources of AMD have cemented the streambed with metal precipitates giving Laurel Run a score of 68% for sediment deposition. Even with these lower scores, the stream channel has been generally unaltered with above average riffle and pool habitat and channel sinuosity. With properly installed erosion and sediment control measures and continued reclamation of mine drainage sites, the stream has high potential for recovery.

Chemical Characteristics

From the very headwaters of Laurel Run, the stream has been affected by mine drainage (Table 2). AMD2, the first significant mine discharge, greatly degrades water quality and supplies the majority of flow to the headwaters of Laurel Run. The flow of this discharge ranges from 132 to 1,987 L/min (35 to 525 gpm) and contributes over 30,380 kg (81,400 lbs) of acidity and 4,740 kg (12,700 lbs) of metals to Laurel Run every year. Comparison between LA9 and LA8 verifies AMD2's impact to Laurel Run. The headwaters also have several small streams with excellent water quality, LA9, UN7, UN6, and UN5. In general, pH, alkalinity, acidity,

Table 1. Habitat assessment summary.

HABITAT	Scoring	STATIONS														STATISTICS	
PARAMETER	Range	LA1	UN1A	UN1D	LA2	UN2A	LA3	LA5	LA6	UN8	LA8	UN5	UN6	UN7	UN8	Avg.	%
1. epifaunal substrate 2. upstream cover	0 - 40	38	36	36	36	26	26	26	36	26	36	28	36	36	26	32.0	80%
3. embeddedness (HG)/ pool substrate characterization (LG)	0 - 20	18	14	19	17	9	9	18	17	13	13	13	14	19	13	14.7	74%
4. velocity/depth (HG)/ pool variablility (LG)	0 - 20	18	18	17	18	5	18	17	18	8	17	8	17	10	8	14.1	70%
5. sediment deposition	0 - 20	15	14	18	13	13	13	4	13	14	14	14	13	19	14	13.6	68%
6. channel flow status	0 - 20	17	18	18	18	15	8	13	13	13	14	13	14	20	13	14.8	74%
7. channel alteration	0 - 20	20	20	20	20	20	19	19	19	19	19	19	19	20	19	19.4	97%
8. frequency of riffles (HG)/ channel sinousity (LG)	0 - 20	19	18	19	18	12	13	13	13	18	18	13	18	19	18	16.4	82%
9. bank stability	0 - 20	17	18	19	18	14	7	14	14	10	16	14	16	18	10	14.6	73%
10. vegetative protection & 11. grazing/disruptive pressures	0 - 40	32	27	27	21	21	30	21	21	21	21	27	21	27	21	24.1	60%
12. riparian vegetative zone width	0 - 20	10	18	20	18	16	9	12	16	18	14	18	12	18	18	15.5	78%
Total Score [1]	**0 - 240**	**204**	**201**	**213**	**197**	**151**	**152**	**157**	**180**	**160**	**182**	**167**	**180**	**206**	**160**	**179.3**	**75%**

Note: Not all monitoring sites are listed; only sites with completed habitat assessments

[1] Optimal: 181 to 240; Sub-Optimal: 121 to 180; Marginal: 61 to 120; Poor: Less than 60

Table 2. Laurel Run water quality data collected July 11-13, 2001.

