

**West Virginia Water Research Institute  
West Virginia University**

**Program Evaluation Report  
Fiscal Years 2003 – 2007**

*Submitted by*

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*Submitted to*

**Office of External Research  
Water Resources Discipline  
U.S. Geological Survey**

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## Preface

The West Virginia Water Research Institute receives an annual Federal matching grant as authorized by section 104 of the Water Resources Research Act of 1984 (Public Law 98-242) as amended by Public Laws 101-397, 104-147, 106-374, and 109-471. Section 104 of the Act requires that the Secretary of the Interior “conduct a careful and detailed evaluation of each institute at least once every 3 years to determine that the quality and relevance of its water resources research and its effectiveness at producing measured results and applied water supply research as an institution for planning, conducting, and arranging for research warrants its continued support under this section.” The U.S. Geological Survey (USGS), Department of the Interior, administers the provisions of the Act. This evaluation report describes, in the format prescribed by the USGS, the research, training, and information transfer activities supported by the section 104 grants and required matching funds in fiscal years 2003 through 2007. Prior to 2007, the Act required an evaluation of the program at least once every 5 years. The last evaluation was conducted in 2004, covering fiscal years 1998 through 2002.

**WEST VIRGINIA WATER RESEARCH INSTITUTE  
EVALUATION REPORT  
FY 2003 – FY 2007**

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**WEST VIRGINIA WATER RESEARCH INSTITUTE  
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**INTRODUCTION**

The Water Resource Issues and Problems of West Virginia

The West Virginia Advisory Committee for Water Research advises the West Virginia Water Research Institute regarding water issues of concern for the state. The Advisory Committee considers input from State and Federal agencies, researchers, the private sector, watershed associations, citizens groups, and the public. The identified issues become research priorities for USGS 104b program requests for proposals (RFP's) released by the WVVRI to state colleges and universities.

The USGS 104B section is an opportunity to support exploratory seed projects to address current and new issues. The WVVRI works closely with state agencies, industry, and others to address issues of concern by conducting research, site visits, field studies, laboratory analyses, technical assistance, and outreach.

The West Virginia Water Research Institute: An Overview

Established in 1967 under Federal legislation carried out by the USGS, the West Virginia Water Research Institute (WVVRI) performs research related to water issues in the state. However, WVVRI's work reaches beyond the borders of West Virginia to help the nation. In fact, the WVVRI is recognized as an international leader in the development of watershed remediation tools and technologies.

The WVVRI provides services in the areas of project development, research, information transfer, outreach, project management, and technical support. By maintaining close communication with our customers (state and federal agencies, industry, private foundations, and watershed associations) we develop proposal-development teams to compete for large-scale environmental research programs.

With diversified funding and support, the WVVRI develops strong, multi-disciplinary research teams by collaborating with various West Virginia University (WVU) colleges and divisions, other higher education institutions, and private firms and consultants. This team approach brings the best expertise available to address the State's water issues. It also allows the WVVRI to perform research in a number of areas at any given time.

The WVVRI is dedicated to the development and delivery of environmental technologies needed by West Virginia's agencies, industry, and the public to remedy historic pollution and minimize new sources of water pollution while maintaining economic competitiveness. The WVVRI also collects and analyzes water and soil

samples to obtain data and provide information needed to make good policy and promulgate sound regulations.

Research findings are disseminated through reports, personal contacts, site visits, publications, web sites, and press releases. The WVWRI supports focused workshops and conferences on water remediation issues. The WVWRI also develops and releases RFP's supported by the USGS 104B section and other sources to conduct environmental research projects and information transfer initiatives.

By focusing on clear project objectives, quality assurance, following sound management practices, and delivering successful cost-effective results, a competitive position with our customers is maintained. In essence, the WVWRI serves as the State's "Go-To" entity for resolving environmental-related issues that arise.

### Mission Statement

*Preserving and restoring the natural environment through research and partnerships with industry, government agencies, academia, and the public.*

### Structure

The WVWRI is a division of the National Research Center for Coal & Energy (NRCCE) at West Virginia University (WVU). Between 2003 - 2007, the WVWRI was comprised of five major programs: The Water Research Program (which includes the USGS 104 program); National Mine Land Reclamation Center; Combustion Byproducts Recycling Consortium; National Environmental Education and Training Center; Hydrology Research Center. During this timeframe, a new program was initiated: the Northern West Virginia Brownfields Assistance Center. The WVWRI consists of thirteen full time staff, one part time staff, and three student workers. All are directly engaged in research projects with the exception of three administrative staff.

### Strategy

The Director and staff of the West Virginia Water Research Institute aggressively search for funding opportunities from Federal and State agencies and the private sector. These funds are used to support specific programs and projects (research and information transfer), are used to match USGS 104b cost share requirements, and cover administrative costs.

The WVWRI strategy relies on using the USGS 104B Section funding to develop competitive capabilities that, in turn, translate into successful proposals funded by a broad spectrum of Federal and State agencies. Over the evaluation period, the WVWRI has successfully leveraged monies against USGS 104B Section monies at a ratio of about 21:1.

The WVWRI strategy also relies on maintaining a broad cadre of researchers within WVU and other institutions throughout the State. We also work with faculty from institutions across the country to form competitive research partnerships. Since West Virginia University (WVU) is the State's flagship research institution, its researchers have played the dominant role. During the evaluation period, 18 research faculty and staff members and 29 students have been supported by USGS 104B Section funds. WVWRI's funding strategy relies on successful competition for Federal dollars while teaming with State agency and industry partners. The latter provide test sites, in-kind support and invaluable background data.

### Accomplishments

1. Assistant Professor, Todd Petty, whose studies to establish biological and water quality criteria for managing watersheds impacted by mining operations which were initially supported by the USGS 104B Section were further supported by the USEPA with a \$600,000 STAR award.
2. WVWRI research led the WVDEP to use our Institute and planning technology to implement the reauthorized Abandoned Mine Land Program's set aside funds for watershed remediation. This is a fund that will be used to systematically evaluate and remediate priority watersheds that are impacted by historic mine drainage.
3. WVWRI research on stream mitigation banking was presented to the WV Legislature and we have been directed to work with the Natural Resources Conservation Services, U.S. Army Corps of Engineers and WVDEP to incorporate our approach into a mitigation banking framework for the state
4. WVWRI research and organizational capability led to the creation by the WV Legislature of Brownfield Assistance Centers to help communities gain access to brownfield development opportunities. Two were created and WVWRI manages the northern center.
5. USGS 104B Section monies have been leveraged with other funding sources at a ratio of 21:1.

WVWRI accomplishments between FY2003 – FY2007 outside the USGS 104 program can be found in *Additional Information for the Evaluation Panel* in the last section of this report.

### Section 104 Objectives

WVWRI's objectives are to continue growing the Institute as the premier water research center in West Virginia; to support new assistant professors in related disciplines grow research programs; and to support student training in research methods, field and laboratory testing, and disseminating results both written and orally.

The following problems of concern to West Virginia are of primary interest and were used as research priorities for U.S. Geological Survey (USGS) 104b program FY2007 requests for proposals (RFP's) distributed to the State's academic colleges and

universities: **energy production impacts on water resources** (oil and gas drilling; hydroelectric; biofuels; etc.); **nutrient reduction/nutrient control/sources of air deposition**; **mercury** (informational fact sheets); **valley fills** (viability of fill areas for community uses; protect as a water source; how to handle sewage); **flooding**; **aquatic ecosystem integrity** (anti-degradation, water quality criteria, nutrient/pathogen impacts, headwater stream valuation/mitigation); **water metrics** (methods for measuring physical, chemical, biological components, in situ monitoring, PPCP's, pathogens in drinking water); **uses for mine water discharge** (drinking water potential for underground mine pools, irrigation, industrial heating/cooling); **industrial processes and urban sprawl** (water budgets, contaminants, flooding, ground-water recharge, storm water applications); and **evaluation of water resources** (uses).

Water resource issues and problems previously identified are revisited each year by the West Virginia Advisory Committee for Water Research and evaluated as to their current relevance. The resultant list of issues serve as the basis of setting research priorities for the RFP issued by the WVVRI in the fall for submission to the U.S. Geological Survey 104b base grant program.

The WVVRI strives to use the USGS 104b base grant program as an opportunity to encourage new initiatives by new researchers within the State to help launch larger more widespread projects funded by other Federal and State agencies. Examples of some success stories to this effect are included in this report.

The WVVRI has aggressively and successfully located other sources of funding in addition to the USGS 104b grant program to fund various research projects to address many of the areas of concern listed above. Information on these various projects is included in this report.

The following is an estimate of the percentage of the total of WVVRI's 104B (base) grant and required matching funds that was, on average, allocated to each of the following areas between FY2003 - FY2007.

<b>Allocation of Federal Grant and Matching Funds Among Program Activities (Percent): FY2003 – FY2007</b>	
Research	40
Information Transfer	7
Education	9
Administration	41
Other (Equipment)	3
Total	100

## INSTITUTIONAL SUPPORT AND EFFECTIVENESS

### Discretionary Base Funding

Between 2003 and 2007, the WVVRI has received \$453,840 from the USGS through the 104b program. Most of these funds are dispersed to water research projects throughout the state. A portion of these funds supports information transfer initiatives and administrative support. In addition, between 2003 and 2007, the WVVRI has received \$815,509 from the State of West Virginia. These funds are used primarily for cost-share on research proposals submitted to various federal and state agencies, including the USGS 104B Section. Between 2003 and 2007, the WVVRI provided \$989,767 in matching funds to the USGS 104B Section. The West Virginia Higher Education Commission also provided \$400,000 in 2006 and 2007 to the WVVRI to support the Northern WV Brownfields Assistance Center.

<b>Appropriated or Other Discretionary Funds Available to the Institute: FY2003 – FY2007</b>					
Source of Discretionary Funds	2003	2004	2005	2006	2007
State of West Virginia	\$153,658	\$157,911	\$157,911	\$173,904	\$172,125
West Virginia Higher Education Commission				\$200,000	\$200,000

### Other Water Resources Research Funding

The WVVRI has also received other Federal and external support to assist in funding water-related research projects. Between FY2003 and FY2007, the WVVRI has received support from the following federal agencies:

- U.S. Geological Survey
- U.S. Environmental Protection Agency
- U.S. Department of Agriculture
- U.S. Department of Energy – Morgantown Energy Technology Center
- U.S. Department of Energy - National Energy Technology Laboratory
- U.S. Department of Interior - Office of Surface Mining

In addition, the following have contributed cash and/or in-kind services to projects managed by the WVVRI:

- West Virginia Department of Environmental Protection
- West Virginia Higher Education Commission
- Wheeling Jesuit University NTTC
- EPRI
- Michigan Technical University
- NEETC

- Friends of Cheat
- GWWF
- Boxley Materials
- Parsons
- Lincoln County Commission
- Marshall University
- West Virginia Department of Health & Human Resources
- Consol of Kentucky
- RDS

The following table reflects the total dollar value of all grants (other than USGS 104 grants), contracts, and cooperative agreements for which the Director or staff of the Institute played a major role in assembling the proposal or otherwise obtaining the grant or contract; the total number of such awards; and the average value of these awards.

<b>Total and Average Value of Water Resources Grants, Contracts, and Cooperative Agreements in Which the Institute Had a Major Role During the Evaluation Period: FY2003 – FY2007</b>	
Total Value of Awards	\$9,455,465
Number of Awards	59
Average Value of Awards	\$160,262

The following table shows the 10 largest awards (other than USGS 104 grants), contracts, and cooperative agreements for which the Director or staff of the Institute played a major role in assembling the proposal or otherwise obtaining the grant or contract. Included are the dollar amount of the contract, grant, or cooperative agreement, the year that it was initiated, and the source of the funds. USGS-Water Resources Research Institute Internships are non-applicable for the WVVRI.

<b>The Ten Largest Water Resources Grants, Contracts, and Cooperative Agreements in Which the Institute Had a Major Role during the Period of the Evaluation: FY2003 – FY 2007</b>			
Title/Topic	Source of Funds	Year Initiated	Amount
A Hierarchical Classification System for Identifying Restoration Priorities and Impact Vulnerability in Mined Watersheds of the Mid Atlantic Highlands	U.S. Environmental Protection Agency	2004	\$607,566
Development and Implementation of a Water Quality Bank & Trade Program for the Potomac River Watershed, WV	U.S. Department of Agriculture	2006	\$527,071
Strategy for Restoring West Virginia	West Virginia	2007	\$472,148

Streams Impaired by Historic Acid Mine Drainage: Technical Support of WVDEP Implementation of AML	Department of Environmental Protection		
Improving the Safety of Coal Slurry Impoundments	Wheeling Jesuit University	2003	\$435,040
Design and Installation of Passive Acid Mine Drainage Treatment System in Impacted Tributaries of the Lower Cheat River Watershed	West Virginia Department of Environmental Protection	2004	\$420,773
Lower Cheat Watershed Passive Treatment Installation: Middlefork of Greens Run, Morgan Run and Pringle Run	West Virginia Department of Environmental Protection	2005	\$408,605
Well Injection Depth Extraction (WIDE) Phase II Deployment at the Former Lockbourne AFB	National Environmental Education Technical Center	2003	\$392,181
Environmental Forensics for Location of Unexploded Ordnance at the Dolly Sods Wilderness Area	National Environmental Education Technical Center	2007	\$368,181
Phase III Well Injection Depth Extraction (WIDE) Full-Scale Demonstration at the Former Lockbourne AFB	Marshall University	2005	\$348,483
Abandoned Mine Pool Flooding of the Pittsburgh, Ohio and Irwin Basins	U.S. Department of Energy-National Environmental Technology Laboratory (Parsons)	2003	\$339,997
Total			\$4,320,046

## USGS 104B SECTION RESEARCH PROGRAM

### Research Projects

Title	WRI-47: Establishing Biological and Water Quality Criteria for Water Resource Management in Mining Impacted Watersheds
Project Number	2002WV6B
Start Date	March 1, 2002
End Date	February 28, 2006
Research Category	Biological Sciences
Focus Categories	Water Quality, Ecology, Management and Planning

Principal Investigators		
Name	Rank During Project Period	Affiliation
J. Todd Petty	Assistant Professor	Forestry-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04	\$36,746	\$110,531		
FY-05			USEPA	\$600,000
FY-06				
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes  X  No \_\_\_). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate	1	
Masters	1	
Ph.D.	1	1
Post Doctoral	No	

Publications	
Publication Type	Publication Citation
Journal Article	Merovich, Jr., G. T., and J. T. Petty. 2007. Interactive effects of multiple stressors and restoration priorities in a mined Appalachian watershed. <i>Hydrobiologia</i> 575:13-31.
Conference Proceedings	Petty, J. T., and J. Barker. 2004. Water quality variability, trace metals, and implications for restoring a mined Appalachian watershed. <i>Proceedings of the American Society of Mining and Reclamation</i> 21:1484-1504.
Ph.D. Dissertation	Merovich, Jr., G. T. 2007. Stream water quality and benthic macroinvertebrate ecology in a coal-mining, acid sensitive region. PhD Dissertation. West Virginia University, Morgantown, WV.

#### Awards and Achievements:

Dr. Petty received the West Virginia University Division of Forestry Hoyt Outstanding Faculty Award, May, 2004.

#### Additional Funding

##### *USEPA STAR Grant*

A proposal entitled *A Hierarchical Classification System for Identifying Restoration Priorities and Impact Vulnerability in Mined Watersheds of the Mid Atlantic Highlands* was submitted to EPA's STAR grant program in January, 2003. In August, 2003, the WVWRI received word from the Environmental Science Research Division of EPA that "EPA's National Center for Environmental Research will be making a recommendation to the Grants Administration Division (GAD) to fund [this] research proposal." The award was received in February, 2004. This \$600,000 grant from the USEPA was received to continue research needed to fully recover mined watersheds; research initiated with the USGS104B Section grant.

Information Transfer:

Petty, J. T. Ecological Considerations for Water Quality Trading Program. Special Meeting of the Cheat TMDL/Water Quality Trading Stakeholder Group, Morgantown, WV. 2004.

Petty, J. T. Integrating Ecological Indices into Water Quality Trading Programs. Annual Meeting of the Electrical Power Research Institute, Environmental Management, San Antonio, TX. 2003.

Petty, J. T. Temporal Variability in Water Quality in a Mined Appalachian Watershed. Annual Meeting of the WV Advisory Committee for Water Research, Stonewall Jackson Resort and Conference Center, Roanoke, WV. 2004.

Petty, J. T., and J. E. Barker. Water Quality Variability, Trace Metals, and Implications for Restoring a Mined Appalachian Watershed. Annual Meeting of the American Society of Mining and Reclamation, Morgantown, WV. 2004.

Title	WRI-48: Impact of Longwall Mining on Headwater Streams in Northern West Virginia
Project Number	2002WV5B
Start Date	March 1, 2002
End Date	February 28, 2006
Research Category	Water Quality
Focus Categories	Water Quality, Treatment

Principal Investigators		
Name	Rank During Project Period	Affiliation
Ben Stout	Associate Professor	Biology-Wheeling Jesuit University

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04	\$17,568	\$31,753		
FY-05				
FY-06				
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). If yes, describe the funding period, source and amount in the funding table.

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate	8	
Masters	1	
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
Proceedings Technical Workshop	Stout, Ben M. III. 2003. <i>Longitudinal profiling of headwater streams</i> , pp. 77-94. In Penrose, D., and L. Eaton. <u>Functions of Intermittent Streams</u> . Technical Information Workshop. North American Benthological Society. Athens, GA. 108p.
Published abstract	The perennial fauna of "intermittent" Appalachian streams. 50 <sup>th</sup> annual meeting of the North American Benthological Society. Pittsburgh, PA. ( <i>Bull. N. Am. Benthological Soc.</i> 19(1):143-4, abstract) June 2, 2002.
Published abstract	Effects of longwall mining on the diversity, longevity, and functionality of benthic macroinvertebrate communities in headwater streams. 51 <sup>st</sup> annual meeting of the North American Benthological Society. Athens, GA. May 29, 2003 ( <i>Bull. No. Am. Benthological Soc.</i> 20(1):210 abstract)

### Awards and Achievements

Ben Stout received the Environmental Stewardship Award, 2007, North American Benthological Society

Title	WRI-54: Passive Treatment of CI Contaminated Waters in Northwestern West Virginia Using Passive Absorptive Technologies
Project Number	2003WV16B
Start Date	March 1, 2003
End Date	February 28, 2005
Research Category	Engineering
Focus Categories	Water Quality

Principal Investigators		
Name	Rank During Project Period	Affiliation
Thomas Guetzloff	Assistant Professor	West Virginia State College
Paul F. Ziemkiewicz	Director	WVWRI-West Virginia Univ.
James Mayhugh	Assistant Professor	West Virginia State College

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06	\$12,384	\$24,769		
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate	1	
Masters		
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation

Awards and Achievements

None.

