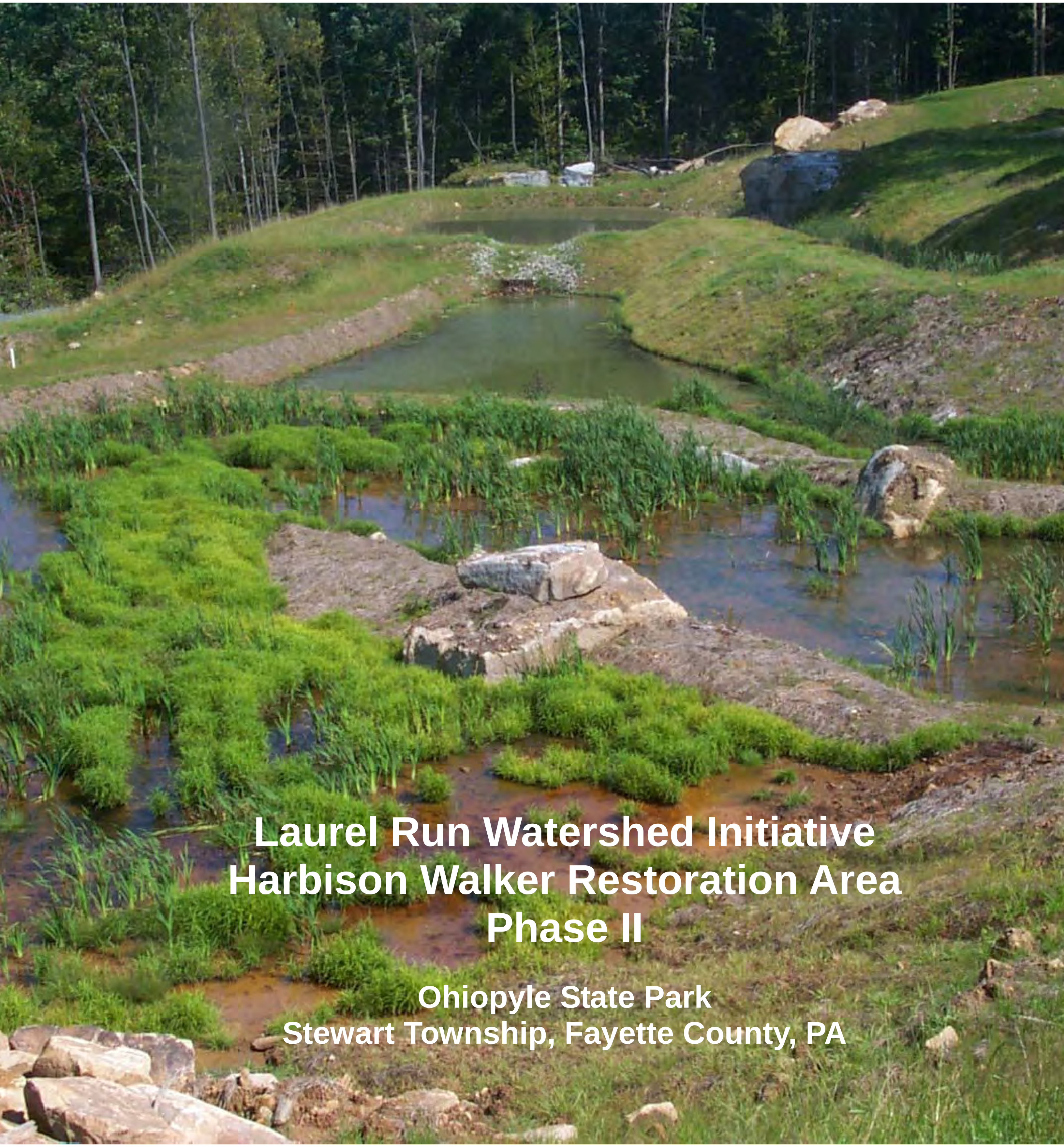


Laurel Run Watershed Initiative
Harbison Walker Restoration Area
Phase II

Ohiopyle State Park
Stewart Township, Fayette County, PA

Stream Restoration Incorporated
A PA Non-Profit Organization 501(c)(3)
3016 Unionville Rd., Cranberry Twp., PA 16066
PH: 724-776-0161 FX: 724-776-0166 sri@streamrestorationinc.org

Date: September 30, 2003

To: Dean Baker, Project Officer
PA Department of Environmental Protection
Bureau of Abandoned Mine Reclamation – Cambria Office
PO Box 149
Ebensburg, PA 15931

Re: Final Report
ME#3591054; Project #EA26-004SW
Harbison Walker Phase II Passive Treatment System
Ohiopyle State Park, Stewart Twp., Fayette Co., PA
200702/FR-trans

The Final Report for the above noted project is enclosed. This report incorporates our understanding of your review comments on the 5/29/03 draft.

The extremely degraded nature of the mine drainage and the high variability in flow rates required the implementation of possibly the most innovative passive treatment complex within the Commonwealth of Pennsylvania. Substantial in-kind/matching funds from the partners were used in order to incorporate examples of all types of passive treatment components. This project has already provided significant advancements in passive technology and watershed restoration and continues to be actively studied.

With the benefit of being located in Ohiopyle State Park, the Harbison Walker Phase I and Phase II systems possess infinite "hands-on" educational and research opportunities which have been enhanced by the recent construction of an on-site shelter by the PA DCNR. The continued support of this effort is expected to spur interest in the restoration of this and other watersheds impacted by abandoned mine drainage. We hope that this submission will meaningfully acknowledge the importance of the project and the funding received through the Growing Greener program.

Please do not hesitate to contact us with recommendations to improve this report, as the submission of a good quality work product is important to all of us.

Your patience and assistance has been very much appreciated.

From: Stream Restoration Incorporated

By: Margaret H. Dunn, PG, President

Sent: First Class Mail

Stream Restoration Incorporated
"Making It Happen" through Public-Private Partnership Efforts

HARBISON WALKER RESTORATION AREA

PHASE II FINAL REPORT

Laurel Run tributary to Meadow Run
(Youghiogheny River Watershed, Ohio River Basin)
Ohiopyle State Park, Stewart Township, Fayette County, PA

A Pennsylvania Growing Greener Watershed Restoration Project

Brief Description of Project Work through Grant and Partnership Contributions

- Compiled water monitoring data (source: PA DEP, etc.)
- Reviewed reference: Hellier, William W., PE, 1999, An Integrated Design Model for Passive Treatment Systems to Abate Water Pollution from Post-Mining Discharges [Ohiopyle State Park]: *in* 1999 Proceedings of National Association of Abandoned Mine Land Programs.
- Prepared funding proposals, completed applications, and received grants, permits, and approvals including: DCNR proposal(1999); DEP Growing Greener proposal(1999 & 2000); PNDI(1999); Cultural Resource(2000); NPDES(2000); E & S Control(2000); Environmental Assessment(2000); Slag Usage(2001)
- Installed approved Erosion and Sediment Controls
- Upgraded existing, and installed new, sludge ponds; pumped, removed, and placed sludge from former active treatment operation; reclaimed sludge ponds
- Treated water with temporary caustic soda system during major construction
- Upgraded existing roadways and a horse trail and installed new access roads
- Expanded project substantially from the Growing Greener proposal (without change orders for additional funding) to include:
  - Increased number of passive components from 8 to over 20
  - Added treatment capability for tributary "C"
  - Increased aggregate used for treatment by 16% from 7870 T to 9400 T
  - Increased constructed wetlands by 32% from 33,800 SF to 49,425 SF
  - Upgraded wetland design and implementation to include high diversity plantings with enhanced wildlife value
  - Increased underdrain system piping by over 90% from <1 mile with 4 outlet valves to >4 miles with 28 valves through addition of two-tiered underdrain systems for all Vertical Flow Ponds

- Upgraded two Vertical Flow Ponds to enable hybrid flow operation (not included in contract)
- Added piping between components to allow operation of the passive complex, excluding diversion well, with a single final effluent point
- Increased abandoned mine reclamation by about 18 acres (includes regarding and revegetating steep existing spoil slopes)
- Added a ~6000 SF non-treatment wetland with high, plant species diversity for wildlife habitat

- Designed passive system complex (25-year design life) to treat discharges AC, B1, B3 and other drainage from an old, 120-acre, surface clay and coal mine

- Installed an innovative passive treatment complex with more than 20 components (functioning 01/08/01) with individual and shared features including:
  - Collection Systems(4)
  - Limestone-Only Vertical/Hybrid Flow Ponds (2 in parallel)
  - Vertical Flow Pond (1 with limestone overlain by compost)
  - Slag-Only Vertical Flow Pond(1)
  - Flush Ponds(3)
  - Settling Ponds(3)
  - Bioswales(2)
  - Open Limestone Channels(2)
  - Aerobic Wetlands(4)
  - Horizontal Flow Limestone Bed(1)
  - Diversion Well with Forebay(1)

- Regraded and revegetated about 25 acres of abandoned mine land

- Planted wetlands with Americorp volunteers and other participants in the public-private partnership effort

- Continued Laurel Run and system component monitoring by participants in the public-private partnership effort

- Conducted before, during, and after site tours; kept photographic log

- Submitted electronic updates, quarterly status reports, final report with "As-Builts" and selected photos, and administered contract

<u>Funding:</u> **Environmental Stewardship and Watershed Protection Grant ME#3591054; EA#26-004SW; $1,196,659.04**

Amerikohl Mining, Inc.; Aquascape; BioMost, Inc.; WOPEC; EIS, LLC; Stream Restoration Inc.[non-profit]; volunteers; ~$300,000 in-kind/match

PUBLIC-PRIVATE PARTNERSHIP

Water Quality Monitoring
PA DEP, District Mining Operations, RD2, Box 603-C, Greensburg, PA 15601-8739
HORANSKY, Ron, Watershed Manager; GREENE, C.R., Insp. Supervisor; HALL, Margaret, Chief, Monitoring & Compliance; TERRETTI, Michael, Dist. Mining Mgr.
(724) 925-5500

Design Considerations
PA DEP, Bureau of Mining and Reclamation, PO Box 209, Hawk Run, PA 16840
HELLIER, William W., PE, Tech Transfer Coordinator(retired)
(814) 342-8133

Project Review, Oversite, Aerial Topography (Pre- and Post-Construction)
PA DEP, Bureau of Abandoned Mine Reclamation, Box 149, Ebensburg, PA 15931
BAKER, Dean, Proj. Officer; HORRELL, Scott, Chief, Field Ops. ; LARDEN, Ray, Insp.
(814) 472-1800

Property Jurisdiction, Public Outreach/Education, Long-Term System Operation
PA DCNR, Ohiopyle State Park, PO Box 105, Ohiopyle, PA 15470
HOEHN, Doug, Park Mgr.; BICKEL, Daniel, Ass't. Mgr.; WALLACE, Barbara, Env. Ed.
(724) 329-8591

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

Passive Treatment Systems, Water Monitoring, Operation & Maintenance
BioMost, Inc., 3016 Unionville Rd., Cranberry Twp., PA 16066
DANEHY, Timothy, EPI; DUNN, Margaret, PG; BUSLER, Shaun, Biologist; DENHOLM, Clifford, Environmental 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

Grant Administration, Education and Public Outreach, Volunteer Effort
Stream Restoration Incorporated, 3016 Unionville Rd., Cranberry Twp., 16066
DANEHY, Timothy, EPI; DUNN, Margaret, PG; BUSLER, Shaun, Biologist; DENHOLM, Clifford, Environmental Scientist; TRETER, Deanna, Office Manager; TRETER, Chris, Biologist Intern; SHORT, Steve, Biologist Intern
(724) 776-0161

TABLE OF CONTENTS

HARBISON WALKER RESTORATION AREA

PHASE II FINAL REPORT

Laurel Run tributary to Meadow Run
(Youghiogheny River Watershed, Ohio River Basin)
Ohiopyle State Park, Stewart Township, Fayette County, PA

submitted to

Pennsylvania Department of Environmental Protection

PROJECT SUMMARY

Prior to implementation of the passive treatment complex, the Pennsylvania Department of Conservation and Natural Resources (DCNR) actively treated discharge AC with hydrated lime and discharge B1 with soda ash briquettes. As treatment is required in perpetuity, sludge handling became problematic as disposal sites were essentially exhausted. In addition, although treated, the discharges negatively impacted the receiving stream, Laurel Run, a High-Quality Cold Water Fishery. Implementation of a passive complex was evaluated in order to address these problems and long-term operational costs.

The Pennsylvania Department of Environmental Protection (DEP) monitored and evaluated discharges AC, B1, B3 and published the following as design criteria(Hellier, 1999):

DEP Passive System Design Parameters

Discharge	flow	pH	alkalinity	Acidity	T. Fe	T. Mn	T. Al
AC	76	3.4	0	420	3	36	49
B1	23	3.5	32	350	128	22	4
B3	10	3.9	4	81	1	9	8

Flow in gpm; concentrations in mg/l; values rounded

Proposing a public-private partnership effort, Stream Restoration Incorporated [non-profit 501(c)(3)], received funding (ME#591054 executed 4/18/00) from the Pennsylvania Department of Environmental Protection through the Commonwealth's Growing Greener initiative. The purpose of the grant was to abate the impact of these three, acidic, metal-bearing, mine discharges (AC, B1, B3) to Laurel Run. The proposal included the permitting, design, and installation of eight passive components.

After receiving the grant, the project was substantially expanded without increasing the requested funding from Growing Greener through the efforts of the project partners. The expansion provided for addressing additional discharges (including unnamed tributary "C"), for increasing the number of passive components to over 20, and for increasing the quantity of aggregate used for alkalinity generation from 7870 T to 9400 T. Land reclamation of steep, barren to poorly vegetated, mine spoil was increased by about 18 acres and the area supporting constructed wetlands was also enlarged and redesigned to promote enhanced wildlife habitat.

In order to abate the impact of the abandoned mine discharges, an innovative passive treatment system complex was installed that included: Collection Systems(4); Limestone-

Only Vertical Flow Ponds (2 in parallel); Vertical Flow Pond with limestone and compost(1); Slag-Only Vertical Flow Pond(1); Flush Ponds(3); Settling Ponds(3); Bioswales(2); naturally-functioning Aerobic Wetlands(4); Horizontal Flow Limestone Bed(1); and Diversion Well(1). Innovative two-tiered underdrain systems (4 cells/tier) with adjustable outlets were installed in each Vertical Flow Pond to enable a more even distribution of flow throughout the pond and to provide a more thorough flushing of accumulated precipitates in the limestone aggregate treatment medium. Through donation of time and resources by project partners, the limestone-only Vertical Flow Ponds have been enhanced to provide hybrid flow capabilities to further aid in maintaining appropriate hydraulic conductivity of the treatment medium. In addition, system flexibility has been added by connecting components to provide the option of operating, excluding the diversion well, with a single final effluent point.

Within a period of approximately 12 months, the mine drainage was being successfully passively treated. Continued efforts by project partners, not covered under the grant, have upgraded the innovative complex.

Raw and Treated Discharge Characteristics (average values)

Discharge	pH	Alkalinity	acidity	T. Fe	T. Mn	T. Al
Raw AC *(ACWL)*	4.0*(5.2)*	0*(6)*	460*(39)*	2*(2)*	41*(16)*	58*(4)*
Raw B1	3.1	0	230	62	30	7
Raw B3	4.3	0	50	<1	7	6
Treated AC/B1/B3	7.1	70	0	<1	3	<1

concentrations in mg/l; values rounded; As an option, after AC treated by Vertical/Hybrid Flow Ponds the flow can be discharged from the wetland(ACWL) into Laurel Run. According to analyses when the ACWL effluent has a pH of 6 or higher prior to entering the stream, the alkalinity exceeds acidity. This appears to be characteristic except when design flow is exceeded. See attached data for sample set.

Currently, the passive treatment system is neutralizing about 430 lbs/day of acidity and preventing about 100 lbs/day of metals from entering Laurel Run. Based on recent and historical monitoring of the discharges and continued functioning of the Harbison Walker Phase II passive treatment system, an estimated average of 157,000 lbs (78 tons) of acidity and 36,500 lbs (18 tons) of metals are expected to be eliminated from the receiving stream annually.

To date, system maintenance and site revegetation has been conducted by Amerikohl Mining, Inc. Minor maintenance and monitoring have been performed by BioMost, Inc. Some piping and valves have been replaced and reseeding of portions of the spoil slopes has been performed.

This project is a “sister” project to the Harbison Walker Phase I site completed through the Pennsylvania Department of Environmental Protection’s “Reclaim PA” initiative. The combined effect of these two innovative passive treatment efforts have made a positive impact to the water quality of Laurel Run by essentially eliminating the acid and metal loadings associated with the abandoned mine discharges.

In order to fully evaluate the continued effectiveness of the system and the degree of success in improving Laurel Run on a long-term basis, project partners will continue to monitor the site, as feasible, after the term of the grant.

COMPREHENSIVE TIMELINE

Date	Description
06/17/97	Site inspection/water sampling - Ronald Horansky(DEP)
03/01/99	Water sampling
09/17/99	Water sampling; site investigation with W. Hellier(DEP), F. Johnson(AMI)
09/30/99	PNDI submission to Ms. Nunaman(DCNR); Project Description, Location Map, Supplement No. 1 (PNDI Search Form)
10/14/99	Pennsylvania Natural Diversity Inventory Review from DCNR received
10/15/99	Water sampling; F. Johnson & three operators(AMI)
10/20/99	Water sampling; site investigation with R. Horansky(DEP); received fax from Earthtech, Inc. with Point File
10/22/99	Receive fax from Robert Hedin regarding his recommendation
10/25/99	Fax copy of Hedin fax dated 10/22/99 to F. Johnson(AMI)
10/28/99	Site investigation with F. Johnson and others(AMI) and DCNR
11/03/99	Site investigation
11/09/99	Water sampling
11/19/99	Water sampling; mtg. ETI survey crew on site with F. Johnson(AMI)
12/17/99	Water sampling by SRI with Ron Horansky(DEP) and F. Johnson(AMI)
12/21/99	Receive notice from Fayette CCD Re: NPDES Permit
12/23/99	Submit initial Growing Greener Grant
01/05/00	Sent info regarding Growing Greener application to M. Killar(WPCAMR)
01/06/00	Notify J. Brahosky(DEP) and D. Hoehn(DCNR) re: Growing Greener app.
01/17/00	Water sampling/site invest. - F. Johnson(AMI), R. Hedin, T. Hilton(WOPEC)
01/19/00	Fax copy of 01/12/00 Killar(WPCAMR) Letter to Stilley(AMI)
01/25/00	Water sampling/site investigation – R. Horansky(DEP), S. Smith, F. Wallace, J. Jaskolka, & D. Hoehn(DCNR), W. Hellier(DEP), M. Kleman(BAMR), T. Hilton(WOPEC); - Review Phase I with DEP & DCNR; - Discuss Phase II proposal; - Informal approval by DEP & DCNR
01/27/00	Harbison Walker Phase II Growing Greener Grant resubmitted
01/31/00	Fax A/C Incremental Titration Test – Calcium Oxide to F. Johnson(AMI)
02/04/00	Revisions to Growing Greener proposal submitted to DEP & DCNR
02/10/00	Submission to DCNR from WOPEC
03/30/00	Water sampling
04/18/00	Contract Execution Date; W-9 Request for Taxpayer ID submitted to DEP; Fax maintenance data for proposed system to J. Brahosky(DEP)
04/20/00	Project update sent to mailing list
04/24/00	Notice from the DEP of grant approval
04/26/00	Field mtg.: T. Hilton(WOPEC); F. Johnson(AMI), D. Baker, E. Cavazza, & M. Kleman(BAMR), A. Thomas & D. Hoehn(DCNR); water sampling
04/27/00	Project update sent to mailing list
04/28/00	Aerial photos & draft Memorandum of Understanding; water sampling
05/10/00	Submit Form 0120-PM-PY0003 Rev. 11/98, Cultural Resource Notice to Bureau of Historic Preservation PA Historical and Museum Commission
05/11/00	Submit to DEP Growing Greener Grant Center: Grant Agreement, Exhibit A, Detailed Budget, & Simplified Budget

05/15/00	Sodium hydroxide delivery for AC temporary treatment
05/16/00	Sodium hydroxide delivery for AC temporary treatment
05/24/00	Receive Notification of Completion of Responsibility from PHMC
05/30/00	Fax Open Limestone Channel design to F. Johnson(AMI)
05/31/00	Notification of App. for NPDES Permit to Fayette CCD
06/01/00	Submit E & S Control Plan to Fayette CCD
06/02/00	Submit Preparedness, Prevention and Contingency Plan
06/06/00	Receive fax from Fayette CCD re: E & S/NPDES permit app. checklist
06/08/00	Meeting to review Wetland Waiver Plans; R. Beran(AQI); water sampling
06/15/00	Fax copy of baffle installation to AMI
06/16/00	Project update sent to mailing list
06/19/00	NPDES permit app. to Fayette CCD; E & S Plan to DEP
06/21/00	Water sampling; mtg. on-site Doug Hoehn and Park Staff(DCNR)
06/22/00	NPDES permit app. to Fayette CCD & mail receipts
06/26/00	Water sampling/site investigation; dye test collection system pipes; review sludge pumping; site mtg: D. Hoehn, R. Fickes, D. Mains, J. Sharrar(DCNR)
06/29/00	Submit NPDES and E&S fees to Fayette CCD
07/06/00	B1ACS stone
07/07/00	B1ACS stone
07/18/00	Receive fax of signed Memorandum of Understanding from DEP
07/14/00	Receive review letter from Fayette CCD re: E & S Plan permit application
08/10/00	Water sampling
08/14/00	Respond to Fayette CCD letter dated 07/14/00 (E&S Plan Revisions)
08/16/00	Fax R. Beran(AQ) copy of FEMA Map
08/18/00	Receive fax from PA One Call System, Inc. Automated Response Service
08/22/00	Fax R. Beran(AQ) copy of water quality database, etc.; Receive fax from PA One Call System, Inc. Automated Response Service
08/23/00	Fax R. Beran(AQ) copy of final wetland project map
08/24/00	Fax map of wetland #2 outline to R. Beran(AQ)
08/25/00	Site inspection and water sampling
08/30/00	Diesel
09/06/00	Field mtg. to review system design with D. Hoehn(DCNR), F. JohnsonAMI); AMI received letter from Frank D. Wallace re: bid on tree logs
09/07/00	Field Investigation - Test pits and pond locations; water sampling
09/08/00	Field Investigation - Test pit locations and reviewed design
09/12/00	Mobilization; geotextile
09/13/00	Diesel
09/14/00	Gate valves
09/19/00	Site tour for West Virginia AMD Task Force; water sampling;
09/20/00	Fax T. Hilton(WOPEC) design for review; submit overview/design to DEP
09/21/00	Send passive treatment design plan to F. Johnson(AMI); mobilization
09/25/00	Diesel fuel and misc. supplies
09/27/00	Misc. supplies

09/28/00	Receive review comments Re: 401 Water Quality Cert. from DEP; receive NPDES permit authorizing stormwater discharge from construction activity; B1B3VFP stone
09/29/00	B1B3VFP slag; compost; misc. supplies
09/30/00	Diesel fuel, valves, misc. supplies
10/02/00	B1VFP slag; B1B3VFP stone
10/03/00	B1VFP slag; B1B3VFP stone; caustic
10/04/00	B1VFP slag; B1B3VFP stone
10/05/00	B1VFP slag; mobilization, misc. supplies
10/06/00	Receive letter of support from DCNR Ohiopyle State Park
10/06/00	B1VFP slag
10/10/00	HFLB stone; B1VFP slag; misc. supplies
10/11/00	HFLB stone
10/12/00	Receive copy of fax J. Stilley(AMI) received from Scott Horrell(BAMR); B1VFP slag
10/13/00	Mtg at BAMR Cambria Office re: contract - J. Brahosky, E. Cavazza, D. Baker, S. Horrell(BAMR), F. Johnson(AMI); Growing Greener Conference; B1VFP slag; mobilization
10/14/00	Growing Greener Conference
10/16/00	B1VFP slag
10/16/00	AQ faxed request for “Comfort Letter” to accelerate construction schedule to J. Chnupa(DEP); faxed revised costs to Fred Johnson
10/17/00	Fax design elevations to ETI; B1B3VFP slag; misc. supplies
10/18/00	Receive fax from Scott Horrell and Eric Cavazza (BAMR); Fax letter to DEP Cambria Office including draft cost estimates; misc. supplies
10/19/00	B1B3VFP slag
10/20/00	B1ACS stone
10/23/00	Mtg. at BAMR Cambria Office re: contract; S. Horrell, E. Cavazza, M. Scheeler, R. Fletcher, T. Malesky(BAMR); F. Johnson, J. Stilley(AMI); Fax costs from 04/24/00 contract to J. Stilley(AMI)
10/24/00	Field mtg. re: wetlands; J. Snyder(DEP); R. Beran, J. Reidenbaugh(AQ); F. Johnson(AMI); water sampling
10/31/00	Receive fax from J. Snyder(DEP) re: USACE Pittsburgh Dist. reviewing project to for obtaining federal authorization; diesel, caustic, fertilizer delivery
11/01/00	Field mtg. re: additional work; F. Johnson(AMI); S. Horrell, M. Scheeler, E. Cavazza(BAMR); J. Brahosky(DEP); D. Bickel, D. Hoehn, A. Thomas(DCNR)
11/02/00	Submit design plans to DEP; mail topo maps & soil amendment recommendations to F. Johnson(AMI)
11/06/00	Receive request from J. Chnupa(DEP) for information re: impact of wetlands; ACVFPN stone
11/07/00	Field mtg, re: stream impact; R. Sobol(USACE); R. Beran(AQ); F. Johnson(AMI); ACVFPN stone
11/08/00	Misc. pipe supplies
11/09/00	Mobilization
11/10/00	ACVFPN stone
11/11/00	ACVFPN stone

11/14/00	Misc. supplies
11/17/00	Stone
11/20/00	Misc. supplies
11/22/00	Fax previous PNDI data to D. Baker(BAMR); BAMR Diversion Well @ Export
11/28/00	Mulch hay; diesel, etc.
11/29/00	E-mail submission of revised p. 3 of Detailed Budget to D. Baker(DEP)
11/30/00	Pipe; mobilization; stone
12/01/00	Respond to DEP letter dated 11/06/00; submit to Fayette CCD – E & S Plan with Narrative, Specs., Calcs., Details, Soil Map, Location Map, etc.
12/06/00	Spreader; misc. supplies
12/07/00	Receive approval from Fayette CCD re: E & S Plan; ACVFPS stone; equipment parts
12/08/00	ACVFPS stone; equipment repairs; misc. supplies
12/12/00	Misc. equipment parts
12/13/00	Receive Diversion Well design from T. Wood(BAMR); ACVFPS stone; Fax copy of Diversion Well design to F. Johnson(AMI)
12/14/00	Re-fax Diversion Well design to F. Johnson(AMI); ACVFPS stone; misc. equipment parts
12/15/00	Site investigation and water sampling
12/20/00	As per F. Johnson(AMI), water turned in A/C system at 8:15 on 12/18/00; diesel; stone; pipe
12/21/00	Diesel; stone; equipment parts
12/22/00	Diversion Well stone; equipment repairs
12/28/00	Equipment parts, misc.
12/30/00	Diesel, supplies/parts, misc.
12/31/00	Manhole for Diversion Well; Stone; misc. supplies
01/04/01	Receive Executed Grant Agreement and Nondiscrimination Posters from DEP; Site Inspection - Diversion Well installation; Fax copy of Grant Contract to J. Stilley(AMI); Receive wetland planting plan from J. Reidenbaugh(AQ) via e-mail
01/05/01	Receive letter from J. Snyder(DEP) re: revisions for 401 Water Quality Cert.
01/09/01	Equipment repair
01/11/01	AQ response to DEP letter dated 01/05/01; diesel; mobilization
01/15/01	Equipment repair and mobilization
01/16/01	Misc. fittings/supplies
01/17/01	Diesel, misc.
01/18/01	Mobilization
01/19/01	Fax copy of contract and simplified budget to Todd(AMI)
01/23/01	Water sampling
01/25/01	Demobilization
01/29/01	Mobilization; pipe fittings
01/31/01	Stone; pipe fittings; equipment parts
02/05/01	Receive fax from ETI
02/07/01	Project update sent to mailing list
02/08/01	Tamper; diesel
02/13/01	Diversion Well (manhole) cover; etc.
02/15/01	Demobilization

02/16/01	Misc. supplies; equipment repairs
02/21/01	Equipment repairs
03/08/01	Receive waiver in accordance with section 7(a) of the Dam Safety and Encroachments Act contingent on construction guidelines from DEP - copy of Initial Notice in PA Bulletin included; - copy of Final Notice included Site inspection, flushing, and water sampling
03/22/01	Site inspection
03/23/01	Site inspection and water sampling
03/26/01	Fax copy of flow diagram to T. Hilton(WOPEC)
04/06/01	Water sampling
04/16/01	Mtg. on-site re: passive system; D. Hoehn and 4 other staff members(DCNR); C. Ranson(US Park Service); water sampling
05/02/01	Receive e-mail of concerns from D. Baker(BAMR); site invest./water sampling
05/04/01	Respond to D. Baker(BAMR) e-mail from 05/02/01
05/08/01	Field mtg. re: passive system and site conditions; D. Baker, E. Cavazza, J. Cuppet, R. Larden, W. Dadamo(BAMR); D. Hoehn, D. Bickel, A. Thomas, G. Schrum(DCNR); T. Hilton(WOPEC); F. Johnson, R. Sanner(AMI)
05/11/01	Roller; site investigation, dye test, and water sampling; diesel
05/16/01	Fax brief timeline to J. Stilley(AMI)
05/17/01	Equipment mobilization
05/18/01	Receive e-mail from D. Baker(BAMR) requesting mtg. minutes from 05/08/01
05/22/01	Submit concerns and information requested from D. Baker(BAMR)
05/25/01	Site inspection
05/29/01	Site inspection and water sampling
05/30/01	Receive e-mail questions from D. Baker(BAMR)
05/31/01	Mulch hay; e-mail reply to D. Baker(BAMR); rip-rap; supplies; diesel
06/01/01	Letter written to R. Fletcher(BAMR) regarding project status; stone
06/11/01	Fax rough copy of reply to R. Fickes(DCNR) in response to 06/01/01; Letter to R. Fletcher(BAMR) from R. Fickes(DCNR); water sampling
06/12/01	Site investigation
06/15/01	05/08/01 field mtg. outline updated with input from those present; Received copy of R. Fletcher(BAMR) response letter to R. Fickes(DCNR) re: 06/01/01 letter; rip-rap
06/16/01	Site investigation
06/18/01	Site investigation; equipment repair/parts
06/19/01	Equipment parts
06/20/01	E-mail site update from D. Baker(BAMR); pipe fittings
06/21/01	Wetland planting with Americorp and Ohiopyle State Park volunteers; stone
06/26/01	Rip-rap; diesel
06/30/01	Pipe and fittings; seed mix; rip-rap
07/08/01	Water sampling
07/09/01	Mobilization
07/11/01	Site investigation and level outlets
07/12/01	Basic Steel Slag for Abandoned Mine Drainage Treatment submitted to DEP; Faxed request to AMI for warranty in writing; received letter of warranty from AMI for two year period (08/31/01 to 08/31/03); hay bales

07/13/01	Personally deliver copy of AMI warranty to D. Baker(BAMR); Field mtg. re: passive system and site conditions; R. Lardin, E. Cavazza, C. R. Greene, R. Horansky, D. Baker, R. Fletcher, S. Horrell, R. Stanley(DEP); D. Hoehn, D. Bickel, G. Hart, A. Thomas, R. Fickes, J., Sharrar, M. Bielo(DCNR); T. Hilton(WOPEC); J. Stilley, F. Johnson(AMI); roller; pipe fittings
07/17/01	Stone
07/20/01	Mobilization
07/23/01	Equipment repair
07/25/01	Rip-rap; hay bales
07/26/01	Site investigation; Stream Assessment; S. Alexander(DEP); M. Bielo, A. Thomas, T. Dayison, and F. Wallace(DCNR)
07/27/01	Site investigation and water sampling
07/31/01	Field meeting
08/02/01	07/31/01 field mtg. outline draft completed; additional data requested from AMI for reimbursement
08/03/01	Meeting minutes draft submitted to attendees (roughly) via e-mail
08/07/01	E-mail request from D. Baker(BAMR) for flow calculations for cells and information used to determine the size of the cells; Water sampling
08/08/01	Summary of remaining issues received from D. Baker(BAMR); Submit slag information to T. Hilton(WOPEC)
08/09/01	Receive letter from ETI regarding pond requirements
08/10/01	Site investigation/water sampling (Slag Titrations and Research)
08/11/01	Slag titrations and research at the office
08/16/01	Questions for waste management from D. Baker(BAMR)
08/17/01	Meeting minutes additions received from D. Baker(BAMR); Respond to Oliver(DCNR) phone call, SRI requests a meeting to discuss testing planned for site; response from Oliver(DCNR) re: testing & DCNR concerns
08/21/01	Receive questions/concerns from Doug Hoehn(DCNR); Receive TCLP Analysis for Weirton Steel Slag from IMS; Submit TCLP Analysis of Basic Steel Slag to DEP; Submit Quarterly Update and Reimbursement Request to DEP; Site inspection and water sampling (Slag Research); Fax lab data (Weirton Steel, Brown's Island) to D. Baker(DCNR)
08/23/01	Site inspection and water sampling
08/24/01	Project update sent to mailing list
08/27/01	D. Baker(DCNR) acknowledged receipt of invoice via e-mail
09/05/01	Notice from the DEP that SRI should seek a co-product approval for slag; Collect slag samples for testing
09/06/01	Field Tour with Fayette County Commissioners
09/09/01	Water sampling
09/19/01	Receive e-mail from Mike Bielo(BAMR) regarding testing; Basset Environmental Inc. will be drilling boreholes and obtaining soil samples beginning 09/24/01; - Gannett Fleming Inc. directing and evaluating drilling ~15 shallow boreholes (~20-25 ft) planned; forwarded Mike Bielo(DCNR) e-mail from 09/19/01 to D. Baker(BAMR)
09/20/01	Fax revised copy of AMI invoice to Todd F.(AMI)

09/21/01	Submit revised Reimbursement Request to DEP; Site investigation and water sampling
10/01/01	Project update sent to mailing list;1 man from AMI repairing valve boxes, etc. this week (10/01/01); following week small excavator performing repair work
10/04/01	Site inspection with D. Baker, S. Horrell(BAMR)
10/08/01	E-mail to D. Baker(BAMR) regarding spillway stone size
10/10/01	E-mail/fax to M. Connolly(IMS) re: slag product information; Submit Environmental Stewardship Project Status Report
10/11/01	Quarterly Report submitted to DEP
10/17/01	Receive letter from Gay Kreiser(DEP) with three copies of Amendment No. 1 and were requested to sign and return all copies to DEP
10/23/01	Resubmit request to IMS for slag information
11/05/01	Receive request from D. Baker(BAMR) for data re: seeding & slag approval
11/13/01	Notice from DEP that SRI has 14 days to seek co-product approval for slag being used on the site
11/14/01	Request copy of old regulations from M. Connolly(IMS) relating to slag co-product designation; Respond to D. Baker(BAMR) information request from 11/05/01
11/16/01	M. Connolly(IMS) response to SRI letter(11/14/01) re: slag co-product data
11/19/01	Submit analysis of basic steel slag to DEP; Send 11/13/01 DEP letter sent to IMS
12/14/01	Site inspection and water sampling
12/18/01	DEP response to 11/19/01 letter
01/03/02	Water sampling by K. Hartner(DEP)
01/04/02	Project update sent to mailing list
01/07/02	Project update sent to mailing list
01/08/02	Submit Amendment No. 1 as per DEP Harrisburg request
01/14/02	Respond to DEP questions in 12/18/01 letter submitted to DEP; send copy of Letter to DEP dated 01/14/02 to IMS
01/15/02	Submit of Environmental Stewardship Project Status Report
01/16/02	Receive TCLP for slag from IMS
02/01/02	Receive Weirton Kish Slag Analysis from IMS
02/06/02	Receive Weirton Kish Slag Analysis from IMS
02/12/02	Continued response to DEP in 12/18/01 letter submitted to DEP
02/15/02	Fax copy of water quality analyses to T. Hilton(WOPEC)
03/01/02	Meeting in DEP Pittsburgh regarding slag
03/08/02	Site inspection, flushing, and water sampling
03/15/02	Receive e-mail from D. Bickel(DCNR) re: construction of teaching station/pavilion
03/18/02	Submit extension request
03/26/02	Resolution letter regarding slag Issue received from DEP
04/02/02	Receive estimate/invoice for materials needed for construction of the teaching pavilion (Request for a check from SRI made out to Lowes for the invoice, to be hand delivered) from D. Bickel(DCNR)
04/09/02	Receive fax of complete 04/08/02 inspection report from C.Greene(DMO)
04/12/02	Receive digital mapping for site from J. Stefanko(DEP)
04/18/02	Submit Environmental Stewardship Project Status Report
05/02/02	Site inspection, system adjustment, and water sampling
05/03/02	Fax request to G & C for sodium analysis of selected water samples taken

	05/02/02
05/15/02	E-mail P. Shah(BAMR) including Flow Diagram of PTS
06/26/02	Dye tests with T. Hilton(WOPEC) and A/C reconfigure effectiveness
06/28/02	Receive draft agreement from P. Shah(BAMR) via e-mail
06/29/02	Field work
07/01/02	Water sampling and pipe installation
07/02/02	Water sampling and pipe installation
07/10/02	Water sampling and ACVFP Dye test by S. Short(SRI)
07/24/02	Water sampling of ACVFP's by S. Short(SRI)
07/25/02	Flushing and water sampling
08/09/02	Field mtg.; Baker, Shah, Horrell, DaDamo(BAMR), Amanda(DMO); water sampling
08/19/02	Water sampling
08/22/02	Water sampling
08/28/02	Flushing and water sampling
09/16/02	Back flushing and water sampling; tour
10/09/02	Site inspection and water sampling
10/18/02	Fax map of ACVFPs to F. Johnson(AMI) re: backflushing; Submitted grant extension request to DEP
11/18/02	Field inspection and water sampling
11/19/02	AMI fixes ACVFP broken pipes
11/20/02	AMI fixes ACVFP broken pipes
11/27/02	Reimbursement Request and Project Status Report submitted to DEP
12/16/02	Site inspection; Replace A/C Valve box; Adjust A/C Vertical Flow Ponds
12/30/02	Site inspection & water sampling; install new risers on ACVFPS/ACVFPN

SITE DESCRIPTION

Introduction

Mining has been conducted for over 200 years in western Pennsylvania. A 120-acre surface clay and coal mining operation (permit #269BSM24) was previously conducted by the Harbison-Walker Refractories Company, a Pittsburgh-based company formed in 1875. Clay mined from the site was processed into firebricks which were used to line industrial furnaces such as those at steel plants. The Lower Kittanning claystone (Kittanning Fm.; Allegheny Gp.) and immediately overlying Lower Kittanning coalbed were mined and/or spoiled at the site. The site was backfilled and portions were revegetated with either grasses and legumes or evergreens. Older, essentially barren, steep outslopes were also present on the site. The permit effluent limits were 6 to 9 pH, alkalinity to exceed acidity, and 7 mg/L total iron. There were no manganese or aluminum effluent limits.

