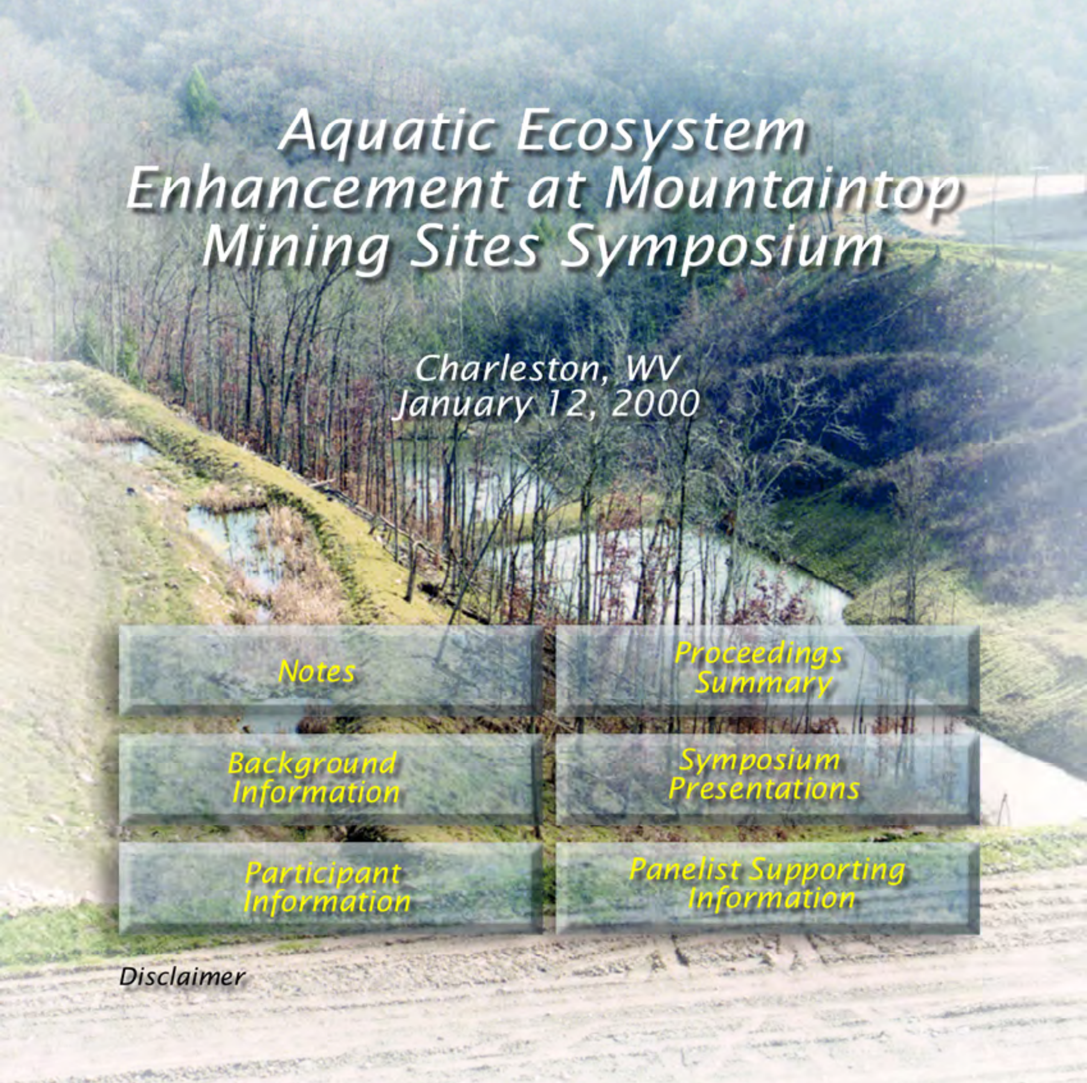


Aquatic Ecosystem Enhancement at Mountaintop Mining Sites Symposium

Charleston, WV
January 12, 2000

Notes

Proceedings Summary

Background Information

Symposium Presentations

Participant Information

Panelist Supporting Information

Disclaimer

Notes

This proceedings is completely linked and bookmarked in Adobe Acrobat portable document format (PDF).

Presentations show on your screen in the thumbnail view. Use the Help button to find out how to view the presentations in full-screen or bookmark views.

Bookmarks help you navigate; double-clicking on a bookmark takes you to the indicated section. Thumbnails help you view a presentation page by page; simply select and click the thumbnail frame.

Participant Information, and Proceedings Summary

Note: to view the information listed in these two sections, click on the titles listed under the sections.

Participant Information

Letter and Agenda

Speaker Biographies

Participants List

Proceedings Summary

Welcome and Introduction

Overview of First Order Watersheds

Mine Site Visit Report

Catenary Coal's Success in Restoring Aquatic Habitat

Panelist Comments and Discussion

- Aquatic Resources
- Vegetation
- Landform

Symposium Recommendations

- Aquatic Resources
- Vegetation
- Landform

Closing Remarks

Symposium Presentations, and Panelist Supporting Information

Note: to view the information listed in these two sections, click on the titles listed under the sections or subsections.

Symposium Presentations

Aquatic Resources on Mining Sites Tour: Courtney Black

Aquatic Ecosystem Enhancements at a Mountaintop Mining Site: Peter Lawson

Excess Spoil Disposal Configuration: John Morgan

An Evaluation of Aquatic Habitats Provided by Sediment Control Ponds and Other Aquatic Enhancement Structures: Randy Maggard

Panelist Supporting Information

Landform

Further Amplification and Clarification of Issues Relating to Landform Restoration: Horst Schor

Aquatic Resources

An Evaluation of Aquatic Ecosystem Enhancement at Four Mountaintop Mining/Valley Fill Sites in West Virgini: Summary, and Report: Rocky Powell

Downstream Impacts of Surface Mining and Valley Fill Construction: Randall Maggard and Ed J. Kirk

An Evaluation of the Aquatic Habitats Provided by Sediment Control Ponds and Other Aquatic Enhancement Structures Located on Mine Permitted Areas in Southern West Virginia: Ed J. Kirk

Benthic Macroinvertebrate Study of Honey Branch, Its Sediment Control Ponds, and Its Influence on the East Fork of Twelvepole Creek Conducted 10/08/99: Ed J. Kirk

Vegetation

List of Articles Related to Restoration Ecology: Steven Handel

TECHNICAL SYMPOSIUM

AQUATIC ECOSYSTEM ENHANCEMENT

AT MOUNTAINTOP MINING SITES
Charleston, West Virginia
January 12, 2000

Dear Participant:

Welcome to this symposium which is part of the ongoing effort to prepare an Environmental Impact Statement (EIS) regarding mountaintop mining and valley fills. The EIS is being prepared by the U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Office of Surface Mining, and U.S. Fish and Wildlife Service, in cooperation with the State of West Virginia. Aquatic Ecosystem Enhancement (AEE) at mountaintop mining sites is one of fourteen technical areas identified for study by the EIS Interagency Steering Committee. Three goals were identified in the AEE Work Plan:

1. Assess mining and reclamation practices to show how mining operations might be carried out in a way that minimizes adverse impacts to streams and other environmental resources and to local communities. Clarify economic and technical constraints and benefits.

2. Help citizens clarify choices by showing whether there are affordable ways to enhance existing mining, reclamation, mitigation processes and/or procedures.

3. Ide identify data needed to improve environmental evaluation and design of mining projects to protect the environment.

Today's symposium was proposed in the AEE Team Work Plans but coordinated planning for the event began September *15,* 1999 when representatives from coal industry, environmental groups and government regulators met in Morgantown. The meeting participants worked with a facilitator from the Canaan Valley Institute to outline plans for the symposium. Several teams were formed to carry out the plans we outlined in the meeting.

A panel of experts in various aspects of ecological restoration was formed to review current reclamation practices on mine sites and suggest improvements. The experts will be participating in various parts of today's symposium, generally following the draft agenda attached. Brief descriptions of each person are included on the attached pages. Since these experts came from various parts of the nation and have not worked together before, we planned a tour of several mine sites to build a common database from which they could speak today. The mine tour was setup under the leadership of Courtney Black of the National Mine Lands Reclamation Center at Morgantown, WV. The team toured four mountaintop and valley fill mine sites in West Virginia on December 7 & 8. The mines visited were Elk Run Mine of Massey Coal, Samples Mine of Catenary Coal, Kiah Creek operations of Pen Coal, and Hobet 21 Mine of Arch Coal.

The purpose of this symposium is to identify opportunities to improve the aquatic ecosystem at mountaintop mining sites through changes in mining and reclamation practices. We focus today's discussion on three themes: land form; aquatic resources; and vegetation. We also realize that much of the audience will be experienced coal operators, experts in their own right, who may bring excellent suggestions for improving current reclamation practices. We welcome your participation in the discussions. At the end of the symposium today, we expect to have lists of specific suggestions for improved reclamation as well as lists of barriers to implementing those suggestions.

I would like to express my appreciation to the West Virginia Mining and Reclamation Association for providing the meeting facilities and the refreshments for this symposium. My appreciation also goes to the National Mined Land Reclamation Center for their assistance in developing the technical program and leading today's meeting. I also wish to thank the National Energy Technology Laboratory for providing the support staff for today's meeting.

A proceeding of today's symposium will be prepared and distributed to each registered participant by the National Energy Technology Laboratory. You will also find more information at the EIS Internet site (http://www.epa.gov/region3/mtntop/) Thank you for your participation and I hope you enjoy the symposium.

Sincerely

Gary Bryant P.E.

Gary Bryant, Team Leader
Aquatic Ecosystem Enhancement Team

Attachments:
Symposium Agenda
Speaker Biographical Sketches

AQUATIC ECOSYSTEM ENHANCEMENT AT MOUNTAINTOP MINING SITES

January 12, 2000
Holiday Inn Charleston House

Symposium Agenda

9:00	Welcome and Introductions- Paul Ziemkiewicz
9:15	Overview of First Order Watersheds - Bruce Wallace
9:45	Mine Sites Visited by the Panel Members - Courtney Black
10:00	Catenary Coal's Success Restoring Aquatic Habitat - Peter Lawson
10:15	***BREAK***
10:30	Panel Introduction - Paul Ziemkiewicz
10:45	Land Form - John Morgan & Horst Schor
11:45	***LUNCH*** *(on your own)*
12:45	Aquatic Resources - Rocky Powell, Randy Maggard, & Bruce Wallace
1:45	Vegetation - Steven Handel & Ben Faulkner
2:45	***BREAK***
3:00	Breakout sessions by theme (Grand Ballroom) to identify benefits & barriers to panelist suggestions. Regulatory experts from WVDEP & OSM will be assigned to each group.
4:00	Reconvene (Lobby Ballroom) to share major points for each theme - Theme Facilitators
4:45	Symposium Summary - Paul Ziemkiewicz
5:00	Adjourn

Aquatic Ecosystem Enhancement at Mountaintop Mining Sites

Background Information

About the Mountaintop Mining/Valley Fill Environmental Impact Statement

The U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (Corps), U.S. Office of Surface Mining (OSM), and U.S. Fish and Wildlife Service (FWS), in cooperation with the State of West Virginia, are preparing an Environmental Impact Statement (EIS) on a proposal to consider developing agency policies, guidance, and coordinated agency decision making processes to minimize, to the maximum extent practicable, the adverse environmental effects to waters of the United States and to fish and wildlife resources from mountain top mining operations, and to environmental resources that could be affected by the size and location of fill material in valley fill sites. The draft EIS will be released for public comment during the summer of 2000. The final EIS is slated for completion by January 2001.

Early in 1998, the four Federal agencies now involved in the EIS formed a work group and agreed on a series of priority areas where more information and analysis would assist them in regulating the effects of valley fills associated with mining operations. Study plans were adopted and funded for undertaking valley fill inventories in West Virginia, Kentucky, and Virginia; for assessing the stability of valley fills; and for assessing the potential for downstream flooding from these mining operations. The agencies also placed priority on studying the impacts of valley fills on aquatic habitat; on surveying and evaluating mitigation practices being employed in West Virginia and neighboring Appalachian Coalfield States; and on evaluating how to better coordinate the Federal regulatory programs. These studies were underway or in the planning stages when the Bragg v. Roberston settlement agreement was reached.

With the decision to prepare an EIS, the agencies brought the coordination of these technical studies under the scope of the EIS, and broadened state participation. The expanded network of agencies has now examined the studies initiated in 1998 and has modified those study plans to make them more useful for the EIS. Additional work plans responding specifically to the EIS mandate have also been drafted.

Team leaders have been selected among the participating agencies for each of the technical study areas, which are listed below. The team leaders worked with a team representative of the expertise of each agency to develop a work plan. The work plans reflect what the agencies believe should be studied, and are subject to revision as work progresses and new insights are gained.

EIS Technical Study Areas:

- Future Mining
- Fill Stability
- Mining and Reclamation Technology

- Flooding Potential
- Fill Hydrology
- Streams
- Fisheries
- Wetlands
- Aquatic Ecosystem Enhancement
- Terrestrial Ecology
- Soil Quality and Forest Productivity
- Socioeconomic Issues
- Mine Dust and Blasting Fumes
- Landscape Ecology/Cumulative Effects

Prelude to the Symposium

The Team Leader for Aquatic Ecosystem Enhancement submitted a work plan for this technical study area to the EIS Steering Committee in July 1999. The work plan, which is available from the EPA Region III internet site containing information related to the EIS (http://www.epa.gov/region3/mtntop/index.htm), identified the goals of the EIS related to Aquatic Ecosystem Enhancement:

- Assess mining and reclamation practices to show how mining operations might be carried out in a way that minimizes adverse impacts to streams and other environmental resources and to local communities. Clarify economic and technical constraints and benefits.

- Help citizens clarify choices by showing whether there are affordable ways to enhance existing mining, reclamation, mitigation processes and or procedures.

- Identify data needed to improve environmental evaluation and design of mining projects to protect the environment.

The Aquatic Ecosystem Enhancement work plan was designed to augment the activities of the Streams and Fisheries Survey work plans and build upon the symposium held under the Mining and Reclamation Technology work plan in June 1999. The work plan included components to evaluate current stream practices and to evaluate opportunities for aquatic ecosystem enhancement using existing information, field monitoring, surveys, and expert reviews. The work plan proposed a workshop (subsequently changed to a symposium) of experts in ecology and stream restoration to review the current practices at specific sites selected by the mining companies and to outline the factors that would contribute to successful stream restoration and aquatic ecosystem enhancement.

An Aquatic Ecosystem Enhancement planning meeting was held September 15, 1999 to outline plans for the symposium on stream restoration and reclamation practices being used at valley fills and mountaintop mines. A panel of experts was selected to tour several mine sites to evaluate the restoration and reclamation practices being used at those sites. The National Mine Land Reclamation Center in cooperation with the West Virginia Mining and Reclamation

Association and the West Virginia Coal Association recommended four sites to be visited by the panel of experts and serve as representative samples of current practices. The site visits occurred during the period December 7-8, 1999 at Elk Run Mine of Massey Coal; Samples Mine of Catenary Coal; Rollem Fork Mine of Pen Coal; and Hobet 21 Mine of Hobet Mining a subsidiary of Arch Coal.

The symposium followed on January 12, 2000 to offer a forum for presentation of the views and recommendations of the panel of experts for aquatic ecosystem enhancement at mountaintop mining sites. The symposium also offered an opportunity for public input, primarily from the mining and reclamation industry, on the barriers (regulatory, financial, or technical) to enhanced reclamation. The symposium was held open to the public, with no registration fee, at the Holiday Inn, Charleston House, in Charleston, West Virginia.

Symposium Attendees

A total of 162 persons registered their names and affiliations to attend the symposium. A complete listing of the registered attendees is included in this proceedings.

The largest group registered included 98 representatives of the coal mining industry along with their suppliers and consultants. The next largest group included 43 members of the government and regulatory community representing the following federal and state agencies; U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Office of Surface Mining, U.S. Geological Survey, West Virginia Division of Environmental Protection, West Virginia Division of Natural Resources, Virginia Department of Mines, Minerals, and Energy, Kentucky Division of Water, and the Kentucky Department of Fish and Wildlife Resources.

There was a notably low turnout from the environmental advocacy community and the general public. However, considering the scientific and technical nature of the program, this was not considered to be detrimental to achieving the symposium objectives. The discussion that transpired between the panel of experts on aquatic ecosystems, the mining industry, and the regulatory community yielded numerous potential enhancements to aquatic resources at mining sites and the barriers to their implementation that will require further evaluation as part of the EIS process.

Aquatic Ecosystem Enhancement at Mountaintop Mining Sites

Speaker Biographies

Paul F. Ziemkiewicz

Paul Ziemkiewicz is a native of Pittsburgh, PA. He received BS and MS degrees from Utah State University in biology and range ecology, respectively. He then received a Ph.D. from the University of British Columbia in Forest Ecology.

After graduating from UBC in 1978, he joined the Alberta Government's Department of Energy. There he directed its reclamation research program in coal and oil sand mining. He also served on Alberta's regulatory review committee and served as the research manager of the Province's coal research program. In 1988, he came to West Virginia University to serve as the Director of the National Mine Land Reclamation Center and the West Virginia Water Resources Research Institute.

He presently serves on a number of federal, state and industry advisory panels on environmental remediation. Dr. Ziemkiewicz has over 70 publications on the topics of mine land reclamation, acid mine drainage, and coal ash application in mines.

J. Bruce Wallace

J. Bruce Wallace received his BS from Clemson University, and MS and Ph.D. from Virginia Tech. He is currently Professor of Entomology and Ecology, University of Georgia in Athens, Georgia, where he teaches courses in stream ecology, aquatic entomology, and immature insects. He has served as major professor of some 38 graduate students at the University of Georgia. Dr. Wallace is author, or co-author, of some 150 scientific papers, including book chapters, concerned with various aspects of stream ecology or aquatic entomology.

Much of his research during the past 25 years has been conducted on southern Appalachian streams at the Coweeta Hydrologic Laboratory, http://sparc.ecology.uga.edu/ (U.S. Forest Service), in western North Carolina and supported primarily by the National Science Foundation. His primary research areas include: linkages between streams and terrestrial ecosystems; role of aquatic invertebrates in stream processes; effects of disturbance and recovery of streams from disturbance; secondary production and aquatic food webs and energy flow; and, organic matter dynamics in headwater streams.

Dr. Wallace is a past president (1991-1992) of the North American Benthological Society. He was the recipient of the 1999 Award of Excellence in Benthic Science from the North American Benthological Society.

D. Courtney Black

D. Courtney Black is the Program Manager for the National Mine Land Reclamation Center at West Virginia University. Mr. Black is a scientist with 6 years of research and project management experience. His primary focus has been in the fields of coal combustion product utilization and field scale acid mine drainage treatment. Mr. Black also serves as the Director of West Virginia University's National Environmental Education and Training Center. NEETC's primary focus is to ensure that health and safety concerns are incorporated into new environmental remediation technologies.

Peter Lawson

A native of County Durham, England, Peter Lawson received his undergraduate degree in Mining Engineering in 1978 from New Mexico Tech. In 1986, while maintaining full time employment in the mining industry, he received his MBA from Ashland University, Ohio. Mr. Lawson has more than 20 years of industry experience, the majority of which has been in surface coal mining in Appalachia. During his career he has worked on projects in western Canada, Russia and Mongolia, as well as having performed work in virtually every major coal-producing basin in the United States. Arch Coal, Inc. has employed Mr. Lawson for 5 years where he is currently President and General Manager of Catenary Coal Company. Catenary Coal Company has received numerous awards for the Samples Mine in Kanawha County where the company's achievements and approach to reclamation have been recognized at both state and national levels. Catenary Coal Company is twice winner of the David C. Callaghan Award, winner of the IMCC National Reclamation Award, and winner of the West Virginia Ducks Unlimited Wetlands Award.

John S.L. Morgan

John S.L. Morgan is an environmental mining consultant with extensive experience in both surface and underground mining for the extraction of metalliferous ores, coal and industrial minerals. He has a specific emphasis on the environmental effects of mining and mine reclamation. He also provides detailed technical expertise in the analysis of mine subsidence prediction and mitigation, acid mine drainage and mine planning.

Mr. Morgan founded Morgan Worldwide Mining Consultants, Inc. in 1995. Previously, he had established Morgan Mining & Environmental Consultants, Ltd. in 1990 with a staff of 18 people and built it into a $2 million per annum operation with 27 employees. The International Mining Consultants Group acquired the company in 1992. Mr. Morgan then served as the Executive Vice President of Weir International Mining Consultants until 1995 when he left to form Morgan Worldwide Mining Consultants, Inc.

Mr. Morgan has been the project manager for a number of mine technical reviews, for a significant number of subsidence investigations, and for environmental compliance and liability analysis reviews for both operating and abandoned mining operations. He is actively involved in projects in all regions of the United States, and has worked in Russia, Indonesia, Ukraine, Poland, Bulgaria, Peru, Argentina and Trinidad. During his career, Mr. Morgan has also worked in rock mechanics in South Africa, and as a planning engineer for open cast coal mining in Britain.

Horst J. Schor

Mr. Schor's educational background includes degrees in Civil Engineering and Geography and Graduate Course work in Environmental Studies.

His professional career spans more than 25 years during which he managed the development of large scale hillside planned communities in Southern California and other projects. Since 1991 he has been an independent consultant serving the private and public sectors on issues of land development, landform restoration and mining reclamation with particular emphasis on geomorphological restoration.

In recent years he has been a consultant to Syncrude Oil of Alberta, Canada re-designing large scale tailing deposits from tar sands excavations to give them natural landform characteristics. Mr. Schor has also been engaged by the State of Kentucky Environmental Protection Agency Water Quality Division, the State of Virginia Department of Minerals, Mines and Energy and the Navajo Nation Environmental Protection Agency to study coal mining reclamation practices in their respective states and make recommendations for improvements.

He is a regular guest lecturer at The University of Wisconsin College of Engineering and most recently was invited to speak at the University of Dresden, Germany.

Rocky Powell, Links 1 and 2

Rocky Powell is the founder and principal of Clear Creeks Consulting, an environmental firm specializing in stream and watershed assessment, management, and restoration. Mr. Powell has over 25 years in the environmental field with experiences that include wildlife and fisheries research, water quality monitoring, natural resources protection, watershed management, stream assessment and restoration, and teaching. Providing environmental consulting services in Maryland, Virginia, West Virginia, North Carolina, Pennsylvania, New York, Vermont and Texas, Mr. Powell has: 1) conducted hundreds of geomorphic watershed and stream assessments; 2) developed watershed management plans; and 3) designed, permitted, provided construction supervision and post-construction monitoring for numerous wetland mitigation and stream restoration projects.

An instructor in the Johns Hopkins University School of Continuing Studies from 1992-1999, he taught graduate and undergraduate courses on stream ecology and stream related issues. He has presented numerous workshops and short courses on stream dynamics, stream protection, assessment, management, and restoration throughout the United States and Canada.

Randy Maggard (links 1 and 2)

Randy Maggard is an Environmental Specialist and Surface Mine Engineer with Pen Coal Corporation. He has degrees in Chemistry and Civil Engineering and has been employed with Pen Coal for the last 14 years. He has been active in environmental affairs related to coal mining and is a member of the West Virginia Surface Mine Drainage Task Force. Pen Coal has received numerous reclamation awards for their operations in West Virginia and Kentucky. Pen Coal has been conducting extensive biological monitoring for the last five years on their Kiah Creek operation located in Wayne, Lincoln, and Mingo counties in southern West Virginia.

Steven N. Handel

Steven N. Handel is a restoration ecologist interested in the establishment of native communities on degraded lands. He serves as professor of ecology and evolution at Rutgers University in New Jersey, where he teaches and does research in the fields of plant ecology, plant-animal interactions, and restoration. Dr. Handel is Director of the new Center for Restoration Ecology at Rutgers. He also has been a biology professor and Director of the Botanical Garden at Yale University. He serves as an editor for the journal Restoration Ecology, and was elected chair of the Plant Ecology Section of the Ecological Society of America. Trained at Cornell University, he and his students have done fieldwork throughout the east coast. As a consultant, he has advised on restoration design on degraded sites such as urban landfills, urban parks, sand mines, and national parks affected by invasive species.

Ben B. Faulkner

Ben B. Faulkner served as a surface mine reclamation inspector for the West Virginia Division of Natural Resources, dealing with inspection, enforcement, and permit review in many southern counties. He has served as an industry biologist and has coordinated reclamation and environmental affairs. He has been a research associate at West Virginia University in the fields of mine reclamation and mine drainage. As a private consultant, he has conducted training seminars for inspectors and operators in AMD prevention, and chemical and passive treatment.

As sole proprietor of Bratton Farm, he has provided professional consulting services to several international corporations and agencies. He has prepared surface mine, deep mine, and other permits and provided environmental management services including designing, installing, and monitoring numerous wetlands, anoxic limestone drains and other passive treatment systems for WVDEP, WVU, and industry. He has performed numerous benthic studies for industry and WVDEP. He serves as a special consultant to WVDEP for acid mine drainage issues.

Aquatic Resources on Mining Sites Tour

D. Courtney Black

National Mine Land Reclamation

West Virginia University

Photographic credit: Heino Beckert, Ph.D.

U.S. DOE, National Energy Technology Laboratory
Morgantown, WV

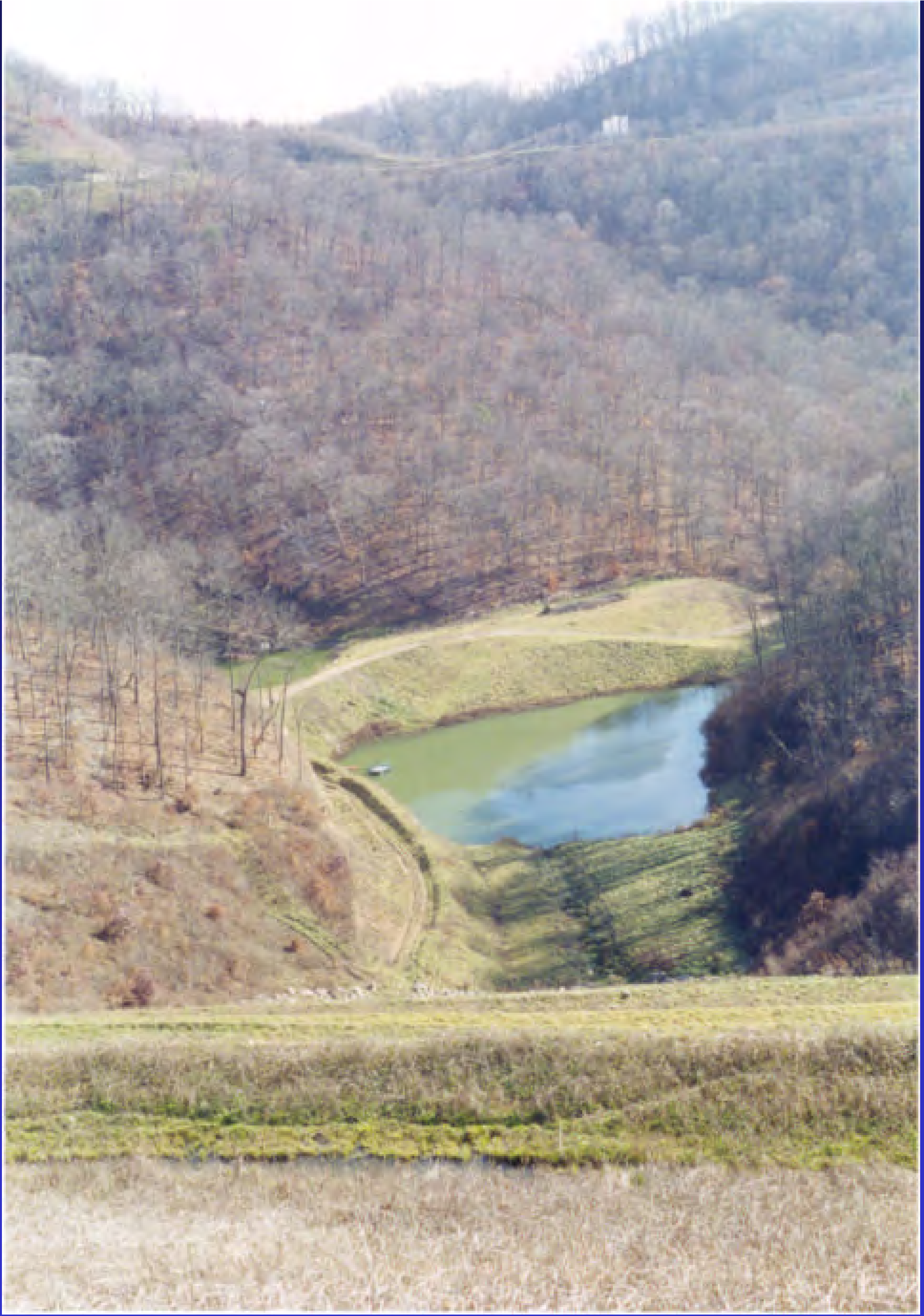
Four Mine Sites

- Elk Run Mine operated by Massey Coal Services
- Samples Mine operated by Catenary Coal
- Wayne County operations of Pen Coal Company
- Hobet Mining #21 – subsidiary of Arch Coal, Inc.

Active pit at Elk Run

View of Active mining from top of valley fill

View of pond below valley fill



Valley Fill # 3
in construction

Ponds at toe of VF #3

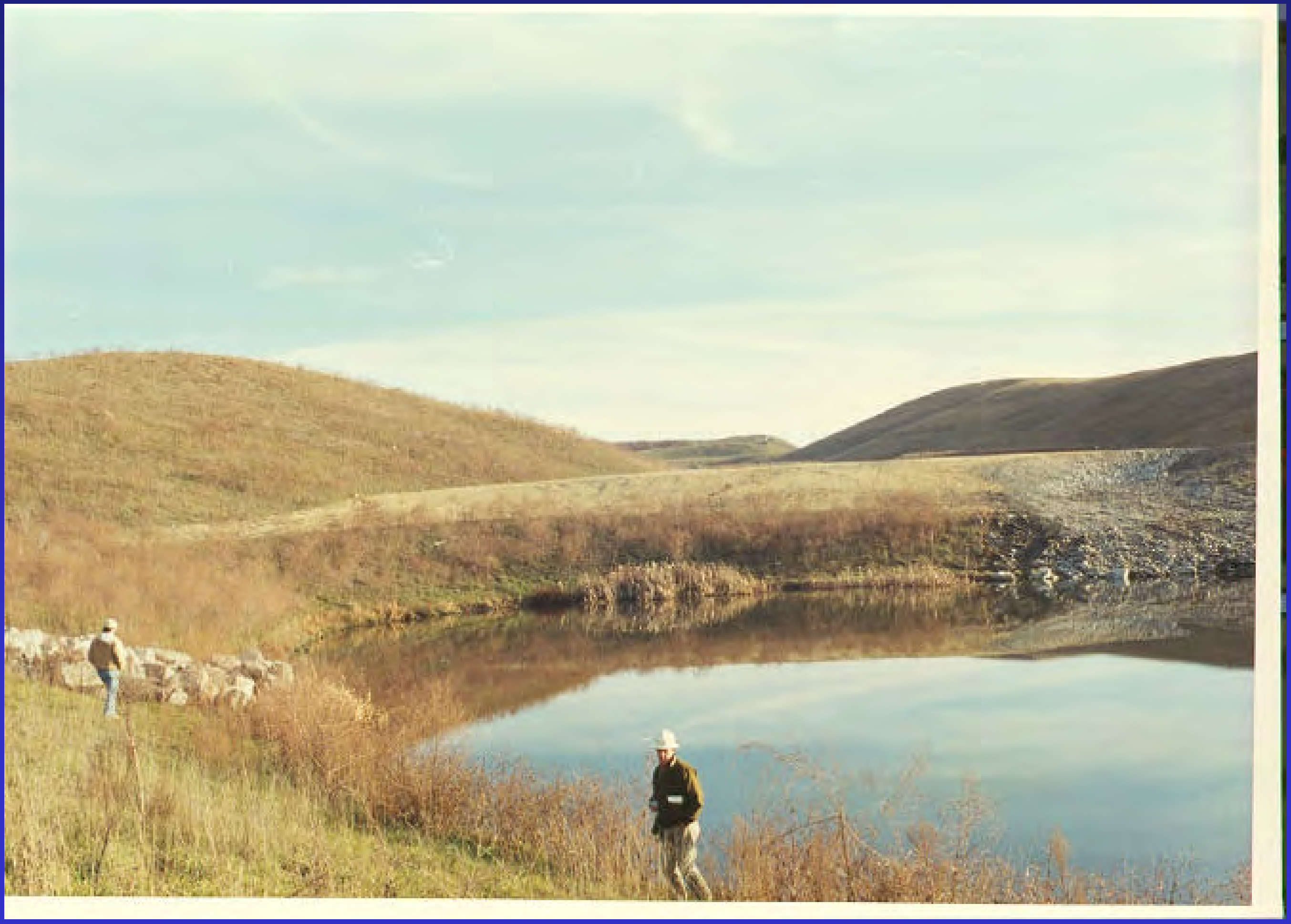
Elk Run Mine

slope has not been compacted, trees have been planted

Samples Mine

Sky Pond and drainage channel

In-stream ponds below 32 acre fill area; good fish populations



Another view of in-stream ponds

Pen Coal
Encapsulation cell for toxic material

Combination Ditch

constructed on 8 month old reclamation for sediment and storm water control

Rollem Fork Surface Mine

Combination Ditch

Rollem Fork Valley Fill

Contoured Valley Fill

Tree planting on 8 year old reclamation – Frank Branch

Hobet Mining #21
20 year old valley fill

10 year old reclamation

Rolling landscape created by dragline; valley fill in center

Coal removed on right side, ditch in center, valley fill on left

Close up of combination ditch

Reclaimed landscape at Hobet #21

Disclaimer

Articles Related to Restoration Ecology

Provided by
Dr. Steven Handel

1. Handel, S.N. 1983. Pollination ecology, plant population structure, and gene flow. Pages 163-211 in *Pollination Biology*, L. Real, editor. Academic Press, NY.

2. Handel, S.N., and A.J. Beattie. 1990. Seed dispersal by ants. *Scientific American* 263:76-83A.

3. Robinson, G.R., S.N. Handel, and V.R. Schmalhofer. 1992. Survival, reproduction, and recruitment of woody plants after 14 years on a reforested landfill. *Environ. Management* 16:265-271.

4. Robinson, G.R., and S.N. Handel. 1993. Forest restoration on a closed landfill: rapid addition of new species by bird dispersal. *Conservation Biology* 7(2) :271-278.

5. Handel, S.N., G.R. Robinson, and A.J. Beattie. 1994. Biodiversity resources for restoration ecology. *Restoration Ecology* 2:230-241.

6. Montalvo, A.M., S.L. Williams, K.J. Rice, S.L. Buchmann, C. Cory, S.N. Handel, G.P. Nabhan, R. Primack, and R.H. Robichaux. 1997. Restoration biology: a population biology perspective. *Restoration Ecology* 5:277-290.

7. Handel, S.N. 1997. The role of plant-animal mutualisms in the design and restoration of natural communities. Pages 111-132 in *Restoration Ecology and Sustainable Development*. K.M. Urbanska, N.R. Webb, and P.J. Edwards, editors. Cambridge University Press, Cambridge.

8. Parsons, W.F.J., J.G. Ehrenfeld, and S.N. Handel. 1998. Vertical growth and mycorrhizal infection of woody plant roots as potential limits to the restoration of woodlands on landfills. *Restoration Ecology* 6:280-289.

9. Handel, S. 1999. Future of region's biodiversity lies in small local forests. *Metro Forest News* 3(1):5,10.

10. Robinson, G.R., and S.N. Handel. 2000. Directing spatial patterns of recruitment during an experimental urban woodland reclamation. *Ecological Applications* 10:174-188.

An Evaluation of the Aquatic Habitats Provided by Sediment Control Ponds and Other Aquatic Enhancement Structures Located on Mine Permitted Areas in Southern West Virginia

Conducted For:

PEN COAL CORPORATION
KIAH CREEK MINE OFFICE
P.O. BOX 191
DUNLOW, WEST VIRGINIA 25511

by:

R.E.I. CONSULTANTS, INCORPORATED
ED J. KIRK, AQUATIC BIOLOGIST
225 INDUSTRIAL PARK ROAD
BEAVER, WEST VIRGINIA 25813
11/23/99

TABLE OF CONTENTS

Introduction 1

Location of Study Area 3

Methods of Investigation:
Physical & Chemical Water Quality, Habitat, Benthic Macroinvertebrates 4

Specific Station Locations / Physical Descriptions 5

Physical & Chemical Water Quality Analysis 8

Habitat Assessment Parameters 9

Habitat Results 10

Description of Benthic Macroinvertebrate Metrics 12

Benthic Macroinvertebrate Results 14

Discussion 17

Conclusions 21

Appendix A
Note: Appendix A is not included; the figures are not available.

Figure 1. Vance Branch (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3).
Figure 2. Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5).
Figure 3. Left Fork of Parker Branch (Pond Number 7).
Figure 4. Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3).
Figure 5. Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3).
Figure 6. Left Fork of Parker Branch (Sediment Ditch Number 6).

Appendix B
Table 1A. Physical and chemical water-quality variables of sediment control ponds.
Table 1B. Physical and chemical water-quality variables of sediment ditches.
Table 2A. Total abundances of benthic macroinvertebrates collected in sediment control ponds.
Table 2B. Total abundances of benthic macroinvertebrates collected in sediment ditches.
Table 3A. Selected benthic macroinvertebrate metrics for sediment control ponds.

Table 3B. Selected benthic macroinvertebrate metrics for sediment ditches.
Table 4A. Habitat scores for sediment control ponds.
Table 4B. Habitat scores for sediment ditches.
Table 5. Vance Branch (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3) macroinvertebrates.
Table 6. Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5) macroinvertebrates.
Table 7. Left Fork of Parker Branch (Pond Number 7) macroinvertebrates.
Table 8. Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3) macroinvertebrates.
Table 9. Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3) macroinvertebrates.
Table 10. Left Fork of Parker Branch (Sediment Ditch Number 6) macroinvertebrates.

Appendix C
Note: Appendix C is not included; the photographs are not available.

Photographs 1 - 2. Vance Branch (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3).
Photographs 3 - 4. Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5).
Photographs 5 - 6. Left Fork of Parker Branch (Pond Number 7).
Photographs 7 - 8. Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3).
Photographs 9 - 10. Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3)
Photographs 11 - 12. Left Fork of Parker Branch (Sediment Ditch Number 6).

AN EVALUATION OF THE AQUATIC HABITATS PROVIDED BY SEDIMENT CONTROL PONDS AND OTHER AQUATIC ENHANCEMENT STRUCTURES LOCATED ON MINE PERMITTED AREAS IN SOUTHERN WEST VIRGINIA.

INTRODUCTION

Typically, sediment ditches and diversion ditches are constructed on coal company property for 3 purposes: 1) to divert surface runoff into more desirable locations and away from work areas and roads 2) to combine flows from several sources into fewer, more manageable discharges, and 3) to slow surface runoff, often laden with sediments, to allow for a settling of the sediments to occur prior to flows entering streams. The larger, sediment control ponds are generally constructed on coal company property also for 3 purposes: 1) to slow surface runoff, laden with sediments, in order to allow for settling to occur prior to flows entering streams 2) to provide a flow-control structure which allows the operators to manage downstream stream flows during periods of either very low or very high flows, and 3) to provide a point of chemical/physical treatment in the event the water quality needs to be adjusted prior to entering the lower portions of the stream.

Construction of these sediment ditches, diversion ditches, and sediment control ponds is not something that is performed without giving serious consideration to the natural conditions which exist on the area in question. Design and construction is performed on a case-by-case analysis which includes the natural hydrology, geomorphology, watershed size, and aquatic life inhabiting the stream. In essence, these ponds are nothing short of professionally engineered structures, designed to address the stream flows as well as the surface runoff which can be expected from the watershed size, and are designed to conform to the natural topography of the area.

Although generally these structures are not designed with many aesthetic qualities in mind, the conditions which exist after construction of the ponds and ditches automatically create circumstances necessary for the natural creation of wetlands. The presence of the warmer, slow-moving, sediment-laden water provides the nutrients and sediment sizes necessary for the production of several aquatic emergent and submerged aquatic plants such as cattails, milfoil, rushes, and sedges. The existence of the continuous water overlying the pond's bottom initiates the chain of events necessary for the creation of hydric soils also necessary for aquatic vegetation. In addition, the placement of the designed ponds, usually located directly in the stream channel at the base of a hollow, or on a wide, flat bench where subsurface and surface runoff will support the on-bench pond, are planned so that they are self-sustaining. Water from the stream as well as from surface runoff are adequate to ensure the existence of the pond for decades.

Nevertheless, according to the West Virginia Department of Environmental Protection-Office of Mining and Reclamation, upon completion of mining in the area, the constructed sediment control pond and/or drainage ditches must be removed prior to being released from permitting regulations and receiving back the mining bond. Breaching of the dam is therefore required from the point of view that in order to return the stream back to its original state, the stream channel must be change back to its original shape.

The purpose of this study was to provide an unbiased, professional examination of the sediment control ponds and sediment ditches which currently exist on mine permitted areas in southern West Virginia. Several ponds of various ages would be studied as to their aquatic and wetland status, and usefulness as quality habitats for fauna inhabiting the area.

LOCATION OF STUDY SITES

The overall study area is located in Wayne County, in southwestern West Virginia. Ponds sampled were located on Vance Branch (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3), Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5), and Left Fork of Parker Branch (Pond Number 7). Sediment ditches sampled were located on Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3), Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3), and Left Fork of Parker Branch (Sediment Ditch Number 6).

METHODS OF INVESTIGATION

At each sampled pond or sediment ditch, measurements for physical water quality were taken. Samples were also collected and returned to the laboratory for chemical analysis. Benthic macroinvertebrate samples were also collected, and the habitat of the stations was evaluated. The individual methodologies are described below.

Physical Water Quality/Water Chemistry

Physical water quality was analyzed on-site at each station. Water temperature, Dissolved Oxygen (DO), pH, and conductivity was measured with a Hydrolab™ Minisonde multi-parameter probe.

Water samples were collected at each of the three pond sites as well as the three sediment ditches, appropriately preserved, and transported to R.E.I. Consultant's laboratory for analysis. All analyses utilized current EPA-approved protocols. Parameters measured at each station were Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), hardness, alkalinity, total sulfates, total acidity, sodium, total aluminum, calcium, total iron, total magnesium, total manganese chlorides, fecal coliform, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

Habitat

The habitat at each of the sites was assessed, rated, and scored on a few parameters in three categories using EPA Rapid Bioassessment Protocols for Use in Streams and Rivers (EPA 440/4-89/001). Because these parameters were originally developed for streams and rivers, emphasis was placed on the quantity and types of vegetation present, pond/ditch slopes, surface acreage, depth, substrate composition, location of pond/ditch relative to detrimental impacts, and composition of surrounding area (forested, open field, heavy haul traffic area, etc...).

Benthic Macroinvertebrates

At each site, collections were made via a Ponar grab sampler. The Ponar grab sampler has several features which make it a desirable choice for the collection of aquatic macroinvertebrates in lentic habitats such as ponds, lakes, as well as lotic deepwater habitats such as rivers. Sampler area was 81 $inch^2$ per replicate. Three samples were taken near the shoreline, and in the best available spots (lowest siltation, highest percentage of gravel/pebble substrate, highest vegetation) at each station. Samples were placed in 1-gallon plastic containers, preserved in 35% formalin, and returned to the laboratory for processing. Samples were then picked under Unitron™ microscopes and detrital material was discarded only after a second check to insure that no macroinvertebrates had been missed. All macroinvertebrates were identified to lowest practical taxonomic level and enumerated. Metrics were then calculated for each station.

SPECIFIC SITE LOCATIONS / PHYSICAL DESCRIPTIONS

Vance Branch Pond (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3)

This station was located on Vance Branch, and was constructed in 1999 (Figure 1). The pond is approximately 400 feet in length, and is approximately 125 feet wide. At the existing water level, the pond is approximately 300 feet in length, approximately 60 feet wide, and has an area of approximately 0.67 acres. The elevation of the pond's bottom is 984.4 feet above sea level. The existing water depth was only about a foot, but the pond provides for 4.19 acre/feet of accumulative sediment storage. Due to the pond's early completion, the banks were only about 50% vegetated, and this was with various rye and other grasses for erosion control. Aquatic vegetation was minimal except for a small quantity of smartweed (Photographs 1 - 2). The banks were very steep along the hillsides, and were noticeably unstable due to their steepness, lack of vegetation, and composition. Alluvial fans were present from erosion. Adequate soils had not yet formed due to the young age of this structure. This pond had noticeably higher levels of solids (Table 1A) probably due to sediments being washed into the pond easier than at older, more established ponds. There was no pond cover present due to the far distance from the surrounding deciduous forest, and the substrate was comprised mostly of sand and silt (Table 4A).

Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5)

This station was located on Rollem Fork, and was constructed in 1997 (Figure 2). The pond is approximately 200 feet in length, and is approximately 150 feet wide. At the existing water level, the pond is approximately 175 feet in length, approximately 130 feet wide, and has an area of approximately 0.30 acres. The elevation of the pond's bottom is 930.0 feet above sea level. The existing water depth is about 20 feet deep due to the steep slopes (2.1:1) of the side, and the pond provides for 2.70 acre/feet of accumulative sediment storage. Even though the pond was completed in 1997, the banks were almost 100% vegetated (Photographs 3 - 4), and this was with various grasses, herbaceous plants such as St. John's wort, and small saplings such as alder. The banks above water level were not too steep, and were noticeably more stable due to their heavier vegetation. No signs of erosion were present. Soils appeared to be more advanced at this structure. There was only a very little pond cover present from the heavy cattails growing around the pond; there was a far distance from the surrounding deciduous forest. The substrate was comprised mostly of sand and gravel (Table 4A).

Left Fork of Parker Branch (Pond Number 7)

This station was located on the Left Fork of Parker Branch, and was constructed in 1991 (Figure 3). The pond is approximately 160 feet in length, and is approximately 240 feet wide. At the existing water level, the pond is approximately 150 feet in length, approximately 225 feet wide, and has an area of approximately 1.0 acres. The elevation of the pond's bottom is 936.0 feet above sea level. The existing water depth was about 10 feet, and the pond provides for 4.98 acre/feet of accumulative sediment storage. Due to the pond being about 8 years old, the banks were 100% vegetated (Photographs 5 - 6), and this was with various grasses, rushes, golden rod, greenbrier, sycamores. Aquatic vegetation was comprised of milfoil (Myriofyllum sp.), pondweed (Potamogeton sp.), and cattails. The banks were not steep along the hillsides, and were stable due to their low-steepness, heavy vegetation, and soil composition. No signs of erosion were present. There was very little pond cover present due to the far distance from the surrounding deciduous forest, but the heavy vegetation provided some cover along the shoreline areas. The substrate was comprised mostly of silt and sand (Table 4A).

Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3)

This station was located on Vance Branch, and was constructed in 1999 (Figure 4). The combination ditch is approximately 2,250 feet in length, is approximately 41 feet wide, and has an area of approximately 2.12 acres. The elevation of the ditch's bottom is about 1000 feet above sea level. The existing water depth was only about a foot, but the combination ditch provides for 4.28 acre/feet of accumulative sediment storage. Even though the ditch was constructed in 1999, the banks were moderately vegetated, and this was with various rye and clover grasses for erosion control. Aquatic vegetation was minimal except for a small quantity of cattails (Photographs 7 - 8). The banks were not too steep along the hillsides, and were noticeably stable due to their low gradient and vegetation. Soils had not yet established due to the young age of this structure. This sediment ditch had noticeably higher levels of suspended solids (Table 1B) probably due to sediments being washed into the structure easier than at older, more established ones. There was no canopy cover present due to the far distance from the surrounding deciduous forest, and the substrate was comprised mostly of silt and clay (Table 4B).

Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3)

This station was located on Rollem Fork, and was constructed in 1997 (Figure 5). The sediment ditch is approximately 900 feet in length, is approximately 40 feet wide, and has an area of approximately 0.83 acres. The elevation of the ditch's bottom is about 950 feet above sea level. The existing water depth was only about a few inches, but the sediment ditch provides for 1.67 acre/feet of accumulative sediment storage. Even though the ditch was constructed in 1997, the banks were 100% vegetated, and this was with various rye and clover grasses, and sedges. Aquatic vegetation was mostly the large abundance of cattails (Photographs 9 - 10). The banks were not too steep along the hillsides, and were noticeably stable due to their low gradient and vegetation. Soils had established and were noted to be gleyed at about 1.5" within the area of the wetland. There was no canopy cover present due to the far distance from the surrounding deciduous forest, and the substrate was comprised mostly of vegetated silt (Table 4B).

