Muddy Run Watershed

Cambria and Clearfield Counties, PA

Mine Drainage

Assessment and Restoration Plan

Prepared for the Clearfield Creek Watershed Association

By NMBS (www.newmilesofblustream.com)

NEW MILES OF BLUE STREAM

June 2010

Funding for this project was provided by the Pennsylvania Department of Environmental Protection's Growing Greener Program

Executive Summary

The Muddy Run Assessment and Restoration Plan was developed in the effort to address pollution problems affecting the Muddy Run Watershed, including all tributaries in this section. The Clearfield Creek Watershed Association (CCWA), a local, nonprofit, volunteer organization, in cooperation with numerous partners, has created this plan to provide users with a road map to guide future restoration and implementation activities within the watershed. CCWA contracted with NMBS to recommend processes and procedures for the completing the field assessment, developing the monitoring plan, and coordinating the monitoring activities with volunteers. NMBS was also employed to assemble the group's data and develop the restoration plan.

The restoration of the Muddy Run watershed presents many challenges and project partners should understand the recommendations identified within are based on the best information on restoration technologies available at the time of its creation using data collected during the assessment phase. Due to the evolving techniques and technologies used in watershed restoration, changing priorities of government agency programs, and the availability of various funding sources used in restoration activities, a periodic review and updating of the plan is highly recommended.

Muddy Run is a major tributary entering Clearfield Creek at the town of Madera. In the completed Assessment Report on Clearfield Creek (Melius and Hockenberry, 2004), no information was collected on Muddy Run, despite extensive AMD in this watershed as known from the Operation Scarlift Report. The goal of the project by the Clearfield Creek Watershed Association was to provide up-to-date information on AMD sources and conditions in this watershed, and to prioritize and develop remediation plans for the acid sources. A key part of the project was to locate all significant AMD sources in the Muddy Run watershed, and to sample them monthly for a year. The results have allowed comprehensive consideration of this watershed along with the rest of Clearfield Creek watershed. Future projects will be directed toward remediation at the high priority sites in the region, using the most effective regional approach.

Extensive coal mining has occurred in the Muddy Run watershed; therefore, the area faces extreme AMD problems. Muddy Run is one of the most severely polluted streams to enter Clearfield Creek. A 1971 Scarlift report prepared by Skelly and Loy states Muddy Run contributes 47% of the pollution to Clearfield Creek, but accounts for only 8% of the watershed. An average pH in the main stem was 4.0 with a net acidity of greater than 100 mg/L, and an acid load of 16,000 lbs/day entering Clearfield Creek.

The project partners assessed the entire watershed which encompasses approximately 37 square miles. The assessment included the main stem of Muddy Run and the tributaries of Curtis Run, Little Muddy Run, East Branch, Banian Run and a few unnamed tributaries.

The headwaters of Muddy Run and associated tributaries begin in the northeast corner of Cambria County, Pennsylvania near Blandburg . The main stream then flows in a northern direction into the southeast corner of Clearfield County until its confluence with Clearfield Creek near the town of Madera. The watershed is located on the Ramey and Blandburg USGS 7.5-minute series topographic maps. The watershed encompasses parts of Beccaria, Bigler, Gulich, and Reade Townships, and flows through the small communities of Madera, Janesville, and Blandburg.

The primary goal of the project partners is to restore and improve water quality within the Muddy Run Watershed; this will in turn improve quality in Clearfield Creek and, ultimately, in the West Branch of the Susquehanna River. Through remediation of abandoned mine drainage and abandoned mine lands within Muddy Run, a cold water fishery can be restored. A large portion of the stream is open to the public, thus, a restored fishery would complement the recreational activities, such as hiking, fishing, hunting, and riding ATVs that already exist within the watershed. Restoration of Muddy Run Watershed should be able to be accomplished through 24 priority treatment projects, which most likely will be reduced if reclamation efforts take place. Through these reclamation efforts, several areas of abandoned mine lands which pose public safety hazards and negatively impact the aesthetic value of the watershed can be restored. The biggest battle within the watershed is treating the Headwaters Area near Blandburg and the Eureka Mine. Additional studies have occurred at these sites and will be taken into consideration during remediation efforts.

Twenty eight (28) notable areas of pollution were sampled monthly for one year in the Muddy Run watershed; twenty four (24) of these are considered significant and need treatment. The impacts in this watershed are severe and related to extensive abandoned mine lands. Some of the discharges are associated with spoil piles, abandoned high walls, and unreclaimed surface mine areas. These discharges would benefit from reclamation activities that would decrease discharge flow rates and improve water quality. Additional sites emanate from underground deep mines. Further investigation into these sites is recommended to determine if sufficient coal remains to make remining economically feasible.

The recommended treatment systems for Muddy Run are mostly passive systems, but due to the severity of water quality and the high flow rates, active treatment is recommended at some of the sites. Also, to be as economical as possible, some of the discharges should be combined and treated actively to decrease the number of treatment systems. The preliminary recommendation for the active treatment systems includes using lime dosers which require no electricity and limited maintenance. These dosers treat discharges directly, along with including settling basins to protect the habitat with the stream itself. The passive treatment systems will use the most appropriate of the technologies available at the time of design and construction. The systems will consist of a combination of aerobic wetlands, vertical flow wetlands, flushing limestone ponds, bioreactors, aerating settling ponds, and manganese limestone beds.