The receiving stream, Laurel Run, a High-Quality Cold Water Fishery, was impacted by untreated and conventionally treated abandoned mine drainage associated with the past operations of this site. This stream flows into Meadow Run, which is a tributary to the Youghiogheny River. These are popular fishing and recreational streams, which have also been classified as High-Quality Cold Water Fisheries. Because of the degradation to the stream by the previous mining activities, the Commonwealth of Pennsylvania assigned Laurel Run a high restoration priority [Ref: 1998 303(d) list]. The current target area for restoration of Laurel Run and the downstream segments of Meadow Run and the Youghiogheny River all lie within one of the premier state recreational facilities in Pennsylvania, Ohiopyle State Park. The Pennsylvania Department of Conservation and Natural Resources assumed the responsibility for perpetual treatment of two (AC and B1) of the seven (AC, B1, B3, 12, 13, 14, trib. “C”) known pollutional discharges on land now within Ohiopyle State Park shown in Figure 1. A conventional lime treatment facility and a soda ash briquette hopper were being used to treat discharge AC and B1, respectively.

A previous grant funded through the Commonwealth’s “Reclaim PA” initiative installed a passive system to treat the acidic, metal-laden discharges 12, 13, and 14. That project is referred to as the Harbison Walker Restoration Area Phase I (Figure 1). A Final Report was previously submitted for Phase I.

This Final Report for the Harbison Walker Restoration Area Phase II addresses the restoration effort associated with upland reclamation and discharges AC, B1, B3, trib. “C”, and unnamed seeps. The financial support for this effort included a grant through the Commonwealth’s “Growing Greener” initiative and from generous contributions from our partners.

Location

Both Phase I and II restoration areas are within Ohiopyle State Park in Stewart Township, Fayette County, PA. The site is east of Laurel Run and north of T-415 (Grover Road) about ½-mile from the intersection with SR-2011. This intersection is about 1 mile south of the park office. (See Location Map Figure I.) The site is located on the 7 ½' USGS Ohiopyle topographic map (PI 1977) at about 39^0 50' 39' latitude and 79^0 29' 30" longitude.

Pre-Construction Site Conditions

Conventional Water Treatment Facilities: A lime plant was operated by the PA DCNR to treat the discharge with the greatest flow (100 gpm). Based on available information, this discharge identified as AC is the combined flow from pipes that extend into the backfill area of the former clay mine. With a pH of 3.5, this discharge has high dissolved aluminum (60 mg/L) and manganese (40 mg/L) concentrations with low concentrations of dissolved iron (2 mg/L). The treated flow entered a series of four to six settling ponds that required periodic cleaning. The large volume of lime sludge generated was pumped to two, intermediate, upgradient ponds in the old mining area and then pumped into boreholes. From a brief inspection of the ponds on 3/1/99, undissolved lime appeared to significantly contribute to the sludge volume. (See photos.) Reportedly, many of the existing boreholes were filled to capacity and sludge had been observed oozing from the ground downslope. From the analysis of a sample collected 6/17/97 by the PADEP Greensburg District Mining Office, the final treated AC effluent, prior to entering Laurel Run, had a 6.4 pH with acidity (74 mg/L) exceeding alkalinity (28 mg/L) and 1.3 mg/L total aluminum. Note that in this instance, even with an acceptable pH, the discharge quality is not in compliance with the effluent limit as acidity exceeds the alkalinity due to the metals content of the drainage.

Soda ash briquettes were used to treat the 30-gpm B1 discharge, which has high dissolved iron (155 mg/L) and manganese (25 mg/L) concentrations, with a relatively moderate concentration of dissolved aluminum (6 mg/L), and low pH of 3.5. Two small settling ponds were in use. On 6/17/97, a grab sample collected of the treated effluent had the following quality: 5.8 pH, 20 mg/L alkalinity, 212 mg/L acidity, 78 mg/L total iron, and 1.3 mg/L total aluminum. Again note that in this instance, the effluent exceeded the permit limits. The seepage for B1 appears to emanate below the spoil area.

Untreated Water (B3, trib. "C"): Discharge B3, trib. "C", and other drainage were not being treated. The B3 discharge with a typical flow rate of 15 gpm has a 4 pH with 0.1 mg/L total iron, 7 mg/l total manganese and 7 mg/L total aluminum, based on review of analyses furnished by William Hellier, PhD, PE, PADEP, Bureau of Mining and Reclamation, Hawk Run Office. B3 appears to consist of surface and near-surface runoff, upwellings in the backfill, and seepage from bedrock (Homewood Sandstone; Pottsville Gp.) along fractures (joints).

In addition, sample analyses of unnamed tributary "C", provided by the PADEP, Greensburg District Mining Office, and by recent sampling during site reconnaissance, indicate that this stream is impacted, with a pH of 4.3 to 4.6, alkalinity ~6 mg/L, acidity

~20 mg/L, and 2 to 3 mg/L dissolved aluminum. Other small-flow, degraded discharges were also observed, many of these seeps appear to emanate from fractures in the Homewood Sandstone.

Impact of Treated and Untreated Drainage on Receiving Stream: As previously noted, the receiving steam is Laurel Run, a High-Quality Cold Water Fishery (PA Title 25, Chap. 93). Analyses of samples collected by the PA DEP, Greensburg District Mining Office on 6/26/98 document that the water quality standards (PA Title 25, Chap. 93) were exceeded due to drainage from this site, even during active treatment. On this date, the total iron concentration in Laurel Run increased from <1 to 3 mg/L and total aluminum increased from <0.5 to 1.4 mg/L. In addition, sulfate was increased from 48 to 109 mg/L and pH was decreased from 6.6 to 6.2. The buffering capacity was also decreased with 30 mg/L alkalinity above the site and 26 mg/L below. (PADEP analyses for LR-3 and LR-4.) About 1400 feet downstream of the site, Laurel Run confluences with Meadow Run which is tributary to the Youghiogheny River.

Site Preparation

Erosion and Sediment Pollution Controls were installed after plan approval by the Fayette County Conservation District. Aquascape completed the Environmental Assessment. A wetland waiver was received. 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. Submission to the PA Historical and Museum Commission revealed nothing of historical interest. PA One Call relating to underground utilities was contacted and the response was “no involvement”. Sludge was removed from the treatment ponds by pumping to upgradient sludge ponds using a “mudcat” and by a loader-truck operation. After dewatering, the sludge was then placed on site, based on DEP- and DCNR-approval. The remaining site for the passive treatment system was cleared and grubbed.

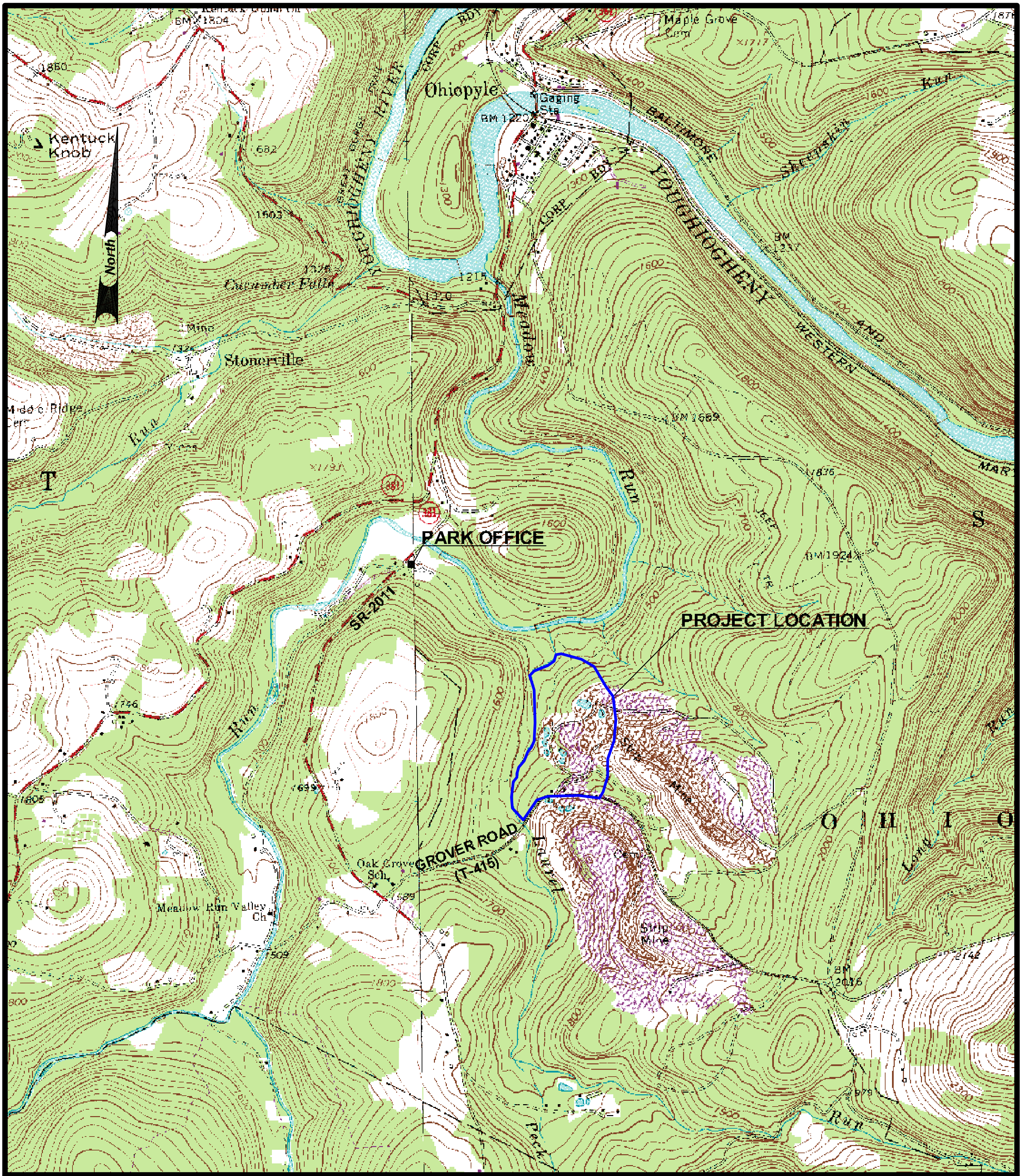


Figure 1: PROJECT LOCATION - USGS 7.5' OHIOPYLE, PA (PI1977) & FORT NECESSITY, PA (PR1973)
Harbison Walker Restoration Effort

Approximate Center of Project (deg-min-sec)
39-50-39 latitute 79-29-30 longitude

2000 1000 0 2000

Stream Restoration Incorporated
Stewart Township, Fayette County, PA
June 2003, Scale 1" = 2000'
BioMost, Inc., Cranberry Twp., PA

200702/Final Report HW LOC

PASSIVE TREATMENT SYSTEM INSTALLATION

Bulk Materials

Spent mushroom compost was used to complement on-site soils for the wetlands substrate. This compost was also placed in a ½-foot thick layer directly overlying the limestone aggregate in the B1B3 Vertical Flow Pond. Limestone aggregate (specified 90% CCE) received from New Enterprise Stone & Lime Co., Inc., New Enterprise, PA was placed in the Vertical Flow Ponds and Horizontal Flow Limestone Bed. Rip-rap spillways were lined with 48% CCE aggregate received from Amerikohl Mining, Inc., Ameristone – Jim Mountain, Mill Run, PA. Oversized (4" x 1") basic steel slag from International Mill Service, Weirton, West Virginia was placed in the B1 Slag-Only Vertical Flow Pond and in the lower inlet end cell of both AC Vertical Flow Ponds and the lower northern cell of the B1B3 Vertical Flow Pond.

Major Construction Equipment

Amerikohl Mining, Inc. completed the site work including sludge handling associated with the existing lime treatment plant and soda briquette system, construction of the passive treatment complex, and land reclamation efforts. The major equipment used at the site includes the following:

Caterpillar 330B Track Hydraulic Excavator(1)
Case 3050 Track Excavator with Hydraulic Hammer(1)
"Mud-Cat" pumping barge(1)
Caterpillar D350 Articulated Trucks(2)
Caterpillar D8R Low Ground Pressure Track-type Tractors (Bulldozer)(1)
Caterpillar D6 Low Ground Pressure Track-type Tractors (Bulldozer)(1)
Caterpillar 963 Track Loader(1)
Case Rubber-Tired End Loader(1)
Mack Tandem Trucks(2)
Caterpillar CB 563 Vibratory Compactor(1)
Hand-held "whacker" compactor(1)
Water pumps
Farm equipment

Volunteer Wetland Plantings

All plantings of constructed wetlands were through volunteer efforts primarily during the warm season of 2001. One of the primary efforts was conducted on June 21, 2001 with Americorp volunteers, Aquascape, Stream Restoration Inc., and Ohiopyle State Park personnel. Later, volunteers also successfully installed bird boxes and other wildlife habitat features through the efforts of Barbara Wallace, Environmental Education Specialist, Ohiopyle State Park.

Hydrophytes used to plant the wetlands were selectively harvested, with permission, from local wetlands with similar water chemistry; thus, promoting a higher probability of becoming successfully established. Substrate material from the construction area was also placed in the wetlands, providing a seed source and volunteer vegetation, which supplemented and contributed to the wetlands' diversity and function. The following wetland species were planted:

Wetland Species Planted

Common Name	Scientific Name	Indicator Status	Hydrologic Regime (preferred)
Button bush	*Cephalanthus occidentalis*	Obligate	Inundated (≤3 ft.)
Water pepper	*Polygonum hydropiperoides*	Obligate	Inundated (≤12 in.)
Broad-leaved cattail	*Typha latifolia*	Obligate	Inundated (≤12 in.)
Soft rush	*Juncus effuses*	Facultative wet +	Inundated (≤12 in.)
Tussock sedge	*Carex stricta*	Obligate	Inundated (≤½ ft.)
Fox sedge	*Carex vulpinoidea*	Obligate	Inundated (≤½ ft.)
Eastern bur-reed	*Sparganium americanum*	Obligate	Inundated (≤½ ft.)
Purple osier willow	*Salix purpurea*	Facultative wet	Saturated to inundated
Purple leaf willow-herb	*Epilobium coloratum*	Obligate	Saturated
Purple stemmed aster	*Aster puniceus*	Obligate	Saturated
Blue vervain	*Verbena hastate*	Facultative wet +	Saturated
Meadow sweet	*Spirea alba*	Facultative wet +	Saturated
Swamp milkweed	*Asclepias incarnata*	Obligate	Saturated to inundated [(1)]
Flat sedge	*Cuperus strigosus*	Facultative wet	Saturated to inundated [(1)]
Silky dogwood	*Cornus amomum*	Facultative wet	Inundated [(2)]

[(1)] ≤75% growing season; [(2)] irregular/seasonal

Naturally-designed wetlands provide multiple functions. The first function is to allow additional oxidation and settling of metal solids. The second function is to provide 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. (See photos.)

Overview of Passive Treatment Components

Notes: all piping SCH40 PVC unless otherwise indicated; all limestone (LS) aggregate specified 90% CCE; AASHTO sizes for stone; sandstone(SS); geotextile liner in VFPs and HFLB; See "As-Builts" and narrative.

Component	**Description**	
AC Collection System	Existing buried 6" piping with cleanouts (visual inspection where exposed) combining discharges A & C; Inlet Control Structure – PADOT Type M concrete box (5'L x 3'W x 3½'H) with 2, 6" risers with adjustable 90^o elbows to ACVFPN & ACVFPS	
AC Vertical Flow Pond South *(ACVFPS)*	Dimensions (top inside)	67' x 310'
	Bedding Stone	½' layer, 48%CCE, #57, calc. SS
(Adjustable risers incorporated in flushing system for alternative operation as Hybrid Flow Pond, not part of original project.)	Treatment Media	2,664 T, 90%CCE, #1, LS; 336 T, (4"x1") basic steel slag (cell LA)
	Underdrain Piping	7,970', 4" laterals with 2, ½"-perfs. 30^o off center top at 4½' spacing; laterals on 4½' centers along 4" solid headers; 2 tiers, 4 quads ea.
	Primary Spillway	8, 4" adjustable effluent risers(1 ea. quad); rip-rap(R4) channel to ACSPWL
	Flushing System	8, 4" flush pipes each w/ 4" ball valve in drained valve box; threaded end plug
	Emergency Spillway	Rip-rap lined, R4, spillway to ACVFPN
AC Vertical Flow Pond North *(ACVFPN)*	Dimensions (top inside)	71' x 321'
	Bedding Stone	½' layer, 48%CCE, #57, calc. SS
(Adjustable risers incorporated in flushing system for alternative operation as Hybrid Flow Pond, not part of original project.)	Treatment Media	2,665 T, 90%CCE, #1, LS; 336 T, (4"x1") basic steel slag (cell LA)
	Underdrain Piping	7,790', 4" laterals with 2, ½"-perfs. 30^o off center top at 4½' spacing; laterals on 4½' centers along 4" solid headers; 2 tiers 4 quads ea.
	Primary Spillway	8, 4" adjustable effluent risers (1 ea. quad); riprap(R4) channel to ACSPWL
	Flushing System	8, 4" flush pipes each w/ 4" ball valve in drained valve box; threaded end plug
	Emergency Spillway	Rip-rap lined, R4, spillway to ACSPWL

AC Flush Pond *(ACFP)* [Crossover (6” pipe with 6” gate valve in meter pit) allows function as SP during hybrid flow of ACVFPN and/or ACVFPS]	Area	15,401 SF(crest of emergency spillway)
	Drawdown Device	4”, perf.(1”), riser with 4” gate valve in valve box discharges to trib. “C”
	Emergency Spillway	Rock-lined spillway to trib. “C”
AC Settling Pond/Wetland *(ACSPWL)* (Inlet to B1VFP from ACSPWL)	Area	11,168 SF (crest of spillway)
	Vegetation	High-diversity native vegetation for wildlife habitat; planted by volunteers
	Spillway	Rip-rap lined, R4, spillway to ACWL
AC Wetland *(ACWL)* [Crossover (6” pipe with 6” gate valve in meter pit) allows conveyance of flow to B1WL1 for additional treatment]	Area	8,745 SF (crest of spillway)
	Vegetation	High-diversity native vegetation for wildlife habitat; planted by volunteers
	Spillway	Rip-rap lined, R4, spillway to watercourse to Laurel Run
B1 Surface/Subsurface Collection System	Anoxic	1,073‘, 6”, perforated, N12 bedded in 385 T, #57, SS
	Oxic	408‘, rock-lined ditches
B1 Slag Vertical Flow Pond *(B1VFP)* (Adjustable risers incorporated in flushing system for alternative operation as Hybrid Flow Pond, not part of original project.)	Dimensions (top inside)	66’ x 105’
	Bedding Stone	½’ layer, 48%CCE, #57, calc. SS
	Treatment Medium	1,003 T, (4”x1”) basic steel slag
	Underdrain Piping	2,200‘, 4” laterals with 2, ½”-perfs. 30^o off center top at 4½’ spacing; laterals on 4½’ centers along 4” solid headers; 1 tier with 4 quads.
	Primary Spillway	4, 4” adjustable effluent risers (1 ea. quad; riprap(R4) channel to B1SP
	Flushing System	4, 4” flush pipes each w/4” ball valve in drained valve box; threaded end plug
	Emergency Spillway	Rip-rap lined, R4, spillway intercepts B1 drainage to B1SP
B1 Flush Pond *(B1FP)* [The rip-rap lined spillway from the B1FP to the ACWL allows function as SP during hybrid flow of B1VFP]	Area	5,054 SF (crest of emergency spillway)
	Drawdown Device	4”, 1”-perfs., riser with 4” gate valve in valve box; discharge to ACWL spillway
	Emergency Spillway	Rip-rap lined, R4, spillway to ACWL
B1 Settling Pond *(B1SP)*	Area	11,588 SF (crest of spillway)
	Spillway	Rip-rap lined, R4, spillway to B1WL1
B1 Wetland 1 *(B1WL1)*	Area	16,273 SF (crest of spillway)
	Vegetation	High-diversity native vegetation for wildlife habitat; planted by volunteers
	Spillway	Rip-rap lined, R4, spillway to B1WL2

B1 (Bioswale) Wetland 2 *(B1WL2)*	Area	1,955 SF (crest of spillway)
	Vegetation	High-diversity native vegetation for wildlife habitat; planted by volunteers
	Spillway	Rip-rap lined, R4, spillway to B1WL3
B1 (Bioswale) Wetland 3 *(B1WL3)*	Area	915 SF (crest of spillway)
	Vegetation	High-diversity native vegetation for wildlife habitat; planted by volunteers
	Spillway	Rip-rap lined, R4, spillway to B1B3VFP
B3A (Open LS Channel) Collection Ditch	Dimensions	831' x 9'
	Lining	Rip-rap lined, R4, 48%CCE; in steep slope area R6, R8+ to B3ASP
B3A Settling Pond *(B3ASP)*	Area	4,019 SF (crest of emergency spillway)
	Primary Spillway	4" barrel with 4" gate valve to B3SP
	Emergency Spillway	Rip-rap lined, R4, spillway to watercourse to Laurel Run
B3 (Open LS Channel) Collection Ditch	Dimensions	632' x 9'
	Lining	Rip-rap lined, R3, 48%CCE; in steep slope area R6, R8
B3 Settling Pond *(B3SP)*	Area	4,033 SF (crest of emergency spillway)
	Primary Spillway	4" barrel with tee; piping extended ' to B1B3VFP
	Emergency Spillway	Rip-rap lined, R4, spillway to watercourse to Laurel Run
B1B3 Vertical Flow Pond *(B1B3VFP)*	Dimensions (top inside)	58'(avg.) x 148'
	Bedding Stone	½' layer, 48%CCE, #57, calc. SS
	Treatment Media	1,300 T, 90%CCE, #1, LS; 160 T, (4"x1") basic steel slag (cell LA); ½' layer spent mushroom compost
	Underdrain Piping	3,434', 4" laterals with 2, ½"-perfs. 30^o off center top at 4½' spacing; laterals on 4½' centers along 4" solid headers; 2 tiers with 4 quads.
	Primary Spillway	8, 8" adjustable effluent risers (1 ea. quad; riprap(R4) spillway to B1B3SPWL
	Flushing System	8, 4" flush pipes each w/4" ball valve in drained valve box; threaded end plug
	Emergency Spillway	Rip-rap lined, R4, spillway to B1B3SPWL

B1B3 Flush Pond *(B1B3FP)*	Area	6,043 SF(crest of emergency spillway)
	Drawdown Device	4", 1"-perfs., riser with 4" gate valve in valve box; discharge to ACWL spillway
	Emergency Spillway	Rip-rap lined, R4, spillway to B1B3SPWL
B1B3 Settling Pond/Wetland *(B1B3SPWL)*	Area	10,219 SF (crest of spillway)
	Vegetation	High-diversity native vegetation for wildlife habitat; planted by volunteers
	Spillway	Rip-rap lined, R4, spillway to B1B3HFLB
B1B3 Horizontal Flow LS Bed *(B1B3HFLB)*	Treatment Medium	1,014 T, 90%CCE, #1, LS
	Manifold	10", 3, 1"-perfs/½', at base along discharge end w/ solid riser to primary spillway
	Primary Spillway	10", solid barrel to rip-rap lined, R4, spillway to Laurel Run
	Emergency Spillway	rip-rap lined, R4, spillway to Laurel Run
Diversion Well Collection System	Stilling Pool	381 SF; 6" barrel with bar-guard conveys flow to Diversion Well; excess flow bypass in natural, oversize durable stone to trib. "C"
Diversion Well	Manhole	Grated, 4' diameter; 10' depth
	Piping	6" inlet piping to tee riser; threaded top cap; riser extended to within 1' of bottom; 1½"-perforations in diffuser
	Treatment Medium	#10, 90%CCE, LS (45 T on-site)
	Primary Spillway	6" piping to trib. "C"

Notes: all piping SCH40 PVC unless otherwise indicated; all limestone (LS) aggregate specified 90% CCE, AASHTO sizes; sandstone(SS); geotextile liner in VFPs and HFLB; See "As-Builts" and narrative.

Comments on Construction of Selected Passive Components

AC Collection System: Only minor modifications to the existing collection system were needed to install the inlet control box. The existing collection system, with piping that extends underground along the hillside, continues to collect the A and C discharges which were previously treated using a lime plant. The inlet control box (PennDOT Type-M) is a concrete structure with two, 6-inch, 90-degree, elbows to control flow into the two AC Vertical Flow Ponds. By rotating the elbows, the flow rate into the AC Vertical Flow Ponds can be individually adjusted. Each pond can operate independently, which is of particular importance during maintenance. The elbows are connected to 6-inch, Schedule 40, PVC pipe that conveys the AC raw water into the AC Vertical Flow Ponds.

AC Vertical Flow Ponds (ACVFPN & ACVFPS): The primary purpose of these Vertical Flow Ponds is to generate alkalinity. The alkalinity in turn neutralizes the acidity and encourages the dissolved metals in the mine drainage to form solids. This system utilizes two Vertical Flow Ponds of approximately equal size built in parallel, designated AC Vertical Flow Pond North(ACVFPN) and AC Vertical Flow Pond South(ACVFPS). The parallel configuration allows for uninterrupted treatment by one pond while 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 (½-foot thickness) was placed on the geotextile prior to installing the lower underdrain system, consisting of solid headers and perforated laterals. A two-foot layer of AASHTO #1, specified 90% CCE, limestone aggregate was then placed directly over the lower underdrain. A second (upper) underdrain, similar to the first, was then installed and covered by a second two-foot layer of limestone aggregate. Compost was not placed in this system as the dissolved iron content in the AC drainage was low.

The underdrain system was installed in order to optimize flow distribution and flushing of accumulated solids. Each of the tiers (upper and lower underdrain) is divided into 4 quadrants or cells for a total of 16 cells (8 cells in each pond.) Each cell discharges through an individual outlet riser pipe. The underdrain was constructed of 4-inch, Schedule 40, PVC pipe. Perforated laterals were placed on 4½-foot centers and connected to a solid header with a sanitary-type tee. Perforations were hand-drilled with two, ½-inch, perforations ~30° from the top of the pipe. The perforation spacing was equal to the lateral spacing (4½ feet). Four separate header pipes were used for each tier, thus dividing the surface area into approximately equal quadrants. Each header pipe extends from the treatment medium through the breastwork to an individual 4-inch ball valve. Prior to the 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 is used to vertically adjust the 3-inch riser to control the flow rates within each cell.

In addition, each pond had one cell of basic steel slag located in the lower tier of the quadrant nearest the inlet (cell LA) to provide an alkalinity boost to the system.

By donation of time and resources of project participants, ACVFPN and ACVFPS have been modified to allow for hybrid flow in order to encourage a more horizontal flow component during operation and a more vertical flow component during flushing in order to discourage established preferential flow paths.

AC Flush Pond (ACFP): Flush water from the ACVFPN and ACVFPS underdrains is directed to the ACFP. Initially the pond was designed to be used only during flushing events, with enough volume to contain an entire flushing for settling and accumulation of solids, prior to discharge. A drawdown device (perforated riser/solid barrel with valve) was installed to decant the flow from flushing events. An emergency spillway, lined with rip rap, was also installed. The receiving stream for both spillways would be tributary "C". Flushing of solids may increase the longevity of acceptable hydraulic conductivity within the Vertical Flow Ponds.

As the ACVFPN & ACVFPS have been modified to allow for hybrid flow operation, the ACFP has been modified for optional use as a settling pond. A 6", SCH40, PVC crossover pipe with 6", gate valve has been installed to convey the water to the AC Settling Pond/Wetland.

<u>AC Settling Pond/Wetland (ACSPWL):</u> The inlet end of this component is a deeper(2 feet, more or less), "dug-out" pond designed for solids accumulation. The outlet end is a wetland, which acts to filter additional solids. Approximately ½ foot of wetland substrate was placed to encourage plant establishment.

A portion (flow rate can be regulated) of the water from this component is directed into the B1 Vertical Flow Pond while the remaining flow enters the AC Wetland.

<u>AC Wetland (ACWL):</u> The discharge from the ACSPWL enters the ACWL to provide additional area for precipitation and accumulation of solids.

During construction of the ACWL, seeps containing a high (129 mg/l) concentration of dissolved iron were encountered. At times, these seeps significantly degrade the treated flow from the ACWL.

Because of this additional degraded seepage and/or when design flows for the AC system are exceeded, there are two options to handle the ACWL effluent. If no further treatment is needed, the ACWL effluent may cascade through a riprap-lined spillway and discharge into Laurel Run. If additional treatment is necessary, the ACWL effluent may be directed (all or portion) to the B1 Wetland.

<u>B1 Surface/Subsurface Collection System:</u> A subsurface collection system consisting of 6-inch, perforated, N-12, pipe bedded in a trench (2'W x 4'D) filled with non-reactive AASHTO#57 aggregate wrapped in drainage-type geotextile was installed to collect the majority of the B1 discharge. An additional surface channel was constructed to direct flow that was not collected by the subsurface collection system to the rock-lined spillway located between the B1 Vertical Flow Pond and the B1 Settling Pond. When the B1 Vertical Flow Pond is discharging into the spillway, the alkalinity in the slag-treated water is consumed by the raw B1 drainage and iron-bearing solids are precipitated. During alternate operation of the B1VFP as a Hybrid Flow Pond with drainage to the B1FP, low-pH iron solids precipitate in the spillway, decreasing iron and acidity concentrations.

B1 Slag-Only Vertical Flow Pond (B1VFP): A portion of the flow in the ACSPWL is directed into the B1VFP, which contains oversized basic steel slag from International Mill Service, Weirton, WV. Published research of others indicated that this slag can generate extremely high concentrations of alkalinity. In this case, the alkaline effluent from the B1VFP could then be mixed with the B1 discharge, in order to precipitate a large portion of the iron within the B1 Settling Pond. Even though the system did not produce the expected alkalinity, manganese is being very effectively removed. The B1VFP can also be operated as an Hybrid Flow Pond with the treated discharge conveyed to the ACWL via B1FP for use in treating the degraded seepage encountered in the ACWL.