Title	WRI-55: Hydrologic Connections and Impacts on Water Supply in the Great Valley Karst Aquifer: A Case Study in Martinsburg, WV
Project Number	2003WV15B
Start Date	March 1, 2003
End Date	February 28, 2006
Research Category	Climate and Hydrologic Processes
Focus Categories	Water Supply, Water Quantity, Water Quality

Principal Investigators		
Name	Rank During Project Period	Affiliation
Dorothy Vesper	Assistant Professor	Geology-West Virginia Univ.
Joseph Donovan	Associate Professor	Geology-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06	\$21,829	\$25,891	USDA	\$216,916
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes X No \_\_\_\_). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters	2	2
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
Journal Article	Vesper, D. J., R. V. Grand, K. Ward, and J. J. Donovan. 2009. Geochemistry and implications for structural control in a spring-dense karst watershed, the Appalachian Great Valley, West Virginia, USA. <i>Environmental Geology</i> 58(3): 667-678.
M.S. Thesis	Grand, Rachel. 2004. M.S. Thesis. A Study of the Karst Springs in the Tuscarora Creek Watershed, WV.
Report	Ward, K. M.S. Project Report. Characterization of the Chemical Response of an Urban Creek and Adjacent Spring to a Large Scale Recharge Event, Martinsburg, Berkeley County, WV.

### Awards and Achievements

Dorothy Vesper, Ph.D., Assistant Professor, Geology, WVU: Elected to the Board of Directors of the Karst Waters Institute.

### Information Transfer

Vesper, Dorothy. Karst and spring characteristics of the Appalachian Valley and Ridge Province. Keynote speaker at Growing Communities on Karst, Shepherdstown WV, 9/17/08

Grand\* RV, Vesper DJ, Donovan JJ (2006) Geochemistry in a spring-dense karst watershed and its relationship to structural patterns, Berkeley County, WV. Geological Society of America, Philadelphia PA, October

Grand\* RV, Vesper DJ (2005) Controls, characterization and small scale chemical variation of Tuscarora Creek watershed, Berkeley County, West Virginia. West Virginia Academy of Sciences, Morgantown WV, April.

Vesper, Dorothy. Berkeley Springs Festival of the Waters, February, 2004. The History, Mystery and Science of Springs

Vesper, Dorothy. 2004. Karst Spring Research at WVU: An Update on On-going Work. Presented at U.S. Geological Survey Great Valley Water-Resources Science Forum, May.

Vesper, Dorothy. October, 2004. Hydrogeochemistry of Karst Aquifers and Springs: Case Studies from Three WV Aquifers. Presented at 3<sup>rd</sup> Annual West Virginia Water Conference, Stonewall Resort and Conference Center, Roanoke, WV.

### Additional Funding

Dorothy Vesper, Principal Investigator, Development of a GIS Database and Assessment of Available Hydrogeologic Data for NCR (National Capital Region) Parks with Karst Geology. Funded by the National Park Service (\$19,993). July 1, 2009 – December 31, 2010.

Dorothy Vesper, Principal Investigator, Identifying Sustainable Water Sources in the Appalachians: Linking Geochemical and Microbial Signatures of Deep Water Flow. Funded by the West Virginia University Research Corporation PSCoR (Program to Stimulate Competitive Research; \$28,092). January 1, 2008 – December 31, 2009.

Assessing the vulnerability of sensitive karst habitats containing RTE [Rare, Threatened and Endangered] species in CHOH [Chesapeake and Ohio Canal National Historical Park]. Funded by the National Park Service National Capital Region. Role: PI, 10/10 – 9/12, \$219,264 (2-year budget)

Novel geochemical tools to predict and monitor the fate and impact of subsurface CO<sub>2</sub> Proposal to Dept. of Energy, National Energy Technology Lab. Role: PI, \$65,000 for 1/10 – 10/10. This proposal was submitted at NETL's request and is for a collaborative project with WVU, NETL and U. Pittsburgh.

Urbanization and climate change impacts on the Great Valley Karst Aquifer, West Virginia-Virginia. Funded by National Research Initiative Competitive Grants Program, U.S. Department of Agriculture and Cooperative State Research, Education and Extensive Service. Role: co-PI with J Donovan, 7/03 – 7/06, \$216,916

Water resources research initiative for Peters Mountain Aquifer. Funded by the WV Water Research Institute. Role: Joint with PI Joe Donovan, 3/04 – 9/06, \$12,000

Title	WRI-60: Changes to In-Stream Suspended Sediment and Turbidity Following Improvements to a Forest Road in West Virginia
Project Number	2004WV26B
Start Date	May 1, 2004
End Date	September 1, 2006
Research Category	Engineering
Focus Categories	Nonpoint Pollution, Sediments, Water Quality

Principal Investigators		
Name	Rank During Project Period	Affiliation
JX Wang	Assistant Professor	Forestry-West Virginia Univ.
Pamela Edwards	Adjunct Assistant Professor	U.S. Forest Service
Joseph McNeal	Director	Forestry-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06	\$25,060	\$50,230		
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters	1	1
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
None.	

Awards and Achievements

None.

Title	WRI-81: Systematic Determination of Water Resource Data and Information Management Needs in West Virginia
Project Number	2006WV79B
Start Date	March 1, 2006
End Date	January 1, 2007
Research Category	Social Sciences
Focus Categories	Management and Planning, Law, Institutions, and Policy, Water Use

Principal Investigators		
Name	Rank During Project Period	Affiliation
Tamara Vandivort	Program Coordinator	WVWRI-West Virginia Univ.
Richard Herd	Program Coordinator	WVWRI-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06				
FY-07	\$10,332	\$20,806		

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters	1	
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
None.	

### Awards and Achievements

None.

Title	WRI-82: In-Stream Turbidity and Suspended Sediment Changes Following Improvements to a Forest Road and Harvesting
Project Number	2006WV76B
Start Date	March 1, 2006
End Date	February 28, 2008
Research Category	Engineering
Focus Categories	Non-point Pollution, Sediments, Water Quality

Principal Investigators		
Name	Rank During Project Period	Affiliation
Jingxin Wang	Assistant Professor	Forestry-West Virginia Univ.
Pamela Edwards	Adjunct Assistant Professor	U.S. Forest Service
Joseph McNeel	Division Director	Forestry-West Virginia Univ.
Lawrence Osborn	Research Associate	Appalachian Hardwood Center-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06				
FY-07	\$14,498	\$30,281	U.S. Forest Service	\$33,355

This project received follow-on funding after completion as a section 104-funded project: (Yes X No \_\_\_). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters	2	2
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
M.S. Thesis	Sharp, William. 2007. Changes to In-stream Turbidity Following Construction of a Forest Road in a Forested Watershed in West Virginia.
M.S. Thesis	Hamons, Gregory. 2007. Modeling Sediment Movement in Forested Watersheds Using Hill-Slope Attributes.
Conference Proceedings	Wang, J.X. 2008. Effects of hill-slope attributes and road construction on sediment movement in forested watershed in West Virginia. Proceedings of ASABE Annual Meeting, Providence RI, June 29-July 2, 2008.

Awards and Achievements

None.

Additional Funding

J.X. Wang, Principal Investigator. Determining Factors Contributing and Controlling Sediment Delivery to Stream Channels-Monongahela National Forest. \$33,355.

Information Transfer

Wang, J.X. 2007. Changes to In-stream turbidity following construction of a forest road in a forested watershed in West Virginia. WV Water Conference 2007

Wang, J. X. The effects of forest management on water quality. Environmental Science and Forestry Department Lecture, State University of New York, Syracuse.

Title	WRI-83: Evaluation of the Environmental Hazard of Selenium in Coal-associated Rocks of the Southern West Virginia Coal Basin
Project Number	2006WV69B
Start Date	March 1, 2006
End Date	February 28, 2008
Research Category	Water Quality
Focus Categories	Toxic Substances, Hydrogeochemistry, Water Quality

Principal Investigators		
Name	Rank During Project Period	Affiliation
Ronald B. Smart	Professor	Chemistry – West Virginia Univ.
Jack Renton	Professor	Geology – West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06				
FY-07	\$15,706	\$34,098		

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). If yes, describe the funding period, source and amount in the funding table.

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.	1	1
Post Doctoral		

Publications	
Publication Type	Publication Citation
Journal article	Pumure, I., J. J. Renton, and R. B. Smart. 2010. Ultrasonic extraction of arsenic and selenium from rocks associated with mountaintop removal/valley fills coal mining: Estimation of bioaccessible concentrations. Chemosphere 78:1295-1300.
Journal article	Pumure, I., J. J. Renton, and R. B. Smart. 2009. Accelerated aqueous leaching of selenium and arsenic from coal associated rock samples with selenium speciation using ultrasound extraction. Environmental Geology 56:985-991.
Ph.D. Student Dissertation	Pumure, Innocent. 2006. Investigation of Selenium and Arsenic in Coal-mining Associated Rocks and Sediments Using Ultrasonic and Sequential Extractions Techniques.

Awards and Achievements

None.

Title	WRI-84: Chloride Sorption to AMD Solids
Project Number	2006WV81B
Start Date	March 1, 2006
End Date	February 28, 2008
Research Category	Engineering
Focus Categories	Water Quality, Treatment, Surface Water

Principal Investigators		
Name	Rank During Project Period	Affiliation
Louis McDonald	Associate Professor	Plant & Soil Science-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06				
FY-07	\$23,229	\$18,735		

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate	1	
Masters	1	
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
None.	

Awards and Achievements

None.

Title	WRI-96: Experimental Investigation into the Changes in Hydrologic and Environmental Quality Associated with Valley Fills
Project Number	2007WV96B
Start Date	March 1, 2007
End Date	February 28, 2009
Research Category	Climate and Hydrologic Processes
Focus Categories	Hydrology, Water Quality, Floods

Principal Investigators		
Name	Rank During Project Period	Affiliation
J. Todd Petty	Associate Professor	Forestry-West Virginia Univ.
Paul F. Ziemkiewicz	Director	WVWRI-West Virginia Univ.
James Stiles	Environmental Engineer	WVWRI-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06				
FY-07	\$29,314	\$65,962		

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters	2	
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
M.S. Thesis	Gingerich, G. 2009. Quantifying changes in ecological function of headwater catchments following large-scale surface mining in southern West Virginia. MS thesis. West Virginia University, Morgantown, WV.

### Awards and Achievements

None.

### Information Transfer

Minter, M. S., Merovich, Jr., G. T., and J. T. Petty. 2008. Poster. Flow variability, water quality, and organic matter processing in intensively mined headwater catchments in southern West Virginia. 2008. Spring Meeting, Southern Division of the American Fisheries Society, Oglebay Resort and Conference Center, Wheeling, WV, February 28-March 2.

Merriam, E., G. Merovich, and J. T. Petty. 2008. Poster. Factors influencing water quality and ecological condition in an intensively mined southern West Virginia Watershed. 2008 Spring Meeting, Southern Division of the American Fisheries Society, Oglebay Resort and Conference Center, Wheeling, WV. February 28-March 2.

Title	WRI-97: Chemical and Flow Characterization of Mining Impacted Streams Using Continuous Water Quality Monitoring and Watershed Modeling
Project Number	2007WV98B
Start Date	March 1, 2007
End Date	February 28, 2009
Research Category	Water Quality
Focus Categories	Water Quality, Surface Water, Models

Principal Investigators		
Name	Rank During Project Period	Affiliation
Jennifer Fulton	Research Associate	WVWRI-West Virginia Univ.
Brady Gutta	Research Associate	WVWRI-West Virginia Univ.
John Quaranta	Program Coordinator	WVWRI-West Virginia Univ.
Paul F. Ziemkiewicz	Director	WVWRI-West Virginia Univ.

Funding
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Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06				
FY-07	\$12,472	\$27,481		

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate	1	
Masters	2	2
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
Conference Proceedings	Skousen, J. and B. Mack. 2006. Water Quality from Above-Drainage Underground Mines over a 35 Year Period. Proceedings of the 2006 International Conference on Acid Rock Drainage. St. Louis, MO. 11 p.
M.S. Thesis	Mack, B. 2007. Water Quality Changes over Time in Upper Freeport and Pittsburgh Coal Mines in West Virginia. Master of Science Thesis. 81 p.
M.S. Thesis	Kamalesh, Joseph. 2008. Analysis of Wastewater Temperature Variations in Six Remote Monitored Onsite Systems.

#### Awards and Achievements

Ben Mack: National Association of State Land Reclamationists Scholarship Winner (2007)

Information Transfer

Mack, B. and J. Skousen. 2007. Water Quality from above Drainage Underground Mines over a 38 year period. Proceedings of the 2007 National Association of State Land Reclamationists National Conference. September 9-12, 2007. Asheville, NC.

Mack, B. and J. Skousen. 2007. Changes in Water Quality of 34 Above Drainage Mines in West Virginia. Proceedings of the 2007 American Society of Mining and Reclamation National Conference. June 3-6, 2007. Gillette, WY.

Title	WRI-99: Selenium Speciation and Removal
Project Number	2007WV105B
Start Date	March 1, 2007
End Date	February 28, 2008
Research Category	Water Quality
Focus Categories	Water Quality, Treatment, Surface Water

Principal Investigators		
Name	Rank During Project Period	Affiliation
Louis McDonald	Associate Professor	Plant & Soil Science-West Virginia Univ.
Richard Herd	Program Coordinator	WVWRI-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06				
FY-07	\$6,993	\$28,844		

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate	1	
Masters	1	
Ph.D.	1	
Post Doctoral		

Publications	
Publication Type	Publication Citation
None.	

Awards and Achievements

None.

Summary of USGS 104B Section Research Projects

The following table lists the number of research projects and the percentage of total research funds expended in each of the six categories over the evaluation period.

Number of Research Projects and Percentage of Research Funds by Research Category: FY2003-FY2007		
Research Category	Number	Percent of Funds
Biological Sciences	1	16.25
Climate and Hydrologic Processes	2	22.62
Engineering	4	33.24
Ground Water Flow and Transport	0	0
Social Sciences	1	4.57
Water Quality	4	23.32
Total	12	100

## Summary of USGS 104B Section Research Publications

The following table provides a count of the number of publications by category for USGS 104 projects.

Number of Research Publications, by Category of Publication: FY2003 – FY2007	
Publication Category	Number
Articles in Refereed Journals	8
Book Chapters	0
Theses and Dissertations	9
Water Resources Institute Reports	1
Articles in Conference Proceedings	4
Other Publications	0

### Most Significant Research

Significant Findings Resulting from Research Supported by the USGS 104 Section at the West Virginia Water Research Institute 2003-2007

#### **2002WV6B; WRI-47: Establishing Biological and Water Quality Criteria for Water Resource Management in a Mining Impacted Watershed**

This study quantified temporal variability in dissolved metals and other solutes within the lower Cheat River watershed as well as the relationships between water chemistry, water quality variability, and specific levels of ecological impairment. This type of information is critical when determining how best to design restoration programs in acid mine drainage impacted watersheds.

#### **2002WV5B; WRI-48: Impact of Longwall Mining on Headwater Streams in Northern West Virginia**

This study measured the extent of longwall mining impacts on headwater streams in northern West Virginia and addresses the question: do streams recover? Findings indicated longwall mining resulted in a net loss of approximately one-half of all headwater streams in Marshall County, West Virginia. Streams were particularly impacted near the source, and most re-emerged downstream. Macroinvertebrate abundance appeared to recover to reference conditions in the lower reaches of longwall mined streams, however, neither diversity nor longevity of the macroinvertebrate community recovered along the stream gradient. There was no indication that the physical, chemical, or biological impacts of longwall mined streams recover over time.

### **2006WV69B; WRI-83: Evaluation of the Environmental Hazard of Selenium in Coal-Associated Rocks of the Southern West Virginia Coal Basin**

The U.S.EPA has detected selenium (Se) in mine drainage waters in southern West Virginia above the current water quality limit of 5 µg L. Most traditional batch extraction methods for measuring selenium utilize lengthy mechanical shaking or soxhlet extractions that may take hours or days for a single extraction to be performed. For the ultrasound method tested in this study, a five-minute application of ultrasound energy to a pulverized rock sample mixture in a 1:10 solid to solution ratio was found to produce useful results for a single extraction. It was determined that ultrasound dissolution is a useful tool for the kinetic extraction of arsenic and selenium and the speciation of selenium from coal-associated rocks.

### **2007WV96B; WRI 96: Experimental Investigation into the Changes in Hydrologic and Environmental Quality Associated with Valley Fills**

This project sought to quantify spatial and temporal variation in organic matter processing within Pigeon Creek, an intensively mined sub-watershed of the Tug Fork River in southern West Virginia. It determined that organic matter decomposition rates were variable, but unrelated to any environmental factors measured. Drainage area, channel complexity, and mining had a significant interactive effect on transport distance of leaves and sticks. Sites below valley fills had enhanced flow levels which resulted in higher transport levels. These results add to our understanding of complex interactive effects of mining on stream ecosystem functions and our ability to compensate for lost headwater functions through restoration actions downstream.

### **2007WV105B; WRI-99: Selenium Speciation and Treatment on Mountaintop Mines**

Selenium (Se) has been detected in mine drainage waters in southern West Virginia above the current water quality limit of 5 µg L. Although an essential element, Se has a very small threshold between essentiality and toxicity. Because the current water quality standard for Se is written as total Se, that is what commercial laboratories provide, however, toxicity and treatment system design and efficiency depend on Se speciation. This study determined a relatively inexpensive, reliable FI-HG-ICP method to speciate Se which will be valuable for research, regulatory, and treatment design needs.

#### Most Distinguished Grant Recipients

**Paul Ziemkiewicz**, Director, WV Water Research Institute

- 2005 Environmental Conservation Distinguished Service Award, Presented by the Society for Mining, Metallurgy and Exploration
- 1985 E.M. Watkin Award for Outstanding Contribution to the Betterment of Land Reclamation in Canada, Presented by The Canadian Land Reclamation Association.

**Todd Petty**, Associate Professor, Forestry, West Virginia University

- 2004 West Virginia University Division of Forestry Hoyt Outstanding Faculty Award

### Summary of Awards

The following is a list of follow-on funding received by three researchers initially supported with USGS 104B Section funds. All were ranked Assistant Professor when they received USGS funds. Two of the three have achieved Associate Professor status.

#### *USEPA STAR Grant*

A proposal entitled *A Hierarchical Classification System for Identifying Restoration Priorities and Impact Vulnerability in Mined Watersheds of the Mid Atlantic Highlands* was submitted to EPA's STAR grant program in January, 2003. In February, 2004, the WVWRI received an EPA award of \$600,000 to continue research needed to fully recover mined watersheds. This research was initiated with the USGS104B Section grant number 2002WV6B.

