WESTERN MARYLAND RC&D
WESTERN MARYLAND
RESOURCE CONSERVATION AND DEVELOPMENT COUNCIL, INC.

Tawes Hall● Room 313 ● Frostburg State University ● Frostburg, Maryland 21532
Phone: 301-687-0722 ● Fax: 301-687-0922
Website: www.wmrcd.org

Project Title: Use of Coal Combustion By-Products to Stabilize Mercury in George's Creek Mine Sediments

---

Name of Organization: Western Maryland Resource Conservation & Development (WMRC&D) Council, Inc.

Principal Investigator: Laura Michael, Environmental Research Associate
Western Maryland RC&D
Tawes Hall, Room 313
Frostburg State University
101 Braddock Road
Frostburg, Maryland 21532

Phone: (301) 687-0722
Fax: (301) 687-0922
Email: lbeeman@gmail.com

Project Partner: Dr. Robert Larivee, Ph.D.
Director, Coal & Shale Analysis Laboratory and
Chair, Department of Chemistry
347 Compton Science Center
Frostburg State University
101 Braddock Road
Frostburg, Maryland 21532

Phone: (301) 687-4091
Fax: (301) 687-7966
Email: rlarivee@frostburg.edu

Total Funding Requested: $150,000.00
Project Duration: 3 Years

Key Words: Coal Combustion By-Products (CCBs), atmospheric fluidized bed combustion (FBC) ash, stabilization, mercury, acid mine drainage, mine sediment, George's Creek basin.

Abstract:

Technical Proposal:

Statement of Problem:

The George's Creek watershed in Western Maryland has been called the most intensively mined basin in the nation, with production dating back to at least 1751 (Fry and Jefferson map, 1752). Its high quality coals supported the installation of the AES Warrior Run power plant, employing atmospheric fluidized bed combustion (FBC). Through the removal of coal, hydrology in the basin has been altered, and acid mine drainage is prevalent. Acid drainage dissolves heavy metals in overburden and remaining coal, contributing substances like mercury to water. Specific coal seams in the basin are suspected sources of mercury, especially among the lower beds. Where pH rises downstream from mine drainage sources, mercury-laden sediments precipitate and collect. In addition, the effective treatment of mine water adds to the problem by causing a build up of precipitated sediment along the stream, requiring removal and sequestration of mercury.

An unpublished study found relatively low base flow mercury concentrations in George's Creek, ranging from 0.5 to 1 nanograms per liter. In contrast, following runoff events, mercury was detected at 50 to 100 nanograms per liter. This suggested that a major source of mercury involved sediment runoff from accumulated mine deposits along the stream. In response to the study, Western Maryland Resource Conservation & Development Council, Inc. (WMRC&D) collected mine sediment samples along George's Creek and tested them for total mercury concentration, finding significant values. Four samples were stabilized using coal combustion by-products (CCBs) including FBC fly ash from the AES Warrior Run power plant. Stabilized mine sediments were reanalyzed and showed reduction of mercury below detection levels set by the Environmental Protection Agency (EPA). Further research is needed to develop the most effective method of stabilizing these mercury-laden sediments, employ more sensitive detection for mercury to ensure that it is permanently sequestered, and to identify potential reuses for the stabilized sediments.

Current Knowledge and Technology:

Although numerous studies examine the nature of acid mine drainage (AMD), metals commonly dissolved within it, and methods for precipitating them, little work has been conducted to establish methods of collecting and sequestering these metals. Iron, aluminum, and manganese investigations dominate past AMD studies, however due to variation in the chemistry of drainage from different coal seams; mercury is an important metal of concern at some locations. In the George's Creek watershed of Western Maryland, precipitated mine sediments have been found to contain high levels of mercury presumably due to the nature of the lower coal beds in the basin. The common use of lime to treat AMD has added to the volume of mine sediments containing mercury by increasing the precipitation of dissolved metals.