B1 Flush Pond (B1FP): Flush water from the B1VFP underdrain system is directed to the B1FP. A drawdown device (perforated riser with valve) was installed to decant the flow associated with flushing events to the rip-rap lined spillway from the ACWL that conveys the final effluent to Laurel Run. During B1VFP operation as a Hybrid Flow Pond, the effluent from this component is conveyed to the B1FP. The rip-rap lined B1FP emergency spillway then conveys the effluent to the ACWL to aid in the treatment of degraded seepage encountered during construction of the ACWL.

B1 Settling Pond (B1SP): The B1 drainage in the riprap-lined spillway enters into the B1SP where additional formation and precipitation of iron-bearing solids occur.

B1 Wetland 1 (B1WL1): Effluent from the B1SP cascades through a riprap spillway into B1WL1 where additional oxidation and precipitation of metals occurs. As noted previously, modifications to the ACWL with the installation of a 6", SCH40, PVC crossover pipe with 6" gate valve (and corrugated piping to convey the flow along the embankment) also allows the flow, or a portion thereof, to be directed into B1WL1 to provide additional treatment of the AC discharge during excessive flows. Earthen berms were constructed to act as flow directional barriers to increase the effective retention time within the wetland by discouraging short-circuiting. Additional microtopographic relief was introduced by creating an irregular bottom.

B1 (Bioswale) Wetland 2 and B1 (Bioswale) Wetland 3 (B1WL2/B1WL3): From the B1WL1 the water flows into the B1WL2 and then the B1WL3, which are two consecutive channel wetlands (bioswales). A riprap spillway between the two bioswales allows for further aeration and iron oxidation. Effluent from B1WL3 enters the B1B3 Vertical Flow Pond via a rock-lined spillway.

B3 & B3A (Oxic Limestone Channels) Collection Systems: A portion of the B3 discharge emanates from a borehole drilled into the old spoil, which previously flowed along an unlined, highly eroded, channel. A rock-lined channel was constructed to convey the flow into the B3 settling/collection pond. An additional discharge known as B3A emanated approximately 300 feet to the east of the borehole discharge, which also previously flowed in another unlined, highly eroded, channel. A second rock-lined channel was constructed and lined with 48% CCE aggregate. This channel not only acts as a diversion ditch conveying the water to the settling/collection pond and reducing erosion, but also adds alkalinity to the discharge.

B3A Settling Pond (B3ASP): Flow collected in the B3A collection system is directed into the (B3ASP), which then flows into the B3 Settling Pond. A restricted orifice flow-type intake device was installed to regulate the flow rate into B3SP to about 10 gallons per minute. The B3ASP acts not only as an energy dissipater during precipitation events but also provides for the precipitation of metal solids generated by treatment with the Oxic Limestone Channels.

B3 Settling Pond (B3SP): The B3SP not only serves as a collection/settling pond for the B3 discharge, but also receives up to ~10 gallons per minute from the B3ASP as well. The combined flow is then conveyed by a 4-inch, Schedule 40, PVC pipe to the B1B3 Vertical Flow Pond for treatment.

B1B3 Vertical Flow Pond (B1B3VFP): The B1B3VFP was originally designed to only receive and treat the B1 partially treated discharge from B1WL3 and the B3 and B3A discharges from the B3SP. Several components were modified, however, in order to provide further treatment to all or a portion of the AC discharge. The design of the B1B3VFP is similar to the AC Vertical Flow Ponds. The B1B3VFP, however, has approximately a ½-foot thick layer of spent mushroom compost directly overlying the limestone aggregate. There is also only one pond.

B1B3 Flush Pond (B1B3FP): Flush water from the B1B3VFP underdrain system is directed to the B1B3FP. A drawdown device (perforated riser with valve) was installed to decant the flow from flushing events to a natural swale prior to entering Laurel Run. A rip-rap lined emergency spillway was installed which also discharges to a natural swale prior to entering Laurel Run.

B1B3 Settling Pond/Wetland (B1B3SPWL): The effluent from the B1B3VFP enters the B1B3SPWL, which was constructed in a similar manner as the ACSPWL. The effluent enters a pool (~ 4 feet in depth) for initial settling of solids. The water depth becomes shallow where the wetland begins. Drainage from B1B3SPWL enters through a rock-lined channel directly into the B1B3 Horizontal Flow Limestone Bed.

B1B3 Horizontal Flow Limestone Bed (B1B3 HFLB): This component provides an alkalinity "boost" before discharging to the stream. Much of the alkalinity generated by the Vertical Flow Ponds is consumed through the precipitation of metals, which produces acidity. The additional alkalinity generated from the Horizontal Flow Limestone Bed generally provides sufficient buffering capacity to the effluent of the passive treatment system, which can help to treat other acidic discharges downstream or at least limit their impact to the treated water. The Horizontal Flow Limestone Bed also removes manganese. Traditionally, water containing dissolved manganese is treated chemically due to the high pH requirement (~10) needed for precipitation. Although a high pH is not generated in a limestone-based system, manganese is removed in this component. This phenomenon is probably due to several factors including the presence of only low concentrations of dissolved iron, the availability of oxygen and alkalinity, and bacteriological activity.

The Horizontal Flow Limestone Bed contains about 5 feet of limestone aggregate. Water enters from the B1B3SPWL through a rock-lined spillway. The water is encouraged to flow horizontally through the limestone to a perforated manifold along the outlet end near the base of the component. A riser pipe extends to within one foot of the top of the limestone, the design water level. The final effluent then flows through a riprap spillway and discharges into Laurel Run. When discharge AC is directed into the B1B3 system, this is the final effluent for the complex, excluding the Diversion Well.

<u>Diversion Well:</u> The main purpose of a diversion well is to add alkalinity to a stream. This diversion well system consists of a collection “pool” for the intermittent/ephemeral tributary “C” with piping to convey the water to the manhole. When the manhole is charged with limestone chips, the force of the churning water “grinds” the limestone chips into fine particles (slurry) which are suspended in the water and discharged directly into tributary “C”. The diversion well was not part of the original proposal; however, the Pennsylvania Department of Environmental Protection requested that one be installed since the site would be used by the Pennsylvania Department of Conservation and Natural Resources as an educational facility. About 45 tons of limestone chips (#10) have been stockpiled in proximity of the manhole for charging the system.

ENVIRONMENTAL IMPACT

Performance of Individual Passive Components

The passive treatment complex at the Harbison Walker Phase II site has been functional since January 2001. Repairs have been made to berms and piping systems. Water sampling has been conducted by BioMost Inc. and the PA DEP. A schematic diagram of the passive system can be seen in Figure 2.

Although sampling has been conducted over the last two years, the results must still be considered initial when considering the design life of the system to be 25 years. Excluding the Diversion Well for trib. "C", originally the complex was constructed to have two separate effluent locations, one for the AC treated discharge and one for the B1 and B3 treated discharges. As an option, however, the system was later modified so that the final effluent for the AC, B1, and B3 discharges can be through the B1B3HFLB outlet pipe. The effectiveness of this passive system is illustrated by Figures 3 & 4 at the end of this section. The following table identifies these initial water quality characteristics through each component of the discharge from the influent to the effluent:

COMPARISON OF WATER QUALITY
Through the
HARBISON WALKER PHASE II PASSIVE TREATMENT SYSTEM
(average values)

Component	pH	Alkalinity	Acidity	Iron	Manganese	Aluminum
AC(Raw)	3.5	0	456	2	41	58
ACVFPN	6.1	63	14	0	20	10
ACVFPS	6.0	91	33	0	16	16
ACSPWL	6.1	28	11	0	17	4
ACWL	5.2	6	39	2	16	4
B1VFP	10.0	108	0	1	1	0
B1(Raw)	3.1	0	230	57	32	8
B1SP	3.4	0	179	51	15	3
B1WL1	3.2	0	162	30	16	4
B1WL2/B1WL3	3.3	0	148	25	14	4
B3(Raw)	4.3	0	47	0	7	6
B3SP	6.1	19	12	1	5	3
B1B3VFP	6.6	46	0	5	10	1
B1B3SPWL	6.6	27	0	3	10	0
B1B3HFLB	7.1	70	0	0	3	0

Average values rounded; alkalinity, acidity, and total metals expressed in mg/L; lab. pH not averaged from H-ion concentrations; See attached data for sample set.

Comments on Performance of Selected Passive Components

<u>AC Vertical Flow Pond North and AC Vertical Flow Pond South (ACVFPN & ACVFPS)</u>: These components function well, except when the design flow of 100 gpm is exceeded. At these times, the pH is below 6 and the acidity exceeds the alkalinity. Testing and

other field investigations were conducted in order to develop technology to improve system functioning. Based on observations, the problem appeared to be the development of preferential flow paths, resulting in short-circuiting within the ponds. Backflushing indicated that part of the reason for the short-circuiting was caused by broken pipes. In late 2002, the ponds were drained, portions of the treatment media removed, and the broken sections of pipe replaced.

The raw AC influent can be described as acidic drainage with low pH and high concentrations of dissolved aluminum and dissolved manganese. The iron concentration is low. The effluent has significantly decreased concentrations of aluminum and manganese with the pH varying in individual riser pipes from 4.5 to 7.5. On average, over 285 lbs/day of acidity are being neutralized and over 38 lbs/day of metals are being retained within the system. This is a decrease in the total aluminum loading by approximately 69% and a decrease in manganese loadings by about 53%. At times, however, the system has been documented to neutralize nearly 400 lbs/day of acidity and to retain over 60 lbs/day of metals.

AC Settling Pond/Wetland(ACSPWL) and AC Wetland(ACWL): These wetlands were planted by Americorp, Aquascape, Stream Restoration Inc., and Ohiopyle State Park volunteers. The wetlands are well vegetated, treating water, and providing wildlife habitat. Some highly-degraded seeps, however, were encountered during construction of the wetlands, which is not surprising considering that the entire passive system complex was constructed in or near the discharge zone. Flow from these seeps can significantly impact the discharge quality.

B1 Slag Vertical Flow Pond(B1VFP): Although the slag-filled Vertical Flow Pond has not generated the alkalinity values predicted, performance has exceeded that expected relating to decrease in metals concentrations, especially manganese. On average, the component is removing 17 mg/L of dissolved manganese, often reducing concentrations to 0.1 mg/L or less while discharging, on average, about 100 mg/L alkalinity as $CaCO_3$. Typically, the effluent from this component has manganese concentrations less than the predicted final effluent manganese concentrations (0.5 mg/L) for the proposed optional active system as determined by Tiff Hilton, WOPEC (See Figure 5).

B1 Settling Pond (B1SP): Without accurate flow measurements, treatment effectiveness of the B1 Settling Pond is difficult to determine. Thick orange precipitates are collecting in the pond and in the influent spillway. Cascading down the effluent spillway also provides for oxygenation, which allows for significant iron removal in the subsequent wetlands.

B1 Wetlands 1, 2, 3 (B1WL1, B1WL2, B1WL3): These wetlands are well vegetated and providing wildlife habitat. Evaluation of their treatment effectiveness is difficult without accurate flow measurements. Based purely on concentrations, the wetlands are removing, on average, about 25 mg/L of iron. The success in iron removal is expected to be due, at least in part, not only to successful vegetation, but also to periodically oxygenating the drainage as the flow is conveyed in the riprap spillways connecting the wetland components.

B1B3 Vertical Flow Pond (B1B3VFP): The B1B3VFP can be evaluated based on comparison of influent and effluent concentrations. The flow entering the B1B3VFP through B1WL3 can be characterized as acidic, low pH drainage, with elevated concentrations of iron and manganese and low concentrations of aluminum. The flow entering the B1B3VFP through the B3 Settling Pond is circum-neutral with low concentrations of metals. The effluent of the B1B3VFP can be described as a net-alkaline discharge with significantly decreased concentrations of iron and aluminum.

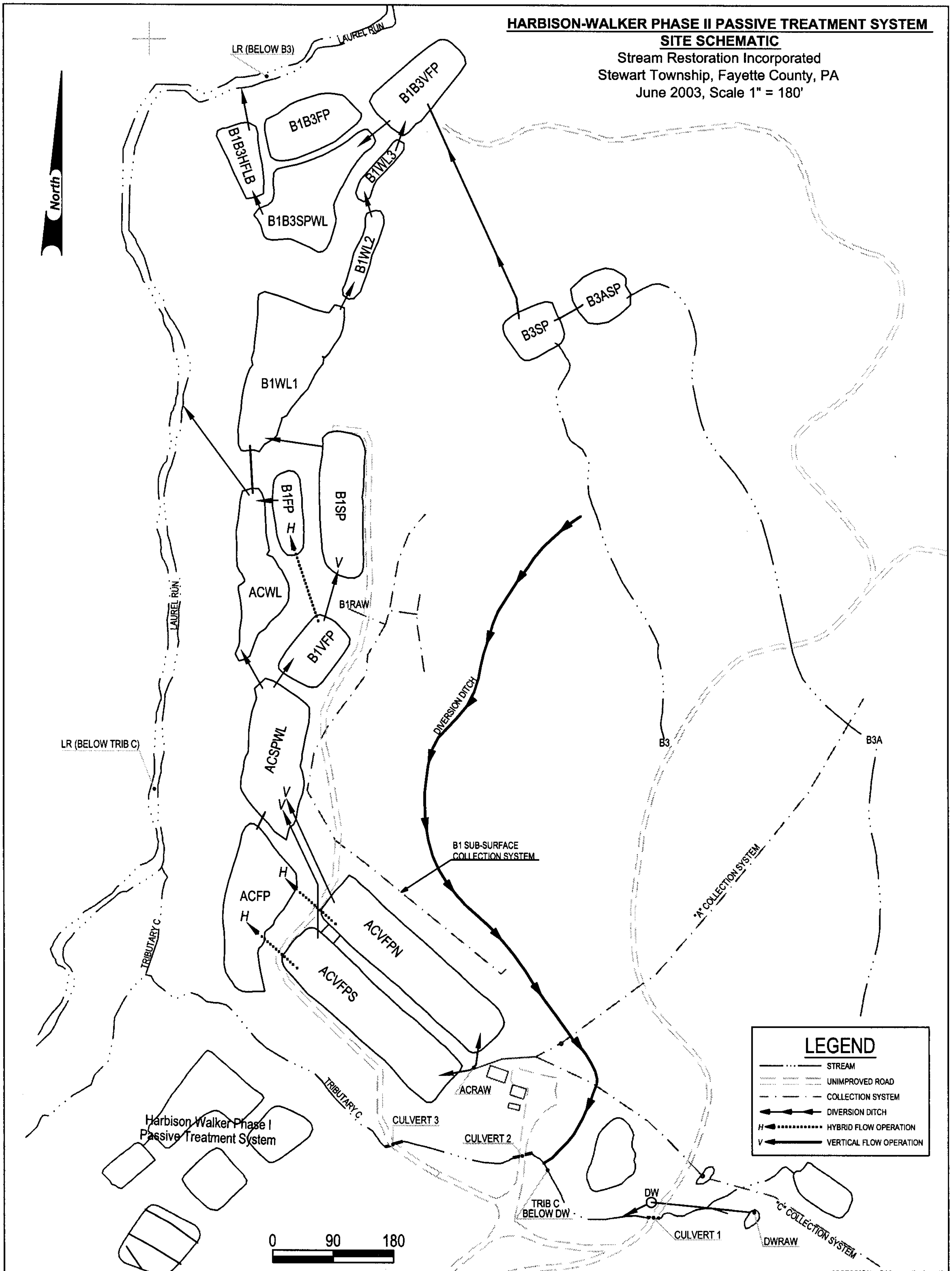
B1B3 Settling Pond/Wetland (B1B3SPWL): The B1B3SPWL is well vegetated and providing wildlife habitat. In addition, iron and aluminum concentrations are reduced while manganese concentrations remain constant.

B1B3 Horizontal Flow Limestone Bed (B1B3HFLB): The B1B3HFLB is working extremely well. Its primary function is to provide an alkalinity "boost" before discharging to the stream, as much of the alkalinity generated by the B1B3VFP is consumed by neutralization of the acidity generated by the precipitation of metals. On average, the B1B3HFLB is discharging at least 40 mg/L alkalinity as $CaCO_3$ (an average loading of about 30 lbs/day of alkalinity). The additional alkalinity generated from the B1B3HFLB should generally provide sufficient buffering capacity to the effluent of the passive treatment system, to help neutralize other acidic discharges downstream or at least limit their impact. Of particular note, the Horizontal Flow Limestone Beds are also successfully removing manganese. This system is removing, on average, about 7 mg/L of manganese and typically reducing the manganese loading by 90-100%. Often this component is discharging manganese concentrations less than the predicted final effluent manganese concentrations (0.5 mg/L) for the proposed optional active system as determined by Tiff Hilton, WOPEC. (See Figure 5.) Characteristically, the final effluent of the system has a 7.1 pH, 70 mg/L alkalinity, and individual dissolved metal concentrations less than 1 mg/L and often less than 0.5 mg/L.

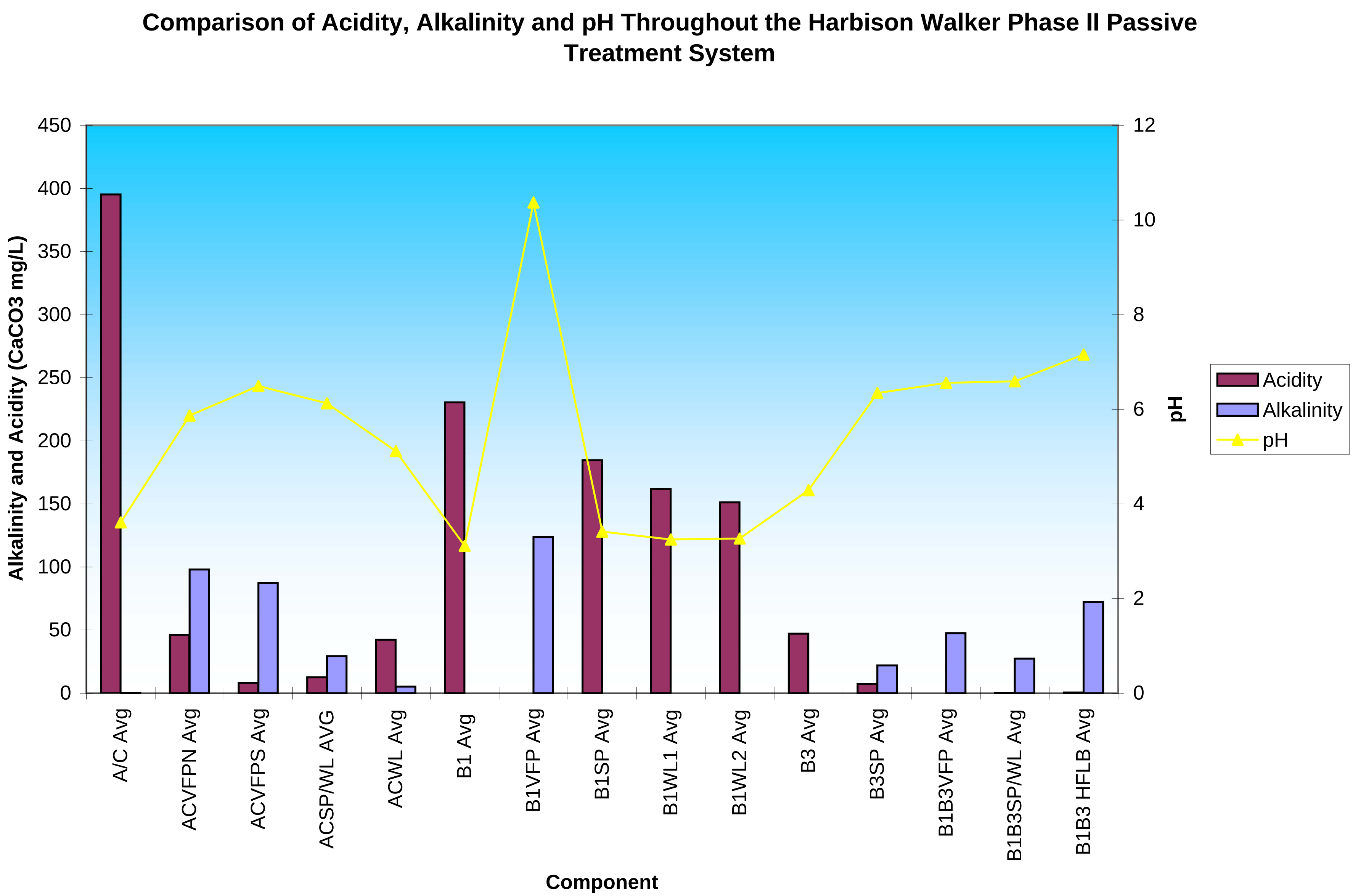
Diversion Well: Limestone aggregate (AASHTO#10) is stockpiled in proximity to the Diversion Well in order to charge the well. A portion of the intermittent to ephemeral Tributary "C" is diverted to the well. Upon charging the well, water sampling of Tributary "C" above and below the discharge is to be monitored. On 9/23/03, during field testing, the influent (upstream trib. "C") to the Diversion Well had a pH of 4.8 and the effluent had a 5.4 pH with an estimated flow of 500 gpm. Trib. "C" below the confluence of the Diversion Well effluent at the access road crossing had an estimated flow of 1000 gpm with a pH of 6.0. The higher pH downstream is thought to be related to the dissolution of suspended limestone particles.

HARBISON-WALKER PHASE II PASSIVE TREATMENT SYSTEM SITE SCHEMATIC

Stream Restoration Incorporated
Stewart Township, Fayette County, PA
June 2003, Scale 1" = 180'



103503/Site Schematic (rev1)


Comparison of Acidity, Alkalinity and pH Throughout the Harbison Walker Phase II Passive Treatment System
Alkalinity and Acidity (CaCO3 mg/L)
450
400
350
300
250
200
150
100
50
0
pH
12
10
8
6
4
2
0
Acidity
Alkalinity
pH
A/C Avg
ACVFPN Avg
ACVFPS Avg
ACSP/WL AVG
ACWL Avg
B1 Avg
B1VFP Avg
B1SP Avg
B1WL1 Avg
B1WL2 Avg
B3 Avg
B3SP Avg
B1B3VFP Avg
B1B3SP/WL Avg
B1B3 HFLB Avg
Component

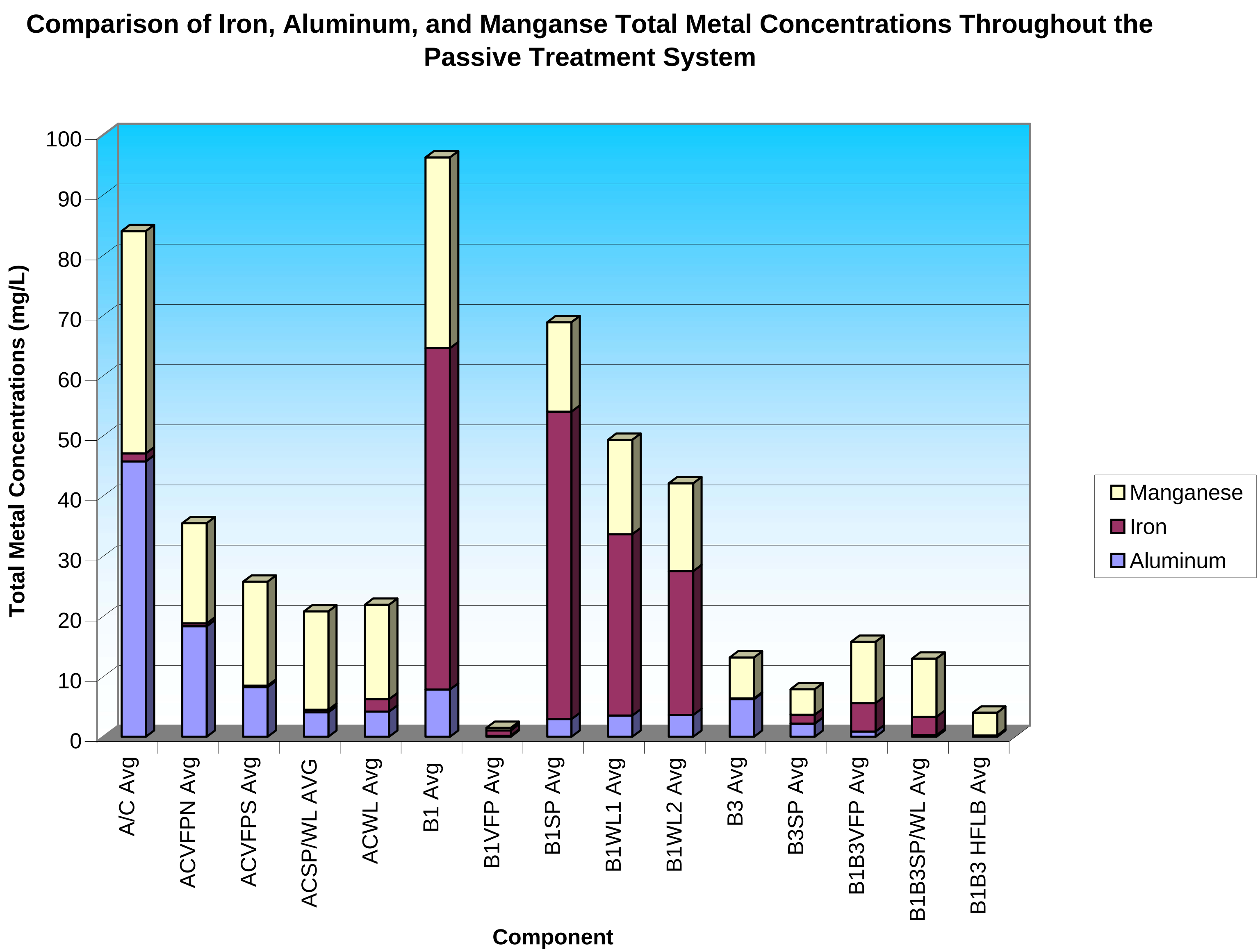

Comparison of Iron, Aluminum, and Manganse Total Metal Concentrations Throughout the Passive Treatment System
Total Metal Concentrations (mg/L)
100
90
80
70
60
50
40
30
20
10
0
A/C Avg
ACVFPN Avg
ACVFPS Avg
ACSP/WL AVG
ACWL Avg
B1 Avg
B1VFP Avg
B1SP Avg
B1WL1 Avg
B1WL2 Avg
B3 Avg
B3SP Avg
B1B3VFP Avg
B1B3SP/WL Avg
B1B3 HFLB Avg
Component
Manganese
Iron
Aluminum

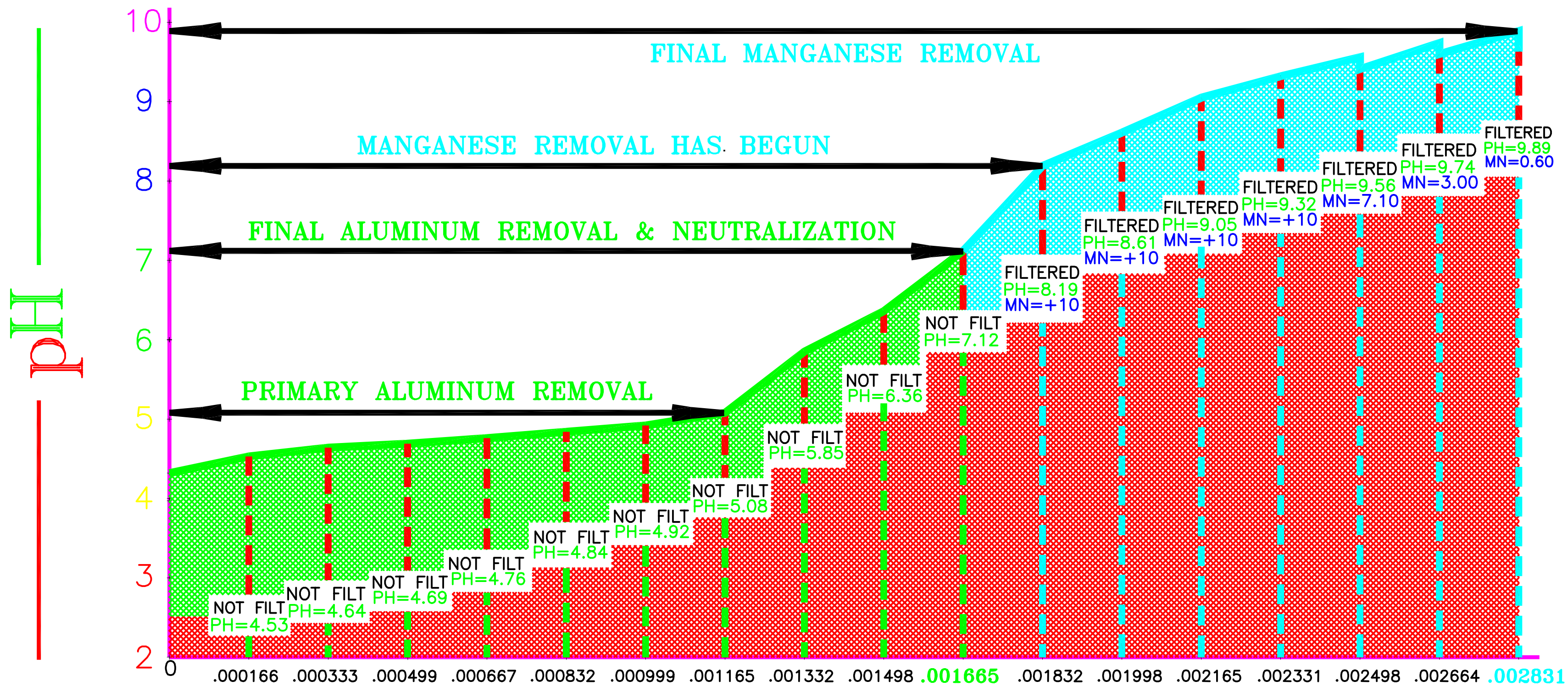
Figure 5: HARBISON WALKER MINE--SAMPLE POINT A/C SEEPS

INCREMENTAL TITRATION TEST--CALCIUM OXIDE

CHEMICAL	TREATMENT LBS./GALLON FOR AL REMOVAL/PH ADJUST.
CAO	0.001665 LBS./GAL. $0.000166/GAL.

CHEMICAL	TREATMENT LBS./GALLON FOR MN REMOVAL
CAO	0.002831 LBS./GAL. $0.000283/GAL.

FLOW	#CAO/DAY (AL)	$/DAY (AL)	#CAO/DAY (MN)	$/DAY (MN)
25 GPM	59.94 LBS.	$ 5.99/DAY	101.91 LBS.	$ 10.19/DAY
50 GPM	119.88 LBS.	$ 11.98/DAY	203.83 LBS.	$ 20.38/DAY
100 GPM	239.76 LBS.	$ 23.97/DAY	407.66 LBS.	$ 40.76/DAY
150 GPM	359.64 LBS.	$ 35.96/DAY	611.49 LBS.	$ 61.14/DAY
200 GPM	479.52 LBS.	$ 47.95/DAY	815.32 LBS.	$ 81.53/DAY



CAO DELIVERED BAG=$0.10/LB.

TITRATION CURVE BY WOPEC

FINAL PH UPON COMPLETE PRECIPITATION = 8.42

METAL	FERRIC IRON	FERROUS IRON	ALUMINUM	MANGANESE
REMOVAL PH	N/A	N/A	7.12	9.89

INFORMATION FOR CURVE PROVIDED BY:
WOPEC TITRATION TEST

FINAL PH=8.42

FINAL MN=0.50

SLUDGE=0.0018 GALS./GAL.

W O P E C

LEWISBURG WEST VIRGINIA

HARBISON WALKER MINE SITE
CALCIUM OXIDE
TITRATION EVALUATION

DATE: 1-25-2000
DESIGNED BY: T. Hilton
DRAWN BY: T. HILTON
SCALE: NOT TO SCALE
STATE: PENNSYLVANIA
COUNTY:
DISTRICT:
NEAREST TOWN:

Measurable Environmental Results

Overall Impact on Site Water Quality: Water quality improvement was immediate upon system installation and has continued throughout the last two years. Flow rates have varied substantially. In addition, formerly untreated discharges, encountered during excavation for the complex, have been included in the treatment system. The system has been treating the mine drainage since January 2001. Water monitoring has included the raw, untreated water, passive treatment components, and Laurel Run, upstream and downstream of the system.

Comparison of the Raw and Final Effluent (average values)

Sampling Point	lab pH	alkalinity	acidity	Fe	Mn	Al
Raw AC *(ACWL)*	3.5*(5.2)*	0*(6)*	456*(39)*	1.5*(2)*	40.6*(16)*	57.5*(4)*
Raw B1	4.0	54	186	56.3	26.1	6.1
Raw B3	4.3	0	47	0.1	6.8	6.3
Treated AC, B1, B3, unnamed seeps	7.1	70	0	0.1	3.4	0.1

Alkalinity, acidity, and total metals concentrations in mg/L; pH not calculated from average H-ion concentrations; According to analyses, when the ACWL effluent pH is 6, the alkalinity exceeds the acidity. When the design flow is exceeded the ACWL effluent pH tends to be <6. Treated AC, B1, B3, unnamed seeps represents the quality of the final effluent when all encountered discharges are combined. See attached analyses for sample set.

Figures 6 and 7 graphically depict the raw and treated water quality. The final effluent, when all encountered discharges are combined, can be characterized as a net alkaline with low to insignificant concentrations of dissolved iron, aluminum, and manganese. Please note that these total metal concentrations are less than the standard surface mine permit effluent limits. Also note that the average manganese concentration is skewed due to the first three samples, which contained elevated levels; however, within 6 months of operation manganese concentrations in the B1B3HFLB discharge were less than 0.5 mg/L. It is believed that this phenomenon is due to the establishment of microorganisms and/or development of autocatalytic processes associated with the precipitation of manganese. The passive system as a whole is reducing manganese concentrations below that predicted for the alternatively proposed active treatment plant. (See Figure 5.) On average, the passive treatment complex is neutralizing about 432 lbs/day of acidity and preventing nearly 100 lbs/day of metals from entering Laurel Run.

General Impact on Receiving Stream: Laurel Run has been impacted by historical mining activities. In addition to the discharges from the Harbison Walker Smith Mine, discharges emanate from an old adjoining minesite immediately upstream. There is a chemical treatment plant currently in operation at the adjoining minesite. Nonetheless, iron staining is noted on the substrate of Laurel Run upstream of the Harbison Walker Restoration Area.

Downstream of the adjoining site, the final effluent from the Harbison Walker Phase I passive system and tributary "C" enter Laurel Run. Discharges #12 and #13 are conveyed through the Phase I passive system and are successfully treated. Discharge #14 is also treated upon mixing with the alkaline final effluent of the Phase I system. This site has the first known installation of a Horizontal Flow Limestone Bed. Refer to the previously submitted Final Report (June 2000) for Phase I. The only treatment available for tributary "C" is the Diversion Well, which was installed as part of Phase II.