If the 24 priority treatment projects are completed, the Muddy Run watershed should be greatly improved. Restoration efforts will allow for the aquatic ecosystem that exists in Little Muddy Run and other tributaries to establish and expand their population to newly restored sections of the main stem of Muddy Run.

TABLE OF CONTENTS:

INTRODUCTION 1

Watershed Vision 1

Purpose of Project 1

Public Participation 2

WATERSHED BACKGROUND 3

Watershed Description 3

History 4

Historical Studies 5

Geology/Topography 6

Location 6
Physiography 7
Geology 7
Soils 11

Wetlands 11

Land Use/Cultural 12

MINING 14

Mining History 14

Historical Permits 15

Scarlift Report: 18

AML 18

DATA COLLECTION 18

Field Reconnaissance 18

Historical Data 19

Documentation of Problem Areas 19

Permission 21

Development of Monitoring Plan 21

Sampling Methodology 21

Data Quality 22

Water Quality Measurements 23

Flow Rate: 23

MAPPING 24
Location maps 24
Monitoring Program 24
Stream Quality 24
DATA ANALYSIS 25
Precipitation during Sampling Period 25
Description of Data 28
Discharge Areas/Water Quality Data 28
A-101 28
BW-01 28
BW-02 29
BW-03 30
CB-10L 30
CM-3R 31
CRD-05 31
CRD-1R 32
CRD-2R 33
DER-2T 33
EU01 34
MCC-01L 34
MUC-10R 35
MUC-11R 35
MUC-9R 36
MUE-1L 36
MUE-2L 37
MUE-2R 38
MUE-5R 38
MUE-6R 39
MUEA-1L 39
MUEA-2R 40
MUEA-3L 40
MUEA-3R 41
MUEA-6R 41
MUEC 42
MUED-1R 43
MUED-3 43
BRQ-10 44
LMQ-10 44
MRQ-10 44
MRQ-20 45
MRQ-30 45
MRQ-40 45
MRQ-50 46
Comparison of Quarterly Stream Samples 46
Macroinvertebrate Data 48

AMD TREATMENT METHODS: 49

TREATMENT, OPERATION, AND MAINTENANCE 55

Operation and Maintenance 55

Prioritization of Treatment Areas 55

Area #1: Lower Muddy and Little Muddy Runs 57
Area #2: Headwaters Region of Muddy Run 67
Area #2A: Upper Reaches of Muddy Run, East Side 67
Area #2B: Upper Reaches of Muddy Run, West Side 74
Area #2C: Muddy Run after confluence of upper headwaters tributaries 81
Area #2D: Curtis Run and Vicinity 87

FUNDING OF THE PROJECT 96

CONCLUSION 96

APPENDIX A: MAPS 1

Watershed in PA 3

Topographic Quads containing Assessment Area 4

Sub Watersheds 5

Impaired Streams 6

Stream Quality 7

AML Priorities 8

Soil survey 9

Geology 10

Wetlands/NWI 11

Treatment sub areas 13

Monthly Sampling 14

Monthly Sampling on Topo 15

Quarterly Sampling 16

Macroinvertebrate Sampling 17

Permits 18

Mine maps 19

Brookwood Mine 20

Eureka Mine 21

Miller Mine 22

Seepage Area 23

APPENDIX B: ASSOCIATED FILES 1
Assessment Data 1
Images 1
Landowners 1
Mine Maps 1
Penn State TMDL 1
Unsuitable for Mining Report 2

APPENDIX C: ALTERNATE RANKING ORDERS 1
Stream miles 1
Acid Load 2
Iron Load 3

APPENDIX D: SOIL DESCRIPTIONS 1

APPENDIX E: MACROINVERTEBRATE STUDY 1
Methods 2
Results 3
Muddy Run at SR-253 (MRQ-50) 5
Curtis Run 6
Little Muddy Run Below Janesville Dam (LMR-JD) 7
Discussion 10
Literature Cited 11

BIBLIOGRAPHY 1

GLOSSARY 1

Introduction

Watershed Vision

It is the vision of the project partners to restore the Muddy Run watershed through remediation of abandoned mine drainage and abandoned mine lands. These efforts will support the goal of improving water quality, and restoring a cold water fishery to the main stem of Muddy Run. Another goal is to improve the land quality for human and wildlife use through the reclamation of abandoned highwalls and spoil areas. Restoration efforts should restore impaired sections of the stream and expand recreational opportunities that already exist within the watershed.

The assessment project provided many hands-on learning opportunities related to mine drainage for youth groups and local residents, another goal of CCWA. Education will lead to long-term stewardship in the watershed and the establishment of a relationship with the community that will work towards protecting and cleaning-up local watersheds.

Purpose of Project

The purpose of this project was to complete a watershed assessment and restoration plan for Muddy Run and the associated tributaries. A comprehensive look at the watershed area is needed before remediation efforts are put into place in order to improve the overall water quality of the tributaries and also to have beneficial impacts to Muddy Run and Clearfield Creek. Clearfield Creek Watershed Association (CCWA) is a local, nonprofit, volunteer organization, who in cooperation with numerous partners, has created this plan to provide users with a road map to guide future restoration and implementation activities within the watershed.