Some studies document the use of plants and biologic organisms to uptake and sequester mercury however more innovative methods are needed for large-scale mercury treatment (Costello, 2003). The EPA has studied the use of augmented microbes to sequester metals including mercury at mine sites (HazTECH News, August 1998). Their Superfund Innovative Technology Evaluation Demonstration Program identified a need for new methods of stabilizing mercury at mine sites.

Due to the source of mercury in some coal seams, research has been completed to evaluate its concentration in ash and gases resulting from the combustion of coal to produce electric power. The use of sorbents to control mercury emissions causes coal combustion by-products (CCBs) including some fly ash and flue gas to contain mercury that could also be stabilized prior to disposal or reuse. An important area of research involves the development of methods to stabilize this source of mercury, and reuse of CCBs to stabilize other environmental sources of mercury would create a two-fold benefit (Sanchez et Al., 2006).

One of the few studies that examined stabilization of mercury using a CCB was conducted at Oak Ridge National Laboratory. The study assessed the use of Mercury Amalgamation Stabilization / Solidification (MASS) to improve on traditional attempts to stabilize mercury in cement mixtures. Cement alone does little to stabilize mercury due to the fact that high pH has little impact on mercury's leaching potential; however the addition of blast furnace slag was found to significantly reduce leaching potential. The use of slag enhanced stabilization of mercury compounds and resulted in encapsulation of elemental mercury. Mercury contaminated soils and sludge samples were evaluated and the study found that stabilization with slag added to traditional cement mixes reduced mercury's leaching potential by several hundred times that of untreated wastes (Spence, 2001).

Further examination of the use of other CCBs is needed to improve on methods of mercury stabilization. This work would not only provide methods for reducing an environmental contaminant of major concern; it would also create new opportunities for beneficial reuses of CCBs by identifying potential products such as stabilized fill to address common concerns in mined lands including subsidence and AMD.

Project Objectives:

The purpose of the proposed project is to conduct research on the effectiveness of atmospheric fluid bed ash as an agent for stabilizing mercury in acid mine drainage sediment. CCB mix designs with the use of various additives will be examined in order to establish a successful method of stabilizing mercury. Potential reuses for the stabilized material will be identified based on the engineering properties of the optimum mixes designed in the study.

Project Description:

The mine sediments to be examined in this study will be identified through a survey of sediment observation and mercury concentration in water samples from Maryland's George's Creek watershed. Sampling and analysis of raw sediments followed by stabilization and analysis of samples found to have high mercury content will follow. For the purpose of assigning work to the various Co-PI's and laboratories that will be involved the work is proposed to be organized according to the following tasks and schedule.

Task 1: Identify sediments to be stabilized

Task 2: Sample and analyze raw sediments using EPA Method 1311 (Toxicity Characteristic Leaching Procedure or TCLP) to extract mercury and EPA Method 7470A (Mercury in Liquid Waste, Cold Vapor Technique) to measure leaching potential.

Task 3: Research optimum stabilization of high mercury content sediments with various AES Warrior Run FBC ash mixes.

Task 4: Analyze stabilized sediments using both TCLP and EPA Method 7470A. Protocols for analysis will be modified if necessary.

Potential Impact of the Project:

Desired impacts of the study include a heightened awareness and improved knowledge of mercury accumulation in mine sediments. A process will be developed to identify and collect contaminated sediments, stabilize mercury with CCBs, and determine beneficial reuses for the stabilized material. Further study would be encouraged including sensitive analysis of mercury and its various forms, study of mercury accumulation in mine sediments, and development of best methods for beneficial reuse of CCBs to stabilize mercury. The research would encourage local groups to complete projects to remove, stabilize, and reuse mine sediments and could be applied to any region where mining and coal-fired energy production occurs. The project will provide benefits to mined land environments as well as producers of CCBs who deal with the increasing demand to find beneficial reuses for the material.

Timeline and Budget Overview:

Funding for the proposed project will be divided among tasks over a three year time period as follows:

	Year 1	Year 2	Tear 3	Total
Task 1	30,000			30,000
Task 2	40,000			40,000
Task 3	30,000	50,000	50,000	130,000
Task 4		50,000	50,000	100,000
Total	100,000	100,000	100,000	300,000 *

* An explanation of budget adjustments will be provided in the detailed budget section below.