In addition to the Diversion Well for tributary "C", the Harbison Walker Phase II passive complex provides treatment for discharges AC, B1, B3, and unnamed seeps. There is the option to have either one or two final effluent points from the complex. When there are two final effluent points, the treated AC drainage plus unnamed seeps encountered during the excavation of the ACVFPN and the constructed wetlands enter Laurel Run from the AC Wetland (ACWL) and the treated B1 and B3 drainage and other encountered unnamed seeps enter Laurel Run from the B1B3 Horizontal Flow Limestone Bed (B1B3HFLB). When all encountered drainage is combined, there is one final effluent point which is the discharge from the B1B3HFLB.

Despite AC, B1, and B3 exceeding design flows at times, comparison of the pre- and post-installation monitoring data at the downstream monitoring point on Laurel Run indicates a slight improvement in stream quality. A very significant indication relating to the impact of the final effluent to the receiving stream was observed on 8/13/03. On this date, the final effluent was pooled in the streambed, having very little mixing with the major flow of Laurel Run. **Numerous minnows** were observed in the pooled area while only two minnows were noted in an adjoining similar area that received only stream flow. The impact on the receiving stream can also be more appropriately described by the decrease in pollutant loadings of the site drainage by more than 156,950 lbs/yr (78 T/yr) of acidity and nearly 36,500 lbs/yr (18 T/yr) of metals. Review of the following table and Figure 8, identifies the increase in pH and alkalinity, and the decrease in acidity, iron and manganese. The aluminum concentrations have essentially remained the same.

Laurel Run Water Quality Before and After Completion of Passive Systems
(average values)

Sampling Point	Field pH	Alkalinity	Acidity	Iron	Manganese	Aluminum
LR Below (Before)	6.83	17	1	0.9	3.2	0.2
LR Below (After)	7.06	24	0	0.4	2.4	0.2

Alkalinity, acidity, and dissolved metal concentrations in mg/L; average pH not calculated from H-ion concentrations; See attached analyses for sample set.

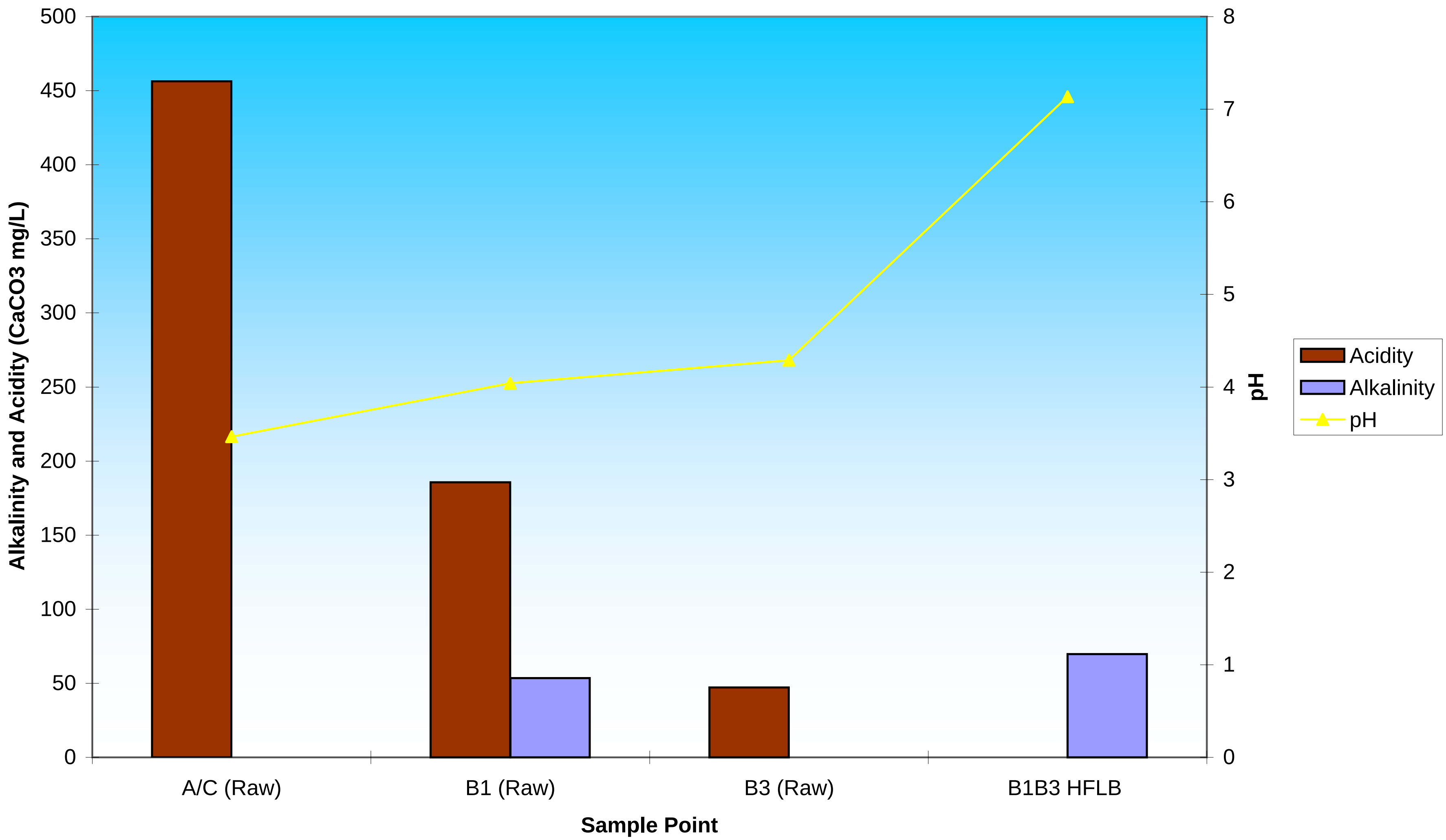
Other Measurable Benefits: In addition to the improvement in Laurel Run, other benefits have resulted from the completion of this project.

- The naturally-functioning wetlands with high plant species diversity have been observed to provide habitat for amphibians and numerous bird species including herons.

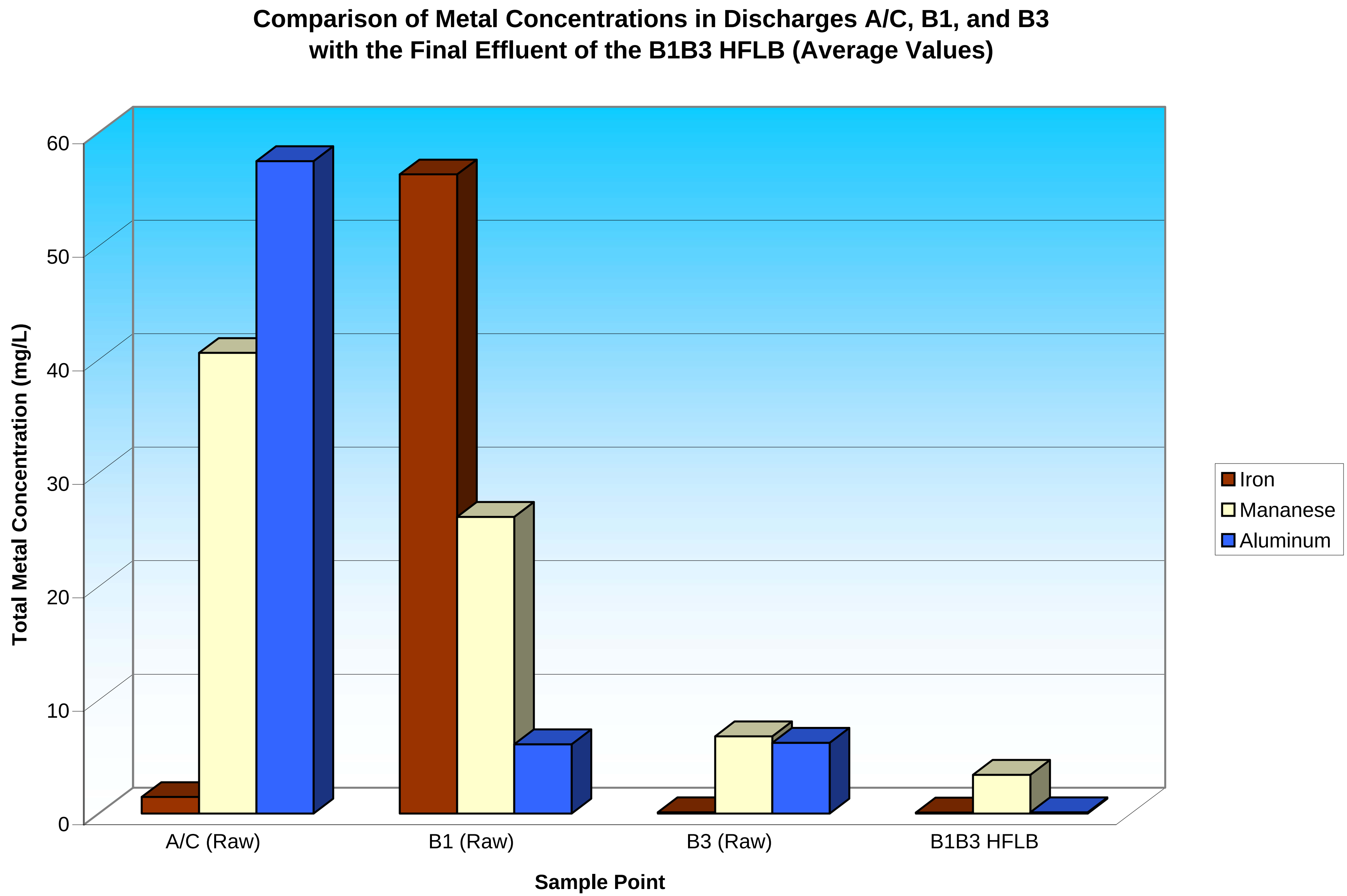
- The passive complex has eliminated the need for harsh chemicals and handling of large volumes of lime sludge, on-going issues associated with the operation of the previous active system.

- As the Harbison Walker Restoration Area is possibly the most complex and innovative passive treatment system within the Commonwealth of Pennsylvania to date, the unique educational and research opportunities are unparalleled. Recognizing this, the PA Department of Conservation and Natural Resources has constructed a pavilion and expansion of their environmental education program has already been initiated.

Comparison of Alkalinity, Acidity, and pH of Discharge A/C, B1, B3 with the Final Effluent From the B1B3 HFLB (Average Values)



See attached monitoring data for sample set.
Figure 6



See attached monitoring data for sample set.
Figure 7

Comparison of Laurel Run Downstream Sampling Point Before and After Passive Treatment System Construction

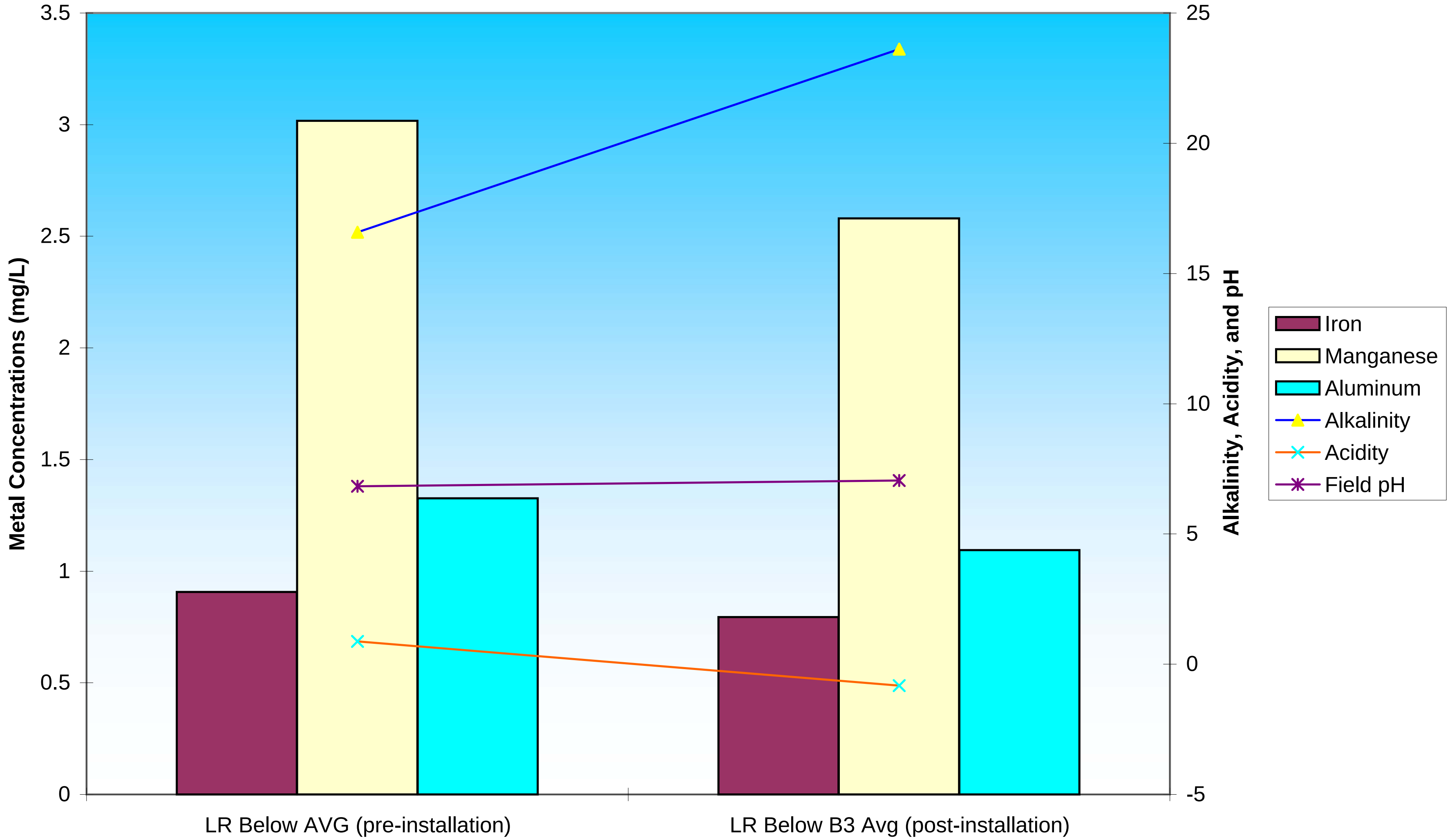


Figure 8

A view of the lime plant and one of the sludge ponds (Center) of the previous active system to treat the A/C discharge at Ohiopyle State Park. A portion of the Harbison Walker Restoration Area Phase I passive treatment system can be seen in the background.

The treatment hopper (left) added hydrated lime to the 100 gpm A/C discharge that contains about 60 mg/L aluminum and 40 mg/L manganese.

Following mixing, the resulting sludge accumulated in Settling Pond #5 (above) which had been filled in, resulting in channelized flow.

Discharge B1 was actively treated using Soda Ash Briquettes dispensed through a hopper (above and bottom left), which then flowed into a settling pond (not shown) and discharged via a rock spillway (bottom right) prior to entering Laurel Run.

Top: Soda Ash Briquette Hopper and settling pond previously utilized to actively treat the B1 discharge.

Bottom Final Settling Pond for the B1 active system discharging treated B1 over the hill towards Laurel Run.

Left: The B1 discharge flowing towards Laurel Run following active treatment with Soda Ash Briquettes.

Bottom: The actively treated B1 discharge flowing into Laurel Run, a High Quality Cold Water Fishery.

View of the B1 mine discharge “kill zone”. Note the lack of vegetation and the accumulation of metal deposits. This is the general area where the A/C Wetland (ACWL) was constructed and easily explains why seeps were encountered within the constructed wetland.

The acidic metal-laden B3 discharge (above) with an average flow of 10 gpm and at times up to 50 gpm was previously untreated and cascaded over an outcrop prior to entering Laurel Run (below).

Barren hillsides characterized the mine site prior to reclamation

Before the Harbison Walker Phase II Passive System could be constructed, the active treatment ponds had to be pumped out.

Construction of the A/C Vertical Flow Ponds by Amerikohl Mining, Inc.

Installation of the diversion well by Amerikohl Mining Inc. at the Harbison Walker Phase II site.

Construction of the B1B3 flush pond that will retain the metal solids during flushing events of the B1B3 Vertical Flow Pond.

Construction of the A/C system including placing of limestone in the Vertical Flow Ponds left and in the spillways right.

View of the construction of the A/C Vertical Flow Ponds.

Drilling and blasting were necessary in order to construct the passive treatment system.

Amerikohl Mining Inc. reconstructing the berm of the B1B3 settling pond as part of their warrantee on the structural integrity of the passive treatment system.

Upon realization that several of the pipes had been broken, the vertical flow pond on the right was drained and a portion of the piping system was removed and replaced.

Replacement of a portion of the piping system of the A/C Vertical Flow Pond by Amerikohl Mining, Inc. as part of the maintenance agreement.

Completed A/C Vertical Flow Ponds North (right) and South (left)

After discharging from the A/C Vertical Flow Ponds, the water flows through a riprap channel into the A/C Settling Pond/Wetland.

The majority of the flow from the A/C Settling Pond/Wetland then flows into the A/C Wetland (above) before dischaging into Laurel Run, which flows into Meadow Run, a tributary to the Youghiogheny River.

A small portion of the A/C Settling Pond Wetland is directed into the B1 Slag Only Vertical Flow Pond to gain sufficient alkalinity to treat the B1 discharge in the B1 Settling pond that follows.

The effluent of the B1 Vertical Flow Pond (white color in the bottom picture) mixing with the B1 discharge (red-orange color) before entering the B1 Settling Pond (above).

B1 Wetland #1 provides further oxidation and settling of solids following the B1 Settling Pond.

The B1 Wetland 2 and 3 are channel wetlands (bioswales) that convey the flow of the B1 discharge into the B1B3 Vertical Flow Pond that provides treatment of the B1 discharge as well as the B3 discharge.

View of the Harbison Walker Phase II passive treatment system looking south towards the top of the system. B1 Wetland #1 is in the foreground. B1 Settling pond is top left.

View of the Harbison Walker Phase II passive treatment system with the B1B3 Settling Pond/Wetland (foreground) and the B1B3 Vertical Flow Pond (upper center).

Large boulders like the one in the foreground and those in the background made construction difficult. In many instances, they were left in place providing an aesthetic element to the site.

The B1B3 Vertical Flow Pond receives and treats the B1 discharge which enters from the wetland channel into the pond via the rock lined spillway (right center) and also the B3 discharge which enters from the B3ASP pipe (center).

The effluent of the B1B3 Vertical Flow Pond flows through the B1B3 Settling Pond/Wetland before entering the Horizontal Flow Limestone Bed (above).

The final effluent of the treated B1 & B3 discharges is from the Horizontal Flow Limestone Bed (right). Depending on the mode of operation, the final effluent may also include the treated A/C discharge. The water cascades in a rip-rap channel before entering Laurel Run. Note the clarity of the final effluent.

Flushing of the B1B3 Vertical Flow Pond. Note the thick, dark orange-colored, iron-bearing, water.

Flushing of the A/C Vertical Flow Pond. Note the white-colored aluminum-bearing, water.

A wetland planting was conducted for the B1B3 wetland (top) and the B1WL2 channel wetland (bottom) by Americorp volunteers, Stream Restoration Incorporated, and Aquascape Wetland and Environmental Services.

A tour of the Harbison Walker Phase II multi-component Passive Treatment System was given by Stream Restoration Incorporated to employees of the PA Department of Conservation and Natural Resources and the PA Department of Environmental Protection.

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
A/C DEP	1/27/95	Estimated	100		3.6				0	444	1.3		37.6		55.9		1107	12
A/C DEP	3/23/95	Estimated	90		3.5				0	478	1.5		48.0		71.6		1107	12
A/C DEP	4/20/95	Estimated	70		3.5				0	398	1.4		41.7		63.1		1220	10
A/C DEP	6/29/95	Estimated	50		3.6				0	474	1.5		61.1		58.3		1795	16
A/C DEP	8/30/95	Estimated	10		3.3				0	796	3.2		66.5		105.0		2030	
A/C DEP	9/25/95				3.3				0	968							1943	
A/C DEP	10/25/95				3.3				0	746	4.0		65.2		99.8		1977	
A/C DEP	3/26/96				3.4				0	410	1.1		33.0		48.2		1057	
A/C DEP	4/29/96				3.3				0	476	1.2		36.9		60.3		1444	
A/C DEP	5/29/96				3.4				0	484	1.3		37.6		58.7		1292	
A/C DEP	7/29/96				3.5				0	490	1.2		42.2		63.4		1436	
A/C DEP	9/20/96				3.4				0	468	1.0		38.2		55.3		1437	
A/C DEP	9/20/96				3.4				0	468	1.0		38.2		55.3		1437	
A/C DEP	10/30/96				3.5				0	466	1.1		34.9		52.8		1578	
A/C DEP	11/21/96				3.6				0	504	1.2		36.5		56.2		1328	
A/C DEP	12/12/96				3.5				0	422	1.1		34.2		51.4		1134	
A/C DEP	1/29/97				3.6				0	412	1.1		34.1		50.3		1499	8
A/C DEP	3/27/98		7		3.5				0	410	1.3		34.4		52.2		1317	
A/C DEP	6/26/98		5		3.5				0	410	1.3		37.6		55.3		1500	
A/C DEP	6/30/98				3.5				0	446	1.3		39.8		59.9		1331	
A/C DEP	9/23/98		1		3.4				0	446	1.5		43.9		71.0		1600	8
A/C DEP	8/22/99		76		3.4				0	420	2.9		36.0		48.9		1219	
A/C DEP	12/17/99		100		3.6				0	406	1.1		35.7		57.6		1490	
A/C DEP	6/6/02				3.3		23		0	507	1.4		40.2		67.4		744	4

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
Min			1		3.3		23		0	398	1.0		33.0		48.2		744	4
Max			100		3.6		23		0	968	4.0		66.5		105.0		2030	16
Avg			51		3.5		23		0	498	1.5		41.5		61.6		1418	10
Range			99		0.3		0		0	570	3.0		33.5		56.8		1287	12

Description: PA DEP water sample analyses; The 8/22/99 data is the design criteria used for the AC System from Hellier, W.W., PE, 1999, An Integrated Design Model for Passive Treatment Systems to Abate Water Pollution from Post-Mining Discharges; 1999 NAAMP

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
A/C	3/30/00	Bucket	136	3.3	3.5	1760	11		0	394	1.0		36.3		46.8		1437	3
A/C	4/28/00	Bucket	142	4.2	3.6	1685	12		0	354	1.0		34.9		42.6		1247	4
A/C	3/23/01	Bucket	112	4.4	3.5	1880	10		0	426	1.7	1.7	34.3	34.1	61.0	60.0	1858	1
A/C	4/16/01	Bucket	100	3.5	3.5	1603	11		0	379	1.7	1.5	30.6	28.4	51.3	50.0	448	5
A/C	7/8/01	Bucket	40	4.0	3.5	1848	14		0	434	1.1	1.1	35.8	35.4	56.0	50.5	1715	6
A/C	8/7/01	Bucket	52	4.5	3.5	2066	14		0	517	1.4	1.3	47.8	44.5	60.3	59.3	1813	4
A/C	9/21/01	Bucket	20	4.5	3.5	2160	14		0	578	1.5	0.6	48.0	31.8	11.9	6.5	1645	4
A/C	3/8/02	Bucket	42		3.4	2183			0	463	1.8	1.5	42.0	40.8	66.6	65.9	1378	3
A/C	5/2/02	Bucket	176	3.3	3.5	1875	12		0	377	1.8	1.8	36.5	36.3	55.3	48.2	1118	2
A/C	8/19/02	Bucket	20	4.3	3.4	2609			0	617	1.6	1.5	54.3	53.7	106.0	100.8	1509	9
A/C	12/30/02	Bucket	71	4.1	3.4	2165	11		0	481	1.6	1.5	46.2	46.0	74.9	72.9	1176	8
Min			20	3.3	3.4	1603	10		0	354	1.0	0.6	30.6	28.4	11.9	6.5	448	1
Max			176	4.5	3.6	2609	14		0	617	1.8	1.8	54.3	53.7	106.0	100.8	1858	9
Avg			83	4.0	3.5	1985	12		0	456	1.5	1.4	40.6	39.0	57.5	57.1	1395	4
Range			156	1.2	0.2	1006	4		0	264	0.8	1.2	23.8	25.3	94.1	94.3	1410	8

Description: Raw abandoned mine discharges A and C combined into one flow and formerly treated actively with hydrated lime; Post-Construction sampled at the influent pipe to the A/C Vertical Flow Ponds North and South.

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
ACVFPN	3/23/01	Bucket	56	5.5				84										
ACVFPN	4/16/01	Bucket	45	6.0	6.3	1884	14		71	0	0.1	0.1	26.3	25.4	11.6	1.2	1475	28
ACVFPN	7/8/01	Bucket	4	7.5	7.1	2083	20		126	0	0.3	0.1	5.2	5.1	0.2	0.1	1379	6
ACVFPN	8/7/01	Bucket	13	6.3	6.5	2030	28		96	0	0.4	0.1	19.1	17.0	8.5	0.2	1480	28
ACVFPN	9/21/01	Bucket	10	5.7	5.6	1943	21		14	41	0.2	0.1	24.8	24.0	11.1	6.3	1571	57
ACVFPN	5/2/02	Bucket	87	4.6				16										
ACVFPN	7/1/02	Bucket	20	4.7				38										
ACVFPN	7/2/02	Bucket	18	6.0				64										
ACVFPN	12/30/02	Bucket	39	5.4	5.3	1775	7		10	30	0.5	0.3	26.2	26.0	18.1	6.9	1333	55
Min			4	4.6	5.3	1775	7	16	10	0	0.1	0.1	5.2	5.1	0.2	0.1	1333	6
Max			87	7.5	7.1	2083	28	84	126	41	0.5	0.3	26.3	26.0	18.1	6.9	1571	57
Avg			32	5.7	6.1	1943	18	51	63	14	0.3	0.1	20.3	19.5	9.9	2.9	1448	35
Range			83	3.0	1.8	308	21	68	116	41	0.3	0.3	21.1	20.9	17.9	6.7	238	51

Description: A/C Vertical Flow Pond North; Receives influent from A/C; Sampled at effluent riser pipes

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
ACVFPS	3/23/01	Bucket	65	5.0				11										
ACVFPS	4/16/01	Bucket	45	5.0	4.7	1792	14		3	128	0.8	0.6	29.6	26.9	48.5	20.7	1448	32
ACVFPS	8/7/01	Bucket	39	6.9	7.1	2306	20		245	0	0.1	0.1	7.3	1.5	0.3	0.2	1437	8
ACVFPS	9/21/01	Bucket	10	6.8	6.9	2141	20		140	0	0.4	0.1	10.4	10.0	1.2	0.2	1451	6
ACVFPS	3/8/02	Bucket	19	6.3	7.1	2210			130	0	0.3	0.3	11.0	10.1	9.8	1.0	1516	37
ACVFPS	3/8/02	Bucket	21	5.1	4.8	1975			4	57	0.8	0.7	19.3	19.2	23.4	10.1	1336	23
ACVFPS	5/2/02	Bucket	99	4.3				54										
ACVFPS	7/1/02	Bucket	24	4.7				37										
ACVFPS	7/2/02	Bucket	30	6.0				116										
ACVFPS	8/9/02	Bucket		5.1				111										
ACVFPS	8/19/02	Bucket	3	6.5				205										
ACVFPS	8/22/02	Bucket	14	5.3				95										
ACVFPS	12/30/02	Assumed	32		5.7	1824			21	13	0.4	0.3	17.4	16.9	16.0	3.5	1226	45
Min			3	4.3	4.7	1792	14	11	3	0	0.1	0.1	7.3	1.5	0.3	0.2	1226	6
Max			99	6.9	7.1	2306	20	205	245	128	0.8	0.7	29.6	26.9	48.5	20.7	1516	45
Avg			33	5.6	6.0	2041	18	90	91	33	0.4	0.3	15.8	14.1	16.5	5.9	1402	25
Range			96	2.6	2.4	514	6	194	242	128	0.7	0.6	22.3	25.4	48.3	20.5	290	39

Description: A/C Vertical Flow Pond South; Receives influent from A/C; Sampled at effluent riser pipes

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
ACSP/WL	3/23/01			6.5	6.5	1710	7		19	0	0.8	0.7	27.9	27.5	4.9	0.3	1688	19
ACSP/WL	4/16/01			6.0	5.9	1662	15		9	52	0.6	0.6	31.6	26.3	3.4	0.3	1584	15
ACSP/WL	7/8/01			4.5	4.4	1140	31		0	47	0.7	0.5	15.6	15.1	5.6	5.4	752	7
ACSP/WL	8/7/01			7.5	7.2	2023	29		79	0	0.1	0.1	14.8	14.8	0.4	0.2	1712	7
ACSP/WL	9/21/01			6.8	6.4	2012	22		28	0	0.3	0.1	2.7	2.3	0.2	0.2	1391	2
ACSP/WL	12/14/01			6.9	7.1	2179	10		70	0	0.1	0.1	2.3	2.1	0.0	0.0	1597	10
ACSP/WL	3/8/02			6.4	7.0	2072	13		29	0	0.3	0.2	12.0	11.3	0.6	0.3	1405	4
ACSP/WL	5/2/02			4.6	4.5	1736	18		1	1	0.7	0.6	24.0	23.8	17.3	13.9	1082	10
ACSP/WL	12/30/02			6.0	6.3	1820	4		16	2	0.5	0.4	19.8	18.7	3.3	0.4	754	20
Min				4.5	4.4	1140	4		0	0	0.1	0.1	2.3	2.1	0.0	0.0	752	2
Max				7.5	7.2	2179	31		79	52	0.8	0.7	31.6	27.5	17.3	13.9	1712	20
Avg				6.1	6.1	1817	17		28	11	0.5	0.4	16.7	15.8	4.0	2.3	1329	10
Range				3.0	2.7	1039	27		79	52	0.6	0.6	29.3	25.4	17.3	13.9	960	18

Description: A/C Settling Pond/Wetland; Receives influent flow from the A/C Vertical Flow Ponds North and South; Sampled at the effluent spillway

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
ACWL	3/23/01			6.7	6.4	1688	9		14	4	3.4	2.9	27.6	27.2	5.3	0.2	1597	27
ACWL	4/16/01			6.4	5.7	1781	15		5	54	3.1	3.0	27.2	25.7	2.4	0.1	1651	10
ACWL	7/8/01			4.5	3.2	1236	25		0	161	6.1	5.5	16.4	16.4	13.8	12.6	725	6
ACWL	8/7/01			4.5	3.8	1890	28		0	48	0.6	0.3	15.7	15.4	1.0	0.9	1542	4
ACWL	8/23/01			5.9	5.9	1731	22		8	4	0.2		10.7		0.3		1506	4
ACWL	9/21/01			4.7	3.9	1747	20		0	29	0.6	0.6	7.9	7.8	0.9	0.7	1204	2
ACWL	12/14/01	Bucket	27	7.0	6.4	1887	11		13	0	1.2	0.8	2.8	2.7	2.0	1.9	1351	4
ACWL	3/8/02	Bucket	38	6.3	6.4	2003	14		7	0	1.9	1.9	11.5	11.5	0.2	0.1	1240	3
ACWL	5/2/02	Bucket	150	4.8	4.5	1580	18		0	81	1.4	1.3	21.6	21.5	11.8	11.7	916	1
ACWL	12/30/02			6.6	6.2	1775	4		8	8	3.8	3.0	18.7	18.5	1.6	0.2	936	10
Min			27	4.5	3.2	1236	4		0	0	0.2	0.3	2.8	2.7	0.2	0.1	725	1
Max			150	7.0	6.4	2003	28		14	161	6.1	5.5	27.6	27.2	13.8	12.6	1651	27
Avg			72	5.7	5.2	1732	17		6	39	2.2	2.1	16.0	16.3	3.9	3.2	1267	7
Range			123	2.5	3.1	767	24		14	161	5.9	5.2	24.8	24.5	13.6	12.5	926	26

Description: A/C Wetland; Receives influent from the ACSP/WL effluent; Effluent of the A/C Wetland can be either discharged into Laurel Run or diverted into the B1WL1; 7/8/01 & 8/7/01 reflects quality of encountered seep not effluent quality

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
ACWL SEEP	12/14/01	Measured	1	4.8	4.2	1404			0	320	145.0	128.5	21.3	20.6	0.4	0.1	945	4
Min			1	4.8	4.2	1404			0	320	145.0	128.5	21.3	20.6	0.4	0.1	945	4
Max			1	4.8	4.2	1404			0	320	145.0	128.5	21.3	20.6	0.4	0.1	945	4
Avg			1	4.8	4.2	1404			0	320	145.0	128.5	21.3	20.6	0.4	0.1	945	4
Range			0	0.0	0.0	0			0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0

Description: Untreated seep encountered in the ACWL

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1VFP	4/16/01	Bucket	8	11.9	11.0	1861	14		139	0	3.5	0.1	1.5	0.0	0.3	0.1	1164	18
B1VFP	7/8/01	Bucket	2	10.0	11.5	2100	23		280	0	0.1	0.1	0.0	0.0	0.2	0.2	849	11
B1VFP	8/7/01				10.3	1752	24		99	0	0.5	0.2	0.6	0.1	0.3	0.3	1166	24
B1VFP	9/21/01	Bucket	14	10.0	9.1	1921	21		37	0	0.1	0.1	0.1	0.0	0.2	0.1	1444	5
B1VFP	3/8/02	Bucket	3	11.5	10.0	1740	8		63	0	0.2	0.1	0.0	0.0	0.0	0.0	1047	24
B1VFP	12/30/02	Bucket	13	8.5	8.1	1811	4		30	-21	0.1	0.1	1.2	1.2	0.1	0.1	857	9
Min			2	8.5	8.1	1740	4		30	-21	0.1	0.1	0.0	0.0	0.0	0.0	849	5
Max			14	11.9	11.5	2100	24		280	0	3.5	0.2	1.5	1.2	0.3	0.3	1444	24
Avg			8	10.4	10.0	1864	16		108	-3	0.7	0.1	0.6	0.2	0.2	0.1	1088	15
Range			12	3.4	3.4	360	20		250	21	3.4	0.2	1.5	1.2	0.3	0.3	595	19

Description: B1 Vertical Flow Pond is a Slag Only Vertical Flow Pond; Influent is received from a portion of the ACSP/WL effluent discharge; Sampled at the effluent riser pipes