According to the 1971 Muddy Run Scarlift report, the entire watershed lies in the gently folded Allegheny Plateau. In the southern part of the watershed, the Allegheny Mountains impose a steep gradient with resulting deeply cut V-shaped valleys. The valleys broaden towards the northern end of the watershed as the gradient caused by the Allegheny Mountains decreases. Highlands are generally capped with resistant sandstone contained within coal measures, and valley bottoms are generally composed of alluvial and colluvial material. The stream course of the watershed is influenced by the northeasterly trending folds and northwesterly trending wrench faults. The surface drainage in the area is fed by springs at coal and sandstone aquifer outcrops. The original hydrology of the watershed has been extensively altered due to coal mining in the area.

Because of the rich coal reserves that existed in the study area, extensive surface and deep mining activities have occurred. These extensive mining activities have resulted in the widespread pollution of Muddy Run and its tributaries. Countless pollutant sources discharge into surface and ground waters of the area. Also, past coal mining has left behind a scarred landscapes, huge amounts of coal refuse, abandoned mine lands (AML) and mine subsidence.

The watershed assessment has allowed for prioritization of the pollution areas for either reclamation or treatment. Existing data from the Scarlift Report and mining permits, and known data collected by other groups was reviewed and/or analyzed as part of the assessment project. This information was used to develop the restoration plan, along with being available for future design projects in order for all project partners to begin the restoration of Muddy Run. Much of that data is available on the accompanying CD.

Public Participation

In order to complete the assessment and restoration plan, CCWA reached out into the local community to gain volunteers willing to participate in the stream reconnaissance, weir installation and monthly sampling, along with relying heavily on their membership. CCWA understands the daunting task of restoring Muddy Run, along with the bigger picture of restoring Clearfield Creek and considers outreach an important aspect of reaching their goals. They conduct monthly meetings, have annual special meetings to present projects and reports, invite guests to present special topics, along with maintaining a website as a few activities to increase membership and encourage public participation.

Significant volunteer contributors to the reconnaissance, weir installation and monthly sampling include the following: Area ABC was managed by Dan McMullen, Shawn Simmers and Dane Kalwanski; Area D was managed by Earl Smithmyer and Arthur Rose; and Area E was managed by Ed McMullen, Gerry McMullen, Ray Hollen and Charles Sutton. In addition, Carl Undercofler worked with Kelly Williams and others of the Clearfield County Conservation District on the instream sampling, along with the reconnaissance and weir installation throughout the watershed. Bryan Rabish of the Cambria County Conservation District greatly assisted with weir installation and other activities.

Watershed Background

Watershed Description

The history of the Muddy Run watershed can be found in the Muddy Run Operation Scarlift Report. The following is a summary of the information contained therein.

The Muddy Run watershed encompasses 37 square miles in 4 townships in Cambria and Clearfield Counties, Pennsylvania. Nearly all of the tributaries within the watershed are acid and Fe-bearing in nature. At the time of the Scarlift study, Muddy Run was contributing approximately 16,000 lbs/day of acid to Clearfield Creek. The acid nature of the tributaries and Muddy Run itself is due to the large and extensive deep mining and surface mining that has taken place in the watershed. Deep mining began in the early 1860s and expanded as coal became the preferred energy source over wood. This unregulated mining activity drastically altered the natural hydrology of the watershed. The Lower Freeport, Clarion, and Lower Kittanning coal seems were the first and most extensively mined because of their high quality and large quantity. As they began to dwindle, mining began to spread to the thinner seams. In the early 1940s, surface mining began to replace deep mining and it has continued until the present time. At the time of the Scarlift report, deep mines on the Lower Kittanning seam were still active. Surface mining continues in the Muddy Run watershed at several sites. These sites along with past mining sites will be addressed in the assessment and restoration plan of Muddy Run.

The headwaters of Muddy Run and associated tributaries begin in the northeast corner of Cambria County, Pennsylvania near Blandburg . The main stream then flows in a northern direction into the southeast corner of Clearfield County until its confluence with Clearfield Creek near the town of Madera. The headwaters of Little Muddy Run and some other tributaries are relatively high quality. The watershed area is located on the Ramey and Blandburg USGS 7.5-minute series topographic maps. The watershed encompasses parts of Beccaria, Bigler, Gulich, and Reade Townships, and flows through the small communities of Madera, Janesville, Beccaria and Blandburg.

The following table provides approximate lengths for several of the named streams in the assessment area. Note that stream lengths only include the length of the named stream; unnamed tributaries are grouped by the stream they feed into and are totaled as a group.

Stream Name	Approx. miles
Banian Run	2.3
Curtis Run	1.7

Stream Name	Approx. miles
East Branch Little Muddy Run	1.9
Little Muddy Run	8.8
Muddy Run	12.1
Tribs To Curtis Run	1.1
Tribs To East Branch Little Muddy Run	0.5
Tribs To Little Muddy Run	10.0
Tribs To Muddy Run	16.0

Total stream miles: approximately 54.3 miles.

The assessment area encompasses approximately 35.3 square miles. Area values were calculated from the geographic coverages obtained from PASDA; since the total is similar to the 37 square miles reported in the Scarlift report, summary descriptions will continue to use the number of 37. The following table provides approximate areas for the same named sub-watersheds in the assessment area. Note that these areas are those represented in a map entitled "sub-watersheds" on page A-5. The areas for these sub-watersheds are for the entire area feeding to the named stream; unlike stream length, this includes unnamed tributaries.