Work Plan:

The proposed project is divided into four main tasks with an additional goal of suggesting areas for further research and reuse of the stabilized material. Work on each task will progress as follows:

Task 1: Identify sediments to be stabilized

Task 1 will involve a preliminary study to locate and determine sediments to be sampled. Information previously developed by PPRP, WMRC&D and the Western Maryland Regional GIS Center (WMRGISC) will guide the collection of 24 water samples along George's Creek to create a map of high mercury input areas. Because mercury concentrations have been observed to spike after runoff occurs, samples will be collected within 48 hours of precipitation events. Data used to determine sample sites will include the location of specific coal seams that are suspected sources of mercury. Geographic Information System (GIS) mapping of abandoned mines in George's Creek has been underway at the WMRGISC since 1998, and will guide the location of mines and drainage points that exist in the suspect seams. Initial data on the characteristics of local coal seams suggests that the lower coal beds of George's Creek, such as the Barton and Franklin may be the biggest contributors of mercury in mine drainage. Additional sample sites will be determined based on known locations of sediment accumulation where mine drainage is treated with lime as it enters George's Creek.

Following the location of sites for water sampling based on mining data, field work will be completed by staff from WMRC&D, WMRGISC, and volunteers from the George's Creek Watershed Association. Water sampling will follow EPA protocol and data collected along with each sample will include a GPS point noting location, and observations of sediment accumulations. For each site where sediment is observed, the size, thickness and nature of the deposit will be noted to assist the sediment sampling phase.

Water samples will be analyzed for mercury at the Coal & Shale Analysis Laboratory (C&SA Lab) using EPA Method 7470. The resulting data will be provided to the WMRGISC, where a map of corresponding sample locations, mercury data, and sediment characteristics will be created using GIS technology. Additional water samples may be added if needed as the map is developed. The preliminary study map will highlight areas of high mercury input and sediment observation to provide a baseline for determining where sediment will be sampled in Task 2 of the project. A set of 192 (± 25%) sediment samples will be selected for analysis.

Task 2: Sample and analyze raw sediments using EPA Method 1311 (Toxicity Characteristic Leaching Procedure or TCLP) to extract mercury and EPA Method 7470A (Mercury in Liquid Waste, Cold Vapor Technique) to measure leaching potential.

Based on data from the preliminary study and map, sediment sampling will occur following EPA protocol. Staff from WMRC&D, WMRGISC and volunteers from the George's Creek Watershed Association will conduct the sampling. At each sample location, a minimum of 1500 to 2000 grams of sediment will be collected based on the amount needed to perform planned tests. Field notes will include data on the size, thickness, and general characteristics of the deposits and a GPS point will be captured at each site. At sites where the sediment deposit is relatively large in size or depth, multiple samples will be collected at various depths. A set of 192 (± 25%) sediment samples will be collected for mercury analysis and stabilization.

Sediment samples will be split into two portions to allow for physical analysis at the WMRC&D Materials Testing Lab and chemical analysis at the C&SA Lab. Work will begin by determining mercury leaching potential in raw sediments at the CS&A Lab using TCLP to extract mercury and EPA 7470A to measure leaching potential. Sediment samples will be processed in sets of 24 along with 6 additional standards for each set. This number was determined based on the equipment and labor available at the C&SA Lab. All raw samples will be analyzed for mercury leaching potential during the first year of the study. Data on the raw samples will be provided to WMRC&D in spreadsheet format in order to begin design of stabilization mixes.

Task 3: Research optimum stabilization of high mercury content sediments with various AES Warrior Run FBC ash mixes.