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1 DEP	1/27/95	Measured	23															
B1 DEP	3/23/95	Measured	21		5.7				42	222	108.0		16.2		0.8		571	4
B1 DEP	4/20/95	Measured	21															
B1 DEP	6/29/95	Measured	19		5.6				26	172	120.0		14.9				692	20
B1 DEP	8/30/95	Measured	13		3.0				0	344	98.5		25.2		5.1		775	8
B1 DEP	9/25/95	Measured	13		6.0				62	274							561	4
B1 DEP	10/25/95	Measured	13	6.0					68	224	121.0		13.8				611	6
B1 DEP	12/20/95	Estimated	15		3.3				0	238	46.2		17.3		7.8		589	
B1 DEP	3/26/96	Measured	17															
B1 DEP	4/29/96	Measured	22															
B1 DEP	5/29/96	Measured	7		3.0				0	194	33.2		14.6		3.8		514	
B1 DEP	7/29/96				3.9				0	172	74.7		19.0		1.2		2772	8
B1 DEP	9/20/96	Estimated	20		3.1				0	458	154.0		23.2		3.3		1023	20
B1 DEP	10/30/96	Measured	19															
B1 DEP	11/21/96	Estimated	20															
B1 DEP	12/12/96	Measured	32		3.2				0	422	142.0		23.5		4.4		975	6
B1 DEP	1/29/97	Measured	29		3.6				0	464	167.0		22.8		3.7		994	
B1 DEP	9/23/98				3.2				0	360	155.0		22.2		2.6		864	
Min			7	6.0	3.0				0	172	33.2		13.8		0.8		514	4
Max			32	6.0	6.0				68	464	167.0		25.2		7.8		2772	20
Avg			19	6.0	4.0				17	295	110.9		19.3		3.6		912	10
Range			25	0.0	3.0				68	292	133.8		11.4		7.0		2258	16

Description: DEP B1 sample

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1 Actively Treated	3/30/00	Weir	23	7.8	8.3	1802	14		350	0	17.1		5.3		0.9		750	14
B1 Actively Treated	4/28/00	Weir	26	7.3	7.2	1428	17		132	0	53.1		13.9		2.3		740	44
Min			23	7.3	7.2	1428	14		132	0	17.1		5.3		0.9		740	14
Max			26	7.8	8.3	1802	17		350	0	53.1		13.9		2.3		750	44
Avg			24	7.6	7.7	1615	16		241	0	35.1		9.6		1.6		745	29
Range			3	0.5	1.1	374	3		218	0	36.0		8.6		1.4		10	30

Description: Effluent of the abandoned mine discharge B1 after being treated actively with Soda Ash Briquettes;

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1	1/23/01			4.5	3.3	1272	6		0	217	49.5	44.3	21.8	21.5	10.2	9.9	688	4
B1	3/23/01			4.7	3.3	1185	7		0	213	37.2	36.2	19.0	18.0	11.4	10.3	897	3
B1	4/16/01			3.5	3.3	1189	10			209	34.3	32.8	18.9	17.8	9.0	8.5	720	7
B1	7/8/01	Bucket	5	4.5	3.0	1433	16		0	240	54.0	53.8	19.9	19.2	8.4	7.6	854	16
B1	8/7/01	Bucket	5	4.5	3.0	1510	18		0	277	67.8	67.0	25.0	24.5	7.3	7.2	849	1
B1	9/21/01	Bucket	2	4.7	3.1	1407	16		0	242	77.8	63.0	97.8	49.8	5.9	5.2	755	4
B1	3/8/02			4.5	2.8	1665	16		0	214	76.7	75.3	19.5	16.9	2.7	2.0	744	21
B1	12/30/02			4.0	3.2	1429	2		0	244	95.9	95.1	20.5	20.3	3.0	3.0	683	20
Min			2	3.5	2.8	1185	2		0	209	34.3	32.8	18.9	16.9	2.7	2.0	683	1
Max			5	4.7	3.3	1665	18		0	277	95.9	95.1	97.8	49.8	11.4	10.3	897	21
Avg			4	4.4	3.1	1386	11		0	232	61.6	58.4	30.3	23.5	7.2	6.7	774	10
Range			3	1.2	0.5	480	16		0	68	61.7	62.3	78.9	32.8	8.8	8.3	214	20

Description: Mine discharge B1 formerly treated actively with Soda Ash Briquettes; Collected by a subsurface anoxic collection system; Sampled at the spillway before i mixing with B1VFP effluent and entering B1SP

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1SP	1/23/01			4.4	3.3	1264	4		0	263	93.3	87.3	19.7	19.4	4.2	1.0	695	4
B1SP	3/23/01			4.9	4.4	1143	7		0	157	38.9	35.0	14.3	13.7	3.2	2.9	1024	5
B1SP	4/16/01			4.1	4.1	1171	14		0	159	53.3	42.3	14.4	13.9	3.2	3.0	982	6
B1SP	7/8/01			4.6	3.0	1400	25		0	177	20.1	18.9	15.0	14.6	3.3	3.3	682	3
B1SP	8/7/01			4.5	3.0	1636	27		0	146	27.1	17.3	13.7	13.1	2.3	2.0	885	4
B1SP	9/21/01			4.7	3.1	1700	21		0	137	32.8	29.0	10.0	9.7	1.7	1.7	755	1
B1SP	3/8/02			3.3	3.0	1465	10		0	255	92.5	91.4	16.9	16.6	2.7	2.6	861	9
B1SP	12/30/02			4.0	3.5	1517	4		0	142	52.3	50.8	13.3	13.1	2.4	2.4	899	12
Min				3.3	3.0	1143	4		0	137	20.1	17.3	10.0	9.7	1.7	1.0	682	1
Max				4.9	4.4	1700	27		0	263	93.3	91.4	19.7	19.4	4.2	3.3	1024	12
Avg				4.3	3.4	1412	14		0	179	51.3	46.5	14.6	14.2	2.9	2.3	848	6
Range				1.7	1.4	557	23		0	127	73.2	74.1	9.7	9.8	2.5	2.2	341	11

Description: B1 Settling Pond; Receives influent from the B1 discharge that has mixed with the B1VFP effluent; Sampled at the effluent spillway

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1WL1	1/23/01			4.7	3.3	1118	0		0	196	54.8	51.8	17.8	17.7	4.8	4.7	641	8
B1WL1	3/23/01			4.4	3.7	1166	10		0	135	30.8	29.1	15.6	13.6	3.5	3.3	1060	3
B1WL1	4/16/01			3.6	3.6	1163	13		0	144	29.5	28.1	14.5	14.4	3.3	3.2	944	6
B1WL1	7/8/01			4.3	3.0	1344	29		0	157	9.2	8.6	19.9	15.8	4.6	4.2	711	6
B1WL1	9/21/01			4.5	3.1	1736	25		0	117	12.1	11.1	10.0	9.8	2.0	1.9	920	2
B1WL1	3/8/02			3.0	2.8	1533	17		0	223	44.5	43.7	16.6	15.6	3.0	2.7	758	3
B1WL1	12/30/02			4.4	3.4	1515	1		0	134	37.6	37.1	13.3	13.2	2.4	2.3	712	8
Min				3.0	2.8	1118	0		0	117	9.2	8.6	10.0	9.8	2.0	1.9	641	2
Max				4.7	3.7	1736	29		0	223	54.8	51.8	19.9	17.7	4.8	4.7	1060	8
Avg				4.1	3.3	1368	14		0	158	31.2	29.9	15.4	14.3	3.4	3.2	821	5
Range				1.7	0.9	618	29		0	106	45.6	43.1	10.0	7.9	2.8	2.8	419	6

Description: B1 Wetland 1; Receives influent from B1SP and discharges into B1WL2; Sampled at effluent spillway

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1WL3	1/23/01			4.6	3.4	1100	0		0	197	57.5	49.8	18.1	17.9	4.7	4.6	692	12
B1WL3	3/23/01			4.5	3.6	1160	9		0	183	25.7	25.6	14.2	14.0	3.6	3.5	965	5
B1WL3	4/16/01			3.6	3.6	1061	15		0	116	21.1	20.1	13.5	13.0	3.6	3.2	766	7
B1WL3	7/8/01			4.0	3.1	1245	20		0	137	7.8	7.4	14.9	14.5	4.9	4.6	568	1
B1WL3	8/7/01			4.5	3.1	1565	28		0	128	6.0	5.7	14.3	13.5	3.4	3.3	885	1
B1WL3	9/21/01			4.7	3.2	1542	20		0	115	11.0	11.0	10.1	9.8	2.1	1.8	823	3
B1WL3	3/8/02	Bucket	27	3.0	3.0	1426	10		0	183	38.2	37.4	17.3	15.6	3.2	2.5	648	5
B1WL3	12/30/02			4.4	3.4	1447	1		0	123	30.3	23.5	13.1	13.1	2.9	2.7	890	8
Min			27	3.0	3.0	1061	0		0	115	6.0	5.7	10.1	9.8	2.1	1.8	568	1
Max			27	4.7	3.6	1565	28		0	197	57.5	49.8	18.1	17.9	4.9	4.6	965	12
Avg			27	4.2	3.3	1318	13		0	148	24.7	22.6	14.4	13.9	3.5	3.3	779	5
Range			0	1.7	0.6	504	28		0	82	51.5	44.1	7.9	8.1	2.8	2.8	397	11

Description: B1 Wetland 3; Receives influent from B1WL1; Effluent discharges into B1B3VFP; Sampled at effluent spillway

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B3 DEP	6/29/95	Measured	1		3.7				0	68	2.3		12.1		9.1		283	108
B3 DEP	10/25/95	Measured	0		3.8				0	108	0.4		14.5		11.9		401	
B3 DEP	3/26/96	Measured	10		4.0				2	64	0.4		6.3		5.4		171	
B3 DEP	4/29/96	Measured	6		3.7				0	84	0.4		8.9		8.0		291	
B3 DEP	5/29/96	Estimated	55		4.8				8	28	0.7		4.0		2.6		193	
B3 DEP	7/29/96				3.9				0	80	0.5		10.7		9.1		305	
B3 DEP	9/20/96	Measured	2		3.8				0	88	0.6		9.0		8.7		245	
B3 DEP	10/30/96	Measured	3		3.9				0	88	0.7		9.2		8.5		288	
B3 DEP	12/12/96	Measured	17		4.4				7	54	1.9		5.9		7.5		223	42
B3 DEP	1/29/97	Estimated	10	4.2					7	72	0.5		6.9		6.5		249	6
B3 DEP	2/28/97	Measured	2		4.0				3	80	0.3		9.5		8.4		290	
B3 DEP	3/27/98	Estimated	10		4.3				7	30			5.3		3.4		255	
B3 DEP	6/26/98	Measured	2		4.0				2	68	0.4		7.5		5.7		259	
B3 DEP	6/30/98				3.9				0	60	1.1		7.0		5.1		272	
B3 DEP	9/23/98	Measured	1		3.9				0	58	0.6		6.5		5.5		312	
Min			0	4.2	3.7				0	28	0.3		4.0		2.6		171	6
Max			55	4.2	4.8				8	108	2.3		14.5		11.9		401	108
Avg			9	4.2	4.0				2	69	0.8		8.2		7.0		269	52
Range			55	0.0	1.1				8	80	1.9		10.5		9.3		230	102

Description: DEP'S B3 Sampling Point

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B3	3/1/99	Bucket	15	4.3	4.3	590	2		0	40	0.1		6.1		5.1		400	1
B3	3/1/99				4.3	590			0	40	0.1		6.1		5.1		400	1
B3	3/30/00			3.8	4.2	545	7		0	55	0.1		7.6		8.1		280	5
B3	4/28/00			4.3	4.3	557	11		0	54	0.1		7.3		6.8		406	1
Min			15	3.8	4.2	545	2		0	40	0.1		6.1		5.1		280	1
Max			15	4.3	4.3	590	11		0	55	0.1		7.6		8.1		406	5
Avg			15	4.1	4.3	571	7		0	47	0.1		6.8		6.3		371	2
Range			0	0.5	0.1	45	9		0	15	0.0		1.5		3.0		126	4

Description: Raw abandoned mine discharge B3 was not treated previously; Collected by an Open Limestone Channel and discharged into B3 Settling Pond;

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
MW6	3/1/99		2	4.0	3.7	1562	10		0	342	56.0		34.2		31.0		1334	1
MW6	3/1/99				3.7	1562			0	342	56.0		34.2		31.0		1334	1
MW6	4/26/00			3.5	3.6	1421	11		0	297	48.9		28.7		25.3		2628	
MW6	6/21/00				3.3	1461			0	285	43.4		25.8		4.3		884	8
MW6	6/26/00	Bucket	0	4.4	3.3	1560	13		0	287	36.3		25.2		22.7		1052	12
MW6	8/25/00		0	4.2	3.1	1707	18		0	259	41.5	21.1	23.2	23.0	20.6	19.0	1080	15
Min			0	3.5	3.1	1421	10		0	259	36.3	21.1	23.2	23.0	4.3	19.0	884	1
Max			2	4.4	3.7	1707	18		0	342	56.0	21.1	34.2	23.0	31.0	19.0	2628	15
Avg			1	4.0	3.4	1546	13		0	302	47.0	21.1	28.5	23.0	22.5	19.0	1386	7
Range			2	0.9	0.6	286	8		0	83	19.7	0.0	11.0	0.0	26.7	0.0	1744	14

Description: Monitoring Well 6; Collected in OLC; part of B3 discharge

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
MW-E	4/26/00			3.6	3.7	533	10		0	72	0.1		5.7		7.4		215	3
MW-E	6/26/00			4.4	3.7	717	11		0	100	0.3		8.4		11.0		427	3
MW-E	3/23/01	Bucket	25	4.1	3.7	560	10		0	80	0.2	0.2	6.3	6.3	9.6	8.5	419	2
MW-E	4/16/01	Cross-section	35	3.8	3.7	538	10		0	82	0.1	0.1	6.2	6.0	9.2	7.8	271	5
Min			25	3.6	3.7	533	10		0	72	0.1	0.1	5.7	6.0	7.4	7.8	215	2
Max			35	4.4	3.7	717	11		0	100	0.3	0.2	8.4	6.3	11.0	8.5	427	5
Avg			30	4.0	3.7	587	10		0	84	0.2	0.2	6.6	6.1	9.3	8.1	333	3
Range			10	0.8	0.1	184	1		0	28	0.1	0.0	2.6	0.3	3.7	0.8	213	3

Description: Monitoring Well E; Collected in OLC, part of B3 discharge

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B3SP	1/23/01	Bucket	1	6.7	6.5	716	1		19	0	3.9	0.1	12.9	5.6	3.9	0.2	394	3
B3SP	3/23/01	Bucket	1	6.7	7.0	434	8		18	0	0.1	0.0	3.1	3.1	0.4	0.3	281	10
B3SP	4/16/01	Bucket	150	4.9	4.6	469	13		2	43	0.1	0.1	4.7	4.6	6.1	5.6	249	6
B3SP	7/8/01	Bucket	10	6.5	6.4	455	18		19	0	0.6	0.2	2.7	2.6	2.0	0.7	237	62
B3SP	8/7/01	NO FLOW																
B3SP	9/21/01	Bucket	1	6.8	6.7	370	20		22	0	3.6	0.1	1.9	1.9	0.3	0.1	150	5
B3SP	3/8/02	Bucket	0	6.0	6.8	345	6		53	0	0.4	0.3	0.2	0.0	0.5	0.2	116	12
B3SP	12/30/02	Estimated	3	5.0	4.7	770	1		2	42	0.1	0.1	7.6	7.5	7.9	7.1	449	7
Min			0	4.9	4.6	345	1		2	0	0.1	0.0	0.2	0.0	0.3	0.1	116	3
Max			150	6.8	7.0	770	20		53	43	3.9	0.3	12.9	7.5	7.9	7.1	449	62
Avg			24	6.1	6.1	508	10		19	12	1.3	0.1	4.7	3.6	3.0	2.0	268	15
Range			150	1.9	2.4	425	19		52	43	3.8	0.3	12.6	7.5	7.5	6.9	333	59

Description: B3 Settling Pond; Receives influent from the OLC which collects the B3 discharge; Effluent is conveyed by pipe to B1B3VFP; Sampled at effluent discharge pipe

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1B3VFP	1/23/01			7.1	7.0	994	1		65	0	2.3	2.1	15.2	14.7	0.2	0.1	608	15
B1B3VFP	4/16/01			6.0	6.2	774	14		17	0	4.4	4.0	7.7	7.5	0.8	0.6	568	7
B1B3VFP	7/8/01	Bucket	39	6.0	6.5	791	24		41	0	4.1	3.6	8.0	8.0	1.0	0.2	499	8
B1B3VFP	8/7/01	Bucket	31	6.5	6.5	1301	25		68	0	8.0	4.5	12.3	11.9	2.0	1.7	798	8
B1B3VFP	9/21/01	Bucket	38	6.8	6.6	1234	20		51	0	2.2	1.3	7.8	7.6	0.4	0.1	733	1
B1B3VFP	3/8/02	Bucket	32	5.4	6.7	1140	5		42	0	7.3	5.3	10.2	10.2	0.8	0.4	678	7
B1B3VFP	12/30/02	Bucket	42	6.2	6.5	1320	2		38	-19	3.7	1.3	5.6	5.3	0.9	0.4	754	8
Min			31	5.4	6.2	774	1		17	-19	2.2	1.3	5.6	5.3	0.2	0.1	499	1
Max			42	7.1	7.0	1320	25		68	0	8.0	5.3	15.2	14.7	2.0	1.7	798	15
Avg			36	6.3	6.6	1079	13		46	-3	4.6	3.1	9.5	9.3	0.9	0.5	663	8
Range			11	1.7	0.8	546	24		51	19	5.7	4.0	9.6	9.4	1.8	1.5	299	14

Description: B1B3 Vertical Flow Pond; Receives influent from the B1WL2 and the B3 Settling Pond; Effluent discharges into B1B3SP/WL; Sampled at the effluent discharge pipes

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1B3SP/WL	1/23/01			6.9	6.7	939	0		48	0	5.8	4.9	13.6	13.3	0.3	0.2	560	15
B1B3SP/WL	3/23/01			6.8	7.0	914	12	21	20	0	3.1	2.3	11.6	11.1	0.3	0.2	757	6
B1B3SP/WL	4/16/01			6.5	6.2	846	16		17	1	3.8	2.5	8.1	8.0	0.5	0.0	614	6
B1B3SP/WL	7/8/01			6.5	6.3	728	30		9	0	0.7	0.3	5.9	5.9	0.1	0.1	432	4
B1B3SP/WL	8/7/01			6.6	6.6	1270	32		52	0	0.6	0.2	10.2	9.7	0.2	0.0	776	4
B1B3SP/WL	9/21/01			7.1	6.7	1295	25		24	0	1.7	0.2	7.9	7.4	0.2	0.1	883	1
B1B3SP/WL	3/8/02			6.6	6.7	1094	14		22	0	5.7	5.0	10.7	10.6	0.3	0.2	637	5
B1B3SP/WL	12/30/02			6.4	6.6	1301	2		25	-12	3.2	2.8	5.7	5.7	0.2	0.1	704	4
Min				6.4	6.2	728	0	21	9	-12	0.6	0.2	5.7	5.7	0.1	0.0	432	1
Max				7.1	7.0	1301	32	21	52	1	5.8	5.0	13.6	13.3	0.5	0.2	883	15
Avg				6.7	6.6	1048	16	21	27	-1	3.1	2.3	9.2	8.9	0.3	0.1	670	6
Range				0.7	0.8	573	32	0	42	13	5.3	4.8	7.8	7.7	0.4	0.2	451	14

Description: B1B3 Settling Pond/ Wetland; Receives influent from B1B3VFP and discharges into B1B3HFLB; Sampled at effluent spillway

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
B1B3 HFLB	1/23/01			7.0	7.1	950	1		73	0	0.3	0.1	13.3	12.8	0.1	0.1	563	8
B1B3 HFLB	3/23/01	Bucket	47	7.0	7.3	941	5	53	49	4	0.1	0.0	9.6	8.8	0.1	0.1	770	3
B1B3 HFLB	4/16/01	Bucket	188	7.0	6.4	878	13		40	0	0.1	0.1	6.6	6.4	0.2	0.0	616	8
B1B3 HFLB	7/8/01	Bucket	23	7.3	7.2	776	23		70	0	0.1	0.1	0.3	0.3	0.1	0.1	429	4
B1B3 HFLB	8/7/01	Bucket	13	7.3	7.2	1301	24		105	0	0.1	0.0	0.4	0.4	0.1	0.1	791	2
B1B3 HFLB	9/21/01	Bucket	18	7.4	7.5	1380	20		78	0	0.0	0.0	0.0	0.0	0.1	0.1	860	2
B1B3 HFLB	1/3/02				6.8	1549			80				0.1	0.0			860	
B1B3 HFLB	3/8/02	Bucket	12	7.5	7.8	1145	4		81	0	0.1	0.1	0.0	0.0	0.2	0.1	595	1
B1B3 HFLB	12/30/02	Bucket	43	6.9	7.0	1302	2		51	-42	0.1	0.0	0.4	0.4	0.0	0.0	629	5
Min			12	6.9	6.4	776	1	53	40	-42	0.0	0.0	0.0	0.0	0.0	0.0	429	1
Max			188	7.5	7.8	1549	24	53	105	4	0.3	0.1	13.3	12.8	0.2	0.1	860	8
Avg			49	7.2	7.1	1136	12	53	70	-5	0.1	0.0	3.4	3.2	0.1	0.1	679	4
Range			176	0.6	1.4	773	23	0	65	46	0.2	0.1	13.3	12.8	0.2	0.1	431	7

Description: B1B3 Horizontal Flow Limestone Bed; Receives influent from the B1B3 SP/WL; Final Effluent for the B1 and B3 discharges and can be the Final Effluent for the A/C discharge as well; Sampled from effluent discharge pipe

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
LR ABOVE TRIB C	12/17/99			6.5	6.9	138	4		13	0	0.3		0.6		0.4		44	5
LR ABOVE TRIB C	12/17/99				6.6				20	0	0.0		0.6		0.0		38	0
LR ABOVE TRIB C	1/25/00				6.7				24	0	0.9		2.3		0.5		102	0
LR ABOVE TRIB C	3/30/00			7.1	6.9	227	10		14	0	0.3		1.6		0.4		74	6
LR ABOVE TRIB C	4/28/00			7.1	7.3	236	13		17	0	0.4		1.9		0.5		80	7
LR ABOVE TRIB C	6/8/00			7.2	7.2	168	13		19	0	0.2		3.2		0.3		42	1
LR ABOVE TRIB C	6/21/00			7.5	7.0	406			25	0	1.5		3.5		0.9		213	1
LR ABOVE TRIB C	6/21/00			7.5	7.1	359			25	0	0.9		3.3		0.2		154	3
LR ABOVE TRIB C	10/24/00			6.9	7.1	291	11		24	0	0.5		2.3		0.1		127	16
LR ABOVE TRIB C	1/23/01			7.0	6.7	194	0		15	0	0.5	0.4	1.4	1.3	0.6	0.4	72	8
LR ABOVE TRIB C	7/8/01			7.2	6.6	252	17		25	0	0.5	0.2	2.1	2.0	0.6	0.2	112	7
LR ABOVE TRIB C	8/7/01			7.3	6.6	366	20		24	0	1.3	0.1	3.2	3.1	0.8	0.0	186	3
LR ABOVE TRIB C	9/21/01			7.0							1.2		3.4		0.5			
LR ABOVE TRIB C	12/30/02			6.7	6.6	208	3		12	-3	0.5	0.4	1.8	1.7	1.0	0.1	75	14
Min				6.5	6.6	138	0		12	-3	0.0	0.1	0.6	1.3	0.0	0.0	38	0
Max				7.5	7.3	406	20		25	0	1.5	0.4	3.5	3.1	1.0	0.4	213	16
Avg				7.1	6.9	259	10		20	0	0.6	0.3	2.2	2.0	0.5	0.2	102	5
Range				1.0	0.7	268	20		14	3	1.5	0.3	2.9	1.8	1.0	0.4	176	16

Description: Laurel Run; Sampling Point located above the confluence with Tributary C; Upstream of passive treatment systems, LR BELOW TRIB C, and LR BELOW B3

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
LR BELOW TRIB C	12/17/99				6.6				19	0	0.0		0.7		0.0		41	0
LR BELOW TRIB C	12/17/99			6.8	6.8	150	4		13	0	0.3		0.7		0.4		51	7
LR BELOW TRIB C	1/25/00				6.7				24	0	0.9		2.6		0.5		143	0
LR BELOW TRIB C	3/30/00			7.0	6.9	254	10		13	0	0.5		2.1		0.9		95	6
LR BELOW TRIB C	4/28/00			6.7	6.9	263	13		13	0	0.4		2.1		0.8		89	5
LR BELOW TRIB C	6/8/00			7.3	6.7	183	14		15	0	1.0		1.3		0.7		50	2
LR BELOW TRIB C	6/21/00				7.0	388			26	0	1.1		3.3		0.2		184	5
LR BELOW TRIB C	10/24/00			7.0	7.1	470	11		24	0	0.6		3.7		0.1		193	10
LR BELOW TRIB C	3/23/01			5.5	5.4	283	6		3	8	0.3	0.3	2.9	2.6	2.5	2.2	191	13
LR BELOW TRIB C	7/8/01			6.5	6.5	332	18		16	0	0.8	0.4	2.7	2.7	0.8	0.1	176	10
LR BELOW TRIB C	8/7/01			6.9	6.6	426	20		24	0	1.3	0.1	3.4	3.2	0.9	0.0	193	1
LR BELOW TRIB C	9/21/01			6.9	6.6	433	16		21	0	1.2	0.7	4.4	3.6	0.6	0.1	208	1
LR BELOW TRIB C	3/8/02			6.5	6.9	230	8		16	0	0.6	0.5	1.5	1.5	0.5	0.3	84	3
LR BELOW TRIB C	5/2/02			6.7	6.4	159	15		10	0	0.3	0.3	1.3	1.2	0.8	0.1	58	2
LR BELOW TRIB C	12/30/02			6.6	6.6	234	3		12	-2	0.6	0.5	2.0	1.9	1.0	0.1	99	9
Min				5.5	5.4	150	3		3	-2	0.0	0.1	0.7	1.2	0.0	0.0	41	0
Max				7.3	7.1	470	20		26	8	1.3	0.7	4.4	3.6	2.5	2.2	208	13
Avg				6.7	6.7	293	12		17	0	0.7	0.4	2.3	2.4	0.7	0.4	124	5
Range				1.8	1.7	320	17		23	11	1.3	0.6	3.7	2.4	2.5	2.2	167	13

Description: Laurel Run; Sampling Point located downstream below the confluence of Tributary C; Upstream of passive treatment system effluent and LR Below B3

Harbison Walker II Water Quality Database

Sample Point	Date	Method of Flow Meas.	Flow (gpm)	Field pH	Lab pH	Spec. cond. (umhos/cm)	Field Temp (C)	Alk. (F) (mg/L)	Alk. (L) (mg/L)	Acid. (mg/L)	T. Fe (mg/L)	D. Fe (mg/L)	T. Mn (mg/L)	D. Mn (mg/L)	T. Al (mg/L)	D. Al (mg/L)	Sulfate (mg/L)	Susp. Solids (mg/L)
LR BELOW B3	3/30/00			6.7	6.6	312	9		10	3	0.7		2.9		1.6		120	7
LR BELOW B3	4/28/00			6.8	6.9	326	13		17	0	0.8		3.0		1.9		141	0
LR BELOW B3	10/24/00			7.0	7.1	408	11		23	0	1.2	0.9	3.2	3.2	0.5	0.2	144	4
LR BELOW B3	1/23/01			7.0	6.7	200	0		15	0	0.6	0.4	1.4	1.3	0.5	0.1	70	7
LR BELOW B3	3/23/01			6.7	6.8	305	6		13	0	0.5	0.2	2.5	2.5	1.6	0.2	187	8
LR BELOW B3	7/8/01			7.6	7.4	470	15		56	0	1.3	0.1	3.4	2.8	3.0	0.3	228	7
LR BELOW B3	8/7/01			7.1	6.7	488	20		26	0	0.5	0.2	2.9	2.8	0.4	0.2	235	4
LR BELOW B3	9/21/01			7.2	6.6	515	16		23	0	1.2	0.6	3.1	3.0	0.3	0.1	250	1
LR BELOW B3	3/8/02			6.8	6.9	285	6		16	0	0.7	0.6	1.7	1.6	0.5	0.0	116	4
LR BELOW B3	12/30/02			7.0	6.8	358	2		16	-6	0.8	0.7	3.1	3.0	1.4	0.9	170	7
Min				6.7	6.6	200	0		10	-6	0.5	0.1	1.4	1.3	0.3	0.0	70	0
Max				7.6	7.4	515	20		56	3	1.3	0.9	3.4	3.2	3.0	0.9	250	8
Avg				7.0	6.8	367	10		22	0	0.8	0.5	2.7	2.5	1.2	0.2	166	5
Range				0.9	0.8	315	20		46	8	0.8	0.8	2.1	1.9	2.7	0.9	180	8

Description: Laurel Run; Sampling point located downstream of discharges and the passive system effluent

Dissolved Oxygen Readings for Harbison Walker Phase II Passive Treatment System

Sampling Point	% DO	Mg/L DO	Temp. C
June 6, 2002 Air Temperature: 36.3 C			
AC	76.5	7.45	23.0
ACVFP	31.2	2.67	23.2
ACSP/WL	64.7	5.72	22.0
B1VFP	21.0	1.72	25.5
B1WL2	63.2	5.64	21.0
B1B3VFP	25.3	2.07	25.4
B1B3SP/WL	75.0	6.11	25.9
B1B3HFLB	24.0	2.02	24.6
June 26, 2002 Air Temperature: 39.1 C			
AC	62.2	5.56	27.2
ACVFP	55.0	4.40	26.7
ACSP/WL	87.0	6.80	29.3
B1VFP	34.8	2.72	27.9
B1WL2	65.9	4.95	30.3
B1B3VFP	21.4	1.70	27.3
B1B3SP/WL	82.3	6.31	28.8
B1B3HFLB	29.2	2.31	28.0

Sampling Point	% DO	Mg/L DO	Temp. C
July 26, 2002 Air Temperature: 22.0 C			
AC	62.5	6.04	16.9
ACVFP	26.1	2.38	20.0
ACSP/WL	47.3	4.15	21.7
B1VFP	19.4	1.62	24.5
B1WL2	55.1	4.79	22.3
B1B3VFP	35.6	3.01	23.9
B1B3SP/WL	43.2	3.70	23.1
B1B3HFLB	17.4	1.48	23.2
August 9, 2002 Air Temperature: 30.8 C			
AC	66.0	6.14	18.7
ACVFP	20.5	1.82	21.2
ACSP/WL	69.0	6.05	21.9
B1VFP	12.9	1.08	24.6
B1WL2	64.1	5.27	25.3
B1B3VFP	73.3	6.42	21.9
B1B3SP/WL	40.1	3.42	23.3
B1B3HFLB	26.4	2.28	22.5

AN INTEGRATED DESIGN MODEL FOR PASSIVE TREATMENT SYSTEMS TO ABATE WATER POLLUTION FROM POST-MINING DISCHARGES

By
William W. Hellier, P.E.[1]

Abstract

An integrated design model has been developed for passive treatment systems to abate water pollution from post-mining discharges. Vertical flow reactors, aerobic and anaerobic limestone channels, and horizontal flow aerobic and compost reactors were considered and applied to suggest a design to abate water pollution from mine discharges to Laurel Run, a designated high-quality cold water fishery flowing through Ohiopyle State Park in Stewart Township, Fayette County, Pennsylvania. The model predicts long-term generation of an effluent with acceptable quality and estimates the cost of implementation for the various discharges.

Design concept

The purpose of this model is to develop a design for passive treatment systems for the abatement of water pollution from postmining discharges that adversely affect the water quality of Laurel Run, a tributary of Meadow Run, a tributary of the Youghiogheny River, at Ohiopyle State Park in Stewart Township, Fayette County, Pennsylvania. The design features a sequence of some or all of the following passive treatment units: (1) A vertical flow reactor consisting of a biotic aerobic pond underlain by an alkaline organic layer that is underlain by an anoxic limestone bed; (2) a horizontal flow abiotic aerobic settling basin or wetland; (3) an aerobic limestone bed.

The theoretical acidity of mine drainage is given by:

$$\text{Theoretical acidity} = 49.6504 \times 10^{(3-pH)} + 5.5643\,[Al^{3+}] + 2.6883\,[Fe^{3+}] + 1.7922\,[Fe^{2+}] + 1.8219\,[Mn^{2+}] + \varphi$$

Equation 1

Where φ is a function of the concentrations of other metals that might contribute acidity. For the purposes of our model, we shall assume that φ is negligible. The untreated mine discharge is directed into the aerobic pond of the vertical flow reactor, where ferrous iron is biologically oxidized to ferric iron. The ferric iron undergoes hydrolysis to ferrous oxyhydroxide, which is retained in the at the surface of the organic layer at the bottom of the pond. Aluminum and divalent manganese pass do not undergo treatment in the pond. The water then flows through the alkaline organic layer, where dissolved oxygen is removed and carbon dioxide is generated. Any unreacted ferric iron is reduced to ferrous iron. Ferrous iron passes through the organic layer unreacted, as does divalent manganese. Aluminum is retained as aluminum hydroxide. Hydrogen ions react with bicarbonates. The water, whose acidity now consists primarily of divalent iron and manganese acidity, then flows into the anoxic limestone bed, where alkalinity is imparted by dissolution of the limestone.

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The water from the vertical flow reactor is then directed into a horizontal flow aerobic reactor, where ferrous iron is oxidized to ferric iron, which undergoes hydrolysis and settles to the bottom of the reactor, thereby also removing some or all of the bicarbonate ions. If the acidity of the untreated mine water cannot be offset by the alkalinity imparted in the vertical flow reactor, a second, third, or even fourth set of vertical flow and horizontal flow reactors must be included in the system.

The acidity of the water from the final horizontal flow reactor now consists primarily of divalent manganese acidity. The water is directed into a horizontal flow aerobic limestone bed, where the manganese is oxidized to manganese dioxide and retained in the bed. The resulting alkaline water, now free of acidity from aluminum, iron, manganese, and hydrogen ion, is then discharged into the receiving stream. A schematic diagram of the integrated passive treatment system is shown in Figure 1.