Left Fork of Parker Branch (Sediment Ditch Number 6)

This station was located on the Left Fork of Parker Branch, and was constructed in 1994 (Figure 6). The sediment ditch is approximately 600 feet in length, is approximately 40 feet wide, and has an area of approximately 0.55 acres. The elevation of the ditch's bottom is about 950 feet above sea level. The existing water depth was about 5 feet, and this sediment ditch provides for over 2.5 acre/feet of accumulative sediment storage. The banks were well vegetated, and this was with various rye and clover grasses, sedges, and goldenrod. Aquatic vegetation consisted of cattails, pondweeds (Potamogeton sp.), and water milfoil (Myriophyllum sp.) (Photographs 11 - 12). There was a heavy algae growth which was presumed to be a result of the higher pH level of this structure (Table 1B). The banks were not too steep along the hillsides, and were noticeably stable due to their low gradient and heavy vegetation. Soils were well established due to the older age of this structure. There was no canopy cover present due to the far distance from the surrounding deciduous forest. The substrate was comprised mostly of clay and silt (Table 4B).

PHYSICAL AND CHEMICAL WATER QUALITY ANALYSIS

Physical and chemical water quality was analyzed at each of the pond and sediment ditch sites sampled on Vance Branch, Rollem Fork, and the Left Fork of Parker Branch. The physical and chemical water quality results are presented in Tables 1A and 1B. Many of the ponds had large differences between like parameters. For instance, the pH on Vance Branch's pond was low with a pH of 5.04, whereas the pH for the pond on the Left Fork of Parker Branch was high with a pH of 8.77. The same observation was true with regards to the sediment ditches. For instance, the pH on Rollem Fork's sediment ditch was low with a pH of 5.32, whereas the pH for the sediment ditch on the Left Fork of Parker Branch was high with a pH of 9.39. Most of the chemical values such as dissolved solids, hardness, sulfates, alkalinity, and most metals were considered fairly high. Although several of these values were considered limiting to the benthic macroinvertebrate communities inhabiting them, it should be remembered that one of the primary purposes of the ponds and sediment ditches is for reducing the high levels of solids and metals by settling them out prior to reaching the downstream portions of the receiving streams.

HABITAT ASSESSMENT

Several habitat measurements were determined (Tables 4A and 4B) at each of the sites sampled. The individual parameters are described below.

Pond/Ditch Surface Acreage - Actual size of the structure in acres. Smaller, shallower ponds and ditches, may not last as long or have as much sediment holding potential, but they will have a larger wetland value as there is less open water and more wetland vegetated area.

Length x Width - Longer, narrower ponds and sediment ditches will eventually have better wetland values for filtering incoming waters and provide more useable habitat for aquatic insects than wider, deeper ponds and sediment ditches.

Accumulative Sediment Storage Potential - Amount of sediment the structure can potentially hold. Larger, deeper ponds and sediment ditches can obviously hold more sediments, but may not have as desirable “wetland” potential.

Bottom Substrate Type - The availability of habitat for support of aquatic organisms. A variety of substrate materials and habitat types is desirable. Substrates comprised of more gravel, pebble, and/or organic materials are more desirable than those comprised mostly of silt and clay.

Bank Stability - Bank stability is rated by observing existing or potential detachment of soil from the upper and lower banks and its potential movement into the structure. Ponds and ditches with poor banks will often have poor instream habitat.

Bank Vegetative Stability - Bank soil is generally held in place by plant root systems. An estimate of the density of bank vegetation covering the bank provides an indication of bank stability and potential instream sedimentation.

Vegetation Type - Describes the vegetation type present. Newer structure will likely have only grasses planted along banks. Older structures can have grasses, several herbaceous species, as well as shrubs and tree saplings. Wetland vegetation on newer structures may not be present, but can consist of several types of algae, submerged and emergent aquatic species at older, more established structure.

Pond/Ditch Cover - Cover vegetation is evaluated in terms of provision of shading and escape cover for fish. A rating is obtained by visually determining the dominant vegetation type covering the exposed pond bottom, bank, and top of bank. Riparian vegetation dominated by shrubs and trees provides the CPOM source in allochthonous systems.

HABITAT RESULTS

Vance Branch (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3)

This on-bench pond had a surface area of 0.67 acres, was 400 feet long by 125 feet wide, and had an accumulative sediment storage potential of 4.19 acre/feet (Table 4A). Due to the recent completion of this structure (1999), banks were only about 50% vegetated, and only with erosional control grasses. The substrate was sandy and silty. Because this structure has tremendous storage potential, it should serve well as a sediment control pond, but banks are steep and unstable, and need to become more established. This structure has fairly good wetland potential as it becomes more established, but only around the edges of the pond, as it will likely have open water in the center for quite some time.

Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5)

This on-bench pond had a surface area of 0.30 acres, was 200 feet long by 150 feet wide, and had an accumulative sediment storage potential of 2.70 acre/feet (Table 4A). Even though it was fairly recently completed (1997), banks were almost 100% vegetated, and with grasses and other herbaceous plants and shrubs. The substrate was sandy and gravely. This structure has good storage potential, and it should serve well as a sediment control pond. Because banks are not steep and stable, this structure will most likely remain an open water pond for quite some time. This structure has good wetland potential along the edge as it becomes more established.

Left Fork of Parker Branch (Pond Number 7)

This pond had a surface area of 1.0 acres, was 160 feet long by 240 feet wide, and had an accumulative sediment storage potential of 4.98 acre/feet (Table 4A). Because it was completed a few years ago in 1994, banks were 100% vegetated, and with grasses and other herbaceous plants, shrubs, and saplings. The substrate was silty. This structure has tremendous storage potential, and it should serve well as a sediment control pond. Because banks are not steep and stable, this structure will most likely remain an open water pond for quite some time. This structure has good wetland potential along the edges, and due to its larger size, may serve very well for waterfowl, fish, and amphibians.

Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3)

This combination ditch had a surface area of 2.12 acres, was 2250 feet long by 41 feet wide, and had an accumulative sediment storage potential of 4.28 acre/feet (Table 4B). Although it had a recent completion date (1999), banks were moderately vegetated, but only with erosional control grasses. The substrate was silty, clay. Because this structure has tremendous storage potential, it should serve well as a combination ditch. This structure has fairly good wetland potential as it becomes more established, especially due to its longer, narrower size. Because of its size, it should do very well as a water filtration structure.

Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3)

This sediment ditch had a surface area of 0.83 acres, was 900 feet long by 40 feet wide, and had an accumulative sediment storage potential of 1.67 acre/feet (Table 4B). Although it also had a recent completion date (1997), banks were well vegetated, but only with grasses, herbaceous plants, and a few shrubs. The substrate was vegetated silt. Although this structure has a low sediment storage potential, it has a tremendous wetland potential, as it is shallow and long. Because of its length and depth, it should do very well as a water filtration structure.

Left Fork of Parker Branch (Sediment Ditch Number 6)

This sediment ditch had a surface area of 0.55 acres, was 600 feet long by 40 feet wide, and had an accumulative sediment storage potential of at least 2.5 acre/feet (Table 4B). Because of its older completion date (1994), banks were very well vegetated, but only with grasses, herbaceous plants, and a few shrubs. The substrate was vegetated silty clay. This structure has a higher sediment storage potential, and should perform well as a sediment control device. It also has good wetland and open water habitat potential.

DESCRIPTION OF BENTHIC MACROINVERTEBRATE METRICS

Several benthic macroinvertebrate measurements were calculated (Tables 3A and 3B) for each of the pond and sediment ditch sites sampled. The individual metrics are described below.

Metric 1. Taxa Richness - Reflects the health of the community through a measurement of the variety of taxa present. Generally increases with increasing water quality, habitat diversity, and habitat suitability. However, the majority should be distributed in the pollution sensitive groups, a lesser amount in the facultative groups, and the least amount in the tolerant groups. Polluted streams shift to tolerant dominated communities.

Metric 2. Modified Hilsenhoff Biotic Index - This index was developed by Hilsenhoff (1987) to summarize overall pollution tolerance of the benthic arthropod community with a single value. Calculated by summarizing the number in a given taxa multiplied by its tolerance value, then divided by the total number of organisms in the sample.

Metric 3. Ratio of Scraper and Filtering Collector Functional Feeding Groups - This ratio reflects the riffle/run community foodbase and provides insight into the nature of potential disturbance factors. The relative abundance of scrapers and filtering collectors indicate the periphyton community composition, availability of suspended Fine Particulate Organic Material (FPOM) and availability of attachment sites for filtering. Filtering collectors are sensitive to toxicants bound to fine particles and should be the first group to decrease when exposed to steady sources of bound toxicants.

Metric 4. Ratio of Ephemeroptera, Plecoptera, Trichoptera (EPT) and Chironomidae Abundances - This metric uses relative abundance of these indicator groups as a measure of community balance. Good biotic condition is reflected in communities having a fairly even distribution among all four major groups and with substantial representation in the sensitive groups Ephemeroptera, Plecoptera, and Trichoptera. Skewed populations with large amounts of Chironomidae in relation to the EPT indicates environmental stress.

Metric 5. Percent Contribution of Dominant Family - This is also a measure of community balance. A community dominated by relatively few species would indicate environmental stress. A healthy community is dominated by pollution sensitive representation in the Ephemeroptera, Plecoptera, and Trichoptera groups.

Metric 6. EPT Index - This index is the total number of distinct taxa within the Orders: Ephemeroptera, Plecoptera, and Trichoptera. The EPT Index generally increases with increasing water quality. The EPT index summarizes the taxa richness within the pollution sensitive insect orders.

Metric 7. Ratio of Shredder Functional Feeding Group and Total Number of Individuals Collected - Allows evaluation of potential impairment as indicated by the shredder community. Shredders are good indicators of riparian zone impacts.

Metric 8. Simpson's Diversity Index - This index ranges from 0 (low diversity) to almost 1 (high diversity). A healthy benthic macroinvertebrate community should have a higher Simpson's Diversity Index.

Metric 9. Shannon-Wiener Diversity Index - Measures the amount of order in the community by using the number of species and the number of individuals in each species. The value increases with the number of species in the community. A healthy benthic macroinvertebrate community should have a higher Shannon-Wiener Diversity Index.

Metric 10. Shannon-Wiener Evenness - Measures the evenness, or equitability of the community by scaling one of the heterogeneity measures relative to its maximal value when each species in the sample is represented by the same number of individuals. Ranges from 0 (low equitability) to 1 (high equitability).

BENTHIC MACROINVERTEBRATE RESULTS

Vance Branch (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3)

A total of 1,144 individuals comprising 8 taxa were collected (Tables 2A and 5). No pollution sensitive (intolerant) taxa were present in this pond. Only one facultative (intermediate tolerance) taxa was present (the springtail Collembola) which comprised 0.3% of the sample. Seven tolerant taxa were present comprising 99.7% of the abundance at this site. The tolerant Dipteran, Chironomidae accounted for 88.5% of the total abundance, and was the most abundant taxa present at this pond on Vance Branch. No EPT groups (mayflies, stoneflies, and caddisflies) were present. No scrapers or collector/filterers were present (Table 3A). The Simpson's and Shannon-Wiener Diversity indices reflected a poorly diversified community; the Shannon-Wiener Evenness value of 0.25 indicated that abundances were poorly distributed among the taxa, or homogeneous. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a heavily pollution tolerant macroinvertebrate community with a relatively poor periphyton community composition.

Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5)

A total of 2,800 individuals comprising 12 taxa were collected (Tables 2A and 6). No pollution sensitive (intolerant) taxa were present in this on-bench pond. Five facultative (intermediate tolerance) taxa were present comprising 22.7% of the sample. The facultative mayfly Caenis (Family: Caenidae) accounted for 16.4% of the site's abundance, and was a significant component to the site's community. Seven tolerant taxa were present comprising 77.3% of the abundance at this site. The tolerant Dipteran, the midge, Chironomidae accounted for 69.1% of the total abundance, and was the most abundant taxa at this sediment pond on Rollem Fork. Four EPT groups (Table 3A) were present which contributed to the EPT:Chironomidae Index in being fairly desirable. No scrapers or collector/filterers were present. A moderate variety of mayflies and caddisflies were collected at this station. The Simpson's and Shannon-Wiener Diversity indices reflected a community moderately-low in diversity, and the Shannon-Wiener Evenness indicated that abundances were only moderately distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a pollution tolerant/facultative, but fairly healthy benthic macroinvertebrate community.

Left Fork of Parker Branch (Pond Number 7)

A total of 4,936 individuals comprising 14 taxa were collected (Tables 2A and 7). No pollution sensitive (intolerant) taxa were present in this pond. Three facultative (intermediate tolerance) taxa were present comprising 20.4% of the sample. The facultative mayfly Caenis (Family: Caenidae) accounted for 13.6% of the site's abundance, and was a significant component to the site's community. Eleven tolerant taxa were present comprising 79.6% of the abundance at this site. The tolerant aquatic worm, Oligochaeta, accounted for 38.2% of the total abundance, and was the most abundant taxa at this sediment pond on the Left Fork of Parker Branch. Three EPT groups (Table 3A) were present which contributed to the EPT:Chironomidae Index in being very desirable. Again, no scrapers or collector/filterers were present, however, a moderate variety of mayflies and caddisflies were collected at this station. The Simpson's and Shannon-Wiener Diversity indices reflected a community moderately-high in diversity, and the Shannon-Wiener Evenness indicated that abundances were well distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a pollution tolerant/facultative, but fairly healthy benthic macroinvertebrate community.

<u>Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3)</u>

A total of 464 individuals comprising 8 taxa were collected (Tables 2B and 8). No pollution sensitive (intolerant) taxa were present in this combination ditch. Two facultative (intermediate tolerance) taxa were present which comprised 1.7% of the sample. The facultative mayfly Baetis (Family: Baetidae) and the springtail, Collembola, each accounted for 0.85% of the site's abundance. Six tolerant taxa were present comprising 98.3% of the abundance at this site. The tolerant Dipteran, Chironomidae accounted for 73.3% of the total abundance, and was the most abundant taxa present at this combination ditch on Vance Branch. Only one EPT group (mayflies, stoneflies, and caddisflies) was present. No scrapers or collector/filterers were present (Table 3B). The Simpson's and Shannon-Wiener Diversity indices reflected a poorly diversified community; the Shannon-Wiener Evenness value of 0.46 indicated that abundances were also relatively poorly distributed among the taxa, or homogeneous. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a very heavily pollution tolerant macroinvertebrate community with a relatively poor periphyton community composition.

<u>Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3)</u>

A total of 2,576 individuals comprising 4 taxa were collected (Tables 2B and 9). No pollution sensitive (intolerant) taxa were present in this sediment ditch. No facultative (intermediate tolerance) taxa were present either. Four tolerant taxa were present comprising 100.0% of the abundance at this site. The tolerant aquatic worm, Oligochaeta, accounted for 42.2% of the total abundance, and was the most abundant taxa at this sediment ditch on Rollem Fork. No EPT groups (mayflies, stoneflies, or caddisflies) (Table 3B) were present, and no scrapers or collector/filterers were present. The Simpson's and Shannon-Wiener Diversity indices reflected a community moderately-low in diversity, and the Shannon-Wiener Evenness indicated that abundances were only moderately distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a very pollution tolerant benthic macroinvertebrate community.

<u>Left Fork of Parker Branch (Sediment Ditch Number 6)</u>

A total of 1,120 individuals comprising 12 taxa were collected (Tables 2B and 10). No pollution sensitive (intolerant) taxa were present in this sediment ditch. Four facultative (intermediate tolerance) taxa were present comprising 11.4% of the sample. The facultative mayfly Caenis (Family: Caenidae) accounted for 9.3% of the site's abundance, and was a significant component to the site's community. Eight tolerant taxa were present comprising 88.6% of the abundance at this site. The tolerant midge, Chironomidae, accounted for 42.9% of the total abundance, and was the most abundant taxa at this sediment ditch on the Left Fork of Parker Branch. Three EPT groups (Table 3B) were present which contributed to the EPT:Chironomidae Index in being fairly desirable. Again, no scrapers or collector/filterers were present, however, a moderate variety of mayflies and caddisflies were collected at this station. The Simpson's and Shannon-Wiener Diversity indices reflected a community moderately-high in diversity, and the Shannon-Wiener Evenness indicated that abundances were moderately-well distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a pollution tolerant/facultative, but fairly healthy benthic macroinvertebrate community.

DISCUSSION

When comparing total abundances and taxa (Table 2A) between the three sediment control ponds sampled on October 08, 1999, it is obvious that large differences exist. The pond on Vance Branch (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3) contained relatively low abundances and low taxa diversity compared to the other ponds sampled, but this pond was only recently completed and therefore had not yet established an aquatic community (both vegetation and insects). Furthermore, this pond had a limiting pH level as well as limiting acidity, aluminum, and iron levels (Table 1A). The pond on Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5) had large total abundances of aquatic insects as well as a desirable number of taxa present even though this was also a relatively new pond (completion date 1997). This was most likely due to the more desirable pH level, and lower acidity, aluminum, and iron levels. The pond on the Left Fork of Parker Branch (Pond Number 7) contained the largest total abundance of aquatic insects as well as the largest number of taxa collected. This was largely due to the older age of the structure (completed in 1991), and due to the lower levels of most metals, even though pH was considered somewhat limiting.

When comparing total abundances and taxa (Table 2B) between the three sediment control ditches sampled on October 08, 1999, it is also obvious that large differences exist. The sediment ditch on Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3) contained low abundances, but moderate taxa diversity. Of the water chemistry parameters tested, only sulfates appeared to be high, thus the recent completion date of this combination ditch and hence the lack of adequate vegetation growth may have been limiting factors. The sediment ditch sampled on Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3) contained the highest total abundances, but lowest taxa diversity of all the sediment ditches sampled. The relatively recent completion date (1997) and the low pH level (Table 1B) were possible limiting factors. The sediment ditch sampled on the Left Fork of Parker Branch (Sediment Ditch Number 6) contained a moderate abundance of aquatic insects, and contained the largest number of taxa. This was somewhat a surprise since the pH level (9.39) was considered limiting.

In general, most of the ponds and sediment control ditches sampled were well represented by the groups of aquatic insects which are normally present in these lentic type habitats. The functional feeding groups scrapers and collector/filterers were never present, but this was not surprising since scrapers need silt-free environments for them to feed on the periphyton that attaches to rock substrates, and since the collector/filterers require faster-moving water in order to feed on the small particles of food which collected on constructed silken nets or on hairs on their bodies. The shredder functional feeding group (those that shred and consume leaves and other detrital materials) was also not well represented, but this group is also considered to be sensitive to disturbances and pollution. Generally, the sites were comprised mostly of tolerant organisms such as midges, dragonflies, and aquatic worms. As stated previously, this was to be expected, and was representative of aquatic insects which thrive in pond-type habitats.

Primarily, there are two reasons for the differences in aquatic insect abundances and taxa diversity between the different sediment ponds and sediment ditches: the age of the structure and water chemistry. The age of the structure is an important factor for several reasons. First, the age determines the overall composition of sediments entering the structure. Newly constructed ponds and sediment ditches are far more likely to receive very large inputs of fill materials and materials employed during the many cutting, grading, and logging activities that occur during the construction processes. Since banks and surrounding areas are barren until erosional-control grasses can be established, precipitation events can add large inputs into the new structure and cause erosional water marks. Older structures, with their established soils and heavier surrounding vegetation can "soak up" or slow much of the rainfall which would have undoubtably scarred newer structures. Second, older structures usually can have surrounding vegetation in the forms of large herbaceous plants, shrubs, and if old enough, saplings and larger trees. These larger plant forms add the detrital materials (leaves and sticks) which are a major source of food input for the aquatic insects inhabiting the sediment control pond or ditch. Thus, older, more established ponds will generally have more insects which feed directly upon the detrital materials which enter the system. These detrital materials are also a key source of the sediments which are necessary for many of the emergent and submerged aquatic plants which will eventually be desirable in the system. Newer structures must rely on food materials entering directly from the incoming streams or being flushed in from surface runoff. Newer structures with poor or unestablished benthic soils do not have the capability to produce the varieties and abundances of aquatic plants that older, more established ponds and ditches possess. Third, heavy surrounding vegetation as well as the aquatic vegetation is the "key" to a wetland's ability to facilitate water filtration. Older, more established ponds and sediment ditches, with heavy vegetation in and around the structure, are excellent at filtering solids and contaminants from the water. This is important if a goal of the structure was to remove solids and other contaminants by filtration or precipitation prior to them entering waterways farther downstream. Newer structures do not have nearly as much filtration capability as older, more vegetated ones. Fourth, the closer surrounding vegetation of the older structures provides shading to the pond's or sediment ditch's shoreline areas, thus providing hiding places for fish (if present), cooler temperatures, and places for terrestrial insects to thrive. Older structures are generally warmer along shoreline areas, and have less areas for terrestrial insects to concentrate. An important note to remember is that when most aquatic insects emerge from their aquatic stage to become an adult, they generally live near the water, and many utilize the surrounding vegetation as places to emerge, mate, and lay eggs.

As stated earlier, water chemistry is also on of the reasons for the differences in aquatic insect abundances and taxa diversity between the different sediment ponds and sediment ditches. Water chemistry is critical because it is directly responsible for two components: the aquatic insects living in the pond or sediment ditch, and the vegetation living both in and around the structure. In essence, poor water chemistry can limit, or completely exclude, the abundances and number of taxa inhabiting the aquatic resource regardless of the structure's physical habitat. Good water chemistry can provide for at least some aquatic insect communities even in the most silted environments containing hardly any food inputs. However, aquatic insects require plants, both living and dead. They utilize the dead plants (leaves, sticks) as food sources, refuge places, and even home structures. They directly use the plants living in the pond also as food sources, refuge places, and home structures, but also use them indirectly as water purifiers and as a major source of their oxygen. Normally, ponds and sediment ditches with a very good establishment of aquatic, semi-aquatic, and terrestrial vegetation will have desirable aquatic insect populations and better water quality compared to a similar, or newer, system without established vegetation. It is critical to remember that none of the aquatic, semi-aquatic, or larger terrestrial vegetation was seeded by the mining company. Waterfowl traveling from pond to pond, ingesting the seeds from the wetland vegetation, then depositing the passed seeds at different pond locations has eventually established the vegetation present at each location. Only the perennial rye, orchard grasses, and clover are used by the mining company for erosional control on newly constructed, or disturbed sites.

These sediment ponds and sediment ditches have added an additional facet to the available habitat that is currently present on mine permitted lands. Regarding the sediment ditches and channels, the Pen Coal Corporation has currently constructed over 6 miles of additional sediment channels. Most of these constructed channels were not stream channels prior to their construction. This relates to over 6 miles of additional aquatic habitat (both stream channel and wetland) which was previously non-existent prior to their construction. With regards to the "on-bench" ponds, it is very important to remember that no aquatic habitat was present in the immediate area prior to their construction. Because they were not constructed from damming an existing mountain stream, but rather from digging a hole and building up the area around the pit, no stream channels were sacrificed. They are supported entirely from surface runoff and subsurface seepage, and not from intermittent or perennial streams. Without on-bench pond and the sediment ponds located at the bottom of hollows, there would be no "natural" ponds available in the area. As an example, on land owned or leased by the Pen Coal Corporation, there are currently over 20 on-bench ponds. With each of these averaging about ½ acre in size, Pen Coal has provided over 10 acres of pond and wetland habitat with just their on-bench ponds. This does not include ponds located at the bottoms of hollows, where some stream length was sacrificed for pond/wetland acreage. This 10 acres is entirely additional pond and subsequent wetland habitat that was not available prior to their construction. These lower ponds, on-bench ponds, and sediment ditches are readily used by aquatic insects, waterfowl, amphibians, reptiles, turkeys and other wildlife creatures. An advantage to the animals which utilize the on-bench ponds, is that they do not have to travel to the bottoms of the hollows for water; they now have water sources closer to the ridgetops with the on-bench ponds. It should also be pointed out that this study was conducted during a serious drought year, and that many small streams were dry, but each of the on-bench ponds and lower elevation ponds still contained a more than adequate supply of water.

It seems ill-conceived that all sediment ditches and sediment control ponds have to be removed in order for coal companies to have fulfilled their obligation to "return the stream to its original state". Return of a stream to its original condition may never be achieved as dramatic changes to the geomorphology of the area most likely have occurred during active mining practices. Even if surrounding areas become heavily vegetated or even wooded, the fill materials exposed can alter water chemistry for many years after mining has ceased in the area. In addition, destruction of these ponds and sediment ditches along with their established wetland areas seems to be a direct violation of the practices established by the U.S. Environmental Protection Agency as well as the U.S. Army Corps of Engineers of avoiding elimination of any wetland areas.

If constructed properly, these sediment control ponds and sediment ditches can do a splendid job in removing solids and other water contaminants both by filtration and by precipitation prior to reaching downstream areas. They also provide aquatic habitats for countless abundances of aquatic insects, amphibians, reptiles, and potentially even fish. Once mining has ceased in the immediate area, these sedimentation ponds could easily be converted into an aesthetic, attractive, and usable wildlife feature with only a few modifications. For example, trees felled into the pond would add both food and habitat for many species of aquatic insects. Additional structures could be placed in the pond to provide hiding habitat for lentic fish species such as sunfish and bass. These structures would also provide a refuge for both fish and insects, act as a breeding ground for many species of insects as well as some fish. Although prohibited from planting permanent, larger-growing vegetation such as trees around structures which are considered temporary, changes in management design could take place these structures were to be considered as a permanent, and additional habitat for the area. Tall grasses, shrubs, and willow saplings, as well as larger trees could then be planted surrounding the pond to provide both a food source from fallen leaves/sticks and shade along shoreline areas. The managed pond could also be easily utilized as a refuge by waterfowl and other lentic-water animals such as amphibians and reptiles. With very little modification, most of the ponds studied for this report could provide an additional facet to the aquatic and semi-aquatic fauna currently found in area.

CONCLUSIONS

Overall, most of the ponds and sediment control ditches sampled were well represented by the groups of aquatic insects which are normally present in these lentic type habitats. The functional feeding groups scrapers and collector/filterers were never present, but this was not surprising since scrapers need silt-free environments for them to feed on the periphyton that attaches to rock substrates, and since the collector/filterers require faster-moving water in order to feed on the small particles of food which collected on constructed silken nets or on hairs on their bodies. The shredder functional feeding group (those that shred and consume leaves and other detrital materials) was also not well represented, but this group is also considered to be sensitive to disturbances and pollution. Generally, the sites were comprised mostly of large abundances and taxa of tolerant organisms such as midges, dragonflies, and aquatic worms. As stated previously, this was to be expected, and was representative of pond-type habitats.

Generally, there are two reasons for the differences in aquatic insect abundances and taxa diversity between the different sediment ponds and sediment ditches: the age of the structure and water chemistry. The age of the structure is an important factor because it determines the overall composition of sediments entering the structure, determines the amount of detrital materials (leaves and sticks) entering the system, determine the type and abundance of aquatic vegetation growing in and around the structure, determine the abundances and types of aquatic insects which can be supported in the system, and determine the filtering potential of the system. Water chemistry is critical because it is directly responsible for two components: the aquatic insects living in the pond or sediment ditch, and the vegetation living both in and around the structure. In essence, poor water chemistry can limit, or completely exclude, the abundances and number of taxa inhabiting the aquatic resource regardless of the structure's physical habitat.

These sediment ponds and sediment ditches have added an additional facet to the available habitat that is currently present on mine permitted lands. Regarding the sediment ditches and channels, the Pen Coal Corporation has currently constructed over 6 miles of additional sediment channels. Most of these constructed channels were not stream channels prior to their construction. With regards to the "on-bench" ponds, it is very important to remember that no aquatic habitat was present in the immediate area prior to their construction. On land owned or leased by the Pen Coal Corporation, there are currently over 20 on-bench ponds. With each of these averaging about ½ acre in size, Pen Coal has provided over 10 acres of pond and wetland habitat with just their on-bench ponds. These lower ponds, on-bench ponds, and sediment ditches are readily used by aquatic insects, waterfowl, amphibians, reptiles, turkeys and other wildlife creatures.

It appears to be an ill-conceived policy that all sediment ditches and sediment control ponds have to be removed in order for coal companies to have fulfilled their obligation to "return the stream to its original state". Return of a stream to its original condition may never be achieved as dramatic changes to the geomorphology of the area have most likely occurred during active mining practices. If surrounding areas become heavily vegetated or even wooded, the fill materials exposed can alter water chemistry for many years after mining has ceased in the area. In addition, destruction of these ponds and sediment ditches along with their established wetland areas seems to be a direct violation of the practices established by the U.S. Environmental Protection Agency as well as the U.S. Army Corps of Engineers of avoiding elimination of any wetland areas.

If constructed properly, these sediment control ponds, sediment ditches, and their subsequent wetlands can do a splendid job in removing solids and other water contaminants both by filtration and by precipitation prior to reaching downstream areas. They also provide aquatic habitats for countless abundances of aquatic insects, amphibians, reptiles, and potentially even fish. Once mining has ceased in the immediate area, these sedimentation ponds could easily be converted into an aesthetic, attractive, and useful habitat feature, and provide an additional facet to the aquatic, semi-aquatic, and terrestrial wildlife currently found in area.

APPENDIX B

TABLE 1A. Physical and chemical water-quality variables of sediment control ponds at Pen Coal Corporation, 08 October 1999.

PARAMETER	Vance Branch (1999)	Rollem Fork (1997)	Left Fork Parker (1991)
Temperature (°C)	14.00	19.42	18.96
Dissolved Oxygen (mg/l)	6.73	6.45	9.61
pH (SI units)	5.04	7.82	8.77
Conductivity (μmhos)	43	189	273
BOD (mg/l)	<2	<2	3
TDS (mg/l)	602	188	278
TSS (mg/l)	554	21	1
Fecal Coliform (#/100ml)	>800	70	1
Hardness (mg/l)	26.5	134	212
Alkalinity (mg/l)	2.5	85.4	74.4
Total Acidity (mg/l)	11.2	<1.0	<1.0
Chlorides (mg/l)	<1.0	<1.0	<1.0
Sulfates (mg/l)	22.6	61.3	139
Aluminum (mg/l)	8.29	0.544	0.053
Antimony (mg/l)	<0.001	<0.001	<0.001
Arsenic (mg/l)	0.003	0.003	<0.002
Barium (mg/l)	0.080	0.040	0.040
Beryllium (mg/l)	<0.001	<0.001	<0.001
Cadmium (mg/l)	<0.0003	<0.0003	<0.0003
Calcium (mg/l)	4.28	34.4	41.1
Chromium (mg/l)	0.008	<0.001	<0.001
Copper (mg/l)	0.013	<0.005	<0.005
Iron (mg/l)	9.79	1.05	0.037
Lead (mg/l)	0.010	<0.002	<0.002
Magnesium (mg/l)	3.85	11.8	26.5
Manganese (mg/l)	0.410	0.160	0.030
Mercury (mg/l)	<0.0002	<0.0002	<0.0002
Nickel (mg/l)	<0.030	<0.030	<0.030
Selenium (mg/l)	<0.003	<0.003	<0.003
Silver (mg/l)	<0.004	<0.004	<0.004
Sodium (mg/l)	0.836	1.16	2.09
Thallium (mg/l)	<0.001	<0.001	<0.001
Zinc (mg/l)	0.034	0.019	<0.002

TABLE 1B. Physical and chemical water-quality variables of sediment ditches at Pen Coal Corporation, 08 October 1999.

PARAMETER	Vance Branch (1999)	Rollem Fork (1997)	Left Fork Parker (1991)
Temperature (°C)	14.38	10.05	18.36
Dissolved Oxygen (mg/l)	7.43	5.42	9.46
pH (SI units)	7.03	5.32	9.39
Conductivity (μmhos)	365	281	96
BOD (mg/l)	<2	<2	<2
TDS (mg/l)	302	288	84
TSS (mg/l)	172	16	3
Fecal Coliform (#/100ml)	>270	49	14
Hardness (mg/l)	285	182	71.0
Alkalinity (mg/l)	39.2	5.8	67.1
Total Acidity (mg/l)	<1.0	13.2	<1.0
Chlorides (mg/l)	<1.0	1.3	1.2
Sulfates (mg/l)	243	210	15.8
Aluminum (mg/l)	0.714	0.491	0.109
Antimony (mg/l)	<0.001	<0.001	<0.001
Arsenic (mg/l)	0.002	0.002	<0.002
Barium (mg/l)	0.023	0.048	0.034
Beryllium (mg/l)	<0.001	<0.001	<0.001
Cadmium (mg/l)	<0.0003	<0.0003	<0.0003
Calcium (mg/l)	71.6	43.0	17.7
Chromium (mg/l)	<0.001	<0.001	<0.001
Copper (mg/l)	<0.005	<0.005	<0.005
Iron (mg/l)	0.422	1.28	0.132
Lead (mg/l)	<0.002	<0.002	<0.002
Magnesium (mg/l)	25.8	18.2	6.50
Manganese (mg/l)	1.44	3.94	0.017
Mercury (mg/l)	<0.0002	<0.0002	<0.0002
Nickel (mg/l)	<0.030	0.036	<0.030
Selenium (mg/l)	<0.003	0.003	<0.003
Silver (mg/l)	<0.004	<0.004	<0.004
Sodium (mg/l)	1.12	1.08	0.690
Thallium (mg/l)	<0.001	<0.001	<0.001
Zinc (mg/l)	0.023	0.074	<0.002

TABLE 2A. Total abundances of benthic macroinvertebrates collected via Ponar grab samples taken from sediment control ponds at the Pen Coal Corporation, 08 October 1999.

TAXON	Vance Branch (1999)	Rollem Fork (1997)	Left Fork Parker (1991)
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Baetis (F)			272
Caenidae			
Caenis (F)		460	672
Ephemerellidae			
Ephemerella (F)		64	
Trichoptera (Caddisflies)			
Polycentropodidae (F)		32	
Rhyacophilidae (F)		64	64
Diptera (True Flies)			
Ceratopogonidae (T)	76	76	416
Chironomidae (T)	1012	1936	976
Coleoptera (Beetles)			
Amphizoidae (T)			64
Dytiscidae (T)	12		48
Cybister (T)			72
Laccophilus (T)	12		
Haliplidae			
Haliplus (T)			8
Hemiptera (Water Bugs)			
Corixidae (T)	4	20	
Mesoveliidae (T)			136
Odonata (Dragonflies)			
Aeshnidae			
Gynacantha (T)			64
Coenagrionidae (T)	20	72	96
Gomphidae (T)			
Dromogomphus (T)		4	
Libellulidae (T)		40	160

TABLE 2A. Continued

TAXON	Vance Branch (1999)	Rollem Fork (1997)	Left Fork Parker (1991)
Collembola (F)	4	16	
Oligochaeta (AquaticWorms) (T)	4	16	1888
smallmouth bass juvenile* (U)		1	
Total Individuals	1,144	2,800	4,936
Total Taxa	8	12	14
Sensitive Ind. (%)	0 (0.0)	0 (0.0)	0 (0.0)
Number of Taxa	0	0	0
Facultative Ind. (%)	4 (0.3)	636 (22.7)	1008 (20.4)
Number of Taxa	1	5	3
Tolerant Ind. (%)	1140 (99.7)	2164 (77.3)	3928 (79.6)
Number of Taxa	7	7	11

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 2B. Total abundances of benthic macroinvertebrates collected via Ponar grab samples taken from sediment ditches at the Pen Coal Corporation, 08 October 1999.

TAXON	Vance Branch (1999)	Rollem Fork (1997)	Left Fork (1994)
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Baetis (F)	4		8
Caenidae			
Caenis (F)			104
Trichoptera (Caddisflies)			
Polycentropodidae (F)			8
Diptera (True Flies)			
Ceratopogonidae (T)	64	448	40
Chironomidae (T)	340	1024	480
Tipulidae			
Tipula (T)			16
Coleoptera (Beetles)			
Amphizoidae (T)	4		
Dytiscidae			
Cybister (T)			8
Laccophilus (T)	8		
Hydrophilidae			
Berosus (T)		16	
Hemiptera (Water Bugs)			
Mesoveliidae (T)			24
Odonata (Dragonflies)			
Coenagrionidae (T)			80
Libellulidae (T)	32		104
Collembola (F)	4		8
Oligochaeta (Aquatic Worms) (T)	8	1088	240
Total Individuals	464	2,576	1,120
Total Taxa	8	4	12

TABLE 2B. Continued

	Vance Branch (1999)	Rollem Fork (1997)	Left Fork (1994)
Sensitive Ind. (%)	0 (0.0)	0 (0.0)	0 (0.0)
Number of Taxa	0	0	0
Facultative Ind. (%)	8 (1.7)	0 (0.0)	128 (11.4)
Number of Taxa	2	0	4
Tolerant Ind. (%)	456 (98.3)	2576 (100.0)	992 (88.6)
Number of Taxa	6	4	8

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 3A. Selected benthic macroinvertebrate metrics for sediment control ponds located at the Pen Coal Corporation, 08 October 1999.

METRIC	Vance Branch (1999)	Rollem Fork (1997)	Left Fork Parker (1991)
Taxa Richness	8	12	14
Modified Hilsenhoff Biotic Index	6.05	6.03	6.06
Ratio of Scrapers to Collector/Filterers	0:0	0:0	0:0
Ratio of EPT:Chironomidae	0:1012	620:1936	1008:976
% Contribution of Dominant Family	88.5% Chiro.[1]	69.1% Chiro.[1]	38.2% Olig.[2]
EPT Index	0	4	3
% Shredders to Total	0.3%	0.6%	0.0%
Simpson's Diversity Index	0.21	0.49	0.78
Shannon-Wiener Diversity	0.74	1.63	2.74
Shannon-Wiener Evenness	0.25	0.46	0.72

1 = Diptera: Chironomidae
2 = Oligochaeta

TABLE 3B. Selected benthic macroinvertebrate metrics for sediment ditches located at the Pen Coal Corporation, 08 October 1999.

METRIC	Vance Branch (1999)	Rollem Fork (1997)	Left Fork (1994)
Taxa Richness	8	4	12
Modified Hilsenhoff Biotic Index	6.19	6.00	6.53
Ratio of Scrapers to Collector/Filterers	0:0	0:0	0:0
Ratio of EPT:Chironomidae	4:340	0:1024	120:480
% Contribution of Dominant Family	73.3% Chiro.[1]	42.2% Olig.[2]	42.9% Chiro.[1]
EPT Index	1	0	3
% Shredders to Total	0.9%	0.0%	0.7%
Simpson's Diversity Index	0.44	0.63	0.75
Shannon-Wiener Diversity	1.37	1.54	2.49
Shannon-Wiener Evenness	0.46	0.77	0.69

1 = Diptera: Chironomidae
2 = Oligochaeta

TABLE 4A. Summary of habitat descriptions for the sediment control ponds located at the Pen Coal Corporation, 08 October 1999.

	Vance Branch (1999)	Rollem Fork (1997)	Left Fork Parker (1991)
Pond/Ditch Surface Acreage			
	0.67	0.30	1.0
Length x Width (feet)			
	400 x 125	200 x 150	160 x 240
Accumulative Sediment Storage (Acre/feet)			
	4.19	2.70	4.98
Bottom Substrate Type			
	sand, silt	sandy, gravel	silty
Bank Stability			
	very steep, unstable	stable	stable
Bank Vegetation Stability			
	≈50% vegetated	100% vegetated	100% vegetated
Vegetation Types			
	grasses (terrestrial)	grasses, shrubs, herbaceous plants, filamentous algae	grasses, shrubs, herbaceous plants, filamentous algae, emergent aquatics
Pond/Ditch Cover			
	none	very little	very little

TABLE 4B. Habitat descriptions for the sediment control ditches located at the Pen Coal Corporation, 08 October 1999.

	Vance Branch (1999)	Rollem Fork (1997)	Left Fork (1994)
Pond/Ditch Surface Acreage			
	2.12	0.83	0.55
Length x Width (feet)			
	2,250 x 41	900 x 40	600 x 40
Accumulative Sediment Storage (Acre/feet)			
	4.28	1.67	>2.58
Bottom Substrate Type			
	silty, clay	vegetated silt	clay, silty
Bank Stability			
	moderately stable	stable	stable
Bank Vegetation Stability			
	moderately vegetated (soils not fully developed)	100% vegetated	100% vegetated
Vegetation Types			
	grasses (terrestrial), some aquatic vegetation	grasses, shrubs, herbaceous plants, filamentous algae, submerged & emergent aquatics	grasses, shrubs, herbaceous plants, filamentous algae, submerged & emergent aquatics
Pond/Ditch Cover			
	open	some	open

TABLE 5. Abundances of benthic macroinvertebrates collected per sample from Vance Branch (Rollem Fork Number 3 Surface Mine; On-Bench Pond Number BP3), 08 October 1999.

TAXON	SAMPLE Ponar 1	Ponar 2	Ponar 3
Insecta			
Diptera (True Flies)			
Ceratopogonidae (T)	8	32	36
Chironomidae (T)	148	648	216
Coleoptera (Beetles)			
Dytiscidae (T)		12	
Laccophilus (T)			12
Hemiptera (Water Bugs)			
Corixidae (T)	4		
Odonata (Dragonflies)			
Coenagrionidae (T)	4	12	4
Collembola (Springtails) (F)	4		
Oligochaeta (Aquatic Worms) (T)	4		
Total Individuals	172	704	268
Taxa	6	4	4

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 6. Abundances of benthic macroinvertebrates collected per sample from Rollem Fork (Rollem Fork Number 2 Surface Mine; On-Bench Pond Number 5), 08 October 1999.

TAXON	SAMPLE Ponar 1	Ponar 2	Ponar 3
Insecta			
Ephemeroptera (Mayflies)			
Caenidae			
Caenis (F)	288	112	60
Ephemerellidae			
Ephemerella (F)	64		
Trichoptera (Caddisflies)			
Polycentropodidae (F)	32		
Rhyacophilidae (F)	64		
Diptera (True Flies)			
Ceratopogonidae (T)	64		12
Chironomidae (T)	1088	272	576
Hemiptera (Water Bugs)			
Corixidae (T)		16	4
Odonata (Dragonflies)			
Coenagrionidae (T)	64		8
Gomphidae			
Dromogomphus (T)			4
Libellulidae (T)	32		8
Collembola (Springtails) (F)		16	
Oligochaeta (Aquatic Worms) (T)		16	
smallmouth bass juvenile* (U)			1
Total Individuals	1696	432	672
Taxa	8	5	7

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 7. Abundances of benthic macroinvertebrates collected per sample from Left Fork of Parker Branch (Pond Number 7), 08 October 1999.

TAXON	SAMPLE Ponar 1	Ponar 2	Ponar 3
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Baetis (F)	80	128	64
Caenidae			
Caenis (F)	224	256	192
Trichoptera (Caddisflies)			
Rhyacophilidae (F)		64	
Diptera (True Flies)			
Ceratopogonidae (T)	80	256	80
Chironomidae (T)	240	512	224
Coleoptera (Beetles)			
Amphizoidae (T)		64	
Dytiscidae (T)	16		32
Cybister (T)	8	64	
Haliplidae			
Haliplus (T)	8		
Hemiptera (Water Bugs)			
Mesoveliidae (T)	8	128	
Odonata (Dragonflies)			
Aeshnidae			
Gynacantha (T)		64	
Coenagrionidae (T)	16	64	16
Libellulidae (T)	32	128	
Oligochaeta (Aquatic Worms) (T)	544	832	512
Total Individuals	1256	2560	1120
Taxa	11	12	7

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 8. Abundances of benthic macroinvertebrates collected per sample from Vance Branch (Rollem Fork Number 3 Surface Mine; Combination Ditch Number CD3), 08 October 1999.

	SAMPLE		
TAXON	Ponar 1	Ponar 2	Ponar 3
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Baetis (F)			4
Diptera (True Flies)			
Ceratopogonidae (T)	12	52	
Chironomidae (T)	56	156	128
Coleoptera (Beetles)			
Amphizoidae (T)		4	
Dytiscidae (T)			
Laccophilus (T)			8
Odonata (Dragonflies)			
Libellulidae (T)	24	4	4
Collembola (Springtails) (F)	4		
Oligochaeta (Aquatic Worms) (T)		4	4
Total Individuals	96	220	148
Taxa	4	5	5

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 9. Abundances of benthic macroinvertebrates collected per sample from Rollem Fork (Rollem Fork Number 2 Surface Mine; Sediment Ditch Number SD-3), 08 October 1999.

	SAMPLE		
TAXON	Ponar 1	Ponar 2	Ponar 3
Insecta			
Diptera (True Flies)			
Ceratopogonidae (T)	48	384	16
Chironomidae (T)	256	576	192
Coleoptera (Beetles)			
Hydrophilidae			
Berosus (T)	16		
Oligochaeta (Aquatic Worms) (T)	384	576	128
Total Individuals	704	1536	336
Taxa	4	3	3

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 10. Abundances of benthic macroinvertebrates collected per sample from Left Fork of Parker Branch (Sediment Ditch Number 6), 08 October 1999.

TAXON	Ponar 1	Ponar 2	Ponar 3
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Baetis (F)	8		
Caenidae			
Caenis (F)	24	64	16
Trichoptera (Caddisflies)			
Polycentropodidae (F)			8
Diptera (True Flies)			
Ceratopogonidae (T)	16	16	8
Chironomidae (T)	112	160	208
Tipulidae			
Tipula (T)		16	
Coleoptera (Beetles)			
Dytiscidae (T)			8
Cybister (T)			
Hemiptera (Water Bugs)			
Mesoveliidae (T)	8	16	
Odonata (Dragonflies)			
Coenagrionidae (T)		64	16
Libellulidae (T)		64	40
Collembola (Springtails) (F)			8
Oligochaeta (Aquatic Worms) (T)	48	16	176
Total Individuals	216	416	488
Taxa	6	8	9

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

Benthic Macroinvertebrate Study of Honey Branch, Its Sediment Control Ponds, and Its Influence on the East Fork of Twelvepole Creek Conducted 10/08/99

Conducted for:

PEN COAL CORPORATION
KIAH CREEK MINE OFFICE
P.O. BOX 191
DUNLOW, WEST VIRGINIA 25511

by:

ED J. KIRK, AQUATIC BIOLOGIST
R.E.I. CONSULTANTS, INCORPORATED
225 INDUSTRIAL PARK ROAD
BEAVER, WEST VIRGINIA 25813
11/24/99

TABLE OF CONTENTS

Introduction 1

Location of Study Area 3

Methods of Investigation:
Physical & Chemical Water Quality, Habitat, Benthic Macroinvertebrates 4

Specific Station Locations / Physical Descriptions 6

Physical & Chemical Water Quality Analysis 9

Habitat Assessment Parameters 10

Habitat Results 13

Description of Benthic Macroinvertebrate Metrics 15

Benthic Macroinvertebrate Results 17

Discussion 21

Conclusions 2 5

Appendix A
Note: Appendix A is not included; figures are not available.

Figure 1. Station Location / Topographical Map

Appendix B
Table 1A. Physical and chemical water-quality variables of stations on Honey Branch and the East Fork Of Twelvepole Creek.
Table 1B. Physical and chemical water-quality variables for Honey Branch sediment control ponds and drainage ditch.
Table 2A. Total abundances of benthic macroinvertebrates collected at stations on Honey Branch and the East Fork of Twelvepole Creek.
Table 2B. Total abundances of benthic macroinvertebrates collected in Honey Branch sediment ponds and drainage ditch.
Table 3A. Selected benthic macroinvertebrate metrics of stations on Honey Branch and the East Fork of Twelvepole Creek.
Table 3B. Selected benthic macroinvertebrate metrics of stations on Honey Branch sediment ponds and drainage ditch.
Table 4A. Habitat scores for stations on Honey Branch and the East Fork of Twelvepole Creek.
Table 4B. Habitat descriptions for Honey Branch sediment ponds and drainage ditch.

Table 5. Upstream Honey Branch (Toe of Valley Fill) macroinvertebrates.
Table 6. Middle Honey Branch macroinvertebrates
Table 7. Downstream Honey Branch (Mouth of Honey Branch) macroinvertebrates
Table 8. Upstream East Fork of Twelvepole Creek macroinvertebrates
Table 9. Downstream East Fork of Twelvepole Creek macroinvertebrates
Table 10. Middle Honey Branch Pond (Pond Number 2) macroinvertebrates
Table 11. Lower Honey Branch Pond (Pond Number 1) macroinvertebrates
Table 12. Honey Branch Sediment Ditch macroinvertebrates

Appendix C.
Note: Appendix C is not included; photographs are not available.

Photographs 1 - 2. Upstream Honey Branch (Toe of Valley Fill) Station.
Photographs 3 - 4. Middle Honey Branch Station.
Photograph 5. Middle Honey Branch Pond (Pond Number 2).
Photograph 6. Lower Honey Branch Pond (Pond Number 1).
Photographs 7 - 8. Honey Branch Sediment Ditch.