#### *National Park Service*

Dorothy Vesper received funding for the *Development of a GIS Database and Assessment of Available Hydrogeologic Data for NCR (National Capital Region) Parks with Karst Geology*. This project was funded by the National Park Service (\$19,993) and has a project period of July 1, 2009 – December 31, 2010.

Dr. Vesper also expects to receive funding for *Assessing the vulnerability of sensitive karst habitats containing RTE [Rare, Threatened and Endangered] species in CHOH [Chesapeake and Ohio Canal National Historical Park]*. This two year project (\$219,264) to be supported by the National Park Service National Capital Region is to run from October, 2010 – September, 2012.

#### *Program to Stimulate Competitive Research*

Dorothy Vesper also received funding to *Identify Sustainable Water Sources in the Appalachians: Linking Geochemical and Microbial Signatures of Deep Water Flow*. Funded by the West Virginia University Research Corporation PSCoR (Program to Stimulate Competitive Research, this \$28,092 project ran from January 1, 2008 – December 31, 2009.

#### *U.S. Department of Energy-National Energy Technology Laboratory*

Dr. Vesper is also receiving funding for *Novel geochemical tools to predict and monitor the fate and impact of subsurface CO<sub>2</sub>* from the U.S. Department of Energy--National

Energy Technology Laboratory. This project runs January-October, 2010 (\$65,000). The proposal was submitted at NETL's request and is for a collaborative project with WVU, USDOE-NETL and the University of Pittsburgh.

*U.S. Department of Agriculture*

Dr. Vesper also collaborated with Dr. Joseph Donovan, WVU on *Urbanization and climate change impacts on the Great Valley Karst Aquifer, West Virginia-Virginia*. This project (\$216,916) was funded by the National Research Initiative Competitive Grants Program, U.S. Department of Agriculture and Cooperative State Research, Education and Extensive Service and ran from July, 2003 to July, 2006.

*U.S. Forest Service*

Dr. J.X. Wang received funding (\$33,355) for *Determining Factors Contributing and Controlling Sediment Delivery to Stream Channels-Monongahela National Forest* from the U.S. Forest Service.

**INFORMATION TRANSFER PROGRAM**

WVWRI's Information Transfer Program from 2003-2007 consisted of sponsoring or co-sponsoring five state water conferences, further developing and maintaining an Institute web site, publications, articles, newsletters, brochures, press releases, fact sheets, and other forms of project dissemination. The following describe the water conferences supported with USGS 104 grant and matching funds.

Title	West Virginia Water Conference 2004
Project Number	2004WV31B
Start Date	March 1, 2004
End Date	February 28, 2005
Research Category	N/A
Focus Categories	Water Quantity, Water Quality, Water Use

Principal Investigators		
Name	Rank During Project Period	Affiliation
Tamara Vandivort	Program Coordinator	WVWRI-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04	\$11,168	\$18,331		
FY-05				

FY-06				
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). If yes, describe the funding period, source and amount in the funding table.

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate	1	
Masters	1	
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
None.	

Awards and Achievements

None.

Title	2005 State Water Conference
Project Number	2005WV54B
Start Date	March 1, 2005
End Date	February 28, 2006
Research Category	N/A
Focus Categories	Water Quantity, Water Use, Water Quality

Principal Investigators		
Name	Rank During Project Period	Affiliation
Tamara Vandivort	Program Coordinator	WVWRI-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05	\$14,844	\$31,141	Canaan Valley Institute; Registration fees	Unknown

FY-06				
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

The Canaan Valley Institute took the lead in this event. They contributed staff time and registration fees were collected to cover costs of the facility, food, and materials.

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
	_____ 2005. Revitalizing Communities through Integrated Restoration: Linking Social, Economic, and Natural Assets-- Answering Questions about Growing an Integrated Restoration Industry in the Highlands. 12 p.

Awards and Achievements

None.

Title	WRI-63: West Virginia Water Resources Inventory and Assessment
Project Number	2005WV52B
Start Date	March 1, 2005
End Date	February 28, 2006
Research Category	Climate and Hydrologic Processes
Focus Categories	Water Quantity, Water Use, Water Supply

Principal Investigators		
Name	Rank During Project Period	Affiliation
Richard Herd	Program Coordinator	WVWRI-West Virginia Univ.
Alyse Schrecongost	Research Associate	WVWRI-West Virginia Univ.
Paul Ziemkiewicz	Director	WVWRI-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05	\$54,092	\$128,568		
FY-06				
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
Report	Quarterly report to WVDEP working group on the WV Water Resources Protection Act, July, 2005.
Report	Quarterly report to WVDEP working group on the WV Water Resources Protection Act, Oct., 2005.
Report	Quarterly report to WVDEP working group on the WV Water Resources Protection Act, Jan., 2006.
Report	Quarterly report to WVDEP working group on the WV Water Resources Protection Act, Apr., 2006.
Report	Schrecongost, Alyse, Richard Herd, and Paul Ziemkiewicz. 2006. West Virginia Water Resources Inventory and Assessment. 39 p.

Awards and Achievements

None.

Information Transfer

Researchers reported quarterly to the West Virginia Department of Environmental Protection Working Group on the West Virginia Water Resources Protection Act.

Herd, R. S., and A. M. Schrecongost. 2005. Water as a commodity: Managing West Virginia water resources for economic development. West Virginia Manufacturers Annual Meeting, June 7, 2005. Morgantown, WV.

Schrecongost, A. M. 2005. West Virginia Water Resource Protection Act, Program Assessment and Management. Presentation to Jackson Kelly Water Resource Seminar. September 7, 2005. Charleston, WV.

Schrecongost, A. M. 2005. West Virginia Water Resource Protection Act, Program Assessment and Management Status Report. Presentation to Water Resources Committee of the West Virginia State Legislature. December, 2005. Charleston, WV.

Title	Water Conference 2006
Project Number	2006WV75B
Start Date	March 1, 2006
End Date	January 1, 2007
Research Category	N/A
Focus Categories	Water Quantity, Water Use, Water Quality

Principal Investigators		
Name	Rank During Project Period	Affiliation
Tamara Vandivort	Program Coordinator	WVWRI-West Virginia Univ.

Funding				
Funding Period	Federal 104 Funds	Required 104 Matching Funds	Other Funding	
			Source	Funds
FY-03				
FY-04				
FY-05				
FY-06	\$15,566	\$31,134	West Virginia Department of Health and Human Resources	\$5,000
FY-07				

This project received follow-on funding after completion as a section 104-funded project: (Yes \_\_\_ No X). *If yes, describe the funding period, source and amount in the funding table.*

Student Support		
Degree Level	Number of Students	Number of Dissertations/Theses
Undergraduate		
Masters		
Ph.D.		
Post Doctoral		

Publications	
Publication Type	Publication Citation
None.	

Awards and Achievements

None.

Publications

Two WVVRI brochures were produced during the evaluation period. Both were all-encompassing of the WVVRI and its related projects and programs. Copies are being mailed to John Schefter, USGS.

Audio-Visual Productions

In 2004, the WVVRI contracted an audio-visual specialist to create short film clips on the WVVRI and specific projects. The film clips were placed on the WVVRI web site and distributed via VHS and DVD. Copies were distributed at the 2004 State Water Conference, State and Federal agencies, researchers, and others. A short clip of one of the segments was aired on West Virginia Public Broadcasting. Copies of the DVD are being mailed to John Schefter, USGS.

Newsletter

The WVVRI does not produce an all-encompassing WVVRI newsletter. Rather, program specific newsletters are produced. Two examples are quarterly newsletters produced for the Combustion Byproducts Recycling Consortium (CBRC) and the Northern West Virginia Brownfields Assistance Center (NBAC). Both newsletters are free. The CBRC and NBAC distribution lists are approximately 600 and 200, respectively. USGS 104B Section funds support clerical assistance in producing and disseminating these newsletters.

## Conferences

### Lead Sponsor:

*Emerging Water Issues...Science and Solutions*; Stonewall Resort, Roanoke, WV; October 28-29, 2004.

*Ensuring Water Resources for West Virginia's Future*; Stonewall Resort, Roanoke, WV; October 11-13, 2006.

### Cosponsor or Supporter:

Water Issues in the Appalachian Region. West Virginia University Law School, Morgantown, WV. October 2-3, 2003.

*Revitalizing Communities through Restoration: Linking Social, Economic and Natural Assets*; Radisson Hotel and Conference Center, Morgantown, WV; October 24-26, 2005.

*Connecting Management to Aquatic Communities*; The Inn at Virginia Tech and Skelton Conference Center, Virginia Tech, Blacksburg, VA; November 26-29, 2007.

*Ohio River Basin Consortium for Research and Education Annual Symposium*; Radisson Inn, Athens, Ohio; October 26-28, 2005.

*WV Surface Mine Drainage Task Force Symposium*, Morgantown, WV, April 15-16, 2003

*WV Surface Mine Drainage Task Force Symposium*, Morgantown, WV, April 18-24, 2004

*WV Surface Mine Drainage Task Force Symposium*, Morgantown, WV, April 19-20, 2005

*WV Surface Mine Drainage Task Force Symposium*, Morgantown, WV, April 18-19, 2006

*WV Surface Mine Drainage Task Force Symposium*, Morgantown, WV, April 10-11, 2007

## Internet Services

The West Virginia Water Research Institute has a home web site (<http://wvri.nrcce.wvu.edu>) and information on its programs and projects are housed there. Information and on line registration for water conferences in which WVWRI is the lead is housed on this web site as well.

## Most Significant Achievements

### 1. Networking

First and foremost is the networking the WVWRI information transfer program provides. The annual state water conferences provide a forum for Federal and State agency representatives, researchers, academia, watershed associations, consultants, and others to come together and discuss water-related issues in the State. The result has been strengthening connections and partnerships to solve issues and discuss policy.

### 2. Student Involvement

Over the years the student involvement in the annual water conferences has increased. Students become aware of water-related issues in the state, work with researchers on USGS 104B Section projects, learn field and laboratory techniques, complete theses and dissertations, give poster and oral presentations at conferences, write papers, and achieve professional employment in the field of water research.

### 3. Strengthening Research Base

The USGS 104B program has supported new up-and-coming researchers and assistant professors gain experience and knowledge in the arena of water related research. This diverse group encompasses hydrologists, soil scientists, biologists, law professors, geologists, and others to collaborate on varied research supported by a variety of sources. The mix of established researchers and newly graduated and newly hired researchers offers a unique blend of skill sets. The WVWRI's information transfer program plays a vital role in bringing these two groups together.

### 4. West Virginia Water Resources Inventory

In March 2004 the West Virginia Legislature adopted Senate Bill 163, the Water Resources Protection Act, which recognized the need to inventory, assess and evaluate the State's water resources for present and future use and enjoyment and protection of the environment. The Legislature recognized for the first time, in statute, that the state's water resources are vital and essential for preserving and promoting the quality of life and economic vitality of the state. The Act called for a one-time, limited assessment of the *quantity* of the state's water resources. It provided for: claiming and protecting state waters for the use and benefit of its citizens; evaluating the nature and extent of its water resources; and identifying activities that impede the beneficial uses of the resource. This was the first statewide initiative to compile and analyze the disparate water quantity related data and information from multiple public agencies, universities

and private sources. The legislation required the Secretary of the West Virginia Department of Environmental Protection (WVDEP) to inventory, assess and evaluate the State's water resources and propose a strategy for water quantity management. The Secretary was to accomplish this mission by soliciting the assistance and cooperation of federal and state agencies and universities who have management responsibility and research capabilities related to state water resources and report to the Legislature by December, 2006. The objective of this project was to provide technical support to the WVDEP in identifying, collecting, assessing, reconciling and analyzing the State's water resources to fulfill the mandate of the Act. A report was completed which provides results of WVWRI findings. Research efforts generated key findings that are important for WVDEP efforts to recommend a state water quantity management program.

## EDUCATION

The following table contains a count of the number of students supported by USGS Section 104 grants and required matching funds over the evaluation period of FY2003 – FY 2007.

Number of Students Supported, by Degree and Grant Type: FY2003 – FY2007		
Degree	Base (104B) Grants	National Competitive (104G) Grants
Undergraduate	12	0
Masters	14	0
Ph.D.	3	0
Post Doc	0	0

The following table contains a count of the total number of dissertations and theses that resulted from this student support.

Number of Theses and Dissertations Resulting from Student Support: FY2003 – FY2007	
Master's Theses	6
Ph.D. Dissertations	2

**ADMINISTRATION, COORDINATION, AND COOPERATION**

The following proposals were submitted to the USGS 104G program between 2003-2007.

2003. Vesper, Dorothy. Age Dating of Regional Karst Waters for Resource and Contamination Assessment, Great Valley Aquifer, WV-VA. Not awarded.

2006. Vandivort, Tamara and Paul Ziemkiewicz. Identifying Water Gaging Data Needs in WV, VA, and MD. Not awarded.

Cooperation

In the table below, the expenditures of Section 104 and required matching funds at the home campus (WVU) and at other universities or organizations are listed.

Expenditure of Section 104 and Matching Funds, by University or Other Organization, State, and Year: FY2003 – FY2007						
University or Organization	State	Section 104 Federal Grant and Matching Fund Expenditures				
		2003	2004	2005	2006	2007
West Virginia University	West Virginia	\$46,658	\$161,272	\$266,484	\$207,426	\$197,791
Wheeling Jesuit University	West Virginia	\$37,434				
West Virginia State College	West Virginia	\$7,836				

Regional Information Transfer Activity

In 2007, the Virginia Water Resources Research Center and the West Virginia Water Research Institute collaborated in a regional water conference at Virginia Tech in Blacksburg, VA.

## Institute Directors over Evaluation Period

The following individual served as Director of the West Virginia Water Research Institute over the evaluation period.

<u>Name</u>	<u>Academic Discipline</u>	<u>Term</u>
Paul F. Ziemkiewicz	Biology; Range Ecology; Forest Ecology	1991 – present

### Awards

Ziemkiewicz, Paul F. 2005. *Environmental Conservation Distinguished Service Award*, Presented by the Society for Mining, Metallurgy and Exploration

### Advisory Boards

The WVWRI Director, Paul Ziemkiewicz, serves on the following advisory committees:

- Member, West Virginia Acid Mine Drainage Task Force
- Member, Eastern Mine Drainage Federal Consortium
- Technical Support Team Leader: Appalachian Clean Streams Initiative/Acid Drainage Technology Initiative
- Member, West Virginia Special Reclamation Fund Advisory Council
- Board of Directors, Upper Mon River Association
- Fellow, USDOE Institute for Advanced Energy Solutions

### Advisory Committee

#### *West Virginia Advisory Committee for Water Research*

The West Virginia Advisory Committee for Water Research serves as the primary advisory committee for the WVWRI. This committee is not set by the state. Its members are solicited by the Director of the WVWRI. This committee meets at least twice each year and reviews proposals submitted to the WVWRI for consideration for further submission to the U.S. Geological Survey for base grant 104b. In addition, the committee identifies statewide water research priorities, reviews the annual request for proposals, evaluates progress of all WVWRI projects, advises the director regarding program direction and management, and identifies opportunities for collaborative research efforts. The Advisory Committee also assists in planning the annual state water conference. This advisory committee consists of representatives of the following organizations:

- U.S. Geological Survey
- U.S. Environmental Protection Agency
- U.S. Department of Energy - National Energy Technology Laboratory
- U.S. Department of Agriculture - Natural Resources Conservation Service
- U.S. Army Corps of Engineers - Huntington, WV District
- West Virginia University
- West Virginia Department of Natural Resources

- Canaan Valley Institute
- West Virginia Bureau for Public Health
- West Virginia Division of Environmental Protection
- U.S. Federal Bureau of Investigation

Research Proposal Review and Selection Process

*Water Resources Research - USGS 104b Program*

Typically in the fall, the WVWRI issues a request for proposals. This RFP is released to contacts at all educational institutions in the state of West Virginia. Researchers across the state submit their proposals to the WVWRI. The WVWRI forwards proposals to the members of the West Virginia Advisory Committee for Water Research for review. The advisory committee makes recommendations as to which proposals should be forwarded to USGS for funding consideration. The WVWRI forwards those proposals to the USGS for funding consideration.

Members of the advisory committee possess a variety of expertise including technical expertise in water chemistry, acid mine drainage, sampling and analytical methodology. The members of this advisory committee represent a cross section of state agencies poised to know which projects merit the relevance to state and regional water resource issues.

Peer Review of Institute Publications

For acid mine drainage related materials, the Acid Drainage Technical Initiative subcommittee reviews. For water-related materials, the West Virginia Water Advisory Committee reviews. In addition, depending on the topic of the publication, appropriate academic faculty members are solicited to review.

Number of Principal Investigators Supported, by Rank and Year

The following table depicts the number, by academic rank at the time of the initiation of the project and year of the principal investigators on research projects supported by Section 104 grants and matching funds in each of the fiscal years from FY03-FY07.

Principal Investigators on Research Projects Supported by Section 104 Grants and Matching Funds, by Academic Rank and Year: FY2003 – FY2007					
Academic Rank	2003	2004	2005	2006	2007
Assistant Professor and below	2	3	2	4	0
Associate Professor	1	1	1	1	4
Professor	1	2	1	2	2
Total	4	6	4	7	6

## ADDITIONAL INFORMATION FOR THE EVALUATION PANEL

This section includes information on the WVWRI's activities outside of the USGS 104 program between FY2003 – FY2007.

### The West Virginia Water Research Institute

The mission of the West Virginia Water Research Institute is to preserve and restore the natural environment through research and partnerships with industry, government agencies, academia, and the public. To achieve this mission, the WVWRI actively seeks external funding from federal, state, and private sources. With diversified funding and support, the WVWRI develops strong, multi-disciplinary research teams by collaborating with various West Virginia University colleges and divisions, other higher education institutions, and private firms and consultants. This team approach brings the best expertise available to address the State's water issues. It also allows the WVWRI to perform research in a number of areas at any given time.

Between FY2003-FY2007, the WVWRI was comprised of the following programs in addition to the USGS 104b water resources research program:

- National Mine Land Reclamation Center
- Combustion Byproducts Recycling Consortium
- National Environmental Education & Training Center
- Hydrology Research Center
- Northern West Virginia Brownfields Assistance Center

These programs are described below.

### Water Resources Research

In addition to water related research supported by the USGS 104B Section, the WVWRI received funding between 2003-2007 to support the following research projects.