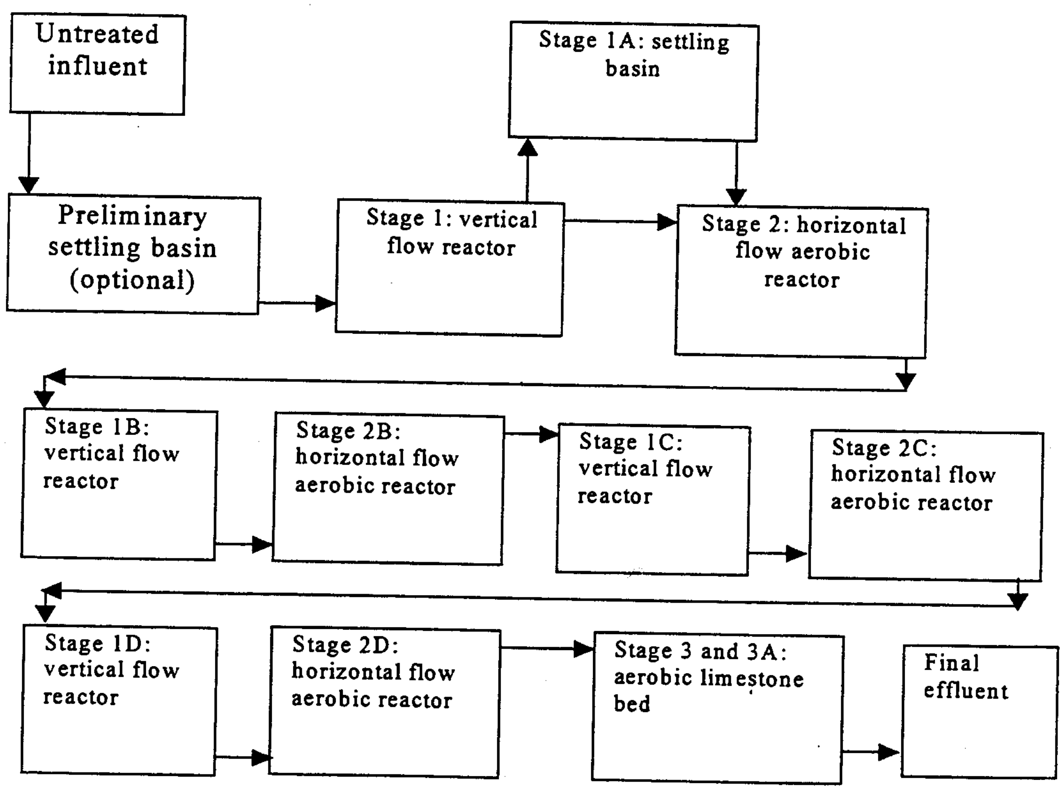

Figure 1: Schematic diagram for a sequential passive treatment system

Chemistry

Vertical flow reactor: Biological oxidation and hydrolysis of ferrous iron

The chemical reactions are:

$$4Fe^{2+} + 4H^+ + O_2 \Leftrightarrow 4Fe^{3+} + 2H_2O$$
$$4Fe^{3+} + 8H_2O \Leftrightarrow 4FeOOH + 12H^+$$

Equation 2

Pesic et al (1989)[1] observed that at pH near 3, oxidation of ferrous iron by bacteria such as *Thiobacillus ferrooxidans* occur at a rate comparable to the abiotic rate of ferrous iron oxidation at pH near 6.2. The proposed biological rate equation (Kirby et al, 1999)[2] is:

$$\partial[Fe^{2+}]/\partial t = - k_{bio}\, C_{bact}\, [Fe^{2+}][O_2][H^+]$$

Equation 3

Where C_{bact} is the concentration of *Thiobacillus ferrooxidans* (mg/L dry weight), $[Fe^{2+}]$ is the concentration of ferrous iron (mol/L), $[O_2]$ is the dissolved oxygen concentration (mol/L), $[H^+]$ is the hydrogen ion concentration (mol/L), and k_{bio} is the rate constant. This rate equation predicts that the rate of biological oxidation is accelerated with decreasing pH. This would suggest that the mechanism of iron removal in either the water column of the vertical flow reactor or in a preceding horizontal flow aerobic reactor under conditions commonly associated with mine drainage consists of a combination of oxidation of Fe^{2+} and hydrolysis of Fe^{3+}. However, as Kirby et al point out, it has proven difficult to measure the effective C_{bact} for purposes of modeling, and further research is necessary. Furthermore, C_{bact} has seldom been measured during routine mine drainage sampling; thus empirical data are lacking. The hydrolysis reaction is essentially instantaneous.

Vertical flow reactor: Removal of dissolved oxygen, reduction of ferric iron, retention of aluminum, and depletion of alkalinity

An example of a reaction that removes dissolved oxygen is is:

$$CH_3CHOHCOOH + O_2 \Leftrightarrow CH_4 + 2CO_2 + H_2O$$

Equation 4

Ferric iron is reduced to ferrous iron. The oxygen is consumed by reactions illustrated by Equation 4. Although some iron may be retained by adsorption at organic sites, at equilibrium ferrous iron passes through the organic layer unreacted: Some temporary adsorption of manganese can occur, but at equilibrium, divalent manganese will also pass through the organic layer unreacted.

$$4Fe^{3+} + 2H_2O \Leftrightarrow 4Fe^{2+} + 4H^+ + O_2$$

Equation 5

Aluminum is hydrolyzed and retained in the organic layer by the nearly instantaneous reaction:

$$Al^{3+} + 3HCO_3^- \Leftrightarrow Al(OH)_3 + 3CO_2$$

Equation 6

Near complete retention of aluminum has been observed during the initial operation of most vertical flow systems. Aluminum retention in the organic layer has been demonstrated by the US Department of Energy (Watzlaf, 1997)[3], and the retention appears to depend on the ability of the organic layer to generate sufficient alkalinity to raise the pH to a level at which aluminum is hydrolyzed. The initial alkalinity and its rate of depletion in the organic layer impose limitations on the retention of aluminum.

Vertical flow reactor: dissolution of limestone

Alkalinity is imparted to the water by dissolution of limestone. Alkalinity is essential for the horizontal flow reactor, next in the sequence, to function. The rate of dissolution is such that a detention time of about 15 hours usually imp[arts the maximum amount of alkalinity.

$$CaCO_3 + H^+ \Leftrightarrow Ca^{2+} + HCO_3^-$$
$$MgCO_3 + H^+ \Leftrightarrow Mg^{2+} + HCO_3^-$$

Equation 7

Horizontal flow aerobic reactor: oxidation of ferrous iron and hydrolysis of ferric iron

The chemical equations are:

$$4Fe^{2+} + 4H^+ + O_2 \Leftrightarrow 4Fe^{3+} + 2H_2O$$
$$Fe^{3+} + 2H_2O \Leftrightarrow FeOOH + 3H^+$$

Equation 8

Refer to Hustwit *et al* (1992)[4], who provide also primary references to Sung and Morgan (1980)[5], Harvard University (1970)[6], and Stumm and Lee (1961)[7].

$$\partial[Fe^{2+}]/\partial t = -k[Fe^{2+}][O_2][H^+]^{-2}$$

Equation 9

wherein all concentrations are expressed in mol/L and the rate "constant" $k = 3 \times 10^{-12}$ mol L^{-1} min^{-1} at T = 20° C. The temperature dependence usually is approximated by an Arrhenius equation. However, for our present purpose, we shall make a first approximation that the water temperature = 20° C. We also shall assume that the contents of the treatment unit are well aerated, so that the dissolved oxygen concentration is essentially constant at its equilibrium solubility of 9.2 mg/L, or 2.875×10^{-4} mol/L (Standard Methods, 1971)[8]. At the pH level encountered in the horizontal flow aerobic reactor that follows a vertical flow reactor, the biological contribution is negligible. The hydrolysis is essentially instantaneous. A practical limitation is placed on the amount of iron than can be removed in the reactor by the inverse dependence of the reaction rate on $[H^+]$. Once the bicarbonate alkalinity has been exhausted, the oxidation reaction will effectively cease, and pH will decline rapidly.

Horizontal flow aerobic limestone bed: oxidation of manganese

The vertical flow reactor and the horizontal flow reactor will have been ineffective in removing manganese, which is removed by the reaction:

$$2Mn^{2+} + O_2 + 4OH^- \Leftrightarrow 2MnO_2 + 2H_2O$$

Equation 10

The oxidation can be approximated by a rate equation such as:

$$\partial[Mn^{2+}]/\partial t = -k[Mn^{2+}][O_2][H^+]^{-2}$$

Equation 11

The half life of the manganese oxidation reaction is 785 minutes at a local pH of 8.09 (Morgan et al., 1985)[9], which we will assume to occur locally at the surfaces of the limestone particles, allowing us to derive the rate constant.

Design

To compensate for non-steady state flow and concentration conditions as well as non-uniform flow, we set the design flow at the 95% upper confidence level, based on empirical data. The design concentrations of aluminum, iron, and manganese are also set at the 95% upper confidence level, while the design influent pH is set at the lower 95% confidence level. A safety factor equal to the mean sulfate concentration divided by the upper 95% sulfate concentration applied to the predicted design volume to arrive at a very conservative final design volume.

Vertical flow reactor

We base our model for the limestone bed on the formula of Hedin and Watzlaf, assume a design life of 25 years, a detention time at the upper confidence level for flow of 15 hours, and an effluent alkalinity of 200 mg/L.

$$M = Q\,\rho_b\,t_d / V_v + Q\,C\,T / x$$

Equation 12

where M is the mass of limestone required (g), Q is the volumetric flow rate of water (m^3/day), ρ_b is the bulk density of limestone (kg/m^3), t_d is the detention time (days), V_v is the bulk void volume fraction, C is the predicted effluent alkalinity concentration (kg/m^3), T is the design life of the drain (days), and x is the $CaCO_3$ fraction for the limestone.

The design depth of the limestone will determine the surface area of the underdrain and of the alkaline anaerobic organic layer. The organic material, typically spent mushroom compost, is supplemented by alkaline material. The available alkalinity is determined empirically from the material to be used. For our model's purposes, we have assigned a value to a hypothetical limestone/mushroom compost mix. The life of the organic layer based on the amount of available carbon will almost always be much greater than 25 years. The needed volume of organic material will be determined by the amount of alkalinity needed to offset the influent hydrogen ion acidity added to the hydrogen ion acidity liberated by the hydrolysis of aluminum for at least 25 years.

The area of the surface water pond will be determined by the area of the organic layer. Usually the depth is set at one meter. To overcome the lack of information needed to apply equation 3 directly, we assume that the detention time is sufficient that 30% of the influent iron present is retained as ferric iron in the pond. The remainder passes into the horizontal flow aerobic reactor. The final area of the vertical flow reactor is determined by designing a one-half meter freeboard above the water surface.

Horizontal flow aerobic reactor

Equation 9 is used to design the horizontal flow aerobic reactor. If possible, the final design effluent iron concentration is set at 1 mg/L. However, the design influent alkalinity of 200 mg/L imposes a limit of 111.59 mg/L on the amount of iron that can possibly be removed. If the influent iron concentration minus 111.59 exceeds desired effluent limits, it is necessary to design a downstream vertical flow reactor to impart more alkalinity, followed by a downstream horizontal flow aerobic reactor to oxidize and hydrolyze the iron. The designer must consider the number of these reactors that it is necessary to design in series to achieve the desired iron removal. The reactor should be designed to achieve as uniform flow as possible.

Horizontal flow aerobic limestone bed

The design of the horizontal flow aerobic manganese removal bed is straightforward, basing the void volume on the amount of detention time predicted by equation 11. The final passive system has been designed to achieve an effluent conforming to effluent standards:

Parameter	30-day average	Daily maximum	Instantaneous maximum
$[Fe]_{total}$ (mg/L)	3.0	6.0	7.0
$[Mn]_{total}$ (mg/L)	2.0	4.0	5.0
Suspended solids (mg/L)	35	70	90
pH	$6.0 < pH < 9.0$		
Acidity (mg/L $CaCO_3$)	Alkalinity – Acidity > 0 at all times		

Table 1: Group A effluent limits normally applied to mine discharges in Pennsylvania

Predicted performance of the passive treatment systems for Ohiopyle State Park

The model was applied to the discharges at Ohiopyle State Park, using the available empirical data and Microsoft Excel spreadsheets. Based on the model, the pollution can be abated passively using the following designs, where Stage 1 is the vertical flow reactor, Stage 1A is a flushing pond built to receive any aluminum hydroxide that might need to be flushed from Stage 1, Stage 2 is the horizontal flow aerobic reactor or wetland, Stage 3 is the horizontal flow aerobic limestone bed, and Stage 3A is limestone that might be added to the volume of Stage 3 to assure obtaining a residual net alkalinity or 20 mg/L.

For Park Seeps #12 and #13, the confidence levels were calculated from an assumed lognormal data distribution. The proposed design combines the flow of these two seeps. Accordingly, the 95% confidence level flows are summed to calculate a composite design flow. The higher 95% confidence level is used for all other parameters except pH, for which the lower 95% confidence level is used. The design generated by the model is summarized in Table 2. Park Seep #14 is to be treated independently. As was done for Park Seeps #12 and #13, a lognormal data distribution is assumed. The design generated by the model is summarized in Table 3.

For the Smith Mine A/C discharge, presently being treated conventionally, the data were assumed to follow a Gaussian distribution, generating a more conservative design than would assumption of a lognormal distribution. The design generated by the model is summarized in Table 4. The mine discharges from the adjacent Potato Ridge Mine include two discharges, known as the Laurel Run Discharge and the Cemetery Discharge, which are treated passively in existing systems designed by others. The third discharge is treated conventionally. A possible refinement would be to design a single passive treatment system to replace conventional treatment for the Potato Ridge and Smith Mine discharges combined. This design will not be illustrated here due to space limitations.

Design Parameters Based on Composite of Park Seeps #12 and #13,and Compliance with Group A Limits	Raw Discharge (influent)	Final Discharge (Effluent)	Passive System Stage	Area (m^2)	Excavated depth (m)
Q (m^3/day)	106.68	106.68	1	1176.96	4.58
pH (s.u.)	2.65	6.40	1A	359.25	3.00
[Al^{3+}] (mg/L)	1.98	0.00	2	275.24	2.00
Total [Fe] (mg/L)	95.85	1.00	3	724.44	2.00
as Fe^{3+} (mg/L)	28.76	0.00	3A	0.00	
as Fe^{2+} (mg/L)	67.10	1.00	Support area	253.59	
[Mn^{2+}] (mg/L)	26.68	2.00	Total area	2789.48	
Theoretical Acidity (mg/L as $CaCO_3$)	359.58	5.46	Cost	$98,496.62	
Theor. Acid. Composite of data	330.95		Hectares:	0.28	
Empirical Acidity	464.77		Acres:	0.69	
Alkalinity	1.00	25.46			
95%Confidence limit [SO_4^{2-}]	924.34				
Avg [SO_4^{2-}]	838.54				
Safety factor	1.19				

Table 2: Design of Passive System for Park Seeps #12 and #13 Combined

Design Parameters Based on Park Seep #14 Alone and Compliance with Group A Limits	Raw Discharge (influent)	Final Discharge (Effluent)	Passive System Stage	Area (m^2)	Excavated Depth (m)
Q (m^3/day)	78.32	78.32	1	1023.48	4.17
pH (s.u.)	2.77	6.40	1A	345.66	3.00
[Al^{3+}] (mg/L)	3.75	0.00	2	246.13	2.00
Total [Fe] (mg/L)	63.99	1.00	3	652.52	2.00
as Fe^{3+} (mg/L)	19.20	0.00	3A	0.00	
as Fe^{2+} (mg/L)	44.79	1.00	Support area	226.78	
[Mn^{2+}] (mg/L)	22.70	2.00	Total area	2494.57	
Theoretical Acidity (mg/L as $CaCO_3$)	277.84	5.46	Cost	$88,083.41	
Theor. Acid. Composite of data	245.72		Hectares:	0.25	
Empirical Acidity	373.38		Acres:	0.62	
Alkalinity	1.00	25.46			
95%Confidence limit [SO_4^{2-}]	757.05				
Avg [SO_4^{2-}]	497.38				
Safety factor	1.52				

Table 3: Design of Passive System for Park Seep #14

Design Parameters Based on Combined Smith Mine A&C Seeps Currently Being Actively Treated and Compliance with Group A Limits	Raw Discharge (influent)	Final Discharge (Effluent)	Passive System Stage	Area (m^2)	Excavated Depth (m)
Q (m^3/day)	414.55	414.55	1	3382.35	5.61
pH (s.u.)	3.42	6.40	1A	1059.94	3.00
[Al^{3+}] (mg/L)	48.90	0.00	2	203.12	2.00
Total [Fe] (mg/L)	2.90	1.00	3	2596.79	2.00
as Fe^{3+} (mg/L)	0.87	0.00	3A	0.00	
as Fe^{2+} (mg/L)	2.03	1.00	Support area	724.22	
[Mn^{2+}] (mg/L)	35.97	2.00	Total area	7966.42	
Theoretical Acidity (mg/L as $CaCO_3$)	362.60	5.46	Cost	$281,294.32	
Theor. Acid. Composite of data	360.24		Hectares:	0.80	
Empirical Acidity	419.77		Acres:	1.97	
Alkalinity	0.00	136.27			
95%Confidence limit [SO_4^{2-}]	1218.56				
Avg [SO_4^{2-}]	1051.11				
Safety factor	1.16				

Table 4: Design of Passive System for Smith Mine A/C discharges (currently conventionally treated)

For the B-1 and B-3 Seeps, the confidence levels were calculated from an assumed lognormal data distribution, as for the Park Seeps. The designs generated by the model are summarized in Tables 5 and 6.

Summary

The Smith Mine discharges at Ohiopyle State Park are amenable to passive treatment. The design model presented here presents one passive treatment possibility. Useful additional information would include the ferrous iron concentration in addition to the total iron concentration. Additionally, empirical studies of the rate of alkalinity generation in a bed made of the limestone to be used would be helpful. Finally, analysis of the organic material to be used should be performed. The use of 95% confidence levels and the safety factor is intended too compensate for the existence of nonuniform, non-steady state conditions. Further work is needed to model the effects of temperature variation. For further development of a pseudo-first order model for metals removal, the reader is referred to Tarutis et al. (1999)[10]

An independent conceptual design proposal is being developed for the Ohiopyle discharges by the Bureau of Abandoned Mine Reclamation. Additionally, a conceptual design proposal is being developed by an independent consultant. The DCNR will evaluate the different concepts and base implementation on cost, the probable abatement of pollution, and environmental interpretation possibilities.

Design Parameters Based on B-1 Seep Alone and Compliance with Group A Limits	Raw Discharge (influent)	Final Discharge (Effluent)	Passive System Stage	Area (m^2)	Excavated Depth (m)
Q (m^3/day)	127.52	127.52	1	1347.87	5.61
pH (s.u.)	3.45	6.40	1A	458.22	3.00
[Al^{3+}] (mg/L)	4.32	0.00	2	371.29	2.00
Total [Fe] (mg/L)	128.07	1.00	3	907.86	2.00
as Fe^{3+} (mg/L)	38.42	0.00	3A	542.75	
as Fe^{2+} (mg/L)	89.65	1.00	Support area	362.80	
[Mn^{2+}] (mg/L)	21.74	2.00	Total area	3990.79	
Theoretical Acidity (mg/L as $CaCO_3$)	345.38	5.46	Cost	$140,914.90	
Theor. Acid. Composite of data	337.57		Hectares:	0.40	
Empirical Acidity	354.14		Acres:	0.99	
Alkalinity	32.21	25.46			
95%Confidence limit [SO_4^{2-}]	1271.08				
Avg [SO_4^{2-}]	905.45				
Safety factor	1.40				

Table 5: Design of Passive System for B-1 Seep

Design Parameters Based on B-3 Seep Alone and Compliance with Group A Limits	Raw Discharge (influent)	Final Discharge (Effluent)	Passive System Stage	Area (m^2)	Excavated Depth (m)
Q (m^3/day)	55.18	55.18	1	622.54	4.58
pH (s.u.)	3.85	6.40	1A	0.00	0.00
[Al^{3+}] (mg/L)	8.29	0.00	2	0.00	0.00
Total [Fe] (mg/L)	0.86	0.60	3	272.44	2.00
as Fe^{3+} (mg/L)	0.26	0.00	3A	0.00	
as Fe^{2+} (mg/L)	0.60	0.60	Support area	89.50	
[Mn^{2+}] (mg/L)	9.47	2.00	Total area	984.48	
Theoretical Acidity (mg/L as $CaCO_3$)	72.20	4.74	Cost	$34,761.94	
Theor. Acid. Composite of data	71.67		Hectares:	0.10	
Empirical Acidity	80.58		Acres:	0.24	
Alkalinity	3.79	186.39			
95%Confidence limit [SO_4^{2-}]	297.08				
Avg [SO_4^{2-}]	264.04				
Safety factor	1.13				

Table 6: Design of Passive System for B-3 Seep

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Harbison Walker--A Hybrid Passive Treatment System

by

T. Hilton, M. Dunn, T. Danehy, C. Denholm, & S. Busler

for

2003 West Virginia Surface Mine Drainage Task Force Symposium

Harbison Walker is an old reclaimed clay mine that is located within the confines of Ohiopyle State Park. This site, although mining was completed years ago, still emits several different types of mine drainage that must be treated prior to entering the receiving stream, Laurel Run. The drainage exists as seeps within and below the mined area, and have the following analysis:

RAW WATER ANALYSIS

Sample Point	pH	Conductance	Acidity	Iron	Manganese	Aluminum	Sulfates
AC Raw Water	3.46	1,880	434	1.65	36.5	56.0	1,437
B1 Raw Water	3.14	1,418	229	60.9	20.18	7.85	749
B3 Raw Water	4.30	574	47.1	0.11	6.74	5.93	400

As exhibited in the chart, parameters of concern are pH/acidity, iron, manganese, and aluminum. Based on the three raw water quality types, an all encompassing hybrid passive treatment system was designed to remediate the quality to current effluent limit requirements that call for a 6-9 pH, an Fe<7, and Alkalinity >Acidity. As you will note on the accompanying drawings, there are essentially three different systems. They are the AC system, B1 system, and the B3 system. As such, within each of the systems, are several treatment components designed, based on flow and quality. These systems all work together to improve water quality so that the final B3 Horizontal Flow Limestone Bed (B3HFLB) discharge has the following median values:

FINAL DISCHARGE WATER ANALYSIS

Sample Point	pH	Conductance	Alkalinity	Iron	Manganese	Aluminum	Sulfates
B3HFLB	6.53	1,145	72.86	0.06	0.44	0.11	629

In order to end up with this type discharge, each individual treatment component had to perform as designed. The components of each system are identified as follows:

System	Component	Comments
AC	**Raw Water Source**	**Seeps collected to make up AC system**
ACVFPN	**3,000 T. Vertical Flow Pond**	**Two tiered multi-cell, 7 cells limestone-1 cell slag**
ACVFPS	**3,000 T. Vertical Flow Pond**	**Two tiered multi-cell, 7 cells limestone-1 cell slag**
ACFP	**35,000 Cu. Ft. Flush Pond**	**Non-Discharging flush pond for ACVFP-S/N-dr. down/spillway**
ACSP/WL	**6,030 Sq. Ft. Settling P./Wetland**	**Primary use for particulate settling from Vertical Flow Ponds**
ACWL	**8,750 Sq. Ft. Wetland**	**Primary use for final particulate settling and polishing**
B1VFP	**1,000 T. Slag-Only Vertical Flow Pond**	**Water from ACSP/WL treated with slag to mix with B1 raw**
B1	**Raw Water Source**	**Seeps collected to make up B1 system**
B1FP	**10,000 Cu. Ft. Flush Pond**	**Non-Discharging flush pond for B1VFP-dr. down/spillway**
B1SP	**9,000 Sq. Ft. Settling Pond**	**Treated Slag alkaline water and B1 raw mix settle in B1SP**
B1WL1	**16,275 Sq. Ft. Wetland**	**Primary use for final particulate settling**
B1WL2	**1,955 Sq. Ft. Wetland**	**Primary use for final particulate settling**
B1WL3	**915 Sq. Ft. Wetland**	**Primary use for final particulate settling**
B3	**Raw Water Sources (2)**	**Seeps collected to make up B3 system**
B3SP	**2-9,000 Cu. Ft. Settling Ponds**	**Seep water from two limestone and slag diversion ditches**
B1B3VFP	**1,400 T. Vertical Flow Pond**	**Two tiered multi-cell, 7 cells limestone-1 cell slag**
B1B3SP/WL	**9,000 Sq. Ft. Settling P./Wetland**	
B1B3FP	**18,000 Cu. Ft. Flush Pond**	**Non-Discharging flush pond for B1B3VFP-dr. down/spillway**
B1B3HFLB	**1,000 T. Horiz. Flow Limestone Bed**	**Manganese removal-Alkalinity generator-Final Discharge**

The basic flow of water starts with the AC raw water split between 2-3,000 ton vertical flow ponds. The treated effluent from the VFP's flows into a combination settling pond and wetland. At this point, there are two travel paths for the water exiting this structure. Part of the water will travel by a valved pipe into a 1,000 ton slag only VFP, while the remaining water flows into another wetland (ACWL). The ACWL can either be discharged into Laurel Run, or it can be diverted to the B1 Wetland (B1WL1) for additional treatment if required. Backing up a bit, the water entering the Slag only VFP is actually the first stage of treatment for the B1 system. As stated, a portion of the treated water from the ACSP/WL system proceeds through the Slag and emerges with approximately a 10.5 pH and an alkalinity of around 80 mg/l. This water immediately mixes with the B1 Raw Water that has been collected through a series of rock drains. The purpose for this segment of treatment was to provide alkalinity and pH for partial treatment of the B1 Raw Water. The mixed waters proceed to the B1 Settling Pond (B1SP) where some of the iron and/or other metals will precipitate. From here, the B1SP effluent travels through three wetlands designated as B1WL1, B1WL2, and B1WL3. The primary purpose for these wetlands is settling. At this point, the AC and B1 treated waters leave the B1WL3 and combine with the B3 system water after entering the B1B3 Vertical Flow Pond (B1B3VFP). Again, before getting too far ahead, let's back up to the B3 system. The B3 Raw water is collected in two diversion ditches that are lined with limestone and slag. The raw water itself in this area is not so bad that the ditches provide enough alkalinity to liberate most of the aluminum, which is then settled out in two settling ponds (B3SP). From the settling ponds, the water moves through a pipe to the B1B3VFP where it joins the AC and B1 waters. Upon exiting the B1B3VFP, the water quality is as follows:

B1B3VFP

Sample Point	pH	Conductance	Alkalinity	Iron	Manganese	Aluminum	Sulfates
B1B3VFP	**6.53**	**1,140**	**41.62**	**4.08**	**8.02**	**0.84**	**672**

This water now flows to a combination Settling Pond & Wetland (B1B3SPWL) and enters the B1B3 Horizontal Limestone Bed (the final treatment structure) with a quality as below.

B1B3SPWL

Sample Point	pH	Conductance	Alkalinity	Iron	Manganese	Aluminum	Sulfates
B1B3SPWL	**6.67**	**939**	**22.06**	**3.10**	**10.20**	**0.26**	**636**

After traveling through the B1B3 Horizontal Flow Limestone Bed, the water discharges into Laurel Run as follows:

B1B3HFLB--FINAL DISCHARGE

Sample Point	pH	Conductance	Alkalinity	Iron	Manganese	Aluminum	Sulfates

B1B3HFLB	**6.53**	**1,145**	**72.86**	**0.06**	**0.44**	**0.11**	**629**

As a final comparison between the raw water versus the final discharge, please note the following:

Sample Point	pH	Conductance	Acid./Alk.	Iron	Manganese	Aluminum	Sulfates
AC Raw Water	**3.46**	**1,880**	**434/0**	**1.65**	**36.5**	**56.0**	**1,437**
B1 Raw Water	**3.14**	**1,418**	**229/0**	**60.9**	**20.18**	**7.85**	**749**
B3 Raw Water	**4.30**	**574**	**47.1/0**	**0.11**	**6.74**	**5.93**	**400**
B1B3HFLB	**6.53**	**1,145**	**0/72.86**	**0.06**	**0.44**	**0.11**	**629**

Harbison Walker is an example of how passive technology has been transforming over the last few years in order to meet more stringent effluent limits associated with TMDL and Anti-Degradation regulations. We want to especially thank the Pennsylvania DEP in allowing us the opportunity to be involved in such a creative process. It is projects such as this which allows us to expand our work and accomplishments in the field of Passive Treatment.

Now that we have walked our way through the different systems, I want to spend some time on some of the things I feel we have learned at Harbison Walker over the last two years.

1--In Real Estate, they say it's "location--location--location". In passive treatment systems it should be "flow distribution--flow distribution--flow distribution". Flow distribution directly relates to retention time, which directly relates to contact time. This particular treatment parameter is what ultimately makes a system succeed or fail. If you stop and think about it, everything involved in water treatment is based on the common parameter of time. If it has to do with settling of particulate matter, it's time. If it's solubilization of a treatment media, it's time. If the treatment process depends on bio-remediation, it's time. I realize that time is not the only treatment parameter, but it provides the basis by which all the other parameters function. Why the sudden revelation? Good question. The final nail in the proverbial coffin came in the form of a dye tracer test that we ran on the AC Vertical Flow Ponds. As the dye entered each of the AC VFP's, some of it chose distinct flow paths towards specific points, while the rest exhibited a minor amount of diffuse flow. We recorded the time that the trace began and within 15-20 minutes, dye began to show in one of the discharge pipes. That was not quite the 12-24 hours we had hoped to find. To make a long story short, it was immediately evident why the AC VFP's were not performing as they should--it was a matter of "TIME". There wasn't enough retention/contact time for the water in either VFP due to the short-circuiting. When you watched the dye, it sort of all begin to make sense. The name of the system describes the very nature of the problem, which is vertical flow. For water to flow vertically downward in the manner we visualize it in this application conditions would have to be perfect. The limestone bed would have to have the exact same density throughout, and the pipe perforations would have to be designed to compensate for line loss and pressure drops across pipe intersections. Since we can all probably agree that this doesn't happen, we can assume there will begin to emerge preferential flow paths through the limestone bed. Any such type of preferential flow entirely defeats our purpose of optimizing contact time. To make it worse, how do we flush these beds? Since gravity still rules, the flushes are vertically downwards. Hmmmm! That's right--the flushing can actually enhance the formation of the preferential flow paths. After standing around and pondering for a while, we decided to change the vertical flow regime of one of the AC VFP's into one utilizing horizontal flow. Since both of the AC VFP's had multi-cell, two tier piping arrangements, we took the ACVFPS and shut off 7 of the eight cells. The eighth cell was located on the bottom and at the discharge end of the pond. Also, the water elevation in the ACVFPS was dropped to just below the surface of the limestone to induce horizontal flow through the pond. We now had a modified horizontal flow system that still had all the pipes of the vertical flow pond. That meant we now had a horizontal flow pond with a vertical flush system. Hmmmm, horizontal flow and vertical flush!! What happened with the effluent quality after we did this? The pH came back up, acidity was replaced with alkalinity, we saw an increased reduction in manganese. The other really interesting aspect of this metamorphism was when some of the crew went back a short time later and flushed the system. Unlike the 15-30 minute flush that we normally experience with flushing VFP's before they are clear, the modified system continued to emit solids for in excess of 3 hours. Ding, ding, ding---are you starting to hear the bell. Anyway, we fell into a modified version of a VFP/HFLB, which performed much better than a VFP alone. What else have we learned?

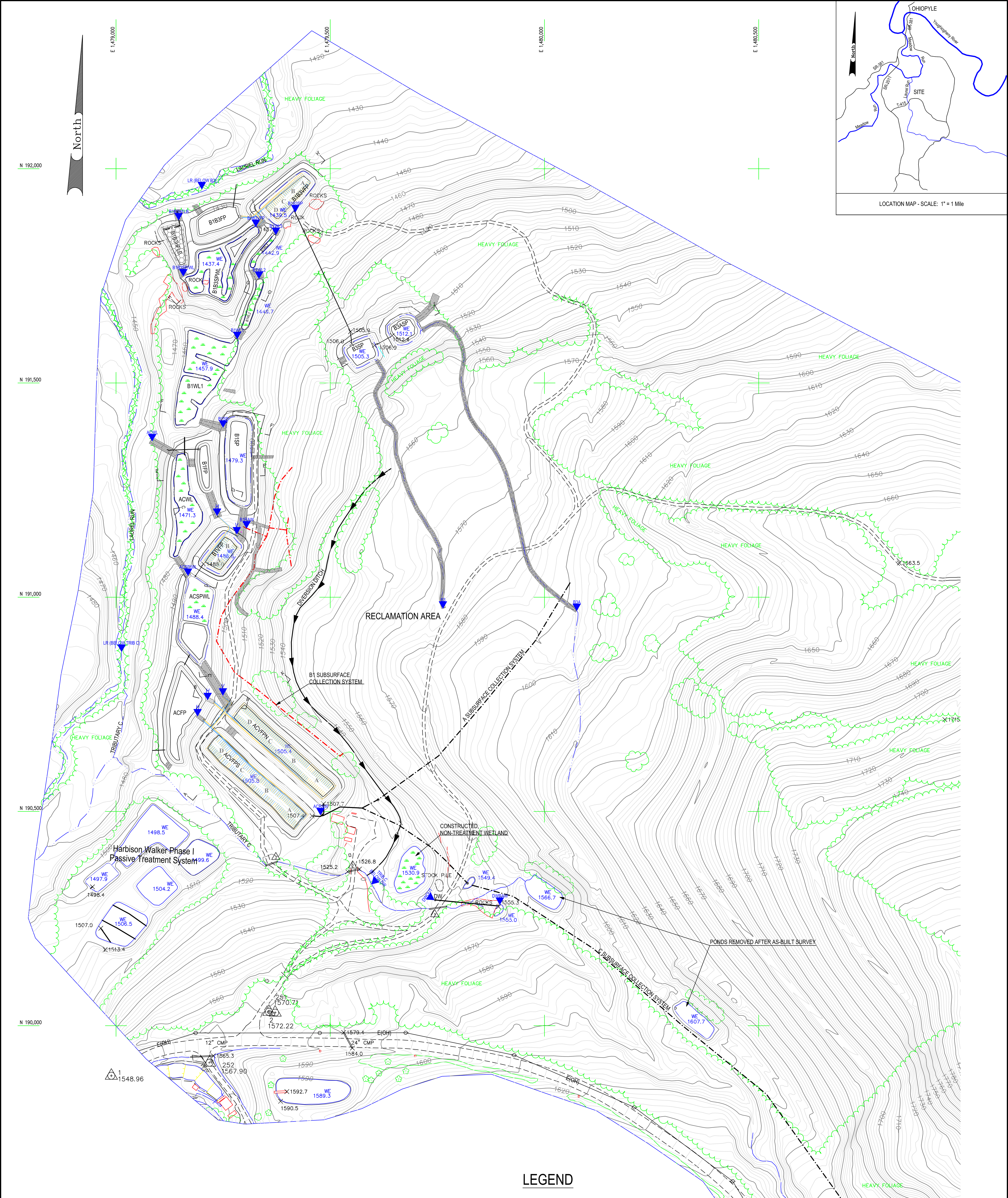
2--We also learned that the Slag only VFP emitted high pH water with moderate alkalinity, based on our design. Actually, the median concentrations for the B1VFP showed a 10.14 pH, 81 mg/l alkalinity, 0.14 mg/l Fe, 0.31 mg/l Mn, and a 0.18 mg/l aluminum. These were total values. the dissolved values were almost non-detectable. We were shooting for high pH values, but also were hoping for much higher alkalinity. Actually, it shouldn't have been any surprise as to the moderate alkalinity, simply due to the chemistry involved. In the slag VFP we are working with hydroxyl alkalinity rather than carbonate alkalinity as associated with limestone. As such, from all my titration work over the years with calcium oxide (primary pH/alkalinity generator in slag), I should have anticipated the alkalinity results based on the pH. I have found that in active treatment systems, alkalinity remains low to moderate in pH values up to a 10.5 pH. At this point, buffering mechanisms begin to kick in, which requires more and more calcium oxide (or other alkaline amendments) in order to increase the pH. As an example, whereas it might take 0.20 grams to increase the pH from a 3.5 to a 10.5, it may take 0.30 grams more to raise the pH from a 10.50-11. This is where you pick up residual alkalinity when actively treating with hydroxyl type chemicals. Therefore, we have to decide if the increase in calcium oxide consumption justifies the resultant alkalinity for what we are trying to accomplish. Another problem in raising the pH up high enough to generate +200 mg/l alkalinity is the precipitation of magnesium in the 10.5-11 pH range. It is a problem since it adds to the ultimate sludge volume. At some active sites, I have seen people treat for 5-10 mg/l of manganese and end up precipitating 150 mg/l of magnesium due to over-treatment. So, all of these concerns are currently being studied like everything else. One thing is for sure though, slag is an amazing water treatment tool, and should play an important role in future treatment systems relative to site specific conditions.