BENTHIC MACROINVERTEBRATE STUDY OF HONEY BRANCH, ITS SEDIMENT CONTROL PONDS, AND ITS INFLUENCE ON THE EAST FORK OF TWELVEPOLE CREEK CONDUCTED 10/08/99

INTRODUCTION

One of the first permitted valley fills in West Virginia was located on Honey Branch. Honey Branch is a first-order tributary of the East Fork of Twelvepole Creek in Lincoln County, in southwestern West Virginia. Contour surface mining activities began in 1987, and were completed in 1991. On going reclamation activities were performed during mining operations. The Honey Branch mining site received its Phase II bond reclamation last year.

In June 1987 Heer, Inc. performed a benthic macroinvertebrate survey to provide a biological assessment of Honey Branch prior to mining activities to satisfy requirements for permit application. In July 1987 the West Virginia Department of Environmental Protection (WV-DEP) performed an informal, qualitative biological survey to confirm the assessments of the stream prior to mining operations. Science Applications International Corporation (SAIC) conducted another survey of Honey Branch in June 1998 to assess the impacts of mining activities and valley fills on the Honey Branch waterway. Several sites sampled during the Heer, Inc. survey were able to be utilized during the SAIC study for direct comparisons to be accurately made. Other sites were not possible to be sampled because they had been completely covered by the construction of valley fills. This study, performed in October 1999 was conducted to verify the present conditions of Honey Branch since mining activities has long since ceased in the area, and to determine if Honey Branch has had any effect on its receiving stream, the East Fork of Twelvepole Creek. Another purpose for the current study came about as a response to the environmental protests on the initial permit submittion. Many of the identical stations which were sampled during previous studies were sampled for this study so that comparisons could be made between the studies, and so that inferences as to macroinvertebrate community trends could be evaluated.

Another purpose of this study was to provide an unbiased, professional examination of the sediment control ponds and sediment ditches which currently exist on Honey Branch. These would be studied as to their aquatic and wetland status, as well as their usefulness as quality habitats for fauna inhabiting the area. Because Pen Coal has acquired the property, the ponds and sediment ditches on Honey Branch are now considered to be permanent structures. Normally, according to the West Virginia Department of Environmental Protection-Office of Mining and Reclamation, upon completion of mining activities, constructed sediment control ponds and/or drainage ditches must be removed prior to being released from permitting regulations if they are considered as temporary structures. Breaching of the dam is therefore required from the point of view that in order to return the stream back to its original state, the stream channel must be change back to its original shape.

Policies within the West Virginia Department of Environmental Protection (WV-DEP) require biological surveys of streams prior to, and after issuance of National Pollutant Discharge Elimination System (NPDES) permits to adequately determine stream biota and potential biological development. Biological data, such as aquatic macroinvertebrate populations, in conjunction with physical and chemical water quality, and habitat data, provide valuable information that are used in the permit review process and are ultimately used to assist in establishing NPDES discharge limitations. These data also act as a powerful monitoring tool in identifying possible pollutant sources and/or habitat alterations and subsequent effects.

LOCATION OF STUDY SITES

The study area is located in Lincoln County approximately 3/4 mile north of the Mingo/Lincoln County line in southwest West Virginia. Honey Branch is a first-order tributary of the East Fork of Twelvepole Creek. The Honey Branch waterway extends approximately 1,500 feet and has a watershed area of approximately 609 acres. The forks of Honey Branch begin at an elevation of approximately 1,100 feet above sea level the stream travels northward to enter the East Fork of Twelvepole Creek at an elevation of approximately 750 feet above sea level.

Three stations were sampled on Honey Branch, at the toe of the primary valley fill, mid-way between the toe and the mouth of Honey Branch, and at the mouth of Honey Branch. Two stations were sampled on the East Fork of Twelvepole Creek, upstream from the confluence with Honey Branch, and downstream from the confluence with Honey Branch. The middle Honey Branch sediment control pond (Pond Number 2), the lower Honey Branch sediment control pond (Pond Number 1), and the sediment ditch on Honey Branch were also sampled.

METHODS OF INVESTIGATION

On October 08, 1999 measurements for flow, physical water quality, and chemical water quality were taken at each of the stream, pond, and sediment ditch stations. Benthic macroinvertebrate samples were also collected, and the habitat of the stations was evaluated. The individual methodologies are described below.

Physical Water Quality

Physical water quality was analyzed on-site at each station. Water temperature, Dissolved Oxygen (DO), pH, and conductivity was measured with a Hydrolab™ Minisonde multi-parameter probe. Flow was measured in the streams with a Marsh-McBirney™ Model 2000 portable flow meter. Stream widths, depths, and velocities were measured, and the resulting average discharge was reported for each station.

Water Chemistry

Water chemistry samples were collected at each station and returned to R.E.I. Consultants, Inc. for processing. Parameters analyzed included acidity, alkalinity, chloride, hardness, sulfate, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), fecal coliform, aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, sodium, thallium, and zinc.

Habitat

For the stream stations, habitat was assessed and rated on nine parameters in three categories using EPA's Rapid Bioassessment Protocols for Use in Streams and Rivers (EPA 440/4-89/001). For the pond and sediment ditch sites, habitat was described as to its quality for fish, macroinvertebrates, and wildlife by assessing the size, shape, sediment storage potential, substrate type, bank stability, and vegetation types.

Benthic Macroinvertebrates

A modified EPA Rapid Bioassessment Protocol III (EPA 440/4-89/001) was utilized in the collection of the benthic macroinvertebrate specimens. At each stream station, collections were made via an Ellis-Rutter™ Portable Invertebrate Box Sampler (PIBS) sampler fitted with a 350-μm mesh size net. The PIBS sampler has several advantages over the standard Surber™ sampler which makes it a desirable choice for the collection of aquatic macroinvertebrates. Sampler area was 0.10 m^2 per replicate. Two samples were taken in a faster flowing riffle area and a third in a slower run area at each station. A kick-net seine was also utilized at each station, but in a slower run/pool area. The kick-net was fitted with a 500-μm mesh size net, and sampled approximately a 1-m^2 area per replicate. For the pond and sediment ditch sites, collections were made via a Ponar grab sampler. The Ponar grab sampler has several features which make it a desirable choice for the collection of aquatic macroinvertebrates in lentic habitats such as ponds, lakes, as well as lotic deepwater habitats such as rivers. Sampler area was 81 $inch^2$ per replicate.

Three samples were taken near the shoreline, and in the best available spots (lowest siltation, highest percentage of gravel/pebble substrate, highest vegetation) at each station.

Samples were placed in 1-l plastic containers, preserved in 35% formalin, and returned to the laboratory for processing. Samples were then picked under Unitron™ microscopes and detrital material was discarded only after a second check to insure that no macroinvertebrates had been missed. All macroinvertebrates were identified to lowest practical taxonomic level and enumerated. Several benthic macroinvertebrate metrics were then calculated for each station.

SPECIFIC STATION LOCATIONS / PHYSICAL DESCRIPTIONS

Upstream Honey Branch Station (Toe of Valley Fill)

This station was located on Honey Branch approximately 70 feet downstream from the toe of the primary valley fill (Photographs 1 - 2). This station corresponded to the same location which was sampled during the SAIC 1998 study. Where the benthic samples were collected the substrate was comprised of approximately 50% bedrock, 25% cobble, 20% gravel, and 5% sand and silt. Average stream width was approximately 3 feet. Average depth was approximately 3 inches where the physical water quality was measured. Average flow was 0.15 cubic feet/second. In-the-field water quality measurements (Table 1A) were as follows: water temperature 13.36°C, Dissolved Oxygen (DO) 6.82 mg/l, pH 6.60, conductivity 400 μmhos. A very desirable amount of Coarse Particulate Organic Matter (CPOM) was present in the form of shredded and whole leaves, sticks, and some large woody debris increasing both the available substrate and the foodbase. The stream contained a fairly desirable ratio of pools, runs, and riffles. The deciduous forest canopy was partly shaded due to the fairly dense forest surrounding the stream. Surrounding vegetation consisted mostly of the trees. Streambanks were very well vegetated, but were steep and appeared to be moderately unstable.

Middle Honey Branch Station

This station (Photographs 3 - 4) was located on Honey Branch below the middle Honey Branch pond (Pond Number 2). This station corresponded to the same location which was sampled during the SAIC 1998 study. Where the benthic samples were collected the substrate was comprised of approximately 25% cobble, 50% gravel, and 25% sand and silt. Average stream width was approximately 3 feet. Average depth was approximately 3 inches where the physical water quality was measured. Average flow was 0.08 cubic feet/second. In-the-field water quality measurements (Table 1A) were as follows: water temperature 14.41°C, Dissolved Oxygen (DO) 7.74 mg/l, pH 7.91, conductivity 367 μmhos. There was a moderate amount of Coarse Particulate Organic Matter (CPOM) which was present in the form of shredded and whole leaves increasing both the available substrate and the foodbase. The stream contained a fairly desirable ratio of pools, runs, and riffles. The deciduous forest canopy was open because the surrounding forest was farther from the stream at this location. Surrounding vegetation consisted mostly of grasses and other herbaceous vegetation. Streambanks were very well vegetated, and were not steep and appeared to be very stable.

Mouth of Honey Branch

This station was located at the mouth of Honey Branch before it entered the East Fork of Twelvepole Creek. This station also corresponded to the same location which was sampled during the SAIC 1998 study. Where the benthic samples were collected the substrate was comprised of approximately 5% boulder, 55% cobble, 30% gravel, 5% sand, and 5% silt. Average stream width was approximately 2.5 feet. Average depth was approximately 2 inches where the physical water quality was measured. Average flow was 0.11 cubic feet/second. In-the-field water quality measurements (Table 1A) were as follows: water temperature 16.29°C, Dissolved Oxygen (DO) 6.64 mg/l, pH 7.92, conductivity 348 μmhos. There was a very desirable amount of Coarse Particulate

Organic Matter (CPOM) which was present in the form of shredded and whole leaves, sticks, and larger woody debris increasing both the available substrate and the foodbase. The stream contained a fairly desirable ratio of pools, runs, and riffles. The deciduous forest canopy was shaded due to the dense surrounding forest at this location. Surrounding vegetation consisted mostly of trees, but shrubs, grasses and other herbaceous vegetation was also present. Streambanks were moderately well vegetated, were somewhat steep, and appeared to be moderately stable.

Upstream East Fork of Twelvepole Creek

This station was located on Twelvepole Creek approximately 100 feet upstream from the confluence with Honey Branch. This station corresponded to the same location which was sampled during the SAIC 1998 study. Where the benthic samples were collected the substrate was comprised of approximately 40% cobble, 50% gravel, 5% sand, and 5% silt. Average stream width was approximately 25 feet. Average depth was approximately 4 inches where the physical water quality was measured. Average flow was 0.11 cubic feet/second. In-the-field water quality measurements (Table 1A) were as follows: water temperature 13.88°C, Dissolved Oxygen (DO) 4.69 mg/l, pH 7.16, conductivity 159 μmhos. There was a desirable amount of Coarse Particulate Organic Matter (CPOM) which was present mainly in the form of shredded and whole leaves increasing both the available substrate and the foodbase. The stream was comprised mostly of large pools and runs; riffle areas were scarce at this location. The deciduous forest canopy was partly shaded at this location. Surrounding vegetation consisted mostly of trees, but grasses and other herbaceous vegetation was also along the streambanks. Streambanks were moderately well vegetated, were undercut at places, but appeared to be moderately stable.

Downstream East Fork of Twelvepole Creek

This station was located on Twelvepole Creek approximately 100 feet downstream from the confluence with Honey Branch. Where the benthic samples were collected the substrate was comprised of approximately 5% boulder, 30% cobble, 50% gravel, 10% sand, and 5% silt. Average stream width was approximately 20 feet. Average depth was approximately 4 inches where the physical water quality was measured. Average flow was 0.21 cubic feet/second. In-the-field water quality measurements (Table 1A) were as follows: water temperature 14.77°C, Dissolved Oxygen (DO) 6.56 mg/l, pH 7.50, conductivity 212 μmhos. There was a desirable amount of Coarse Particulate Organic Matter (CPOM) which was present mainly in the form of shredded and whole leaves increasing both the available substrate and the foodbase. The stream was comprised of a fairly good ratio of pools, runs, and riffle areas at this location. The deciduous forest canopy was partly shaded at this location. Surrounding vegetation consisted mostly of trees, but grasses and other herbaceous vegetation was also along the streambanks. Streambanks were moderately well vegetated, were undercut at places, but appeared to be moderately stable.

Honey Branch's Middle Pond (Pond Number 2)

This station was located on Honey Branch, and was constructed in 1988 (Photograph 5). The pond has an area of approximately 0.53 acres. The existing water depth was about 4 feet. Due to the pond being over 10 years old, the banks were 100% vegetated, and this was with various grasses, rushes, sweet flag, woolgrass, golden rod, greenbrier, and alders. Aquatic vegetation was comprised of milfoil (Myriofyllum sp.), pondweed (Potamogeton sp.), and cattails. Fish were present, but not positively identified to species. The banks were not steep along one side, but were stable due to their overall steepness, heavy vegetation, and established soil properties. No signs of erosion were present. There was some pond cover present due to the closer distance from the surrounding deciduous forest, and from the heavy vegetation surrounding the shoreline areas. The substrate was comprised mostly of silt with large abundances of detrital material (Table 4B).

Honey Branch's Lower Pond (Pond Number 1)

This station was located on Honey Branch, and was also constructed in 1988 (Photograph 6). This large pond is approximately 500 feet in length, and is approximately 300 feet wide, and has an area of approximately 1.01 acres. The elevation of the pond's bottom is approximately 780 feet above sea level. The existing water depth was about 6 feet. Due to the pond being over 10 years old, the banks were 100% vegetated, and this was with various grasses, rushes, sedges, sweet flag, woolgrass, golden rod, greenbrier, alders, and willows. Aquatic vegetation was comprised of cattails. Fish and bullfrogs were present, but were not positively identified to species. The banks were only steep along one side, but were stable due to their heavy vegetation, and well established soils. No signs of erosion were present. There was some pond cover present due to the close distance from the surrounding deciduous forest, and from the heavy vegetation surrounding the shoreline areas. The substrate was comprised mostly of silt with very large abundances of detrital material (Table 4B).

Honey Branch Sediment Ditch

This station was located on Honey Branch, and was constructed in 1988 (Photographs 7 - 8). The sediment ditch is approximately 100 feet in length, is approximately 20 feet wide, and has an area of approximately 0.05 acres. The existing water depth was only about a foot. Because the sediment ditch was constructed over ten years ago, the banks were very well vegetated with grasses, sedges, autumn olive, alder, scarlet maple, and box elder. Aquatic vegetation consisted primarily of cattails. The banks were not too steep along the hillsides, and were noticeably stable due to their low gradient and heavy vegetation. Soils were very well established due to the older age of this structure. This sediment ditch had noticeably lower dissolved oxygen levels (Table 1B) probably due to the heavy organic loading at this site. There was some canopy cover present due to the young trees growing and from the surrounding cattails. The substrate was comprised almost entirely of heavily organic and detrital materials (Table 4B).

PHYSICAL AND CHEMICAL WATER QUALITY ANALYSIS

Physical and chemical water quality was analyzed at each of the three stations sampled on Honey Branch, the two stations sampled on the East Fork of Twelvepole Creek, two of the sediment ponds on Honey Branch, and in Honey Branch's sediment ditch (Figure 1). The physical and chemical water quality results are presented in Tables 1A and 1B. Most values determined in Honey Branch were fairly similar with desirable DO levels, adequate pH levels, desirable alkalinity, low acidity, and low concentrations of metals. However, the dissolved solids, hardness, and sulfates were elevated, but were not considered limiting. Of the stations on the East Fork of Twelvepole Creek, most values were similar and desirable with near neutral pH levels, lower conductivity, lower hardness and alkalinity, and lower solids than for the stations on Honey Branch. The downstream East Fork station had higher levels of most parameters compared to the upstream East Fork station, but this was entirely due to the influence of Honey Branch. No values on the East Fork of Twelvepole Creek were considered limiting to the aquatic fauna as each station contained many individuals comprised of several taxa which are sensitive to pollutants.

For the Honey Branch sediment ponds and sediment ditch, most of the chemical values such as dissolved solids, hardness, sulfates, alkalinity, and most metals were very similar to those determined in the main channel of Honey Branch. Although several of these values were considered elevated, none were considered too limiting to the aquatic fauna, and it should be remembered that one of the primary purposes of the ponds and sediment ditches is for reducing the high levels of solids and metals by settling them out prior to reaching the downstream portions of the receiving streams.

Based on these data, Honey Branch can be classified as a moderate fertility, high buffering capacity, hard-water stream within the areas sampled; the East Fork of Twelvepole Creek can be classified as moderate fertility, moderate buffering capacity, hard-water stream within the areas sampled.

HABITAT ASSESSMENT

Stream Parameters

Several habitat measurements were calculated (Table 4A) for each of the stations sampled on Honey Branch and the East Fork of Twelvepole Creek. The individual parameters are described below.

Parameter 1. Bottom Substrate - The availability of habitat for support of aquatic organisms. A variety of substrate materials and habitat types is desirable. The bottom substrate is evaluated and rated by observation.

Parameter 2. Embeddedness - The degree to which boulders, rubble, or gravel are surrounded by fine sediment indicates suitability of the stream substrate as habitat for benthic macroinvertebrates as well as for fish spawning and egg incubation. Embeddedness is evaluated by visual observation of the degree to which larger particles are surrounded by sediment.

Parameter 3. Stream Flow - Stream flow relates to the ability of a stream to provide and maintain a stable aquatic environment.

Parameter 4. Channel Alteration - The character of sediment deposits from upstream is an indication of the severity of watershed and bank erosion and stability of the stream system. Channelization decreases stream sinuosity, thereby increasing stream velocity and the potential for scouring.

Parameter 5. Bottom Scouring and Deposition - These parameters relate to the destruction of instream habitat resulting from channel alterations. Deposition and scouring is rated by estimating the percentage of an evaluated reach that is scoured or silted.

Parameter 6. Pool/Riffle or Run/Bend Ratio - These parameters assume that a stream with riffles or bends provides more diverse habitat than a straight or uniform depth stream. The ratio is calculated by dividing the average distance between riffles or bends by the average stream width.

Parameter 7. Bank Stability - Bank stability is rated by observing existing or potential detachment of soil from the upper and lower stream bank and its potential movement into the stream. Streams with poor banks will often have poor instream habitat.

Parameter 8. Bank Vegetative Stability - Bank soil is generally held in place by plant root systems. An estimate of the density of bank vegetation covering the bank provides an indication of bank stability and potential instream sedimentation.

Parameter 9. Streamside Cover - Streamside cover vegetation is evaluated in terms of provision of stream-shading and escape cover for fish. A rating is obtained by visually determining the dominant vegetation type covering the exposed stream bottom, bank, and top of bank. Riparian vegetation dominated by shrubs and trees provides the CPOM source in allochthonous systems.

Sediment Pond and Sediment Ditch Measurements

Several habitat measurements were also determined (Table 4B) at each of the Honey Branch pond and sediment ditch sites sampled. The individual parameters are described below.

Pond/Ditch Surface Acreage - Actual size of the structure in acres. Smaller, shallower ponds and ditches, may not last as long or have as much sediment holding potential, but they will have a larger wetland value as there is less open water and more wetland vegetated area.

Length x Width - Longer, narrower ponds and sediment ditches will eventually have better wetland values for filtering incoming waters and provide more useable habitat for aquatic insects than wider, deeper ponds and sediment ditches.

Accumulative Sediment Storage Potential - Amount of sediment the structure can potentially hold. Larger, deeper ponds and sediment ditches can obviously hold more sediments, but may not have as desirable “wetland” potential.

Bottom Substrate Type - The availability of habitat for support of aquatic organisms. A variety of substrate materials and habitat types is desirable. Substrates comprised of more gravel, pebble, and/or organic materials are more desirable than those comprised mostly of silt and clay.

Bank Stability - Bank stability is rated by observing existing or potential detachment of soil from the upper and lower banks and its potential movement into the structure. Ponds and ditches with poor banks will often have poor instream habitat.

Bank Vegetative Stability - Bank soil is generally held in place by plant root systems. An estimate of the density of bank vegetation covering the bank provides an indication of bank stability and potential instream sedimentation.

Vegetation Type - Describes the vegetation type present. Newer structure will likely have only grasses planted along banks. Older structures can have grasses, several herbaceous species, as well as shrubs and tree saplings. Wetland vegetation on newer structures may not be present, but can consist of several types of algae, submerged and emergent aquatic species at older, more established structure.

Pond/Ditch Cover - Cover vegetation is evaluated in terms of provision of shading and escape cover for fish. A rating is obtained by visually determining the dominant vegetation type covering the exposed pond bottom, bank, and top of bank. Riparian vegetation dominated by shrubs and trees provides the CPOM source in allochthonous systems.

HABITAT RESULTS

Upstream Honey Branch Station (Toe of Valley Fill)

This station received excellent substrate and instream cover (primary) ratings, good to excellent channel morphology (secondary) ratings, and fair to excellent riparian and bank structure (tertiary) ratings. Overall, this upstream station on Honey Branch contained more than adequate food sources, flows, excellent habitat and cover, but was slightly limited by bank stability and the lack of deeper pools (Table 4A).

Middle Honey Branch Station

This station received excellent substrate and instream cover (primary) ratings, good to excellent channel morphology (secondary) ratings, and fair to excellent riparian and bank structure (tertiary) ratings. Overall, this station on Honey Branch contained adequate food sources, fine flows, good cover and bank stability, but was limited by the lack of better streamside cover and deeper pools (Table 4A).

Downstream Honey Branch (Mouth of Honey Branch)

This station received good to excellent substrate and instream cover (primary) ratings, good to excellent channel morphology (secondary) ratings, and good riparian and bank structure (tertiary) ratings. Overall, this station located at the mouth of Honey Branch contained adequate food sources, but was limited by deposition, bank stability, and streamside cover (Table 4A).

Upstream East Fork of Twelvepole Creek

This station received fair to excellent substrate and instream cover (primary) ratings, fair to excellent channel morphology (secondary) ratings, and good riparian and bank structure (tertiary) ratings. Overall, this station above the confluence with Honey Branch contained good habitat and adequate food sources, but was severely limited by the lack of riffle areas, bank stability, and the lack of adequate streamside cover (Table 4A).

Downstream East Fork of Twelvepole Creek

This station received excellent substrate and instream cover (primary) ratings, good to excellent channel morphology (secondary) ratings, and good riparian and bank structure (tertiary) ratings. Overall, this station below the confluence with Honey Branch contained good habitat and adequate food sources, but was limited by deposition, bank stability, and the lack of adequate streamside cover (Table 4A).

Honey Branch's Middle Pond (Number 2)

This pond had a surface area of 0.53 acres and was approximately 150 feet long by 150 feet wide (Table 4B). Because it was completed many few years ago in 1988, banks were 100% vegetated, and with grasses, herbaceous plants, shrubs, saplings, and larger trees. The substrate was silty, detrital material. This structure has fairly good storage potential, and it should serve well as a sediment control pond. Because banks are stable, this structure will most likely remain an open water pond for quite some time. This structure has good wetland potential, and due to its larger size, may serve very well for waterfowl, fish, and amphibians.

Honey Branch's Lower Pond (Number 1)

This pond had a surface area of 1.01 acres, and was approximately 500 feet long by 300 feet wide (Table 4B). Because it was completed many few years ago in 1988, banks were 100% vegetated, and with grasses, herbaceous plants, shrubs, saplings, and larger trees. The substrate was silty, detrital material. This structure has fairly good storage potential, and it should serve well as a sediment control pond. Because banks are fairly stable, this structure will most likely remain an open water pond for quite some time. This structure has tremendous wetland potential, and due to its large size, should serve very well for waterfowl, fish, and amphibians. In addition, due to its placement and surrounding settings, this structure has a very high aesthetic value.

Honey Branch Sediment Ditch

This sediment ditch had a surface area of 0.05 acres, and was approximately 100 feet long by 20 feet wide (Table 4B). Because it was completed many few years ago in 1988, banks were 100% vegetated, and with grasses, herbaceous plants, shrubs, saplings, and larger trees. The substrate was heavily organic, detrital material. This structure has some storage potential, but appears to be close to reaching its full potential. This structure has good wetland potential, even though it was small in size.

DESCRIPTION OF BENTHIC MACROINVERTEBRATE METRICS

Several benthic macroinvertebrate measurements were calculated (Tables 3A and 3B) for each of the stations sampled on Honey Branch, the East Fork of Twelvepole Creek, the Honey Branch sediment ponds and the sediment ditch on Honey Branch. The individual metrics are described below.

Metric 1. Taxa Richness - Reflects the health of the community through a measurement of the variety of taxa present. Generally increases with increasing water quality, habitat diversity, and habitat suitability. However, the majority should be distributed in the pollution sensitive groups, a lesser amount in the facultative groups, and the least amount in the tolerant groups. Polluted streams shift to tolerant dominated communities.

Metric 2. Modified Hilsenhoff Biotic Index - This index was developed by Hilsenhoff (1987) to summarize overall pollution tolerance of the benthic arthropod community with a single value. Calculated by summarizing the number in a given taxa multiplied by its tolerance value, then divided by the total number of organisms in the sample.

Metric 3. Ratio of Scraper and Filtering Collector Functional Feeding Groups - This ratio reflects the riffle/run community foodbase and provides insight into the nature of potential disturbance factors. The relative abundance of scrapers and filtering collectors indicate the periphyton community composition, availability of suspended Fine Particulate Organic Material (FPOM) and availability of attachment sites for filtering. Filtering collectors are sensitive to toxicants bound to fine particles and should be the first group to decrease when exposed to steady sources of bound toxicants.

Metric 4. Ratio of Ephemeroptera, Plecoptera, Trichoptera (EPT) and Chironomidae Abundances - This metric uses relative abundance of these indicator groups as a measure of community balance. Good biotic condition is reflected in communities having a fairly even distribution among all four major groups and with substantial representation in the sensitive groups Ephemeroptera, Plecoptera, and Trichoptera. Skewed populations with large amounts of Chironomidae in relation to the EPT indicates environmental stress.

Metric 5. Percent Contribution of Dominant Family - This is also a measure of community balance. A community dominated by relatively few species would indicate environmental stress. A healthy community is dominated by pollution sensitive representation in the Ephemeroptera, Plecoptera, and Trichoptera groups.

Metric 6. EPT Index - This index is the total number of distinct taxa within the Orders: Ephemeroptera, Plecoptera, and Trichoptera. The EPT Index generally increases with increasing water quality. The EPT index summarizes the taxa richness within the pollution sensitive insect orders.

Metric 7. Ratio of Shredder Functional Feeding Group and Total Number of Individuals Collected - Allows evaluation of potential impairment as indicated by the shredder community. Shredders are good indicators of riparian zone impacts.

Metric 8. Simpson's Diversity Index - This index ranges from 0 (low diversity) to almost 1 (high diversity). A healthy benthic macroinvertebrate community should have a higher Simpson's Diversity Index.

Metric 9. Shannon-Wiener Diversity Index - Measures the amount of order in the community by using the number of species and the number of individuals in each species. The value increases with the number of species in the community. A healthy benthic macroinvertebrate community should have a higher Shannon-Wiener Diversity Index.

Metric 10. Shannon-Wiener Evenness - Measures the evenness, or equitability of the community by scaling one of the heterogeneity measures relative to its maximal value when each species in the sample is represented by the same number of individuals. Ranges from 0 (low equitability) to 1 (high equitability).

BENTHIC MACROINVERTEBRATE RESULTS

Upstream Honey Branch Station (Toe of Valley Fill)

A total of 626 individuals comprising 22 taxa were collected (Tables 2A and 5). Five pollution sensitive (intolerant) taxa comprising 6.9% of the station's abundance were present. The sensitive mayfly Leptophlebia (Family: Leptophlebiidae) contributed 5.4% to the total abundance at this upstream station. Nine facultative (intermediate tolerance) taxa were present comprising 7.2% of the station's total abundance. The facultative springtail Collembola contributed 3.4% to the total abundance. Eight tolerant taxa were present comprising 85.9% of the abundance at this station. The tolerant aquatic worm, Oligochaeta, accounted for 51.1% of the total abundance, and was the most abundant taxa present at this station on Honey Branch. Ten EPT groups (Table 3A) were present which aided the EPT:Chironomidae Index in being fairly desirable. All functional feeding groups were present and were fairly well represented at this station. A very wide variety of stoneflies and caddisflies were collected at this station; mayflies were less abundant. The Simpson's and Shannon-Wiener Diversity indices reflected a moderately diverse community; the Shannon-Wiener Evenness value of 0.52 indicated that abundances were only moderately distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a moderately healthy, but pollution tolerant macroinvertebrate community with a fairly good periphyton community composition.

Middle Honey Branch Station

A total of 558 individuals comprising 21 taxa were collected (Tables 2A and 6). Five pollution sensitive (intolerant) taxa comprising 18.3% of the station's abundance were present. The sensitive beetle Family: Elmidae contributed 14.0% to the total abundance at this Honey Branch station. Eight facultative (intermediate tolerance) taxa were present comprising 22.9% of the sample. The facultative stonefly Leuctra (Family: Leuctridae) contributed 10.0% to the total abundance. Eight tolerant taxa were present comprising 58.8% of the abundance at this station. Again, the tolerant aquatic worm, Oligochaeta, accounted for 30.0% of the total abundance, and was the most abundant taxa at this station on Honey Branch. Eight EPT groups (Table 3A) were present which contributed to the EPT:Chironomidae Index in being very desirable. All functional feeding groups were present and were very well represented. A wide variety of stoneflies and caddisflies were collected at this station; mayfly population was again low. The Simpson's and Shannon-Wiener Diversity indices reflected a very diverse community, and the Shannon-Wiener Evenness indicated that abundances were moderately well distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a more balanced and less tolerant community than the upstream station.

Downstream Honey Branch Station (Mouth of Honey Branch)

A total of 306 individuals comprising 19 taxa were collected (Tables 2A and 7). Five pollution sensitive (intolerant) taxa comprising 10.8% of the station's abundance were present. The sensitive caddisfly Family: Philopotamiidae contributed 5.2% to the total abundance at this station. Seven facultative (intermediate tolerance) taxa were present comprising 20.6% of the sample. The facultative caddisfly Family: Hydropsychidae accounted for 8.5% of the station's abundance. Seven tolerant taxa were present comprising 68.6% of the abundance at this station at the Mouth of Honey Branch. The tolerant midge, Chironomidae, accounted for 28.1% of the total abundance, and was the most abundant taxa of aquatic insect present. Nine EPT groups (Table 3A) were present which again aided the EPT:Chironomidae Index in being very desirable. All functional feeding groups were present and were well represented. A wide variety of mayflies, stoneflies, and caddisflies were collected at this station. The Simpson's and Shannon-Wiener Diversity Indices reflected a community moderately-high in diversity, and the Shannon-Wiener Evenness indicated that abundances were well distributed among the taxa, or heterogeneous. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a pollution tolerant, but healthy macroinvertebrate community with a very good periphyton community composition.

Upstream East Fork of Twelvepole Creek

A total of 1,800 individuals comprising 18 taxa were collected (Tables 2A and 8). Five pollution sensitive (intolerant) taxa comprising 37.6% of the station's abundance were present. The sensitive beetle Family: Elmidae contributed 15.8% to the total abundance at this station on the East Fork of Twelvepole Creek. Nine facultative (intermediate tolerance) taxa were present comprising 17.8% of the sample. The facultative mayfly Isonychia (Family: Oligoneuridae) accounted for 5.8% of the station's abundance, and was a significant contributor to the station. Four tolerant taxa were present comprising 44.7% of the abundance at this station above the confluence with Honey Branch. The tolerant midge, Chironomidae, accounted for 27.6% of the total abundance, and was once again the most abundant Family of aquatic insect present. Ten EPT groups (Table 3A) were present which again aided the EPT:Chironomidae Index in being very desirable. All functional feeding groups were present and were very well represented. Again, a wide variety of mayflies, stoneflies, and caddisflies were collected at this station. The Simpson's and Shannon-Wiener Diversity Indices reflected a community moderately-high in diversity; the Shannon-Wiener Evenness indicated that abundances were moderately well distributed among the taxa, or heterogeneous. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a slightly unbalanced, but healthy macroinvertebrate community.

Downstream East Fork of Twelvepole Creek

A total of 1,244 individuals comprising 14 taxa were collected (Tables 2A and 9). Five pollution sensitive (intolerant) taxa comprising 31.8% of the station's abundance were present. The sensitive mayfly Stenonema (Family: Heptageniidae) contributed 10.5% to the total abundance at this station on the East Fork of Twelvepole Creek. Only two facultative (intermediate tolerance) taxa were present comprising 3.5% of the sample. The facultative caddisfly Family: Hydropsychidae accounted for 2.6% of the station's abundance. Seven tolerant taxa were present comprising 64.7% of the abundance at this station below the confluence with Honey Branch. The tolerant midge, Chironomidae, accounted for 53.4% of the total abundance, and was once again the most abundant Family of aquatic insect present. Five EPT groups (Table 3A) were present which again aided the EPT:Chironomidae Index in being moderately desirable. All functional feeding groups were present and were very well represented. A wide variety of mayflies were collected at this station; stoneflies and caddisflies were not very well represented. The Simpson's and Shannon-Wiener Diversity Indices reflected a community with moderate diversity; the Shannon-Wiener Evenness indicated that abundances were moderately distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a somewhat unbalanced, but fairly healthy macroinvertebrate community.

Honey Branch's Middle Pond (Number 2)

A total of 2,720 individuals comprising 9 taxa were collected (Tables 2B and 10). Only one pollution sensitive (intolerant) taxa was present, the mayfly, Ephemera (Family: Ephemeridae), which contributed 1.2% to the total abundance of this pond. Two facultative (intermediate tolerance) taxa were present comprising 7.1% of the sample. The facultative mayfly Baetis (Family: Baetidae) accounted for 4.7% of the site's abundance, and was a significant component to the site's community. Six tolerant taxa were present comprising 91.7% of the abundance at this site. The tolerant midge, Chironomidae, accounted for 55.9% of the total abundance, and was the most abundant taxa at this middle sediment pond on Honey Branch. Three EPT groups (Table 3B) were present which contributed to the EPT:Chironomidae Index in being fairly desirable. Again, no scrapers or collector/filterers were present, however, a moderate variety of mayflies were collected at this station. The Simpson's and Shannon-Wiener Diversity indices reflected a community moderately-low in diversity, and the Shannon-Wiener Evenness indicated that abundances were moderately distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a very pollution tolerant benthic macroinvertebrate community.

Honey Branch's Lower Pond (Number 1)

A total of 1,392 individuals comprising 8 taxa were collected (Tables 2B and 11). No pollution sensitive (intolerant) taxa were present. Three facultative (intermediate tolerance) taxa were present comprising 13.8% of the sample. The facultative mayfly Caenis (Family: Caenidae) accounted for 9.2% of the site's abundance, and was a significant component to the site's community. Five tolerant taxa were present comprising 86.2% of the abundance at this site. The tolerant midge, Chironomidae, accounted for 49.4% of the total abundance, and was the most abundant taxa at this lower sediment control pond on Honey Branch. One EPT group (Table 3B) was present which helped to contribute to the EPT:Chironomidae Index. Again, no scrapers or collector/filterers were present. Not a wide variety of mayflies were collected at this station (Caenis was the only taxa). The Simpson's and Shannon-Wiener Diversity indices reflected a community moderately-low in diversity, and the Shannon-Wiener Evenness indicated that abundances were moderately distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a very pollution tolerant benthic macroinvertebrate community.

Honey Branch's Sediment Ditch

A total of 2,192 individuals comprising 8 taxa were collected (Tables 2B and 12). Only one pollution sensitive (intolerant) taxa was present, the beetle, Peltodytes (Family: Haliplidae), which contributed 1.6% to the total abundance of this sediment ditch. Two facultative (intermediate tolerance) taxa were present comprising 13.1% of the sample. The facultative mayfly Baetis (Family: Baetidae) accounted for 12.4% of the site's abundance, and was a significant component to the site's community. Five tolerant taxa were present comprising 85.3% of the abundance at this site. The tolerant midge, Chironomidae, accounted for 37.2% of the total abundance, and was the most abundant taxa at this sediment ditch on Honey Branch. One EPT group (Table 3B) was present which contributed to the EPT:Chironomidae Index in being fairly desirable. Again, no scrapers or collector/filterers were present, and only the one taxa of mayflies was collected at this station. The Simpson's and Shannon-Wiener Diversity indices reflected a community with moderate diversity, and the Shannon-Wiener Evenness indicated that abundances were moderately-well distributed among the taxa. The Modified Hilsenhoff Biotic Index (HBI) and the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) indicated a pollution tolerant/facultative benthic macroinvertebrate community.

DISCUSSION

One-way analysis of variance (ANOVA) comparing the abundances of aquatic macroinvertebrates between the three stations sampled on Honey Branch concluded that abundances between the three sites were not statistically significantly ($\propto = 0.05$) different (F value = 1.82). In addition, a one-way ANOVA comparing the number of taxa of aquatic macroinvertebrates between the three stations on Honey Branch also concluded that there was no significant difference in the number of taxa collected between the three stations.

When comparing total abundances between these three stations sampled on Honey Branch (Table 2A), it is somewhat apparent that differences exist. As stated previously, these differences were not statistically different. The Upstream Station (Toe of the Valley Fill) contained the largest total abundance as well as a couple more taxa than the Middle and Downstream (Mouth) Stations. Habitat (Table 4A) was very generally excellent and also very similar between the three Honey Branch sites with the exception of bank stability and streamside cover, but these parameters were not limiting to the aquatic fauna. Water chemistry (Table 1A) was overall fairly desirable, but the stations on Honey Branch did have elevated levels of sulfates, hardness, dissolved solids, and some metals, although these levels were not considered too limiting as several sensitive taxa comprised of many individuals were collected. Influence from the sediment ponds located on Honey Branch was also not limiting to the stream macroinvertebrate populations as the Upstream Honey Branch station (above the sediment ponds) did not have significantly more desirable aquatic insect populations than the Downstream Honey Branch station which was located below all sediment ponds and valley fills. The Downstream site did have lower total abundances of aquatic insects, but percentages of sensitive and facultative groups actually increased at the downstream station compared to the upstream station. It is also very interesting to note that the total disturbed area of the Honey Branch watershed is 261.69 acres or 43% of the total watershed area. Because this is now considered to be a high percentage of total disturbed area within a watershed, one would expect that the Honey Branch stream stations would have had poorer macroinvertebrate communities. However, the three stations located on Honey Branch contained relatively healthy populations of aquatic insects. This is based on the macroinvertebrate data which depicted that many individuals were collected from a very large number of taxa. Samples were comprised of many EPT groups and individuals (Table 3A), and all functional feeding groups were present and were generally well represented. It is obvious that the loss of a portion of the headwater area of Honey Branch from valley fills has not eliminated nor negatively affected the macroinvertebrate community downstream as originally believed.

One-way analysis of variance (ANOVA) comparing the abundances of aquatic macroinvertebrates between the two stations sampled on the East Fork of Twelvepole Creek concluded that abundances between the two sites were not statistically significantly ($\propto = 0.05$) different (F value = 1.06). In addition, a one-way ANOVA comparing the number of taxa of aquatic macroinvertebrates between the two stations also concluded that there was no significant difference in the number of taxa collected between the two sites on the East Fork of Twelvepole Creek. This observation is crucial, because it exemplifies that the discharge from Honey Branch is not having a negative impact on the aquatic insect abundances located on the East Fork of Twelvepole Creek.

When comparing total abundances and taxa between these two stations sampled on the East Fork of Twelvepole Creek (Table 2A), one can observe that a few differences exist. As stated previously, these differences were not statistically different. From the water chemistry data (Table 1A), one can observe that overall water quality at both the East Fork of Twelvepole Creek's stations was desirable with near neutral pH levels, desirable alkalinity, and low conductivity, acidity, hardness, solids, sulfates, and most metals. In general, the downstream station on the East Fork of Twelvepole Creek had higher levels of most chemical constituents, but none were considered limiting to the aquatic fauna. These higher levels was obviously from the discharge of Honey Branch. From the habitat data (Table 4A), the downstream station on the East Fork had more desirable substrates as well as a better representation of riffle areas. There was, however, a shift in the community from one comprised of fairly equal percentages of sensitive and tolerant individuals at the upstream station, to one comprised of many more tolerant than sensitive individuals at the downstream station. This shift is undoubtably a factor of the water chemistry from Honey Branch. Although total abundances and total taxa are not significantly affected from the discharge, the water chemistry is affecting the composition of the macroinvertebrate community downstream. Nevertheless, both of the East Fork of Twelvepole Creek stations were considered healthy because they were comprised of a large number of taxa consisting of large abundances of aquatic insects. They both contained large numbers of sensitive individuals from several taxa. Both stations also contained wide varieties and large abundances of mayflies, stoneflies, and caddisflies (Table 3A).

The two stations located on the East Fork of Twelvepole Creek were not statistically compared to the stations located on Honey Branch because the streams represent different order (size) streams (the East Fork of Twelvepole Creek is at least 3rd order at the confluence with Honey Branch; Honey Branch is 1st order). With different order or stream sizes comes automatic differences in habitat (Table 4A), water quality/chemistry (Table 1A), and benthic macroinvertebrate communities (Table 2A).

The two ponds studied on Honey Branch (Pond Number 2 and Pond Number 1) contained large and low total numbers of aquatic insects, respectively. They both, however, contained relatively low numbers of taxa even though they were the older, more established structures (completion dates in 1988). This may have been due to the somewhat high pH levels, the more alkaline waters, or the elevated sulfates, magnesium, and/or chloride levels. The sediment ditch on Honey Branch contained a relatively large abundance of aquatic insects as well as a moderate number of taxa. No single chemical parameter or habitat parameter appeared limiting with the exception of the low dissolved oxygen level of 2.57 (Table 1B).

In general, the ponds and sediment control ditch on Honey Branch were well represented by the groups of aquatic insects which are normally present in these lentic type habitats. The functional feeding groups scrapers and collector/filterers were not present (Table 3B), but this was not surprising since scrapers need silt-free environments for them to feed on the periphyton that attaches to rock substrates, and since the collector/filterers require faster-moving water in order to feed on the small particles of food which collected on constructed silken nets or on hairs on their bodies. The shredder functional feeding group (those that shred and consume leaves and other detrital materials) was also not well represented, but this group is also considered to be sensitive to disturbances and pollution. Generally, the sites were comprised mostly of tolerant organisms such as midges, dragonflies, and aquatic worms (Table 2B). As stated previously, this was to be expected, and was representative of aquatic insects which thrive in pond-type habitats.

If constructed properly, these sediment control ponds and sediment ditches can do a splendid job in removing solids and other water contaminants both by filtration and by precipitation prior to reaching downstream areas. They also provide aquatic habitats for countless abundances of aquatic insects, amphibians, reptiles, waterfowl, terrestrial wildlife, and potentially even fish. It should be pointed out that prior to mining, there was very little wetland habitat available on Honey Branch. Now, with the construction of the three sediment control ponds and the sediment ditch, several acres of open water as well as the subsequent wetland areas surrounding each pond and the sediment ditch have been added to the area. In addition, prior to mining, Honey Branch consisted of about 1,500 feet of intermittent stream. Now, there is approximately 1-2 miles of drainage ditches and main stream channel present, and but with the ponds available, total water surface area is considerably greater. The ponds studied for this report, undoubtably, provide an additional facet to the aquatic and semi-aquatic fauna currently found in area.

These sedimentation ponds can easily be converted into aesthetic, attractive, and usable wildlife features with very few modifications. For example, trees felled into the pond add both food and habitat for many species of aquatic insects. Additional structures can be placed in the ponds to provide hiding habitat for lentic fish species such as sunfish and bass. These structures also provide a refuge for both fish and insects, act as a breeding ground for many species of insects as well as some fish. Although prohibited from planting permanent, larger-growing vegetation such as trees around structures which are considered temporary, changes in management design could take place if these structures were to be considered as a permanent, and additional habitat for the area. Tall grasses, shrubs, and willow saplings, as well as larger trees could then be planted surrounding the pond to provide both a food source from fallen leaves/sticks and shade along shoreline areas.

If one compares this study to the previous conducted studies, several comparisons can be made. At the Upstream Honey Branch site (Toe of the Valley fill), during the SAIC Study (1998), only 41 organisms were collected from six taxa. Twenty-nine were isopods, leaving only 12 listed as being in the Class Insecta. There were seven EPT individuals from two taxa. During the Heer, Inc. sampling (1987), only six organisms from four taxa were collected. There were no common taxa present between the 1987 or 1998 studies. From Table 2A, during the current study, there were 626 individuals from 22 taxa collected. At the Middle Honey Branch site, during the SAIC Study, 172 individuals from 14 taxa (6 EPT taxa) were collected. During the Heer, Inc. Study, no organisms were collected at this site. From Table 2A, there were 558 individuals from 21 taxa (8 EPT taxa) collected. At the Downstream Honey Branch site (Mouth of Honey Branch), during the 1998 SAIC Study, 154 individuals from eleven taxa (4 EPT taxa) were collected. During the 1987 Heer, Inc. Study, 22 individuals from seven taxa (4 EPT taxa) were collected at the mouth of Honey Branch. During the current study, 306 individuals from 19 taxa (including 9 EPT taxa) were collected (Tables 2A and 3A). At the Downstream East Fork of Twelvepole Creek station, during the SAIC Study, 154 individuals from 16 taxa (9 EPT taxa) were collected. During the Heer, Inc. Study, 15 organisms from 6 taxa (1 EPT taxa) were collected. From this current study, 1,244 individuals from 14 taxa (5 EPT taxa) were collected at the downstream station on the East Fork of Twelvepole Creek.

Presumably, no upstream station on the East Fork of Twelvepole Creek was sampled during the SAIC and the Heer, Inc. Studies. Therefore, no determination on possible effects on East Fork's downstream station from Honey Branch's discharge could not be made. From the water chemistry data from the SAIC Study, iron levels are very similar; manganese levels have increased at the Upstream and Middle Honey Branch sites; TSS levels are similar; chloride levels are similar on Honey Branch, but have increased on the East Fork of Twelvepole Creek; magnesium levels are similar on Honey Branch, but have increased on the East Fork of Twelvepole Creek; calcium levels are similar on Honey Branch, but have increased on the East Fork of Twelvepole Creek; and sodium levels have increased at all sites. Most of these increases are most likely not significant, and are believed to be non-limiting as overall benthic macroinvertebrate results have become more desirable since the 1998 study. Even though overall tolerance levels determined for the current study depict more tolerant communities at each site than depicted from the previous studies, caution should be used here since the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) were based on much smaller total numbers of individuals and very few taxa.

CONCLUSIONS

Influence from the sediment ponds located on Honey Branch was also not limiting to the stream macroinvertebrate populations as the Upstream Honey Branch station (above the sediment ponds) did not have significantly more desirable aquatic insect populations than the Downstream Honey Branch station which was located below all sediment ponds and valley fills. The Downstream site did have lower total abundances of aquatic insects, but percentages of sensitive and facultative groups actually increased at the downstream station compared to the upstream station. It is also very interesting to note that the total disturbed area of the Honey Branch watershed is 261.69 acres or 43% of the total watershed area. Because this is now considered to be a high percentage of total disturbed area within a watershed, one would expect that the Honey Branch stream stations would have had poorer macroinvertebrate communities. However, the three stations located on Honey Branch contained relatively healthy populations of aquatic insects. This is based on the macroinvertebrate data which depicted that many individuals were collected from a very large number of taxa. The stations contained a wide variety of stoneflies, mayflies, and caddisflies, and were represented by all functional feeding groups. Of the physical and chemical water quality parameters analyzed at the Honey Branch locations, none were considered too limiting, although several were considered to be elevated. Food inputs were readily available, and habitat was considered excellent at each location due to the surrounding forest, which obviously contributed to the desirable aquatic macroinvertebrate communities inhabiting Honey Branch. It is obvious that the loss of a portion of the headwater area of Honey Branch from valley fills has not eliminated nor negatively affected the macroinvertebrate community downstream as originally believed.

Overall, the benthic macroinvertebrate populations found at the two stations located on the East Fork of Twelvepole Creek were considered to be healthy because they were comprised of communities containing a very wide variety of taxa and very large abundances of individuals. They also were comprised of many sensitive and facultative individuals represented by several taxa. Both stations contained a wide variety of mayflies; stoneflies and caddisflies were less represented at the downstream East Fork station. All functional feeding groups were present and were well represented at both stations. Of the physical and chemical water quality parameters analyzed at both locations, none were considered limiting, although the effects from Honey Branch entering the East Fork of Twelvepole Creek were observable in the water chemistry data. There was also a shift towards a more tolerant community at the downstream East Fork station. Nevertheless, both stations contained desirable benthic macroinvertebrate communities which was a result of the good water quality, desirable habitat, and available food inputs.