As data on the mercury leaching potential of raw samples begins to arrive at the WMRC&D Materials Testing Lab, technicians will begin developing test mixes for stabilization of mercury using FBC ash provided by the AES Warrior Run power plant. Various mix designs using both bag house fines and coarser bed drain material will be examined. Mix designs will be guided by preliminary tests conducted by WMRC&D that show potential for reducing mercury's leaching potential below EPA drinking water standards. These initial tests added AES Warrior Run CCBs at a proportion of 30% by weight to AMD sediment samples. Of this 30%, a useful mix of 2/3 bag house material and 1/3 bed drain material was found to significantly reduce mercury leaching. Beginning with this successful mix design, additional test mixes will be developed in order to determine the optimum amount and proportions of FBC materials that should be used to stabilize mercury and provide some strength to allow reuse of the material. As the project progresses and reuses for the stabilized material are considered, some mixes may be created replacing bed drain material with lime kiln dust in order to supply a free lime source and keep particle size to a minimum if pumping the material is required. In addition, due to the difficult nature of stabilizing mercury, various additives will be examined to enhance the CCB stabilization of mercury.

In considering possible reuses of the stabilized material, a subset of samples from mixes that successfully reduced leaching potential will be tested for compacted unconfined compressive strength. Mixes that provide a stabilized material with a minimum of 100 psi can be used as structural fill. Based on measured strength characteristics, some potential reuses will be identified.

As optimum mixes are developed, the stabilized samples will be provided to the C&SA Lab for mercury leaching analysis to be compared to results from the corresponding unstabilized samples.

Task 4: Analyze stabilized sediments using both TCLP and EPA Method 7470A. Protocols for analysis will be modified if necessary.

The C&SA Lab will perform a second analysis of mercury leaching potential on stabilized samples for comparison with results from the raw sediments. The same procedures will be followed in accordance with EPA methods for TCLP and Cold Vapor Analysis of mercury. Results will be provided to WMRC&D for determination of best mixes based on reduction of leaching potential and strength of the stabilized material that will allow for beneficial reuse.

Anticipated Outcome and Results:

Beginning with Task 1, results produced will include a map of high mercury input areas for George's Creek with locations of sediments noted. Data on water and sediment characteristics will allow for the determination of sampling sites for sediment. In Task 2, data will be summarized in a spreadsheet of mercury leaching potential of raw mine sediments. Task 3 will develop optimum mix designs using FBC material to stabilize mercury and provide desired strength characteristics for beneficial reuse of the stabilized material. Data on the reduction of mercury's leaching potential following FBC stabilization will be produced in Task 4, and will allow for determination of optimum mix designs for stabilizing mercury in mine sediments and reusing the stabilized material.

Yearly updates will be provided and a final deliverable will report the optimum methods for reducing mercury leaching potential in mine sediments using CCBs. Strength characteristics of optimum mixes will be discussed along with potential reuses for the stabilized material. Suggestions for further study will be proposed.

This study will provide useful insight for dealing with the issue of mercury accumulation in mine sediments and would be relevant to any area with both coal mining and coal-fired power plants. A successful method for stabilizing mercury could provide a solution to an important environmental concern. The impact of mining coal would be reduced while also providing a beneficial reuse for power plant CCBs. As the production of CCBs by the electric utilities sector rises, a reuse that reduces the need for disposal and provides an environmental benefit would be a great achievement.

Qualifications and Prior Experience:

WMRC&D Council and Materials Testing Laboratory

The WMRC&D Council conducts research on the properties, stabilization potential, and beneficial reuse of CCBs for the Maryland Department of Natural Resources Power Plant Research Program. Laura Michael, Environmental Research Associate for WMRC&D,

has supplemented this work with five years studying coal mining in Western Maryland and the beneficial reuses of coal combustion by-products. Mrs. Michael also has five years of experience working in academia as a physical geography adjunct and laboratory technician studying soils and geomorphology.

The Materials Testing Laboratory is managed by Gary Reeves, a Research Hydrogeologist for WMRC&D. Mr. Reeves has over 30 years experience in geotechnical engineering, hydrogeology, and information technology. Mr. Reeves began his career as an engineering geologist with the West Virginia Department of Highways Materials Control, Soil and Testing Division, supervising the testing of soils for state highway construction projects and study of CCBs in highway construction.