Station Sample ID	LA1	UN1A	UN1BA	UN1BB	UN1BC	UN1C	UN1D	UN1E	LA2	UN2A	LA3	LA5	AMD1	LA6	LA8	UN5	UN6	UN7	AMD2	LA9
Field Parameters																				
Air T (^oC)	19.8	23.3	23.3	22.8	22.8	17.5	23.3	23.3	23.3	17.5	19.4	20.6	21.7	19.5	18.4	27	27	27	20.9	19
Water T (^oC)	17.3	18.5	22	19.4	17	15.6	18.6	20.4	18.2	17.5	16.3	17.1	N/A	16.4	13.1	15.7	14.2	11.3	10.4	15.4
pH	5.5	7	6.5	N/A	N/A	3.3	6	3.4	4.2	3.3	6	6.2	6	4.8	5.3	6.6	N/A	7.6	4.7	6.5
Cond (μmhos)	619	449	601	567	779	766	498	549	736	786	802	754	1180	751	605	600	761	764	942	107
Dissolved O_2	7.9	8	5.2	7.4	2.9	9.5	8.3	8.2	7.4	9.5	8.5	8.4	5.3	9.3	8.5	8.3	9.3	8.2	8.4	No Flow
Flow (L/min.)	4211	1591	57	113	57	122	467	189	2620	<1	1885	1734	397	1491	1120	15	101	98	170	<1
Laboratory Parameters																				
pH	4.9	6	6.5	4.2	6.7	3.1	5.6	3	4.1	3.1	5.7	5.5	6.1	4.7	4.7	N/A	6.8	6.5	3.0	5.9
Alkalinity	6.3	22	48	4.6	38	0	10	0	2.6	0	11.6	10.6	66	6.4	8.4	N/A	50	52	0	10.8
Acidity	42.2	33	0	61.8	0	122.8	45.6	61.8	41.8	122.8	53.2	52.4	52.4	54.9	49.2	N/A	0	0	202	6.8
TSS	4	14	<3	<3	16	44	24	12	4	44.9	8	8	12	4	12	N/A	18	8	5	<3
SO_4	276.7	190.6	245.1	442.1	236.7	194.2	211.6	135.2	359.7	194.2	318.6	478.6	540.6	328	356.1	N/A	470	341.3	449	<20
Fe - tot.	2.5	2.0	3.1	0.4	1.5	23.5	2.1	2.6	3.5	23.5	11.3	8.9	43.0	0.7	2.0	N/A	< 0.3	< 0.3	18.1	< 0.3
Mn - tot.	2.9	0.8	1.1	2.4	0.8	3.6	1.5	6.8	3.7	3.6	3.7	1.9	2.5	1.1	0.7	N/A	< 0.1	< 0.1	1.6	0.1
Al - tot.	0.9	0.8	< 0.5	3.5	< 0.5	7.3	1.1	3.1	1.0	7.3	0.9	1.3	< 0.5	2.0	4.2	N/A	< 0.5	< 0.5	14.1	< 0.5

Note: Parameters in mg/L unless otherwise noted.

sulfates, and total suspended solids were in healthy ranges with some buffering capacity.

Two unnamed tributaries enter Laurel Run before the second major discharge. Sample sites on these tributaries, UN3 and UN4, were not sampled due to dry summer conditions. Thus, LA7 was not taken since the water quality of Laurel Run would not have been affected. UN3 originates from several, old mining settling ponds.

By the time Laurel Run reaches sampling station LA6, less than 2 mg/L of metals remain in the water, having almost entirely precipitated within the stream. This station also monitors conditions of Laurel Run before AMD1. AMD1 is an alkaline discharge emanating from an abandoned highwall. This discharge increases pH, alkalinity, metals, sulfates, and specific conductance of Laurel Run, as seen from LA5. Even a third of a mile downstream at LA3, Laurel Run is still severely affected by the AMD1 discharge. UN2 is the last tributary prior to entering the steep valley of the lower portion of the watershed. It flows southwest with low flow and metals.

Figure 3: UN1A entering degraded Laurel Run.

At site LA2 there are decreases in pH, alkalinity, acidity, total suspended solids, aluminum, iron, and sulfates while manganese slightly increases. Again, this is due to the precipitation of the metals on the streambed. UN1A is the mouth of another impacted stream to Laurel Run (Figure 3). UN1BA, UN1BB, UN1BC, and UN1E are mine discharges that represent the majority of flow to this tributary. UN1C contains the lowest pH and highest concentrations of metals affecting this tributary to Laurel Run. Finally, LA1 is at the mouth of Laurel Run. In comparison with the upstream sample station of LA2, LA1 increases in pH and alkalinity and decreases in metal and sulfate concentrations.

<u>After Construction of Passive Treatment System</u>. Since the passive treatment system was placed online treating the AMD2 discharge, over a mile of Laurel Run has significantly improved.

Samples taken October 15, 2001 indicate that the passive treatment system is drastically reducing the amount of iron, aluminum, and manganese into Laurel Run (Table 3, Figure 4 and 5).

Table 3. Comparison of water quality data through passive treatment system.