In general, the ponds and sediment control ditch on Honey Branch were well represented by the groups of aquatic insects which are normally present in these lentic type habitats. The functional feeding groups scrapers and collector/filterers were not present, but this was not surprising since scrapers need silt-free environments for them to feed on the periphyton that attaches to rock substrates, and since the collector/filterers require faster-moving water in order to feed on the small particles of food which collected on constructed silken nets or on hairs on their bodies. The shredder functional feeding group (those that shred and consume leaves and other detrital materials) was also not well represented, but this group is also considered to be sensitive to disturbances and pollution. Generally, the sites were comprised mostly of tolerant organisms such as midges, dragonflies, and aquatic worms. As stated previously, this was to be expected, and was representative of aquatic insects which thrive in pond-type habitats.

Much greater abundances as well as more taxa of aquatic insects were collected during this study compared to previous studies conducted at the same locations. Some of the levels of water chemistry constituents have remained similar; others have increased, but not to limiting levels, and mostly on the East Fork of Twelvepole Creek. Some shifts towards more tolerant communities may have occurred since the previous studies, but caution should be used since the relative percentages of the three tolerance groups (sensitive, facultative, and tolerant) were based on much smaller total numbers of individuals and very few taxa.

APPENDIX B

TABLE 1A. Physical and chemical water-quality variables for stream stations on Honey Branch and on Twelvepole Creek, above and below confluence with Honey Branch, 08 October 1999.

PARAMETER	Upstream Honey Branch	Midstream Honey Branch	Mouth Honey Branch	Upstream Twelvepole Creek	Downstream Twelvepole Creek
Flow (ft^3/s)	0.15	0.08	0.11	0.11	0.21
Temperature ($^\circ$C)	13.36	14.41	16.29	13.88	14.77
Dissolved Oxygen (mg/l)	6.82	7.74	6.64	4.69	6.56
pH (SI units)	6.60	7.91	7.92	7.16	7.50
Conductivity (μmhos)	400	367	348	159	212
Acidity (mg/l)	<1.0	<1.0	<1.0	<1.0	<1.0
Alkalinity (mg/l)	138	126	123	85.1	93.7
Chloride (mg/l)	3.5	3.8	3.5	12.0	9.3
Hardness (mg/l)	303	284	267	87	137
Sulfate (mg/l)	188	167	152	28.2	66.3
TDS (mg/l)	412	418	358	166	218
TSS (mg/l)	3	2	3	14	6
Fecal Coliform (#/100ml)	23	14	4	150	110
Aluminum (mg/l)	0.109	0.116	0.076	0.130	0.102
Antimony (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (mg/l)	0.002	<0.002	<0.002	0.003	<0.002
Barium (mg/l)	0.033	0.030	0.040	0.045	0.043
Beryllium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium (mg/l)	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Calcium (mg/l)	53.4	49.6	48.1	20.9	28.9
Chromium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005
Iron (mg/l)	0.370	0.358	0.060	0.481	0.316
Lead (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002
Magnesium (mg/l)	41.2	38.8	35.7	8.46	15.7
Manganese (mg/l)	0.255	0.139	0.026	0.068	0.046
Mercury (mg/l)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nickel (mg/l)	<0.030	<0.030	<0.030	<0.030	<0.030
Selenium (mg/l)	<0.003	<0.003	<0.003	<0.003	<0.003
Silver (mg/l)	<0.004	<0.004	<0.004	<0.004	<0.004
Sodium (mg/l)	7.86	7.35	6.88	10.7	9.95
Thallium (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (mg/l)	0.004	0.009	0.003	0.016	<0.002

TABLE 1B. Physical and chemical water-quality variables for Honey Branch sediment control ponds and ditch, 08 October 1999.

PARAMETER	Middle Honey Branch Pond (1988)	Lower Honey Branch Pond (1988)	Honey Branch Sediment Ditch (1988)
Temperature (°C)	11.83	16.71	11.29
Dissolved Oxygen (mg/l)	10.34	7.25	2.57
BOD (mg/l)	<2	<2	3
pH (SI units)	8.19	7.87	6.67
Conductivity (μmhos)	357	342	450
Acidity (mg/l)	<1.0	<1.0	<1.0
Alkalinity (mg/l)	122	121	94.6
Chloride (mg/l)	3.9	3.8	2.4
Hardness (mg/l)	280	268	349
Sulfate (mg/l)	167	161	274
TDS (mg/l)	324	381	501
TSS (mg/l)	3	<1	11
Fecal Coliform (#/100ml)	105	6	9
Aluminum (mg/l)	0.064	0.125	0.070
Antimony (mg/l)	<0.001	<0.001	<0.001
Arsenic (mg/l)	<0.002	<0.002	<0.002
Barium (mg/l)	0.028	0.035	0.019
Beryllium (mg/l)	<0.001	<0.001	<0.001
Cadmium (mg/l)	<0.0003	<0.0003	<0.0003
Calcium (mg/l)	49.1	47.3	68.2
Chromium (mg/l)	<0.001	<0.001	<0.001
Copper (mg/l)	<0.005	0.012	<0.005
Iron (mg/l)	0.307	0.275	0.130
Lead (mg/l)	<0.002	<0.002	<0.002
Magnesium (mg/l)	38.3	36.3	43.4
Manganese (mg/l)	0.154	0.126	0.165
Mercury (mg/l)	<0.0002	<0.0002	<0.0002
Nickel (mg/l)	<0.030	<0.030	<0.030
Selenium (mg/l)	<0.003	<0.003	<0.003
Silver (mg/l)	<0.004	<0.004	<0.004
Sodium (mg/l)	8.06	7.78	8.98
Thallium (mg/l)	<0.001	<0.001	<0.001
Zinc (mg/l)	<0.002	0.010	0.002

TABLE 2A. Total abundances of benthic macroinvertebrates collected via Surber and Kick-net samples from stream stations on Honey Branch and Twelvepole Creek, above and below confluence with Honey Branch, 08 October 1999.

TAXON	STATION Upstream Honey Branch	Midstream Honey Branch	Mouth Honey Branch	Upstream Twelvepole Creek	Downstream Twelvepole Creek
Insecta					
Ephemeroptera (Mayflies)					
Ameletidae					
Ameletus (F)		8	12		
Baetidae					
Baetis (F)				36	
Baetiscidae					
Baetisca (S)				68	126
Caenidae					
Caenis (S)				76	30
Ephemerellidae					
Ephemerella (F)			2	12	
Heptageniidae					
Stenonema (S)			1	244	130
Leptophlebiidae					
Leptophlebia (S)	34				
Oligoneuridae					
Isonychia (F)				104	
Plecoptera (Stoneflies)					
Capniidae (S)			2		8
Chloroperlidae (S)	4	4	6		
Leuctridae					
Leuctra (F)	2	56	4	36	
Perlidae (S)	1				
Perlodidae (F)	3	12			
Taeniopterygidae (F)	2			16	
Trichoptera (Caddisflies)					
Hydropsychidae (F)	2	26	26	88	32
Lepidostomatidae					
Lepidostoma (S)	2				
Limnephilidae (F)		4			
Philopotamiidae (S)		16	16		
Polycentropodidae (F)	8	4	2		
Rhyacophilidae (F)	4			4	

TABLE 2A. Continued.

TAXON	STATION Upstream Honey Branch	Midstream Honey Branch	Mouth Honey Branch	Upstream Twelvepole Creek	Downstream Twelvepole Creek
Diptera (True Flies)					
Ceratopogonidae (T)	38	8		28	24
Chaoboridae (T)		2			
Chironomidae (T)	148	148	86	496	664
Simuliidae (F)		4		20	
Stratiomyidae (T)		2			
Tabanidae (T)	8				
Tipulidae					
Dicranota (T)		2			
Hexatoma (T)	16			4	
Tipula (T)		2	4		2
Coleoptera (Beetles)					
Elmidae (S)	1	78	8	284	102
Psephenidae (S)				4	
Saldidae (S)	1	2			
Hemiptera (Water Bugs)					
Corixidae (T)	2				
Odonata (Dragonflies)					
Coenagrionidae (T)_					2
Cordulegastridae					
Cordulegaster (T)					5
Gomphidae (T)	2		13		
Hagenius (T)			16		
Lanthus (T)			20		
Megaloptera (Hellgrammites)					
Corydalidae					
Corydalus (S)		2			
Collembola (Springtails) (F)	22	2	2		
Oligochaeta (Aquatic Worms) (T)	320	156	69	276	104
Planaridae (Flatworms) (T)	4	8	2		4
Crayfish (F)	2	12	15	4	11

TABLE 2A. Continued.

TAXON	Upstream Honey Branch	Midstream Honey Branch	STATION Mouth Honey Branch	Upstream Twelvepole Creek	Downstream Twelvepole Creek
salamander larvae* (U)	1				
clams* (U)				16	16
snails* (U)				4	
Johnny darter* (U)				1	
Total Individuals	626	558	306	1,800	1,244
Taxa	22	21	19	18	14
Sensitive Ind. (%)	43 (6.9)	102 (18.3)	33 (10.8)	676 (37.6)	396 (31.8)
Sensitive Taxa	5	5	5	5	5
Facultative Ind. (%)	45 (7.2)	128 (22.9)	63 (20.6)	320 (17.8)	43 (3.5)
Facultative Taxa	9	8	7	9	2
Tolerant Ind. (%)	538 (85.9)	328 (58.8)	210 (68.6)	804 (44.7)	805 (64.7)
Tolerant Taxa	8	8	7	4	7

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive   (F) = Facultative   (T) = Tolerant   (U) = Unclassified

TABLE 2B. Total abundances of benthic macroinvertebrates collected via Ponar grab samples taken from Honey Branch sediment control ponds and sediment ditch at the Pen Coal Corporation, 08 October 1999.

TAXON	Middle Honey Branch Pond (1988)	Lower Honey Branch Pond (1988)	Honey Branch Sediment Ditch (1988)
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Baetis (F)	128		272
Caenidae			
Caenis (F)	64	128	
Ephemeridae			
Hexagenia (S)	32		
Diptera (True Flies)			
Ceratopogonidae (T)	624	384	800
Chironomidae (T)	1520	688	816
Tipulidae			
Tipula (T)	32		
Coleoptera (Beetles)			
Dytiscidae (T)			16
Haliplidae			
Peltodytes (T)			32
Odonata (Dragonflies)			
Coenagrionidae (T)	16	16	48
Corduliidae			
Cordulia (T)	16	16	
Collembola (F)		48	16
Oligochaeta (Aquatic worms) (T)	288	96	192
Crayfish (F)		16	
clams* (U)	16	208	
Total Individuals	2,720	1,392	2,192
Total Taxa	9	8	8

TABLE 2B. Continued

	Middle Honey Branch Pond (1988)	Lower Honey Branch Pond (1988)	Honey Branch Sediment Ditch (1988)
Sensitive Ind. (%)	32 (1.2)	0 (0.0)	32 (1.6)
Number of Taxa	1	0	1
Facultative Ind. (%)	192 (7.1)	192 (13.8)	288 (13.1)
Number of Taxa	2	3	2
Tolerant Ind. (%)	2,496 (91.7)	1,200 (86.2)	1,872 (85.3)
Number of Taxa	6	5	5

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 3A. Selected benthic macroinvertebrate metrics for stations on Honey Branch and stations on Twelvepole Creek, above and below confluence with Honey Branch, 08 October 1999.

METRIC	Upstream Honey Branch	Midstream Honey Branch	Mouth Honey Branch	Upstream Twelvepole Creek	Downstream Twelvepole Creek
Taxa Richness	22	21	19	18	14
Modified Hilsenhoff Biotic Index	5.46	4.77	4.57	4.76	5.26
Ratio of Scrapers to Collector/Filterers	2:2	80:46	9:42	532:212	232:32
Ratio of EPT:Chironomidae	62:148	130:148	71:86	684:496	326:664
% Contribution of Dominant Family	51.1% Oligochaeta	30.0% Oligochaeta	28.1% Chironomidae	27.6% Chironomidae	53.4% Chironomidae
EPT Index	10	8	9	10	5
% Shredders to Total	5.4%	13.3%	4.6%	2.9%	0.6%
Simpson's Diversity Index	0.67	0.82	0.85	0.85	0.68
Shannon-Wiener Diversity	2.33	3.01	3.27	3.14	2.32
Shannon-Wiener Evenness	0.52	0.68	0.77	0.75	0.61

TABLE 3B. Selected benthic macroinvertebrate metrics for the Honey Branch sediment control ponds and sediment ditch located at the Pen Coal Corporation, 08 October 1999.

METRIC	Middle Honey Branch Pond (1988)	Lower Honey Branch Pond (1988)	Honey Branch Sediment Ditch (1988)
Taxa Richness	9	8	8
Modified Hilsenhoff Biotic Index	6.06	6.11	5.82
Ratio of Scrapers to Collector/Filterers	0:0	0:0	0:0
Ratio of EPT:Chironomidae	224:1520	128:688	272:816
% Contribution of Dominant Family	55.9% Chiro.[1]	49.4% Chiro.[1]	37.2% Chiro.[1]
EPT Index	3	1	1
% Shredders to Total	0.0%	3.4%	0.7%
Simpson's Diversity Index	0.63	0.66	0.70
Shannon-Wiener Diversity	1.91	1.99	2.06
Shannon-Wiener Evenness	0.58	0.66	0.69

1 = Diptera: Chironomidae

TABLE 4A. Habitat scores for the stations on Honey Branch and stations on Twelvepole Creek, above and below confluence with Honey Branch, 08 October 1999.

	Upstream Honey Branch	Midstream Honey Branch	Mouth Honey Branch	Upstream Twelvepole Creek	Downstream Twelvepole Creek
<u>Primary - Substrate and Instream Cover</u>					
1. Bottom Substrate and Available Cover (0-20)	18	18	18	14	17
2. Embeddedness (0-20)	18	19	16	16	17
3. Flow/Velocity (0-20)	16	18	18	10	16
<u>Secondary - Channel Morphology</u>					
4. Channel Alterations (0 - 15)	12	14	10	14	12
5. Bottom Scouring and Deposition (0 - 15)	12	14	11	13	10
6. Pool/Riffle, Run/Bend Ratio (0 -15)	11	11	14	7	12
<u>Tertiary - Riparian and Bank Structure</u>					
7. Bank Stability (0 -10)	5	10	7	6	7
8. Bank Vegetation Stability (0 -10)	9	10	7	7	7
9. Streamside Cover (0 - 10)	8	5	6	7	7

Note: The scoring for each	<u>Excellent</u>	<u>Good</u>	<u>Fair</u>	<u>Poor</u>
Primary	16 - 20	11 - 15	6 - 10	0 - 5
Secondary	12 - 15	8 - 11	4 - 7	0 - 3
Tertiary	9 - 10	6 - 8	3 - 5	0 - 2

TABLE 4B. Summary of habitat descriptions for the Honey Branch sediment control ponds and sediment ditch located at the Pen Coal Corporation, 08 October 1999.

	Middle Honey Branch Pond (1988)	Lower Honey Branch Pond (1988)	Honey Branch Sediment Ditch (1988)
Pond/Ditch Surface Acreage			
	0.53	1.01	0.05
Length x Width (feet)			
	150 X 150	500 X 300	100 X 20
Bottom Substrate Type			
	silty, detrital	silty, detrital	all organic
Bank Stability			
	stable	fairly stable	very stable
Bank Vegetation Stability			
	100% vegetated	100% vegetated	100% vegetated
Vegetation Types			
	grasses, shrubs, herbaceous plants, filamentous algae, submerged & emergent aquatics	grasses, shrubs, herbaceous plants, filamentous algae, submerged & emergent aquatics	grasses, shrubs, herbaceous plants, filamentous algae, submerged & emergent aquatics
Pond/Ditch Cover			
	some	none	some

TABLE 5. Abundances of benthic macroinvertebrates collected per sample from the Upstream Honey Branch Station, Toe of the Valley Fill, 08 October 1999.

	SAMPLE			
TAXON	Surber 1	Surber 2	Surber 3	Kick
Insecta				
Ephemeroptera (Mayflies)				
Leptophlebiidae				
Leptophlebia (S)				34
Plecoptera (Stoneflies)				
Chloroperlidae (S)	4			
Leuctridae				
Leuctra (F)	2			
Perlidae (S)	1			
Perlodidae (F)	1			2
Taeniopterygidae (F)	2			
Trichoptera (Caddisflies)				
Hydropsychidae (F)	2			
Lepidostomatidae				
Lepidostoma (S)			2	
Polycentropodidae (F)		4		4
Rhyacophilidae (F)			4	
Diptera (True Flies)				
Ceratopogonidae (T)	2		4	32
Chironomidae (T)	12	40	24	72
Tabanidae (T)		4		4
Tipulidae				
Hexatoma (T)	2	8	4	2
Coleoptera (Beetles)				
Elmidae (S)	1			
Saldidae (S)	1			
Hemiptera (Water Bugs)				
Corixidae (T)				2
Odonata (Dragonflies)				
Gomphidae (T)				2
Collembola (Springtails) (F)	2	8	8	4
Oligochaeta (Aquatic Worms) (T)	28	204	64	24

TABLE 5. Continued.

TAXON	Surber 1	Surber 2	Surber 3	Kick
	SAMPLE			
Planaridae (Flatworms) (T)		4		
Crayfish (F)				2
salamander larvae* (U)	1		1	
Total Individuals	60	272	110	184
Taxa	13	7	7	12

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 6. Abundances of benthic macroinvertebrates collected per sample from the Midstream Honey Branch Station, 08 October 1999.

TAXON	SAMPLE Surber 1	Surber 2	Surber 3	Kick
Insecta				
Ephemeroptera (Mayflies)				
Ameletidae				
Ameletus (F)		8		
Plecoptera (Stoneflies)				
Chloroperlidae (S)	4			
Leuctridae				
Leuctra (F)		56		
Perlodidae (F)	2		10	
Trichoptera (Caddisflies)				
Hydropsychidae (F)	4	20		2
Limnephilidae (F)		4		
Philopotamidae (S)		16		
Polycentropodidae (F)	2	2		
Diptera (True Flies)				
Ceratopogonidae (T)			4	4
Chaoboridae (T)				2
Chironomidae (T)	48	32	56	12
Simuliidae (F)		4		
Stratiomyidae (T)			2	
Tipulidae				
Dicranota (T)	2			
Tipula (T)	2			
Coleoptera (Beetles)				
Elmidae (S)	38	24	6	6
Saldidae (S)	2			
Megaloptera (Hellgrammites)				
Corydalidae				
Corydalus (S)	2			
Collembola (Springtails) (F)			2	
Oligochaeta (Aquatic Worms) (T)	20	16	76	44
Planaridae (Flatworms) (T)	4	4		
Crayfish (F)	2	2	2	6

TABLE 6. Continued.

	SAMPLE Surber 1	Surber 2	Surber 3	Kick

Total Individuals	132	192	158	76
Taxa	13	12	8	7

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 7. Abundances of benthic macroinvertebrates collected per sample from the Downstream Honey Branch Station, Mouth of Honey Branch, 08 October 1999.

TAXON	SAMPLE Surber 1	Surber 2	Surber 3	Kick
Insecta				
Ephemeroptera (Mayflies)				
Ameletidae				
Ameletus (F)	4	4	4	
Ephemerellidae				
Ephemerella (F)		2		
Heptageniidae				
Stenonema (S)		1		
Plecoptera (Stoneflies)				
Capniidae (S)		2		
Chloroperlidae (S)	6			
Leuctridae				
Leuctra (F)				4
Trichoptera (Caddisflies)				
Hydropsychidae (F)	6	14	6	
Philopotamidae (S)	6	2	8	
Polycentropodidae (F)			2	
Diptera (True Flies)				
Chironomidae (T)	34	14	14	24
Tipulidae				
Tipula (T)				4
Coleoptera (Beetles)				
Elmidae (S)	4	2	2	
Odonata (Dragonflies)				
Gomphidae (T)	4	1		8
Hagenius (T)				16
Lanthus (T)				20
Collembola (Springtails) (F)			2	
Oligochaeta (Aquatic Worms) (T)	12	9	20	28
Planaridae (Flatworms) (T)			2	
Crayfish (F)		1	2	12

TABLE 7. Continued.

	SAMPLE			
	Surber 1	Surber 2	Surber 3	Kick
Total Individuals	76	52	62	116
Taxa	8	11	10	8

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 8. Abundances of benthic macroinvertebrates collected per sample from the Upstream Twelvepole Creek Station, Above confluence with Honey Branch, 08 October 1999.

TAXON	SAMPLE Surber 1	Surber 2	Surber 3	Kick
Insecta				
Ephemeroptera (Mayflies)				
Baetidae				
Baetis (F)	16	12		8
Baetiscidae				
Baetisca (S)	24	20	16	8
Caenidae				
Caenis (S)	12	28	24	12
Ephemerellidae				
Ephemerella (F)	12			
Heptageniidae				
Stenonema (S)	68	124	32	20
Oligoneuriidae				
Isonychia (F)	16	56	32	
Plecoptera (Stoneflies)				
Leuctridae				
Leuctra (F)	8	16	8	4
Taeniopterygidae (F)		16		
Trichoptera (Caddisflies)				
Hydropsychidae (F)	12	20	52	4
Rhyacophilidae (F)	4			
Diptera (True Flies)				
Ceratopogonidae (T)			20	8
Chironomidae (T)	120	128	192	56
Simuliidae (F)	4	16		
Tipulidae				
Hexatoma (T)				4
Coleoptera (Beetles)				
Elmidae (S)	60	96	80	48
Psephenidae (S)	4			
Oligochaeta (Aquatic Worms) (T)	40	120	56	60
Crayfish (F)				4

TABLE 8. Continued.

	SAMPLE			
	Surber 1	Surber 2	Surber 3	Kick
clam* (U)	4	4	8	
snail* (U)		4		
Johnny darter* (U)		1		
Total Individuals	400	652	512	236
Taxa	14	12	10	12

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 9. Abundances of benthic macroinvertebrates collected per sample from the Downstream Twelvepole Creek Station, Below confluence with Honey Branch, 08 October 1999.

TAXON	SAMPLE Surber 1	Surber 2	Surber 3	Kick
Insecta				
Ephemeroptera (Mayflies)				
Baetiscidae				
Baetisca (S)	64	26	20	16
Caenidae				
Caenis (S)	12	4	6	8
Heptageniidae				
Stenonema (S)	28	14	32	56
Plecoptera (Stoneflies)				
Capniidae (S)	4	4		
Trichoptera (Caddisflies)				
Hydropsychidae (F)	8		24	
Diptera (True Flies)				
Ceratopogonidae (T)	20		4	
Chironomidae (T)	404	92	132	36
Tipulidae				
Tipula (T)			2	
Coleoptera (Beetles)				
Elmidae (S)	16	24	20	42
Odonata (Dragonflies)				
Coenagrionidae (T)				2
Cordulegastridae				
Cordulegaster (T)			2	3
Oligochaeta (Aquatic Worms) (T)	52	20	24	8
Planaridae (Flatworms) (T)	4			
Crayfish (F)		4	2	5
clam* (U)	4		8	4
Total Individuals	612	188	268	176
Taxa	10	8	11	9

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms

(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 10. Abundances of benthic macroinvertebrates collected per sample from Middle Honey Branch Pond (Pond Number 2), 08 October 1999.

TAXON	SAMPLE Ponar 1	 Ponar 2	 Ponar 3
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Baetis (F)	96	16	16
Caenidae			
Caenis (F)			64
Ephemeridae			
Hexagenia (S)	32		
Diptera (True Flies)			
Ceratopogonidae (T)	320	160	144
Chironomidae (T)	896	240	384
Tipulidae			
Tipula (T)	32		
Odonata (Dragonflies)			
Coenagrionidae (T)			16
Corduliidae			
Cordulia (T)			16
Oligochaeta (Aquatic Worms) (T)	128	112	48
clams* (U)			16
Total Individuals	1504	528	688
Taxa	6	4	7

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 11. Abundances of benthic macroinvertebrates collected per sample from Lower Honey Branch Pond (Pond Number 1), 08 October 1999.

TAXON	SAMPLE Ponar 1	Ponar 2	Ponar 3
Insecta			
Ephemeroptera (Mayflies)			
Caenidae			
Caenis (F)	64		64
Diptera (True Flies)			
Ceratopogonidae (T)	96	256	32
Chironomidae (T)	192	192	304
Odonata (Dragonflies)			
Coenagrionidae (T)	16		
Corduliidae			
Cordulia (T)	16		
Collembola (Springtails) (F)	48		
Oligochaeta (Aquatic Worms) (T)	96		
Crayfish (F)	16		
clams* (U)	80	64	64
Total Individuals	544	448	400
Taxa	8	2	3

* = Not included in abundance or taxa calculations. For observation only.

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

TABLE 12. Abundances of benthic macroinvertebrates collected per sample from Honey Branch Sediment Ditch, 08 October 1999.

TAXON	SAMPLE Ponar 1	Ponar 2	Ponar 3
Insecta			
Ephemeroptera (Mayflies)			
Baetidae			
Baetis (F)	112	64	96
Diptera (True Flies)			
Ceratopogonidae (T)	288	320	192
Chironomidae (T)	208	320	288
Coleoptera (Beetles)			
Dytiscidae (T)	16		
Haliplidae			
Peltodytes (S)			32
Odonata (Dragonflies)			
Coenagrionidae (T)	16	32	
Collembola (Springtails) (F)	16		
Oligochaeta (Aquatic Worms) (T)		64	128
Total Individuals	656	800	736
Taxa	6	5	5

( ) Classification of Pollution Indicator Organisms
(S) = Sensitive (F) = Facultative (T) = Tolerant (U) = Unclassified

Aquatic Ecosystem Enhancements At A Mountaintop Mining Site

Presented January 12, 2000
Charleston, West Virginia

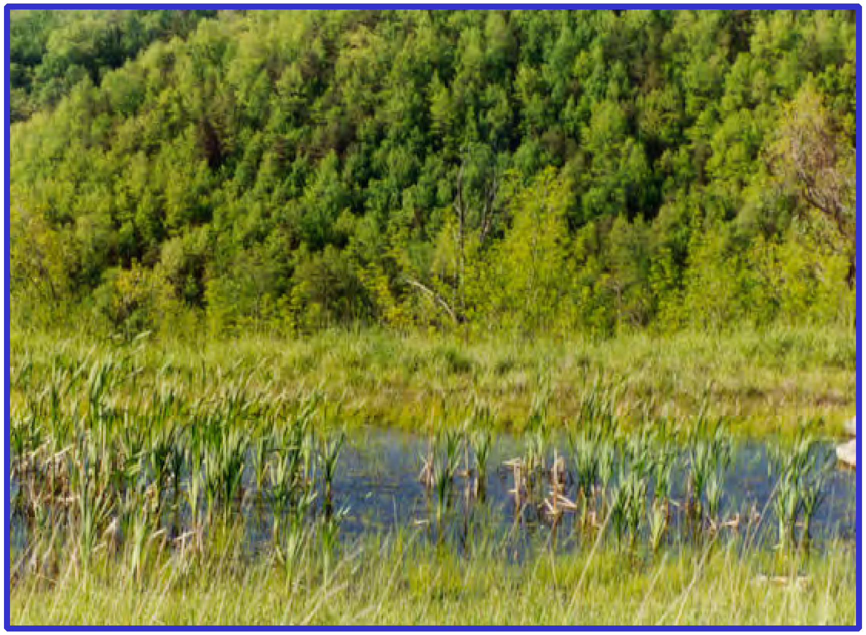
Coal Catenary

Aquatic Ecosystem Enhancement At A Mountaintop Mining Site

- Background / Scope of Samples Mine Project
- Structures constructed as conditions of permits
  - In-stream ponds
  - On bench structures
- Aquatic Ecosystem Enhancement Projects
  - G-Ponds
  - Abandoned Mine Land Projects
- Landform Restoration

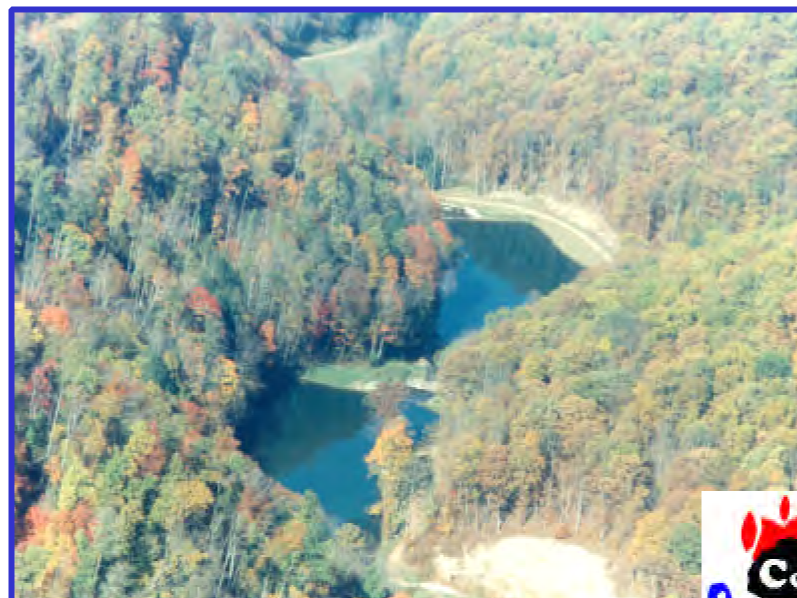
Aquatic Ecosystems Constructed as Conditions of Permits

In-stream Ponds



On Bench Structures

Examples of in-stream ponds...

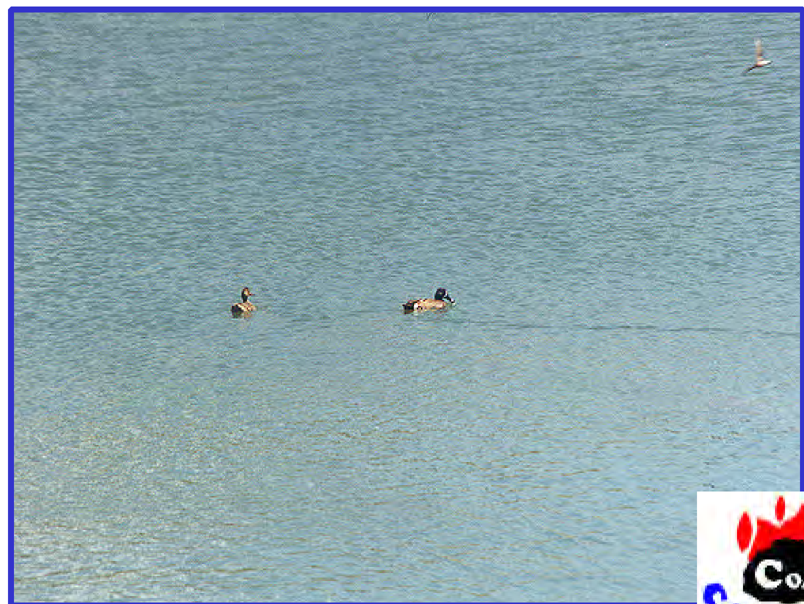


COAL CATENARY

Examples of on bench structures...



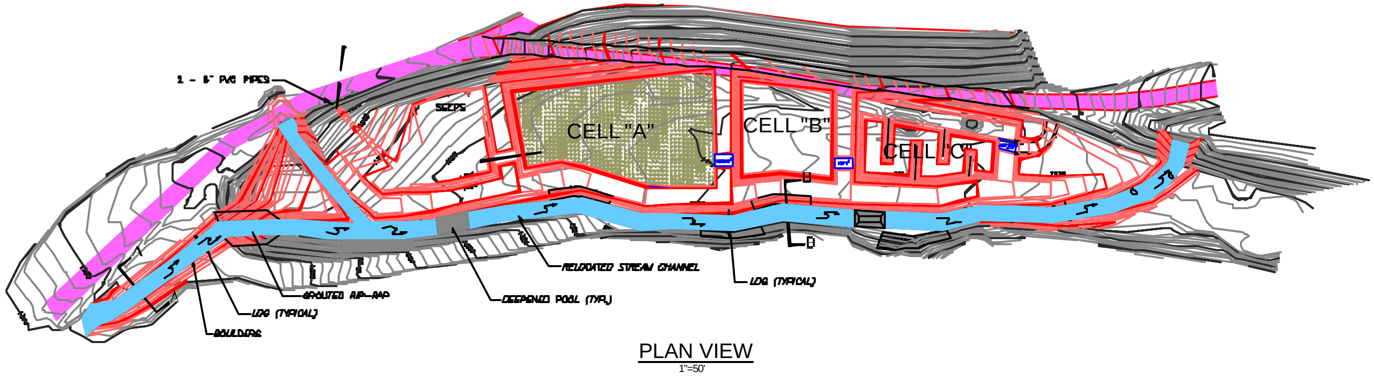

Aquatic Ecosystem Enhancement...

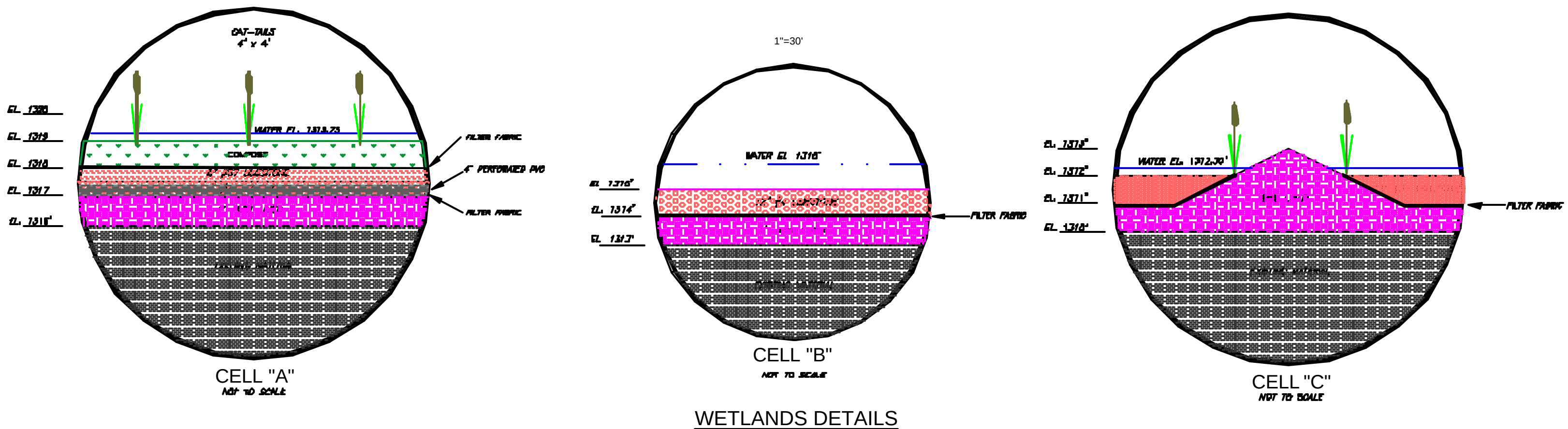


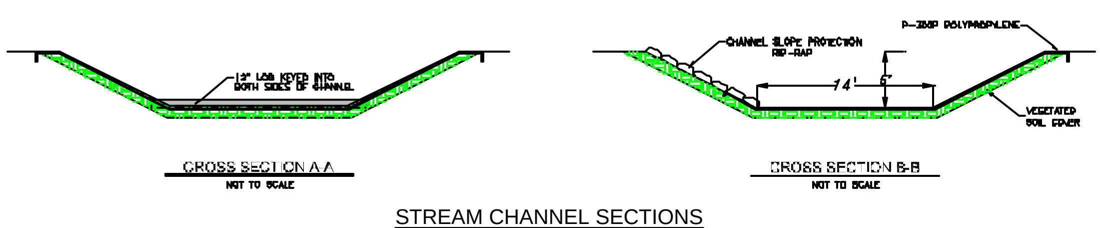
Abandoned Mine Lands Projects...


Areas of Pre- Law Mining


Engineering Design of Wetlands...

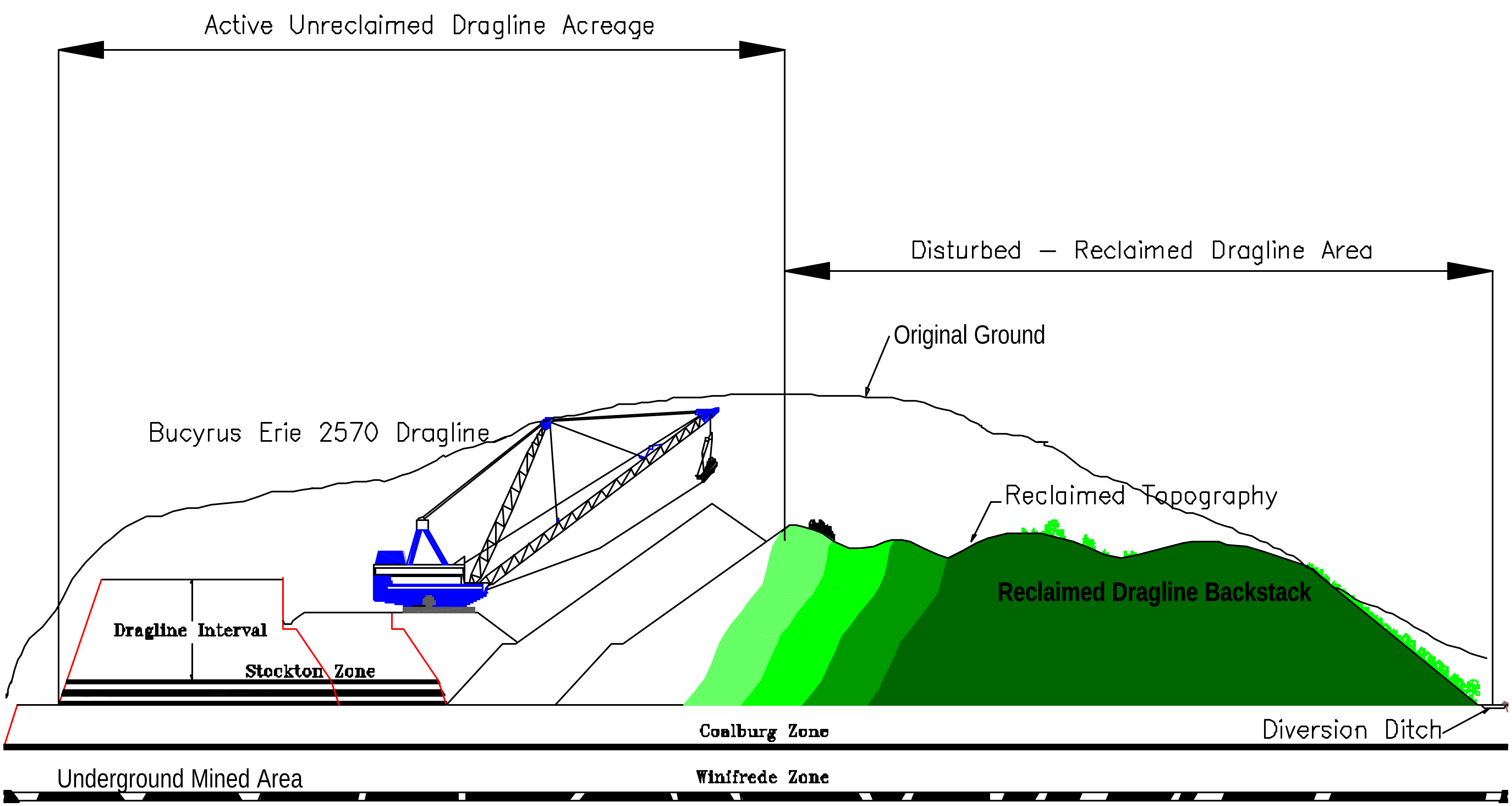






Construction of Wetlands

Land Forms Restoration...



During Mining

Reclaimed Area

Reclaimed Area

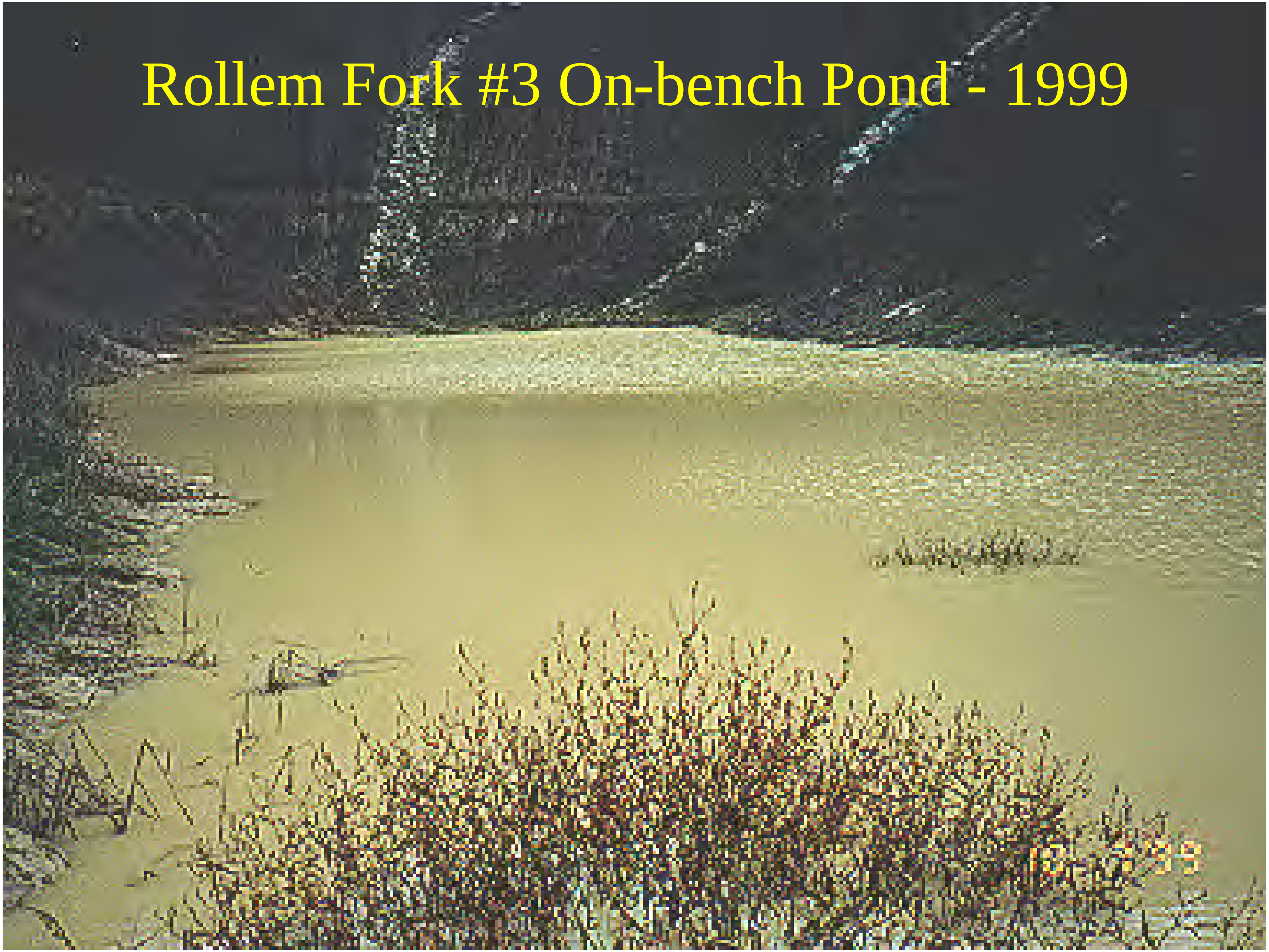
Reclaimed Area


COAL
CATENARY

An Evaluation of Aquatic Habitats provided by Sediment Control Ponds and Other Aquatic Enhancement Structures

Randy Maggard
Pen Coal Corporation

Rollem Fork #3 On-bench Pond - 1999



Rollem Fork On-Bench Pond #5 - 1997


Left Fork of Parker Branch #7 -1991
10 8 93

Macroinvertebrates

	Vance Branch -99	Rollem Fork -97	Left Fork -91
Taxa Richness	8	12	14

Rollem Fork Combination Ditch - 1999

Rollem Fork Sediment Ditch - 1997

Left Fork Sediment Ditch - 1994

Comparisons

- Headwater Streams vs. Wetlands and Ponds

Downstream Impacts of Surface Mining
And Valley Fill Construction

by

Randall Maggard, Ed Kirk

Abstract Pen Coal Corporation has been conducting a detailed monitoring program on Trough Fork watershed to determine the downstream impact of mining operations. This program involves the monitoring of both water chemistry and benthic macroinvertebrates at upstream and downstream locations during the spring and fall since 1995. The study was initiated prior to any mining activity, and will continue through the completion of mining and reclamation activities. This report is a summary of the data gathered as of the fall of 1998.

Key Words: Watershed, Perennial Stream, Intermittent Stream, Water Chemistry, Benthic Macroinvertebrates, Valley Fill, Wildlife Habitat.

Introduction

Pen Coal Corporation has extensive mining operations located near Dunlow, in southern Wayne County, West Virginia. The operations consist of an active underground mine in the Coalburg Seam, two active underground mines and two active surface mines in the 5-Block seam, a preparation plant, a refuse fill, and an impoundment. Each of these operations are located in the watershed of the East Fork of Twelvepole Creek.

Mining operations began at the Honey Branch Surface Mine in September 1987. This operation consisted of contour mining and valley fill construction associated with the Coalburg seam. During the summer of 1988 Pen Coal began mining operations at the Frank Branch Surface Mine that involved contour mining and point removal with valley fill construction associated with the 5-Block seam.

Note:

1) Paper presented at the 1999 Annual Meeting of the West Virginia Acid Mine Drainage Task Force, Morgantown, WV, April 13 & 14, 1999.
2) Randall Maggard, Environmental Specialist, Pen Coal Corporation, Dunlow, WV. R.E.I. Consultants, Inc., Beaver, WV, Ed Kirk, Aquatic Biologist.
3)

The mining operations involving the 5-Block seam have continued to expand to involve the drainage areas of Kiah Creek and Trough Fork, which are also tributaries of the East Fork of Twelvepole Creek.

Some minor water quality problems were detected during 1990, which were easily treated and corrected. As mining progressed northward, the elevation of the 5-Block seam has continued to drop closer to drainage. This created some operational problems due to the lack of available valley fill areas. This also caused an increase in the quantity of surface water which entered the mining area. During 1993, the water quality problem associated with the surface mining of the 5-Block seam became more pronounced, and required a more intensive effort to control and abate. Pen Coal began an extensive "Water Quality Improvement Plan" in February 1994 to determine the most cost effective method for treatment of the existing problems and methods to prevent or minimize future problems.

As part of the "Water Quality Improvement Plan", Pen Coal began an extensive benthic macroinvertebrate monitoring program in the affected watersheds during the fall of 1995. The Trough Fork watershed was undisturbed during the fall of 1995, but mining was projected for the area, therefore Trough Fork was included in the monitoring program. This monitoring has continued each spring and fall since that time.

Statement of Purpose

The purpose of this paper is to share the data that Pen Coal Corporation has gathered with the coal mining industry and other interested parties. The writers would like to specifically address the following points of significance:

- ?? The most dramatic change which occurs during surface mining with valley fill construction is the disturbance and associated change in land configuration and vegetation.
- ?? The chemical composition (quality) and volume of the water downstream from these operations do change. These changes will be discussed in more detail.
- ?? The benthic macroinvertebrate communities that exist downstream of these operations do change as a result of the changes in the chemical and physical characteristics of the receiving streams.

Surface Impacts

Trough Fork is a first order stream which has a watershed of approximately 2,882 acres. Pen Coal's currently permitted mining activities will impact approximately 580 acres, or 20% of the Trough Fork watershed.

Trough Fork has approximately 16,200 linear feet of perennial stream with approximately 44,400 linear feet of intermittent tributaries (Based on USGS topographic mapping). The value of these intermittent tributaries is an item that is currently under hot debate. The mining activities by Pen Coal will directly impact approximately 19,800 linear feet of these tributaries either by direct mineral removal, or by valley fill construction. This amounts to about 44% of the intermittent tributaries of Trough Fork. Only one of these individual tributaries, Vance Branch, exceeded 250 acres.

The post-mining configuration of the reclaimed mine sites will consist of six valley fills of various sizes, eighteen ponds, approximately 40,000 linear feet of sediment or diversion channels, and approximately 575 acres of regraded land. This land will then be revegetated with various grasses, legumes, shrubs and trees to enhance wildlife habitat. This is what will replace the pre-mining site that originally consisted of 580 acres of unmanaged forestland and 19,800 linear feet of intermittent streams.

Methods

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected following a modified Rapid Bioassessment Protocol III (EPA/440/4-89/001) at both an upstream (BM-005) station and a downstream (BM-006) station on Trough Fork in October and April since 1995 (Figure 1). An Ellis-Rutter™ Portable Invertebrate Box Sampler (PIBS) with a sample area of $0.1m^2$ was utilized in the both the riffle habitats and in a slower run/pool habitat for a total of three replicates per station. A standard kick-net seine (sample area = $1.0\ m^2$) was also utilized at each station, but in a run/pool habitat. Invertebrate samples were preserved in 10% formalin, picked under microscopes, and detrital material was checked a second time to insure that no individuals were missed. All macroinvertebrates were indentified to lowest practical taxonomic level, enumerated, and several metrics were calculated using the data.