<b>Water Resources Research Projects FY-03 Through FY-07</b> (not including USGS 104B Section projects)					
Project No.	Title	Funding Source	Amount	Cost Share	Total Project Value
WRI-23	Potomac Headwaters Sampling Project	WVDEP	\$29,442	\$0	\$29,442
WRI 50	Strategies for Cooling Electric Generating Facilities Utilizing Mine Water	USDOE/METC	\$179,615	\$44,991	\$224,606

WRI 51	A Hierarchical Classification System for Identifying Restoration Priorities and Impact Vulnerability in Mined Watersheds of the Mid Atlantic Highlands	USEPA	\$607,566	\$0	\$607,566
WRI-62	Preparation of Hydrologic Unit Plans	WVDEP	\$231,250	\$0	\$231,250
WRI-66	Watershed Bacterial Study and Decentralized Wastewater Demonstration, Mud River Watershed, Lincoln County, WV	USEPA/ Lincoln Co. Commission	\$334,464	\$86,892	\$421,356
WRI-71	Performance Evaluation of Advanced Onsite Wastewater Treatment Options	USEPA	\$119,971	\$9,241	\$129,212
WRI-91	Statistical Analysis of Nutrient Trends in the Ohio River	WV Higher Education Commission	\$4,913	\$0	\$4,913

## Project Descriptions

### WRI-23: Potomac Headwaters Sampling Project

*Principal Investigator: Paul Ziemkiewicz, Director, WVWRI*

In recent years a major poultry industry has developed around the headwaters of the South Branch of the Potomac River in West Virginia. This area has seen a 100% increase in the poultry industry between 1993-1996. There are over 800 operators producing 90 million birds and 350,000 tons of litter (manure and bedding) each year. The area is primarily rural with on-lot sewage systems and other agricultural enterprises including cattle, corn, apple and forage production. The rapid growth of the poultry industry raised concerns over water quality in the Potomac River and the Chesapeake Bay. Pollutants such as coliforms, other bacteria and nutrients have been found in the South Branch and its tributaries and the poultry industry has been implicated. This study was designed as a systematic and comprehensive examination of the bacterial and nutrient loadings in the South Branch of the Potomac River.

The results of this project helped the WV Department of Agriculture ensure that the best technical tools were available to assist in its decision making process relative to agricultural wastes in the Potomac Headwaters.

**WRI-50: Strategies for Cooling Electric Generating Facilities Utilizing Mine Water**  
***Principal Investigator: Paul Ziemkiewicz, Director, WVWRI***

Thermal electric power generation requires large volumes of water. There are three main uses for this water: cooling water, boiler feed, and flue gas desulfurization (emission scrubbing). The cooling cycle condenses steam at the end of the turbine cycle and requires, by far, the greatest volume of water.

Earlier studies conducted by West Virginia University identified large potential water resources in flooded, abandoned coal mines in the Pittsburgh Coal Basin. This study evaluated the technical and economic potential of the Pittsburgh Coal Basin water source to supply new power plants with cooling water.

We found that the use of net alkaline mine water would, under current economic conditions, be competitive with a river-source in a comparable size water cooling system. On the other hand, utilization of net acidic water would be higher in operating cost than the river system by 12 percent. This analysis did not account for any environmental benefits that would accrue due to the treatment of acid mine drainage, which in many locations is an existing public liability. In summary, mine water utilization for power plant cooling was considered a strong option for meeting water needs of new plant in selected areas.

Analysis of the thermal and water handling requirements for a 600 megawatt power plant indicated that Type B, earth coupled cooling, would not be feasible. It was determined that Type B cooling would be possible, under the right conditions, for thermal power plants of 200 megawatts or less.

The significance of this work included identifying cost saving alternatives to the current coal fired power plant cooling process. Non-traditional water sources such as coal mine discharges have the potential to reduce the capital cost of acquiring the cooling water while at the same time improving the efficiency of the cooling process due to the constant water temperatures associated with deep mine discharges. In addition, the potential use of the underground mines themselves as a wide area heat sink was evaluated for feasibility.

**WRI-51 A Hierarchical Classification System for Identifying Restoration Priorities and Impact Vulnerability in Mined Watersheds of the Mid Atlantic Highlands**  
***Principal Investigator: Todd Petty, Associate Professor, Forestry, WVU***

The objectives of this project were to:

1. Develop and validate a spatially explicit, GIS-based model that uses information on landscape attributes to predict instream physical, chemical, and biological conditions at the stream segment scale in two intensively mined West Virginia watersheds (Cheat River and Tygart Valley River).

2. Use model outputs to develop a hierarchical classification system for identifying stream restoration and protection priorities at the stream segment and sub-watershed scale (12-digit HUC).
3. Produce a technical platform that can be used to guide implementation of watershed based approaches to aquatic resource management, with a special emphasis on implementation of strategic, watershed-scale mitigation programs in mined Appalachian watersheds.

The rationale for this study is that the GIS-based modeling system and the hierarchical classification system are needed to facilitate implementation of watershed based approaches to aquatic resource management. Successful completion of the objectives provides the technical framework needed to develop and implement water quality trading programs, watershed based permits, strategic mitigation and impact compensation programs, optimized watershed restoration programs, holistic watershed planning, adaptive watershed monitoring and assessment programs and efficient data maintenance, analysis, and synthesis. Successful implementation of watershed based approaches will make it possible to achieve watershed scale improvements more quickly, at lower cost, and with the help of a more diverse stakeholder group than traditional or *ad hoc* management approaches.

#### **WRI-62 Preparation of Hydrologic Unit Plans**

***Principal Investigator: Joseph Donovan, Associate Professor, Geology, WVU and Director, Hydrogeology Research Center***

Lick Run is a tributary of the Cheat River with a drainage area of approximately 4.86 square miles. Nearly all of the drainage basin is affected by acid mine drainage (AMD). It is on the US EPA 303d list of mine drainage impaired streams. Surveys in 1996 found no benthic life, a very low pH, and high levels of aluminum, manganese and iron. During extensive sampling in 2003, impacts to the stream have been identified as non-point sources, primarily pre-law underground mines. Amelioration projects were completed which consisted of wet seals, filling vertical shafts, constructing limestone channels, filling subsistence holes and revegetating refuse areas. This project reduced the amount of AMD-derived pollutants discharged into the Cheat River, which is a major recreational resource.

#### **WRI-66: Watershed Bacterial Study & Decentralized Wastewater Demonstration, Mud River Watershed, Lincoln Co., WV**

***Principal Investigator: Ric MacDowell, Lincoln County, WV Extension Agent, WVU***

Between 2005 and 2008, a water quality study was performed in the Left Fork of the Mud River Watershed, Lincoln County, WV as part of an EPA-funded initiative. Baseline sampling locations were selected along several tributaries within the study area that had residences in need of onsite wastewater treatment systems. Four quarters of baseline sampling occurred between November 2005 and September 2006. Parameters analyzed in the field included pH, dissolved oxygen, specific conductivity, temperature,

stream flow, nitrates, and turbidity. Grab samples were collected and analyzed in the laboratory for total coliform, and E. Coli.

Following wastewater treatment system installations, tributary water quality monitoring was adjusted to focus on segments of tributaries where systems had been installed. The purpose in focusing on these segments was to determine if there were any measurable changes in bacterial contamination in the tributaries following system installation.

Baseline sampling results throughout the entire watershed showed that total coliforms exceeded 1,000/100 mL 90% of the time and E.Coli exceeded 235/100 mL 59% of the time. Total dissolved solids (TDS), pH, and nitrates were all within acceptable limits. Dissolved oxygen (DO) fell below the critical limit of 5 mg/L thirteen times. Specific conductivity only reach levels >300  $\mu\text{s}/\text{cm}$  five times.

Post-wastewater treatment system installation sampling results showed that total coliforms exceeded 1,000/100 mL 83% of the time. Fecal coliforms exceeded 400/100 mL 51% of the time, and E. Coli exceeded 235/100 mL 84% of the time. Specific conductivity and nitrates were within acceptable limits. pH was within acceptable range 95% of the time and dissolved oxygen fell just below 5 mg/L on two occasions at one site. Turbidity exceeded 10 NTUs 75% of the time on all tributaries sampled.

Even though post-installation monitoring data is limited, it is interesting to note that a comparison of E. Coli results for three of the tributaries which had both baseline and post-system installation monitoring performed shows reductions in E. Coli. This may indicate that installation of wastewater treatment systems to residences along these tributaries is leading to improvements in the water quality of the tributaries. As additional wastewater treatment systems are installed in the watershed, conducting additional tributary sampling for bacteria will likely reflect an improvement in tributary water quality.

## **WRI-71: Performance Evaluation of Advanced Onsite Wastewater Treatment Options**

***Principal Investigator: Tamara Vandivort, Program Coordinator, WVWRI***

A study sponsored by the U.S. Environmental Protection Agency's Chesapeake Bay Program evaluated appropriate technologies to achieve an end-of-pipe performance standard equal to or less than 14.0 mg/L total nitrogen (average) and a net reduction in phosphorus. These standards support the 1987 Chesapeake Bay Agreement strategy to reduce the nutrients, nitrogen and phosphorus, entering the Bay by 40% by the year 2000.

Residential dwellings with engineered systems located adjacent to the Bay, or within critical drainage areas, were identified. Homes with 2-4 year round residents whose owners were willing to participate in the study were selected. The four onsite wastewater treatment systems used in the study had already been in operation for at least a year. The systems were modified to a configuration of multi-compartment septic

tank, media filtration, recirculation and disposal to a drainfield. The phosphorus reducing system included low pressure pipe distribution into an expanded shale media in the drainage bed.

When the systems were operating properly, the technologies used in this study consistently and reliably reduced average nitrogen and net phosphorus. Periodic maintenance is necessary to ensure systems are operating properly.

Pollution in the form of excess nutrients, primarily nitrogen and phosphorus, entering the Chesapeake Bay are creating significant water quality problems. Central sewerage treatment systems are often not available in rural and suburban areas requiring homeowners to rely on individual septic tanks or other systems to dispose of household waste on-site. This study confirmed that engineered aerobic systems can provide a higher level of treatment and better protect water resources than conventional septic systems when functioning properly. Recent advances in technology have made aerobic treatment systems efficient and affordable for homeowners.

**WRI – 91: Statistical Analysis of Nutrient Trends in the Ohio River**  
***Principal Investigator: Richard Herd, Program Coordinator, WVWRI***

Nutrient levels in our oceans are causing increasing global concern in many coastal areas, including the Gulf of Mexico. Increased nutrient levels cause algal blooms that deplete oxygen and is detrimental to marine life. Nutrients from agricultural runoff, industrial run off, and wastewater treatment plants travel downstream to the Gulf of exacerbating the problem.

Agricultural sources contribute 64% of the nitrogen in the Gulf of Mexico (Goolsby, 1999); the Ohio River Basin contributes 32% of the total nutrient load entering the gulf from the Mississippi River. West Virginia is one of the headwater regions of the Ohio River. It is probable that the state's agriculture industry would be affected by any policy put in place to reduce the nutrient load to the Gulf of Mexico. Policy makers need to understand the relationships between water quality on this tributary and water quality in the gulf.

This project determined the West Virginia nutrient inputs to the Ohio River from upstream tributaries as well as the temporal and spatial trends in nutrient concentrations along the Ohio River from Pittsburgh PA to Cairo IL. Data from 31 monitoring stations between Pittsburgh and Cairo as well as the monitoring station on the Monongahela River at Point Marion, PA were used to show the cumulative nutrient load from upstream Ohio River Basin tributaries in West Virginia. Temporal water quality trends from 1990-2005 were analyzed adding new levels of temporal and spatial analysis. Correlations between nutrients, flow, DO and TSS were determined.

This project has helped to develop information that will be useful for policy development to address nutrients entering our waterways.

## **National Mine Land Reclamation Center (NMLRC)**

Coal mine reclamation rehabilitates land and water affected by current and historic mining operations. The National Mine Land Reclamation Center works to improve methods for protecting streams from mine pollution and develop ways to establish productive forests on mined land. Working with State and Federal agencies, citizen watershed organizations and the coal industry, the NMLRC has pioneered large-scale watershed reclamation strategies that mesh regulatory programs with voluntary remediation. The NMLRC works to further the understanding of the hydrologic and ecological impacts of the coal mining industry by exploring technologies that mitigate these impacts. Research being performed by the NMLRC is addressing both impact measurements as well as mitigating technologies that are critical to the viability of the coal mining industry while safeguarding surface and groundwater quality in the Appalachian states. The following is a list of all NMLRC projects over fiscal years 2003-2007.

<b>National Mine Land Reclamation Center Projects FY-03 Through FY-07</b>					
Project No.	Title	Funding Source	Amount	Cost Share	Total Project Value
WV-126	WV Stormwater Program Assessment	USEPA	\$65,520	\$0	\$65,520
WV-127	Watershed Based Plan – Buckhannon	WVDEP	\$7,000	\$0	\$7,000
WV-137	Lamberts Run Passive Treatment Installation: Site 5	WVDEP	\$146,334	\$97,614	\$243,948
WV-139	Lamberts Run Passive Treatment Installation: Site #9	WVDEP	\$149,605	\$99,737	\$249,342
WV-140	Smooth Rock Lick of the Upper Buckhannon Smooth Rock Lick #3	WVDEP	\$64,401	\$0	\$64,401
WV-153	A Strategic Watershed Mitigation Plan for the Pigeon Creek Watershed Mingo County, WV	Consol of Kentucky	\$120,000	\$0	\$120,000
WV-173	Abandoned Mine Pool Flooding of the Pittsburgh, Ohio and Irwin Basins	USDOE/ Parsons	\$339,997	\$0	\$339,997
WV-191	Reforestation and Enhanced CO2 Sequestration of Surfaced Mine Land in WV and AMD Treatment Design and Installation	EPRI	\$154,461	\$29,032	\$183,493
WV-206	Design and Installation of Passive Acid Mine Drainage Treatment System in Impacted Tributaries of the Lower Cheat River Watershed	WVDEP	\$541,626	\$0	\$541,626
WV-213	Improving the Safety of Coal Slurry Impoundments	Wheeling Jesuit University	\$435,040	\$0	\$435,040
WV-217	Long Branch Passive AMD Treatment Project	WVDEP	\$176,807	\$0	\$176,807
WV-218	Oldaker Property AMD Project: Design and Installation of a Passive Treatment System	WVDEP	\$144,000	\$0	\$144,000

WV-219	Coal Slurry Impoundment Monitoring	NTTC/WJU	\$167,996	\$0	\$167,996
WV-221	Muzzleloader Club AMD Project: Design and Installation of a Passive Treatment System	WVDEP	\$106,663	\$0	\$106,663
WV-229	Passive Treatment Installation – Dream Mountain – Muddy Creek	WVDEP	\$288,390	\$0	\$288,390
WV-231	Implementation of the Watershed Based Plan for AMD Remediation in the Cheat River Watershed	Friends of Cheat	\$288,390	\$0	\$288,390
WV-232	Development and Demonstration of a Modeling Framework for Assessing the Efficacy of Using Mine Water for Thermoelectric Power Generation	USDOE/NETL	\$338,250	\$86,817	\$425,067
WV-233	Lower Cheat Watershed Passive Treatment Installation: Middle Fork of Greens Run, Morgan Run, and Pringle Run	WVDEP	\$333,829	\$0	\$333,829
WV-237	Development and Implementation of a Water Quality Bank and Trade Program for the Potomac River Watershed, WV	USDA	\$527,071	\$588,858	\$1,115,929
WV-238	In-situ Mitigation of Iron in a Net-alkaline Environment	USDOI/OSMRE	\$100,000	\$48,070	\$148,070
WV-244	Technical Support for Implementing the West Virginia AML Program	WVDEP	\$472,178	\$0	\$472,178
WV-246	West Run Watershed Based Plan	WVDEP	\$10,182	\$0	\$10,182

## **Project Descriptions**

### **WV – 126: West Virginia Stormwater Program Assessment**

***Principal Investigator: Richard Herd, Program Coordinator, WVWRI***

West Virginia's 33 municipal separate storm sewer systems (MS4s) are located across the entire state. Most MS4s are small cities and towns; others include the state Division of Highways and a federal penitentiary. Storm water discharges from these MS4s often contain high levels of sediment, bacteria, nutrients, and metals. MS4 permits are designed to reduce these pollutants.

The goal of this project is to help MS4s better implement their permits, thereby reducing storm water pollution in a more cost-effective manner. To accomplish this goal, project objectives included:

- (1) Collecting information through file research, interviews, and surveys to identify obstacles, best practices, and opportunities related to MS4 permit implementation across West Virginia; and
- (2) Disseminating lessons learned to MS4 communities and their consultants, WVDEP, and other interested parties.

Based on the background research and survey results, project partners analyzed the data and compiled a final report which included an analysis of the information collected, a statistical analysis of the survey results, and other information collected through the entire project period. The report provided recommendations on how MS4s can better implement their permits and provided quantitative conclusions about which measurable goals are being met, using which methods, and partnering with which organizations. Successful case studies were highlighted, obstacles and challenges noted including suggestions for overcoming them.

Project findings were disseminated in a number of ways including reports distributed to key staff at WVDEP and USEPA, to all MS4s in the state and a PDF version has been posted online. A PowerPoint presentation was created and used to present findings at strategic opportunities such as the state Municipal Water Quality Association and WVDEP storm water workshops. In addition, project partners presented results at regional conferences to provide information to out-of-state regulators and MS4s, particularly those from small rural states that may face many similar obstacles and opportunities. This systematic assessment will help small communities learn from others to more cost-effectively reduce storm water pollution, and will help WVDEP meet its goal of efficiently managing its MS4 program.

### **WV-127: Buckhannon River Watershed-Based Plan**

***Principal Investigator: Brady Gutta, Research Associate, WVWRI***

The purpose of this plan was to document the existing characteristics and conditions within the Buckhannon River watershed, as well as identify areas in need of restoration.

The original Buckhannon River Watershed-Based Plan was completed in 2004. However, watershed-based plan requirements were later amended by the US EPA. As a consequence of these federal rule changes, the Buckhannon River Watershed-Based Plan needed to be amended as well. The scope of the original plan was expanded to include more background information about the watershed as well as pollution sources that had been discovered since the initial plan was written. Project implementation progress and water quality data from specific monitoring sites were also updated as part of the amendments to the original watershed-based plan.

Locating and prioritizing water quality problems is important when determining the overall health of a watershed. Once all pollution sources have been found, a watershed-based plan is constructed in order to receive future funding for pollution remediation. Updating the Buckhannon River Watershed-Based Plan ensured a more complete accounting of the pollution sources within the watershed and allowed for more efficient use of reclamation funding by determining where the greatest amount of remediation could occur for the lowest price.