Stabilized combustion by-products designed by the Materials Testing Laboratory have been successfully employed in pilot projects in Western Maryland. A stabilized CCB design for flowable fill was used to seal stream loss zones in a karst landscape. In just a few hours, a dry streambed had its flow restored due to the successful injection of stabilized FBC grout from a local power plant. The lab has also completed designs for use of CCBs to stabilize soluble metals in acid mine drainage sediments and dredged material from Maryland waterways. With these materials typically considered hazardous spoil, the designs have demonstrated that stabilized industrial and commercial products can be produced from materials historically considered to be environmental liabilities.

Another long-term project maintained by the Materials Testing Laboratory is the long-term water quality monitoring of a mine complex grouted with CCBs at Winding Ridge near Friendsville, Maryland (Rafalko, 2000). Grouted over 10 years ago in a joint venture with state and federal regulatory agencies, the production of dissolved metals in seepage continues to decline as the pH steadily rises. According to the latest data, a 90% increase in seepage pH has occurred since the mine was grouted with stabilized combustion by-products (Guynn et Al., 2008).

Coal & Shale Analysis Laboratory

Chemical analysis of water and sediment samples will be conducted at the Coal & Shale Analysis Laboratory at Frostburg State University (FSU). The lab is managed by Dr. Robert Larivee, Chair of the Chemistry Department at FSU. Dr. Larivee has over 25 years of research experience in qualitative and quantitative chemical analysis, instrumental analysis, and environmental chemistry. He is an expert in aquatic chemistry, trace metal analysis, metal complexations, statistical and data analysis, environmental analysis, and instrumental analysis.

Dr. Larivee has 20 years of teaching experience in qualitative and quantitative chemical analysis, instrumental analysis, general chemistry, and environmental chemistry and has served as Department Chair for the last four years. Prior to beginning his academic experience, Dr. Larivee accumulated extensive managerial and administrative skills serving as an officer in the United States Army.

With the establishment of the Coal & Shale Analysis Laboratory, the integration of services with the WMRC&D Materials Testing Laboratory enables complimentary research capabilities that permit FSU to economically perform projects involving the fabrication of stabilized coal combustion products for large-scale industrial and commercial applications.

Western Maryland Regional GIS Center at Frostburg State University (WMRGIS Center)

The WMRGISC has provided research, field work, and GIS mapping of abandoned mines in Western Maryland through a project sponsored by the Maryland DNR Power Plant Research Program (MD DNR PPRP) since 1998. Past projects have supported the design of AMD treatment installations and study of deep mines for CCB grouting projects and monitoring programs.

WMRGIS Center is managed by Jason Litten and supported by two GIS Specialists, all of whom hold a degree in Environmental Analysis & Planning from Frostburg State University. In addition, one of the GIS Specialists holds a geology degree and worked in the coal industry for several years. Part time students are employed at the center, and will be used to support collection of field samples and GPS points for this project. GIS maps to support the study will be created under the supervision of the GIS Specialists.

Related work currently ongoing under other support:

Research on the stabilization of CCBs, mine sediments, dredged material, and other waste products is underway at WMRC&D's Materials Testing Laboratory. Studies to determine beneficial uses of CCBs, especially in abandoned mine applications such as deep mine placement and stream sealing are a major area of focus. Partnerships with regional power plants, watershed groups and state and federal agencies have supported projects such as the Winding Ridge Demonstration and Hoyes Run Stream Sealing, both using 100% CCB grouts.

WMRC&D staff and the WMRGISC conduct ongoing research on abandoned mines of Western Maryland to support a database of GIS mine mapping and information on local events involving subsidence, mine drainage, mine fires and out gassing, and impacts to local hydrology. This work provides an important source of information to the proposed project.

The Coal & Shale Analysis Laboratory focuses on chemical analysis of CCBs and CCB-stabilized materials along with study of local coals, shales and energy-bearing geologic sources. They regularly run TCLP and Cold Vapor Analysis of water, sediment and stabilized material samples for various projects partnering with WMRC&D.

All of these studies are supported by the MD DNR Power Plant Research program, along with additional funding from partners such as the Appalachian Regional Commission, local watershed groups, and Maryland power plants.