Water Chemistry

Water samples were collected in October and April since 1995 at both the upstream (BM-005) site and the downstream (BM-006) site (Figure 1), appropriately preserved, and transported to R.E.I. Consultant's laboratory for analysis. The Water Quality Parameters measured for each sampling site are listed below:

Flow	Sulfates
pH	Sodium
Conductivity	Aluminum
TDS	Calcium
TSS	Iron
Hardness	Magnesium
Alkalinity	Manganese
Acidity	Chlorides

Parameters analyzed in-the-field were pH, conductivity, dissolved oxygen, water temperature, and stream flows. These parameters are good indicators of the water quality of a particular station, and when used in conjunction with the macroinvertebrate data, can indicate any changes which occur as one progresses downstream.

Some of the individual parameters are described in more detail as to their role in evaluating water quality below:

Flow:

The flow is an indicator of the surface and groundwater discharges in the watershed.

pH:

The pH is a measure of the hydrogen ion concentration and is preferred to be in the 6.5 to 8.5 range in natural waters.

Conductivity:

The conductivity is the ability of a solution to conduct electrical current. The conductivity is directly related to the amount of materials dissolved in the water.

TDS:

The TDS (Total Dissolved Solids) is a measure of the amount of dissolved materials in the water is directly related to the conductivity, and generally preferred to be less than 1000 mg/l.

TSS:

The TSS (Total Suspended Solids) is a measure of the undissolved solids which are suspended in the water. Any land disturbance can lead to increases in TSS.

Hardness:

The hardness is typically a measure of the amount of calcium, magnesium and iron in the water. The hardness typically increases as the concentration of these elements increase.

Alkalinity:

The capacity of water to accept hydrogen ions is called alkalinity. This is important in the chemistry and biology of natural waters. Alkalinity serves as a pH buffer and reservoir for inorganic carbon, thus helping to determine the ability of water to support algal growth and other aquatic life. Alkalinity can be used as a measure of water fertility. It is important to distinguish between an elevated pH and high alkalinity, the difference is pH is an intensity factor while alkalinity is a capacity factor.

Acidity:

The capacity of water to neutralize OH^- is referred to as acidity. The acidity in natural waters generally results from the presence of weak acids such as CO_2 and acidic metal ions, particularly Fe^{3+}.

Sulfate:

The sulfate content of natural waters in the Appalachian region is typically low in undisturbed watersheds (10 to 50 mg/1). When surface disturbance occurs, such as mining or highway construction, and sulfide bearing rock is exposed to weathering, sulfate concentrations typically increase in the watersheds. Sulfate concentrations in the 300 to 400 mg/l range can give water a bitter taste an concentrations of 600 to 1000 mg/l has laxative effect.

Sodium:

The sodium concentration of natural waters in the Appalachian region is typically very low and increases area usually attributed to human activities such as highway salting, water treatment or oil and gas production.

Aluminum:

The aluminum concentrations in natural waters is typically attributed to suspended clay particles or to dissolved aluminum if severe acid mine drainage is encountered.

Calcium:

The most common cation in most freshwater systems is calcium and often has the most influence on aquatic chemistry. Calcium is a key element in many geochemical processes and minerals constitute the primary sources of the calcium ion in water.

Iron:

The iron concentrations in natural waters in the Appalachian region vary greatly. The sources of iron can range from suspended iron clay minerals to dissolved iron from natural seeps or discharges from manmade disturbances such as mining or construction activities.

Magnesium:

Probably the second most common cation in most freshwater, magnesium behaves similar to calcium and is usually associated with calcium concentrations and contributes to hardness.

Manganese:

The manganese concentrations in natural waters in the Appalachian region vary. The sources are typically the result of weathering of sedimentary rocks. The concentrations can increase dramatically when large quantities of rock are exposed to weathering such as surface mining or highway construction.

Chlorides:

The chloride concentrations are typically low in natural waters in the Appalachian region but may increase as a result of highway de-icing or oil and gas production.

Results

Benthic Macroinvertebrates

In general, the total number of benthic macroinvertebrate individuals has increased dramatically at the upstream (BM-005) site since pre-mining conditions in October 1995 from 193 individuals in April 1996 to 1,009 individuals in October 1998 (Tables 3 and 4). In addition, taxa richness has increased slightly at the upstream stations since October 1995. The number of Ephemeroptera, Plecopetera, and Trichoptera (EPT) groups has also slightly increased since pre-mining conditions in October 1995. A trend in the benthic community's tolerance is hard to distinguish at the upstream site, but a slight negative trend towards a more tolerant community is somewhat evident from the increasing Hilsenhoff Biotic Index (HBI) as well as the relative percentages within the three tolerance groups. The decreasing Diversity and Evenness measures also indicate a slightly less diverse and less equitable community at the upstream site since October 1995 (Tables 3 and 4).

In general, the total number of benthic macroinvertebrate individuals has most likely increased at the downstream station (BM-006) since pre-mining conditions in October 1995 from 496 individuals in October 1995 to 2,777 individuals in October 1998. Taxa richness may have increased slightly at the downstream station. Number of EPT taxa has probably remained unchanged at the downstream station (Tables 3 and 4). The macroinvertebrate community, however, has depicted a negative trend in the tolerance as indicated by the increasing HBI, and by the changes of percentages within the three tolerance groups. The decreasing Diversity and Evenness measures also indicate a somewhat less diverse and less equitable population of aquatic macroinvertebrates at the downstream station since October 1995.

Water Chemistry

In general, all parameters analyzed have remained relatively unchanged at the upstream (BM-005) site since pre-mining samples were collected in October 1995 (Tables 1 and 2). However, at the downstream site (BM-006), several parameters have increased since pre-mining conditions in October 1995. These include conductivity, TDS, TSS, hardness, alkalinity, sulfates, sodium, calcium, and magnesium. Those parameters which have exhibited dramatic increases at the downstream site are conductivity (64 ?mhos in April 1996 to 1061 ?mhos in October 1998), TDS 64 mg/1 in April 1996 to 727 mg/1 in October 1998), hardness (22.4 mg/1 in April 1996 to 303 mg/1 in April 1998), alkalinity (20.9 mg/1 in April 1996 to 137 mg/1 in October 1998), sulfates (15.3 mg/1 in April 1996 to 354 mg/1 in October 1998), sodium (1.05 mg/1 in April 1996 to 141 mg/1 in October 1998), calcium (4.44 mg/1 in April 1996 to 80.2 mg/1 in April 1998), and magnesium (2.74 mg/1 in April 1996 to 30.3 mg/1 in October 1998).

Discussion

The most significant change in water quality was the sulfate concentrations which were most likely attributed to the oxidation of sulfide bearing overburden exposed during the mining operations. Some water treatment have occurred during these operations to neutralize the acidity produced by the oxidation of pyritic overburden. The treatment chemicals utilized were calcium oxide and sodium hydroxide which most likely contributed to the dramatic increases which also were observed in the calcium and sodium concentrations at the downstream sampling site. There was also an increase in magnesium which was probably also attributed to the weathering of magnesium bearing clays. The other increases such as conductivity, TDS, hardness, and alkalinity are directly related to the previously discussed increases in sulfate, calcium, sodium, and magnesium.

A desirable increase that occurred, however, was the increase in alkalinity which was originally in the 20 mg/l range. This increase in alkalinity to the 60 to 100 mg/l range should provide a much more fertile aquatic habitat.

Another change which was observed has been the increase in base flow at the downstream sampling point when compared with the upstream sampling point during low flow conditions which are typical during the October sampling. These have been confirmed on numerous occasions by visual observations. Even though these flows are small, they are very critical to aquatic life. These increases in flows can more easily guarantee year round flows which then make a difference between a stream containing rich populations of benthic macroinvertebrates and fish, to streams completely drying up in the dryer seasons, which is obviously devastating to aquatic life.

As stated previously, many of the water chemistry parameters have increased several fold at the downstream site since pre-mining conditions existed in October 1995. It is interesting to note that although mining activities commenced in February 1996, changes in water chemistry were not observed until the October 1996 sampling event.

These increases in water chemistry constituents, however, were not observable in the aquatic macroinvertebrate data until possibly the April 1997 sampling event, but definitely by the October 1997 sampling event. The only observable negative trend at the downstream station has been the shift in community structure from a more pollution sensitive, more diverse, and more evenly distributed community to one which is more pollution tolerant, less diverse, and less evenly distributed. Nevertheless, total abundances of benthic macroinvertebrates has continued to increase, and taxa richness has probably increased slightly at the downstream station since mining activities commenced in February 1996.

Conclusions

Even though many individual water chemistry constituents of the water quality at Trough Fork's downstream site have continued to escalate, the catastrophic results once predicted within the benthic macroinvertebrate communities have not been observed. The changes in water chemistry would probably have occurred even if valley fills had not been constructed due to hydrologic interactions with the backfilled and regraded areas at the coal seam elevation and higher. The increases in dissolved solids occurred as a result of the unavoidable increased weathering of exposed rock during mining. Pen Coal will continue to study the Trough Fork watershed through the completion of mining and reclamation activities to determine the long-term impacts that the mining operation has on the watershed. Since Pen Coal began mining in the East Fork of Twelvepole Creek watershed in 1987, 70% of its thirteen surface mine permits involved mining and valley fill construction in watershed greater than 250 acres. The changes proposed by the various Regulatory Agencies regarding mining and valley fills in watersheds greater than 250 acres could significantly impact future mining operations for the entire coal industry. A careful review of existing data should be undertaken and thoroughly evaluated by proven scientific methods.

References

Dal-Tex 1998, An evaluation of mountaintop mining and valley construction efforts upon the surface hydrologic benthic systems, 24 pp.

Hubbard, D., 1990, Mayflies of the World: A Catelog of the Family and Genus Group Taxa: (Insecta:Ephemeroptera).

Kentucky Division of Water, September 1997, Guidelines for stream and wetland protection in Kentucky, Natural Resources and Environmental Protection Cabinet, Frankfort, Kentucky, 52 pp.

Manahan, S. 1993, Fundamentals of Environmental Chemistry, Lewis Publishers, Boca Raton, Florida, 844 pp.

McCafferty, W. and A. Provousha, 1981, Aquatic Entomology, Jones and Bartlett Publishers, Sudbury, Massachusetts, 448 pp.

Merritt, R.W. and K.W. Cummins, 1984, An Introduction to the Aquatic Insects of North America, 2nd edition. Kendall/Hunt Publishing Company, Dubuque, IA, 722 pp.

Pfieder, E., G. Clark, H. Hartman, A. Soderburg 1972, Surface Mining, The American Institute of Mining, Metallurgical, and

Petroleum Engineers, Inc., New York, 1061 pp.
Sengupta, M. 1993, Environmental Impacts on Mining, Monitoring, Restoration, and Control, Lewis Publishers, Boca Raton, Florida, 494 pp.
Stewart, K., B. Stark, J. Stanger, 1993, Nymphs of the North American Stonefly Genera (Plecoptera), Thomas Say Foundation, College Park, Maryland.
U.S. EPA, September 1998, Draft Final Report: Analysis of Valley Fill Impacts Using Benthic Macroinvertebrates, U.S. Environmental Protection Agency, Region III, Philadelphia, Pennsylvania, 43 pp.
Van Der Leeden, F., F. Troise, D. Todd 1990, The Water Encyclopedia, Lewis Publishers, Boca Raton, Florida, 808 pp.
Wiggins, Glenn B., 1995, Larvae of the North American Caddisfly Genera (Trichoptera), University of Toronta Press, Toronto, 2nd edition.

Excess Spoil Disposal Configuration

Presented by:

John Morgan

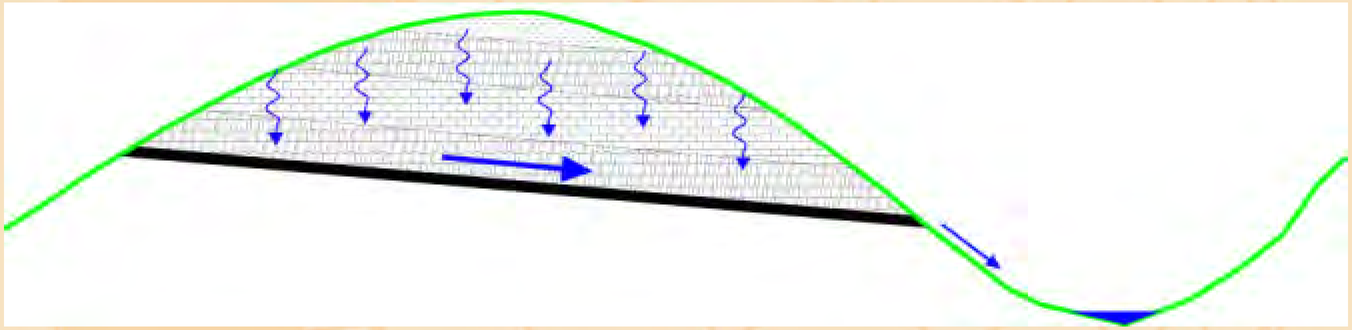
Why no water on backfill?

- High permeability of backfill
- Broken and mixed overburden from blasting and excavation
- Backfill has no defined horizons
- Change to pre-mining stratigraphy
- No aquicludes until pavement
- Infiltration from ditches

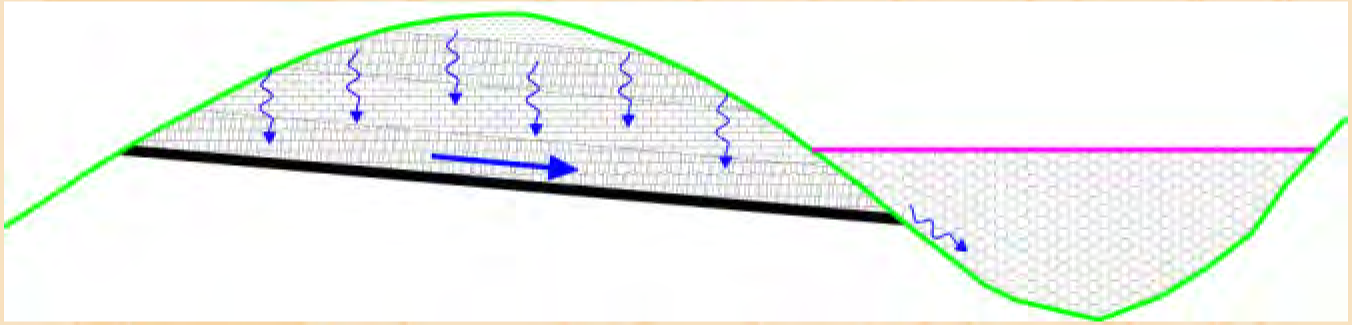
Where is water?

- Storm flow in ditches
- Subsurface flow on coal pavement
- Subsurface flow discharge at down dip outcrop
- Some outcrop discharges covered by valley fill
- Discharge at toe of valley fill
- Very few surface flows
- Some ponds on solid benches

Subsurface Flow



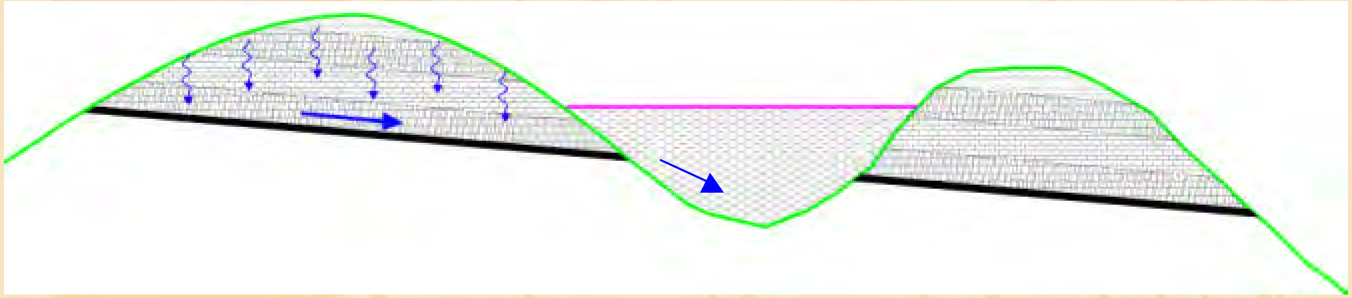
Subsurface Flow (with fill)



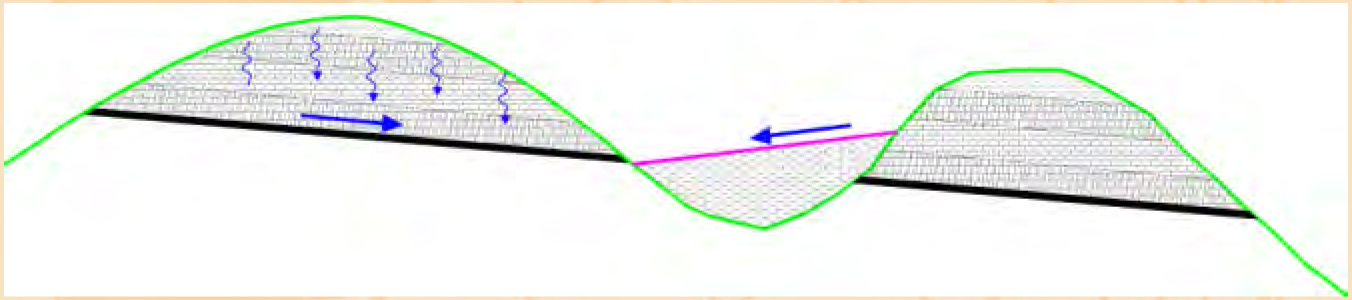
Alternative Backfill Configuration?

- Objectives
  - Intercept groundwater discharge
  - Decrease ditch gradients
- Alternative Configuration
  - Construct combination conventional / side-hill fill
  - Tilt top surface of valley fills to one side
  - Create incised groin ditch with flatter slope

Typical Valley Fill Regrade



Modified Valley Fill Regrade



Evaluation of skewed fill

- Advantages
  - Intercepts flow at outcrop
  - Collects some surface flow
  - Increases probability of perennial flow
- Disadvantages
  - Increased flow rate in single ditch
  - Concerns with regulatory stipulations for side hill fill
  - Some increase in fill haulage height

AOC Model

- Provides an objective and reproducible means to define AOC
- Allows a subjective approach to be replaced with a volumetric definition
- Optimizes the placement of spoil
- Volumetric approach gives operator flexibility over final design
- Allows landforming, stream restoration and aquatic habitat projects

Participants List

Aquatic Ecosystem Enhancement at Mountaintop Mining Sites Symposium

January 12, 2000

Craig Aaron
Evergreen Mining
P.O. Box 972
Cowen, WV 26206
Phone: 304/226-2111
Fax: 304/226-5474
E-mail: caaron@aeiresources.com

Larry Abbot
Summit Engineering, Inc.
400 Allen Drive, Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: labbot@summit-engr.com

Gary Acord
Cline Resources & Development
430 Harper Park Drive
Beckley, WV 25801
Phone: 304/ 255-7458
Fax: 304/255-4908
E-mail:

Larry Alt
WV DEP
10 McJunkin Road
Nitro, WV 25177
Phone: 304/759-0510
Fax: 304/759-0528
E-mail: Lalt@mail.dep.state.wv.us

Jim Ashby
Mettiki Coal, LLC
293 Table Rock Road
Oakland, MD 21550
Phone: 301/334-5336
Fax: 301/334-1602
E-mail: jashby@gcnet.net

U.K. Bachhawat
Pittston Coal Management Company
P.O. Box 11718
Charleston, WV 25339
Phone: 304/347-8200
Fax: 304/347-8980
E-mail: ubachhaw@pistonminerals.com

Terry Ball
Massey Coal Services
P.O. Box 484
Omar, WV 25638
Phone: 304/946-2421
Fax: 304/946-2404
E-mail: terry.ball@masseycoal.com

Marla Barbour
Kentucky Department of Fish and
Wildlife Resources
Arnold L. Mitchell Building
#1 Game Farm Road
Frankfort, KY 40601
Phone: 502/564-7109, x367
Fax: 502/564-4519
E-mail: marla.barbour@mail.state.ky.us

Heino Beckert
US DOE NETL
P.O. Box 880 Collins Ferry Road
Morgantown, WV 26507-0880
Phone: 304/285-4132
Fax: 304/285-4403
E-mail: heino.beckert@netl.doe.gov

Robert Bays
Arch Coal
5311 Ashbrook Road
Cross Lanes, WV 25313
Phone: 304/369-6222 x139
Fax: 304/369-0542
E-msil: bbays@archcoal.com

Les Bincent
Virginia Department of Mines, Minerals,
and Energy
P.O. Drawer 900
Big Stone Gap, VA 24219
Phone: 540/523-8159
Fax: 540/523-8163
E-mail: lsb@mme.state.va.us

Courtney Black
WVU National Mine Land Reclamation Center
202 E NRCCE
P.O. Box 6064
Morgantown, WV 26506
Phone: 304/293-2867 x5447
E-mail: dblack@wvu.edu

Brian Bolling
Charleston Daily Mail
1001 Virginia Street East
Charleston, WV 25301

Frank Borsuk
Potesta & Associates, Inc.
2400 MacCorkle Avenue, SE
Charleston, WV 25304
Phone: 304/342-1400
Fax: 304/343-9031
E-mail: faborsuk@potesta.com
faborsuk@teays.net

Darin Brown
Kimberly Industries, Inc.
One Wellford Way
Charleston, WV 25311
Phone: 304/346-3775
Fax: 304/346-3798

Earl H. Brown, Jr.
GAI Consultants, Inc.
315 70th Street, SE
Charleston, WV 25304
Phone: 304/926-8100
E-mail: gaiwv@citynet.net

Gary Bryant
U.S. EPA
1060 Chapline St.
Wheeling, WV 26003
Phone: 304/234-0230
Fax: 304/234-0257
E-mail: bryant.gary@epamail.epa.gov

R. Scott Bumsworth
GAI Consultants, Inc.
315 70th Street, SE
Charleston, WV 25304
Phone: 304/926-8100
E-mail: gaiwv@citynet.net

Carey Butler
WPI
3606 Collins Ferry Road Suite 202
Morgantown, WV 26505
Phone: 304/598-9383 x15
Fax: 304/598-9392
E-mail: carey_butler@mt.wpi.org

Jim Canterbury
Mountain State Company
P.O. Drawer O
Cedar Grove, WV 25039
Phone: 304/949-4762
Fax: 304/949-4764
E-mail:

Steven Case
Coal Mac, Inc.
P.O. Box 3428
Pikeville, KY 41502
Phone: 606/432-0171
Fax: 606/437-4213
E-mail: SLCase@EastKy.net

Doug Chambers
USGS - WRD
11 Dunbar St.
Charleston, WV 25301
Phone: 304/347-5130
Fax: 304/347-5133
E-mail: dbchambe@usgs.gov

Mary Channel
WV Division of Environmental Protection
116 Industrial Drive
Oak Hill, WV 25901
Phone: 304/465-1911
Fax: 304/465-0031
E-mail: mchannel@mail.dep.state.wv.us

George Chappel
Summit Engineering, Inc.
400 Allen Drive, Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: gchappel@summit-engr.com

Casey Clapsaddle
U.S. Fish and Wildlife Service
Suite 322
315 S Allen Street
State College, PA 16801
Phone: 814/234-4090
Fax: 814/234-0748
E-mail: casey_clapsaddle@fws.gov

Debbie Collinsworth
EcoSource, Inc
112 Dennis Drive
Lexington, KY 40503
Phone: 606/277-8686
Fax: 606/277-8686
E-mail: ecosourtce@hotmail.com

James W. Copley, Jr.
Coastal Coal-West Virginia, LLC
Brooks Run Operation
61 Missouri Run Road
Cowen, WV 26206
Phone: 304/226-5391

Danny Cox
Massey Coal Services, Inc.
P.O. Box 1951
Charleston, WV 25327
Phone: 304/345-3556
Fax: 304/345-3623
E-mail: danny.cox@masseycoal.com

Richard Darnell
WVDEP -AML&P
10 McJunkin Road
Nitro, WV 25071
Phone: 304/ 759-0521
Fax: 304/759-0527

Ron Damron
Piston Coal Management Company
P.O. Box 11718
Charleston, WV 25339
Phone: 304/347-8200
Fax: 304/347-8980
E-mail: rdamron@pistonminerals.com

David Densmore
U.S. Fish and Wildlife Service
Suite 322
315 S Allen Street
State College, PA 16801
Phone: 814/234-4090
Fax: 814/234-0748
E-mail: david_densmore@fws.gov

Kent DesRocher
Arch of WV
P.O. Box 1 HC 614, Box 156
Yolyn, WV 25654
Phone: 304/369-6222, ext. 134
304/792-8200
Fax: 304/369-0542
304/792-8260
E-mail: kdesrocher@archcoal.com

Lori W. Dials
Kentucky Department of Fish and
Wildlife Resources
Arnold L. Mitchell Building
#1 Game Farm Road
Frankfort, KY 40601
Phone: 502/564-7109, x375
Fax: 502/564-4519
E-mail: lori.dials@mail.state.ky.us

Barry Doss
AEI Resources
P.O. Box 489
Cabin Creek, WV 25035
Phone: 304/595-3330
Fax: 304/595-3301
E-mail: bdoss@aeiresources.com

Joe Dotson
Massey Coal Services
P.O. Box 484
Omar, WV 25638
Phone: 304/946-2421
Fax: 304/946-2404

John L. Dovak
Kentucky Division of Water
14 Reilly Road
Frankfort, KY 40601
Phone: 502/564-3410
Fax: 502/564-0111
E-mail: sampson@nrdep.nr.state.ky.us

Roger Dunlap
Kimberly Industries, Inc.
One Wellford Way
Charleston, WV 25311
Phone: 304/346-3775
Fax: 304/346-3798

J. D. Elkins
Summit Engineering, Inc.
203 Main Avenue
Logan, WV 25601
Phone: 304/752-5038
Fax: 304/752-5039
E-mail: jelkins@summit-engr.com

Larry Emerson
Arch Coal, Inc.
P.O. Box 6300
Huntington, WV 25771
Phone: 304/526-3581
Fax: 304/526-3680
E-mail: lemerson@archcoal.com

Erkan Esmer
Esmer Associates, Inc.
P.O. Box 426
Boomer, WV 25031
Phone: 304/779-2131
Fax: 304/779-2859
E-mail: esmer@intelos.net

Ben Faulkner
Bratton Farm
171 Willowbrook Road
Princeton, WV 24740
Phone: 304/487-2886
Fax: 304/425-3727
E-mail: bratfarm@pol.net

James Felby
Catenary Coal Company
251 Frame Road
Elkview, WV 25071
Phone: 304/595-7233
Fax: 304/595-4063

Kermit Fincham, Jr.
Progress Coal
HC 78
P.O. Box 1796
Madison, WV 25130
Phone: 304/369-9101
Fax: 304/369-9105
E-mail: kermit.fincham@masseycoal.com

Michael A. Fioravante
GAI Consultants, Inc.
315 70th Street, SE
Charleston, WV 25304
Phone: 304/926-8100
E-mail: gaiwv@citynet.net

David Fisher
Sturm Environmental Services
P.O. Box 650
Bridgeport, WV 26330
Phone: 304/623-6549
Fax: 304/623-6552
E-mail: ses@iolinc.net

Blair Gardner
Arch Coal, Inc.
City Place One
St. Louis, MO 63141
Phone: 314/994-2725
Fax: 314/994-2734
E-mail: bgardner@archcoal.com

Anthony Gatens
Arch of WV
HC 61, Box 156
Yolyn, WV 25654
Phone: 304/792-8253
Fax: 304/792-8260
E-mail: agatens@archcoal.com

Bryce D. Good
GAI Consultants, Inc.
315 70th Street, SE
Charleston, WV 25304
Phone: 304/926-8100
E-mail: gaiwv@citynet.net

T.J. Gregorsky
Fola Coal Company
P.O. Box 180
Bickmore, WV 25019
Phone: 304/587-4100
Fax: 304/587-2469
E-mail: wvsailor@fola.wv.net

David Gruber
Biological Monitoring, Inc.
1800 Kraft Drive Suite 101
Blacksburg, VA 24060
Phone: 540/953-2821
Fax: 540/951-1481
E-mail: bmi@biomon.com

Jack Hagewood
Pittston Coal
P.O. Boc 11718
Charleston, WV 25339
Phone: 304/587-4777 x33
E-mail: JHagewood@pittstonminerals.com

Steven Handel
Department of Ecology, Evolution, and Natural Resources
Rutgers University
1 College Farm Road
New Brunswick, NJ 08901-1582
Phone: 732/932-4516
E-mail: handel@aesop.rutgers.edu

Rebecca Hanmer
U.S. Environmental Protection Agency
4505 F Street
Washington, DC 20460
Phone: 202/260-4470
Fax: 202/401-5341
E-mail: hanmer.rebecca@epa.gov

Jimmy Harless
Hampden Coal
P.O. Box 1389
Gilbert, WV 25601
Phone: 304/664-2960
Fax: 304/664-2962

Leith Hartman
Pritchard Mining
184 1/2 Summers St.
Charleston, WV 25301
Phone: 304/346-2268
E-mail: rlh3@citynet.net

David Hartos
OSM
3 Parkway Center
Pittsburgh, PA 15220
Phone: 412/937-2909
Fax: 412/937-3102
E-mail: dhartos@osmre.gov

Gary Hatfield
Rawl Sales
Box 722
Matewan, WV 25678
Phone: 304/235-4290
Fax: 304/235-3034
E-mail: gary.hatfield@masseycoal.com

David Hibbs
Cummins Cumberland, Inc.
5304 Ashbrook Road
Cross Lanes, WV 25313
Phone: 304/776-5376
E-mail: drhibbs@ibm.net

Nancy Hieb
WV Division of Environmental Protection
116 Industrial Drive
Oak Hill, WV 25901
Phone: 304/465-1911
Fax: 304/465-0031
E-mail: nhieb@mail.dep.state.wv.us

Cliff Higgerson
Hobet Mining
P.O. Box 305
Madison, WV 25130
Phone: 304/369-8126
E-mail: chiggerson@archcoal.com

J.D. Higginbotham
Bluestone Coal Corporation
P.O. Box 1085
Beckley, WV 25801
Phone: 304/252-8528
Fax: 304/255-6106
E-mail: jdhjr@bluestoneindustries.com

Tiff Hilton
WOPEC
RR2 Box 294B
Lewisburg, WV 24901
Phone: 304/645-7633
Fax: 304/645-4985
E-mail: WOPEC@newwave.net

Ken Hodak
Arch of WV
P.O. Box 1 HC 614, Box 156
Yolyn, WV 25654
Phone: 304/792-8200
Fax: 304/792-8260
E-mail: khodak@archcoal.com

Michael Hoeft
WV Division of Natural Resources
Route 1, Box 484
Point Pleasant, WV 25550
Phone: 304/675-0871
Fax: 304/675-0872
E-mail: hoeftm@mail.wvnet.edu

William Hoffman
U.S. Environmental Protection Agency
1650 Arch Street
Philadelphia, PA 19104
Phone: 215/814-2787
E-mail: hoffman.william@epamail.epa.gov

Teresa Hughes
US. Army Corps of Engineers
502 8th Street
Huntington, WV 25701
Phone: 304/529-5710
Fax: 304/529-5085
E-mail:
Teresa.D.Hughes@Lrh01.usace.army.mil

Mike Isabell
Fola Coal Company
P.O. Box 180
Bickmore, WV 25019
Phone: 304/587-4100
Fax: 304/587-2469
E-mail: wvsailor@fola.wv.net

Scotty Ison
P&A Engineers
P.O. Box 470
Alum Creek, WV 25003
Phone: 304/756-4066
Fax: 304/756-4068
E-mail: pandawv@newwave.com

Ken Job
Marrowbone Development Co.
P.O. Box 119
Naugatuck, WV 25685
Phone: 304/393-3736

Jamie Johnson
Arch Coal, Inc.
P.O. Box 305
Madison, WV 25130
Phone: 304/369-6222
Fax: 304/369-6829
E-mail: jajohnson@archcoal.com

Randy Kelley
WV Division of Natural Resources
525 Tiller Street
Logan, WV 25601
Phone: 304/792-7075
Fax: 304/792-7078
E-mail: kellyr@mail.wvnet.edu

Robert Kenny
Triangle Survey
One Valley Square Suite 970
Charleston, WV 25301
Phone: 304/342-4989

Robert Kiser
Appalachian Technical Services
P.O. Box 98
Whitesburg, KY 41858
Phone: 606/633-0613
Fax: 606/633-0616

Eugene Kitts
Summit Engineering, Inc.
400 Allen Drive, Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: gkitts@summit-engr.com

Allen Klein
U.S. Department of the Interior
Office of Surface Mining
3 Parkway Center
Pittsburgh, PA 15220
Phone: 412/937-2828
Fax: 412/937-2903
E-mail: aklein@osmre.gov

Keith Krantz
WV DNR
Rt 1, Box 484
Pt. Pleasant, WV 25504
Phone: 304/ 675-0871

Peter Lawson
Catenary Coal
5914 Cabin Creek Road
Eskdale, WV 25075
Phone: 304/595-4036
Fax: 304/595-4063
E-mail: plawson@archcoal.com

Penny Loeb
11234 Richard Grove Drive
Great Falls, VA 22066
Phone: 703/430-3451
Fax:
E-mail: cfdodge@msa.com

Mike Mace
WV Division of Environmental Protection
No. 10 McJunkin Road
Nitro, WV 25143
Phone: 304/759-0595
Fax: 304/759-0587
E-mail: mmace@mail.dep.state.wv.us

Paul Maggard
Appalachian Technicla Services
P.O. Box 98
Whitesburg, KY 41858
Phone: 606/633-0613
Fax: 606/633-0616
E-mail: atsincky@kih.net

Randy Maggard
PenCoal
P.O. Box 191
Dunlow, WV 25511
Phone: 304/385-4951
E-mail: randy_maggard@pencoal.com

Robert Marsh
Pen Coal Corp
P.O. Box 191
Dunbar, WV 25511
Phone: 304/385-4950
Fax: 304/385-4594
E-mail: Robert_Marsh@pencoal.com

Bob Martin
P&A Engineers
P.O. Box 279
Louisa, KY 41230
Phone: 606/673-4413
Fax: 606/673-4415
E-mail: pandaky@foothills.net

David L. Martin
Coastal Coal-West Virginia, LLC
Brooks Run Operation
61 Missouri Run Road
Cowen, WV 26206
Phone: 304/226-5391

Larry Mauk
Hampden Coal
P.O. Box 1389
Gilbert, WV 25601
Phone: 304/664-2960
Fax: 304/664-2962

Bernard Maynard
Office of Surface Mining
Building No. 3
Parkway Center Complex
Pittsburgh, PA 15220
Phone: 412/937-2873
Fax: 412/937-3012
E-mail: bmaynard@osm.gov

Cindy Maynard
WV DEP
No. 10, McJunkin Road
Nitro, WV 25143
Phone: 304/759-0570
Fax: 304/759-0527
E-mail: cmaynard@mail.dep.state.wv.us

Raymond Maynard
White Flame Energy
Box 379
Red Jacket, WV 25692
Phone: 304/426-6090

Ron McAhron
Cannelton Coal
P.O. Box 150
Cannelton, WV 25036
Phone: 304/442-5106
Fax: 304/442-9451
E-mail: rmcahron@aeiresources.com

John McDaniel
Arch Coal, Inc.
P.O. Box 305
Madison, WV 25130
Phone: 304/369-6222
Fax: 304/369-6829
E-mail: jmcdaniel@archcoal.com

John McNew
White Flame Energy
P.O. Box 343
Red Jacket, WV 25692
Phone: 304/426-6090
Fax: 304/426-4231
E-mail: iam4wv@cwv.net

Scott McPhilliamy
U.S. Environmental Protection Agency
1060 Chapline Street
Wheeling, WV 26003-2995
Phone: 304/234-0233
Fax: 304/234-0257
E-mail: mcphilliamy.scott@epamail.epa.gov

Chuck Meadows
P&A Engineers
P.O. Box 279
Louisa, KY 41230
Phone: 606/673-4413
Fax: 606/673-4415
E-mail: pandaky@foothills.net

Terry Messinger
U. S. Geological Survey
11 Dunbar St.
Charleston, WV 25301
Phone: 304/347-5130 x270
Fax: 304/347-5133
E-mail: tmessing@usgs.gov

Ron Miller
P&A Engineers
P.O. Box 279
Louisa, KY 41230
Phone: 606/673-4413
Fax: 606/673-4415
E-mail: pandaky@foothills.net

Earl Moles
Arch Coal, Inc.
5914 Cabin Creek Road
Eskdale, WV 25075
Phone: 304/595-7259
Fax: 304/595-4063
E-mail: emoles@archcoal.com

Dawn Moore
U. S. Geological Survey
11 Dunbar St.
Charleston, WV 25301
Phone: 304/347-5130 x285
Fax: 304/347-5133
E-mail: damoore@usgs.gov

Randy Moore
EG&G M/S O03
P.O. Box 880 Collins Ferry Road
Morgantown, WV 26507-0880
Phone: 304/285-4606
Fax: 304/285-4200
E-mail: randy.moore@netl.doe.gov

John Morgan
Morgan Worldwide Mining Consultants
P.O. Box 888
Lexington, KY 40588
Phone: 606/259-0959
E-mail: mwmc@aol.com

Rick Morgan
Hobet Mining
P.O. Box 305
Madison, WV 25130
Phone: 304/369-8126
E-mail: rmorgan@archcoal.com

Ginger Mullins
U.S. Army Corps of Engineers
502 8th St.
Huntington, WV 25701
Phone: 304/529-5710
Fax: 304/529-5085
E-mail: gingerm@lrh.usace.army.mil

Mike Murphy
Hampden Coal
P.O. Box 1389
Gilbert, WV 25601
Phone: 304/664-2960
Fax: 304/664-2962

Pat Murphy
Summit Engineering, Inc.
203 Main Avenue
Logan, WV 25601
Phone: 304/752-5038
Fax: 304/752-5039
E-mail: pmurphy@summit-engr.com

Joseph B. Myers
Coastal Coal-West Virginia, LLC
Brooks Run Operation
61 Missouri Run Road
Cowen, WV 26206
Phone: 304/226-5391

Randall Myers
Randall Myers Land Surveyors
255 Caney Valley Road
Markleysburg, PA 15459
Phone: 724/329-4994
Fax: 724/329-4994

Pam Nixon
WV Department of Environmental Protection
No. 10, McJunkin Road
Nitro, WV 25143
Phone: 304/759-0570
Fax: 304/759-0527
E-mail: pnixon@mail.dep.state.wv.us

Brian Osborn
Mepco, Inc.
P.O. Box 1209
Morgantown, WV 26507
Phone: 304/328-5757
Fax: 304/328-5743
E-mail: mepcoeng@access.mountain.net

Rocky Parsons
WVDEP
105 S. Railroad St.
Philippi, WV 26416
Phone: 304/457-3219
Fax: 304/457-5613

Katherine Paybins
USGS-WRD
11 Dunbar St.
Charleston, WV 25301
Phone: 304/347-5130
Fax: 304/347-5133
E-mail: kpaybins@usgs.gov

Bob Penn
OSM
Box 116 1941 Neely Road
Big Stone Gap, VA 24219
Phone: 540/523-0001
Fax: 540/523-4303
E-mail: RPenn@osmre.gov

Gary Persinger
Penn Virginia Coal Co.
Suite 100, One Cabin Center
Chesapeake, WV 25315
Phone: 304/949-5630
Fax: 304/949-6090

Dennis Phipps
Summit Engineering, Inc.
203 Main Avenue
Logan, WV 25601
Phone: 304/752-5038
Fax: 304/752-5039
E-mail: dphipps@summit-engr.com

Dale Pike
CONSOL Inc.
1800 Washington Road
Pittsburgh, PA 15241
Phone: 412/831-4524
Fax: 412/831-4513

Rocky Powell
Clear Creek Consulting
1317 Knopp Road
Jarrettsville, MD 21084
Phone: 410/692-2164
E-mail: rockypowell@msn.com

Ken Politan
WVDEP
10 McJunkin Road
Nitro, WV 25177
Phone: 304/759-0510
Fax: 304/759-0528
E-mail: kpolitan@mail.dep.sate.wv.us

Terry Potter
Coal Mac, Inc.
P.O. Box 3428
Pikeville, KY 41502
Phone: 606/432-0171
Fax: 606/437-4213
E-mail: tpotter@archcoal.com

David Rasnick
Summit Engineering, Inc.
101 Summit Drive
Pikeville, KY 41501
Phone: 606/432-1447
Fax: 606/432-1440
E-mail: drasnick@summit-engr.com

Jim Ratcliff
Summit Engineering, Inc.
400 Allen Drive, Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: jratcliff@summit-engr.com

Chad Reed
Summit Engineering, Inc.
400 Allen Drive, Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: creed@summit-engr.com

David Rider
U.S. Environmental Protection Agency
1650 Arch Street
Philadelphia, PA 19104
Phone: 215/814-2787
E-mail: rider.david@epamail.epa.gov

Jeff Robinson
Summit Engineering, Inc.
101 Summit Drive
Pikeville, KY 41501
Phone: 606/432-1447
Fax: 606/432-1440
E-mail: jrobinson@summit-engr.com

Mike Robinson
OSM
3 Parkway Center
Pittsburgh, PA 15220
Phone: 412/937-2882
Fax: 412/937-3012
E-mail: mrobinso@osmre.gov

Ron Robinson
Virginia Department of Mines, Minerals,
and Energy
P.O. Drawer 900
Big Stone Gap, VA 24219
Phone: 540/523-8159
Fax: 540/523-8163
E-mail: rdr@mme.state.va.us

Frank Rose
Piston Coal Management Company
P.O. Box 11718
Charleston, WV 25339
Phone: 304/347-8200
Fax: 304/347-8980
E-mail: frose@pistonminerals.com

Bill Sampson
Kentucky Division of Water
14 Reilly Road
Frankfort, KY 40601
Phone: 502/564-3410
Fax: 502/564-0111
E-mail: sampson@nrdep.nr.state.ky.us

Horst Schor
H.J. Schor Consulting
626 N. Pioneer Dr.
Anahiem, CA 92805
Phone: 714/778-3767
Fax: 714/778-1656
E-mail: hjschor@jps.net

Tom Serenko
Summit Engineering, Inc.
101 Summit Drive
Pikeville, KY 41501
Phone: 606/432-1447
Fax: 606/432-1440
E-mail: tserenko@summit-engr.com

Jim Serfis
EPA
515 N. Jackson St.
Arlington, VA 22201
Phone: 202/564-7161
E-mail: serfis.jim@epa.gov

Gary Sharp
WV Division of Natural Resources
Wildlife Section
Route 1, Box 484
Point Pleasant, WV 25550
Phone: 304/675-0871
Fax: 304/675-0872

Guy Shelledy
Fola Coal Company
P.O. Box 180
Bickmore, WV 25019
Phone: 304/587-4100
Fax: 304/587-2469
E-mail: wvsailor@fola.wv.net

Jeff Skousen
West Virgina University
1106 Agricultural Sciences
Morgantown, WV 26506-6108
Phone: 304/293-6256
Fax: 304/293-2960
E-mail: jskousen@wvu.edu

Eric Somerville
U.S. EPA, Region 4
Wetlands Section
61 Forsyth Street, SW
Atlanta, GA 30303
Phone: 404/562-9414
Fax: 404/562-9343
E-mail: somerville.eric@epa.gov

Keith Spears
Summit Engineering, Inc.
101 Summit Drive
Pikeville, KY 41501
Phone: 606/432-1447
Fax: 606/432-1440
E-mail: kspears@summit-engr.com

Vivian Stockman
Ohio Valley Environmental Coalition
249 Millstone Run
Spencer, WV 25276
Phone: 304/927-3265
Fax: 304/927-3265
E-mail: vivian@wvadventures.net

Jennifer Stump
Gannett Fleming Inc.
207 Senate Ave,
Camp Hill, PA 17011
Phone: 717/763-7211 x 2885
Fax: 717/763-7323
E-mail: jstump@gfnet.com

Dan Sweeney
EPA
1650 Arch St.
Philadelphia, PA 19013
Phone: 215/814-5731
Fax: 215/814-2301
E-mail: sweeney.dan@epa.gov

Aaron Taylor
Kimberly Industries, Inc.
One Wellford Way
Charleston, WV 25311
Phone: 304/346-3775
Fax: 304/346-3798

Pat Taylor
Summit Engineering, Inc.
400 Allen Drive, Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: ptaylor@summit-engr.com

Cindy Tibbott
U.S. Fish and Wildlife Service
Suite 322
315 S Allen Street
State College, PA 16801
Phone: 814/234-4090
Fax: 814/234-0748
E-mail: cindy_tibbott@fws.gov

Gary D. Tinnel
Coastal Coal-West Virginia, LLC
Brooks Run Operation
61 Missouri Run Road
Cowen, WV 26206
Phone: 304/226-5391

Zac Totten
Summit Engineering, Inc.
400 Allen Drive, Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: ztotten@summit-engr.com

Rena Turner
Piston Coal Management Company
P.O. Box 11718
Charleston, WV 25339
Phone: 304/347-8200
Fax: 304/347-8980
E-mail: rturner@pistonminerals.com

Dave Vande Linde
WVDEP
10 McJunkin Road
Nitro WV 25143
Phone: 304/759-0510
Fax: 304/759-0528
E-mail: dvandelinde@mail.dep.state.wv.us

Marvin Vernatter
Kimberly Industries, Inc.
One Wellford Way
Charleston, WV 25311
Phone: 304/346-3775
Fax: 304/346-3798

Sandy Vilar
WPI
3606 Collins Ferry Road Suite 202
Morgantown, WV 26505
Phone: 304/598-9383 x10
Fax: 304/598-9392
E-mail: sandy_vilar@mt.wpi.org

Mike Vines
White Flame Energy
P.O. Box 343
Red Jacket, WV 25692
Phone: 304/ 426-5405
Fax: 304/426-5406
E-mail: wvcoalboss@yahoo.com

Jan Wachter
US DOE NETL
P.O. Box 880 Collins Ferry Road
Morgantown, WV 26507-0880
Phone: 304/285-4607
Fax: 304/285-4403
E-mail: jan.wachter@netl.doe.gov

Kevin Wall
Western Pocahontas Properties
P.O. Box 2827
Huntington, WV 25727
Phone: 304/522-5757
Fax: 304/522-5401
E-mail: kwall@wpplp.com

Bruce Wallace
Department of Entomology
University of Georgia
413 Biological Sciences Building
Athens, GA 30602-2603
Phone: 706/542-7886
Fax: 706/542-2279
E-mail: wallace@sparc.ecology.uga.edu

Kevin Whipkey
Cline Resource & Development Co.
430 Harper Park Dr.
Beckley, WV 25801
Phone: 304/255-7458
Fax: 304/255-4908
E-mail: rkwhipkey@teays.net

Mark White
Arch of WV
P.O. Box 1 H 614, Box 156
Yolyn, WV 25654
Phone: 304/369-6222, ext. 138
304/792-8200
Fax: 304/369-0542
304/792-8260
E-mail: mwhite@archcoal.com

Darcy White
WV Division of Environmental Protection
No. 10 McJunkin Road
Nitro, WV 25143
Phone: 304/759-0595
Fax: 304/759-0587
E-mail: dwhite@mail.dep.state.wv.us

Darren Whitlock
Summit Engineering, Inc.
400 Allen Drive, Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: dwhitlock@summit-engr.com

Ronald A. Wigal
Canaan Valley Institute
P.O. Box 673
Danis, WV 26260
Phone: 304/866-4739
Fax: 304/866-4759
E-mail: rwigal@mail.canaanvi.org

Andy Willis
Mining Consulting Services, Inc.
P.O. Box 207
Kimper, KY 41539
Phone: 606/835-3009
Fax: 606/835-3011
E-mail: awillis@miningusa.com

Allen Wood
WVDEP/AML
116 Industrial Drive
Oak Hill, WV 25801
Phone: 304/465-1911

Eddie Workman
Southern Land Company
300 Capitol Street
Suite 1401
Charleston, WV 25301
Phone: 304/346-3661
Fax: 304/346-3630

Mark S. Workman
Coastal Coal-West Virginia, LLC
Brooks Run Operation
61 Missouri Run Road
Cowen, WV 26206
Phone: 304/226-5391

Matt Workman
P&A Engineers
P.O. Box 279
Louisa, KY 41230
Phone: 606/673-4413
Fax: 606/673-4415
E-mail: pandaky@foothills.net

Dale Wright
Bluestone Coal Corporation
P.O. Box 1085
Beckley, WV 25801
Phone: 304/252-8528
Fax: 304/255-6106
E-mail: dwright@bluestoneindustries.com

Steve Young
145 Stricker Road
Charleston, WV 25314
Phone: 304/343-9369
Fax: 304/343-9369

Paul Ziemkiewicz
WVU National Mine Land Reclamation Center
P.O. Box 6064
Morgantown, WV 26505
Phone: 304/293-2867
E-mail: pziemkie@wvu.edu

An Evaluation of Aquatic Ecosystem Enhancement at Four Mountaintop Mining/Valley Fill Sites in West Virginia

Prepared for
U.S. Environmental Protection Agency
Wheeling, WV

Prepared by
Clear Creeks Consulting

January 2000

Contents

Introduction 1

Background Information 1

Methodology 4

Assessment Results

- Elk Run Coal Company East of Stollings Surface Mine 5
- Catenary Coal Company Samples Surface Mine 14
- Penn Coal Corporation Kiah Creek Mine 24
- Arch Coal Company Hobet #21 Mine 34

Summary of Findings 43

Summary of Recommendations 46

AN EVALUATION OF AQUATIC ECOSYSTEM ENHANCEMENT AT FOUR MOUNTAINTOP MINING/VALLEY FILL SITES IN WEST VIRGINIA

Introduction

The purpose of this report is to present the results of an assessment conducted at four (4) mountaintop mining/valley fill sites in southwestern West Virginia. The assessment focused on evaluating: 1) the effectiveness of current mining and reclamation practices relative to minimizing adverse impacts to stream ecosystems; and 2) the potential for improving current practices to mitigate for unavoidable adverse impacts. The assessment is a component of the Interagency Environmental Impact Statement Technical Study. The assessment involved conducting on-site tours of the four mountaintop mining/valley fill sites, reviewing information/data provided by the mining companies, collecting additional information/data on-site through interviews with mining company staff and field observations of current practices, and photographically documenting those field observations. This assessment did not include detailed monitoring, surveys or field data collection. Information for some sites was unavailable or nonexistent. Where little or no information was available on pre-mining and post-mining conditions the evaluation was based on information gathered from the research literature and field observations. Consequently, the findings may reflect potential, rather than actual differences between pre-mining and post-mining conditions.