Subwatershed Name	Approx. square miles
Banian Run	2.0
Curtis Run	1.6
East Branch Little Muddy Run	1.7
Little Muddy Run	12.8
Muddy Run	17.2

Total square miles: approximately 35.3 square miles.

History

Generations of area residents have made their living and enjoyed recreation throughout the Muddy Run watershed. Recreation, including fishing, has been a favorite past time in this area, and despite degradation of the stream by AMD and AML, tributaries within the watershed still contain a viable wild trout population. Mining occurred within this watershed from the late 1800's to the present, affecting both water quality and aesthetics of the surrounding landscape. Deep mining accounted for most of the coal extracted prior to the 1940's, after which surface mining predominated.

According to the TMDL completed on Little Muddy Run, the largest subwatershed, studies assessed the biological community present in Little Muddy Run. In general, these studies found that the macroinvertebrate community was depressed at most sites within the subwatershed. However, the headwaters of Little Muddy Run has no AMD impact and springs found in this area are used as a drinking water supply. Little Muddy Run is attaining it's designated uses within this headwater reach. The PFBC stopped stocking the Little Muddy Run from 1986 to 1995. Remediation efforts in the upper reaches of Little Muddy Run resulted in the PFBC being able to stock again in 1996. These efforts within Little Muddy Run can be replicated within the larger watershed and allow for trout to repopulate.

Also found within the Little Muddy Run watershed is Janesville Dam in the mid-reaches. The impoundment that the dam creates was drained in the 1980's due to the effects of AMD. It has since been refilled and now is stocked with brook trout by the PFBC. The dam creates a small impoundment used for recreational purposes (non-motorized boating, fishing, picnicking). Again, this is evidence that remediation efforts within the larger watershed can be successful and it is possible to restore a cold water fishery.

Historical data on mining was gathered and/or reviewed during the watershed assessment. The historical data which was electronically gathered is included on the accompanying CD. For more information on historical data see the accompanying CD or read the additional summary in Appendix B.

Historical Studies

Background data in this area was collected during the compilation of the Scarlift Report. This report was just a "snapshot" and no long term monitoring has occurred, other than on active mine permits. In addition to the Scarlift Report, considerable information was compiled for an Unsuitable for Mining (UFM) designation in 1998 and a recent report has become available which can be found on the CD. This database contains permit data to 1998, plus some sampling of discharges and stream sites for the UFM study. A crude reconnaissance of parts of Muddy Run was conducted by Dr. Arthur Rose in 2003-2004, and a few samples were collected and analyzed by Rose and Donna Carnahan of Clearfield County Conservation District. Recently, the Eureka 29 discharge, the Brookville shaft discharge and several other nearby outflows have been sampled as part of a BAMR-SRBC study of mine pools for supplementing the low-flow of the Susquehanna River (GAI Consultants, 2007). A TMDL was completed for the Little Muddy Run watershed in 2005, along with an additional UFM study in 2010. Penn State students also recently completed a simplified TMDL on the watershed (Penn State Students, 2010).

These historical documents were used in the development of the sampling plan and their data considered in the prioritization of projects within the watershed. Their recommendations were also considered in the development of the restoration plan.

The text for the 2005 Little Muddy Run TMDL can be found on-line at http://www.epa.gov/reg3wapd/tmdl/pa_tmdl/LittleMuddyRun/LittleMuddyRunAL_DR.pdf.

Geology/Topography

This section on Geology and Topology has been taken from the Scarlift report (Skelly and Loy, 1971). A copy of this report can be found at http://www.amrclearinghouse.org/Sub/SCARLIFTReports/. No significant changes in geology, location, or topography are believed to have occurred in the time since this report was drafted.

Location

The Susquehanna River drains 20,900 square miles of Pennsylvania's 45,300 square mile total area. It is reported that 650 miles of significant tributaries have been rendered essentially sterile of biological activity by acid mine drainage discharges (U.S. Corps of Engineers, "Susquehanna River Basin, Mine Drainage Study", January, 1971). Additionally, some 230 miles of principal streams are seriously degraded or periodically threatened by this mine pollution. A recent report indicates 1205 miles of waterways are impaired by AMD in the Susquehanna River Basin (Susquehanna River Basin Commission, 2008)

Muddy Run is one principal source of pollution to Clearfield Creek which, in turn, is a principal source of pollution to the West Branch Susquehanna River in 1971 and in a later study by the US Geological Survey in 1984 (Hainly and Barker, 1993) A Federal study indicated that Muddy Run contributed over 47% of the acid mine drainage pollution load to Clearfield Creek, although it accounts for only 8% of the watershed area (U.S. Corps of Engineers, "Susquehanna River Basin, Mine Drainage Study", January, 1971).

The northern 3/4 of the Muddy Run watershed is situated in the southeast corner of Clearfield County, Pennsylvania; the southern 1/4 of the watershed is situated in the northeast corner of Cambria County, Pennsylvania. The watershed is bounded on the north by Madera, on the south by Blandburg, and is centered about Janesville and Beccaria. The center of the watershed is 17 miles north of Altoona, and 18 miles south of Clearfield. The 37 square mile watershed (48 square mile study area) has a maximum width of 5 miles and a maximum length of 10 miles. Muddy Run flows in a northerly direction to its confluence with Clearfield Creek at Madera. From there, Clearfield Creek flows north to its confluence with the West

Branch Susquehanna River near Leonard, Pennsylvania. Banion Run, Little Muddy Run, East Branch, and Curtis Run are the only named tributaries to Muddy Run. The watershed includes portions of Bigler, Gulich, Reade and Beccaria Townships.