**WV-140: Smooth Rock Lick of the Upper Buckhannon River Passive AMD Treatment Project**

***Principal Investigator: Brady Gutta, Research Associate, WVWRI***

This project seeks to remediate the acid mine drainage from the Smooth Rock Lick #3 mine. The reclamation of 1.5 miles of Smooth Rock Lick is addressed by the Upper Buckhannon Watershed-Based Plan. The Upper Buckhannon Watershed Based Plan indicates that 37,564 lbs/year of aluminum and 48,194 lbs/yr of iron need to be reduced to meet TMDL goals. Upon installation of the treatment system at Smooth Rock Lick #3, we anticipate a total reduction of 2,464 pounds per year of acidity and 288 pounds per year of aluminum. The Smooth Rock Lick passive treatment project is currently undergoing pre-construction sampling by the Buckhannon River Watershed Association. Engineering has been completed and NMLRC is in the process of applying for the necessary permits in order to begin construction. Construction will begin in spring of 2010. Lessening the impacts of water draining from coal mines has a positive impact on water quality downstream.

**WV-153: A Strategic Watershed Mitigation Plan for the Pigeon Creek Watershed Mingo County, WV**

***Principle Investigator: Todd Petty, Associate Professor, Forestry and Director, Watershed Technical Assistance Center***

A century of neglect has resulted in high levels of degradation in the condition of watersheds and receiving waterbodies throughout the Tug Fork River drainage in southern West Virginia. Pigeon Creek is an example of this problem where the overall quality of the Pigeon Creek mainstem in the area of Delbarton, WV is highly depressed. The watershed has been mined for decades, including pre-law surface and deep mines, as well as extensive large scale surface mining and associated valley fills in more recent years. In addition, the watershed is highly populated, with most of the buildable

space along the river valley being fully developed. These intensive development activities (mining and urbanization) have contributed to declines in water quality to the point that Pigeon Creek is viewed as a liability, rather than a community asset.

The goals of this project were to establish a rigorous, science-based process for developing watershed scale restoration plans for intensively mined watersheds of southern West Virginia. In addition, when properly constructed, watershed restoration plans can serve as a framework for integrating resources from a diverse group of investors. The *specific objectives of this plan* were to develop a GIS-based modeling and analysis framework; Quantify current watershed conditions; Identify dominant factors limiting ecological conditions; Identify general restoration needs and specific restoration opportunities; Construct a series of “ecological units” (EcoUnits) that can be used to estimate the ecological benefits of specific restoration actions; And to present a framework for including stream mitigation as a contributor to watershed scale restoration of the Pigeon Creek watershed.

The rationale for establishing these plans is that watershed scale approaches are the most efficient and cost-effective means of meeting goals for aquatic resource restoration and protection.

### **WV-173: Abandoned Mine Pool Flooding of the Pittsburgh, Ohio and Irwin Basins**

This was the fourth and final phase of the EPA Region III Mine Pool project, a multi-year endeavor funded by the U.S. Department of Energy – National Energy Technology Laboratory (DOE-NETL) and Parsons. This project was a collaborative effort of three major universities: West Virginia University, the University of Pittsburgh, and Carnegie Mellon University. The focus of this phase was to complete the tasks initiated in previous phases of the project. These tasks included mapping of underground mine pools, monitoring mine levels and water chemistry, rates of water rise and differences between shallow cover near outcrops versus central basin, and project dissemination. Mine mapping products have been completed on a topographic base for 61 quadrangles in West Virginia and Pennsylvania. These maps are available for public access and retrievable on [www.hrc.nrcce.wvu.edu](http://www.hrc.nrcce.wvu.edu). Spatial distribution on mine-water chemistry was plotted using 161 samples of mine water taken during 1999-2003 at 115 locations throughout the Pittsburgh coal basin. pH is bimodal throughout the basin, with few exceptions, with most above-drainage mines being less than 4.5 and most below-drainage mines being above 4.5. Iron is the highest-concentration metal and is generally uniformly distributed with minor variations apparently related to discharge age. Manganese and aluminum are low in concentration and generally restricted to above-drainage and near-outcrop mine settings. Alkalinity is found primarily in deeper, below drainage mines, especially those that have been discharging for several years. A few mines show very high alkalinities, attributed to high pCO<sub>2</sub> values sustained in these waters. Net alkalinity is bimodal as for pH. Most mines that are below drainage in the basin are net alkaline, even though they carry a significant iron load. Sodium is present in elevated concentrations in a few mines and appears to be restricted to immature (recent) mine discharges. Sulfate is generally uniform but tends to be higher in more

recently flooded mines. Spatial variability of mine-water chemistry in Pittsburgh mine basin is believed to be non-random and thought to be controlled by 1) age of mine discharge post-flooding (the time duration for which the discharge has existed); 2) depth of mine and degree of exposure to oxygen, e.g., below drainage versus above drainage; and 3) spatial variability between mine locations in factors such as overburden geology/chemistry and closed mine management. Monitoring stations with automatic water level loggers were installed and water levels determined. Water level trends on the eastern side of the basin are rising in three West Virginia mines and in four Pennsylvania mines. On the west side of the basin, closed mines are flooding slowly and no known discharges of any magnitude have been identified. A water quality model of the Monongahela River was constructed the purpose of which is to simulate the affect of a release o AMD from the Shannopin mine into Dunkard Creek on the water quality of the Monongahela River. The results of the model indicate that an uncontrolled, continuous release of AMD from the Shannopin mine starting in the spring of 1988 would have had significant impact on the water quality of the Monongahela River downstream of Dunkard Creek. Major impacts to the river would be in the form of depressed pH levels and elevated iron concentrations. Finally, active efforts were undertaken to disseminate research results from all phases of the project.

#### **WV-191: Reforestation and Enhanced CO<sub>2</sub> Sequestration of Surfaced Mine Land in WV and AMD Treatment Design and Installation**

***Principle Investigator: Jeff Skousen, Professor of Soils and Land Reclamation Specialist West Virginia University***

Returning surface mined land to a productive forest must consider factors such as soil depth, soil physical and chemical properties, soil compaction, ground cover competition, tree species selection, and tree planting techniques. The objective of this research was to evaluate tree survival and growth in weathered brown sandstone and in unweathered gray sandstone. 11 hardwood species were commercially planted. After three growing seasons, tree survival was 86% on gray sandstone and 74% on brown sandstone, and 78% on non-compacted areas and 79% on compacted. Many surface mined areas originally reclaimed for pasture and hay land post-mining land uses in Appalachia are being converted to forestland.

The forests of eastern North America were once home to the American chestnut which produced rot-resistant wood for construction and nuts for food. A disease caused by a fungus, *Cryphonectria parasitica*, spread through the US forests, and by 1950, 4 billion trees had perished and an important wildlife and timber tree was lost. Reestablishing chestnut trees on reclaimed surface mines has recently gained attention and several studies have been undertaken to measure survival and growth of trees on these disturbed sites.

Performance of Passive Treatment Systems for Acid Mine Drainage

State and federal reclamation programs, mining operators, and citizen-based watershed organizations have constructed hundreds of passive systems in the eastern United States over the past 20 years to provide reliable, low cost, low maintenance mine water treatment in remote locations. In 2000, we evaluated 116 systems comprised of eight system types in eight states. We revisited 14 of these sites in 2004 to confirm results from the earlier study. Each system was monitored for influent and effluent flow, pH, net acidity, and metal concentrations. Performance was normalized among types by calculating acid load removed, and also by converting construction cost, projected service life, and metric tons of acid load treated into cost per ton of acid treated. Most passive systems were effective for >5 yrs, yet there was wide variation in performance within each system type.

If loose mine soils are conducive to chestnut and hardwood growth, then establishment and dispersal from planted islands of blight-resistant hybrids throughout the range of the Appalachian coal region would aid in the goal of restoring the chestnut and sequestering a large volume of carbon.

### **WV-206 A&B: Design and Installation of Passive AMD Treatment Systems in Tributaries of the Lower Cheat River Watershed**

***Principal Investigator: Brady Gutta, Research Associate, WVWRI***

These projects were designed to remediate acid mine drainage (AMD) in 3 tributaries of the Cheat River. Sovern Run, has been impaired by numerous surface and underground mines. Pre-construction chemistry at the site had a pH of 3 and an acidity of 288 mg/L. In addition, the AMD had high levels of iron, aluminum and manganese, 21.4 mg/L, 31.3 mg/l and 3.0 mg/L respectively. A passive treatment system consisting of open limestone channels, limestone leachbeds, and two steel slag leach beds were installed.

Pringle Run has been impaired by numerous surface and underground mines. The site consists of an unreclaimed highwall/faceup with two collapsed/buried portals. The site had a pre-construction pH of 2.8, acidity of 160 mg/L, with metal concentrations of 19 mg/L for iron, 29 mg/L for aluminum, and 2.6 mg/L for manganese. This project constructed a vertical flow system built in two stages with the first portion of the reactor built on the terrace adjacent to the portals. The second component of the vertical flow system, an Anoxic Limestone Drain (ALD), was constructed on the lower portion of the project area and was designed to treat mine drainage in an anoxic environment. A settling pond is located at the outfall of the ALD with open limestone channels connecting the ALD to the pond and then to the discharge point.

Muddy Creek is a major contributor of acidity to the Cheat River. The area adjacent to the Creek has been impacted by numerous surface and underground mines. The project consists of four seeps on a strip bench above the creek. The site had a pre-construction pH of 3.1, acidity of 162 mg/L, with metal concentrations of 7.3 mg/L for iron, 15.5 mg/L for aluminum, and 5.37 mg/L for manganese. Pre-construction acid

loads from the site totaled 55 tons/year. This project consists of four limestone leach beds, as well as open limestone channels.

Water quality sampled on Sovern Run at the discharge end of the system shows the pH is now over 9 with net alkalinity of 171 mg/L and Fe, Al, and Mn concentrations of 0.03 mg/L, 0.5 mg/L, and 0.02 mg/L, respectively. The Pringle Run site has removed approximately 66 tons per year of acidity. Of the four leachbeds installed at Muddy Creek, two are performing while the other two have failed. Leachbeds 1 and 2 have not treated any acidity while leachbeds 3 and 4 have treated approximately 19.7 and 22.8 tons per year.

### **WV-213: Improving the Safety of Coal Slurry Impoundments**

***Principal Investigator: John D. Quaranta, Program Coordinator, WVWRI***

This program addresses a potential hazard in Southern West Virginia, eastern Kentucky and western Virginia, home to many of the approximately 150 coal slurry impoundments in the country. Communities are threatened by slurry pond failures. Recent impoundment failures are only the latest in a series of incidents in the region involving coal slurry impoundments. The Martin County Coal Company's Big Branch mine refuse impoundment, in Martin County, Kentucky, failed on October 11, 2000, sending more than 300 million gallons of water and coal sludge down into nearby creeks and into the Big Sandy River which borders Kentucky and West Virginia. More than 110 miles of waterways in West Virginia and Kentucky were negatively impacted. Considered by the Environmental Protection Agency to be the worst environmental disaster in the southeastern United States, the amount of water and sludge far exceeded the Exxon Valdez oil spill. Fortunately, no lives were lost, but the environmental damage carried as far as the Mississippi River and cost in the millions of dollars.

This project addressed the stability of these impoundments and provided an opportunity to fulfill the National Academy of Sciences' committee recommendations, as well as provide additional information about the most reliable, feasible, and economical methodologies for reducing the amount of coal mine waste and improving impoundment security.

In the initial year the project worked with WVDEP to identify and characterize high risk impoundments, undertake a comprehensive review of mining methods, coal preparation and power industry needs. We also examined coal processing alternatives which would reduce the amount of mine waste and considered alternative methods of disposal and reduction of coal waste products. We examined technical alternatives as recommended by the NAS regarding waste minimization and the reduction of currently existing impoundments through upgrading to commercial product. Mine maps and mine survey accuracy issues were considered and geophysical techniques reviewed and applied to the pilot projects.

This demonstration project allowed the regulatory agencies to determine if and to what extent any additional regulatory actions or monitoring should occur. Further, as NAS

recommended, a review and risk assessment system was established as part of the pilot program and models to enhance the environmental and economic efficiencies of the mining systems.

### **WV-217: Long Branch Passive AMD Treatment Project**

***Principal Investigator: Brady Gutta, Research Associate, WVWRI***

The Longbranch of Paint Creek project, located near Burnwell, WV consisted of constructing a 10,000 foot open limestone channel in an effort to combat the 160 tons of acid entering into ten mile fork each year. The open limestone channel has been effective at removing the aluminum as well as neutralizing the acidity. The Longbranch of Paint Creek drains into Ten Mile Fork before entering into the Paint Creek. The open limestone channel installed on Longbranch has also had a significant impact on the chemistry of Ten Mile Fork. The pH has increased by 11%; the acidity has decreased by 10% while the alkalinity has increased by 82%. The metal concentrations have also seen decreased of 50%, 60% and 13% for iron, aluminum, and manganese, respectively.

Lessening the impacts of water draining from coal mines has a positive impact on water quality downstream.

### **Lambert Run Restoration Projects:**

- **WV-218: Oldaker AMD Project: Design and Installation of a Passive AMD Treatment System**
- **WV-221s: Muzzleloader Club Project Sampling**
- **WV-221: Muzzleloader Club AMD Project: Design and Installation of a Passive AMD Treatment System**
- **WV-139: Lambert Run Passive AMD Treatment System, Site #9**
- **WV-137: Lambert Run Passive AMD Treatment System, Site #5**

***Principal Investigator: Brady Gutta, Research Associate, WVWRI***

The Lambert Run Restoration Project seeks to restore the water quality of this stream that has been degraded from past mining activities. Twelve water sampling and monitoring visits to the watershed in 2003, during high, medium, and low flows, determined concentrations and loads of aluminum, iron and manganese exceeded water quality standards. Partnerships were developed and a Watershed Plan was drafted and approved.

Sources of the severe water impairment were identified and passive treatment systems were designed to correct pH problems and remove metals from running water by oxidizing natural wetlands. Passive treatment systems have been designed and installed in 5 locations to balance acidity and remove high concentrations of metals from water draining formerly mined areas.

Lambert Run has been listed as an impaired stream in West Virginia's listing of 303(d) streams in 1996 and 1998. In 2002, the West Fork River Total Maximum Daily Load

(TMDL) was finalized and Lambert Run was earmarked for reductions in metals, primarily Iron, Aluminum and manganese. Implementation of the proposed Plan will restore it to water quality standards. This was the first watershed based plan in West Virginia to receive EPA approval with the goal being the eventual removal of the stream from the list of 303(d) impaired streams.

**WV-219: Coal Slurry Impoundment Monitoring**

***Principal Investigator: John D. Quaranta, Program Coordinator, WVWRI***

Following the breakthrough and release of coal slurry in Martin County, Kentucky on October 11, 2000 the United States Congress requested the National Research Council (NRC) to examine ways to reduce these types of accidents. The NRC completed their study titled “*Coal Waste Impoundments, Risks, Responses, and Alternatives,*” which identified numerous areas of concern and the committee presented recommendations for improving the design, operation, and safety of coal slurry impoundments. This research addresses the National Research Council’s report specific to research on the development, implementation, and evaluation of state-of-practice electronic instrumentation for monitoring parameters within the embankment, slurry pool, and toe area of an operating West Virginia coal refuse impoundment.

The scientific accomplishments of this research include comprehensive discussions and documentation of the engineering design, fabrication, assembly, and field construction and commissioning of a prototype automatic wireless data collection system for monitoring impoundment performance (weather data, piezometric water levels, pH, Specific Conductance, and Oxidation Reduction Potential). The project successfully accomplished the project objectives and brought on-line the completed wireless data acquisition system that can function primarily without assistance to collect data that is relevant to coal slurry impoundment stability and safety.

This project will continue to collect data over the next year and provide the information to the impoundment design engineers and the West Virginia University Coal Impoundment Research program. This project has provided key insight into remote monitoring system needs and limitations as applied to coal slurry impoundments. Future efforts would include collaboration with instrumentation vendors for commercialization of complete monitoring packages to support MSHA’s visual inspection requirements.

**WV – 229: Passive Treatment Installation – Dream Mountain – Muddy Creek**

***Principal Investigator: Brady Gutta, Research Associate, WVWRI***

The Dream Mountain Project is located on Muddy Creek which is a direct tributary into the Cheat River. Muddy Creek discharges into the Cheat River just northwest of Ruthbelle, in Preston County, WV, and is a major source of acidity and metals associated with the remnants of the coal mining process. Abandoned coal mining operations from the early 1900’s, active mines and bond forfeited sites are scattered throughout the watershed. These mine sites produce acid mine drainage (AMD) and

excess metals which have caused the impairment of Muddy Creek and its inclusion on the State's 303 (d) list of impaired streams. The project area consists of approximately 5 to 7 mine portals spread out over the eastern portion of the Dream Mountain Game Ranch. The Dream Mountain facility is a private fenced game reserve that contains large White-tailed Deer, Buffalo, and Elk. They offer paid hunts as well as stays in cabins that are on site.

This project consists of constructing steel slag leach beds in two freshwater tributaries, installing open limestone channels to convey the water from the portals, and constructing two wetlands for the metals to precipitate into. The goals of this project are the approximate removal of 416,416 pounds per year of acid, 64,528 pounds per year of iron, 39,328 pounds per year of aluminum, and 4,016 pounds per year of manganese. The system will also generate extra alkalinity to neutralize downstream sources of mine acid. Construction of this project began in July of 2009 after difficulty in gaining landowner access after the property changed hands. Completion is anticipated in early spring 2010.

This project will clean up additional pollution from Muddy Creek. It is aimed at helping to remove Muddy Creek from the state's 303(d) list of impaired watersheds. Its successful completion will add 7 tenths of a mile of fishable water in Muddy Creek. This project should be completed in spring, 2010.

**WV-231: Implementation of the Watershed Based Plan for AMD Remediation in the Cheat River Watershed**

***Principal Investigator: Richard Herd, Program Coordinator, WVWRI***

The primary objective of the project is to strategically apply various acid mine drainage treatment technologies to restore water quality in 27 stream miles of the Muddy Creek basin within the Cheat River watershed. Different treatment types will be evaluated in terms of costs and ecological benefits. It provides a more effective framework for restoring the maximum number of stream miles within watersheds from acid mine drainage impairment. The National Mine Land Reclamation Center at the West Virginia Water Research Institute is an internationally recognized leader in the development of acid mine drainage treatment technologies.

This initiative provides a unique opportunity to reduce a substantial acid load to the Cheat River and to develop a cost-effective restoration framework that could be transferable to other sub-watersheds within the Cheat and elsewhere throughout Appalachia.