Background Information

No information or data is available that characterizes the pre-mining conditions at the four mountaintop mining/valley fill sites. Therefore, the following background information is presented to provide a baseline for comparison to existing conditions. Since the four sites evaluated are all located in the Western Appalachian Plateau physiographic province of West Virginia, the information presented focuses on characteristics of stream ecosystems in this region.

First and second order watersheds/streams and the higher order systems, of which they are an integral component, are dynamic units in the landscape. Within these units the entire complex of interacting physical, chemical and biological processes operate to form a fairly self-supporting ecosystem. Key structural components of these ecosystems include physical characteristics of the watersheds and streams draining them, biological communities, and energy and material resources. Functional components included the physical, chemical and biological processes that affect long-term stability and govern the flow of energy and material through the ecosystems.

First and second order watersheds in the Western Appalachian Plateau are generally characterized by steep, V-shaped valleys. Elevational relief is high, with ridges reaching elevations up to 2000 feet and valley floors situated 400 – 600 feet lower in elevation. The down-valley slopes of these watersheds are often greater than 10% and adjacent hillslopes exceeding 50% are not uncommon. The stream systems exhibit a dendritic pattern. Since the region is a plateau there is no general trend to valley aspect.

Land cover is typically deciduous forest. Depending on historical land use practices, the typical structure of these forests includes a canopy layer of mature trees, an understory layer of smaller trees, a shrub layer, and a groundcover layer. The soil of the forest floor is usually covered with a layer of humus or leaf litter. Although soils may be thinner and/or less permeable in some areas, under these forested conditions organic material, soil microorganisms, and plant roots tend to increase soil porosity and permeability, and stabilize soil structure thereby increasing infiltration rates.

As a consequence of high infiltration rates stream baseflows are fairly reliable, except under drought conditions. Interception of precipitation in the forest canopy, high evapotranspiration rates, and soil condition serve to maintain relatively low surface runoff rates during storm events. Forest cover, litter and the presence of lower vegetation also moderate soil microclimate, in particular the depth and frequency of soil frost. Thus infiltration may occur even during the colder months. The higher infiltration rates and lower runoff rates tend to moderate storm discharge volumes in-channel except during larger, less frequent storm events (RI: 50 – 100 YRS). In lower reaches where valley floors are wider, floodplains have developed. These areas serve to detain floodwaters that overtop the channel banks, thereby extending the time of concentration and moderating the effects of these flows on downstream reaches. In some watersheds these floodplain areas support wetland communities, particularly where groundwater discharges at the base of hillslopes.

Due to vegetative cover, stable soil structure, and low runoff rates, soil erosion and sediment transport from upland areas is minimal. The stabilizing effect of vegetation and moderate storm flow volumes result in relatively small inputs of sediment from in-channel sources as well.

The morphologic characteristics of stream channels in these first and second order watersheds vary in confinement, slope, bed features, and bed materials. Steeper reaches are characterized as a cascading or step-pool morphology with irregularly spaced drops and scour pools. The spacing of these features is highly irregular and is controlled by bedrock and large woody debris (LWD). These channels are entrenched (< 1.4) and confined between adjacent hillslopes. Width/depth ratios are low (< 12). Channel gradient can range 4% to 10+%. These channels are relatively straight with sinuosities less than 1.2. Reaches with these characteristics correspond to the A and Aa+ stream types presented in <u>A Classification of Natural Rivers</u> (Rosgen, 1994).
Moderate gradient reaches, 2-4%, usually exhibit riffle-scour pool or rapid-scour pool morphology. At the steeper end of this gradient range they may transition into step-pool morphology. These reaches are characterized by moderate entrenchment (1.4 – 2.2) and a wider valley floor. The valley floor will function as a floodplain for storm flows greater than bankfull and may support wetland communities. Width/depth ratios greater than 12. Channel sinuosity is not high (1.1 – 1.5) but is greater than the A stream types. These channels correspond to B stream types (Rosgen, 1994). Flatter gradient reaches (i.e., less than 2%) are usually not entrenched and may have a well developed floodplain that supports wetland communities. Width to depth ratios are high (> 12). Sinuosity is also higher (1.2 – 2.1) than the steeper A and B stream reaches. These channels correspond to C stream types (Rosgen, 1994). Channel materials in the Aa+, A, B and C stream types vary depending on the lithography of the watershed. In this region headwater reaches most commonly exhibit boulder or cobble beds with lesser amounts of gravels, sands or silts. Bedrock reaches are interspersed throughout. The geometry and dimensions of these channels have been shaped and maintained by the bankfull discharges that occur on roughly an annual basis (RI: 1 – 2 YRS). As indicated previously, the volume of these storm flows is moderated by the forested conditions typical of these watersheds.

The physicochemical properties (e.g., temperature, pH, dissolved gases, and dissolved and suspended organic and inorganic compounds) of the water flowing in these streams are influenced by many factors. In headwater streams, weathering and dissolution of rock is commonly the major determinant of stream water chemistry. However, land use is also a significant factor. For example, in forested watersheds reduced insolation moderates the diel and annual range and seasonal minimum-maximum stream temperatures. Water temperature, in turn, affects the solubility of dissolved gases and solids, as well as the rate of chemical reactions. Litterfall and the decomposition of plant and animal material in forested watersheds are a source of inorganic nutrients that are transported to the stream via throughflow of infiltrated rain and groundwater discharge.

In headwater streams, it is generally recognized that allochthonous material (i.e., leaves, needles, and woody debris falling or blown into the stream from the adjacent forest) and autochthonous sources (i.e., periphyton) are important sources of simple carbon compounds and that they complement one another seasonally. However, forested stream systems are primarily heterotrophic (i.e., rely primarily on allochthonous material) as an energy source. Although autotrophic production is provided by periphytic diatoms, standing biomass is usually kept low by stream scour, invertebrate grazing, and forest shade. Therefore, the ratio of autotrophic production to heterotrophic respiration (P:R) is low (<1).

Consequently, large particulate shredders (e.g., Trichoptera, Plecoptera, Coleoptera, Diptera) and fine particulate collectors-gatherers (e.g., Ephemeroptera, Chironomidae, and Ceratopogonidae) are co-dominant in the macroinvertebrate community of headwater streams. Periphyton grazers (e.g., Ephemeroptera, Trichoptera, Diptera, Lepidoptera, and Coleoptera) and predators (e.g., Megaloptera, Plecoptera, Trichoptera, and Odonata) make up smaller percentages of this community. Primary production provided by algae and macrophytes and a macroinvertebrate community with a large percentage of collector-filterers (e.g., Trichoptera, Diptera, and Ephemeroptera) are more typically associated with higher order reaches where there is less shade, slower moving water, and fine particulate organic matter is transported in suspension. Fish species in these headwater streams are generally those adapted to cold or cool, swift flowing water, with moderately high – high dissolved oxygen concentrations. Benthic invertebrate feeders and too a lesser extent piscivores are the most representative trophic guilds of the fish community.

To contribute energy to the food web of the stream reach, organic material (i.e., leaves, needles, twigs) must be retained in the channel where it can be processed. Therefore, retention and export determine the contribution of organic matter to the stream system. Small headwater stream systems are generally efficient at retaining coarse particulate organic material (CPOM) and processing it to fine particulate organic matter (FPOM) and dissolved organic matter (DOM). Interstices in the streambed and roughness elements, such as boulders and large woody debris in the channel, promote retention. Export of organic matter depends on the hydraulic power of the stream, size of the particle, and retentive capacity of the channel.

Methodology

The first part of the assessment involved the evaluation of current practices relative to minimization of adverse impacts to the stream ecosystems via avoidance or mitigation (i.e., restoration or replacement of structure and function). Evaluating complex natural systems and the effects of alterations to one or more of their components is a difficult task. Although the limitations outlined in the *Introduction* precluded a more detailed assessment, to the extent practical a number of considerations were incorporated into the evaluation process. Based on the characterization of first and second order watersheds/stream ecosystems presented in the *Background Information* a number of relevant questions were postulated. The answers to these questions are presented as findings in this report.

1. Are the watershed/valley characteristics consistent with pre-mining conditions?
2. Is the vegetative cover consistent with pre-mining conditions?
3. Have the soil characteristics been modified?
4. Has the hydrologic regime been altered?
5. Has the sediment regime been modified?
6. Is channel morphology consistent with a natural, stable channel form?
7. Have the physicochemical properties of the streams been altered?
8. Have the biotic communities, trophic structure, and energy sources of the stream ecosystems changed?

Although not included in this evaluation, these same questions should be posed relative to the degree to which current mining and reclamation practices have altered or maintained the natural (pre-mining) structure and function of the higher order watershed/stream ecosystems to which these sites drain.

The second part of the assessment involved identifying opportunities for modifying current practices or implementing new approaches that would minimize the adverse impacts of the mining operations. These are presented as recommendations in this report.

Assessment Results

1. Elk Run Coal Company
East of Stollings Surface Mine

a. General

This mine is located south of the town of Racine, West Virginia. The site has been mined since 1987. The operations on this site consist of surface mining of ridge tops with shovel and truck and loader. The streams draining the site include first and second order tributaries to Mudlick Fork and Stollings Fork, which are part of the Laurel Creek/Big Coal River/Kanawah River drainage system. The mining operation will produce approximately 250 million cubic yards of overburden. Roughly 34.8% (86.2 million cubic yards) of that material will be disposed of in the seven (7) proposed valley fills. The valley fills are composed of durable rock fill built in 50 to 100 foot lifts.

Stormwater runoff conveyance and sediment control are provided for via a network of perimeter sediment ditches, groin ditches, and sedimentation ponds. This network is designed to convey all storm flows up to and including the 100-year runoff event and sediment that is eroded and transported from exposed surfaces. The perimeter ditches collect and convey stormwater flow across the face of the valley fill. Although the dimensions of the ditches vary with drainage area, they are usually constructed on 20 - 30 foot wide benches and have a relatively flat gradient. They are stabilized with a grass mix. Groin ditches convey stormwater flow down the face of the valley fill. They are usually 10 – 15 feet wide. Although breaks in slope occur at the benches where the perimeter ditches contribute their flow, the groin ditches are generally very steep. Groin ditches are lined with large rock to provide stabilization. Sedimentation ponds are constructed at the base of the valley fill to capture and retain sediment transported off the exposed valley fill or active mining areas. The ponds are sized to manage the entire valley fill area. Since baseflow from the streams buried beneath the valley fill discharges into the ponds they retain a permanent pool. The ponds outfall immediately upslope from the receiving streams, Mudlick Fork and Stollings Fork.

b. Evaluation of Current Practices

1. Watershed/Valley Characteristics

The watershed impacted by Valley Fill #3 provides an example of how the mining operation and reclamation will alter the watershed/valley characteristics at this site. The pre-mining difference in elevational relief from the ridgelines to the valley floors was fairly significant. The elevations of the ridgelines ranged from 1800 - 1900 feet while the elevation of the valley floor at its confluence with Mudlick Fork was 1150 feet, an elevational difference of as much as 750 feet. The watershed is being reconstructed with flat or broadly rounded ridgelines, lower in elevation, and a broad valley floor, higher in elevation. Consequently, the elevational difference between the ridgelines and new valley floor will be 100 – 150 feet

Although the overall valley slope of the watershed was greater than 10%, pre-mining the down-valley profile included areas of varying slopes. Some valley reaches were very steep, while other reaches had a fairly gentle slope. Current reclamation practices have created a down valley slope that is uniformly moderate (4%) along the top of the fill and uniformly steep (80%) down the face of the fill.

The pre-mining cross-section of the valley also exhibited variability. Hillslopes were characterized by natural breaks where the form and gradient of the slopes changed from steep and convex to relatively gentle and concave and back to steep and convex. As pointed out above, ridgelines have been constructed to recreate the natural landform. Unfortunately this effort falls short across the top of the valley fill and down the face of the fill, where form is still linear and slopes uniform.

These modifications have reduced the size of the drainage area. The drainage pattern will be altered and more closely resemble a modified trellis. Although the watershed will still trend northwest southeast, its aspect relative to the prevailing winds, precipitation, and insolation will be altered due to the changes in valley form.

2. Vegetative Cover

On this site all vegetation was cleared and grubbed prior to the mining operation commencing. Reclaimed areas were seeded with a grass mix, which included K-31. A few areas have been sparsely planted with one or two species of trees. However, at the time of the tour most stabilized areas were covered with grasses and a few widely scattered volunteer shrubs. The remnant forests on site were isolated on undisturbed hillslopes adjacent to sedimentation ponds along Mudlick Fork and Stollings Fork, and as yet unmined ridgelines.

3. Soil Characteristics

The valley fill is a durable rock fill laid down in lifts. The native topsoil and subsoil layers were removed as part of the mining operation. They were not separated and stockpiled for reuse during reclamation. The material laid down during reclamation is a coarse mixture of rock and other overburden material (e.g., sandstone, limestone, clay, shale, subsoils). This valley fill material has a very high percentage of mineral soil and very low percentage of organic matter. As such it will make a very poor growth medium for reestablishing a forest. No information was available regarding its permeability or infiltration rates. However, since this unconsolidated material is composed of varying types of rock and soil, it is likely that some areas will be permeable and other areas impermeable. Another factor affecting the permeability of this material is mechanical compaction of the fill surface by heavy equipment.

4. Hydrologic Regime

In the areas toured it appeared that baseflows are still flowing along the old valley floor, emerging at the base of the valley fill into the sedimentation ponds. The perimeter sediment ditches and groin ditches carry flow during and immediately after storm events. There is no baseflow in these channels. Although no data was available relative to the volume and time of concentration of storm flows, based on the characteristics of the fill material, compaction of the fill surface, and a relatively sparse vegetative cover, it is likely that the volume of runoff is significantly greater than under pre-mining conditions. It is also likely that the time of concentration for these flow events has been reduced with the potential to effect downstream reaches. The perimeter ditches and sedimentation ponds help detain runoff and may provide some management for the increased runoff.

5. Sediment Regime

No data was available to allow a quantitative comparison of erosion and sediment transport rates. However, it is likely that erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are significantly higher than pre-mining conditions. However, it appears that disturbed areas routed to the perimeter ditch/groin ditch/sedimentation pond systems are being managed effectively thereby limiting actual sediment loadings to the receiving streams. Erosion of channel bed and banks in receiving streams adjusting to increased storm flows could provide an unmanaged source of sediment to downstream reaches.

6. Channel Morphology

Based on a review of the site map provided, it appears that approximately 10,500 feet of the first and second order streams on site have been permanently impacted by valley fill. Another 3500 feet of stream channel has been temporarily impacted for construction of access roads, and sedimentation ponds.

The morphology of the perimeter ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The perimeter ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep (80%). There are no discernible bed features (i.e., step-pools or riffle-pools). Since the channels are designed to convey runoff from larger storm events all flows are confined to that one channel. Consequently, there are no natural channels with typical baseflow and bankfull channels and an adjacent floodprone bench or floodplain. However, it should be noted that the constructed channels appeared to be stable and functioning as designed.

7. Physicochemical Properties

The Elk Run Coal Company collected water quality data in the Spring, Summer, and Fall of 1999. Although that data was unavailable for this assessment, water quality data collected from streams draining similar surface mining/valley fill operations may apply to this site. On the sites they were monitoring, Maggard and Kirk (1998) found that several water quality parameters varied from pre-mining levels. Their data indicates that conductivity, total dissolved solids, hardness, alkalinity, sulfates, sodium, calcium, and magnesium levels had increased significantly.

R.E.I. Consultants, Inc. (1999) evaluated the water quality of sedimentation ponds constructed on similar mining sites. They found that water quality varied considerably with the age of the facilities. For example, pH ranged from 5.04 - 8.77, in newer and older ponds respectively. They reported that most of the chemical values (e.g., dissolved solids, hardness, alkalinity, sulfates, and most metals) were initially fairly high, diminishing somewhat with the age of the structure. Their data may apply to the ponds on this site.

8. Biotic Communities, Trophic Structure, and Energy Sources

The Elk Run Coal Company collected biological data in the Spring, Summer, and Fall of 1999. Although that data was unavailable for this assessment, biological data collected from streams draining similar surface mining/valley fill operations may apply to this site. On the sites they monitoring, Maggard and Kirk (1998) found that the benthic macroinvertebrate community downstream of mining/valley fill operations shifted toward more pollution tolerant species. Their data indicates that the number of individuals and taxa richness increased, while diversity and evenness decreased.

R.E.I. Consultants, Inc. (1999) evaluated the biological communities in sedimentation ponds constructed on other similar mining sites. They found that the biotic communities developing in the sedimentation ponds include species typical of a lentic ecosystem. Macrophytes and filamentous algae provide primary production. Allochthonous material enters these sites as litterfall from forests on adjacent hillslopes.

The benthic macroinvertebrate community is composed of typical pond species (e.g., Diptera, Coleoptera, Hemiptera, Odonata, and Oligochaeta). The communities in the newer facilities exhibited low abundance and diversity, and were represented predominantly by very pollution tolerant species. The older facilities, where water quality was better and vegetation was abundant, exhibited higher abundance and diversity. Species present were still primarily pollution tolerant organisms. The fish community was not represented in the ponds. In the short-term at least, it is not likely that these structures will provide habitat for amphibians since most amphibian species are very sensitive to poor water quality.

Elk Run Coal Company's East of Stollings Surface Mine

Looking across valley fill toward active mining area.

Active mining area with adjacent reclaimed area. Photo taken from valley fill looking toward sedimentation pond.

Older (pre-1994) reclaimed area. Valley fill with groin ditch to perimeter ditch.

More recent (post-1994) reclaimed area. Valley fill with perimeter ditches and groin ditches to convey runoff from slopes.

Active valley fill with perimeter ditches across face of fill.

Sedimentation ponds at base of valley fill. Photo shows undisturbed slopes on both sides and perimeter ditch in fill to left.

Groin ditch to perimeter sedimentation ditch in older area.

Photo shows sedimentation ditch at older site.

Outfall control structure for sedimentation ditch

2. Catenary Coal Company
Samples Surface Mine

a. General

This mine is located near the town of Eskdale, West Virginia. Catenary Coal Company acquired the site in 1989 and the current expansion commenced in 1993. The operations on this site consist of dragline surface mining of ridge tops. The streams draining the site include first and second order tributaries to Cabin Creek and White Oak Creek/Big Coal River, which are in the Kanawah River drainage system. In 1998 the mining operation moved 80 million bank cubic yards of material. Roughly 25% (20 million loose cubic yards) of that material was disposed of in valley fills. The valley fills are composed of durable rock fill built in 50 to 100 foot lifts.

Stormwater runoff conveyance and sediment control are provided for via a network of combination ditches, groin ditches, and sedimentation ponds. This network is designed to convey all storm flows up to and including the 100-year runoff event and sediment that is eroded and transported from exposed surfaces. The combination ditches collect and convey stormwater flow across the top of the valley fill. The combination ditches are 10 – 15 feet wide across the bottom and have a relatively flat gradient. They were stabilized with a grass mix. Groin ditches convey stormwater flow down the face of the valley fill. They are usually 10 – 15 feet wide. Although breaks in slope occur at the benches, the groin ditches are generally very steep. Groin ditches are lined with large rock to provide stabilization. Sedimentation ponds were constructed at the top and base of the valley fill to capture and retain sediment transported off the exposed valley fill or active mining areas. The ponds are sized to manage the entire area draining to them. Some of the ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. Where this baseflow discharges into the sedimentation ponds they retain a permanent pool.

c. Evaluation of Current Practices

1. Watershed/Valley Characteristics

The pre-mining difference in elevational relief from the ridgelines to the valley floors was fairly significant. The surface mining/valley fill significantly reduced the elevational difference between the original ridgelines and valley floors. However, contour/landform grading and backstacking of overburden to heights of 300 feet has restored some of the relief and recreated ridgelines.

Although the overall valley slope of the watershed was greater than 10%, pre-mining the down-valley profile included areas of varying slopes. Some valley reaches were very steep, while other reaches had a fairly gentle slope. Current reclamation practices have created a down valley slope that is uniformly moderate along the top of the fill and uniformly steep down the face of the fill.

The pre-mining cross-section of the valley also exhibited variability. Hillslopes were characterized by natural breaks where the form and gradient of the slopes changed from steep and convex to relatively gentle and concave and back to steep and convex. As pointed out above, ridgelines have been constructed to recreate the natural landform. Unfortunately this effort falls short across the top of the valley fill and down the face of the fill, where form is still linear and slopes uniform.

These modifications have reduced the size of the drainage area. The drainage patterns have been altered and more closely resemble a modified trellis. As result of the changes in landform, the watershed aspect relative to prevailing winds, precipitation, and insolation has been altered.

2. Vegetative Cover

On this site all vegetation was cleared and grubbed prior to the mining operation commencing. Reclaimed areas were seeded with a grass mix, which included K-31. A few areas have been sparsely planted with one or two species of trees. However, at the time of the tour most stabilized areas were covered with grasses and a few widely scattered volunteer shrubs. The remnant forests on site were isolated on undisturbed hillslopes adjacent to downstream reaches and unmined ridgelines.

3. Soil Characteristics

The valley fill is a durable rock fill laid down in lifts. The native topsoil and subsoil layers were removed as part of the mining operation. They were not separated and stockpiled for reuse during reclamation. The material laid down during reclamation is a coarse mixture of rock and other overburden material (e.g., sandstone, limestone, clay, shale, subsoils). This valley fill material has a very high percentage of mineral soil and very low percentage of organic matter. As such it will make a very poor growth medium for reestablishing a forest. No information was available regarding its permeability or infiltration rates. However, since this unconsolidated material is composed of varying types of rock and soil, it is likely that some areas will be permeable and other areas impermeable. Another factor affecting the permeability of this material is mechanical compaction of the fill surface by heavy equipment.

4. Hydrologic Regime

Some of the combination ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. In the areas toured the baseflows are maintaining a permanent pool in sedimentation ponds and supporting wetland vegetation around the margins of the pond and in the ditches. Reclamation of the Kayford Refuse Pile along Tenmile Fork was completed in 1999. This reclamation included construction of a series of ponds, artificial wetland systems, and a channel that conveys baseflow and stormflow.

Although no data was available relative to the volume and time of concentration of storm flows, based on the characteristics of the fill material, compaction of the fill surface, and a relatively sparse vegetative cover, it is likely that the volume of runoff is significantly greater than under pre-mining conditions. It is also likely that the time of concentration for these flow events has been reduced with the potential to effect downstream reaches. The combination ditches and sedimentation ponds help detain runoff and therefore may be providing some management for the increased storm flows.

5. Sediment Regime

No data was available to allow a quantitative comparison of erosion and sediment transport rates. However, it is likely that erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are significantly higher than pre-mining conditions. However, it appears that disturbed areas routed to the combination ditch/groin ditch/sedimentation pond systems are being managed effectively thereby limiting actual sediment loadings from the site to the receiving streams. Increased storm flows from the site could contribute to channel adjustment and instability of downstream reaches, thereby creating a potential source of uncontrolled sediment.

6. Channel Morphology

No information was available to determine the linear feet of stream channel impacted by the valley fills. However, given the size of the fill areas observed on site it appears that major sections (i.e., several miles) of the first and second order streams on site have been impacted by valley fill or the construction of the sedimentation ponds.

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The perimeter ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. The one combination ditch observed during the tour along the top of the fill appeared to be developing discernible bed features (i.e., riffle and pools). However, since the channels are designed to convey runoff from larger storm events all flows are confined to that one channel. Consequently, there are no bankfull channels with an adjacent floodplain. It should be noted that the engineered channels constructed along the top and down the face of the valley fill appeared to be stable and functioning as designed.

The channel constructed at the Kayford Reclamation site is also an engineered channel. It has two distinct reaches. The upper reach starts at the base of the large sedimentation pond. This reach is wide, trapezoidal, relatively flat and entrenched. It appeared to be lined with a geotextile erosion control fabric. Given its dimensions, it is obviously designed to carry fairly significant storm flows. Unfortunately, because it is entrenched there is no floodplain surface to convey the high flows. During high flows channel velocities and shear stresses will be considerable. This situation could affect the long-term stability of the reach. The lower reach is also wide and trapezoidal, but very steep. This section is lined with geotextile fabric and rock. During the tour of this area, it was observed that the bed of the lower reach is incising immediately downstream of the break in slope between the upper and lower reach and a headcut is eroding into the upper reach. This unstable condition is probably the result of a number of interrelated factors, including the unusually high shear stresses generated through the entrenched upper reach and at the point where the slope suddenly increases at the upstream end of the lower reach, the morphology of the channel in the steep reach, the size of rock used to stabilize the reach, and flow eroding material from beneath the fabric. The natural reach immediately downstream exhibited heavy sedimentation. If not corrected, the headcut will continue upstream, destabilizing the upper reach.

7. Physicochemical Properties

Although no water quality data was available for this assessment, Maggard and Kirk (1998) monitoring streams draining similar mining/valley fill operations found that several water quality parameters had varied from pre-mining levels. Their data indicates that conductivity, total dissolved solids, hardness, alkalinity, sulfates, sodium, calcium, and magnesium had increased significantly. Their findings may apply to the receiving streams on this site.

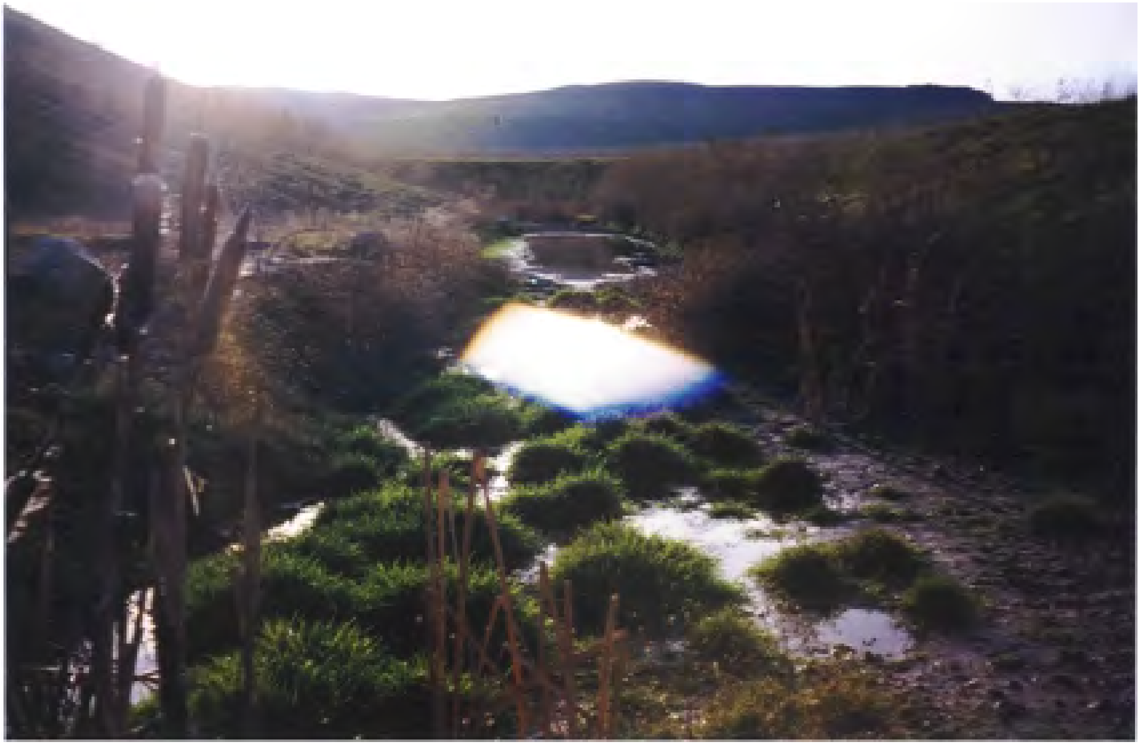
R.E.I. Consultants, Inc. (1999) evaluated the water quality of sedimentation ponds constructed on similar mining sites. They found that water quality varied considerably with the age of the facilities. For example, pH ranged from 5.04 - 8.77, in newer and older ponds respectively. They reported that most of the chemical values (e.g., dissolved solids, hardness, alkalinity, sulfates, and most metals) were initially fairly high, diminishing somewhat with the age of the structure. These findings may apply to the ponds on this site.

8. Biotic Communities, Trophic Structure, and Energy Sources

No biological data was available for this assessment. However, Maggard and Kirk (1998) monitoring streams below similar mining/valley fill operations found that the benthic macroinvertebrate community shifted toward more pollution tolerant species. Their data indicates that the number of individuals and taxa richness increased, while diversity and evenness decreased. These findings may apply to the tributaries of Cabin Creek and White Oak Creek.

R.E.I. Consultants, Inc. (1999) evaluated the biological communities in sedimentation ponds constructed on similar mining sites. The biotic communities that have developed in these facilities include species typical of a lentic ecosystem. Macrophytes and filamentous algae provide primary production. Allochthonous material enters these sites as litterfall from forests on adjacent hillslopes.

The benthic macroinvertebrate community is composed of typical pond species (e.g., Diptera, Coleoptera, Hemiptera, Odonata, and Oligochaeta. The communities in the newer facilities exhibited low abundance and diversity, and were represented predominantly by very pollution tolerant species. The older facilities, where water quality was better and vegetation was abundant, exhibited higher abundance and diversity. Species present were still primarily pollution tolerant organisms. The fish community was not represented in the ditches and ponds. It is not likely that these structures will provide habitat for amphibians since most amphibian species are very sensitive to poor water quality.



Ditch draining upper sedimentation pond.

Ditch draining upper sedimentation pond

On-line sedimentation pond downstream of valley fill

Concrete spillway of on-line sedimentation pond

Wetland ponds downstream of sedimentation pond. Photo shows runoff ditch to right of wetland ponds. This ditch conveys baseflow and stormflows.

Runoff ditch along right valley wall adjacent to wetland ponds

Headcut erosion at break in slope at downstream end of runoff ditch

Headcut erosion working upstream through steep section of runoff ditch

Heavy sedimentation in receiving stream below runoff ditch

Heavy sedimentation in receiving stream below runoff ditch

3. Pen Coal Corporation
Kiah Creek Mine

a. General

This mine is located near the town of Ferrellsburg, West Virginia. The operations at this site consist of ridgetop and contour surface mining utilizing truck and loader methods. The streams draining the site include first and second order tributaries to Vance Branch of Trough Fork and Rollem Fork of Kiah Creek, which are part of the East Fork of Twelvepole Creek drainage system. The mining operation will produce approximately 360 million cubic yards of overburden. Approximately 25% (9 0 million cubic yards) of that material will be disposed of in the proposed valley fills. The valley fills are composed of durable rock fill built in 50 to 100 foot lifts.

Stormwater runoff conveyance and sediment control are provided for via a network of combination ditches, groin ditches, and sedimentation ponds. This network is designed to convey all storm flows up to and including the 100 year runoff event and sediment that is eroded and transported from exposed surfaces. The combination ditches collect and convey stormwater flow around the perimeter of the valley fill. Although the dimensions of the ditches vary with drainage area, they are commonly constructed with 10 - 15 foot bottom widths and 6 – 8 foot depth. They have a relatively flat gradient and stone weirs are spaced regularly along the ditches to improve sedimentation rates. The ditches are stabilized with a grass mix. Groin ditches convey stormwater flow down the face of the valley fill. They are usually 10 – 15 feet wide. Although, breaks in slope occur at the benches where the perimeter ditches contribute their flow, the groin ditches are generally very steep. Groin ditches are lined with large rock to provide stabilization. Sedimentation ponds are constructed on the benches along the valley fill and at the base of the valley fill to capture and retain sediment transported off the exposed valley fill or active mining areas. The ponds are sized to manage the entire disturbed area. Some of the ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. Where this baseflow discharges into the sedimentation ponds they retain a permanent pool. In other areas baseflow from the streams buried beneath the valley fill discharges into the ponds providing a permanent pool. Such is the case with the ponds that outfall immediately upslope from the receiving streams, Vance Branch and Rollem Fork.

d. Evaluation of Current Practices

1. Watershed/Valley Characteristics

In the areas toured the majority of the operations were contour mining. Ridgetop mining made up only a small percentage of the overall mining activity. Consequently, the amount of valley fill and disturbance to ridgelines was significantly less than observed on other mining sites where ridgetop mining made up the larger percentage of the operations.

The pre-mining difference in elevational relief from the ridgelines to the valley floors was fairly significant. In areas of ridgetop mining/valley fill the elevational difference between the original ridgelines and valley floors fill have been significantly reduced. Contour grading and backstacking of overburden has restored some of the relief.

Although the overall valley slope of the watershed was greater than 10%, pre-mining the down-valley profile included areas of varying slopes. Some valley reaches were very steep, while other reaches had a fairly gentle slope. In the valley fill areas, current reclamation practices have created a down valley slope that is uniformly moderate along the top of the fill and uniformly steep down the face of the fill.

The pre-mining cross-section of the valley also exhibited variability. Hillslopes were characterized by natural breaks where the form and gradient of the slopes changed from steep and convex to relatively gentle and concave and back to steep and convex. Reconstructed landform is still predominantly linear on this site.

2. Vegetative Cover

On this site clearing and grubbing of vegetation was mostly restricted to the areas to be mined. Consequently, the undisturbed ridgelines and hillslopes above and below the areas of contour mining are still heavily forested. Recently reclaimed areas along Vance Branch and Rollem Fork were seeded with a grass mix and appeared to have a dense grass cover. Some unmined valley floor areas were cleared to accommodate construction of access roads, sedimentation ponds, relocation of the stream channel, and floodplain fill. These areas were seeded with a grass/clover mix and appeared to have a dense grass cover.

A reclamation site along Frank's Branch was toured to observe a reforestation effort that was completed 10 years ago. One area appeared to be progressing very well. In addition to the initial plantings, it was evident that volunteer species were doing well. This has probably increased overall diversity of this early-successional vegetative community. The overall vegetation was dense enough, even without foliage, to make it difficult to determine the location of the groin ditch routed down the face of the valley fill. Interestingly, an area immediately adjacent on the same slope had experienced rill and gully erosion immediately after reclamation. The area had been repaired, stabilized with a grass mix (that included K-31) and reforested. Although, the two areas were the same age, this slope area was still covered in grass with only a few widely scattered shrubs.

3. Soil Characteristics

The valley fill is a durable rock fill laid down in lifts. The native topsoil and subsoil layers were removed as part of the mining operation. They were not separated and stockpiled for reuse during reclamation. The material laid down during reclamation is a coarse mixture of rock and other overburden material (e.g., sandstone, limestone, clay, shale, subsoils). This valley fill material has a very high percentage of mineral soil and very low percentage of organic matter. Because this material makes a very poor growth medium for reestablishing a forest a 6-inch layer of topsoil is added overall reclaimed areas. No information was available regarding permeability or infiltration rates of the valley fill material. However, Mr. Randy Maggard (personal communication) characterized this unconsolidated material as a "psuedo-karst" landscape, composed of varying types of rock and soil that will be permeable in some areas and impermeable in others. Another factor affecting the permeability of the fill material is mechanical compaction of the fill surface by heavy equipment.

4. Hydrologic Regime

Some of the combination ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. These ditches support wetland vegetation. The baseflows are also maintaining a permanent pool in all the sedimentation ponds observed. Many of the ponds exhibited a dense growth of wetland vegetation around their margins. Although no data was available relative to the volume and time of concentration of storm flows, based on the characteristics of the fill material, compaction of the fill surface, and a relatively sparse vegetative cover, it is likely that the volume of runoff is significantly greater than under pre-mining conditions. It is also likely that the time of concentration for these flow events have been reduced with the potential to affect downstream reaches. The combination ditch/groin ditch/sedimentation pond systems help detain runoff and therefore may be providing some management for the increased storm flows.

5. Sediment Regime

No data was available to allow a quantitative comparison of erosion and sediment transport rates. However, it is likely that erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are significantly higher than pre-mining conditions. However, it appears that disturbed areas routed to the combination ditch/groin ditch/sedimentation pond systems are being managed effectively thereby limiting actual sediment loadings to the receiving streams. Erosion of the stream bed and banks in areas that adjust to accommodate the increased storm flow volumes provides a potential unmanaged source of sediment to downstream reaches.

6. Channel Morphology

Based on a review of the site maps provided, it appears that approximately 8000 linear feet of first and second order streams were permanently impacted by valley fill in the Rollem Fork area. Another 3200 linear feet stream channel (and adjacent floodplain) of Rollem Fork have been temporarily impacted for the construction and maintenance of the sedimentation ponds. It is important to note that the contour mining operations on this site have significantly reduced the potential impact on the Rollem Fork system relative to the impacts observed at other sites where ridgetop mining operations dominate.

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The combination ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. There are no discernible bed features (i.e., riffle-pools) in the combination ditches. However, several of the groin ditches appeared to be developing a step-pool morphology. Since the channels are designed to convey runoff from larger storm events all flows are confined to that one channel. They were not designed to have a baseflow, and bankfull channel with and adjacent floodplain. It should be noted that the constructed channels appeared to be stable and functioning as designed.

7. Physicochemical Properties

Pen Coal Company at their mining sites has collected stream and pond water quality data. Although no stream data was available for the sites evaluated in this assessment, Maggard and Kirk (1998) monitoring streams draining other Pen Coal mining sites found that several water quality parameters had varied from pre-mining levels. Their data indicates that conductivity, total dissolved solids, hardness, alkalinity, sulfates, sodium, calcium, and magnesium had increased significantly. These trends in water quality may apply to the receiving streams on this site as well.

R.E.I. Consultants, Inc. (1999) evaluated the water quality of combination ditches and sedimentation ponds constructed in the Vance Branch, Rollem Fork, and the Left Fork of Parker Branch drainage basins. Water quality varied considerably between the sampling sites. For example, pH ranged from 5.04 - 8.77 in the ponds and from 5.32 – 9.39 in the combination ditches. They found that most of the chemical values (e.g., dissolved solids, hardness, alkalinity, sulfates, and most metals) were high. They found that water quality improved with the age of the structure.

8. Biotic Communities, Trophic Structure, and Energy Sources

Pen Coal Company has collected a considerable amount of stream and pond biological data at their mining sites. Although no stream data was available for the sites evaluated in this assessment, Maggard and Kirk (1998) found that the benthic macroinvertebrate communities downstream of mining/valley fill operations shifted toward more pollution tolerant species. Their data indicates that the number of individuals and taxa richness increased, while diversity and evenness decreased. These findings may apply to Rollem Fork and Vance Branch.

R.E.I. Consultants, Inc. (1999) evaluated the biological communities in the combination ditches and sedimentation ponds constructed in the Vance Branch, Rollem Fork, and the Left Fork of Parker Branch drainage basins. The biotic communities that have developed in the combination ditches and sedimentation ponds include species typical of a lentic ecosystem. Macrophytes and filamentous algae provide primary production. Allochthonous material enters these sites as litterfall from forests on adjacent hillslopes.

The benthic macroinvertebrate community is composed of typical pond species (e.g., Diptera, Coleoptera, Hemiptera, Odonata, and Oligochaeta. The communities in the newer facilities exhibited low abundance and diversity, and were represented predominantly by very pollution tolerant species. The older facilities, where water quality was better and vegetation was abundant, exhibited higher abundance and diversity. Species present were still primarily pollution tolerant organisms. The fish community was not represented in the ditches and ponds. It is not likely that these structures will provide habitat for amphibians since most amphibian species are very sensitive to poor water quality.

Combination ditch with ponded baseflow

Outfall of combination ditch. Baseflow has gone subsurface into valley fill.

Combination ditch with baseflow supporting wetland vegetation

Wetland vegetation and filamentous algae in combination ditch

Groin ditches convey storm flow down face of valley fill

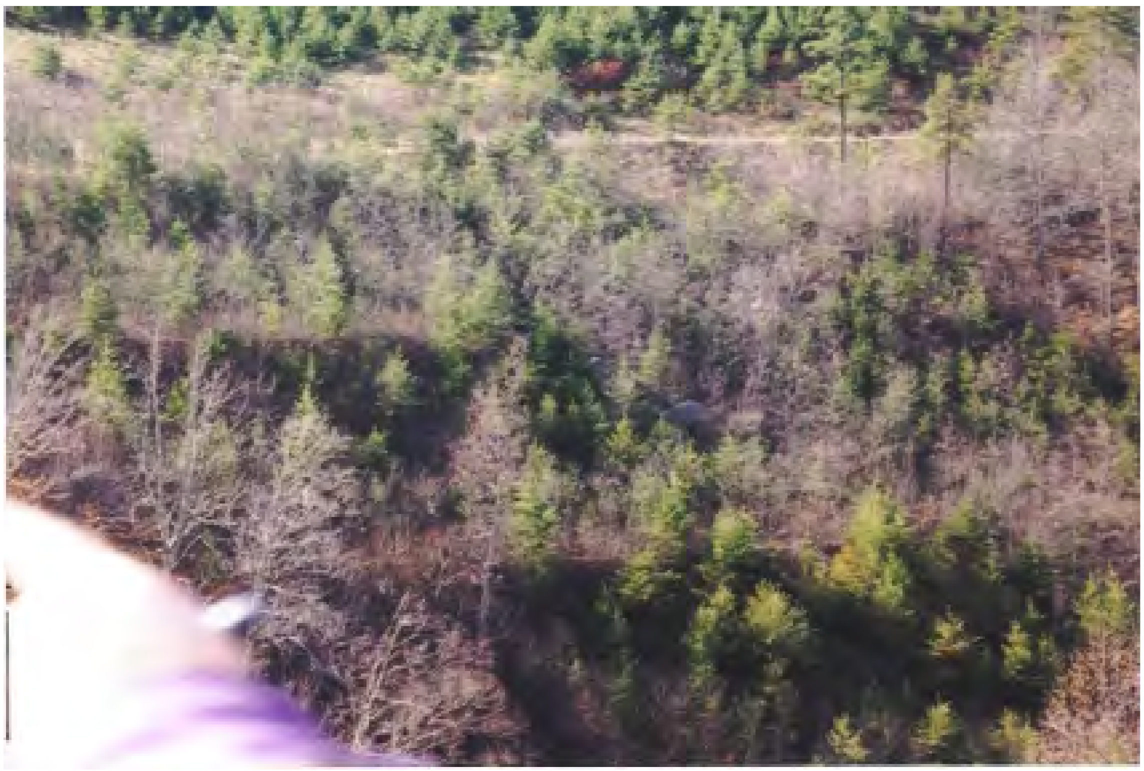
Groin ditch from upper sedimentation pond.
Photo shows outfall pipes from pond and early evolution of
“natural” channel within ditch.

Groin ditch into first of lower sedimentation ponds in series

Relocated reach of Rollem Fork.

Photo shows undisturbed forested hillslope to left and floodplain fill to right.

Reforestation of old valley fill along Frank’s Branch.



Reforestation of old valley fill.
Groin ditch barely visible in center of photo.

4. Arch Coal Company
Hobet # 21 Mine

a. General

This mine is located near the town of Madison, West Virginia. The operations at this site consist of ridgetop surface mining utilizing walking dragline and electric shovel methods. The streams draining the site include first and second order tributaries to Little Coal River and Mud River which are part of the Guyandotte River Creek drainage system. Approximately 30 -35% of the overburden material removed will be disposed of in valley fills. The valley fills are composed of durable rock fill built in 50 to 100 foot lifts.

Stormwater runoff conveyance and sediment control are provided for via a network of combination ditches, groin ditches, and sedimentation ponds. This network is designed to convey all storm flows up to and including the 100-year runoff event and sediment that is eroded and transported from exposed surfaces. The combination ditches collect and convey stormwater flow around the perimeter of the valley fill. Although the dimensions of the ditches vary with drainage area, they are commonly constructed with 10 - 15 foot bottom widths and 6 – 8 foot depth. They have a relatively flat gradient and stone weirs are spaced regularly along the ditches to improve sedimentation rates. The ditches are stabilized with a grass mix. Groin ditches convey stormwater flow down the face of the valley fill. They are usually 10 – 15 feet wide. Although breaks in slope occur at the benches where the perimeter ditches contribute their flow, the groin ditches are generally very steep. Groin ditches are lined with large rock to provide stabilization. Sedimentation ponds are constructed at points along the combination ditches on top of the valley fill. Although the tour did not include the base of the valley fill presumably ponds have been constructed there as well. This system serves to convey storm runoff and capture and retain sediment transported off the exposed valley fill or active mining areas. The ponds are sized to manage the entire disturbed area. . Some of the ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. Where this baseflow discharges into the sedimentation ponds they retain a permanent pool. In other areas baseflow from the streams buried beneath the valley fill discharges into the ponds providing a permanent pool.

e. Evaluation of Current Practices

1. Watershed/Valley Characteristics

Operations on this site involve surface mining of ridgetops. Consequently, the amount of valley fill and disturbance to ridgelines is significant. The pre-mining difference in elevational relief from the ridgelines to the valley floors was fairly significant. Removal of ridgetops and disposal of overburden in valley fill has significantly reduced the elevational difference between the original ridgelines and valley floors. Contour/landform grading and backstacking of overburden to heights of 100 feet has restored some of the relief and natural landform.

Although the overall valley slope of the watershed was greater than 10%, pre-mining the down-valley profile included areas of varying slopes. Some valley reaches were very steep, while other reaches had a fairly gentle slope. In the valley fill areas, current reclamation practices have created a down valley slope that is uniformly moderate along the top of the fill and uniformly steep down the face of the fill.

The pre-mining cross-section of the valley also exhibited variability. Hillslopes were characterized by natural breaks where the form and gradient of the slopes changed from steep and convex to relatively gentle and concave and back to steep and convex. Reclamation has restored some of the valley cross-section along the ridgelines. Although the valley floor sits much higher in elevation, in some areas there has been an obvious effort to recreate the swale and meander associated with a naturally formed valley floor. The oldest area observed was reclaimed in the early 1980's. Reclamation of this area involved 250 feet of conventional fill with four-foot lifts and a chimney core drain down the center of the valley fill. In this area the valley fill is predominantly linear with a uniform slope.

2. Vegetative Cover

On this site all vegetation was cleared and grubbed prior to the mining operation commencing. Reclaimed areas were seeded with a grass mix. A few areas have been densely planted with one or two species of shrubs and trees.

The new valley floor in the older (1980's) reclamation area is predominantly grasses with scattered shrubs and trees and the adjacent slopes have a fairly good cover of trees. However, the revegetation effort on these slopes has resulted in an even-aged stand that lacks the species diversity and multi-layered vertical structure of a natural forest.

Most of the stabilized areas on site are covered with grasses and a few widely scattered volunteer shrubs. The remnant forests on site were isolated on undisturbed hillslopes adjacent to downstream reaches and unmined ridgelines.