Station Sample ID	AMD2	VFP	WL
Field Parameters			
Air T (^oC)	N/A	N/A	N/A
Water T (^oC)	9.8	11.0	13.4
pH	4.3	7.1	7.4
Cond (µmhos)	821.3	659.5	1721.5
Dissolved O_2	N/A	N/A	N/A
Flow (L/min.)	571	1061	1061
Laboratory Parameters			
pH	3.1	7.3	7.5
Alkalinity	0.0	228.0	284.6
Acidity	146.4	0.0	0.0
TSS	5.5	12.0	11.0
SO_4	369.8	650.3	777.7
Fe - tot.*	9.7	2.3	2.1
Mn - tot.*	1.1	1.2	1.5
Al - tot.*	11.4	1.3	1.1

Note: Parameters in mg/L unless otherwise noted. VFP = Vertical Flow Pond effluent, WL = Wetland effluent

Figure 4: View of flush pond and Vertical Flow Ponds looking south.

Figure 5: Vertical Flow Pond effluent entering unplanted wetland area to the south. Effluent of wetland enters Laurel Run.

In addition, the system is eliminating all acidity and producing over 250 mg/L of alkalinity. Further downstream, however, AMD1 and additional smaller AMD seeps reduce the amount of alkalinity to about 50 mg/L $CaCO_3$ at station LA3 (Figure 6).

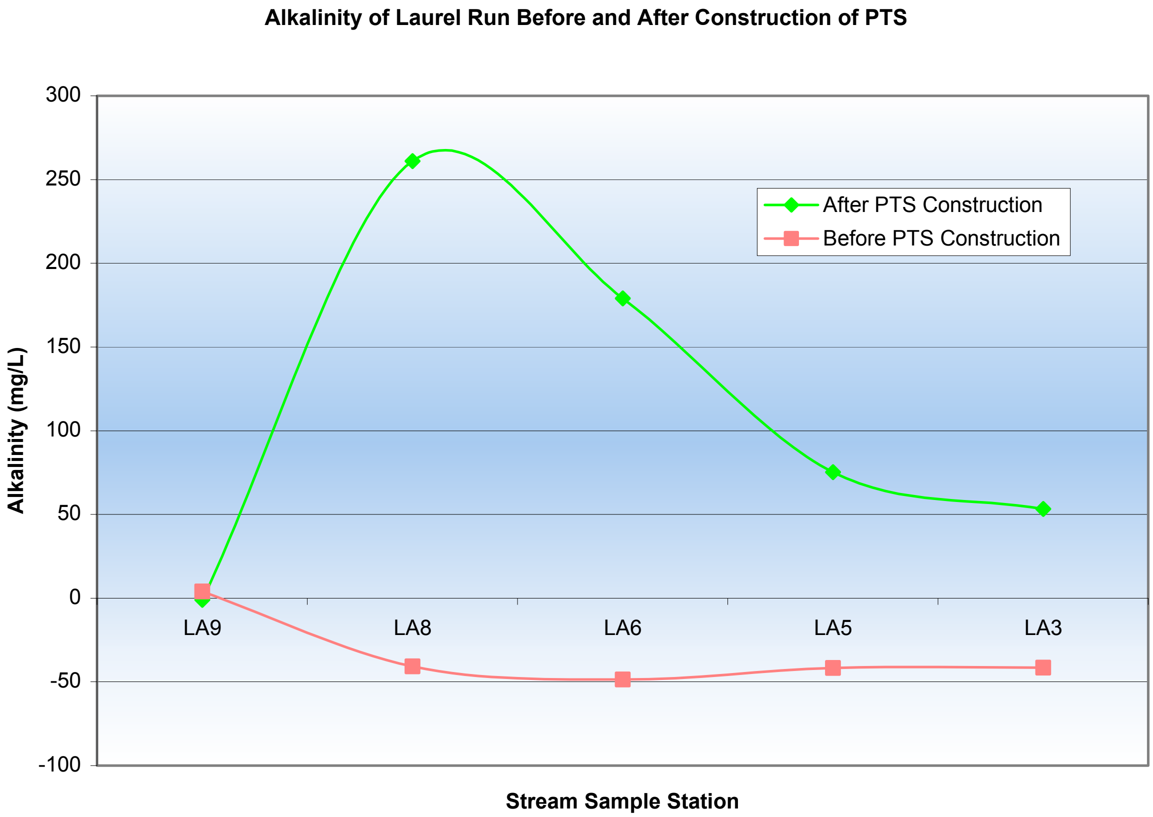

Figure 6. Comparison of alkalinity of Laurel Run before and after construction of passive treatment system.