**WV-232: Development and Demonstration of a Modeling Framework for Assessing the Efficacy of Using Mine Water for Thermoelectric Power Generation**

***Principal Investigator: Richard Herd, Program Coordinator, WVWRI***

This project developed a model for assessing the efficacy of using abandoned mine water for power generation. The project builds upon the research conducted by

WVWRI that evaluated the availability and cost-effectiveness of using mine pool water from the Pittsburgh coal seam in northern WV and SW Pa. as well as the potential environmental impacts resulting from mine pool flooding in the Monongahela, Pittsburgh, Irwin and Ohio geologic basins. The model was developed concurrently with design and construction of the 300 megawatt Beech Hollow Power Project waste coal to energy plant in Robinson Township, Washington County, Pa approximately 12 miles southwest of Pittsburgh. The plant is projected to use between 2,000-3,000 gallons per minute.

The project objective is to provide a framework that energy developers can use to assess mine water availability, its cost, and the technical and regulatory aspects and environmental benefits of such use. In the United States thermoelectric generation is second only to agriculture in terms of total water use. Increasing demand for adequate, reliable and economical electrical energy is placing increasing demand on freshwater resources potentially resulting in water use conflicts with other water users. This framework will facilitate the use of mine water for power generation and other large industrial users thereby reducing demand on freshwater resources while abating mine discharges the primary cause of water quality impairment throughout the region.

The project will help address two societal issues: The increasing demand for power generation and its effect on freshwater resources and the potential environmental impacts that can result from mine pool breakouts. Utilizing an impaired resource such as polluted mine pool water is a win-win for both the economy and environment.

**WV-233: Lower Cheat Watershed Passive Treatment Installation: Middle Fork of Greens Run, Morgan Run, and Pringle Run**

***Principal Investigator: Brady Gutta, Research Associate, WVWRI***

The Lower Cheat Watershed Passive Treatment Project sought to remediate three sources of acid mine drainage in three different sub-watersheds of the Cheat River. In order to implement this project, partnerships were developed and a Watershed Plan was drafted and approved. Passive treatment systems were designed and installed to neutralize acidity and remove high concentrations of metals from water draining these formerly mined areas.

Water sampling and monitoring visits to the three sub-watersheds were taken during high, medium, and low flows in order to determine the amount of acidity and metal concentrations that needed to be reduced. All three discharges were found to be in exceedence of water quality standards for iron, aluminum, and manganese. Passive treatment systems were designed to correct pH problems and remove metals from the mine discharges. Various alkaline treatments were used to remediate these discharges, including limestone leach beds, steel slag leach beds, and open limestone channels, among others.

Greens Run, Pringle Run, and Morgan Run were listed as impaired streams in West Virginia's listing of 303(d) streams in 1996 and 1998. In 2001, the Cheat River Total

Maximum Daily Load (TMDL) document was finalized and all three of these sub-watersheds were earmarked for reductions in metals (primarily iron, aluminum and manganese), as well as acidity. Implementation of the proposed Plan is helping to restore these sub-watersheds to water quality standards. Completion of these passive treatment projects has also reduced the acid and metal loadings in the mainstem of the Cheat River, which will aid in the reestablishment of the Cheat River as a fishery and recreational destination.

**WV-237: Development and Implementation of a Water Quality Bank and Trade Program for the Potomac River Watershed, WV**

***Principal Investigator: Richard Herd, Program Coordinator, WVWRI***

Excess nutrients entering the Potomac River are creating significant downstream water quality problems. Under the Clean Water Act (CWA), West Virginia is required to address the downstream problems in the Potomac River Watershed – a tributary of the Chesapeake Bay. West Virginia has committed to reducing the amount of phosphorus entering the Potomac River by 33% and nitrogen by 35%. Programs such as nutrient trading are being implemented to help meet the nutrient reduction requirements that EPA will impose by December, 2010.

Water Quality Trading is an innovative approach to efficiently achieve water quality goals. Trading is based on the fact that various nutrient sources in a watershed can face very different costs to control the same pollutant. Trading programs allow facilities facing high pollution control costs to meet their regulatory obligations by purchasing environmentally equivalent (or superior) pollution reductions from other sources with lower pollution reduction costs, thus achieving water quality improvement at a lower overall cost.

This project developed a methodology for calculating potential nutrient reduction credits resulting from various agricultural practices applied in West Virginia. These calculations have been integrated into West Virginia's online water quality trading platform called NutrientNet.

NutrientNet uses six steps to calculate Nitrogen and Phosphorus Credits involving Ratios, Factors and Baselines. This Credit Calculation program helps suppliers and buyers of nutrient credits define the product more clearly. It ensures that real and verifiable pollution load reductions are established.

Reducing nutrients in the Chesapeake Bay has been identified as a priority by Bay states and the US Environmental Protection Agency. Nutrient trading programs have proven to be a cost-effective means to achieve this goal. Voluntary incentive-based programs such as nutrient trading reduce the need for less flexible and mandatory regulations to control these sources of pollution.

## **WV-238: In-situ Mitigation of Iron in a Net-alkaline Environment**

***Principal Investigator: Richard Herd, Program Coordinator, WVWRI***

This study investigates the hydrodynamics of flow in the T&T / Ruthbelle mine complex, in Preston County West Virginia. This complex consists of three mines: T&T #2, T&T #3, and Ruthbelle. On April 25 1994 a blowout at the T&T #2 pit mouth resulted in environmental impacts to Muddy Creek and the Cheat River. A subsequent Consent Decree led to a hydrologic study of the mine complex and the injection of 80,845 tons of limestone sand as an *in situ* treatment.

The study also evaluates the efficacy of *in situ* use of hydrogen peroxide as an oxidizing agent. This requires that the flow to be treated be concentrated in one or just a few mine entries. Two holes were drilled into the mine. The upstream hole was for hydrogen peroxide injection and the downstream hole was for sampling of the mine water.

Field measurements of pH, oxidation reduction potential (ORP), and dissolved oxygen (DO) all responded to the addition of hydrogen peroxide. Field titration of the raw mine water using pH, DO and ORP were conducted to establish the ferrous oxidation end point. This injection rate was varied periodically and the effect of these different rates were measured at the sampling well. Water samples were also taken and measured for total, dissolved and ferrous iron.

This project allowed costs and flows to be determined as well as application rates for hydrogen peroxide. It allowed for more accurate estimations of application rates and the appropriate allowances for sludge storage and limestone sand injection.

## **WV-244: Technical Support for Implementing the West Virginia AML Program**

***Principal Investigator: Richard Herd, Program Coordinator, WVWRI***

The WV Water Research Institute has provided technical support to the WV Department of Protection (WVDEP), Office of Abandoned Mine Land and Reclamation for implementation of the expanded Abandoned Mine Land (AML) program. The technical assistance services provided to WVDEP included:

1. Development and application of a GIS-based restoration alternative decision support system to visually illustrate remediation alternative outcomes and costs.
2. Estimation of the economic benefits of water quality restoration accomplished under the AML program.
3. Application of an EcoUnit (EU) concept to identify cold- and warm-water fishery restoration priorities.
4. AMD remediation designs (type, size, location) that target maximum recovery of productive fisheries.
5. Cost – Benefit analysis of alternative remediation designs.
6. Design of monitoring programs to quantify the ecological and economic benefits.
7. Data analysis, report writing, and presentations to the public.

The implementation process developed by WVWRI provides WVDEP a scientifically sound, transparent and defensible process for prioritizing and implementing restoration actions that achieve the greatest ecological benefits per dollar invested in stream restoration.

#### **WV-246: West Run Watershed Based Plan**

***Principal Investigator: Brady Gutta, Research Associate, WVWRI***

The purpose of this plan is to document the existing characteristics and conditions within the West Run watershed, and identify problem areas for restoration. Existing water quality and watershed data was compiled which identified 3 problem areas in the watershed including acid mine drainage, bacterial contamination and storm water runoff. Field surveys were conducted to verify existing data and additional data was collected. Further studies were undertaken to identify the sources of these problems.

Locating and prioritizing water quality problems is important when determining the overall health of a watershed. Once all pollution sources have been found, a watershed-based plan must be constructed in order to receive future funding for pollutant remediation. The results of this watershed-based plan will aid in the efficient use of reclamation funding and will provide the largest amount of remediation for the lowest price.

#### **The Combustion Byproducts Recycling Consortium**

The Combustion Byproducts Recycling Consortium (CBRC) program was developed as a highly focused program to remove and/or minimize the barriers for effective management of over 123 million tons of coal combustion byproducts (CCBs) annually generated in the USA. At the time of launching CBRC in 1998, about 25% of the CCBs were beneficially utilized while the remaining were disposed in on-site or off-site landfills. Ten years later, 43% of CCBs were beneficially utilized.

Due to the national scope of the CBRC program and the varying priorities between regions, three regional geographic areas were identified as East, Midwest, and West. Regional centers were located at the University of Kentucky, Southern Illinois University, and the University of North Dakota. The program's National center was headquartered at West Virginia University.

During the ten year tenure of CBRC (FY1998-FY2007), 52 peer-reviewed projects were funded nationwide. Of those 52 projects, 21, 18, and 13 were funded in the eastern, mid-western, and western regions, respectively. The U.S. Department of Energy – National Energy Technology Laboratory provided \$5,973,861; industry and state sources provided \$4,775,313 for a total program value of \$10,749,176. Almost all projects were cooperative projects involving industry, government, and academia to: 1) develop professional capacity near-term as well as long-term; 2) keep research highly focused to enhance beneficial utilization of CCBs; and 3) provide rapid transfer of

technologies and information to the marketplace to have near-term positive impacts. The following table lists the project funded between FY2003 – FY2007.

CBRC Projects Funded Between FY2003 – FY2007							
Fiscal Year	Project No.	Title	Principal Investigator	Organization	Federal \$	Non-Federal \$	Total Project Value \$
FY-05	05-CBRC-E08	National Network of Research and Demonstration Sites for Agricultural and Other Land Application Uses of FGD Products	Dick	Energy Industries of Ohio	105,000	63,149	168,149
FY-05	05-CBRC-E18	Field Testing of Arsenic and Mercury Bioavailability Model from Land-Applied Coal Combustion Byproducts	Pier	West Virginia University	17,647	28,815	46,462
FY-05	05-CBRC-E19	Community-based Social Marketing: The Tool to Get Target Audiences to Use Coal Combustion Byproducts	Buggeln	Illinois State Geologic Survey	40,436	13,868	54,304
FY-05	05-CBRC-M09	Cold In-Place Recycling of Asphalt Pavements Using Self-Cementing Fly Ash: Analysis of Pavement Performance and Structure Number	Misra	New Mexico State Univ.	18,831	19,057	37,888
FY-05	05-CBRC-M16	In Situ Stabilization of Gravel Roads with CCPs	Edil	University of North Dakota	48,886	17,004	65,890
FY-05	05-CBRC-M20	New Technology Based Approach to Advance Higher Volume Fly Ash Concrete with Acceptable Performance	Obla	Ohio State University	113,974	64,657	178,631
FY-05	05-CBRC-M23	Manufacturing Building Products with Fly Ash and Advanced Coal Combustion	Chou	Tennessee Valley Authority	38,250	50,903	89,153

		Byproducts					
FY-05	05-CBRC-W03	Evaluation of Coal Combustion Byproducts for In Situ Treatment of Acid Mine Drainage	Canty	University of Tennessee	11,601	1,270	12,871
FY-05	05-CBRC-W04	Using Class C Fly Ash to Mitigate Alkali-Silica Reactions in Concrete	Dockter	University of Missouri	37,500	21,466	58,966
FY-05	05-CBRC-W08	Evaluation of the Durability and Commercial Potential of 100% Fly Ash Concrete	Stephens	University of Wisconsin	71,544	22,679	94,223

## Project Descriptions

### **05-CBRC-E08: National Network of Research and Demonstration Sites for Agricultural and Other Land Application Uses of FGD Products** ***Principal Investigator: Warren Dick, Ohio State University***

The long-term goal was to develop new strategies for the beneficial use of FGD products in agriculture. The main objective was to evaluate the effectiveness of a novel strategy to create a national network to test and demonstrate the benefits of FGD products in agriculture. To achieve this objective, three sub-objectives were developed.

1. Develop a workshop to bring together interested parties to pool current knowledge and to create a national research and development network related to large-volume beneficial uses of FGD products in agriculture and other land application uses.
2. Determine the appropriate rates and technologies of FGD products use in agriculture.
3. Evaluate the soil chemical and environmental effects of FGD products when applied to different soil types for improving crop productivity.

A workshop was held in St. Louis, MO in September 2006. Sixty-five people from regulatory, utility, marketing, research, and farming sectors attended. Experiments were designed for a minimum of two years of crop production and data collection. Environmental effects of gypsum application were monitored. The first site was established in 2007 in North Dakota. Results from year one indicated higher wheat yields when high rates of both commercial agricultural gypsum and FGD gypsum were applied. However, the increases in yield were not statistically significant. Gypsum applications showed no strong effects on the chemistry of the wheat grain or on grain quality. Additional sites are being established in five other states. Data obtained from these network sites will be made available to network participants to help promote sound agricultural and environmental use of FGD gypsum in the United States (Dick 2008).

**05-CBRC-E18: Field Testing of Arsenic and Mercury Bioavailability Model from Land-Applied CCBs**

***Principal Investigator: Paul Pier, Tennessee Valley Authority***

The overall objective of this project was to provide a model to predict the uptake of arsenic (As) and mercury (Hg) by plants in response to CCB application rates to soil, based on CCB/soil characteristics. This will provide a measure of contaminant bioavailability for plants and concomitant risk assessment for soils that are being considered for CCB application thus eliminating the need to grow plants to maturity at each site to obtain risk assessment data. Greenhouse studies were conducted. The first study consisted of sorghum sudan grass, sunflower, and brake fern, an arsenic accumulator, grown in a potted soil amended with fly ash. The second study consisted of corn, soybean, and brake fern grown in soil amended with FGD gypsum. Data was used to develop a multiple-variable regression model for predicting As and Hg plant uptake. This predictive model can be used when considering amending soil with fly ash or FGD gypsum (Pier, 2008).

**05-CBRC-E19: Community-based Social Marketing: The Tool to Get Target Audiences to Use CCBs**

***Principal Investigator: Richard Buggeln, University of Tennessee***

The overarching goal of this project was to demonstrate the utility of Community-Based Social Marketing (CBSM), a method for implementing sustainable agricultural use of combustion by-products by farmers, and in so doing to develop a model that can be expanded and applied to other CCBs. To achieve this goal, the project had the following objectives: 1) Use CBSM to create a commitment to use a combustion byproduct, flue-gas desulfurization gypsum (FGD gypsum), among agricultural communities in Tennessee; and 2) make the CBSM tool understandable and accessible to members of the Combustion Byproducts Recycling Consortium (CBRC) in order to facilitate its transferability to other combustion byproduct generators/markets.

Farmer enlistment was good and the project remained on target. The Director of the University of Tennessee Center for Industrial Services has made funds available to see the project through to its completion scheduled for June 2009. The Tennessee Valley Authority has also agreed to continue its support and Temple-Inland is considering making a commitment to the project (Buggeln, 2007).

**05-CBRC-M09: Cold In-Place Recycling of Asphalt Pavements Using Self-Cementing Fly Ash: Analysis of Pavement Performance and Structure Number**

***Principal Investigator: Anil Misra, University of Missouri***

Full-Depth Cold In-Place Recycling (CPR) with self-cementing fly ash has been shown to be an effective method of converting conglomerate pavement sections into durable roads. CPR demonstration projects have been performed in several states, where it has been shown to produce longer road life at a major savings. This technology

provides several economic and environmental benefits. The process recycles deteriorated asphalt pavement and self-cementing fly ash, reduces energy consumption, diesel emissions, land disposal requirements, virgin resource utilization, and increases road longevity. In addition to providing environmental benefits and long-lasting pavements, it has been reported that this technology could result in savings of up to 33% over conventional techniques.

A demonstration of this process on approximately 2.5 miles of roadway consisting of two different segments was conducted in August 2004. As a result, model construction specifications and a pre-construction testing program were developed. In addition, the construction procedures and the monitoring methods were documented and evaluated. Subsequently, the falling weight deflectometer (FWD) tests were conducted at different locations on these roads after 1.5-years of project completion. The deflection bowls measured in the FWD tests were analyzed to back calculate the resilient moduli of the road base. These moduli were utilized to estimate the structural layer coefficient which is a measure of the relative ability of a unit thickness of a material to function as a structural component of the pavement and may be used to calculate the structure number needed for the design of layer thicknesses. The conservatively recommended layer coefficient values, which ranged from 0.18 to 0.20, were considerably higher than the AASHTO design requirement of 0.14 for the layer coefficient of flexible pavement granular base. The high layer coefficients for recycled asphalt base (RAB) base course may allow for thinner asphalt wear surfaces, thereby reducing construction costs (Misra, 2008).

**05-CBRC-M 16: In Situ Stabilization of Gravel Roads with CCPs**  
***Principal Investigator: Tuncer Edil, University of Wisconsin***

The focus of this project was to develop a new large-volume application for self-cementing CCPs for in situ stabilization of gravel roads. The study assessed the engineering properties of two recycled materials and a natural aggregate. Laboratory experiments involved road surface gravel (RSG), a recycled pavement material (RPM), and a natural crushed aggregate (Class 5 base). California Bearing Ratio (CBR), resilient modulus (Mr), and unconfined compressive strength (UCS) were determined. The recycled materials were blended with two fly ash contents (10% and 15%) and had three curing times (7, 28, and 56 days). A Class C fly ash with 0.7% (LOI) was used. Resilient modulus and unconfined compression strength tests were also conducted to assess the impact of freeze-thaw cycling.

Unstabilized, three materials had CBR less than typically desired for base course (CBR  $\geq$  50). CBRs of RSG and RPM with fly ash were 3 to 11 times the unstabilized material alone. The CBR and UCS for RSG and RPM increased with increasing fly ash content and curing time. After five freeze-thaw cycles, the UCS of RSG and RPM mixed with fly ash was still higher (5 and 18%) than the UCS of material not subjected to freeze-thaw cycling. The SRM of RSG and RPM blended with fly ash increased with fly ash content and curing time, with the rate of increase being largest between 7 and 28 days of curing.

Fly ash reduced plastic strains of RSG and RPM during resilient modulus testing. Freeze-thaw cycling had a small effect on the summary resilient modulus (SRM) of Class 5 base, RSG, or RPM with or without fly ash, with no consistent effect for materials mixed with fly ash. Environmental assessment and field performance were undertaken on a segment of gravel county road (CR 53) that was stabilized with fly ash prior to paving in 2005. The results indicate a very successful application of the technology (Camargo, *et al.*, 2008).