Have we learned anything else? Of course. We learned that trying to construct passive systems in the wet and/or Winter months can result in problems associated with soil stability and also problems with the VFP piping system with regards to connections. We learned to design multiple individual systems at the same site with cross over pipes for emergency situations or for maintenance purposes. We learned that back flushing the system, when done properly, reveals much more than a dye tracer test. In other words we have learned a great deal and continue to learn on a daily basis due to the all encompassing design of the Harbison Walker systems. We want to thank the State of Pennsylvania one more time for their efforts relative to the grants programs. For without those grants, none of this type work would be possible.

If you have any further questions concerning these systems, please don't hesitate to contact Margaret Dunn or Tim Danehy at (724) 776-0161, or myself (Tiff Hilton) at (304) 645-7633.

HARBISON WALKER PASSIVE TREATMENT SYSTEM
MEDIAN QUALITY VALUES 3/2000-12/2002

Sample Point	pH	Conductance	Alkalinity/Acidity	T. Fe/D. Fe	T. Mn/D. Mn	T. Al/D. Al	Sulfates
AC Raw Water	3.46	1,880	0/434	1.65/----	36.5/36.3	56.0/----	1,437
ACVFPS	5.97	2,058	75.8/6.40	0.38/----	14.2/13.5	12.9/2.24	1,442
ACVFPN	5.70	1,943	70.5/0	0.33/----	24.7/24.0	11.1/1.16	1,475
ACSP/WL	6.41	1,820	19.4/0	0.47/----	15.55/----	3.27/0.29	1,405
ACWL	5.80	1,761	6.22/18.5	1.65/----	16.05/----	1.77/0.71	1,295
B1VFP (SLAG)	10.14	1,836	81.0/0	0.14/----	0.31/0.02	0.18/0.09	1,105
B1 Raw Water	3.14	1,418	0/229	60.9/58.4	20.18/----	7.85/7.37	749
B1SP	3.22	1,432	0/158	45.6/38.6	14.3/13.8	2.93/2.48	873
B1WL1	3.22	1,255	0/150	30.1/28.6	16.1/14.9	3.38/3.24	836
B1WL2	3.25	1,335	0/132	23.4/21.6	14.2/13.8	3.48/3.26	794
B3 Raw Water	4.30	574	0/47.1	0.11/----	6.74/----	5.93/----	400
B3SP	6.54	455	0/18.6	0.37/0.09	3.07/3.06	1.95/0.26	249
B1B3VFP	6.53	1,140	41.62/0	4.08/3.55	8.02/8.00	0.84/0.38	672
B1B3SPWL	6.67	939	22.06/0	3.10/2.30	10.20/9.70	0.26/0.11	636
B1B3HFLB	6.53	1,145	72.86/0	0.06/-----	0.44/----	0.11/0.06	629



LEGEND

- PASSIVE SYSTEM COMPONENT
- CONTOUR - INDEX
- CONTOUR - INTERMEDIATE
- WATER
- E(OH) UTILITY LINE (E-ELECTRIC)
- CULVERT
- UTILITY POLE
- ROAD
- OUT BUILDING OR OTHER STRUCT.
- TREELINE
- 4" PVC SCH 40 SOLID (UPPER TIER)
- 4" PVC SCH 40 PERFORATED (UPPER TIER)
- 4" PVC SCH 40 SOLID (LOWER TIER)
- 4" PVC SCH 40 PERFORATED (LOWER TIER)
- 6" N-12 PERFORATED
- 6" PVC SCH 40 SOLID
- 6" PVC SCH 40 PERFORATED
- 4" PVC SCH 40 SOLID
- RIP RAP (R-4) SPILLWAY/CHANNEL
- X1213.6 SPOT ELEVATION
- A A' AS BUILT CROSS SECTION
- WATER SAMPLE POINT
  V - VERTICAL FLOW
  H - HYBRID FLOW

PASSIVE TREATMENT SYSTEM SUMMARY CHART

COMPONENT	DESCRIPTION	COMMENTS
ACVFPN	3,001 T VERTICAL FLOW POND	2 TIERED UNDERDRAIN/FLUSH SYSTEM INCL. 4 INVID. OUTLET CELLS PER TIER: (7) 90% CCE LS CELLS & (1) SLAG CELL
ACVFPS	3,000 T VERTICAL FLOW POND	2 TIERED UNDERDRAIN/FLUSH SYSTEM INCL. 4 INVID. OUTLET CELLS PER TIER: (7) 90% CCE LS CELLS & (1) SLAG CELL
ACFP	15,401 SF FLUSH POND	NON-DISCHARGING FLUSH POND FOR ACVFPN & ACVFPS INCL. DRAW-DOWN DEVICE AND EMERGENCY SPILLWAY
ACSP/WL	11,168 SF SETTLING POND/WETLAND COMPLEX	PARTICULATE SETTLING FACILITY
ACWL	8,745 SF WETLAND	PARTICULATE SETTLING FACILITY
B1VFP	1,003 T SLAG-ONLY VERTICAL FLOW POND	10 GPM± OF TREATED A/C DISCHARGE USED TO PRODUCE HIGHLY ALKALINE WATER; 2 TIERS/2 OUTLET CELLS PER TIER
B1FP	5,054 SF FLUSH POND	NON-DISCHARGING FLUSH POND FOR B1VFP INCL. DRAW-DOWN DEVICE AND EMERGENCY SPILLWAY
B1SP	11,588 SF SETTLING POND	MIX B1 DISCHARGE WITH HIGHLY ALKALINE WATER FROM B1VFP; PARTICULATE SETTLING
B1WL1	16,273 SF WETLAND	PARTICULATE SETTLING FACILITY
B1WL2	1,955 SF WETLAND	PARTICULATE SETTLING FACILITY
B1WL3	915 SF WETLAND	PARTICULATE SETTLING FACILITY
B1B3VFP	1,300 T VERTICAL FLOW POND	2 TIERED UNDERDRAIN/FLUSH SYSTEM INCL. 4 INVID. OUTLET CELLS PER TIER: (7) 90% CCE LS CELLS & (1) SLAG CELL
B1B3SP/WL	10,219 SF SETTLING POND/WETLAND COMPLEX	PARTICULATE SETTLING FACILITY
B1B3FP	6,043 SF FLUSH POND	NON-DISCHARGING FLUSH POND FOR B1B3 VFP INCL. DRAW-DOWN DEVICE AND EMERGENCY SPILLWAY
B1B3HFLB	1,014 T HORIZONTAL FLOW LIMESTONE BED	MANGANESE REMOVAL AND ALKALINITY GENERATOR
B3SP	4,033 SF SETTLING POND	COLLECTION OF B3 DISCHARGE, SEDIMENT SETTLING FACILITY, DIRECT FLOW INTO PIPE
B3ASP	4,019 SF SETTLING POND	COLLECTION OF B3A DISCHARGE; OVERFLOW OF PRECIPITATION EVENTS; CONTROL/DIRECT FLOW IN B3SP
DW	125 CF DIVERSION WELL	COLLECTION OF TRIB C; ALKALINITY GENERATOR
B3 OLC	5,688 SF OPEN LIMESTONE CHANNEL	COLLECTION AND CONVEYANCE OF B3 DISCHARGE TO B3SP; ALKALINITY GENERATOR
B3A OLC	7,479 SF OPEN LIMESTONE CHANNEL	COLLECTION AND CONVEYANCE OF B3A DISCHARGE TO B3ASP; ALKALINITY GENERATOR

Notes:
Base map prepared by PA DEP, BAMR, from aerial photographs taken May 11, 2001.
As-Built EDM survey by Earthtech, Inc., Johnstown, PA with additional information from site inspections provided by BioMost, Inc. and Amerikohl Mining, Inc.
AC subsurface collection system based on Harbison Walker Reclamation Plan provided by the Greensburg DMO, DEP. Location is approximate.
Wetland surface areas calculated at approximate water elevation.
Water surface areas and elevations subject to change based on passive component permeability and/or spillway outlet conditions.
Diversion ditch not located by survey.

Passive Component Abbreviations:
FP - Flush Pond
SP - Settling Pond
VFP - Vertical Flow Pond
WL - Wetland
DW - Diversion Well

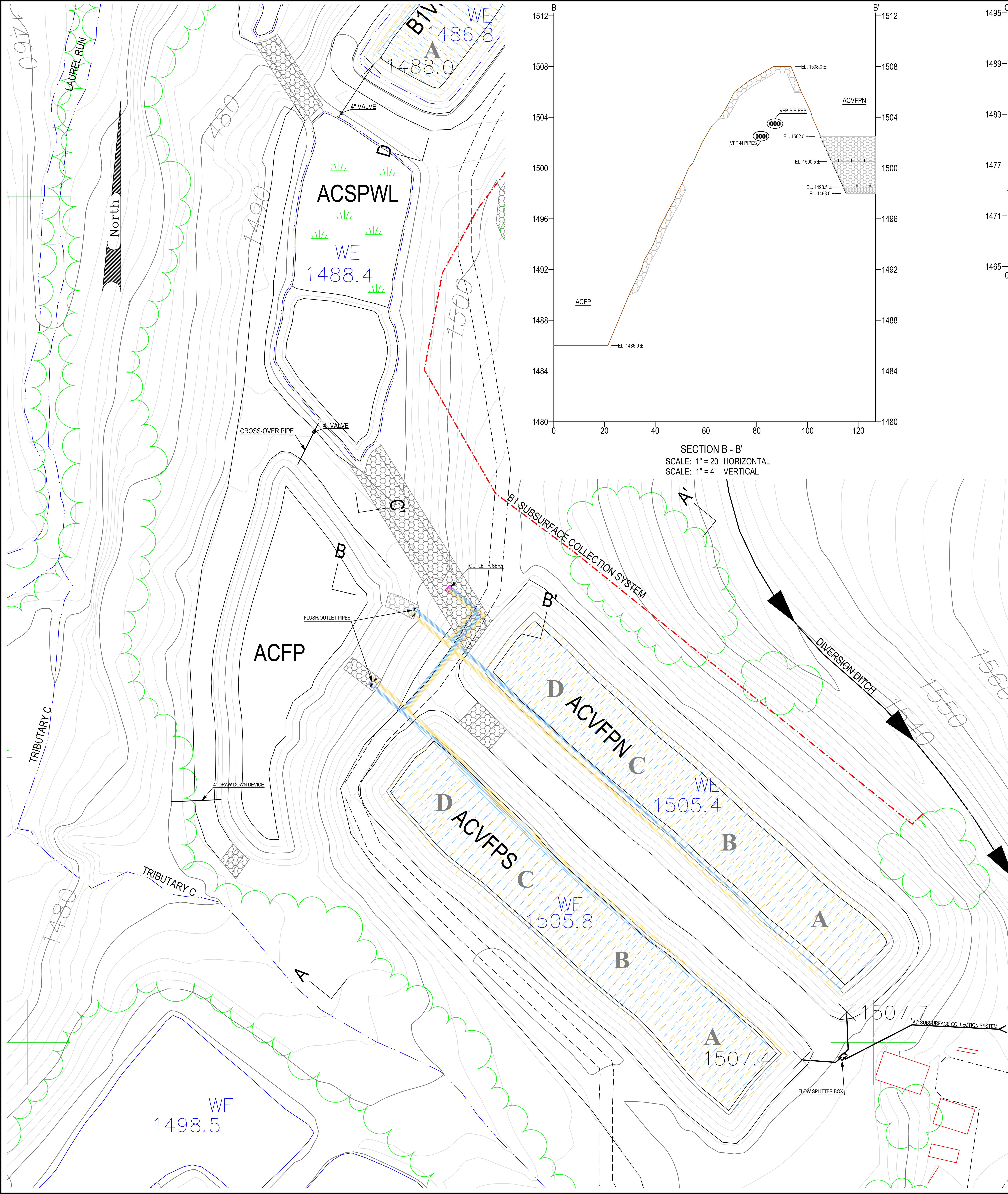
100 50 0 100 200

Draft:
Plan to be revised to depict recently-completed and scheduled future upgrades.

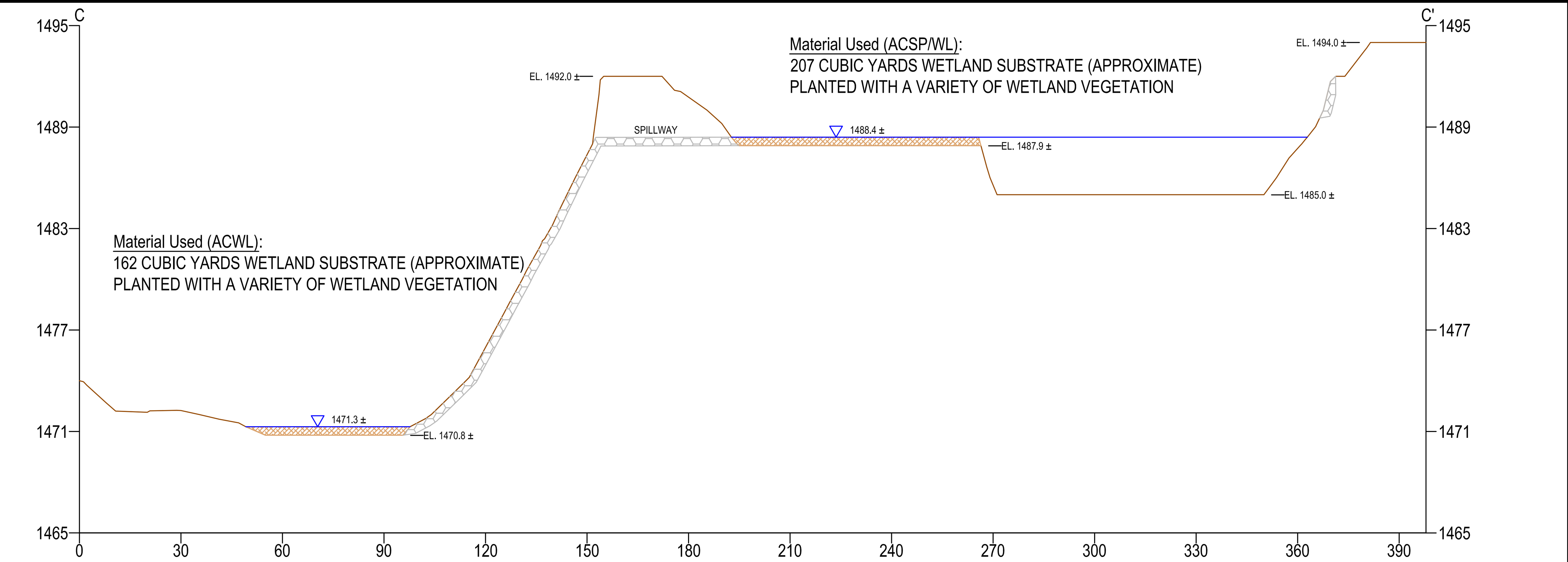
SHEET 1 OF 4

AS-BUILT PLANS - PROJECT AREA
HARBISON WALKER PHASE II
Laurel Run Watershed Initiative
STREAM RESTORATION INCORPORATED
situate in
Ohiopyle State Park
Stewart Township, Fayette County, PA
Scale: 1" = 100' Date: 6/2003
BioMost, Inc., Cranberry Twp., PA

103503/Harbison Walker II As-Built/Plan View



SECTION B - B'
SCALE: 1" = 20' HORIZONTAL
SCALE: 1" = 4' VERTICAL



SECTION C - C'
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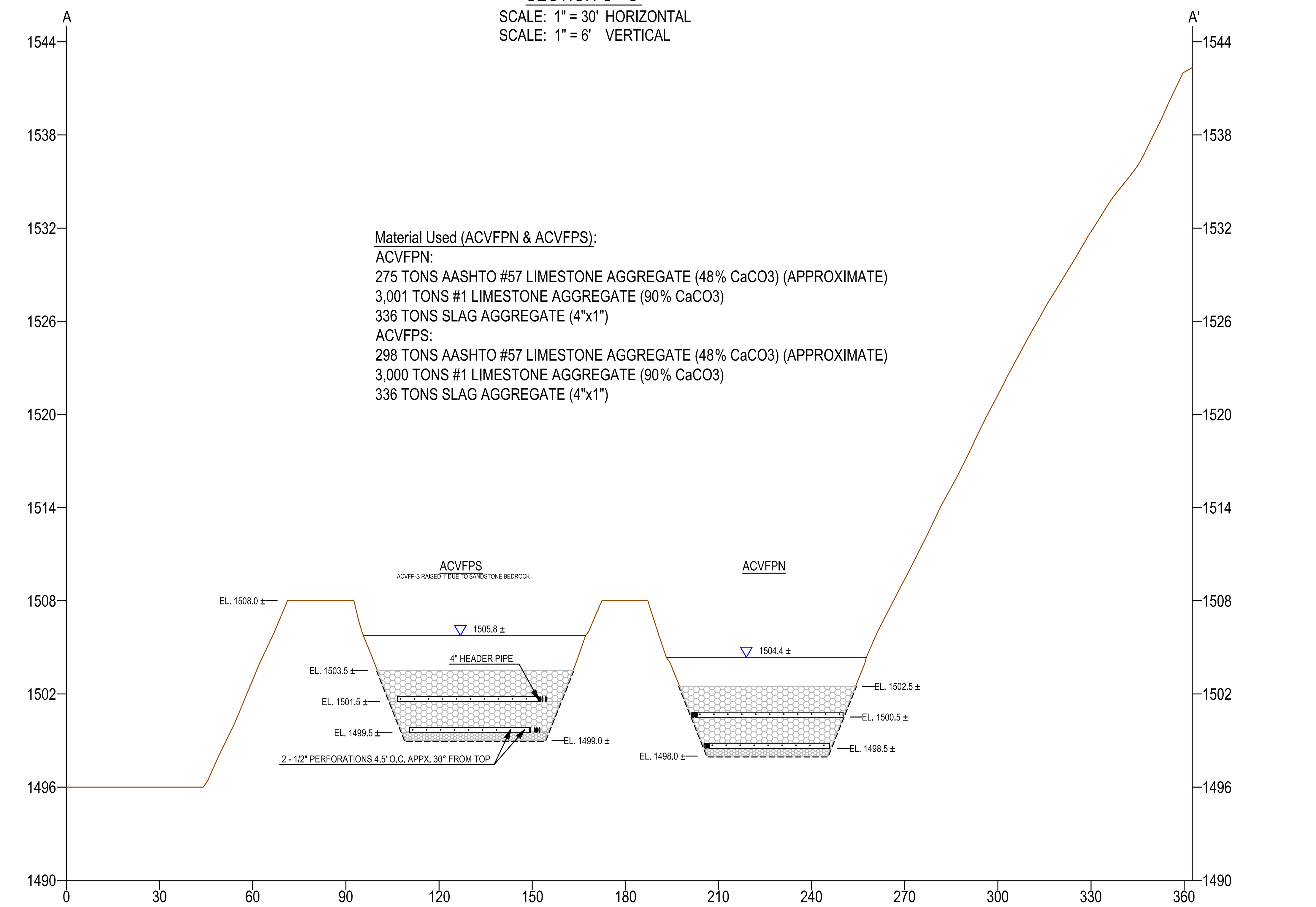
SCALE: 1" = 6' VERTICAL



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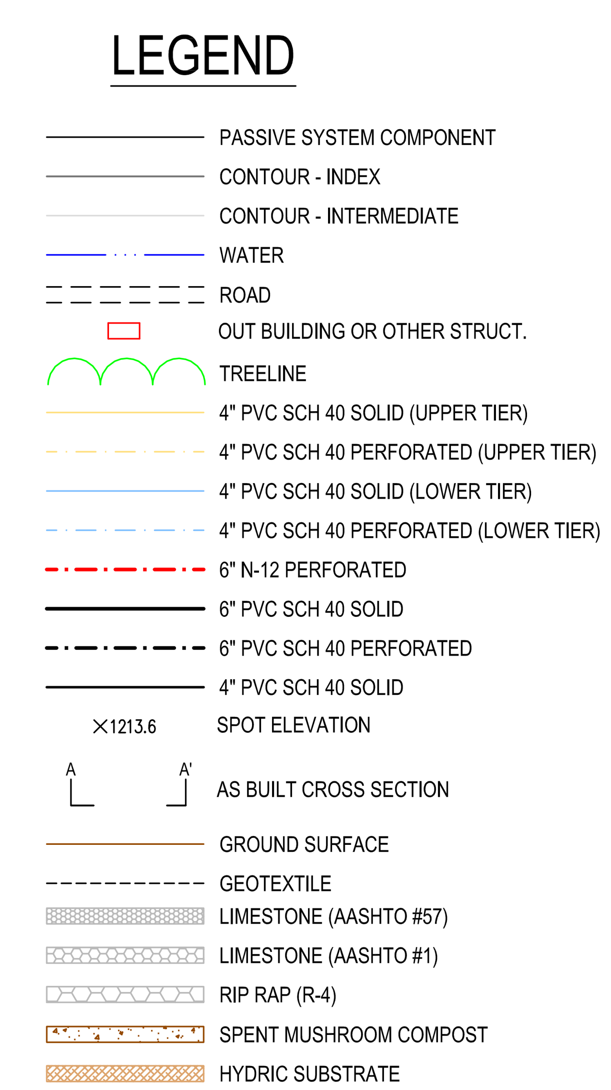
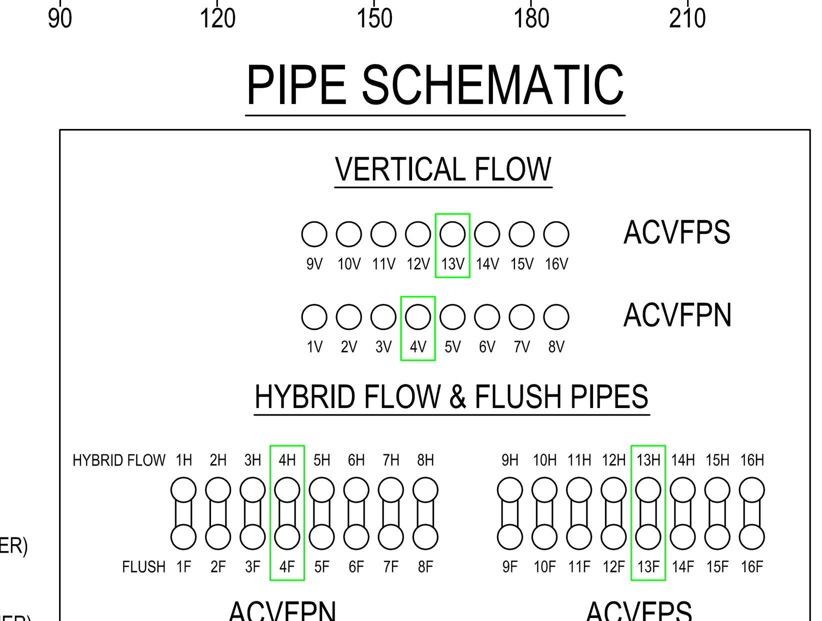
SCALE: 1" = 6' VERTICAL





NOTE:
Pipe schematic drawn as if standing in the ACVFP spillway looking easterly towards the discharge and flush pipes. ☐ : Slag Cell

KEY TO PIPING

ACVFPN

PIPE #	TIER	QUAD
1V, 2H, 3F	LOWER	D
2V, 2H, 2F	LOWER	C
3V, 3H, 3F	LOWER	B
4V, 4H, 4F	LOWER	A
5V, 5H, 5F	UPPER	D
6V, 6H, 6F	UPPER	C
7V, 7H, 7F	UPPER	B
8V, 8H, 8F	UPPER	A

ACVFPS

PIPE #	TIER	QUAD
9V, 9H, 9F	UPPER	A
10V, 10H, 10F	UPPER	B
11V, 11H, 11F	UPPER	C
12V, 12H, 12F	UPPER	D
13V, 13H, 13F	LOWER	A
14V, 14H, 14F	LOWER	B
15V, 15H, 15F	LOWER	C
16V, 16H, 16F	LOWER	D

Notes:
Base map prepared by PA DEP, BAMR, from aerial photographs taken May 11, 2001.
As-Built EDM survey by Earthtech, Inc., Johnstown, PA with additional information from site inspections provided by BioMost, Inc. and Amerikohl Mining, Inc.
AC subsurface collection system based on Harbison Walker Reclamation Plan provided by the Greensburg DMO, DEP. Location is approximate.
Wetland surface areas calculated at approximate water elevation.
Compost/hydric substrate volume calculated from As-Built Plans (Approximate).
Water surface areas and elevations subject to change based on passive component permeability and/or spillway outlet conditions.
Diversion ditch not located by survey.

Passive Component Abbreviations:
FP - Flush Pond
SP - Settling Pond
VFP - Vertical Flow Pond
WL - Wetland

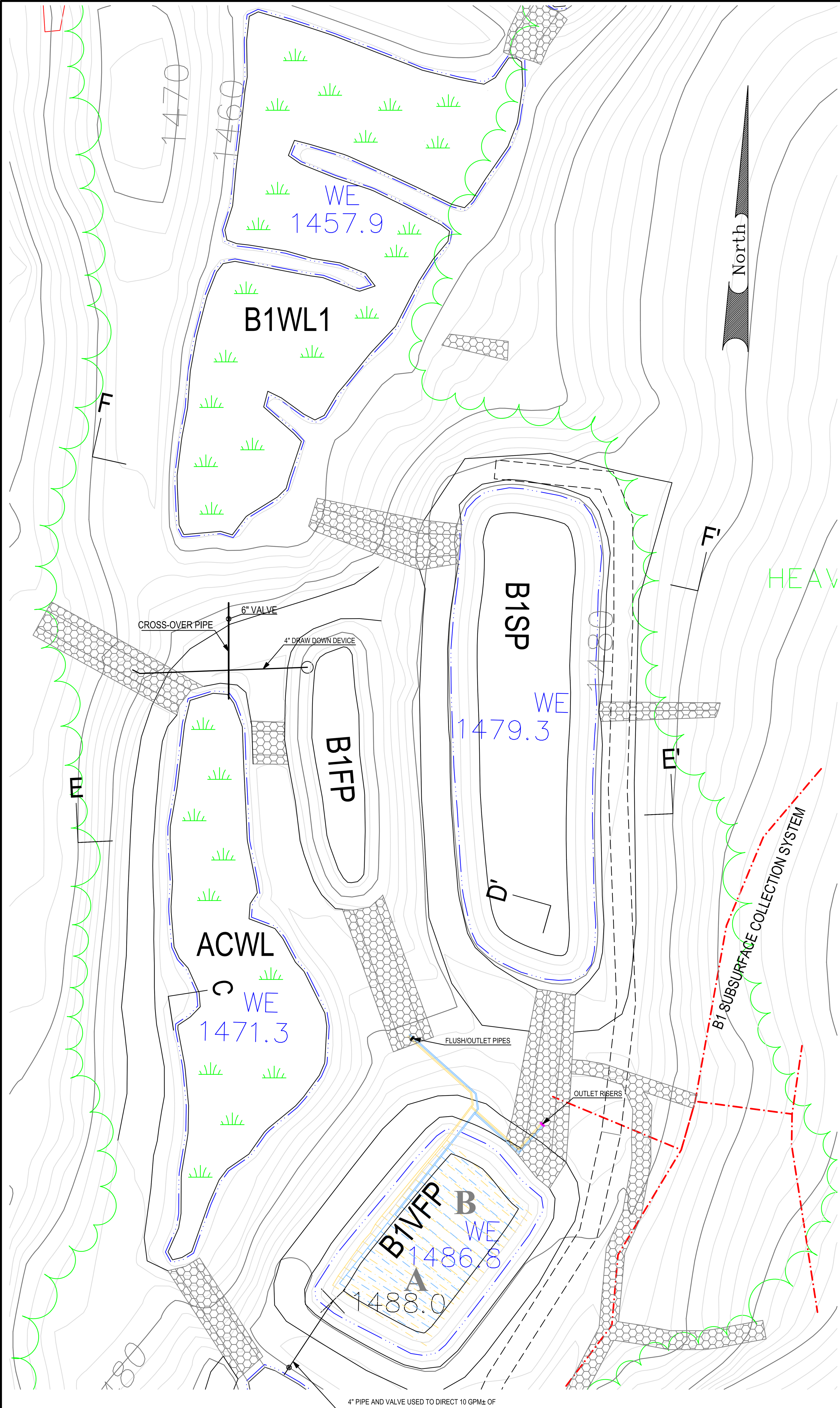
Draft:
Plan to be revised to depict recently-completed and scheduled future upgrades.