Biological Characteristics

Potential aquatic insect habitat was sampled at all stations. The numbers of individuals and kind of taxa were lower than could be found in a physically similar, healthy stream. Iron and aluminum precipitate dominated the substrate at the majority of these stations. This precipitate has a direct affect on the macroinvertebrate populations by reducing viable habitat and food resources for macroinvertebrates (Gray, 1996).

At the time of sampling, the following stations were the only sites having populations of aquatic life: UN1D, UN6, and UN7 (Table 3). Two of these sites, UN6 and UN7, are in the headwaters of the watershed and are not affected by mine drainage. These streams contained several macroinvertebrates with a variety of tolerance levels. The other station, UN1D, is a small tributary located in the lower portion of the watershed, which was effected by several AMD discharges. Only three species of aquatic macroinvertebrates were found at this station, Corydalidae, Decapoda, and Hydropshychidae (Table 4). Corydalidae is an extremely sensitive macroinvertebrate, however, only one individual of this species was discovered. It is a predatory species capable of traveling large distances in search of food (Merritt and Cummins, 1996; Borror and White, 1970). Thus, it may not represent the quality of this portion of the stream. Decapoda and Hydropshychidae are mid-range tolerant organisms indicative of some impact (Barbour et al., 1999).

Table 4: Qualitative aquatic macroinvertebrate survey results.

Sample Station	Macroinvertebrate	Tolerance Index
UN1D	Corydalidae	0
	Decapoda	6
	Hydropshychidae	4
UN06	Decapoda	6
	Hydropshychidae	4
	Peltoperlidae	0
UN07	Decapoda	6
	Emphemerellidae	1
	Gastropid	6 to 8
	Hydropshychidae	4
	Peltoperlidae	0
	Polycentripodidae	6
	Tipulida	3

Aside from the obvious metal precipitation and poor water quality, Laurel Run has a high gradient, adequate dissolved oxygen, promising benthic habitat, and a predominately-forested watershed. UN6 and UN7 are an excellent background reference for water quality obtainable if stream restoration were to take place.

It should be noted again that Laurel Run does have the excellent potential for fish propagation with deep pools, undercut banks, boulders, submerged logs, and root masses. If restored, Laurel Run could be classified as a coldwater fishery.

Conclusions

A rapid assessment of the existing conditions within a watershed can be completed in a cost effective manner. This assessment was completed through a public-private partnership effort. Watershed groups with little financial resources can greatly benefit from an assessment of this type. Potential applications of the survey include future restoration and conservation planning, Total Maximum Daily Load (TMDL) studies, or can be a part of a larger watershed study.

Based on findings from this survey and a review of historical data:

1. The headwaters are generally spring-fed, have excellent forest and benthic habitat, and show a high potential for revitalizing water quality and biota upon stream restoration.
2. Two abandoned mine discharges are sources for the majority of metal and acid loading to Laurel Run.
3. Remediation of these discharges would restore miles of stream.
4. Many smaller discharges and seeps are found throughout the watershed.

The constructed passive treatment system at AMD2 has effectively eliminated the impacts of the underground discharge located in the headwaters of Laurel Run. There is a dramatic difference in low tolerant aquatic macroinvertebrates at the headwaters and no aquatic populations below, mainly due to AMD. Since the watershed has a forested area, a stable riparian buffer zone, an epifaunal substrate, adequate dissolved oxygen, and a high gradient the healthy upstream macroinvertebrate populations could inoculate the downstream reaches. Follow-up plans include post-treatment assessments, periodic monitoring, continued public participation, and prospecting other areas for complete watershed restoration.

Acknowledgements

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Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
RAW	0/15/200	Bucket	35		3.0	1193	10		0	286	23.2	1.9	20.0	748	3
RAW	2/18/200	Bucket	525	4.5	3.7	290	9		0	41	2.7	0.3	2.4	116	2
RAW	4/18/2002	Bucket	257	4.3	3.3	628	10		0	92	6.7	0.9	6.9	268	4
RAW	6/17/2002	Bucket	179	4.5	3.1	773	10		0	169	9.3	1.1	0.3	302	5
RAW	3/15/2005			4.4	3.0	1059	10		0	196	17.6	1.6	15.4	547	1
Min			35	4.3	3.0	290	9		0	41	2.7	0.3	0.3	116	1
Max			525	4.5	3.7	1193	10		0	286	23.2	1.9	20.0	748	5
Avg			249	4.4	3.2	789	10		0	157	11.9	1.2	9.0	396	3
Range			490	0.2	0.8	903	1		0	245	20.5	1.6	19.7	633	4