Physiography

The topography of the Muddy Run watershed is influenced by structural features imposed by two physiographic provinces of Pennsylvania - the Allegheny Plateau and the Valley and Ridge Province . The entire watershed, however, lies within the gently folded Allegheny Plateau.

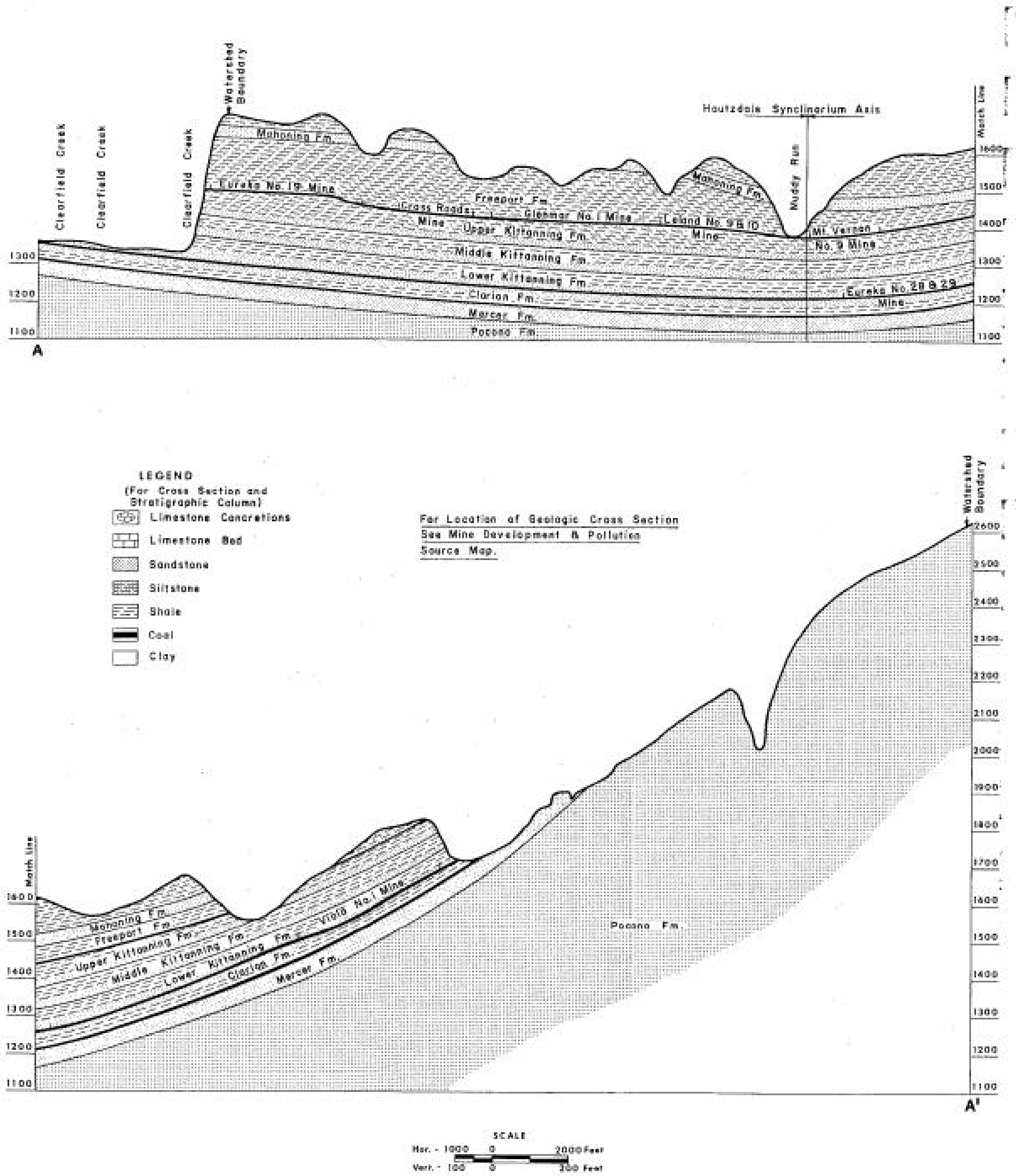
This situation is responsible for a total relief of approximately 1150 feet as well as varying stream maturity regimes. In the south, the steadily rising flank of the Allegheny Mountains imposes steep gradients and the accompanying vertical downcutting results in relatively deep V-shaped valleys. The valleys broaden and local relief decreases toward the northern end of the watershed as the gradient imposed by the Allegheny front decreases. The highlands are generally capped by resistant sandstones contained within the coal measures and the valley bottoms are alluvial/colluvial fill. Farming is mostly confined to the flat upland regions while the valley sides and bottoms are forested. The stream courses in the watershed are influenced by both the northeasterly trending folds and the northwesterly trending wrench faults.