3. Soil Characteristics

The valley fill is a durable rock fill laid down in lifts. The native topsoil and subsoil layers were removed as part of the mining operation. They were not separated and stockpiled for reuse during reclamation. The material laid down during reclamation is a coarse mixture of rock and other overburden material (e.g., sandstone, limestone, clay, shale, subsoils). This valley fill material has a very high percentage of mineral soil and very low percentage of organic matter. This material makes a very poor growth medium for reestablishing a forest. No information was available regarding permeability or infiltration rates of the valley fill material. However, since this unconsolidated material is composed of varying types of rock and soil it is likely that some areas will be permeable and other areas will be impermeable. Another factor affecting the permeability of the fill material is mechanical compaction of the fill surface by heavy equipment.

4. Hydrologic Regime

Some of the combination ditches intercept groundwater at the back edge of the cut along the down dip side of the valley fill and therefore carry a baseflow. These ditches support wetland vegetation. The baseflows are also maintaining a permanent pool in all the sedimentation ponds observed. Many of the ponds exhibited a dense growth of wetland vegetation around their margins. Although no data was available relative to the volume and time of concentration of storm flows, based on the characteristics of the fill material, compaction of the fill surface, and a relatively sparse vegetative cover, it is likely that the volume of runoff is significantly greater than under pre-mining conditions. It is also likely that the time of concentration for these flow events has been reduced with the potential to effect downstream reaches. The combination ditch/groin ditch/sedimentation pond systems help detain runoff and may provide some management of the increased storm flows.

5. Sediment Regime

No data was available to allow a quantitative comparison of erosion and sediment transport rates. However, it is likely that erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are significantly higher than pre-mining conditions. However, it appears that disturbed areas routed to the combination ditch/groin ditch/sedimentation pond systems are being managed effectively thereby limiting actual sediment loadings to the receiving streams. Erosion of the stream bed and banks in areas that adjust to accommodate the increased storm flow volumes may provide one unmanaged source of sediment to downstream reaches.

6. Channel Morphology

No information was available to determine the linear feet of first and second order streams permanently impacted by the valley fills. However, given the size of the fill areas observed during the tour the total stream length impacted is probably fairly substantial (i.e., several miles).

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The combination ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. There are no discernible bed features (i.e., riffle-pools) in the combination ditches. Since the channels are designed to convey runoff from larger storm events all flows are confined to that one channel. They were not designed to have a baseflow and bankfull channel with and adjacent floodplain. It should be noted that the constructed channels appeared to be stable and functioning as designed.

During the tour a combination channel in the Stanley Fork drainage basin was observed. This channel was constructed along the edge of a cut-slope and valley fill on the down dip side of the valley. Completed in 1995, it carries a baseflow and supports wetland vegetation. This drainage system also includes a series of shallow ponds and wetlands. The constructed channel is routed away from the face of the valley fill outfalling instead down an undisturbed forested hillslope. The result of this design has been to initiate the carving of a channel down a slope where none had previously existed. At the time of the tour it was evident that this channel is in its early evolutionary stages and would be characterized as a gully or G stream type (Rosgen, 1994). Although, the upper 200 feet of this reach is relatively stable, the lower sections are very unstable. Scour and degradation of the channel bed is proceeding in a downslope direction as a result of concentrated flows directed over these extremely steep slopes. In addition, a significant headcut was observed eroding upslope. This channel will continue to adjust for some time to come. Eventually it may erode to bedrock. This condition and/or the accumulation of large woody debris (LWD) will arrest the bed degradation and provide vertical control. Lateral adjustment will continue until the channel has carved the dimensions necessary to convey the bankfull and greater storm flows. Until this channel has reached a state of equilibrium it will be a significant source of sediment to downstream reaches. It is not known if this channel represents a common situation on this or other mining sites.

7. Physicochemical Properties

Although no receiving stream water quality data was available for this site, Maggard and Kirk (1998) monitoring streams draining other mountaintop mining/valley fill sites found that several water quality parameters had varied from pre-mining levels. Their data indicates that conductivity, total dissolved solids, hardness, alkalinity, sulfates, sodium, calcium, and magnesium had increased significantly. These trends in water quality may apply to the receiving streams on this site as well.

R.E.I. Consultants, Inc. (1999) evaluated the water quality of combination ditches and sedimentation ponds constructed on other similar mining sites. Water quality varied considerably between their sampling sites. For example, pH ranged from 5.04 - 8.77 in the ponds and from 5.32 – 9.39 in the combination ditches. They found that most of the chemical values (e.g., dissolved solids, hardness, alkalinity, sulfates, and most metals) were high. They found that water quality improved with the age of the structure. Their findings may apply to the water quality of the combination ditches and ponds on this site.

8. Biotic Communities, Trophic Structure, and Energy Sources

Although no receiving stream biological data was available for this site, Maggard and Kirk (1998) found that the benthic macroinvertebrate community downstream of mining/valley fill operations shifted toward more pollution tolerant species. Their data indicates that the number of individuals and taxa richness increased, while diversity and evenness decreased. These findings may apply to the tributaries of Little Coal River and Mud River downstream of this site.

R.E.I. Consultants, Inc. (1999) evaluated the biological communities in the combination ditches and sedimentation ponds constructed on other mining sites. The biotic communities that have developed in the combination ditches and sedimentation ponds include species typical of a lentic ecosystem. Macrophytes and filamentous algae provide primary production.

The benthic macroinvertebrate community is composed of typical pond species (e.g., Diptera, Coleoptera, Hemiptera, Odonata, and Oligochaeta. The communities in the newer facilities exhibited low abundance and diversity, and were represented predominantly by very pollution tolerant species. The older facilities, where water quality was better and vegetation was abundant, exhibited higher abundance and diversity. Species present were still primarily pollution tolerant organisms. The fish community was not represented in the ditches and ponds. In the short-term, it is unlikely that these structures will provide habitat for amphibians since most amphibian species are very sensitive to poor water quality.

Reclaimed area (1990).
Photo shows restored ridgelines, ponds, wetlands, and reforestation.

Recently reclaimed area with restored ridgelines and wetland system on valley fill

Face of recent valley fill

Combination ditch with baseflow

Combination ditch with baseflow. Photo shows wetland vegetation along margins of ditch.

Outfall of combination ditch routed over undisturbed forested hillslope

Gully erosion on forested hillslope. Headcut eroding in an upslope direction.

Summary of Findings

The results of this assessment indicate that current mining and reclamation practices result in significant adverse impacts to the first and second order stream ecosystems on mountaintop mining/valley fill sites. At all four sites evaluated watershed and stream characteristics have been significantly, and in most cases, permanently altered.

The shape, slope, size and aspect of the watersheds and valleys have been altered. Removal of ridgetops and raising of valley floors by disposal of overburden in valley fills have significantly reduced the pre-mining difference in elevational relief between the ridgelines and valley floors. The natural variability characteristic of valley profiles and cross-sections has been replaced with linear landforms and uniform slopes. Reclamation has reduced the size of the drainage area for some sites and enlarged it for others. Drainage patterns have been altered from the characteristic dendritic pattern to one best described as a modified trellis. Although the watersheds have no common aspect or orientation, for some reclaimed sites their original aspect has been modified.

Some sites have incorporated contour/landform grading and backstacking of overburden into their reclamation operations. The results of these efforts were obvious in restored elevational relief and more natural ridgelines. However, the watersheds and valleys are still very different than under pre-mining conditions. Some, perhaps all of these differences have the potential to modify the influence of prevailing winds, precipitation, and insolation on the hydrologic regime, soil characteristics, vegetative communities, and channel morphology which, in turn, effect the physical, chemical and biological characteristics of the stream ecosystem.

The creation of steep uniform slopes, disruption of the native soil and geologic strata by the mining operations, construction of fill surfaces with highly variable permeability, compaction of soils by heavy equipment, and alteration from forest to grassland all serve to modify the hydrologic regime of the sites. The result of these modifications is increased storm flow volumes and decreased time of concentration relative to pre-mining forested conditions. Although, the combination ditch/groin ditch/sedimentation pond systems are designed to convey storm runoff, it is unclear how effective these systems are at actually managing the increased flows and restoring the pre-mining hydrology.

In addition to the effects on hydrology mentioned above, the alterations in soil characteristics make the sites poorly suited for reestablishing forest cover. The soils are very sterile, that is, high in mineral content and low in organic matter content. The unconsolidated nature of the fills results in some areas with extremely high permeability rates typified by droughty soil conditions while other areas that have relatively low permeability rates typified by perched water conditions. Neither situation is conducive to reestablishing a natural forest. Soil conditions will naturally improve with time. However, until suitable soil characteristics redevelop the vegetative cover will be limited to grasses and scattered shrubs. The situation is exacerbated by the lack of potential seed banks adjacent to reclaimed areas on many sites. This situation is due to the complete removal or isolation of mature forests from the reclamation sites. Sites where forested ridgelines or hillslopes are adjacent to reclaimed areas may provide a source of pioneer species. However, without substantial changes to current practices reestablishing natural forest conditions on most of these sites could take as long as 400-500 years (S. Handel, personal communication).

Erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are probably much higher than under pre-mining conditions. The combination ditch/groin ditch/sedimentation pond systems are being managed effectively and limit the actual sediment loadings to the receiving streams. However, erosion of the streambed and banks in areas that adjust to accommodate the increased storm flow volumes provide a potential unmanaged source of sediment to downstream reaches. Two specific problem areas were pointed out in the *Assessment Results* section. The first area involved an entrenched runoff ditch that was experiencing headcut erosion at the break in slope where the channel gradient suddenly increased. The second site involved a combination ditch that had been routed away from the face of the valley fill outfalling down an undisturbed forested hillslope. The results of this situation were even more severe. Scour and degradation of the channel bed is proceeding in a downslope direction and a significant headcut is eroding upslope. Until these channels have been stabilized or naturally evolve to a state of equilibrium they will be significant sources of sediment to downstream reaches. It is not known if these cases represent common situations on surface mining sites.

If the size of the valley fill areas observed during the tour is representative of mountaintop mining/valley fill operations, the total stream length of first and second order streams that could be impacted by current and future surface mining operations is substantial. Utilizing information from these sites it is estimated that approximately 10 linear feet of stream channel are directly and permanently impacted (i.e., buried beneath valley fills) for each acre of surface mining. An additional 3 feet of stream channel are directly and temporarily impacted (i.e., construction of on-line sedimentation ponds) for each acre of surface mining. This equates to 12,000 linear feet (2.27 miles) of permanent impacts and 3600 linear feet (0.68 miles) of temporary impacts or a total of 15,600 linear feet (2.95 miles) of impacts on a 1200-acre surface mining site. These numbers raise two critical questions. Can these impacts be avoided? How can unavoidable impacts be minimized and/or mitigated?

Consideration is being given to mitigating for the adverse impacts to the natural channels on surface mining sites by creating aquatic habitat in the drainage systems (i.e., ditches and ponds) routinely constructed to convey runoff and control sediment eroded from the disturbed areas on site. On a linear foot basis this should be feasible since an equivalent number of miles (or greater) of channel are created in the combination and groin ditches.

The critical issue is whether the constructed drainage systems can mitigate for the impacts to the natural stream ecosystems on the surface mining sites. The results of this assessment provide insight on this issue.

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The combination ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. There are no discernible bed features (i.e., riffle-pools, step-pools) in the ditches. These ditches were designed to convey runoff from larger storm events with all flows confined to one channel. They were not designed to have a baseflow and bankfull channel and an adjacent floodprone area.

Most of the drainage systems observed during the tour carry storm flow only (i.e., during and immediately following storm events). Only a few sites were observed where these ditches and ponds had been constructed along the edge of a cut-slope and valley fill on the down dip side of the valley. These ditches and ponds do carry a baseflow. Most of these drainage systems support wetland vegetation. The more complex systems include combination ditches and a series of shallow ponds and wetlands.

Although biotic communities have developed in many of the ditches and ponds the species present are typical of lentic ecosystems. Abundance and diversity are low and most species are very pollution tolerant. The structure of the biotic community is in part due to channel morphology (wide, shallow and low gradient) and flow conditions (i.e., slow moving or standing/ponded water). It is also influenced by poor water quality and a lack of vegetation.

Woody vegetation in the riparian zone is sparse or non-existent. No obvious attempts have been made to plant trees or shrubs in these areas. Consequently, macrophytes and filamentous algae provide primary production in these systems.

The results of this assessment indicate that first and second order stream ecosystems are being significantly impacted by mountaintop mining/valley fill operations. Current mining and reclamation practices have not been effective at avoiding or minimizing adverse impacts to these stream ecosystems and aquatic habitat enhancement in the constructed drainage systems does not mitigate (i.e., replace) the natural structure and function of the first and second order stream ecosystems that existed pre-mining. .

Summary of Recommendations

This section focuses on recommended approaches for minimizing and mitigating unavoidable adverse impacts to first and second order stream ecosystems on mountaintop mining/valley fill sites.

1. Modifications to Overburden Disposal and Reclamation Practices

Current mountaintop mining/valley fill practices involve the removal of overburden from ridgetops to expose the coal seam(s) for mining. The overburden removed is disposed of in the adjacent stream valleys. Valley fill is usually laid down in 50 to 100 foot lifts. The new valley floor (i.e., top of valley fill) may be 400-600 feet above the original valley floor. Generally, lifts are constructed such that the face of successively higher lifts is set back 25-40 feet from the lift immediately below it. This creates a bench of uniform width across the valley fill. Removal of ridgetops and disposal of overburden in valley fill significantly reduces the elevational difference between the original ridgelines and valley floors. In the valley fill areas, current reclamation practices create a down valley slope that is uniformly moderate along the top of the fill and uniformly steep down the face of the fill. The reconstructed landform is predominantly linear and uniform on most sites.

Landform grading and backstacking of overburden to heights of 200 –300 feet would restore some of the relief and natural landform of the ridgelines. The backstacking to higher elevations would also provide additional upland disposal areas thereby reducing the volume of overburden placed in valley fills. Although millions of cubic yards of overburden material are removed during the mining operation, regulation requires that the bulk (80%) of the material segregated for disposal as valley fill must have been determined to be durable and geochemically suitable. A portion of the overburden removed will be unsuitable for valley fill disposal. It would seem that these requirements would encourage the disposal of overburden material in upland areas as opposed to the valley fills.

Landform grading and modifying construction practices for the fill lifts could restore the natural form and slope of the valleys. This would involve constructing irregular lifts of varying face height and bench width. For example, a series of 15-foot high lifts with 10 foot wide benches might be followed by a series of 5 foot high lifts with 50 foot wide benches. Lifts could be constructed such that those along the margins of the fill at the interface with the hillslopes extend further out while those toward the center of the valley fill are inset. The left side of a lift could be constructed higher than the right side to provide variable cross-valley slopes.

Utilizing this approach, valleys could be recreated with a down-valley profile that includes areas of varying slopes. Some valley reaches would be very steep, while other reaches would have moderate or even fairly gentle slope. The variability exhibited by the pre-mining valley cross-section could be restored creating ridgelines and hillslopes with natural breaks where the form and gradient of the slopes change from steep and convex to gentle and concave and back to steep and convex. Although the valley floor would still sit much higher in elevation, the swale and meander associated with a naturally formed valley floor could be recreated.

The characteristics of the fill material itself should be modified. The upper layers must be amended to provide a growth medium suitable for reestablishing a natural forest. This could be accomplished by working in stages. The first stage would involve laying down a layer of mulch and topsoil. The mulch can be prepared from the vegetation cleared and grubbed from a new surface mining site. The topsoil can be salvaged from that same surface mining site as well. After the soil has been prepared it is fertilized and seeded with a grass mix of rye and clovers and native meadow grasses.

To initiate the process of reestablishing a natural forest, a variety of native of tree and shrub pioneering species should be planted on the newly reconstructed ridgelines and hillslopes and along the valley floors, concentrating on the drainage ways. This vegetative community should be established (10-15 years) prior to the introduction of native tree and shrub forest species. Where reclaimed areas are adjacent to undisturbed forests this successional process may be accelerated.

2. Restoration of stream channels and floodplains

Opportunities for restoration of existing streams were harder to identify where ridgetop mining operations were predominant and valley fills had been extensive. For example, removal of on-line ponds from all the tributaries to Mudlick and Stollings Creek at Elk Run's East of Stollings Mine site would recapture approximately 1800 linear feet of stream channel with the two longest individual reaches being less than 500 feet each and the rest ranging from 100 – 250 linear feet. However, on sites where contour mining was predominant and valley fills had not been as extensive a number of restoration opportunities exist. For example, removal of on-line sedimentation ponds, floodplain fill, and sections of access road from Rollem Fork at Pen Coal's Kiah Creek Mine site would recapture approximately 3600 feet of stream channel.

Rollem Fork provides an excellent example for presenting recommendations for restoration of stream channels and floodplains. Rollem Fork appears to have been relocated at some time in the past. Floodplain fill resulting from construction of the pond berms, disposal of sediment removed from the ponds, and construction of the access road has confined the stream between the fill and the adjacent hillslope. This condition has created an entrenched G stream type channel. Woody riparian vegetation is sparse along the fill side of the channel. One restoration approach would involve lowering of the pond berms, and removal of floodplain fill and sections of access road. The existing stream channel should be relocated away from the hillslope and towards the center of the valley floor. This would also provide a floodprone area to accommodate overbank flows. The off-line ponds at the base of valley fill and in the floodplain could be combined and reconstructed as one large freshwater marsh with varying hydrologic regimes (i.e., permanently flooded, seasonally flooded and seasonally saturated). The outfall pipes should be removed. The new outfall to this freshwater marsh/pond would be a small E stream type channel that meanders along the floodplain before emptying into Rollem Fork. The margins and seasonally saturated areas could be planted with trees and shrubs and the flooded areas with emergent vegetation. The riparian zone along both banks of the stream should be heavily planted with native trees and shrubs.

3. Modifications to design of combination ditch/groin ditch/sedimentation ponds

Many of the combination ditches and groin ditches observed convey storm flows only. Most of them appeared to be stable and functioning as designed. Unless baseflow can be diverted to these channels, there is no reason to modify them. Where opportunities exist to capture groundwater and generate a baseflow, the channels should be constructed with natural channel morphology including planform, profile, and cross-sectional geometry. Vertical and horizontal controls and flow diverting structures should be installed to stabilize the channel bed and banks.

The design of these natural channels would include baseflow and bankfull channels and floodprone areas. The channel form should be consistent with that appropriate for the valley type in which they will be constructed. For example, the steeper reaches (i.e., down the face of the fill) of a groin ditch redesigned as a natural stream channel would have the characteristics of an A or Aa+ stream type with a step-pool morphology. The lower gradient reaches (i.e., across the top of the bench) of groin ditches and most combination ditches redesigned as a natural channel would have the characteristics of B, C or E stream types. Selection of the appropriate stream type would be guided by the characteristics of stream types and valley types presented in A Classification of Natural Rivers (Rosgen, 1994) and Applied River Morphology (Rosgen, 1996).

Specific design parameters would be developed utilizing a Natural Channel Design Approach that includes: the use of regional hydrologic and hydraulic geometry curves; channel morphology data obtained from field surveys of stable reference reaches of the same stream type as that determined to be appropriate for the particular on-site situation; vertical bed control provided by boulder and log drop structures, rock sills, cross vanes, etc.; horizontal bank control provided by toe boulders, soil fabric lifts, and dense growth of trees and shrubs along the banks and in the adjacent riparian zone. Flow diverting structures (e.g., rock vanes j-hook vanes, cross vanes, w-weirs, etc.) can take stress off the banks by diverting flows toward the center of the channel. The vertical and horizontal controls and flow diverting structures are installed and key points along the channel. They stabilize the channel bed and banks as well as create and maintain diversity of channel features and habitat. Sedimentation ponds can be redesigned to create shallow marsh and open water habitats in the floodprone areas adjacent to the lower gradient channels (i.e., C and E stream types). Plantings of submerged aquatic, emergent, and woody vegetation would improve water quality and enhance the habitat for benthic macroinvertebrates, amphibians, reptiles and waterfowl. The natural channel design approach has the greatest chance for success if it also incorporates the modifications to valley fill practices presented above.

AN EVALUATION OF AQUATIC ECOSYSTEM ENHANCEMENT AT FOUR MOUNTAINTOP MINING/VALLEY FILL SITES IN WEST VIRGINIA

Summary for
Aquatic Ecosystem Enhancement at Mountaintop Mining Sites Symposium

by
Rocky O. Powell
Clear Creeks Consulting

In preparation for this symposium an assessment was conducted at four (4) mountaintop mining/valley fill sites in southwestern West Virginia. The purpose of the assessment was to evaluate the effectiveness of current mining and reclamation practices relative to minimizing and/or mitigating adverse impacts to stream ecosystems. During the symposium the findings of this evaluation were summarized and recommendations presented for improving current practices to better mitigate for unavoidable impacts. This paper provides a brief overview of the evaluation process, as well as a summary of the findings and recommendations.

Evaluating complex natural systems and the effects of alterations to one or more of their components is a difficult task. Although time and resource limitations precluded a more detailed assessment, to the extent practical a number of considerations were incorporated into the evaluation process. Based on a working knowledge and understanding of the structure and function of undisturbed first and second order watersheds/stream ecosystems a number of relevant questions were postulated:

1. Are the watershed/valley characteristics consistent with pre-mining conditions?
2. Is the vegetative cover consistent with pre-mining conditions?
3. Have the soil characteristics been modified?
4. Has the hydrologic regime been altered?
5. Has the sediment regime been modified?
6. Is the channel morphology of the mine drainage ditches consistent with a natural, stable channel form?
7. Has the channel morphology of the receiving streams been altered?
8. Are the physicochemical properties of the drainage ditches and ponds conducive to supporting the same or similar populations of aquatic organisms as the impacted first and second order streams?
9. Have the physicochemical properties of the receiving streams been altered?
10. Are the biotic communities, trophic structure, and energy sources of the drainage ditches and ponds the same or similar to the impacted first and second order streams?
11. Have the biotic communities, trophic structure, and energy sources of the receiving streams been altered?

The answers to these questions formed the basis for the evaluation process and guided the recommendations presented.

The results of this assessment indicate that current mining and reclamation practices result in significant adverse impacts to the first and second order stream ecosystems on mountaintop mining/valley fill sites.

The shape, slope, size and aspect of the watersheds and valleys have been altered. Removal of ridgetops and raising of valley floors by disposal of overburden in valley fills have significantly reduced the pre-mining difference in elevational relief between the ridgelines and valley floors. The natural variability characteristic of valley profiles and cross-sections has been replaced with linear landforms and uniform slopes. Reclamation has reduced the size of the drainage area for some sites and enlarged it for others. Drainage patterns have been altered from the characteristic dendritic pattern to one best described as a modified trellis. Although the watersheds have no common aspect or orientation, for some reclaimed sites their original aspect has been modified.

Some sites have incorporated contour/landform grading and backstacking of overburden into their reclamation operations. The results of these efforts were obvious in restored elevational relief and more natural ridgelines. However, the watersheds and valleys are still very different than under pre-mining conditions. Some, perhaps all of these differences have the potential to modify the influence of prevailing winds, precipitation, and insolation on the hydrologic regime, soil characteristics, vegetative communities, and channel morphology which, in turn, effect the physical, chemical and biological characteristics of the stream ecosystems.

The creation of steep uniform slopes, disruption of the native soil and geologic strata by the mining operations, construction of fill surfaces with highly variable permeability, compaction of soils by heavy equipment, and alteration from forest to grassland all serve to modify the hydrologic regime of the sites. The result of these modifications is increased storm flow volumes and decreased time of concentration relative to pre-mining forested conditions. Although, the combination ditch/groin ditch/sedimentation pond systems are designed to convey storm runoff, it is unclear how effective these systems are at actually managing the increased flows and restoring the pre-mining hydrology.

In addition, alterations in soil characteristics make the sites poorly suited for reestablishing forest cover. The soils are very sterile, that is, high in mineral content and low in organic matter content. The unconsolidated nature of the fills results in some areas with extremely high permeability rates typified by droughty soil conditions while other areas have relatively low permeability rates typified by perched water conditions. Neither situation is conducive to reestablishing a natural forest. Soil conditions will naturally improve with time. However, until suitable soil characteristics redevelop the vegetative cover will be limited to grasses and scattered shrubs. The situation is exacerbated by the lack of potential seed banks adjacent to reclaimed areas on many sites. This situation is due to the complete removal or isolation of mature forests from the reclamation sites. Sites where forested ridgelines or hillslopes are adjacent to reclaimed areas may provide a source of pioneer species. However, without substantial changes to current practices, reestablishing natural forest conditions on most of these sites could take a very long time.

Erosion and sediment transport rates from upland sources (i.e., active mining areas, valley fill areas, and adjacent disturbed areas) are probably much higher than under pre-mining conditions. The combination ditch/groin ditch/sedimentation pond systems are being managed effectively and appeared to limit the actual sediment loadings to the receiving streams. However, erosion of the streambed and banks in areas that adjust to accommodate the increased storm flow volumes provide a potential unmanaged source of sediment to downstream reaches. Unstable conditions that develop in the drainage system provide another source of sediment. Two specific problem areas were pointed out during the presentation.

Consideration is being given to mitigating for the adverse impacts to the natural channels on surface mining sites by creating aquatic habitat in the drainage systems (i.e., ditches and ponds) routinely constructed to convey runoff and control sediment eroded from the disturbed areas. On a linear foot basis this should be feasible since an equivalent number of miles (or greater) of channel are created in the combination and groin ditches.

The critical issue is whether the constructed drainage systems can mitigate for the impacts (i.e., replace the structure and function) to the natural stream ecosystems on the surface mining sites. The results of this assessment provide insight on this issue.

The morphology of the combination ditches and groin ditches are consistent with that of engineered drainage-ways, not natural stream channels. The combination ditches are wide, trapezoidal, and relatively flat. The groin ditches are also trapezoidal but very steep. There are no discernible bed features (i.e., riffle-pools, step-pools) in the ditches. These ditches were designed to convey runoff from larger storm events with all flows confined to one channel. They were not designed to have a baseflow and bankfull channel and an adjacent floodprone area.

Most of the drainage systems observed during the tour carry storm flow only (i.e., during and immediately following storm events). Only a few sites were observed where these ditches had been constructed along the edge of a cut-slope and valley fill on the down dip side of the valley. These ditches do carry a baseflow. Most of these drainage systems support wetland vegetation. The more complex systems include combination ditches and a series of shallow ponds and wetlands.

Although biotic communities have developed in many of the ditches and ponds the species present are typical of lentic ecosystems. Abundance and diversity are low and most species are very pollution tolerant. The structure of the biotic community is in part due to channel morphology (wide, shallow and low gradient), flow conditions (i.e., slow moving or standing/ponded water), poor water quality, wide seasonal fluctuations in water temperature, and a lack of woody vegetation.

Woody vegetation in the “riparian zone” is sparse or non-existent. No obvious attempts have been made to plant trees or shrubs in these areas. Consequently, unlike forested streams where leaf litter and other allochthonous material provide the source of energy, for the ditch systems macrophytes and filamentous algae provide the bulk of primary production.

Based on the results of this assessment it was concluded that current mining and reclamation practices have not been effective at avoiding or minimizing adverse impacts to these stream ecosystems. Further, as currently implemented, aquatic habitat enhancement in the constructed drainage systems does not mitigate (i.e., replace) the natural structure and function of the first and second order stream ecosystems that existed pre-mining. .

The following modifications to current practices are recommended as approaches that will improve the potential for mitigating unavoidable adverse impacts to stream ecosystems on mountaintop mining/valley fill sites.

1. Modifications to Overburden Disposal and Reclamation Practices

   Landform grading and backstacking of overburden to higher elevations than current practices call for would restore some of the relief and natural landform of the ridgelines. The backstacking to higher elevations would also provide additional upland disposal areas thereby reducing the volume of overburden placed in valley fills. Modifying construction practices for the fill lifts could restore the natural form and slope of the valleys. This might involve constructing irregular lifts of varying face height and bench width. Lifts could be constructed such that those along the margins of the fill at the interface with the hillslopes extend further out while those toward the center of the valley fill are inset. One side of a lift could be constructed higher than the other side to provide variable cross-valley slopes.

   Utilizing this approach, valleys could be recreated with a down-valley profile that includes areas of varying slopes. Some valley reaches would be very steep, while other reaches would have moderate or even fairly gentle slopes. The variability exhibited by the pre-mining valley cross-section could be restored creating ridgelines and hillslopes with natural breaks where the form and gradient of the slopes change from steep and convex to gentle and concave and back to steep and convex. Although the valley floor would still sit much higher in elevation, the swale and meander associated with a naturally formed valley floor could be recreated.

   The characteristics of the fill material itself should be modified. The upper layers must be amended to provide a growth medium suitable for reestablishing a natural forest. This could be accomplished by laying down layers of mulch and topsoil. The mulch could be prepared from the vegetation cleared and grubbed from a new surface mining area. The topsoil could be salvaged from that same surface mining area as well.

   To initiate the process of reestablishing a natural forest, over-seeding with a grass mix of rye, clovers and native meadow grasses would reduce competition with tree and shrub seedlings. A variety of native of tree and shrub pioneer species could be planted on the newly reconstructed ridgelines and hillslopes and along the valley floors, concentrating on the drainage ways. This vegetative community should be established prior to the introduction of native tree and shrub forest species. Where reclaimed areas are adjacent to undisturbed forests this successional process may be accelerated.

2. Restoration of stream channels and floodplains

   Opportunities for restoration of existing streams were harder to identify where ridgetop mining operations were predominant and valley fills had been extensive. However, on sites where contour mining was predominant and valley fills had not been as extensive a number of restoration opportunities exist. For example, removal of on-line sedimentation ponds, floodplain fill, and sections of access road would recapture a significant length of stream channel.

   Rollem Fork at Penn Coal Company's Kiah Creek Mine could provide an excellent opportunity for demonstrating restoration of a natural stream channel and floodplain. Floodplain fill resulting from construction of the pond berms, disposal of sediment removed from the ponds, and construction of the access road has confined the stream between the fill and the adjacent hillslope. This condition has created an entrenched F/G stream type channel. Woody riparian vegetation is sparse along the fill side of the channel. One restoration concept would involve lowering of the pond berms, and removing floodplain fill and sections of access road. The existing stream channel could be relocated away from the hillslope and towards the center of the valley floor. This would provide a floodprone area to accommodate overbank flows on both sides of the channel. The off-line ponds at the base of valley fill and in the floodplain could be combined and backfilled to create one large freshwater marsh with varying hydrologic regimes (i.e., permanently flooded, seasonally flooded and seasonally saturated). The outfall pipes could be removed with the outflow from the freshwater marsh/pond conveyed by a small E stream type channel that meanders along the floodplain before emptying into Rollem Fork. The margins and seasonally saturated areas of the marsh/pond could be planted with trees and shrubs and the flooded areas with emergent vegetation. The riparian zone along both banks of the stream could be heavily planted with native trees and shrubs.

3. Modifications to design of combination ditch/groin ditch/sedimentation ponds

   Many of the combination ditches and groin ditches observed convey storm flows only. Most of them appeared to be stable and functioning as designed. Unless baseflow can be diverted to these channels, there is no reason to modify them. Where opportunities exist to capture groundwater and generate a baseflow, the ditches could be reconstructed with natural channel morphology including planform, profile, and cross-sectional geometry. Vertical and horizontal controls and flow diverting structures could be installed to stabilize the channel bed and banks.

   The design of these natural channels should include baseflow and bankfull channels and floodprone areas. The channel form should be consistent with that appropriate for the valley type in which they will be constructed. For example, the steeper reaches (i.e., down the face of the fill) of a groin ditch redesigned as a natural stream channel would have the characteristics of an A or Aa+ stream type with a step-pool morphology. The lower gradient reaches (i.e., across the top of the bench) of groin ditches and most combination ditches redesigned as a natural channel would have the characteristics of B, C or E stream types. Selection of the appropriate stream type would be guided by the characteristics of stream types and valley types presented in <u>A Classification of Natural Rivers</u> (Rosgen, 1994) and <u>Applied River Morphology</u> (Rosgen, 1996).

   Specific design parameters would be developed utilizing a Natural Channel Design Approach that includes: the use of regional hydrologic and hydraulic geometry curves; and channel morphology data obtained from field surveys of stable reference reaches of the same stream type as that determined to be appropriate for the particular on-site situation.

   Channel stabilization techniques would include; vertical bed control provided by boulder and log drop structures, rock sills, cross vanes, etc.; horizontal bank control provided by toe boulders, soil fabric lifts, and a dense growth of trees and shrubs along the banks and in the adjacent riparian zone. Installation of flow diverting structures (e.g., rock vanes j-hook vanes, cross vanes, w-weirs, etc.) would take stress off the banks by diverting flows toward the center of the channel. The vertical and horizontal controls and flow diverting structures would stabilize the channel bed and banks as well as create and maintain diversity of channel features and habitat.

Sedimentation ponds can be redesigned to create wet meadow, shallow marsh and open water habitats in the floodprone areas adjacent to the lower gradient channels (i.e., C and E stream types). Plantings of submerged aquatic, emergent, and woody vegetation would improve water quality and enhance the habitat for benthic macroinvertebrates, amphibians, reptiles and waterfowl.

The natural channel design approach has the greatest chance for success if it also incorporates the modifications to valley fill practices presented above.

Aquatic Ecosystem Enhancement at Mountaintop Mining Sites

Welcome and Introduction

Dr. Paul Ziemkiewicz

Dr. Ziemkiewicz, Director of the National Mine Land Reclamation Center and West Virginia Water Research Institute at West Virginia University, welcomed the attendees and explained the format of the symposium. He emphasized that the gathering was a technical symposium on improvements to current mining and reclamation techniques that will enhance the aquatic ecosystem. Furthermore, he made it clear this was not a forum to debate the practice of mountaintop mining.

He went on to describe two colossal coal refuse failures from mining history (Aberfan, Wales and Buffalo Creek, West Virginia) that resulted in many deaths and that led to most of the current regulations regarding the technical design of valley fills. These current regulations emphasize drainage through the fill materials and discourage standing water, such as ponds and streams, which affect the margin of safety for fills. Thus, he expressed the opinion that environmental considerations were not a major driver for the current regulations- safety was the paramount concern.

However, state-of-the-art in geotechnical engineering has advanced to the point that valley fills that include some streams and ponds in the final design could be safely considered, according to Dr. Ziemkiewicz. He introduced the symposium attendees to a group of distinguished experts who will suggest practices that may enhance the resulting aquatic ecosystem downstream from valley fills. He also noted that during the breakout sessions everyone would have an opportunity to identify barriers to implementing these enhanced practices.

Overview of First Order Watersheds

Dr. Bruce Wallace

Dr. Wallace provided a scientific view of the role of first order watersheds in the ecosystem and the impact of mountaintop mining with valley fills. Dr. Wallace highlighted data from ongoing experimental and descriptive studies of southern Appalachian watersheds and stream processes at the Coweeta Hydrologic Laboratory in western North Carolina where he has been working for 25 years. According to Dr. Wallace, the eighty kilometers of small headwater streams on this area owned by the U.S. Forest Service are much like the streams found in the central Appalachian region around mountaintop mining areas. He pointed out that organic material in these streams is the most important source of energy for downstream areas. He commented that nearly eighty percent of this energy comes from the detritus (decomposed organic material) from the surrounding forests.

Dr. Wallace noted that small streams in the ecosystem:

- Have maximum interface with the terrestrial environment with large inputs of organic matter from the surrounding landscape.

- Serve as storage and retention sites for nutrients, organic matter and sediments.

- Are sites for transformation of nutrients and organic matter to fine particulate and dissolved organic matter.

- Are the main conduit for export of water, nutrients, and organic matter to downstream areas.

He continued his presentation by noting that benthic organisms that shred course organic material and woody debris increase the rate of fine particulate and dissolved material that is exported downstream. He explained that leaves that enter the stream are first colonized by bacteria and fungi and then the invertebrates eat the microbially conditioned leaf material. Next he noted that these biota assimilate less than ten percent of the organic material they consume allowing the remainder to pass back into the stream. Thus, according to Dr. Wallace, the resulting fine and dissolved organic material is much more amenable to downstream transport with less than two percent of organic material continuing downstream as course particulate.

Diversity of detritus is essential to the production of organic material for release downstream, according to Dr. Wallace. He noted that different types of leaves decompose at different rates and tend to be in harmony with the different biota lifecycles in the nearby streams. One experiment that he participated in at Coweeta constructed a canopy over a segment of stream to preclude certain types of leaf material from the stream. He summarized the experimental conclusion that after six years with this cover in place, the Coweeta stream had the lowest secondary productivity of any stream recorded in the world, including many located in the Arctic tundra. Thus, according to Dr. Wallace, diverse detritus material is very important to the production of organic energy in the stream and this is one reason we should be considering a diverse array of detritus resources at a reclamation site and not just a single species of rapidly decomposing material.

Dr. Wallace further described experiments at Coweeta covering more than eleven years that have compared the rate of decomposition in treated streams [treated with insecticide], where there is less than a full complement of benthic invertebrates, to decomposition in untreated or natural streams. Based on the large quantity of data accumulated, he and others concluded that it took more than twice as long in the treated streams to decompose the same amount of organic material compared to the untreated streams. This led Dr. Wallace to the conclusion that reducing the number of invertebrates reduces the amount of decomposition and, as a result, the amount of fine particulate and dissolved organic material that is transported downstream. Furthermore, he noted that when the treatment was ended, there was rapid recolonization of invertebrates, which restored the downstream transport of organic material.

According to Dr. Wallace, measurements made at the Coweeta Laboratory over a period of fifteen years determined that the first and second order streams from this area provide more than fifty metric tons of fine particulate and dissolved organic material to the downstream reaches. Dr. Wallace noted that this amorphous detritus, as it is referred to in the downstream waters, is a major food source, especially for filter feeders, which eventually affects the entire food chain. He concluded his remarks on this experiment by stating that this organic material, which originated in the first and second order watersheds, represents more than eighty percent of the food supply for some downstream species.

Dr. Wallace explained that the measure of retention of organic material in watersheds is described by a term called "spiraling length, " which is the distance traveled by organic matter before its uptake by some organism and later reintroduction into the stream. He noted that this distance tends to be very short in headwaters, on the order of a meter, and very long downstream, usually several kilometers. Thus, Dr. Wallace concluded that organic material is retained for long periods of time in the first and second order watersheds where it is produced.

Temperature ranges for headwater streams throughout the seasons tends to be very important, stated Dr. Wallace. He explained that the growth of organisms is dependent on the cyclic temperature of the water, cueing many lifecycle events- pupation and mating, for example. Dr. Wallace highlighted the fact that the water coming from the toe of a valley fill tends to be at a mean annual temperature rather than at a seasonally appropriate temperature, which adversely affects the growth cycle of many stream organisms. Dr. Wallace expressed the opinion that leaving the ponds intact below the fill may help replicate the annual thermal variation further downstream. This idea will be explored further during the breakout sessions.

Dr. Wallace provided the following summary of the major roles of headwater streams in two categories, physical and biological:

Physical

- Headwater streams tend to moderate the hydrograph, or flow rate, downstream.

- They serve as a major area of nutrient transformation and retention.

- They provide a moderate thermal regime compared to downstream waters- cooler in summer and warmer in winter .

- They provide for physical retention of organic material as observed by the short "spiraling length."

Biological

- Biota in headwater streams influence the storage, transportation, and export of organic matter.

- Biota convert organic matter to fine particulate and dissolved organic matter.

- They enhance downstream transport of organic matter.

- They promote less accumulation of large and woody organic matter in headwater streams.

- They enhance sediment transport downstream by breaking down the leaf material.

- They also enhance nutrient uptake and transformation.

Dr. Wallace made the additional point that small headwater streams in the Appalachians often harbor unique biota. According to Dr. Wallace, Morse et al. (1997) consider 19 species of mayflies, 7 species of dragonflies, 17 species of stoneflies, and 38 species of caddisflies to be vulnerable to extirpation at present in the southern Appalachians. He noted that many of the rare species are know from only one or two locations in springs, brooks or seepage areas. Furthermore, he stated, many small streams, seeps, springs, and brooks have not been fully explored. Dr. Wallace provided the following reference citations on this aspect of first order watersheds.

Morse, J. C., B. P. Stark, W. P. McCafferty, and K. J. Tennessen. 1997. Southern Appalachian and other southeastern streams at risk: implications for mayflies, dragonflies, stoneflies, and caddisflies. pp. 17-42, in: G. W. Benz, and D. E. Collins (eds.) *Aquatic Fauna in Peril: The Southeastern Perspective*. Special Publication 1, Southeastern Aquatic Research Institute, Lenz Design and Communications, Decatur, GA. 554 p.

Morse, J. C., B. P. Stark, and W. P. McCafferty. 1993. Southern Appalachian streams at risk: Implications for mayflies, stoneflies, caddisflies, and other aquatic biota. *Aquatic Conservation: Marine and Freshwater Ecosystems* 3:293-303.

Mine Site Visit Report

Courtney Black

Mr. Black summarized the tour taken by the experts to four mine sites on December 7-8, 1999. By way of introduction, Dr. Ziemkievicz made note that while we have many distinguished experts on these issues in West Virginia, introducing some outside experts may help us to generate some new ideas for consideration. Mr. Black organized the visits as a means of introducing the panel of experts to actual mountaintop mining and reclamation practices and the environmental conditions that result.

Mr. Black made note that the sites visited were:

- Elk Run Mine, operated by Massey Coal

- Samples Mine, operated by Catenary Coal Company

- Rollem Fork Mine, operated by Pen Coal
- Hobet Mining 21, operated by Hobet Mining, a subsidiary of Arch Coal

Mr. Black presented a number of photographs taken during the visit. His presentation is included with this proceedings. The images he presented from Elk Run depict several valley fills, sediment ponds at the toe of the fills, and downstream reaches. He noted there was evidence of water retention in the sediment ditches that could support aquatic resources. He commented that the experts had observed an experimental area where the backfill material was not heavily compacted to promote the growth of vegetation. According to Mr. Black, Massey Coal also produced rolling landforms in the some of the fill areas that differed from the typical engineered fill site in slope gradient and benching.

Mr. Black commented that at the Samples Mine, the experts viewed an in-stream pond constructed by Catenary Coal Company. Several species of insects had been introduced into this pond to rebuild the ecosystem, according to Mr. Black. Mr. Lawson described this site in more detail during the next presentation.

Mr. Black stated that at the Rollem Fork Mine, being developed by Pen Coal, a large amount of toxic materials handling and encapsulation work was necessary based on the pre-mining conditions. He further noted that Pen Coal created a number of combination ditches for storm water and sediment control and that these are required to be removed within a specified time period after the site is closed to comply with existing regulations. During the site visit, the experts inquired if the ditches that contain developed wetland activity can be left intact after site closure. According to Mr. Black, the experts also observed several nontraditional landscape profiles. Mr. Black commented that at the Frank Branch portion of the mine site, several species of trees were observed including pines and Russian olives with evidence of natural succession underway.

Mr. Black described the Hobet 21 Mine site, a twenty-year old mining operation that offered views of more established reclamation sites. According to Mr. Black, one observation made by the experts was that there were too few species present. He noted that excavation by the large dragline coincidentally added some rolling landform profiles. As at the other sites, he commented that there was evidence of developing aquatic ecosystems that would have to be removed before release of the closure bond.

Catenary Coal's Success in Restoring Aquatic Habitat

Peter Lawson

Mr. Lawson began his presentation by noting the broad significance of the EIS and the potential impact on coal mining in West Virginia and throughout the country. Mr. Lawson spoke about four topics related to the Samples Mine operation; the scope and background of the Samples Mine, structures that are constructed as a condition of permits and two enhancement projects, the G-Ponds and the Abandoned Mine Land Mitigation Project.

Mr. Lawson began with the history of the site. He noted that the Samples Mine land was acquired by the company in 1989 and developed to the point of full production in 1995. In the year 2000, he expects to extract approximately 6.5 million tons of coal from the site and move about 95 million yards of overburden. According to Mr. Lawson, the site employs about 500 full-time employees and contractors.

He stated that all runoff from a mining site has to be diverted to runoff ponds that meet NPDES discharge permit conditions further downstream. He noted there are required structures that include both in-stream ponds and on-bench structures, including ditches and shallow ponds. According to Mr. Lawson, current law requires that these be designed to handle major storm events ranging from 10-year, 24-hour storms up to 100-year, 24-hours storms. At Samples Mine, he noted that Catenary Coal Company has completed construction of 23 in-stream ponds with 275 acre-feet of storage capacity at a cost of about $2.5 million dollars. He also commented that upstream ponds tend to accumulate any sediment from the mining operation and many of the downstream ponds are completely free of sediment and provide excellent aquatic habitat. They have also completed 4,300 linear feet of on-bench structures at the site. Mr. Lawson highlighted one in-stream pond that was built at the toe of a fill in a previously ephemeral or intermittent portion of the landscape that now provides perennial water flow. He noted that many of the on-bench structures also contain water year around and provide excellent habitat for vegetation, aquatic organisms, and water fowl.

The G-Ponds enhancement project, continued Mr. Lawson, is a combination of structures constructed in between two consecutive ridges to enhance the post-mining land use. He described the southern most ponds as shallow to attract wading birds and to give them refuge from the coyote, bobcat, and bear that have moved back into the area. The northern ponds, he explained, have deep pools to promote fish spawning and have floating nests for geese. These ponds are fed by both above ground and underground water sources according to Mr. Lawson. He noted that Catenary Coal used what they have termed “starter kits” of aquatic organisms including bass, bluegill, yellow perch, native minnows, crayfish, bull frog tadpoles, snails, clams, and water fleas. According to Mr. Lawson, they also added duck potatoes, water lilies, soft stem bull rush and cat tails along with red and silver maples, pin oak, and white pine. Mr. Lawson presented photographs showing the site being used last summer for an employee picnic when the ponds were stocked with sport fish.

Prior to acquisition of the land by Catenary Coal, continued Mr. Lawson, surface and underground mining had occurred on the site up until the mid 1970s and there were three large, abandoned refuse piles, covering about 155 acres and containing ten million yards of refuse, that needed to be reclaimed. Reclamation of these sites was beyond the scope of the original permits, according to Mr. Lawson, but offered an opportunity for mitigation of stream loss as a result of the Samples Mine valley fills. He also noted that reclamation provided immediate and long-term benefits to the community by improving the quality of water flowing into the Cabin Creek watershed. He explained that during heavy rains there was uncontrolled heavy flow and resulting black water in the adjacent stream and there were also large areas around the site producing acid-mine drainage. He stated that the site was graded and a large amount of cover material and topsoil was brought into the area taking care to protect the natural or volunteer vegetation that had developed over the years. He discussed the drainage channels that were installed to control the runoff and the wetland that was constructed to treat the acid-mine drainage with a series of four limestone cells, along with a relocated stream channel. He noted that vegetation was added to the wetland for biologic treatment and polishing cells were added to improve the quality of the water exiting the system.

As an introduction to the next portion of the symposium, Mr. Lawson highlighted a misperception that mountaintop mining operations using draglines leave large flat areas with monolithic structures uncharacteristic of the Appalachian region. At the Samples Mine, he pointed out, the dragline was used to move overburden from one area to another and lift the elevation of the material to an average of about 225 vertical feet of relief above the lowest coal seam being mined. This could not be economically accomplished by a truck and shovel operation at this site according to Mr. Lawson. Photographs presented by Mr. Lawson showed how this is being accomplished at the Samples Mine.

Mr. Lawson expressed the opinion, which he supported by several photographs, that the mining industry has become very good at the reclamation of sites in accordance with the approved post-mining land use, including fish and wildlife habitat.

Panelist Comments and Discussion

The seven experts that toured the mining sites were each provided an opportunity to introduce their individual and collective perspectives on the subject of Aquatic Ecosystem Enhancement. These remarks are grouped into three areas (Aquatic Resources, Vegetation, and Landform) with corresponding breakout sessions later in the symposium. Each topical area was followed by a brief question and answer session with remaining questions deferred to the breakout sessions.

Aquatic Resources

Rocky Powell, **Dr. Bruce Wallace**, and **Randy Maggard**

Comments by Mr. Powell

Mr. Powell prepared a written report, which is included as an appendix to this proceedings, containing his observations and recommendations from the tour of the four mine sites and he highlighted the report for the audience. Then he focused his remarks on the subject of stream channel morphology as he had mentioned during the morning session of the symposium.

Mr. Powell used a series of eight criteria to compare pre-mining and post-mining conditions of the aquatic ecosystems at each mine site:

- Are the valley and watershed characteristics consistent with pre-mining conditions?

- Is the vegetative cover consistent with pre-mining conditions?

- Have the soil characteristics been modified?
- Has the hydrologic regime been modified?
- Has the sediment regime been modified?
- Is channel morphology consistent with a natural, stable channel form?
- Have the physiochemical properties of the streams been altered?
- Have the biotic communities, trophic structure, and energy sources of the stream ecosystems changed?

He acknowledged that he had to rely on his experience with other watersheds in the region to complete the assessment due to the lack of pre-mining conditions for the mine sites that were visited. His report provides a detailed presentation of the regional watershed characteristics that were used as a pre-mining baseline for the assessment.