Description: Influent of the passive treatment system taken at the influent pipe to the Vertical Flow Ponds; Abandoned Mine Discharge; Same as 50-7

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
VFP-E	0/15/200	Bucket	15	7.5	7.6	32	15		634	0	5.1	2.1	0.9	1040	14
VFP-E	2/18/200	Bucket	254	7.0	7.2	780	7		99	0	0.9	0.7	0.9	407	13
VFP-E	4/18/2002	Bucket	141		6.8	670	14		86	0	1.9	1.0	1.0	286	6
VFP-E	6/17/2002	Bucket	49	7.0	7.3	732	17		96	0	5.8	1.3	1.3	290	9
VFP-E	3/15/2005				6.5	876	21		59	-28	14.8	3.0	3.4	565	10
Min			15	7.0	6.5	32	7		59	-28	0.9	0.7	0.9	286	6
Max			254	7.5	7.6	876	21		634	0	14.8	3.0	3.4	1040	14
Avg			115	7.2	7.1	618	15		195	-6	5.7	1.6	1.5	518	10
Range			239	0.5	1.1	844	14		575	28	13.9	2.3	2.5	753	8

Description: Composite sample of the Effluent pipes from Vertical Flow Pond East

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
VFP-W	0/15/200	Bucket	20	7.0	7.0	1152	15		114	0	2.6	1.2	2.4	785	12
VFP-W	2/18/200	Bucket	270	7.0	7.2	674	7		65	0	0.7	0.9	0.9	369	9
VFP-W	4/18/2002	Bucket	116		6.6	630	15		56	0	0.4	0.9	1.7	269	6
VFP-W	6/17/2002	Bucket	130	7.0	7.1	682	17		72	0	1.6	1.1	0.3	286	7
VFP-W	3/15/2005				6.7	882	22		91	-66	31.1	8.1	0.3	500	41
Min			20	7.0	6.6	630	7		56	-66	0.4	0.9	0.3	269	6
Max			270	7.0	7.2	1152	22		114	0	31.1	8.1	2.4	785	41
Avg			134	7.0	6.9	804	15		79	-13	7.3	2.4	1.1	442	15
Range			250	0.0	0.6	522	15		58	66	30.7	7.3	2.2	516	35

Description: Composite sample of the effluent pipes o of Vertical Flow Pond West

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
WL	0/15/200	Assumed	35	7.7	7.7	2713	20		487	0	3.4	2.2	1.1	1181	13
WL	2/18/200	Assumed	524	7.0	7.4	730	7		82	0	0.8	0.8	1.0	375	9
WL	4/18/2002	Assumed	257	7.0	7.1	640	21		71	0	0.6	0.8	0.8	279	3
WL	6/17/2002	Assumed	179	7.0	7.7	708	24		94	0	1.2	1.0	1.0	329	9
WL	3/15/2005			7.0	7.2	864	24	69	66	-52	0.1	2.6	0.1	457	1
Min			35	7.0	7.1	640	7	69	66	-52	0.1	0.8	0.1	279	1
Max			524	7.7	7.7	2713	24	69	487	0	3.4	2.6	1.1	1181	13
Avg			249	7.1	7.4	1131	19	69	160	-10	1.2	1.5	0.8	524	7
Range			489	0.7	0.6	2073	17	0	421	52	3.3	1.8	1.1	901	12

Description: Final Effluent of the passive treatment system which discharges from the consturcted wetlands

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
FP	11/1/2001				7.3	946			188	0	0.2	0.9	0.1	410	8
FP	6/17/2002			5.5	7.1	460	14		22	0	0.3	1.5	0.2	203	1
Min				5.5	7.1	460	14		22	0	0.2	0.9	0.1	203	1
Max				5.5	7.3	946	14		188	0	0.3	1.5	0.2	410	8
Avg				5.5	7.2	703	14		105	0	0.2	1.2	0.1	306	5
Range				0.0	0.1	486	0		165	0	0.1	0.6	0.1	208	7