Both the stratigraphically high position of the Allegheny Group and the fluvial dissection are responsible for the many coal outcrops above surface drainage in the area. The surface drainage system was mainly fed by springs at both the coal outcrops and the intervening sandstone aquifer outcrops; however, the original hydrology of the watershed has been extensively altered by coal mining.

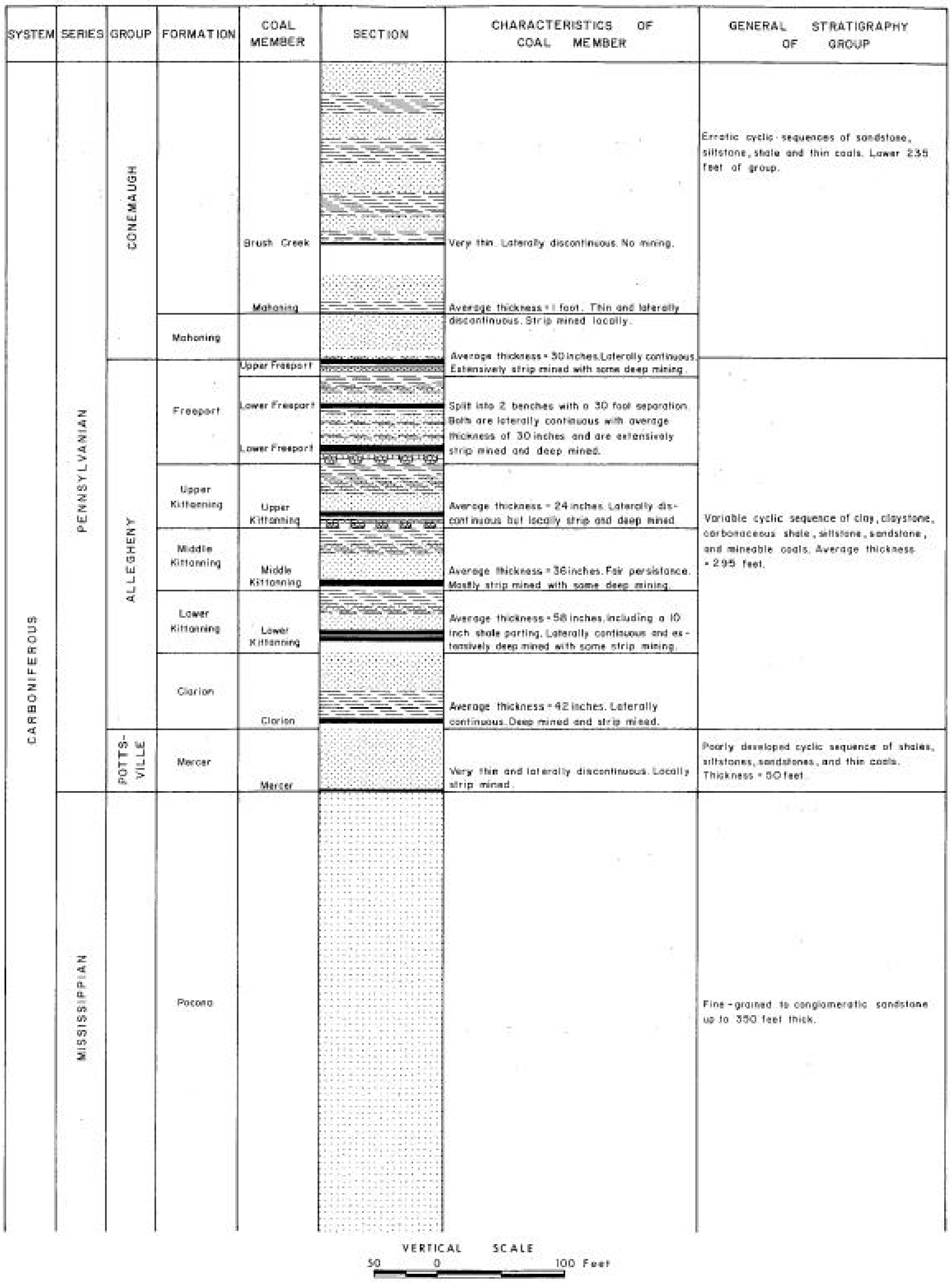
Geology

Surface formations in the Muddy Run watershed range from the upper 350 feet of the Mississippian Pocono Formation to the lower 200 feet of the Pennsylvania Conemaugh Group, comprising a stratigraphic thickness of nearly 1,000 feet. The valley bottoms are filled with up to 25 feet of Quaternary alluvium.

The Allegheny group contains the most important formations in the watershed. These are the coal measures ranging vertically from the Clarion formation to the Freeport formation. The formations comprising the Allegheny group consist of erratic cyclic sequences of underclay, coals, claystones, shales and sandstones deposited during a period of fluctuating mild tectonic activity. (Figures below taken from the Scarlift Report).