Facilities and equipment available:

Most equipment and facility-related needs for the proposed study are already in place at various locations on the Frostburg State University campus. GPS (global positioning system) equipment, GIS workstations and software have been supplied by the MD DNR PPRP at the WMRGISC. The WMRC&D Materials Testing Laboratory is also supported by PPRP and research contracts for Maryland power plants. Materials for CCB mix design and strength testing are available at the lab and additional purchases for the proposed study would mainly involve items such as sample containers. Labor costs for employees at all locations are provided through a MD DNR PPRP research grant to support study of CCBs and Maryland abandoned mines.

Although major equipment is already installed at the Coal & Shale Analysis Laboratory, some upkeep costs such as torch replacements for the ICP-AES (Inductively Coupled Plasma-Atomic Emissions Spectrometer) and maintenance fees would be required to support the study. In addition, purchase of sample containers and four chemicals for mercury analysis would provide items not regularly used at the lab. All costs for the chemistry lab have been included in the budget for mercury analysis and costs per sample. Due to the current availability of equipment and the unique partnership between WMRC&D and the Coal & Shale Analysis Laboratory, the fess for mercury analysis will be a fraction of the cost that would be charged by a commercial lab.

Personnel roles and responsibilities:

The Principal Investigator will be responsible for managing the overall progress of the proposed study by coordinating the completion of work at all partner locations, gathering and analyzing data as it is created, and completing all reporting and deliverables to the funding agency. Staff at the WMRGISC will support field sampling of water and sediments and provide technicians for the capture of GPS points and GIS mapping of field data. Additional volunteer field technicians will be provided by the George's Creek Watershed Association. Study of CCB mix designs at the WMRC&D Materials testing Laboratory will be supervised by Gary Reeves and completed by Erin VanMeter with the assistance of one to two student lab technicians from Frostburg State University. Chemical analysis at the Coal & Shale Lab will be supervised by Dr. Robert Larivee with work performed by technician Erin VanMeter with the help of a student lab assistant. Ms. VanMeter will be responsible for the entry of data and its reporting to the Principal Investigator.

Detailed Budget:

In studying the problem of mercury stabilization in preparation for the full proposal, it was determined that the issue was more complicated than originally anticipated. Information including a study at Oak Ridge National Laboratory (Spence, 2001) suggests that it may be more difficult to fully stabilize mercury than originally thought. Because the stabilization of mercury in sediments is an important environmental concern and prevalent in abandoned mine lands, the Maryland DNR PPRP is willing to provide additional in-kind services and support to double the original budget request. This

additional funding will be used to support staff salaries and to complete additional work to establish additives to enhance the stabilization of mercury with CCBs. Also, a subset of stabilized samples will be tested for strength characteristics and applications for reusing the stabilized sediments will be proposed. A commitment letter for these funds is attached.

The cost for the proposed project will now total approximately $300,000, with one half of these funds requested from Oak Ridge Associated Universities. WMRC&D will handle the division of costs, dividing payment for services among the following partner agencies: WMRC&D, the C&SA Lab, and the WMRGISC.

Total cost for services provided by WMRC&D will be $ 160,000. The WMRC&D will supervise the project and assume the lead on Tasks One and Three as described in the work plan. A total cost of $30,000 is provided for the preliminary study to cover field sampling, mercury analysis of 24 water samples, and creation of a GIS map of mercury input areas and sediment locations at the WMRGISC. The total also includes three years of labor costs for the Principal Investigator at a rate of $18.15 per hour for 20 hours per week spent overseeing the completion of the project. In addition, supervision of the Materials Testing Lab and training of student technicians will be handled by Gary Reeves at a rate of $24.52 per hour for 10 hours per week. One to two student technicians will be employed for a total of 20 hours per week at $8 per hour to support work at both the WMRC&D and Coal & Shale Labs. Services at the Materials Testing Lab, including CCB mix design for approximately 192 samples and a subset of strength testing for 50 stabilized samples will be performed for $30 per test, totaling about $11,000. An additional $2,500 was added to bring the total to $160,000 and allow for small equipment needs and a small margin of adjustment in sample numbers.