Description: Effluent pipe of the Flush Pond

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-3	5/9/2000	Cross-section	132	5.9	4.9	476	17		2	19	0.4	0.8	1.8	190	10
50-3	5/31/2000			5.6	4.8	360	15		2	21	0.4	0.7	1.8	164	3
50-3	6/27/2000	Cross-section	117	4.8	4.7	539	17		1	22	0.3	1.1	1.9	277	4
50-3	7/21/2000	Cross-section	127	4.7	4.6	584	16		1	27	0.3	1.1	3.1	321	2
50-3	7/12/2001	Flow Meter	394	4.8	4.7	751	16		6	55	0.7	1.1	2.0	328	4
50-3	0/15/200			7.5	7.5	1568	13		179	0	7.4	1.9	0.6	844	36
Min			117	4.7	4.6	360	13		1	0	0.3	0.7	0.6	164	2
Max			394	7.5	7.5	1568	17		179	55	7.4	1.9	3.1	844	36
Avg			193	5.6	5.2	713	16		32	24	1.6	1.1	1.9	354	10
Range			277	2.8	3.0	1208	4		179	55	7.2	1.2	2.5	680	34

Description: Laurel Run; 1 mile downstream of abandoned underground mine discharge 50-7 and upstream of 50-1

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-7	5/9/2000	Weir	140	4.2	3.2	759	11		0	118	7.4	1.0	9.1	270	7
50-7	5/31/2000	Weir	210	4.0	3.2	610	11		0	101	6.2	0.8	6.5	257	6
50-7	6/27/2000			4.5	3.1	894	10		0	159	11.6	1.1	22.1	448	10
50-7	7/21/2000	Weir	50	4.4	3.0	1004	10		0	180	10.2	1.4	13.8	379	4
50-7	5/2/2001	Weir	154	4.5	3.1	755	9		0	96	6.9	0.9	7.7	322	3
50-7	6/12/2001	Weir	128	4.5	3.1	732	9		0	122	8.8	1.0	8.2	284	4
50-7	6/29/2001	Weir	70	4.3	3.0	940	10		0	158	1.8	1.3	10.7	426	11
50-7	8/8/2001	Weir	45	4.0	3.0	1036	9		0	202	18.1	1.6	14.1	449	5
Min			45	4.0	3.0	610	9		0	96	1.8	0.8	6.5	257	3
Max			210	4.5	3.2	1036	11		0	202	18.1	1.6	22.1	449	11
Avg			114	4.3	3.1	841	10		0	142	8.9	1.1	11.5	354	6
Range			165	0.5	0.3	426	2		0	106	16.4	0.8	15.6	192	8

Description: Underground mine opening; major pollution source to Laurel Run headwaters. PTS online 9/19/01. Post-construction monitoring at influent p

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-8	5/9/2000			4.1	3.3	703	11		0	110	7.2	0.9	8.0	252	13
50-8	5/31/2000				3.3	574			0	83	5.2	0.7	5.5	201	6
50-8	6/27/2000	Cross-section	142	4.3	3.2	696	12		0	115	8.2	0.8	7.3	312	7
50-8	7/21/2000	Cross-section	79	4.0	3.0	945	10		0	181	13.9	1.4	11.7	397	1
50-8	5/2/2001	Cross-section	185	4.5	3.2	674	10		0	95	6.2	0.8	7.3	321	2
50-8	6/12/2001			4.4	3.1	774	10		0	113	9.6	1.0	7.1	273	3
50-8	6/29/2001	Assumed	70	4.5	3.0	980	10		0	157	11.7	1.3	11.1	411	5
50-8	8/8/2001	Assumed	45	4.3	2.9	1034	10		0	211	18.9	1.6	15.0	426	11
Min			45	4.0	2.9	574	10		0	83	5.2	0.7	5.5	201	1
Max			185	4.5	3.3	1034	12		0	211	18.9	1.6	15.0	426	13
Avg			104	4.3	3.1	798	10		0	133	10.1	1.1	9.1	324	6
Range			140	0.5	0.4	460	2		0	128	13.8	1.0	9.5	225	12

Description: Laurel Run; Downstream of abandoned mine discharge 50-7; see 50-19 for post-construction monitoring.