GEOLOGIC CROSS SECTION



STRATIGRAPHIC COLUMN OF SURFACE ROCK

This varying paleoenvironment is also responsible for a set of seemingly incongruous conditions existing today. The drainage from the mines on the Clarion, Lower Kittanning and Middle Kittanning seams is predominantly acidic with large concentrations of iron and sulfate. The mine drainage from the Upper Kittanning, Lower Freeport, and Upper Freeport seams is predominantly alkaline with relatively high concentrations of iron generally in the ferrous state. This may be explained by the association of fresh water limestone in the form of thin beds or concretions within the underclays of these three latter formations. The mildly fluctuating rate of subsidence and the subsequently variable base level resulted in an open water to swamp to fluvial-deltaic depositional sequence responsible for the complex stratigraphic nature of the coal measures. Such an environment of deposition often contains areas of restricted water and high biochemical oxygen demand, resulting in a reducing atmosphere. The coal seams and adjacent strata reflect this condition by their high content of sulfuritic compounds such as pyrite and marcasite. Limestone was occasionally deposited/precipitated in back swamp areas during periods of the sedimentary cycle. The acidity caused by the oxidation and hydrolysis of these iron disulfides in the mine drainage is neutralized to various degrees when this limestone occurs below a coal seam or in spoil from a surface mine. The resultant higher pH causes the ferrous iron to be precipitated as ferric hydroxide (yellowboy).

Structurally, the area is controlled by a series of northeast striking folds. These folds are doubly plunging and the strike of the bedding approximates their axial trend. The axis of the Houtzdale-Snowshoe Syncline passes through Utahville, Beccaria, Ramey and Houtzdale with the trough being bounded on the southeast by the Allegheny front and on the northwest by the Laurel Hill Anticline. The coal measures of the Allegheny group and portions of the Mahoning coal of the Conemaugh group have been protected from erosional processes by this structural low, while the up dip approaches to the Laurel Hill anticline and the Allegheny front expose the lower lying Mercer and Pocono formations.

A series of northwesterly trending wrench faults cross the watershed in a pattern roughly perpendicular to the fold axis and parallel to the stress vector responsible for the folding. The largest fault in the area is the Tipton Fault, which separates the Eureka Mine No. 28 from the Brookwood Shaft Mine on the Lower Kittanning coal seam. It has, along with its splay faults, displaced the Lower Kittanning in this area with such intensity that coal extraction was impossible. This same area is complemented with similar faults, and in general their intensity increased toward the southeast. Another significant wrench fault passes northwestward down Curtis Run and vicinity (Faill et al., 1989).

Soils

The 2005 NRCS data shows that there are approximately fifty five major soil units found along the main stem and tributaries of Muddy Run, with six making up nearly 50% of the watershed. The top six dominant soils along the main stem are Cedarcreek extremely channery loam, moderately steep (95D), Bethesda very channery silt loam, 8 to 25 percent slopes (92D), Gilpin channery silt loam, 8 to 15 percent slopes (GlC), Rayne-Gilpin complex, 15 to 25 percent slopes (RcD), Ernest silt loam. 8 to 15 percent slope (ErC), and Gilpin channery silt loam, 3 to 8 percent slopes. Soil descriptions for the seventeen major soil units found near the stream corridor within the watershed based can be found in Appendix D. Approximately thirty eight other soil units are found in the area of study. Information in this section was obtained from data provided by NRCS as well as a review of the Clearfield County Soil Survey. Several discrepancies were noted between the NRCS data and the older Soil Survey; the newer data was presumed to be more accurate for contemporary use.

Wetlands

The Muddy Run Watershed was reviewed on the National Wetlands Inventory Map (NWI). The maps for the project area are the NWI 7.5 Minute Ramey and Blandburg Quadrangles. Based on review of this mapping, two hundred and twenty nine wetland areas (229) were identified within the Muddy Run Watershed. Sixty-one (61) of these are freshwater forested/shrub wetlands, fifty-three (53) are freshwater emergent wetlands, and one hundred fifteen (115) are freshwater ponds. Please refer to map pages A-11 and A-12 for the NWI mapping.

The following is a list of wetlands found in Muddy Run. This information is important in determining wetland impacts during construction of treatment systems.

Description	Type	Acres	Count
Freshwater Emergent Wetland	PEM1A	52.0	44
	PEM1Fb	4.5	3
	PEM1Fh	0.6	2
	PEM1Fx	0.7	4
		57.8	**53**

Description	Type	Acres	Count
Freshwater Forested/Shrub Wetland	PFO1A	202.2	17
	PFO4A	13.1	6
	PFO5Fb	1.7	3
	PSS1/EM1A	6.7	2
	PSS1/FO4A	10.9	3
	PSS1/FO4C	5.3	2
	PSS1A	14.1	7
	PSS1C	16.9	13
	PSS1Ch	0.8	2
	PSS4A	3.5	6
		275.1	**61**
Freshwater Pond	PUB/FO5Fh	1.9	2
	PUBFx	9.7	26
	PUBHh	43.4	29
	PUBHx	45.6	58
		100.5	**115**
Total		**433.4**	**229**

Land Use/Cultural

The Muddy Run watershed is mainly forested and undeveloped. The headwaters of Muddy Run and associated tributaries begin in the northeast corner of Cambria County, Pennsylvania near Blandburg . The main stream then flows in a northern direction into the southeast corner of Clearfield County until its confluence with Clearfield Creek near the town of Madera. The watershed area is located on the Ramey and Blandburg USGS 7.5-minute series topographic maps. The watershed encompasses parts of Beccaria, Bigler, Gulich, and Reade Townships, and flows through the small communities of Madera, Janesville, and Blandburg.