### **05-CBRC-M20: New Technology Based Approach to Advance Higher Volume Fly Ash Concrete with Acceptable Performance**

***Principal Investigator: Karthik Obla, National Ready Mixed Concrete Association***

A major obstacle that limits the widespread use of High-Volume Fly Ash (HVFA) concrete is its lower early-age strength as documented in research studies conducted in the laboratory with standard cured strength specimens. The objective of this study was to demonstrate, using maturity-based techniques, that the actual in-place strength of HVFA concrete in a structure is higher than that indicated by strength measured on field-cured cylinders. This is due to the higher in-place temperature resulting from the slower dissipation of heat of hydration due to the greater mass of structural members. The in-place strength of concrete in the structure can be determined by monitoring its temperature history over time, calculating the maturity, and by estimating the in-place strength from the pre-calibrated strength-maturity relationship. The maturity concept assumes hydraulic cement concrete of the same maturity will have similar strengths, regardless of the combination of time and temperature yielding the maturity. Maturity concepts are well established for Portland cement concretes but they are not so established for HVFA concrete mixtures containing chemical admixtures. The Arrhenius and Nurse-Saul maturity functions are commonly used to establish the maturity index. The Arrhenius maturity function is considered more accurate and was used in this study. The Arrhenius maturity function requires the use of mixture-specific activation energy to improve predictions of strength.

The activation energy quantifies the temperature sensitivity of the concrete mixture. An initial task was to determine the activation energy of each of the concrete mixtures using the procedure outlined in ASTM C1074. Various fly ashes (Class C and Class F fly ash meeting the standard ASTM C618) with multiple dosages (20% to 50% by mass of cementitious materials) were used in this study. Activation energies of these mixtures were determined. Some unexpected trends of strength based on curing temperature were observed for these fly ash mixtures. The fly ash mixtures cured at elevated temperatures demonstrated higher long-term strengths than anticipated in comparison to the strength of specimens cured at lower temperatures.

The next step was to develop strength-maturity relationships in the laboratory for four of the concrete mixtures. Additionally, pullout load versus compressive strength correlations were developed. To validate the strength predictions based on maturity, four concrete blocks and slabs were prepared in the field during the period of October to

December, when the ambient temperature ranged from 15.5 degrees C (60deg F) to 7.5 degrees C (45 degrees F). The in-place compressive strength of the concrete blocks and slabs were predicted based on the following approaches: 1) match-cured cylinders; 2) pullout testing using the pullout versus compressive strength relationship previously developed; 3) maturity based on the activation energy and strength-maturity relationship previously measured; and 4) field-cured cylinders (Obla, 2008).

### **05-CBRC-M23 Manufacturing Building Products with Fly Ash and Advanced Coal Combustion Byproducts**

***Principal Investigator: Melissa Chou, Illinois State Geological Survey***

Due to more stringent NO<sub>x</sub> and SO<sub>2</sub> standards, the production of FGD (flue gas desulfurization) byproducts, as well as fly ash and bottom ash, will continue to increase. The utilization of bottom ash or FGD byproducts (sulfite-rich and sulfate-rich materials) instead of, or in combination with, fly ash was investigated for the production of large quantities of high-quality fired construction bricks. Various combinations of fly ash, bottom ash, FGD sulfite-rich material, and FGD sulfate-rich material were used as a partial substitute for the shale to mix with clay. These commercial-size fired bricks showed good physical appearance, with no scum, lime pops, cracks, black hearts, or red hearts. The majority of the fired bricks produced met the ASTM classification for a severe weathering grade. The remainders were acceptable for moderate- or negligible-weathering grade. Bricks containing FGD sulfite-rich material were whiter in color, lower in compressive strength, and greater in water absorption capacity than regular fired bricks containing no CCBs. The fired bricks containing fly ash/bottom ash blends were comparable with the regular fired bricks without CCBs in color. In particular, the addition of bottom ash to the brick composition increased the redness of the brick color, improved the brick's compressive strength, and decreased its water absorption capacity.

All the fired bricks containing CCBs produced from the bench-scale tests are considered environmentally safe construction products. The fly ash and bottom ash from the specific source for this project can be recommended for use in making fired bricks. However, the use of FGD byproducts as an ingredient in fired bricks is not recommended because their high sulfur concentration may pose issues of secondary emissions during brick firing. The FGD byproducts may be more suited for conditioning soil or for making sulfur fertilizer, in addition to wallboard application (Chou *et al.*, 2008).

### **05-CBRC-W03: Evaluation of CCBs for In Situ Treatment of Acid Mine Drainage**

***Principal Investigator: Geoff Canty, CC Environmental***

The purpose of this work was to study the long-term effectiveness of Alkaline Injection Technology (AIT). This *in situ* technology uses alkaline coal combustion byproducts (CCBs) to provide alkalinity, increase pH, and precipitate metals to remove them from the mine water. As the mine water reaches the ground surface, the quality of acidic mine drainage (AMD) is improved. Because this method of treating AMD does not rely on active physical and chemical processes such as combined neutralization and

precipitation, the cost of treatment is greatly reduced. Fewer chemical inputs, equipment, personnel and funds are required by AIT. Furthermore, AIT can be, in many cases, combined with other passive treatment technologies such as treatment wetlands, sequential alkaline producing systems (SAPS), anoxic limestone drains, and many combinations of these systems.

Two AIT projects were undertaken to evaluate AIT in an abandoned coal mine located in southeast Oklahoma, near the town of Red Oak. The mine is located in the Interior Province, Western Region Coal Field, in the Howe-Wilburton Coal District. This down-dip slope operation undermined approximately 46.5 acres. In 1997, the first AIT project imparted a limited amount of alkalinity to the system. While this project had positive results, they were relatively short-lived. In December 2001, the second AIT project injected approximately 2500 tons of fluidized bed combustion (FBC) ash using the same injection wells. The second project was more successful. As of June 2007, the second AIT project was still exhibiting success. This project examined the long-term AIT treatment of the seep for a period of 13 months.

Water quality during the treatment phase (following the 2001 injection) before the 2006-07 monitoring project averaged pH and alkalinity of 8.35 and 87.9 ppm as  $\text{CaCO}_3$ , respectively, and iron, manganese, and aluminum concentrations of 14.3 ppm, 2.5 ppm, and 4.8 ppm, respectively. The 2001 AIT demonstration can be described in three phases.

As of June 2007, the mine water was in Phase 2b of treatment. Phase 2b is distinguished by slightly decreasing pH and increasing alkalinity. Alkalinity increased from a low in August 2002 of 30 ppm as  $\text{CaCO}_3$  after the injection to approximately 227 ppm in June 2007. As bicarbonate became the more important species, there was an observed increase in alkalinity. Alkalinity continued to gradually increase from August of 2002 at a rate of 0.12 ppm as  $\text{CaCO}_3$  per day. The pH decrease observed during Phase 2b has been approximately 0.0004 units per day from 7.2 to 6.6.

During Phase 2, the concentrations of iron and manganese were expected to reach a threshold as pH continued to decrease. As of June 2007, iron and manganese were approaching background levels (before 1997 injection) with concentrations of 116 ppm and 5.2 ppm, respectively. Both iron and manganese are influenced by the carbonate system. In contrast, aluminum concentrations were well below background levels. Aluminum forms a hydroxide solid within this pH range and is not influenced by the carbonate ligand. Aluminum levels are not likely to increase until the pH returns to pre-injection levels (i.e., <5) at some time in the future. As of June 2007, the concentration of aluminum was 0.045 ppm, compared to pre-injection levels of 7.8 ppm. Aqueous carbon dioxide and carbonic acid species ( $\text{H}_2\text{CO}_3^*$ ) concentrations have yet to reach pre-injection levels of 3.8 mm. In June 2007,  $[\text{H}_2\text{CO}_3^*]$  was 2.7 mm. Because  $\text{H}_2\text{CO}_3^*$  is still increasing to pre-injection levels, it is unknown how much longer Phase 2b will continue. Consequently, the duration and beginning of Phase 3, wherein an equilibrium between injected alkalinity and the partial pressure of carbon dioxide in the headspace will be reached, is unknown.

This treatment technology has been successful in treating AMD as of June 2007. The mine water at the discharge contained considerable alkalinity and circumneutral pH. AIT has been successful at removing metals from mine water and is treated further by the passive treatment cells downstream from the seep. The receiving stream of this mine water was much less negatively impacted than before the injection. This improvement was shown by the significant enhancement of the macro-invertebrate community, aquatic habitat and riparian vegetation.

Nickel, zinc, and arsenic were also monitored in this report to ensure this treatment strategy did not increase the concentrations of toxic metals that are sometimes found in CCBs. This monitoring period exhibited a significant decrease in nickel and zinc in the mine water from pre-injection levels (94% and 95% decrease, respectively).

AIT improves water quality by increasing alkalinity and reducing metal loading. Using these technologies in combination can greatly increase their effectiveness. AIT can be used to pre-treat mine water entering other AMD passive treatment cells. Consequently, treatment cell efficiency is improved. While this monitoring project has shown the success of this technology to date, the longevity could be further assessed (Winfrey, *et al.*, 2008).

#### **05-CBRC-W04: Using Class C Fly Ash to Mitigate Alkali-Silica Reactions in Concrete**

***Principal Investigator: Bruce Dockter, University of North Dakota***

CBRC funded year 1 of this 3 year study. In this study, ASTM standard methods are to be applied to fly ash samples and cast specimens produced using varying levels of Class C fly ashes. In addition to empirical tests, researchers will evaluate specimens using advanced electron microscopy techniques to look at the mineralogy of the ash and the aggregates and, especially, the reaction products. Researchers anticipate that results will confirm limited unpublished work that indicates the efficacy of using higher percentages of Class C fly ash to mitigate ASR when using moderately reactive aggregates.

A very comprehensive and diverse group of industry sponsors was successfully assembled for this project. They include Boral Material Technologies Inc., Western Region Ash Group, Holcim (U.S.) Inc., Lafarge North America Inc., WE Energies, Nebraska Ash Company, Ash Grove Resources, and Mineral Resource Technologies Inc. Between all of these companies, 14 types of fly ash will be tested using two cement sources. As of June, 2008, all members were in the process of sending in samples.

There were mainly three ASTM methods for evaluating expansion because of alkali-silica reactivity. The first is ASTM C1260, "Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)," and is probably the most widely used test method. Another commonly used test method is ASTM C1293, "Determination of Length Change of

Concrete Due to Alkali-Silica Reaction.” A third and more recent specification, ASTM C1567, “Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method),” addresses ASR mitigation using supplementary cementitious materials such as fly ash.

For the laboratory effort, it was decided to use ASTM C1567 for the bulk of the testing. Some of the samples tested under this method will also be evaluated using the concrete method ASTM C1293. All laboratory testing will be performed in future years 2 and 3 of the project.

The year 1 CBRC-funded activities were achieved as proposed. At the time of the original proposal, there were only three industry sponsors; now there are seven. An evaluation of existing literature on the topic of ASR has helped in focusing the needed laboratory effort for the next two years of this research effort. Much of the laboratory work will be conducted using the standard test method ASTM C1567. A selected ash sample from each sponsor will also be evaluated using the concrete prism method ASTM C1293. The EBSD will also be a useful tool to evaluate fly ash mineralogy and ASR mitigation.

The proposed mix proportions and test matrix will include the following replacement levels:

- Class C fly ash: 30%, 40%, and 50%
- Class F fly ash: 20% and 35%
- Class C/F blends: 20% and 30% (Dockter, 2008).

#### **05-CBRC-W08: Evaluation of the Durability and Commercial Potential of 100% Fly Ash Concrete**

***Principal Investigator: Jerry Stephens, Montana State University***

Building upon previous research conducted at Montana State University on concretes in which 100% of the binder is Class C fly ash from the Corette power plant in Billings, Montana, the specific objectives of this project were threefold: 1) to identify additional fly ashes that could be used in 100% fly ash concretes; 2) to develop fly ash concrete mixtures with entrained air (which is a proven mechanism to improve freeze-thaw resistance in traditional concretes); and 3) to determine the durability of these concretes under various environments.

Three fly ashes similar in composition and production to the Corette fly ash were screened as potential binders in 100% fly ash concrete, namely, fly ashes from the Port Neal (Sioux City, Iowa), Dave Johnston (Glenrock, Wyoming), and Council Bluffs (Council Bluffs, Iowa) power plants. Based on laboratory trial mixtures, concretes made with the Port Neal and Dave Johnston fly ashes had properties similar to those obtained using the Corette ash (e.g., 28-day compressive strength approaching 4,000 psi), and the Dave Johnston ash was selected for further consideration in addition to the Corette ash. Entrained air appeared to be readily induced in the Corette concrete using a

commercial admixture. This entrained air had little effect on the workability of the fresh concrete, while it noticeably decreased the strength of the hardened concrete.

From a durability perspective, the freeze-thaw resistance of the Corette fly ash concrete (determined following ASTM C666) is promising, while there may be concerns about the performance of the Dave Johnston concrete (these test are on-going). Relative to ASR, both the Corette and the Dave Johnston concretes exhibited very little reactivity when tested following the test method described in ASTM C1260. The sulfate resistance test (ASMT C1012 is of relatively long duration, and no meaningful results have yet been obtained although these tests are on-going. Relative to hydrogen sulfide/microbial related deterioration of fly ash concrete, no significant corrosion was seen in samples exposed for approximately 2-1/2 months to a sulfur enriched, wastewater-based microbial environment.

The results of this project have substantially increased the body of knowledge on 100% fly ash concretes. While the basic strength and other engineering properties of concretes made using just Class C fly ash from the Corette power plant in Billings, Montana, as the binder (without any Portland cement) have been known for some time, little definitive information has been available on: 1) whether other similar fly ashes exhibit the same degree of cementing action as the Corette fly ash and can be used as the binder in fly ash concretes, and 2) whether these concretes offer acceptable durability for their intended application (e.g., construction of buildings, bridges, pavements, wastewater structures, etc.). Prior to this test program, the durability of fly ash concretes could only be speculated on based on knowledge of, and past experience with, Portland cement concretes (Stephens, 2008).

#### CBRC National Steering Committee

The CBRC program had a National Steering Committee to identify both national and regional research priorities. They reviewed requests for proposals and reviewed the performance of the Combustion Byproducts Recycling Consortium annually. In addition, they reviewed proposals submitted in response to the RFP's and made recommendations to DOE-NETL as to which should be funded. The NSC advised the CBRC (WVWRI) Director on strategic direction for the program and reviewed project final reports. This committee met twice yearly.

The National Steering Committee consisted of representatives from the following organizations:

- ! Ohio Coal Development Office
- ! Interstate Mining Compact Commission
- ! University of New Hampshire
- ! TXU Energy
- ! American Coal Ash Association
- ! U.S. Army Corps of Engineers
- ! Tennessee Valley Authority

- ! University of Kentucky
- ! Utility Solid Waste Activities Group
- ! Office of Surface Mining
- ! Illinois Office of Coal Development and Marketing
- ! U.S. Environmental Protection Agency

### Significant Achievements

Specific CBRC achievements are given below:

- The CBRC has developed professional expertise in the area of CCBs throughout the nation. The 52 funded projects were distributed through 21 states. Within each region, local area power plants and regulatory agencies worked with professionals leading the projects and enhanced their expertise even further.
- Most projects led to graduation of one or more M.S. or Ph.D-level students. The enhanced capacity continues to provide technology and information transfer expertise to industry and regulatory agencies.
- Several technologies were developed and demonstrated that are either commercial or have such proven potential. These include: 1) Use of CCBs for road base and sub-base applications; 2) full-depth, in situ stabilization of gravel roads or highway or pavement construction recycled materials; and 3) fired bricks containing up to 30%-40% F-fly ash. In addition, some technologies were developed that were not commercialized during this period but have such potential. These include development of CCBs-based transmission poles and construction materials using sulfate-rich scrubber sludge.
- About 25% of cement is currently allowed to be replaced by fly ash. Laboratory studies have been completed that indicate that much higher amounts of fly ash could be added in cement-concrete applications under some circumstances. Additional studies are needed in this area to extend these results to field evaluations.
- Management of CCBs in mine settings remains a viable alternative. A study of the long-term environmental effects of structural fills in a surface mine was completed. This study has provided much-needed data for permitting large-volume management in both beneficial as well as non-beneficial use settings.
- Of the CBRC projects funded, some of the projects with the most potential for encouraging large-volume utilization of CCBs are the projects dealing with the agricultural use of flue gas desulfurization (FGD) gypsum.
- With power plants adding and enhancing FGD systems in response to the 2005 EPA Clean Air Interstate Rule and the saturation of the traditional wallboard market, there is a need to utilize the growing amounts of FGD gypsum entering the market. Agricultural uses are a good outlet, providing a sustainable market for gypsum.
- Educational efforts to reach farmers were an important component in the projects since, without the buy-in from the customers, FGD gypsum runs the risk of being stigmatized as a poor, and possibly toxic, substitute for natural gypsum. The CBRC projects demonstrated that the latter perception has no basis in fact.

- The use of fly ash in large fills, as in an airport runway extension project, and as a substitute for Portland cement, was also promoted among the projects.
- Evolving air quality standards impact the nature of the fly ash produced, whether it is an increase in fly ash carbon due to the 1990's conversion to low-NOx combustion or an increase in ammonia on fly ash due to the installation of selective catalytic reduction systems. In both cases, traditional markets could be jeopardized, taking fly ash off of the market at a time when DOE is striving to increase overall utilization of CCBs. The CBRC projects addressed these problems.
- The use of CCBs in mine fills as a means of reducing acid mine drainage is another example of a large-scale use of material. While mine utilization is likely less of a long-term use than, for example, the agricultural use of FGD gypsum, it has the potential to solve environmental problems left by previous generations of coal mining.
- In addition to the direct outcomes of CBRC funded projects outlined above, several other projects were completed with support from other sources of funding. Some examples of such projects included: 1) Development and use of flowable fills containing CCBs; 2) high-strength cattle feedlot construction materials; 3) large-volume fly ash-based highway barriers; 4) demonstration of underground placement of CCBs-based paste backfills for higher extraction and subsidence control; 5) development of frictional materials for automotive brake applications; and 6) novel value-added materials concepts from Integration Gasification Combined Cycle (IGCC) byproducts.
- It is difficult to quantify the impact of the CBRC on CCBs utilization trends. However, it is fair to say the CBRC program had a significant positive impact on increased utilization of CCBs in every region in the USA. Today, the overall utilization of CCBs in the USA is over 43%.
- CBRC has led to a large number of healthy cooperative relationships among researchers, industry, and government agencies that will continue to have long-term positive impacts on the CCBs management topics.
- CBRC research has also had a large impact on CCBs management across the globe. Information transfer activities and visitors from leading coal producing countries such as South Africa, Australia, England, India, China, Poland, Czech Republic and Japan are truly noteworthy.
- Overall, CBRC has been a truly successful cooperative research program. It has brought together researchers, industry, government, and regulators to deal with management issues related to production of CCBs with varying characteristics.
- The coal combustion industry is constantly changing. The increased amount of fluidized-bed combustion products, the potential for the entry of gasification products in the market, and the variety of products from the co-combustion of coal/biomass/tires/etc., all indicate that more research is needed to keep pace with the evolving market. In this context, it is unfortunate that the CBRC will no longer be a venue for the exploration of emerging technologies.