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-9	5/9/2000			6.4	5.4	121	18		2	6	0.1	0.0	0.2	17	12
50-9	5/31/2000			6.1	5.8	108	15		3	5	0.2	0.0	0.1	22	3
50-9	6/27/2000	Cross-section	72	6.0	5.8	167	18		3	8	0.2	0.1	0.3	22	5
50-9	7/21/2000	Dry		5.5	5.9	132			6	6	0.3	0.9	0.1	20	4
50-9	7/21/2000	Dry													
50-9	5/2/2001	Cross-section	31	5.8	6.1	107	12		3	1	0.1	0.0	0.1	22	1
50-9	6/12/2001			6.3	6.2	111	15		4	5	0.1	0.1	0.1	16	2
50-9	6/29/2001	Dry													
50-9	7/13/2001			6.5	5.9	107	15		11	7	0.0	0.1	0.0	0	0
50-9	8/8/2001	Dry													
50-9	0/15/200	Dry													
50-9	4/18/2002	Estimated	60	5.9	5.8	92	13		3	0	0.1	0.0	0.1	20	2
50-9	6/17/2002			6.0	6.1	90	15		4	2	0.3	0.2	10.3	22	7
Min			31	5.5	5.4	90	12		2	0	0.0	0.0	0.0	0	0
Max			72	6.5	6.2	167	18		11	8	0.3	0.9	10.3	22	12
Avg			54	6.1	5.9	115	15		4	5	0.1	0.1	1.3	18	4
Range			41	1.0	0.7	77	6		8	8	0.3	0.9	10.3	22	12

Description: Laurel Run; Upstream of abandoned mine discharge 50-7

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-11	5/31/2000			6.3	5.2	477	16		3	20	5.2	1.6	1.4	256	7
50-11	6/27/2000			5.9	5.9	738	17		6	30	12.0	2.7	1.3	451	6
50-11	7/21/2000			6.7	3.0	15	0		0	198	17.8	3.9	1.2	744	18
50-11	5/2/2001	Cross-section	236	5.8	5.3	656	19		3	16	7.0	2.4	1.3	361	1
50-11	6/12/2001			6.0	5.4	681	15		3	17	8.6	2.7	1.4	405	5
50-11	6/29/2001			6.0	5.3	817	19		3	22	10.7	3.6	1.1	456	5
50-11	7/12/2001	Flow Meter	498	6.0	5.7	802	16		12	53	11.3	3.7	0.9	319	8
50-11	8/8/2001	Cross-section		6.0	5.3	890	21		3	30	13.3	5.1	1.1	522	8
50-11	10/15/2001			6.6	6.5	1222	13		53	0	10.8	4.1	0.3	710	24
50-11	6/17/2002			6.0	6.5	175	14		8	0	1.8	0.4	0.5	80	5
Min			236	5.8	3.0	15	0		0	0	1.8	0.4	0.3	80	1
Max			498	6.7	6.5	1222	21		53	198	17.8	5.1	1.4	744	24
Avg			367	6.1	5.4	647	15		9	39	9.8	3.0	1.1	430	9
Range			262	0.9	3.5	1208	21		53	198	15.9	4.6	1.1	664	23

Description: Laurel Run; 1 1/2 miles downstream of abandoned mine discharge 50-7 (near Plant-It Earth)

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-13	5/2/2001	Cross-section	164	4.7	3.9	506	11		0	30	2.1	0.4	3.3	293	2
50-13	6/12/2001			4.7	3.6	580	12		0	50	5.2	0.6	4.8	235	4
50-13	6/29/2001	Cross-section	103	4.6	3.4	711	13		0	74	3.9	0.8	7.1	367	6
50-13	7/13/2001	Flow Meter	4	6.6		600	16								
50-13	8/8/2001	Cross-section	69	4.0	3.2	866	14		0	146	6.8	1.1	9.2	426	9
50-13	0/15/200			7.0	6.2	600	17		10	0	0.5	0.6	0.3	353	3
50-13	6/17/2002			6.0	7.4	465	15		25	0	0.2	0.1	0.5	181	2
Min			4	4.0	3.2	465	11		0	0	0.2	0.1	0.3	181	2
Max			164	7.0	7.4	866	17		25	146	6.8	1.1	9.2	426	9
Avg			85	5.4	4.6	618	14		6	50	3.1	0.6	4.2	309	4
Range			160	3.0	4.2	401	6		25	146	6.6	1.0	8.9	244	7

Description: Laurel Run; downstream of unamed tributaries; Pre-and Post- construction monitoring shows improvement to 3/4 -mile stream segment locat