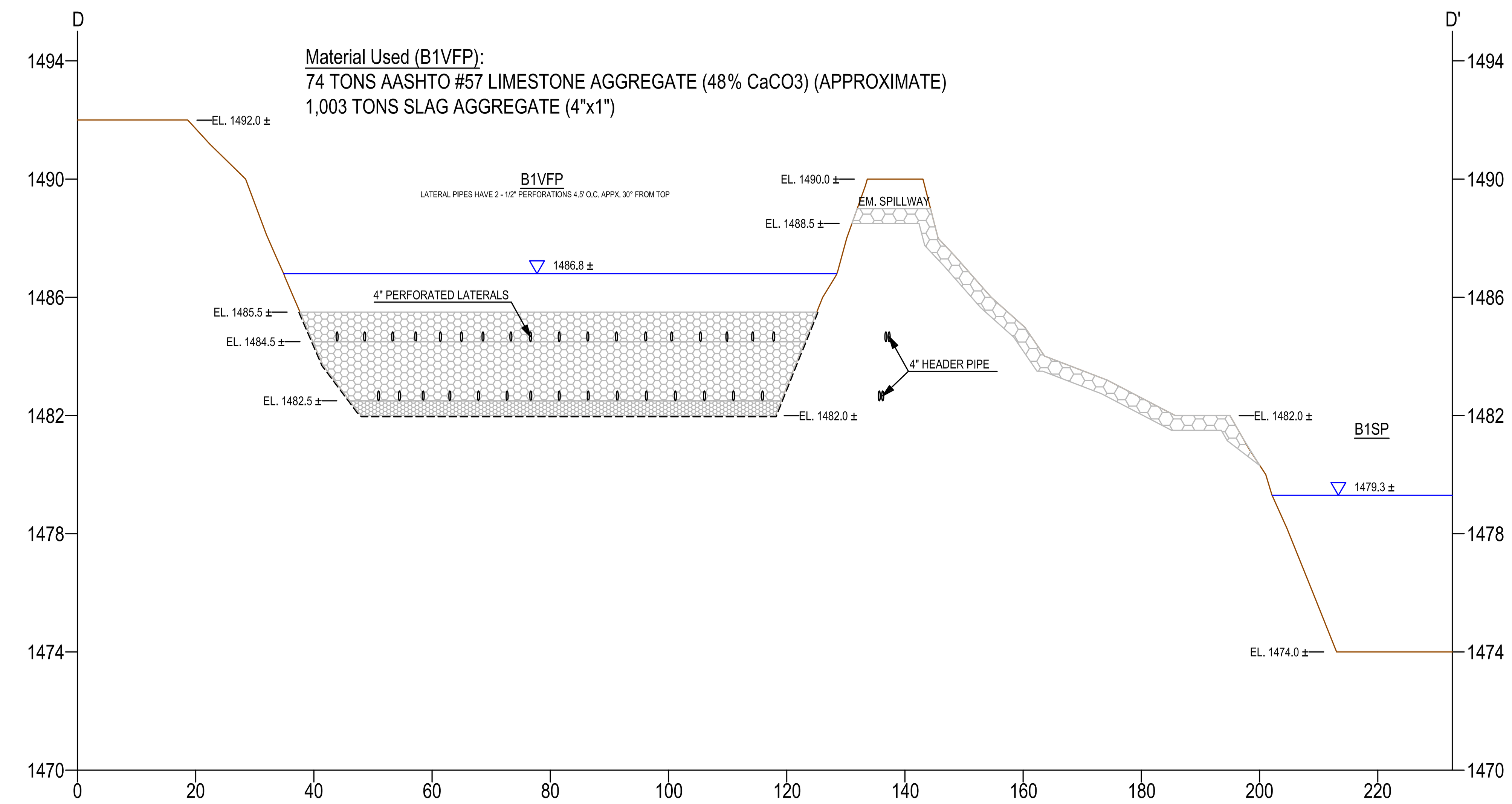
30 15 0 30 60

SHEET 2 OF 4

AS-BUILT PLANS - AC SYSTEM
HARBISON WALKER PHASE II
Laurel Run Watershed Initiative
STREAM RESTORATION INCORPORATED
situate in
Ohiopyle State Park
Stewart Township, Fayette County, PA
Scale: 1" = 30' Date: 6/2003
BioMost, Inc., Cranberry Twp., PA

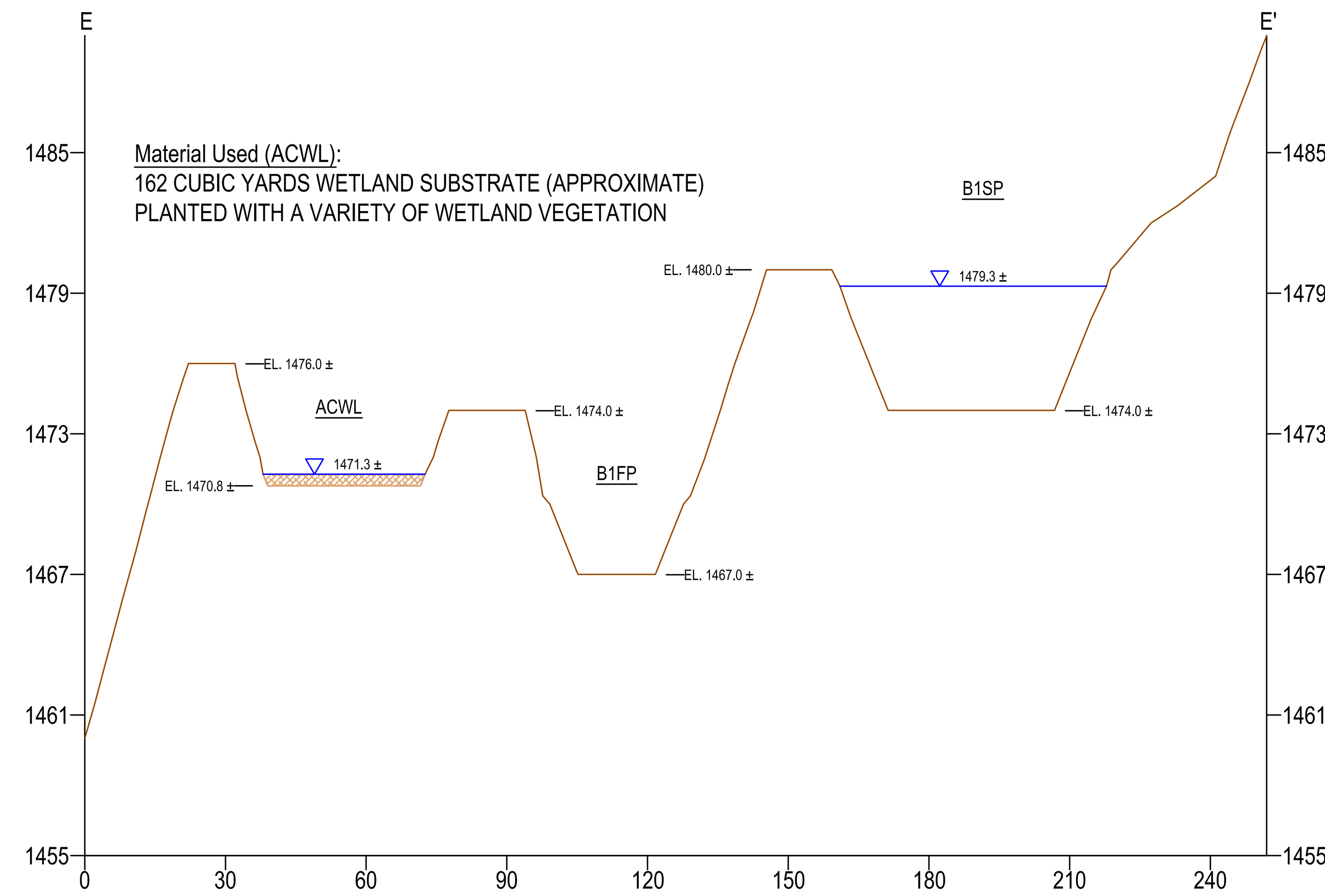
103503/Harbison Walker II As-Built/AC





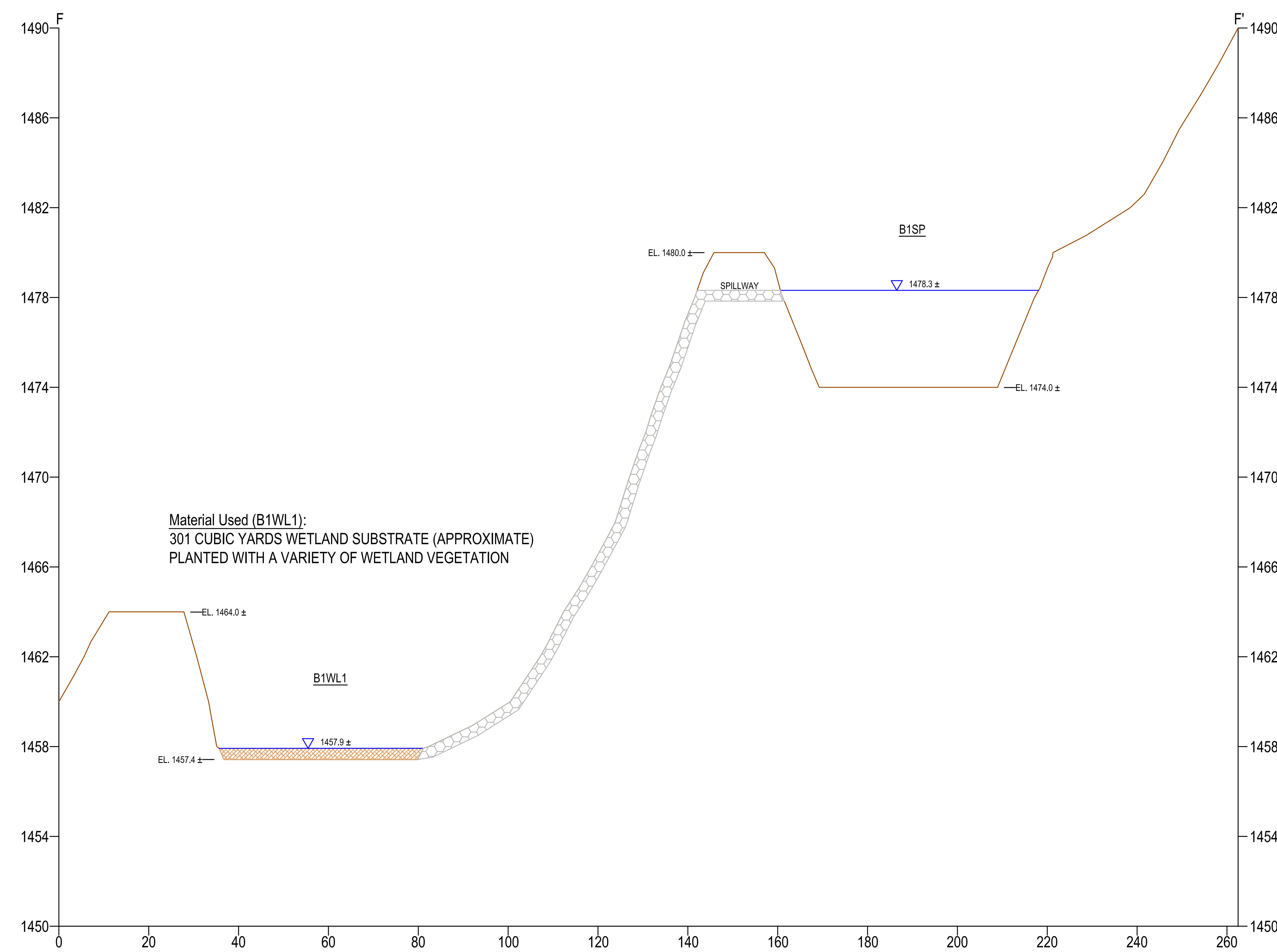
SECTION D - D'

SCALE: 1" = 20' HORIZONTAL
SCALE: 1" = 4' VERTICAL



SECTION E - E'

SCALE: 1" = 30' HORIZONTAL
SCALE: 1" = 6' VERTICAL



SECTION F - F'

SCALE: 1" = 20' HORIZONTAL
SCALE: 1" = 4' VERTICAL

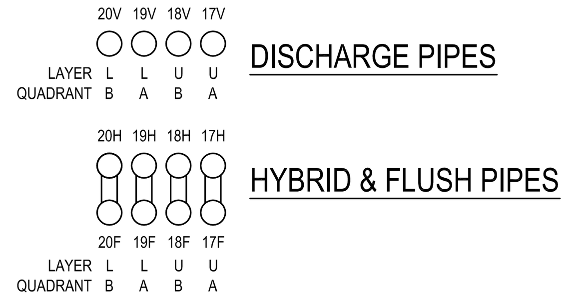
LEGEND

- PASSIVE SYSTEM COMPONENT
- CONTOUR - INDEX
- CONTOUR - INTERMEDIATE
- WATER
- ROAD
- OUT BUILDING OR OTHER STRUCT.
- TREELINE
- 4" PVC SCH 40 SOLID (UPPER TIER)
- 4" PVC SCH 40 PERFORATED (UPPER TIER)
- 4" PVC SCH 40 SOLID (LOWER TIER)
- 4" PVC SCH 40 PERFORATED (LOWER TIER)
- 6" N-12 PERFORATED
- 6" PVC SCH 40 SOLID
- 6" PVC SCH 40 PERFORATED
- 4" PVC SCH 40 SOLID
- ×1213.6 SPOT ELEVATION
- A A' AS BUILT CROSS SECTION
- GROUND SURFACE
- GEOTEXTILE
- LIMESTONE (AASHTO #57)
- LIMESTONE (AASHTO #1)
- RIP RAP (R-4)
- SPENT MUSHROOM COMPOST
- HYDRIC SUBSTRATE

Notes:
Base map prepared by PA DEP, BAMR, from aerial photographs taken May 11, 2001.
As-Built EDM survey by Earthtech, Inc., Johnstown, PA with additional information from site inspections provided by BioMost, Inc. and Amerikohl Mining, Inc.
Wetland surface areas calculated at approximate water elevation.
Compost/hydric substrate volume calculated from As-Built Plans (Approximate).
Water surface areas and elevations subject to change based on passive component permeability and/or spillway outlet conditions.

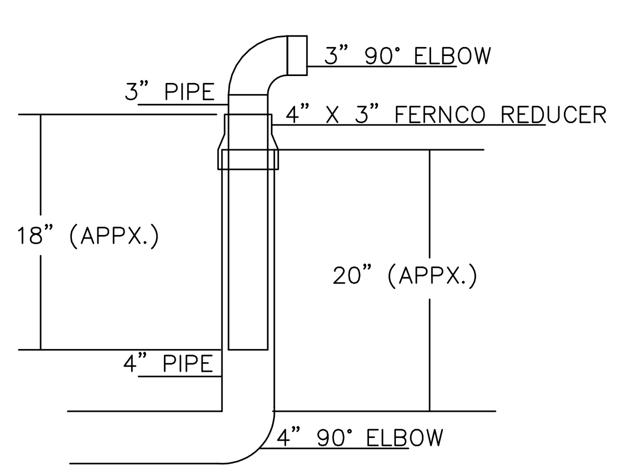
Passive Component Abbreviations:
SP - Settling Pond
VFP - Vertical Flow Pond
WL - Wetland
FP - Flush Pond

B1VFP PIPE SCHEMATIC

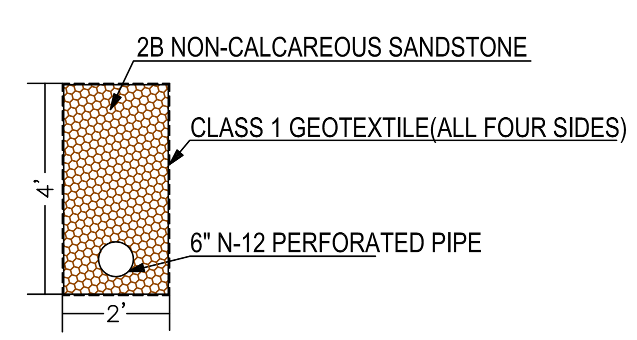


NOTE:
Pipe schematic drawn looking southerly towards the discharge and flush pipes.

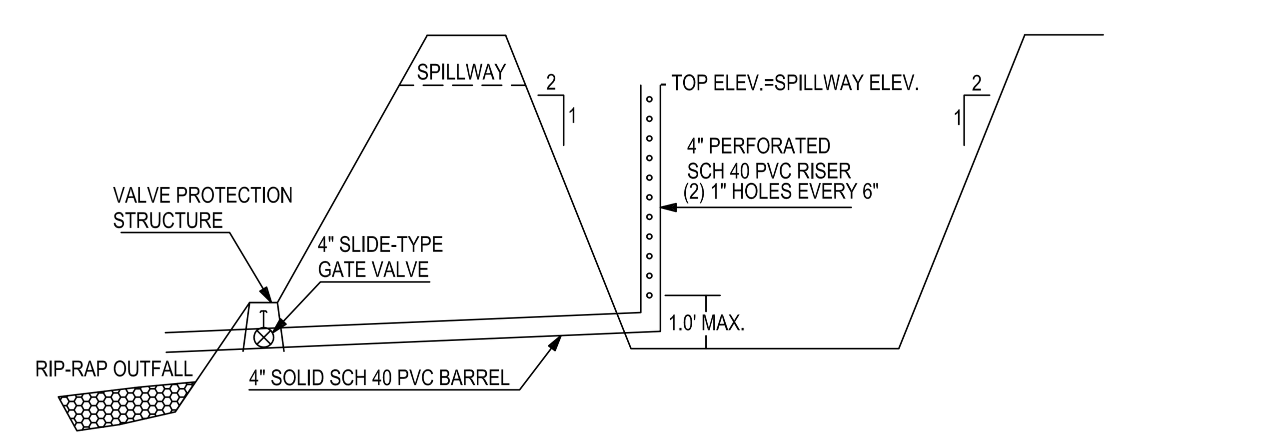
Layer: L - Lower Tier, U - Upper Tier
Quadrant: Corresponds to VFP labels



SCALE: 1" = 1'
ADJUSTABLE OUTLET RISER TYPICAL



B1 SUBSURFACE COLLECTION SYSTEM SECTION
(NOT TO SCALE)



4" DRAW DOWN DEVICE TYPICAL
(NOT TO SCALE)

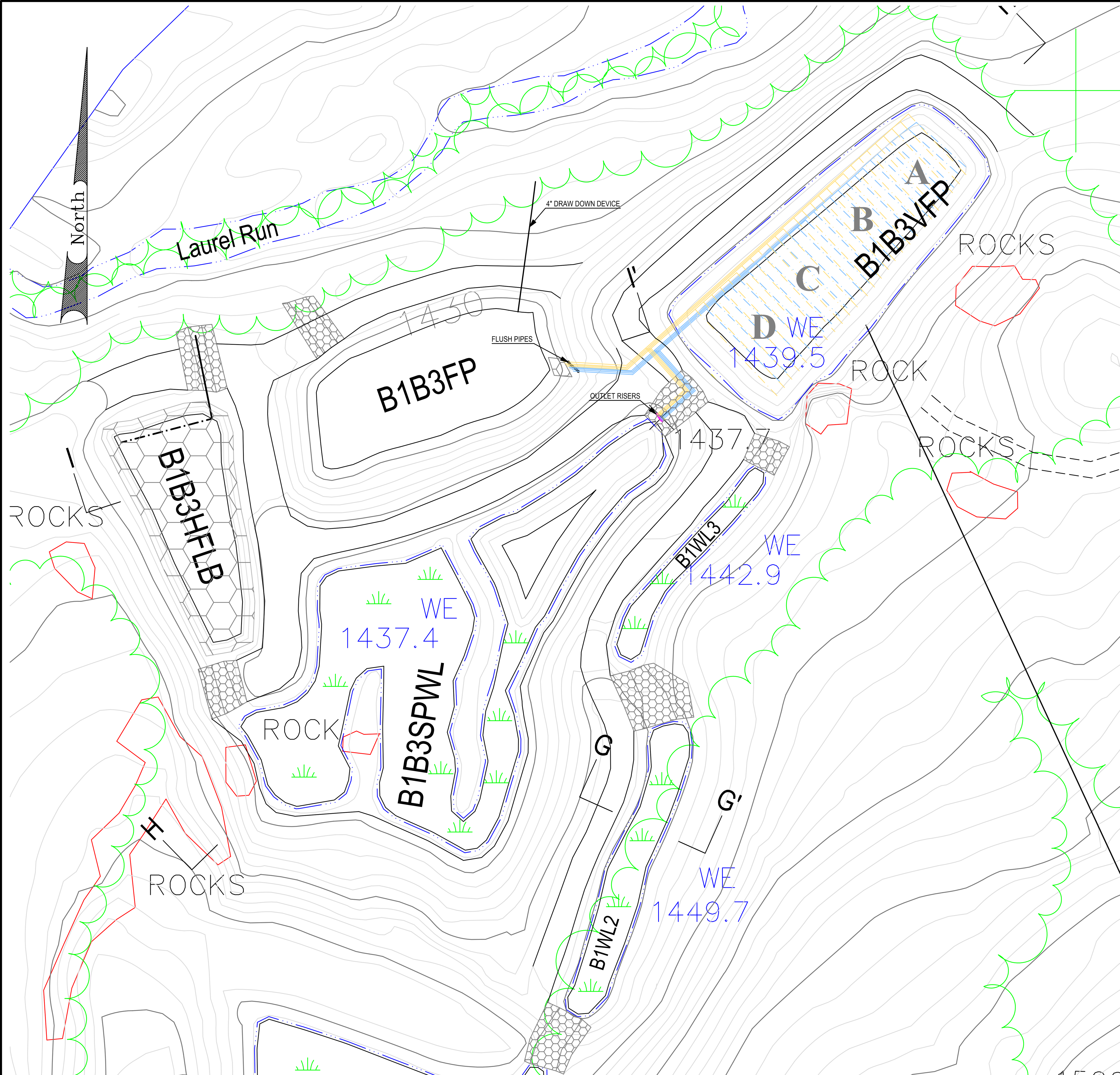
Draft:
Plan to be revised to depict recently-completed and scheduled future upgrades.

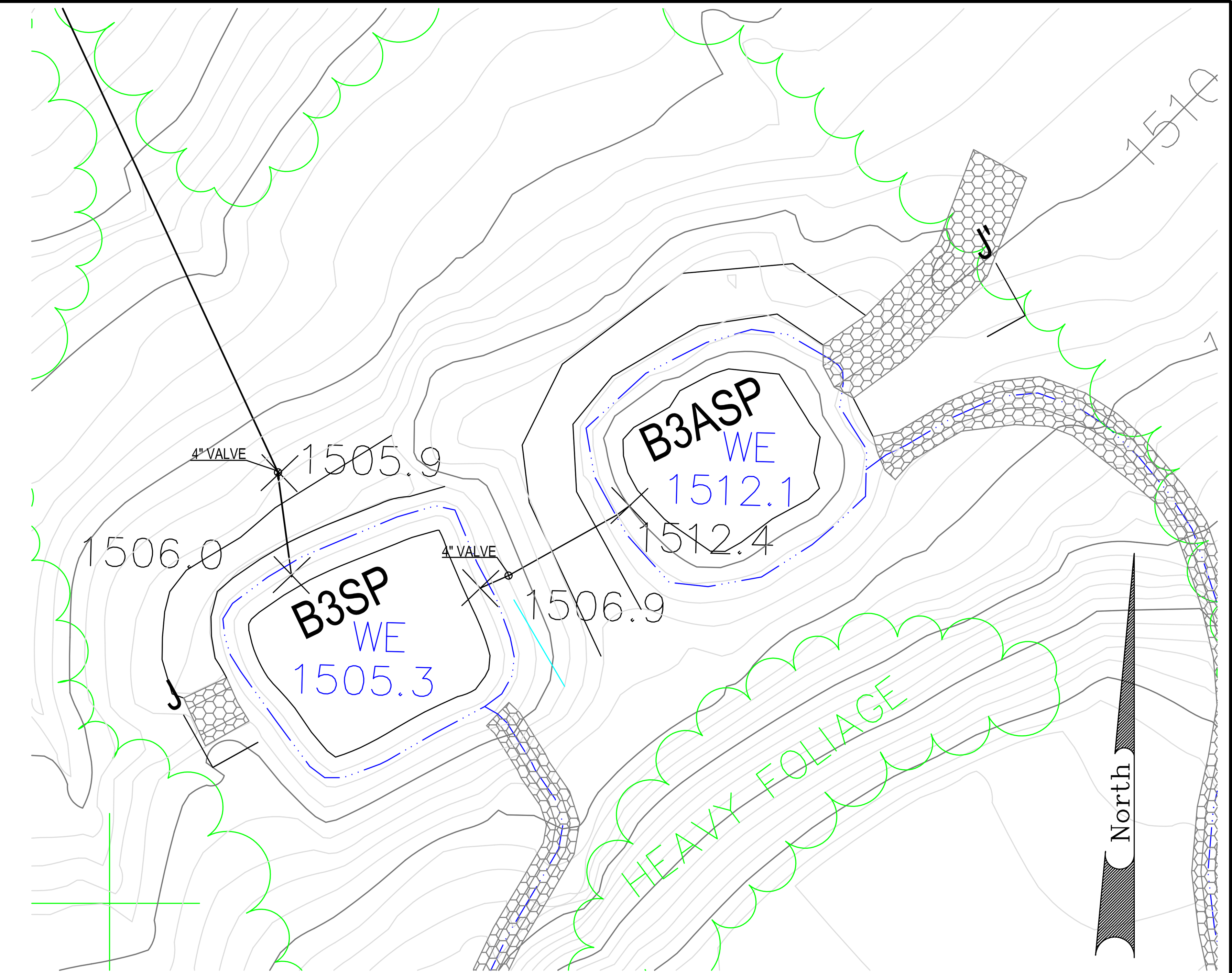
30 15 0 30 60

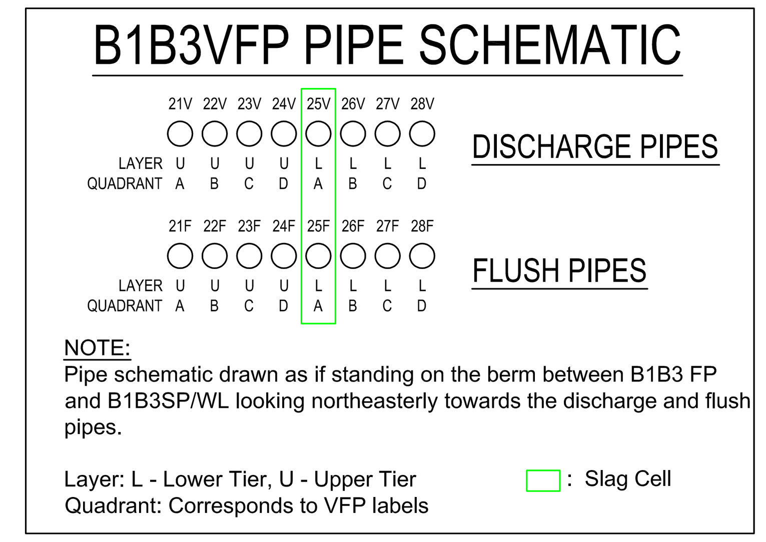
SHEET 3 OF 4

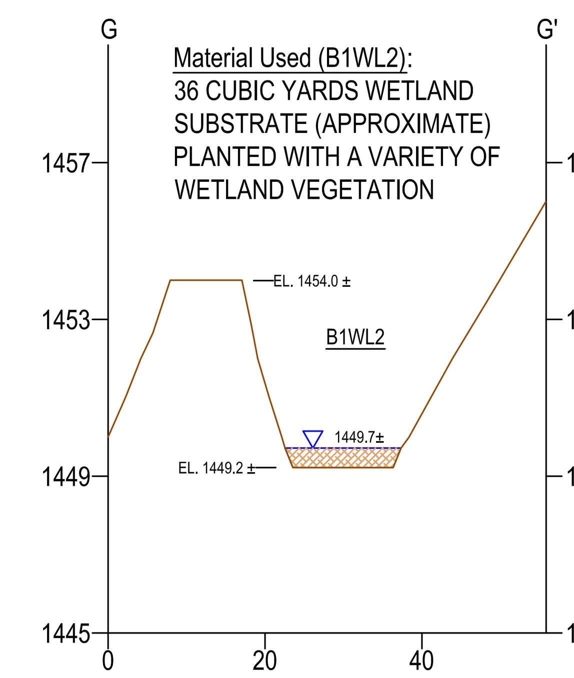
AS-BUILT PLANS - B1 SYSTEM
HARBISON WALKER PHASE II
Laurel Run Watershed Initiative
STREAM RESTORATION INCORPORATED
situate in
Ohiopyle State Park
Stewart Township, Fayette County, PA
Scale: 1" = 30' Date: 6/2003
BioMost, Inc., Cranberry Twp., PA

103503\Harbison Walker II As-Built\B1

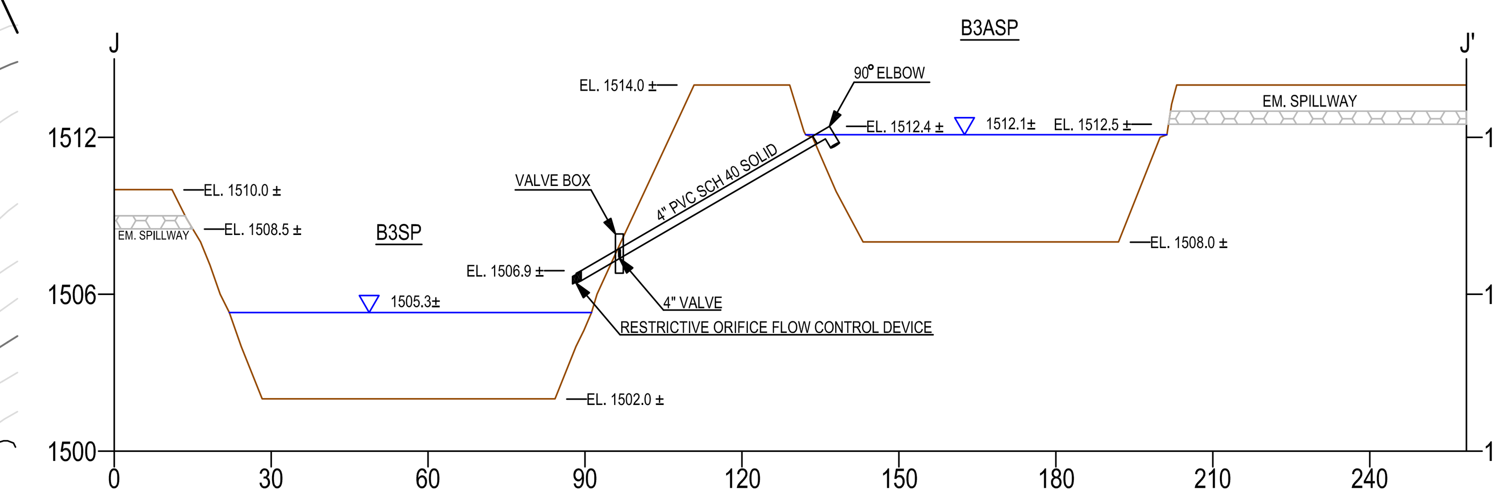




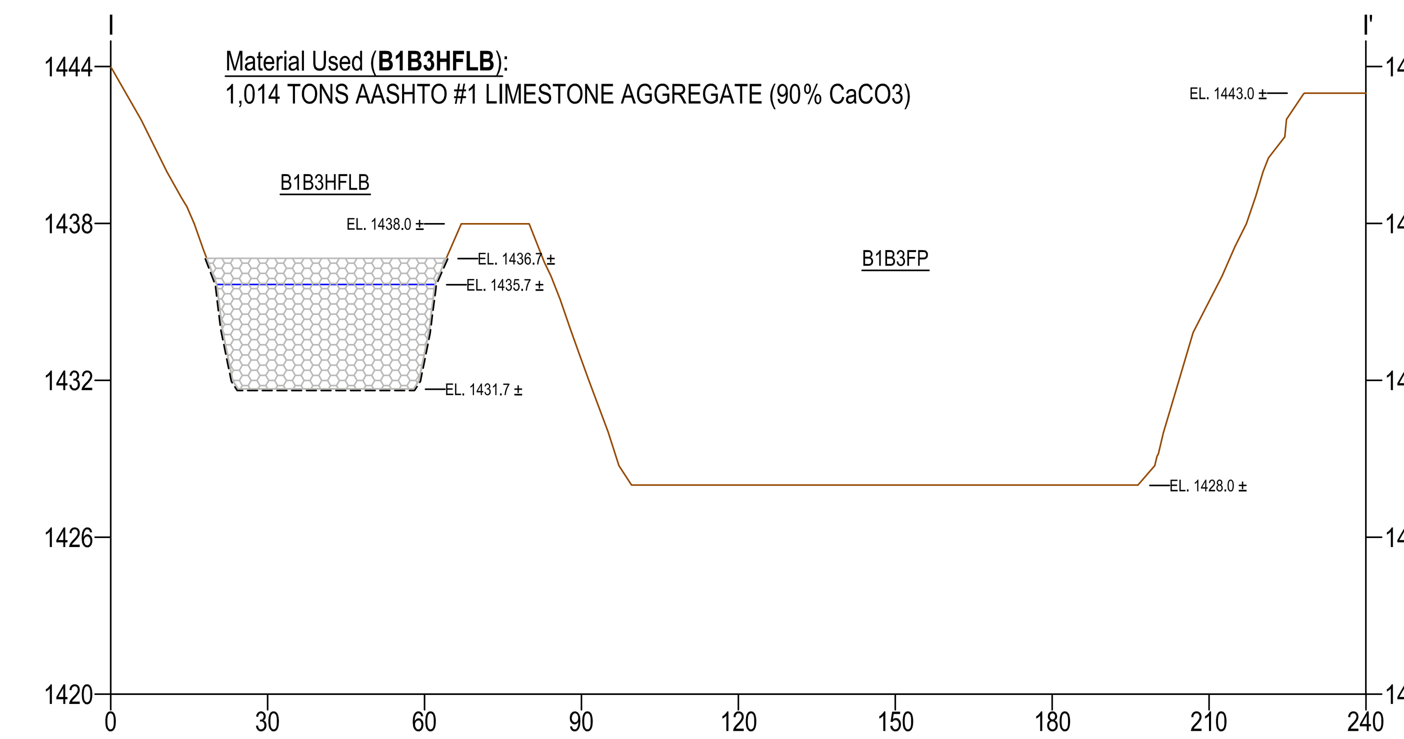




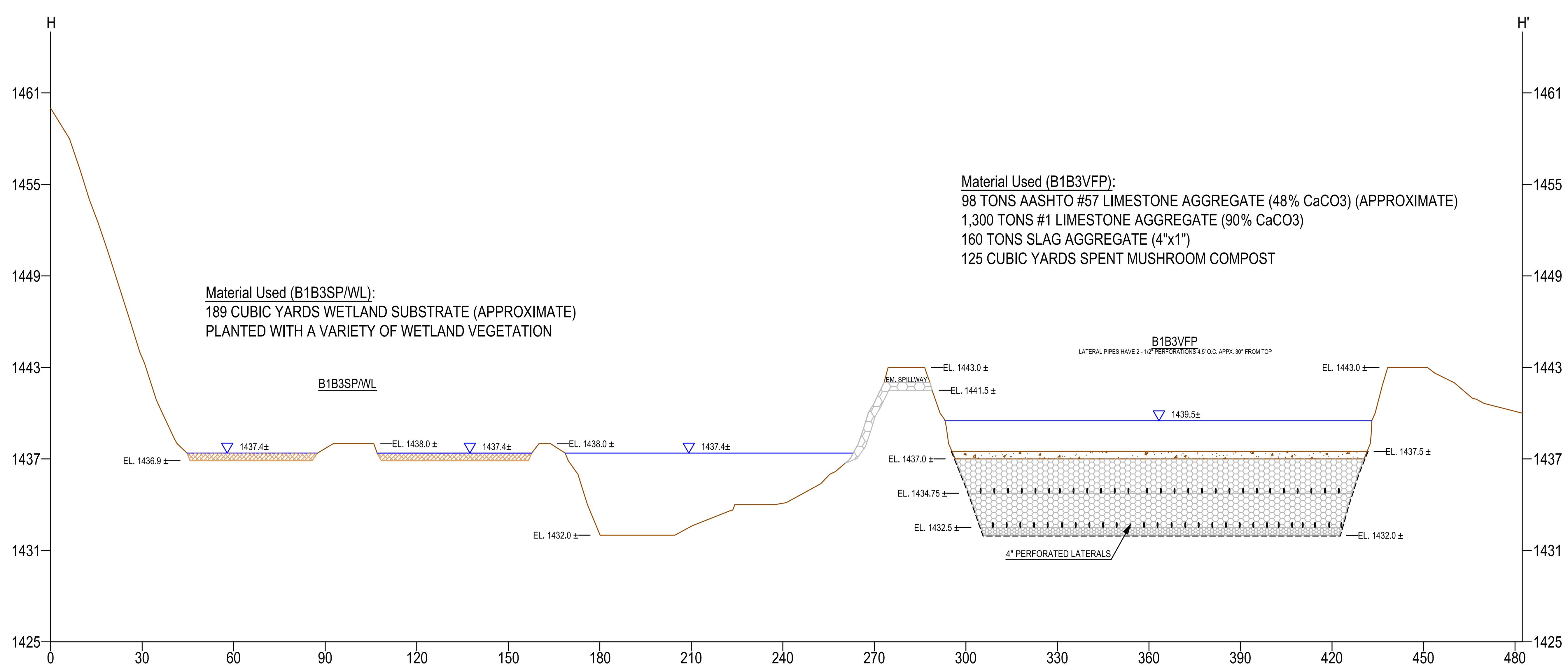
SECTION G - G'
SCALE: 1" = 20' HORIZONTAL
SCALE: 1" = 4' VERTICAL



SECTION J - J'
SCALE: 1" = 30' HORIZONTAL
SCALE: 1" = 6' VERTICAL



SECTION I - I'
SCALE: 1" = 30' HORIZONTAL
SCALE: 1" = 6' VERTICAL



SECTION H - H'
SCALE: 1" = 30' HORIZONTAL
SCALE: 1" = 6' VERTICAL

LEGEND

- PASSIVE SYSTEM COMPONENT
- CONTOUR - INDEX
- CONTOUR - INTERMEDIATE
- WATER
- ROAD
- OUT BUILDING OR OTHER STRUCT.
- TREELINE
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- 6" PVC SCH 40 PERFORATED
- 4" PVC SCH 40 SOLID
- ×1213.6 SPOT ELEVATION
- A A' AS BUILT CROSS SECTION
- GROUND SURFACE
- GEOTEXTILE
- LIMESTONE (AASHTO #57)
- LIMESTONE (AASHTO #1)
- RIP RAP (R-4)
- SPENT MUSHROOM COMPOST
- WETLAND SUBSTRATE

Notes:
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30 15 0 30 60

Draft:
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SHEET 4 OF 4

AS-BUILT PLANS - B1B3 SYSTEM
HARBISON WALKER PHASE II
Laurel Run Watershed Initiative
STREAM RESTORATION INCORPORATED
situate in
Ohiopyle State Park
Stewart Township, Fayette County, PA
Scale: 1" = 30' Date: 6/2003
BioMost, Inc., Cranberry Twp., PA

103503/Harbison Walker II As-Built/B1B3