The total budget provided to the Coal & Shale Analysis Laboratory will be $ 140,000. Labor costs include three years of support with ten hours per week supervision by Dr. Larivee at a rate of $25 per hour. Erin VanMeter will perform the majority of the chemical analyses, provide support to the Materials Testing Lab, and organize data to supply to the principal investigator. This will require about 20 hours per week at a rate of $15. Fees for chemical analysis will total $23,000, based on a rate of $26 per sample to analyze water samples for mercury leaching potential and a rate of $45.55 per sample for sediment, which will require TCLP extraction prior to mercury measurement. Some chemicals that are not regularly used at the lab will be purchased through project funds to support mercury analysis and a small amount of funding has been allotted for sample containers.

A major benefit to the budget for the proposed project involves the competitive pricing of laboratory testing fees. Low cost analysis of mercury is available to the WMRC&D at the Coal & Shale Analysis Laboratory due to an established partnership. The WMRC&D assisted with procurement of an Appalachian Regional Commission grant to form the Coal & Shale Lab. The MD DNR PPRP, a client of the WMRC&D, sponsors a Lab Technician position who works jointly at both the Coal & Shale Lab and the WMRC&D Materials Testing Laboratory. Because equipment at both labs has been installed to support other currently funded projects, little additional funding will be required to

support the proposed project. Past successful partnerships with Maryland power plants provide a source of donated CCBs for research. Although the task of establishing a method to stabilize mercury with CCBs is a difficult one, the partnerships built by WMRC&D will serve as a great asset to the project.

Resumes of key personnel:

Laura Michael, Principal Investigator

Education:

M.A. coursework completed, degree pending thesis completion
Physical Geography with specialization in geomorphology and soils
Michigan State University

B.S. in Environmental Analysis & Planning
Frostburg State University, 1999

Related work experience:

Western Maryland Resource Conservation & Development Council, Frostburg, MD
Environmental Research Associate, 2005 to present

- Specializing in watershed and abandoned mine studies of Western Maryland
- Beneficial reuses of coal combustion by-products (CCBs)
- Mine placement of stabilized CCBs

Gary Reeves, Manager of WMRC&D Materials Testing Laboratory

Education:

B.S. in Computer Science
Frostburg State University, 1986

B.S. in Geology
West Virginia University, 1975

Related work experience:

Western Maryland Resource Conservation & Development Council, Frostburg, MD
Research Hydrogeologist and Materials Testing Laboratory Manager, 2004 to present

- Manages the development of stabilized CCB mixes and analysis of engineering properties for potential reuses

Resource Applications, Inc., Burke, VA
Senior Associate, 1990

- Conducted hydrologic research to support reclamation of hazardous waste sites

Johnson Engineering, Fort Myers, FL
Hydrogeologist, 1980 – 1986

- Performed hydrologic studies to support the creation of environmental impact statements and reclamation plans

West Virginia Department of Highways, Charleston, WV
Engineering Geologist, 1977 – 1980

- Worked with materials testing and creation of CCB mixtures for pavement design

Dr. Robert Larivee, Project partner at Coal & Shale Analysis Laboratory

Education:

Ph.D. in Analytical Chemistry
University of Delaware, 1989

M.S. in Chemistry – Environmental Sciences and Resources
Portland State University, 1984

B.A. in Chemistry
Rhode Island College, 1976

Related work experience:

Frostburg State University Chemistry Department, Frostburg, MD
Professor of Chemistry, 1989 to present
Department Chair, 2005 to present
Director of Coal & Shale Analysis Laboratory, 2008 to present

Erin VanMeter, Lead lab technician at Coal & Shale Analysis Laboratory

Education:

B.S. in Biochemistry
Frostburg State University, 2009

Related work experience:

Frostburg State University Chemistry Department's Coal & Shale Analysis Laboratory, Frostburg, MD
Lead Lab Technician, 2009 to present