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-14	5/2/2001	Cross-section	71	6.0	6.5	731	10		47	0	0.1	0.0	0.2	406	3
50-14	6/12/2001			6.0	6.9	677	10		43	0	4.4	3.7	4.8	311	3
50-14	6/29/2001	Estimated	50	6.5	6.3	708	11		46	0	0.0	0.0	0.2	418	1
50-14	7/13/2001	Flow Meter	26	7.6	6.5	764	11		52	0	0.0	0.0	0.0	341	8
50-14	8/8/2001	Estimated	15		7.1	717	11		45	0	0.2	0.1	0.6	378	3
50-14	0/15/200			7.3	6.9	768	13		51	0	0.1	0.1	0.1	509	1
Min			15	6.0	6.3	677	10		43	0	0.0	0.0	0.0	311	1
Max			71	7.6	7.1	768	13		52	0	4.4	3.7	4.8	509	8
Avg			41	6.7	6.7	728	11		47	0	0.8	0.6	1.0	394	3
Range			56	1.6	0.8	91	3		9	0	4.4	3.7	4.8	198	7

Description: Unnamed tributary #1; North of PTS closest to UG mine discharge

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-15	5/2/2001	Cross-section	49	6.0	6.5	709	10		47	0	0.0	0.0	0.0	425	2
50-15	6/12/2001			6.0	6.7	651	9		43	0	0.0	0.0	0.1	300	4
50-15	6/29/2001	Estimated	35	6.3	6.5	741	11		45	0	0.0	0.0	0.1	418	1
50-15	7/13/2001	Flow Meter	27		6.8	761	14		50	0	0.0	0.0	0.0	470	18
50-15	8/8/2001	Estimated	20	7.0	7.0	733	16		42	0	0.3	0.2	0.3	384	2
50-15	0/15/200			7.5	6.9	746	14		45	0	0.1	0.1	0.1	440	3
Min			20	6.0	6.5	651	9		42	0	0.0	0.0	0.0	300	1
Max			49	7.5	7.0	761	16		50	0	0.3	0.2	0.3	470	18
Avg			33	6.6	6.7	724	12		45	0	0.1	0.0	0.1	406	5
Range			29	1.5	0.6	110	7		8	0	0.3	0.2	0.3	170	17

Description: Unnamed tributary #2 directly north of PTS

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-17	5/2/2001	Cross-section	164	5.5	5.1	505	20		2	6	1.0	0.5	2.3	276	3
50-17	6/12/2001			4.8	4.7	501	15		1	23	0.8	0.5	3.3	231	4
50-17	7/13/2001	Flow Meter	296	5.3	4.7	605	13		8	49	2.0	0.7	4.2	356	12
50-17	8/8/2001	Cross-section	70	4.5	4.6	640	21		1	34	0.8	1.1	5.7	378	4
50-17	10/15/2001			7.5	7.5	1744	13		261	0	7.8	1.7	0.5	703	16
50-17	6/17/2002			5.5	7.6	590			58	0	0.5	0.4	0.6	278	6
Min			70	4.5	4.6	501	13		1	0	0.5	0.4	0.5	231	3
Max			296	7.5	7.6	1744	21		261	49	7.8	1.7	5.7	703	16
Avg			177	5.5	5.7	764	16		55	19	2.2	0.8	2.8	370	8
Range			226	3.0	3.0	1243	8		260	49	7.2	1.3	5.2	471	13

Description: Laurel Run ; at bridge along SR-2014; Located about 1/ 1/2 mile downstream of passive treatment system.

Laurel Run Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (Field) (mg/L)	Alk. (lab) (mg/L)	Acidity (mg/L)	Iron (mg/L)	Manganese (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
50-19	0/15/200			7.5	7.6	2068	15		322	0	3.3	1.8	0.7	744	18
50-19	4/18/2002			7.0	6.7	446	17		34	0	0.5	0.4	0.5	179	2
50-19	6/17/2002			6.0	7.6	566	17		52	0	0.8	0.5	0.8	248	4
50-19	8/15/2005			7.4	7.3	754	22		56	-43	0.5	1.4	0.1	427	1
Min				6.0	6.7	446	15		34	-43	0.5	0.4	0.1	179	1
Max				7.5	7.6	2068	22		322	0	3.3	1.8	0.8	744	18
Avg				7.0	7.3	959	18		116	-11	1.2	1.0	0.5	400	6
Range				1.5	0.9	1622	7		287	43	2.8	1.4	0.8	565	17

Description: Laurel Run; just downstream of passive treatment system final effluent confluence.