Based on his analysis, Mr. Powell concluded that the streams and ponds he observed did not serve to mitigate (replace the structure and function of) the original first and second order watersheds. Mr. Powell noted that the focus of his comments will be on enhancement, or improvement to the existing practices of mining and reclamation, with respect to aquatic resources. He pointed out that, in his opinion, the mining operators are doing a very good job of complying with current regulations and in many cases go beyond the regulations.

Mr. Powell commented that in the pre-mining condition, storm flows are moderate, runoff is minimal, and base flow is fairly reliable. The exception, he noted, is in shale and sandstone areas where flow may discontinue, especially during the summer. First and second order streams have base flow cross-sections where this base flow is channeled according to Mr. Powell. He explained these streams also have a flood surface where storm flows are channeled after they exceed the base flow section. In the post-mining condition, he noted, the reconstructed streams have little or no base flow and are designed to carry only storm flow and with a lack of base flow, there is no area for aquatics to live. He pointed out that there was evidence in the field that, with time, many of these constructed ditches and channels are evolving into a series of steps and pools. He also noted that the shape of the constructed channels is trapezoidal and designed to carry all the flow in one channel which differs from a natural channel. Mr. Powell showed pictures of several constructed channels and the erosion problems they endure including head cuts that travel up channel and scour erosion that travels downstream.

From an aquatic standpoint, Mr. Powell reiterated that without base flow there is little hope of establishing aquatic life forms. The mining industry, according to Mr. Powell, has constructed many storm flow channels that are very effective at handling storm flows and reducing the sediment loading on downstream water resources but do not contain base flow to support aquatic life forms. Mr. Powell expressed confidence, based on what he observed during the site visits and other recent study, that the mining industry could be successful in constructing natural channels with base flow capable of supporting aquatic organisms. Mr. Powell presented a number of examples of natural stream systems with various overall gradients, both steep and shallow, and explained how each had its own aquatic ecosystem. He also emphasized reclamation to natural channel flow with visual examples from several of his reclamation projects.

Comments by Dr. Wallace

Dr. Wallace followed Mr. Powell and provided his observations from the mine site visits. He started off by noting that he only observed flowing water in two places at the four sites that were visited. He commented that, perhaps, it is unrealistic to try to recreate lotic habitats in these areas. While he supports protecting every stream that exists, he noted that we may need to look to other values in these mined areas. He expressed the opinion that the trade off is between wetlands and headwater streams- they both have value. Headwater streams are a major feature in Appalachia, according to Dr. Wallace, while ponds and wetlands are relatively rare in this region. Furthermore, according to Dr. Wallace, streams normally have maximum interface with the terrestrial environment acquiring energy resources from the adjacent watershed whereas in ponds and wetlands the primary forms of energy are algae or plant material that enter the detritus food web. Streams have important linkages to downstream areas whereas wetlands vary, according to Dr. Wallace. Wetlands observed during the mine site visits, he continued, were not linked to the downstream watersheds - again, not that they do not have value but they do not replace the pre-mining streams. However, he noted, the wetlands do tend to limit the effect of disturbances on the downstream watersheds. Also, Dr. Wallace continued, the biologic communities found in streams tend to be indicative of disturbance whereas in wetlands this is much less so. Therefore, he concluded, trying to replace the aquatic resource of original streams may not be possible and there is certainly a trade-off between a reconstructed stream and a wetland.

One way to look at this tradeoff, stated Dr. Wallace, is in terms of minimizing the effect of valley fills on downstream reaches. He noted that the problem with the temperature coming from the base of a fill is that it is somewhat like a spring- nearly constant annual temperature. With a pond, Dr. Wallace noted, you will have exceptionally warm water in the summer and cold water in the winter. He expressed the opinion that we could redesign our ponds with larger shallow areas and increased throughput for the overall pond. Increasing the shallow zone, according to Dr. Wallace, will increase the amount of aquatic macrophytes and the benefits derived from them and the increased amount of wetland may also address the water chemistry problem that he hypothesizes to exist downstream from the toe of the valley fill. Dr. Wallace also noted that a number the sites have long straight stretches of drainage ditch that could be improved by creating a more natural, meandering run as proposed by Mr. Powell.

Changing the design of these wetlands, commented Dr. Wallace, simply by increasing the diversity of vegetation could improve the contribution to the ecosystem, particularly groundwater recharge. Also, he noted, creating an anaerobic condition as exists in many wetlands is an important contribution to denitrification and to transformation of sulfates in mine drainage to an immobile form- two important contributions to the quality of groundwater.

Dr. Wallace provided the following tabulation of some relevant comparisons of small streams and ponds or wetlands.

Headwater Streams	Ponds and Wetlands
Major features of the Appalachian landscape	Present, but rare in Appalachian landscape
Maximum interface with terrestrial environment	Less interface with terrestrial environment
Energy resources from adjacent watersheds as leaves, detritus, etc.	Primarily autochthonous primary production from algae and aquatic plants
Important energy links to downstream areas. Creeks and rivers strongly connected into a system	Rather closed energy system with less linkage, if any, to other areas, or downstream
Disturbance in headwaters can influence downstream areas	Little effects of disturbance on other ecosystems
Important retention and transformation of nutrients and organic matter	Can be important sites of nutrient storage and uptake provided sufficient littoral zone with plants
Biological communities (at least animals) often indicative of disturbance	Biological communities not as indicative of disturbance

Comments by Mr. Maggard

Randy Maggard summarized his views as consistent with the views of Dr. Wallace; do we want to try to replace intermittent and perennial streams or should we proceed with the development of wetlands and ponds? Mr. Maggard noted that someone had made the comment to him that there are no aquatic resources on reclaimed mine sites- only mud holes. He commented in reply that, while they may start off as mud holes, they do not remain mud holes. Mr. Maggard presented several photographs of sediment pond projects developed by Pen Coal. He indicated that his company has performed a number of studies that substantiated the aquatic resources that are present in these habitats and that they are improving over time.

Mr. Maggard provided three of these studies to the other experts of the panel for their use during the mine site visits. The document citations are presented below and the documents are included in the Panelist Supporting Information part of this proceedings.

Maggard, Randall and Ed Kirk. "Downstream Impacts of Surface Mining and Valley Fill Construction." Paper presented at the 1999 Annual Meeting of the West Virginia Acid Mine Drainage Task Force. Morgantown, WV. April 13-14, 1999

An Evaluation of the Aquatic Habitats Provided by Sediment Control Ponds and Other Aquatic Enhancement Structures Located on Mine Permitted Areas in Southern West Virginia. Conducted for Pen Coal Corporation; Kiah Creek Mine Office; P.O. Box 191; Dunlow, West

Virginia 25511. Prepared by R.E.I. Consultants, Incorporated; Ed J. Kirk Aquatic Biologist; 225 Industrial Park Road; Beaver, West Virginia 25813. November 23, 1999.

Benthic Macroinvertebrate Study of Honey Branch, Its Sediment Control Ponds, and Its Influence on the East Fork of Twelvepole Creek Conducted 10/08/99. Conducted for Pen Coal Corporation; Kiah Creek Mine Office; P.O. Box 191; Dunlow, West Virginia 25511. Prepared by R.E.I. Consultants, Incorporated; Ed J. Kirk Aquatic Biologist; 225 Industrial Park Road; Beaver, West Virginia 25813. November 24, 1999.

Questions and Answers

The conclusion of Mr. Maggard's presentation was followed by a period of questions and answers on the subject of Aquatic Resources. Only one question was asked during this session.

Q: [to John Morgan] Do you see any situation where you can add streams or wetlands higher up on the hills in these fill areas? Is basal flow rare or can it occur at any site? Do you think from the number of West Virginia mining sites you have seen that this [basal flow] is possible at most sites?

A: As mentioned earlier, responded Mr. Morgan, it will be difficult to create basal flow at an elevation any higher than the outcrop of the lowest seam being mined. He continued by noting that the features that Randy Maggard showed are on the down dip side of the mined area where basal flow will typically occur. On most mine sites you will have some area where basal flow can be captured according to Mr. Morgan.

Vegetation

Ben Faulkner and **Dr. Steven Handel**

Comments by Mr. Faulkner

Mr. Faulkner began his remarks by noting that the only water that is consistently available around these sites is from the sediment channels down gradient from the surface-mined area and from the ponds and sediment structures below the valley fill. He commented that the valley fill provides a desirable source of water with near constant temperature and with plenty of dissolved oxygen that is of interest to the aqua culture industry. Furthermore, he continued, it is important to recognize that during the drought last summer the only source of consistent water flow in first and second order streams was from these valley fills. Although fills may change the appearance of the stream, it creates a different, not necessarily a worse, aquatic habitat according to Mr. Faulkner. He expressed the opinion that we should encourage leaving ponds on and below fills and encourage diversification of vegetation in and around the water courses to provide the shade and detritus that Dr. Wallace has identified as important to the ecosystem.

Mr. Faulkner described several practical and regulatory considerations for revegetation in and around drainage structures and watercourses.

1. Engineering considerations for hydrologic appurtenances
    - Safety considerations
    - Erosion considerations
    - Terrestrial and aquatic habitat enhancement
    - Final reclamation considerations
2. Tree and shrub species for forestry and wildlife planting plans
    - Water availability and management
3. Natural succession on surface mines
    - Alien species vs. natives
4. Logistics and economics of revegetation and reforestation

He noted that safety is of paramount consideration in surface mine development and reclamation. Mr. Faulkner commented that engineering watercourses for direction and retention of seepage and surface runoff must safely pass design storms. Furthermore, he continued, any efforts toward enhancement of the aquatic habitat provided by these structures must not compromise the safety or sediment control objectives of the structure.

Encouraging wildlife and aquatic life in watercourses and structures is generally of no negative influence on mining operations, according to Mr. Faulkner, with the exception of muskrats or beavers which may compromise the principal spillway elevation or interfere with bank stability. Seldom, he noted, can unreinforced grass covers be used in diversion ditches on steep slopes. Mr. Faulkner stated that where velocities exceed the maximum allowable for vegetative cover (3 fps), rock rip rap is used. He further stated that there is no comparison of cost, and slopes are kept as flat as possible to permit the lower velocities and cheaper grass banks whenever possible to control erosion. He identified two concerns in planting additional stems of shrubs or trees around sediment or drainage structures. First, the root system of woody vegetation, if planted in proximity to pipe conduits, will grow along those conduits compromising the integrity of the pipe and the compacted fill around it. Second, any plantings where water is impounded against compacted fill must be planned with this in mind.

Another concern in aquatic habitat enhancement, according to Mr. Faulkner, is that although the “long range” view is sought when selecting vegetation, one must realize that the long range (seral succession climax) of standing water in the Appalachian geology and geography associated with West Virginia is a grassy meadow and then a climax hardwood forest. Furthermore, he noted, there is no naturally occurring lentic community in the state with the exception of a one acre pond in the eastern panhandle. According to Mr. Faulkner, the future of all pools of standing water in the state (from man-induced activities, beaver dams, or inadvertent activity such as railroad or highway fills) is to be filled with sediment and become a meadow and then grow into a forest. He commented that established lentic aquatic habitat is present only for a limited time. Furthermore, he continued, there will always be a lotic community, but it will also change as the site ages. Additionally, he noted, increasing the number of woody stems around a lentic water body will accelerate the desiccation of the pool during periods of drought as the trees mature and their need for water increases. According to Mr. Faulkner, this will accelerate the natural succession of the water body to a meadow and eventual hardwood forest, actually reducing the number of years of lentic habitat and strongly influencing the remaining lotic habitat.

Mr. Faulkner commented that the lotic aquatic habitat on mountain-top mining sites is quite limited and that spoil swell necessitates steep slopes and watercourses or gentle watercourses over valley fill crests or backfill. This material, he commented, is so porous that it usually holds water only in response to significant precipitation events. The only location water can be found with some continuity is in down-dip sediment structures along the outcrop (sediment channels) or at the toe of the valley fills according to Mr. Faulkner. Generally, he noted, the only dependable lotic water is from the toe of the fill to the sediment pond, and this is generally a short distance. However, he continued, both these locations provide some dependable aquatic habitat which may be enhanced through land use and focused vegetation efforts.

During the drought in West Virginia this summer, the only first order watersheds with flow contained proven springs or valley fills according to Mr. Faulkner. The fills through their porous nature, he commented capture all seepage and runoff within the watershed and slowly release the water over a several month period, flattening out the wide runoff flows seen in an undisturbed or disturbed watershed. Generally, Mr. Faulkner commented, valley fill flows (at the toe) are oxygenated with reduced amounts of sediment and a constant temperature. He expressed the opinion that this constant, moderate temperature (generally about 55° F) is ideal for fish aqua culture. Substantial interest, according to Mr. Faulkner, has been raised about this resource in the state in the last few years including an extensive study and investment by the West Virginia Department of Agriculture and U.S. Department of Agriculture. Mr. Faulkner expressed the opinion that water quality at mines in West Virginia is generally of good quality, with only five percent of all NPDES sites requiring even occasional water quality attention.

The lentic habitat in shallow sediment ponds and channels can be made to be more beneficial for aquatic life with the planting of shrubs and trees to add detritus according to Mr. Faulkner. This coarse particulate organic matter, he noted, will be available to the shredder macroinvertebrates that will export fine particulate organic material downstream to the valley fill sediment ponds and receiving streams.

Mr. Faulkner stated that economics is of particular concern at drainage structures. Only a handful of hydrophilic woody stems are available from the state nursery according to Mr. Faulkner. He continued that the state nursery makes these plants available a full order of magnitude cheaper than commercial nurseries. He commented that state nurseries should be encouraged to provide additional viable species at a reasonable price. He also noted that substantial work was done on tree species, soil building and vegetation through the U.S. Department of Agriculture in the 1960's and 1970's and this material is available to the mine operator.

The sediment channels and valley fill ponds represent the best available aquatic habitat on surface mines, according to Mr. Faulkner, but they are often removed within a few years at the landowners request because of liability concerns. He stated that this complicated question will require a collective agreement between operator, regulator, and landowner.

In summary, Mr. Faulkner noted that fills on surface mines offer some significant benefits:

- A constant, moderate temperature and oxygenation which is optimum for aquatic life.
- Fills “meter out” water during drought.
- Fills provide “different” aquatic habitat (lentic) which is rare in mountains of West Virginia compared to plenteous lotic habitat.

He concluded that during reclamation we should encourage:

- Leaving ponds on and below fills.
- Planting diverse vegetation in/around watercourses to provide shade and detritus.

Comments by Dr. Handel

Dr. Steven Handel, a professor of ecology and evolution at Rutgers University, focused his presentation on the issue of landscape links and the potential of using natural landscape processes and links to restore and enhance wetland environments. Using the example of an oak woodland in West Virginia, Dr. Handel discussed the links between the first order streams and the surrounding terrestrial habitat. What can we do, he asked, in areas where there is sufficient base flow to support a first order stream to make them function in a manner similar to some of these natural streams? He added the question , how can we build on the natural ecological processes to rebuild self-sustaining natural landscapes at a minimum cost?

The difference between restoration ecology and landscaping is one of process and change according to Dr. Handel. He noted that for an ecologist the design has a wildlife value with a minimum amount of subsequent human involvement while a landscaper creates a human-dominated landscape with plants available from the commercial nursery. What the restoration ecologist plants to begin the process may all be gone in a few years according to Dr. Handel. He added that success is achieved when the original plants are replaced in natural succession by other self-sustaining native plants.

Dr. Handel highlighted that the value of small first order streams is enormous as has been pointed out today by others. He emphasized that his interest in these streams is based on their benefit to the surrounding wildlife. He noted that small ponds and flowing water attract wildlife to the area. While displaying photographs of a mine reclamation project and the rip rap lined drainage channels, he emphasized the opportunity to improve the surrounding ecosystem by encouraging the growth of vegetation. He rhetorically posed the question, how can we do this on very large sites that are engineered with large areas of grass and small clusters of trees? He responded that a concept that should be of interest to this audience is the idea of designing the site restoration to attract birds- natural landscapers. That design, he noted, includes perching, foraging, and nesting areas, and areas where they can find protection from their enemies.

He explained that his recent studies have considered the idea of encouraging natural succession by creating “islands” that attract natural seed dispersers (birds). Out west, he noted, people have experimented with the idea of transplanting an area of natural vegetation in a chunk on reclaimed mine sites. The experiment, he explained, included establishing twenty of these “islands” with traps under the trees to find out what types of seeds were being introduced into the area and are they appropriate natural succession plants. He continued to explain that samples taken during the first four months of the study collected approximately 14,000 seeds in a 65 square meter area including 26 native plant species that were not planted on the reclaimed site. This, he concluded, showed that this link in nature could be quickly established by providing a target for the birds to perch on and some remnant of the native vegetation in the surrounding area to provide the seeds. Of importance to this audience, he noted, is to know that the small pockets of native vegetation that are left intact at a site become a critical source of seeds to stimulate the subsequent natural succession during the reclamation process.

Seeds are only one part of reestablishing plant demography according to Dr. Handel. The quality of soil and the ground cover placed at the site are also important, he added, to the development of seedlings and eventual self-sustaining growth. He noted that there is general agreement that it is important to limit the amount of compaction of the top layers of soil at the site. He expressed the opinion that we must also modify the amount and type of ground cover that we place to control erosion, which is as important for proper development of the ecosystem as it is for the safety of the site. Deep rooted ground covers bind the soils and make space for the small seedlings of woody plants, he explained. He noted that this was discussed at the industry meeting last spring (1999) in Kentucky with the conclusion that operators must be trained to tread lightly on the land and to modify the types of ground cover used.

Dr. Handel also noted that diversity of vegetation is essential. He commented that the panel of experts observed many examples of wetlands on mine sites that are heavily populated with cattails. However, commented Dr. Handel, there was not sufficient diversity of vegetation. He continued to explain that what is missing are the blueberry, elderberry, willows and other shrubs and herbs that are typical of watercourses in the southeast where there is sun and adequate water. To get those back, he noted, we will have to jumpstart the process ourselves. He concluded with the comment that having only one species of plant is insufficient to promote natural succession because it will not attract a variety of birds.

Dr. Handel identified the presence of wild bees, which are essential to setting seeds and cultivating plants, as another consideration to enhance the natural succession process. There are over 8,000 species of wild bees in North America according to Dr. Handel. He explained that bees nest in soft ground or hollow trees and eat nectar and that simple modifications to encourage the habitat development of bees are necessary including the addition of flowering groundcover since grasses are all wind pollinated. Dr. Handel also noted that microbial processes in the soil are essential to the development of plant roots. He continued to explain that there are businesses that sell small packets of innoculum but we do not necessarily have to buy them. Sometimes, he noted, the necessary microbes will move back in by themselves if we have remnant forest areas near the mine site. Dr. Handel commented that studies have shown that in newly disturbed areas the amount of fungi on plant roots dissipated rapidly with the distance into the distressed area from the edge of site. He explained that this can cause the stressed nature of the woody plants and the inability of these plants to sustain growth. Dr. Handel noted that if we can hold, stockpile, and respread the original topsoil, we can retain these microbial populations and accelerate their reestablishment across the site.

Dr. Handel described an experiment that measured the ability of native plant species to grow on sites reclaimed with typical mixtures of rough grasses (fescue and Timothy). He explained that of more than 8,000 native plant species seeds only 130 seedlings were able to establish themselves in the soil and native grass mixture of a reclaimed site. The only species that were successful, he noted, were chokeberries, hackberries, dogwoods, spicebush, white oak, and sumac. He concluded that the typical mixture of rough grasses challenged the development of native species. Additionally, he noted that this further emphasized the interrelation of all the aspects of reclamation (seeds, groundcover, bees, “islands”, water) and how they affect the resulting ecosystem.

Dr. Handel described the reclamation project at the Powell River site where the compaction had been carefully controlled and the topsoil stockpiled and remixed. He commented that this provided a good example of the more advanced reclamation techniques that lead to greater value for the landowner. He noted that increasing the value to the landowner for subsequent land use creates an important economic incentive that could translate into lower lease rates to the coal operator. He also pointed out a typical rip rap drainage channel and expressed concern that it is so commonly used throughout the region. According to Dr. Handel, there are situations where more suitable techniques may be used with little or no increased cost that would enhance the value of the water structure. He presented photographs of several alternative bioengineering projects that would replace rip rap. One example project, he noted, used organic fabric that will remain in place for several years until the plant growth is sufficiently established to protect the drainage channel from erosion. This particular example, according to Dr. Handel, had sustained two fifty-year floods in sequential years with no observable damage to the channel. Dr. Handel also commented that nursery stock may not have adequate biodiversity to develop a self-sustaining community. Accordingly, he concluded that we need a mixture of genotypes and these need to be reflected in our regulations.

He concluded his presentation by listing several environmental enhancement considerations to the hydraulic engineering that goes into a reclamation project:

- Create situations where restoration leads to reproduction.
- Assembly of new communities.
- Enhance invasibility by inviting natural dispersers.
- Establish successional processes.

- Meta-populations; linkages to the remnant forests that surround the site such as islands.
- Buffer natural populations by having more plants in riparian zones.
- Ecological processes.
- Habitat links.
- Cost effective management and monitoring.

Dr. Handel commented that drainage channels and sediment ponds solve the engineering problems but they only create plumbing devices. He expressed the opinion that we would like to add to the hydraulic engineering concerns by introducing living restoration ecology solutions. Then together, he concluded, we can create a habitat that can begin to restore the ecological services we all depend on.

Questions and Answers

Dr. Ziemkiewicz expressed his observation that some of the recommendations appeared to be contradictory. For example, he continued, topsoil recovery preserves nutrients and, to some extent, the microbial population. He noted that many topsoils contain significant clay and spreading them on the surface can lead to significant compaction. He opened the question and answer session by raising the first question.

Q: [To the panel] Which is more important, the microbial population or the need for loose compaction? How many cases where topsoil is stockpiled do we see native plant populations subsequently emerge?

A: Mr. Faulkner explained that there is very little topsoil to begin with in so many areas and it is difficult to collect because of the roots and rocks. Furthermore, he noted that the desirable qualities of topsoil do not store well. He expressed the opinion that when topsoils are removed and subsequently remixed with spoil material very little of the microbial population will remain to support the desirable species.

C: Mr. Faulkner commented regarding Dr. Handel's point about bee populations. Mr. Faulkner explained that while there are many grasses on these reclaimed sites, we also have many plants that encourage pollinators such as trefoil and crown vetch. While many people dislike these ground covers, exclaimed Mr. Faulkner, they do have flowers for much of the growing season.

C: Dr. Handel responded to Mr. Faulkner with agreement that these flowering species are an enhancement. Dr. Handel also followed up on Mr. Faulkner's comments regarding topsoil by noting that topsoil is only a thin veneer above sandstone in mountain forests. Yet, he noted, these areas support huge forests suggesting that you do not need much topsoil. The issue is soil quality and not quantity according to Dr. Handel. Microbes are essential, he exclaimed, and studies have shown that you can create very healthy soils with only a small amount of topsoil mixed with crushed, weathered brown sandstone. Limiting the focus to the riparian zone, he continued, topsoil material would have to be introduced and minimizing the amount of compaction is critical. At one site, he observed, tilling the soil only six inches caused a dramatic increase in plant growth. On the point of stockpiling topsoil, Dr. Handel agreed that this can lead to anoxic conditions that damage the microbes. He concluded on this point by noting that some special handling is required to maximize the ecological value of the subsequent use of these topsoils.

C: Mr. Powell commented on the cost of restoration. He noted that there are many opportunities for stream restoration or creation of new streams. Creation of new streams at mountaintop mining sites, he stated, should not cause additional expense, it is a matter of changing the way the fill material is laid down. He also pointed out the difference of the higher gradient systems and that they require somewhat different techniques to control the energy of the stream compared to the bioengineering projects presented by Dr. Handel. In both cases, Mr. Powell concluded, the establishment of vegetation is essential to the long-term stability of the system.

Q: Mr. Morgan asked Mr. Powell for his opinion regarding sediment ponds and the value of multiple spillways, primary and emergency.

A: Mr. Powell explained that there may be benefit from changing some of the larger sediment ponds to shallow marshes with multiple channels to restore some lengths of channel.

C: Dr. Handel commented that it would be beneficial if we could find some way to increase the complexity or diversity of the streams. He added that this might include adding boulders, logs, snags, and channeling diversity that would have significant benefit to the development of the ecosystem and cost very little.

Q: [To the panel] What is the value of organic debris that is now lost during the process of creating a valley fill? According to the person asking the question, some in the Division of Natural Resources have felt the real loss is not so much the stream or the landform but the loss of the topsoil and the organic debris that has built up over time in the coves and valleys. He continued by noting that the DNR is looking at the possibility of collecting the material from one valley area and using that in the restoration of adjacent areas.

A: Dr. Handel commented that this debris should be mixed into the topsoil of adjacent areas and not burned. He explained that by placing the organic material back into the ground, it will rot and support the development of insects and other essential species. He expressed the opinion that it loses all its value when it is burned. Using this debris to restore a site, he continued, would be an enhancement that could be offset by a cleverly applied tax break and make improvements to having only hundreds of acres of grasslands. He stated that he has observed many sites reclaimed to grasslands when that is not typical of this region. Dr. Handel expressed the opinion that sites need to be set up to eventually return to a more natural ecosystem with much greater long-term economic value.

C: Mr. Maggard responded to Dr. Handel's closing remark with his observation that some landowners prefer the grassland because it offers more opportunity for near term economic potential.

Landform

Horst Schor and **John Morgan**

Comments by Mr. Schor

Mr. Schor described his interest as the changes in landform that take place when man makes use of the land for some purpose. Much of his work evolved as a response to urbanization on the west coast but his work has become of interest around the world as people deal with issues similar to mountaintop removal mining in Appalachia. The photographs he presented depict the radical alteration of the landscape with the resulting man-made landforms that coincidentally alter the hydrology into a sheet flow pattern. He noted that the progressive erosion of these man-made sites typically changes the site back toward a natural system of radial patterned swales. He suggested that reclamation of the site to natural landform analogs with vegetation concentrated in the swales is more visually appealing and more stable in the long-term. The concentration of moisture in the swales and focusing the development of vegetation in these areas promotes a more sustainable ecosystem, according to Mr. Schor.

Mr. Schor noted the distinction in the post-mining land forms at surface mines and at mountaintop mining operations. Surface mines, he observed, tended to retain much of their natural relief (elevation and contour) while there was a dramatic change to the relief at mountaintop mining sites. He noted that the reformed land shapes tend to promote sheet runoff across large areas channeled into streams without much transition from top to bottom. He also noted that Catenary Coal had succeeded in recreating a ridgeline in a man-made landform. The next step toward his concept of natural landform regrading, he explained, would be to also depress the valley fills recreating a natural runoff path. According to Mr. Schor, an example of this concept was designed into the Pine Creek Branch valley fill in Kentucky, which was permitted with a depressed valley fill design, but the fill has not yet been constructed.

Mr. Schor described a project he had recently completed for the Department of Power and Water, City of Los Angeles, which involved a half million-yard valley fill. In the photograph he presented, the main drainage path was a curvilinear pattern with radial drainage paths leading to it throughout the length of the run. The benefit of the project, according to Mr. Schor, was that the Corps and the FWS granted credit for wetland and riparian woodland habitat mitigation where the project had concentrated runoff in the swaled areas, thus avoiding the cost of going off-site to achieve mitigation. He noted that depressing the valley fill and raising the ridgelines would affect the areal size of the fill. However, he also noted that, based on the information he gathered during the tour, these valley fills only account for about thirty percent of the total backfill material handled at the sites. He expressed the opinion that it should not affect the cost of the operation substantially. Based on his experience with the Los Angeles project, Mr. Schor explained that depressing the valley and raising the ridgeline caused only a ten percent reduction in the holding capacity of the design fill.

Comments by Mr. Morgan

Mr. Morgan pointed out that what the industry has been asked to do [reclamation] it has learned to do very well. According to Mr. Morgan, the objective of the symposium was to explore where we might alter the objectives of the industry during reclamation to satisfy environmental concerns regarding the resulting aquatic ecosystem. With the current valley fill design, commented Mr. Morgan, we are removing streams and replacing them with upland habitats that have far less aquatic resources. Mr. Morgan explained that there is currently no water on the backfill for a number of reasons including:

- Greater permeability in the mine spoil leading to greater infiltration.
- Nothing to retard the flow during storm events.
- No defined horizons within the backfill like in the pre-mining configuration.
- No aquicludes until you reach the outcrop of the lowest coal seam.

Mr. Morgan presented a diagram of a model surface mining operation and explained that the water in the fill area infiltrates into the backfill material until it reaches the pavement under the lowest coal seam. The outcrop of this flow is typically at the toe of the valley fill, explained Mr. Morgan. He continued on to note that some surface water is captured in the surface drainage ditches but it also tends to quickly infiltrate. According to Mr. Morgan, in fill areas there are very few surface flows except during storm events and there are very few ponds allowed to remain on the backfill area. He expressed the opinion that this is driven by the objectives of the Approximate Original Contour (AOC) Model, which minimizes the areal extent of a valley fill based on geo-technical considerations.

Mr. Morgan proposes an alternate geometry for the placement of spoil in the valley fill area that allows the subsurface flow over the pavement horizon to emerge onto a low point of the valley fill. Identifying where this will occur and intercepting this subsurface flow will provide perennial flow further up the mountain, according to Mr. Morgan. He noted that the experts saw an example at the Pen Coal operation in Wayne County of the increased perennial flow from ditches down dip of the valley fill. Mr. Morgan proposed constructing more of a side-fill in the valley fill area tilting the face to one side, rather than a horizontal surface, to intercept the subsurface flow at a reasonably low gradient creating a stable surface aquatic resource. The disadvantage of this configuration, according to Mr. Morgan, is that you will have a concentration of water flow on one side of the fill and there will be regulatory concerns as you try to meet the 2:1 slope and 50-foot separation of benches on a side fill. There will likely be additional costs to place the side fill material further up on the hill, he explained.

Mr. Morgan proposed a change to the AOC Model to allow the operator the flexibility to vary from the strict geometric approach and introduce landforming as a means of improving the aquatic habit in reclamation areas. He introduced a comparative study of the current AOC model and the alternative side fill configuration, which uses a volumetric definition for AOC, for a site in eastern Kentucky that had not been mined. According to his model, the side hill fill model actually covered less area because the backfill material was placed further up on the mountain. He further depicted a third phase to the AOC process to optimize the extent of the fill somewhere between these two solutions to allow the operator the flexibility to introduce additional landforming.

Questions and Answers

Mr. Schor and Mr. Morgan then entertained questions from the audience:

Q: [to Mr. Schor] Are you aware that the design surface water flows for this region [Appalachia] are much greater than in southern California? Also, our fills have a much greater volume than the example you showed. How do you know that your concept will work in this region and the fill will not all erode away?

A: Mr. Schor explained that the half million cubic yard project [for the City of Los Angeles] was only one example but is comparable in size to some of the valley fills in this area. Also, he explained, the last project he worked on was over 22 million yards of soil. With respect to the water flow, Mr. Schor continued, the criteria is how the drainage is concentrated into the tributaries; the larger water flow of this area would necessitate smaller concentration areas like smaller valleys. The person asking the question followed up that based on his extensive experience he has noted many fills constructed to the current design standard that could not withstand the extreme water flows of this area and failed.

A: Rocky Powell added that in his presentation later he would draw a comparison between pre-mining morphology and post-mining conditions. Mr. Powell noted that in post-mining conditions the ecosystem is changed from forested watersheds to grasslands. Additionally, he explained, we have reduced the time of concentration by departing from natural landforms, which has the effect of increasing erosion. He noted that restoring the natural landform and restoring the vegetation will increase the storage in the channel and convey the water in a more controlled manner.

Q: [to Mr. Schor] What requirements that the mining industry is currently under would have to be changed for your concept to be implemented at large-scale surface mines?

A: Mr. Schor replied that the operator would have to have relief from current design requirements for surface slope and bench requirements. According to Mr. Schor, examples of this were observed at the Samples Mine where they had not only restored the ridgeline but also did not have any benches. Furthermore, he commented, the equipment operator at this site explained his technique for preventing erosion was to grade the surface in a way that prevents the concentration of too much surface water- exactly as his theory suggests. Mr. Schor noted that the equipment operator had coincidentally developed this technique from field observation.

Q: [to Mr. Schor] What proportion of fill material would require rehandling or special handling to accomplish your concept?

A: Mr. Schor explained that this would be up to the operator but could actually be less. In a project he worked on in Virginia, explained Mr. Schor, the operator left two or three planned fill areas open. He thought the alternative concept might require an average of about thirty percent change in the amount of material handled.

Q: [to Mr. Morgan] What changes would you make to the AOC Model to accomplish your modified valley fill proposal?

A: Mr. Morgan explained that AOC calculates excess spoil that would require placement in a valley fill. He commented that the amount of material that is placed back on bench should be maximized. The volume of material placed in the valley fill should be minimized, according to Mr. Morgan, and not be greater than that calculated by the AOC Model. Mr. Morgan expressed the opinion that the operator should have the flexibility to put material where it best supports his operation.

Q: [to Mr. Morgan] Assume the mine is designed to AOC. Then you depress the valley fills and raise the ridgelines to construct natural landforms. This appears to increase the length of the stream affected. Please comment.

A: Mr. Morgan responded that this would be true in many cases. However, he noted, the issue of covering up a stream is a value judgement that should consider the quality of the original stream length. He concluded that the potential benefit from increasing the length of stream affected compared to the benefit of the proposed reclamation project is an issue that should be considered during the EIS process.

Q: [to Mr. Morgan] The AOC optimization approach conveyed in the slides does not reflect many of the necessary working conditions of a mining operation.

A: Mr. Morgan responded that the initial and additional material must be placed on the mined area.

Q: [to Mr. Schor] Are there other landforms possible for valley fills? For example, how about a finger ridge?

A: Mr. Schor replied that there are a myriad of alternatives for natural landforms.

Symposium Recommendations

The symposium participants each selected to attend one of three concurrent breakout sessions to follow up on the conclusions and recommendations of the experts. These sessions were facilitated by representatives of the Department of Energy who are otherwise uninvolved with the development of the EIS. The focus of each session was to review the key conclusions and recommendations of each expert and to identify the associated benefits and potential barriers (regulatory, technical, liability, or cost) to implementing them. The experts were present in their respective breakout sessions and the Aquatic Ecosystem Enhancement Team Leader placed knowledgeable representatives of the regulatory community, particularly WVDEP and OSM, in each session. The summary presented by each facilitator to the reconvened symposium is presented below.

Aquatic Resources

Dr. Jan Wachter (National Energy Technology Laboratory), the Aquatic Resources Breakout Facilitator, presented the consensus recommendations from his breakout group to the reassembled Symposium. He noted that almost uniformly, the barriers were regulatory in nature and there were few concerns about technical, cost, or liability issues with these recommendations. Two of the recommendations developed in this breakout session were included with other breakout reports for consistency of subject matter.

1. *Make extensive use of existing sedimentation ponds and sedimentation ditches to create fisheries and wetlands thereby enhancing aquatic ecosystems on reclaimed mining sites.*

Benefits: The feasibility has been demonstrated. No major additional costs are incurred issues.

Barriers: Current regulations provide little or no consideration for aquatic ecosystem enhancement in ponds and wetlands. They are viewed primarily as a means of sediment control. Regulatory connotations inhibit long-term use. Landowners will retain long-term liability for the ponds and wetlands. Design standards for ponds and wetlands are not habitat related but are driven by storm water transport criteria. Need to have flexibility in regulations to encourage designs that consider base flow and bank full loading. In summary, there are very few incentives to develop standing water on the site, primarily due to geotechnical safety issues in SMCRA.

2. *Take advantage in the design of the valley fill for the generation and maintenance of base flow to create perennial aquatic habitat*

Benefits: Development of base flow is critical to the development and enhancement of the aquatic ecosystem. It is difficult not to have base flow (e.g., chimney drain effect) directed to the center of the hollow.

Barriers: Engineering driven regulations oppose and are frequently counterproductive to aquatic ecosystem enhancement (e.g., engineering stability goals versus aquatic enhancement goals). No incentives are given to the operator for designing stream channels and other aquatic habitat into the valley fill structure to establish base flow.

3. *Create incentives (or remove disincentives) for companies to voluntarily manage wetlands at reclamation sites.*

Benefits: Provides incentives to the operator and landowner to develop and maintain aquatic habitat.

Barriers: Regulation reform is needed with "hold harmless" consideration with respect to wetlands and other aquatic habitat, especially related to the landowner's liability if he should need to remove or fill in the wetlands.

4. *Modify overburden disposal and valley fill practices to minimize the impact on primary and secondary streams.*

Benefit: Minimizes the impact on natural streams.

Barrier: Deferred discussion of barriers to Landform breakout due to time constraints.

5. *Restore existing stream channels and flood plains where opportunities exist.*

Benefit: Minimizes the impact on natural streams.

Barrier: Also deferred discussion of barriers to Landform breakout due to time constraints.

Vegetation

Dr. Heino Beckert (National Energy Technology Laboratory), the Vegetation Breakout Facilitator, presented the following summary to the reassembled symposium. His breakout group reached consensus on six key recommendations with the associated benefits and barriers. The seventh recommendation below was developed in the Aquatic Resources Breakout Session and moved to this list for consistency of subject matter.

1. Stockpile native topsoil for use in lining banks of streams, ponds, and wetlands; also provide pre-treatment of topsoils to increase soil aeration:

Benefits: Increase of moisture retention capability of soil, facilitate infiltration of water and plant seeds; increase likelihood of successful revegetation.

Barriers: Difficulties in obtaining enough suitable topsoil; storage of topsoil may decrease its fertility by leaching and loss of microbial content.

2. Avoid use of exotic invasive plants in revegetation efforts.

Benefits: Development and maintenance of native flora, which is best suited for providing appropriate habitat for native wildlife and for erosion control.

Barriers: None; but nurseries must be encouraged to make available appropriate native plant species; this may present difficulties and increase of overall revegetation costs.

3. Plant a mix of different genotypes.

Benefits: Provides for the appropriate genetic diversity, resulting in better resistance to pathogens and will ensure healthy habitat suitable for a variety of native fauna.

Barriers: Nurseries will market what they can sell; it may be difficult to obtain a healthy genetic mix of the appropriate species instead of clones of species selected for revegetating mine sites.

4. Plant a buffer zone around streams and ponds.

Benefits: Enhancement of aquatic communities; results in ecological advantages by providing appropriate habitat for littoral flora and fauna.

Barriers: Restriction of access for cleaning ponds of sediments; possible safety concerns with pipes being damaged by tree roots.

5. Use of bio-engineering materials for use in stream channels and banks.

Benefits: Prevents erosion, stabilizes banks, enhances seed development and speeds up the overall revegetation process.

Barriers: Suitable only in moderately flat terrain; must last at least five years while vegetation becomes properly established; may require engineering approval for installation.

6. Plant ground cover to attract and keep pollinating insects.

Benefits: Promotes reproduction of planted vegetation.

Barriers: Wildflower seeds are expensive; care must also be taken that these plants do not crowd out those species planted for the actual revegetation project.

7. (From Aquatic Resources Group) *Modify soil characteristics in order to restore native species. Restore the innoculum to the topsoil and allocate topsoil for riparian and ridge zones-not necessarily the entire landscape.*

Benefits: Encourages the restoration of native species and diversity to the reclaimed site and provides riparian and ridge buffer zones.

Barriers: This recommendation conflicts with current topsoil regulations such as the one that provides a requirement for pH maintenance. May be counter to the decreased use by regulators of the "fish and wildlife land-use option" for non-AOC sites. Cost and education of regulators and operators are also barriers.

Landform

Mr. Randy Moore (EG&G), the Landform Breakout Facilitator, presented the consensus of his breakout group to the reconvened symposium. This breakout group identified two summary recommendations. A third recommendation below was developed in the Aquatic Resources Breakout Session and moved to this list for consistency of subject matter:

1. Promote natural landforms on backfill areas to create more natural drainage patterns.

NOTE: For more discussion on natural landform regrading on reclaimed areas, see the earlier discussion by Mr. Horst Schor and the relevant supporting information in the appendix. "Natural landforms" for this region of Appalachia are NOT flat top fills with a terraced face. Fills and regraded mined lands would have rounded tops with fairly smooth hill side slopes and valleys with stream channels - similar to unmined areas nearby.

Benefits: Natural landforms promote establishment of more stable and productive aquatic ecosystems in the drainage system. In some cases, the reclaimed site aquatic resources may be of greater economic value than the existing resources that were impacted by earlier land use.

Barriers: The principal barrier is the current 100-foot buffer zone imposed by Judge Haden's ruling based on the Clean Water Act, which prohibits valley fills on existing natural streams even temporarily. Additionally, landform contouring on the valley fill can extend the footprint required for disposing of the excess spoil. Longer lengths of streams can be impacted than currently allowed by the AOC model.

2. *Capture flow from down dip side of the mine site and within the valley fill to create base flow within the valley fill.*

NOTE: Water percolates down through the rocks and soils which have been placed back on the floor of the mined area. The floor of the mine is usually an aquatard which redirects the groundwater to the down dip side where it emerges as a "spring." If these "springs" are covered by valley fills in the reclamation process, they can be directed to the toe of the fill through special channels built to carry the flow directly to the discharge point and minimize contact with fill material.

Benefit: Capturing base flow from subsurface flow on the down dip side of the mine site provides an attractive opportunity to enhance the aquatic resources within the valley fill area.

Barrier: Capturing base flow at the outcrop of subsurface flow requires the movement of substantial spoil higher up on the backfill. Mr. Lawson demonstrated how this is possible with a dragline but could be costly at a truck and shovel operation. Any landforming to create natural relief or develop base flow, other than surface contouring, must occur during the initial movement of material while the large earthmoving equipment is still available or it may not be economically feasible. Additionally, the haul roads necessary to create the side fill will create additional compaction that is counterproductive to some post-mining land uses, such as commercial forestry.

3. (From Aquatic Resources Group) *Modify drainage systems to create stream and wetland areas on steeper regions.*

Benefit: Natural streams and wetlands in steeper regions is more characteristic of the Appalachia region. Note that there are not many wetlands in the Appalachian region that were not created by humans.

Barrier: The requirement to limit the total area of valley fills restricts the ability to construct more natural configurations. Aquatic ecosystem enhancement with natural channels may require the development of larger valley fills than allowed by the AOC model.

Closing Remarks

Dr. Ziemkiewicz expressed his appreciation to the group for their effort to develop the recommendations along with the benefits and barriers for further consideration during the EIS process. For his closing remarks, he provided his perspective on each of the three symposium focus areas, Vegetation, Aquatic Resources, and Landforms. He included a list of issues that must be developed further during the course of the EIS to be able to translate these recommendations into practice and such that the public will be able to understand their full benefit and costs.

Vegetation: He discussed the issues of soil reconstruction and plant community development. He noted that soil reconstruction is actually a very complicated issue; how to manage it, how to create soil, what criteria describes sufficient soil quality compared to overburden? How should reconstructed soil be handled? How long can they be stockpiled and still retain their beneficial qualities? Dr. Ziemkiewicz also discussed the issue of soil decompaction and the implications for compaction from using a dragline compared to a truck and shovel operation. He also noted the issues; is decompaction permanent? While it is necessary to reestablish vegetation, how effective is it over time? Dr. Ziemkiewicz commented that all of these questions and more will have to be addressed to communicate consistent criteria in advance to operators for the reclamation of a mine site.

Dr. Ziemkiewicz also discussed the complexity of plant community development. He asked the question, what kind of plant communities are needed at a reclamation site? Obviously, continued Dr. Ziemkiewicz, we need several different types including aquatic, riparian, and upland forests. He continued to question what species of plants should each type include? The regulation, according to Dr. Ziemkiewicz, must identify critical plant communities and essential native plant species. Another key issue he noted is that there is a need coordinate natural plant succession on mine sites while maintaining adequate erosion control because the operator cannot immediately plant oak trees or pine trees on a spoil area and hope to be successful. He concluded that we must have realistic expectations that consider natural succession to be able to coincidentally achieve erosion control while restoring natural ecosystems.

Aquatic Resources: Dr. Ziemkiewicz asked the question, can streams be reestablished on mine spoil? From his experience, he commented, many operators have expended a lot of resources to try and place streams across spoil material without success. He continued that these reaches are difficult to maintain due to the high permeability of the mine spoil. According to Dr. Ziemkiewicz, operators and regulators have to consider the value of constructed wetlands compared to the value of the original ephemeral streams that may be covered in the process of valley fill. Furthermore, he questioned what is the comparative productivity of wetlands, ponds, and streams on mine sites? He commented that we may not be very close to getting the answers for this and other questions necessary to consider a regulatory basis for developing aquatic resources.

Landform: He summarized the issue as the optimization of placement of fill material in a valley fill or by back hauling. Dr. Ziemkiewicz noted that we must be able to prescribe how to configure the landscape to meet all the competing criteria including aquatic ecosystem enhancement.

At the end of the EIS process, he concluded, we must be able to proclaim what we are trying to accomplish and the public must be able to understand the benefit to the aquatic ecosystem in comparison to other concerns.

FURTHER AMPLIFICATION AND CLARIFICATION OF ISSUES RELATING TO LANDFORM RESTORATION
by
HORST J. SCHOR

The impact on aquatic habitat and the elimination of streams through the valley fill process is really secondary and only provided the legal "hook" to those opposed to current practices of Mountain Top Removal/Valley Fills. It has been my observation that the primary and more fundamental issue is, what is perceived by a large segment of the public as the destruction, the "flattening out" of an existing, pristine, mountainous topography with the concurrent loss of the entire biological habitat on a fairly significant scale.
Current reclamation practices do not typically:

- restore a natural topography – mountain tops and valleys and the associated topographic relief
- restore a natural hydrologic system, they only "control" drainage
- restore streams but, build engineered ditches
- re-vegetate the reclaimed forms to their original or approximate original condition; distribution of trees, shrubs and ground cover species is not done by aspect or by elevation but, rather uniform and standardized; single groundcover mix is optimized for quick germination, dense coverage and erosions prevention often preventing success of other plant and tree species

All of the above objectionable practices can be mitigated if the industry and its regulatory agencies are willing, and some issues have already been addressed by some companies. Reclamation efforts at the Sample and Holbert Mines demonstrated that the industry is capable of restoring the mountaintop component of the original landforms and they need to be commended for their efforts.

Not only does it recapture an aesthetic element of West Virginia's topography, it is also reported to be more cost effective than conventional practices in drag line operations. It further controls erosion on constructed fill slopes without unsightly, traditional benching techniques by breaking the man made topography into smaller, none-erosive tributary drainage areas - just like in nature.

In terms of landform restoration, we are half-way there!

However, the element, even with their efforts, that is still missing, is the recreation of the valley form. Some of their spoil fills (parts of the recreated ridge tops) are actually stacked on top of valley fills. Valley fills need to be significantly depressed so that there can be a more gradual transition of the valley floor downstream from the fill segment to the undisturbed natural valley/stream. Mountain top fill heights are then increased to make up for loss of the valley's holding capacity.

Valleys are the foundation for streams. They are the collectors of both surface and subsurface drainage, they capture, hold, concentrate and channel the water and together with the topography and vegetative cover become part of the overall aesthetic natural landscape of any mountainous terrain.

You can't have streams without valleys forms, you can only build drainage ditches or, as Dr. Handel put it so well, build plumbing devices.

I believe that the loss of the valley form with its associated stream habitat through the filling process, appears to be the most serious and objectionable element in the public's perception. It is only through ways of restoring this landform component with its habitat that we can hope to find a middle ground to resolve the controversy, or valley fills may become highly restrictive, if not off limits entirely.

It would be unfortunate if, because of the inflexibility of the industry, a court's ruling would set reclamation practices rather than the technical expertise and the creative minds of the industry itself and the cooperation of regulatory agencies. It is recognized that this will require different design techniques, construction processes and maybe even machinery to achieve this objective but, that has been done before as this industry evolved from underground to surface operations.

References

O'Dell, John. 1991. Grading on the Curve, Developer Goes for Natural Look in Sculpting Hills for Talega Project. *Los Angeles Times*, Friday, July 12, 1991, Section D, Business.

Schor, Horst. 1980. Landform Grading: Building Nature's Slopes. *Pacific Coast Builder*, June 1980.

Schor, Horst J. 1993. Landform Grading: Comparative Definitions of Grading Designs. *Landscape Architect*, Vol. 9, No. 11, November 1993, p. 23-25. The article is available at: http://www.landscapeonline.com; click on Research & Editorial, "Click to Continue," Elemental Concerns, Erosion Control, and the title of the paper: 93/11 Landform Grading: Comparative Definitions of Grading Designs.

Schor, Horst J., and Donald H. Gray. 1995. Landform Grading and Slope Evolution. *Journal of Geotechnical Engineering*, Vol. 121, No. 10, October 1995, p. 729-734. A brief discussion of the article is available at: http://www.asce.org; click on Publications, search, search, Journal Paper. Key in the title: Landform Grading and Slope Evaluation and then click on it to see the reference and the brief discussion.