With the current focus in Washington on the environmental safety of CCBs, the findings of this program's research are especially pertinent.

## Hydrology Research Institute (HRC)

Established in 2002, the HRC is dedicated to improving the understanding and management of West Virginia's water resources. The Center's researchers are actively studying applied water problems in the state, conducting research that addresses acid mine drainage, flooding and discharge from abandoned mines, groundwater supply and protection, and other watershed management issues. The HRC assembles multi-disciplinary research teams from West Virginia University and other higher education institutions to investigate current hydrologic science issues that are of interest to industry, government, and the general public.

<b>HRC Projects Funded FY-03 Through FY-07</b>					
Project No.	Title	Funding Source	Amount	Cost Share	Total Project Value
HRC-4	Monitoring and Exploration for Flooded Pools in the Pittsburgh Coal Basin, Northern West Virginia	WVDEP	\$125,340	\$0	\$125,340

### Project Descriptions

#### **HRC – 4: Monitoring and Exploration for Flooded Pool in the Pittsburgh Coal Basin, Northern West Virginia**

***Principal Investigator: Joseph Donovan, Director, Hydrogeology Research Center and Professor, Geology, WVU***

Water levels in West Virginia's mine pools of the Pittsburgh seam have both raised and fallen in the period 2001-present due to groundwater recharge and industry control efforts. This project monitored groundwater levels in approximate 15 key mines in northern West Virginia including the Morgantown-Fairmont area and the Wheeling area. Water levels were collected using sealed pressure transducers downloaded monthly and processed to yield daily data. In addition, a new well was drilled, installed, and instrumented in the Wheeling area to assist in piecing together mine-pool distribution. Locations of approximately 30 discharges in the Wheeling area were mapped from state and local sewage treatment agencies. The resulting interpretations were used to (a) determine if industry remained within limits of compliance for mine water control in the Morgantown-Fairmont area and (b) determine where mine discharges from AML sources in the Wheeling area are actually reaching receiving streams.

Two maps at scale 1:100,000 show mining hydrogeology of two parts of northern WV with large subsurface mine pools. Results allow public understanding of the scope and control efforts associated with post-mining flooding of underground mines.

## National Environmental Education & Training Center (NEETC)

NEETC is a non-profit group that provides environmental training and develops new technologies to protect workers. The following is a listing of NEETC projects funded over fiscal years FY2003-FY2007.

<b>NEETC Projects Funded FY-03 Through FY-07</b>					
Project No.	Title	Funding Source	Amount	Cost Share	Total Project Value
NE-14	NEETC Center of Excellence	NEETC	\$596,310	\$0	\$596,310
NE-15	Well Injection Depth Extraction (WIDE) Phase II Deployment of the Former Lockbourne AFB	NEETC	\$392,181	\$0	\$392,181
NE-16	NEETC Center of Excellence	NEETC	\$43,783	\$0	\$43,783
NE-17	Well Injection Depth Extraction (WIDE) Phase II Deployment at the Former Lockbourne AFB	NEETC	\$149,924	\$0	\$149,924
NE-18	NEETC Center of Excellence	NEETC	\$45,000	\$0	\$45,000
NE-19	Exposure Assessment on Sampling Protocol	NEETC	\$9,521	\$0	\$9,521
NE-20	NEETC Center of Excellence	NEETC	\$65,000	\$0	\$65,000
NE-22	NEETC Center for Excellence	NEETC	\$65,000	\$0	\$65,000
NE-23	Environmental Forensics for Location of Unexploded Ordnance at the Dolly Sods Wilderness Area	NEETC	\$368,181	\$0	\$368,181
NE-24	Techniques for Detection and Remediation of Environmental Contamination by Nitroaromatic Compounds	NEETC	\$31,601	\$0	\$31,601

## **Project Descriptions**

### **NE-14, NE-16, NE-18, NE-20 and NE-22: National Environmental Education Training Center Center of Excellence**

***Principal Investigator: John D. Quaranta, Program Coordinator, WVWRI***

The WVU-NEETC Center of Excellence supports the National Environmental Education and Training Center (NEETC Inc.) by providing engineering and development support by way of management expertise in the following key areas:

1. Review and comment on NEETC Inc. initiatives in the area of environmental technology.
2. Manage all WVU-Center of Excellence projects either on- or off-campus.
3. Contribute to WVU-Water Research Institute conferences including Brownfields and WRI's annual conference.
4. Manage subcontracting of WVU's projects and vendors located regionally to WVU in support of NEETC Inc.'s programs.
5. Supplement NEETC's reduced staff by providing administrative support such as high volume document scanning, updating program schedules, and assisting with reporting deliverables.
6. Attend the annual SERDP Technology conference in Washington, DC and attend meetings as directed by NEETC.

### **NE-19: Exposure Assessment on Sampling Protocol**

***Principal Investigator: John D. Quaranta, Program Coordinator, WVWRI***

Industrial hygienist generally place air sampling probes on the mid to upper torso of workers when attempting to determine their inhaled concentrations. A review of the literature does not supply convincing evidence that concentrations measured on the chest are equal to inhaled concentrations. This research is a continuation of research from 6/1/01 to 5/30/05 and extends the testing to incorporate additional subjects at the original test conditions plus one additional cross draft.

In summary, results demonstrate that:

- 1) concentrations were roughly half as high for standing as sitting,
- 2) breathing through a tube reduced the concentrations at most sampling sites but was not statistically significant,
- 3) concentrations varied significantly with velocity and followed an inverted-V profile. The slopes of the V were nearly twice as great for sitting then they were for standing.
- 4) concentrations for different human subjects ranged over a 4 to 1 range for the same conditions. It is likely that differing body sizes, body shapes, and lengths of hair contributed to the differences among subjects.
- 5) Concentrations at the mouth were often substantially different from concentrations elsewhere.

The outcomes of the study raise serious concerns about the accuracy of sampling on the chest, especially at the lapels when the source is near the worker and airflow is from

the back. It is particularly important to note that the resulting sampling errors may vary greatly if the subject is sitting rather than standing and may depend strongly on the airflow velocity, which generally is difficult to characterize in the field.

**NE-23: Environmental Forensics for Location of Unexploded Ordnance at the Dolly Sods Wilderness Area**

***Principal Investigator: John D. Quaranta, Program Coordinator, WVWRI***

This project sampled and analyzed soil specimens associated with unexploded ordnance from the West Virginia Maneuver Area within the Dolly Sods Wilderness Area, Canaan Valley National Wildlife Refuge and private lands in Grant, Tucker and Randolph Counties of West Virginia. The Department of the Army conducted training in the area in 1943 & 1944. A portion of the area included an impact area used for heavy artillery and mortar firing ranges. The research focused on characterization and investigation of the environmental contamination resulting from military ordnance and the “blow-in-place” method of detonations. This study determined the environmental impacts of the “blow-in-place” detonations and made recommendations to lessen the impact in future such activities.

**NE-24: Techniques for Detection and Remediation of Environmental Contamination by Nitroaromatic Compounds**

***Principal Investigator: John D. Quaranta, Program Coordinator, WVWRI***

Extensive environmental contamination is often found within military installations where munitions have been manufactured, stored, or decommissioned. Environmental impacts at these sites can be widespread, including contamination of groundwater, surface water, and soils with toxic materials. The U.S. Army Corps of Engineers (USACE) is tasked with the environmental restoration of these Department of Defense (DoD) installations under the Defense Environmental Restoration Program for Formerly Used Defense Sites (DERP-FUDS).

In order to develop appropriate remediation programs for contaminated FUDS, it is necessary to have a working knowledge of all available *in situ* technologies used to detect and treat environmental contamination caused by DoD activities. The West Virginia Water Research Institute (WVWRI) has produced a comprehensive database of literature relating to the remediation needs of two sister ordnance works, the Plum Brook and West Virginia Ordnance Works. These facilities are heavily contaminated with nitroaromatic compounds resulting from the production of explosives during World War II.

The database produced through this project will build the capacity of the USACE Huntington, West Virginia District Office to develop appropriate *in situ* treatment systems for nitroaromatic soil and groundwater contamination at FUDS within the Huntington District.

## **Northern West Virginia Brownfields Assistance Center (NBAC)**

In 2005, the West Virginia State Legislature recognized the lost economic and social value in abandoned contaminated lands or "brownfields." The Legislature created the Northern and Southern Brownfields Assistance Centers to work with the West Virginia Department of Environmental Protection, West Virginia Development Office to help communities plan and implement brownfields redevelopment projects.

Many small communities in rural West Virginia do not have the staff or technical expertise to undertake brownfields redevelopment projects on their own. NBAC staff support community efforts to turn brownfields in their communities into productive land again. Providing real assistance to such a large coverage area (33 northern West Virginia counties) is a challenge that requires significant collaboration across sectors and agencies.

The Northern West Virginia Brownfields Assistance Center, housed at West Virginia University's Water Research Institute, empowers communities to plan and implement brownfields redevelopment projects in the state's northern 33 counties by conducting general citizen and local government education efforts and by providing assistance to specific local communities interested in the reuse of brownfields in their communities. Support can be provided to help groups solicit grants and low-interest loans for site assessments, clean-ups, and environmental job training as well as provide support for preliminary legal and planning work. The Center prioritizes requests from communities that are already working on community-wide development planning and may be interested in integrating brownfields redevelopment into those plans.

A brownfield is a property, the expansion, redevelopment, or reuse of which may be complicated by the actual or perceived presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties increases local tax bases, facilitates job growth, utilizes existing infrastructure, takes development pressures off of undeveloped, open land, improves adjacent property values, and both improves and protects the environment.

### Northern West Virginia Brownfields Assistance Center Advisory Board

The NBAC was initiated in 2005 with West Virginia State Legislative funding to assist communities in northern West Virginia address brownfield properties and enhance economic development. The mission of the Advisory Board is to provide advocacy, accountability, and guidance on increasing the efficacy for the Northern West Virginia Brownfields Assistance Center. The advisory board meets with NBAC staff quarterly to inform and support NBAC staff on strategic, technical, and logistical issues related to the Center's mission to promote enhanced economic development in West Virginia through innovative redevelopment of brownfields sites.

Objectives include:

- Advise Center staff on strategic planning;
- Facilitate and generate opportunities for linking Brownfields redevelopment with West Virginia development objectives;
- Assist in the identification, prioritization of sites, and projects;
- Provide specialized advice and guidance on fulfilling the legislative mandated tasks; and
- Advocate innovative brownfields projects to promote enhanced economic development in West Virginia.

Members include representatives from:

- WV Department of Environmental Protection
- Claude Worthington Benedum Foundation
- Randolph County Development Authority
- Cummings/Riter Consultants, Inc.
- Babst, Calland, Clements & Zomnir
- SRA International
- Davis Trust Company
- Water Works, LLC
- The Ferguson Group

<b>Brownfields Projects Funded FY-03 Through FY-07</b>					
Project No.	Title	Funding Source	Amount	Cost Share	Total Project Value
BF-02	West Virginia Environmental Job Training Grant	USEPA	\$161,505	\$0	\$161,505

### **Project Descriptions**

#### **BF-02: West Virginia Environmental Job Training Grant**

***Principal Investigator: Patrick Kirby, Program Coordinator, WVWRI***

This project coordinated developed and implemented an environmental job training and employment program, Environmental Jobs for WV, targeting underemployed or unemployed residents who attained the skills needed to gainfully serve communities of Northern West Virginia that are beset by environmental problems. West Virginia, with its mountainous terrain and historical isolation from major metropolitan centers, has retained a strong sense of local community identity that is regionally unique. These factors, however, have also contributed to a lack of economic diversification and environmental degradation that the state is working to reverse. This program brought together community groups, job training organizations, educators, investors, lenders,

developers, employers, and other affected parties to provide quality, relevant training for residents in communities impacted by brownfields and to move them into environmental jobs in the area.

In Northern West Virginia, good-paying jobs in traditional natural resource extraction and manufacturing such as coal mining and steel production are disappearing. Development of communication technologies and infrastructure fuels new development, but this type of economic activity does little to engage the vulnerable populations in Northern West Virginia. Environmental Jobs for WV has given many of Northern West Virginia's underemployed an opportunity to learn a technical skill set, allowing them to contribute their own community while enjoying the benefit of good-paying jobs.

### Significant Accomplishments

A few noteworthy results include:

- Assistance to over 40 communities in obtaining and administering \$2,591,000 in EPA, WVDEP, and private foundation funds.
- Approval of 8 Targeted Brownfield Assessment grants through EPA Region 3's Brownfield Revitalization Program or WVDEP's Land Restoration Division, at an estimated value of \$250,000.
- Conducted 3 state-wide Brownfield conferences averaging 140 participants per event.
- Recognition by EPA Region 3 as a unique and successful model for providing brownfields assistance, not available anywhere else in the U.S.
- Obtaining various funding and partnering resources for alternative energy research and development on former industrial and surface mine properties.
- Placed 40 participants from the Brownfields Job Training Program in gainful environmental employment.
- Created a library of resources on redevelopment for the public and private sector.
- Started a Rail-Trail Initiative to assist communities across the State work with WVDEP, WVDOT and the railroad industry to overcome the environmental barriers to creating new trails.
- Developed over a dozen partnerships with other state agencies, and resource providers to enhance the opportunities available to West Virginia communities.

## West Virginia Water Research Institute Program Value by Year: FY2003 – FY2007

West Virginia Water Research Institute Summary of Program Value: FY2003 – FY2007			
Program	Sponsoring Agency	Cost-Share Match	Total Program Value
Water Research (other than USGS 104B Section)	\$1,298,164	\$96,133	\$1,394,297
National Mine Land Reclamation Center	\$4,977,740	\$950,128	\$5,927,868
Combustion Byproducts Recycling Consortium	\$503,669	\$302,868	\$806,537
National Environmental Education & Training Center	\$1,766,501	\$0	\$1,766,501
Hydrogeology Research Center	\$125,340	\$0	\$125,340
Northern WV Brownfields Assistance Center	\$161,505	\$0	\$161,505
Total	\$8,832,919	\$1,349,129	\$10,182,048

### Significant Research

Some of the significant research performed by the WVRWI from 2003-2007 include the following:

#### **WRI-66: Watershed Bacterial Study & Decentralized Wastewater Demonstration, Mud River Watershed, Lincoln County WV**

Between 2005 and 2008, a water quality study was performed in the Left Fork of the Mud River Watershed, Lincoln County, WV as part of an EPA-funded initiative. Baseline sampling locations were selected along several tributaries within the study area that had residences in need of onsite wastewater treatment systems. Four quarters of baseline sampling occurred between November 2005 and September 2006. Grab samples collected and analyzed in the laboratory for total coliform, and E. Coli showed that total coliforms exceeded 1,000/100 mL 90% of the time and E.Coli exceeded 235/100 mL 59% of the time.

Following wastewater treatment system installations, tributary water quality monitoring was adjusted to focus on segments of tributaries where systems had been installed.

The purpose in focusing on these segments was to determine if there were any measurable changes in bacterial contamination in the tributaries following system installation. Post-wastewater treatment system installation sampling results showed that total coliforms exceeded 1,000/100 mL 83% of the time. Fecal coliforms exceeded 400/100 mL 51% of the time, and E. Coli exceeded 235/100 mL 84% of the time.

It is interesting to note that a comparison of E. Coli results for three of the tributaries which had both baseline and post-system installation monitoring performed shows reductions in E. Coli. This may indicate that installation of wastewater treatment systems to residences along these tributaries is leading to improvements in the water quality of the tributaries.

### **WV-237: Development and Implementation of a Water Quality Bank & Trade Program for the Potomac River Watershed, WV**

Excess nutrients entering the Potomac River are creating significant downstream water quality problems. Under the Clean Water Act (CWA), West Virginia is required to address the downstream problems in the Potomac River Watershed – a tributary of the Chesapeake Bay. This project developed a methodology for calculating potential nutrient reduction credits resulting from various agricultural practices applied in West Virginia. These calculations have been integrated into West Virginia's online water quality trading platform called NutrientNet. Voluntary, incentive-based programs, such as nutrient trading, reduce the need for less flexible and mandatory regulations to control these sources of pollution.

### **WRI-51: A Hierarchical Classification System for Identifying Restoration Priorities and Impact Vulnerability in Mined Watersheds of the Mid-Atlantic Highlands**

This study established a GIS-based modeling system and the hierarchical classification system needed to facilitate implementation of watershed based approaches to aquatic resource management. It provides the technical framework needed to develop and implement water quality policy, regulations, mitigation, monitoring and assessments. These approaches make it possible to achieve watershed scale improvements more quickly, at lower cost, and with the help of a more diverse stakeholder group than traditional or *ad hoc* management approaches.

### **NE-23: Environmental Forensics for Location of Unexploded Ordnance at the Dolly Sods Wilderness Area**

This project sampled and analyzed soil specimens associated with unexploded ordnance from the West Virginia Maneuver Area within the Dolly Sods Wilderness Area, Canaan Valley National Wildlife Refuge in West Virginia. The Department of the Army conducted training in the area in 1943 & 1944. A portion of the area included an impact area used for heavy artillery and mortar firing ranges. The research focused on environmental contamination resulting from military ordnance and the "blow-in-place"

method of detonations and made recommendations to lessen the impact in future such activities.

#### **HRC-04: Monitoring and Exploration for Flooded Pool in the Pittsburgh Coal Basin, Northern West Virginia**

Water levels in West Virginia's mine pools of the Pittsburgh seam have both raised and fallen in the period 2001-present due to groundwater recharge and industry control efforts. This project monitored groundwater levels in approximate 15 key mines in northern West Virginia. The resulting interpretations were used to determine if industry remained within limits of compliance for mine water control and to determine where mine discharges from AML sources are actually reaching receiving streams. Results allow public understanding of the scope and control efforts associated with post-mining flooding of underground mines. These findings also led to a State/Private partnership to treat pending mine discharge.

#### **Information Transfer Activities**

##### **Conferences and Workshops**

*Monongahela Basin Mine Pool Project Public Meeting*  
October 9, 2003; First United Methodist Church, Washington, PA

*Combustion Byproducts Recycling Consortium Technical Session*  
October 5, 2004; Denver, CO

*2006 West Virginia Brownfields Conference*, Charleston, WV, September 26-27, 2006.

*2007 West Virginia Brownfields Conference, Bridgeport Conference Center, Bridgeport, WV, September 25, 2007.*

*Recycling Real Estate: Lending Opportunities for Bankers.*, Stonewall Resort and Conference Center, April 3, 2007.

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The following is a list of publications resulting from WVVRI projects (other than USGS 104B Section) between FY2003-FY2007.

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