The acid nature of the tributaries and Muddy Run itself is due to the large and extensive deep mining and surface mining that has taken place in the watershed. Deep mining began in the early 1860s and expanded as coal became the preferred energy source over wood. This unregulated mining activity drastically altered the natural hydrology of the watershed. The Lower Freeport, Clarion, and Lower Kittanning coal seams were the first and most extensively mined because of their high quality and large quantity. As they began to dwindle, mining began to spread to the thinner seams. In the early 1940s, surface mining began to replace deep mining and it has continued until the present time. At the time of the Scarlift report, active deep mines on the Lower Kittanning seem were still being performed. Surface mining continues in the Muddy Run watershed at several sites.

Minimal logging has also occurred at various times within the watershed up until recent times. A wood products plant is located at Beccaria. At this time, much of the watershed is reclaimed surface mines, highwalls, or forested area. Spoil piles cover much of the mining areas; many are adjacent to streams. There are no other industrial or other water quality impacts in the watershed. There are many small towns throughout the watershed but their small populations pose little threat to the watershed.

As of now the recreational opportunities are minimal for Muddy Run. There is fishing, swimming and boating opportunities at Janesville Dam, which has good water quality, however, few want to boat or swim in “orange” water located throughout the majority of the watershed. Restoration efforts throughout the watershed will help the local community take pride in their backyard and begin using Muddy Run for recreational purposes. As stream miles are restored, individuals from outside the area will begin using the stream and nearby Clearfield Creek for fishing and canoeing, bringing tourist dollars to the area. An exact value is hard to calculate, though some have tried. These efforts will ultimately improve and restore a 37 square mile watershed and will positively impact the local economy.

Trout Unlimited conducted an economic assessment of the West Branch to put actual values to anecdotal knowledge that has existed that AMD impacted streams reduce property values, along with reducing recreational spending. Their study showed that in Clearfield County a property loses 5% of its total value if it is located within 200 ft of an AMD stream. This results in a loss of $4 million dollars to the residents of Clearfield County.

Recreational spending is difficult to put a number on, but studies have shown that roughly $4 billion dollars is spent in PA for hunting and fishing each, totalling $8 billion dollars of revenue for equipment, goods, and licenses. In a 2007 PAFBC study, they estimated that $22.3 million dollars is lost annually in the West Branch from lack of sport fishing. Improved water quality not only creates jobs in these rural areas, but also increases tourism and outside dollars being spent in local communities.

Mining

Mining History

According to the Scarlift report, mining was begun in Clearfield County in order to supply coal to the eastern Pennsylvania market. The first load of coal was shipped down the Susquehanna River in 1804 (U.S. Corps of Engineers, "Susquehanna River Basin, Mine Drainage Study", January, 1971). Coal mining has been a major factor in the economy of the Muddy Run area since the development of the Moshannon Coal Basin in the 1860's. Towns such as Madera, Smith Mills (now Janesville), Beccaria, Glasgow, Blandburg and Smoke Run owe their existence to this initial surge of mining. As the major seams were exhausted, towns such as Allemans, Glasgow and Blandburg were economically boosted by the development of other seams.

The Moshannon Basin or Houtzdale-Snowshoe Syncline has preserved most of the Allegheny Group from erosion. Its axis passes through the watershed in a north northeast direction across Muddy Run and breaks to the east-northeast at Smoke Run, passing through Ramey and Houtzdale. Deep mining has been performed on both limits of this trough, with the Lower Freeport (locally termed Moshannon) being extracted first. The Lower Freeport is split in this vicinity, and most of the deep mining (within the watershed) has taken place on the lower bench which averages 36 inches in thickness. The seam rejoins at the northeast boundary of the watershed where it averages 44 inches in thickness.

The Lower Kittanning seam was extensively deep mined along the southeast limb of the basin by Berwind-White Coal Company, and by the Hale Coal Company. It represented a profitable venture because of its lateral continuity, good quality, and persistent lateral thickness averaging 54 inches, including a 10 inch parting. Major deep mining activity on the Lower Kittanning coal lasted from the early 1900's to the early 1950's. One such example is the Miller Mine, (MUE-11R). Additional mines can be found throughout the watershed and information can be found at the Pennsylvania GS Bulletin (Faill et al., 1988). The Clarion coal was also deep mined during the same period as the Lower Kittanning. It is well developed along the northwest limb of the basin and averages 42 inches in thickness in this area. Liberty Coal Company, Middle Penn Coal Company, and Margaret McGlynn performed most of the mining on this seam. The southeast limb has also been explored somewhat, with Harbison-Walker Refractories performing most of the mining. Most of the mining activity since World War II, however, has been confined to stripping methods as a result of changing coal economics. Along the axis of the syncline the Upper and Lower Freeport seams have been extensively strip mined by the Flango Brothers Coal Company and others while on either flank, the Clarion and Lower, Middle, and Upper. Kittanning seams have been strip mined by S. J. Mountz and Powell Company. Additional surface mining has taken place in the watershed and permits were investigated for this report. A list of mining activity can be found in the historical permit table below.

Muddy Run was polluted prior to passage of effective mine drainage control legislation. This pollution emanates largely from deep mines which have been abandoned for many years, and were not affected by the 1965 amendments to the Clean Streams Law regulating deep mine drainage. There is evidence that some surface mines have created additional pollution sources by intercepting deep mine workings, thereby releasing acid water. Some major sources of pollution are apparently surface clay mines which not regulated by State law until 1977. The Commonwealth's first Clean Streams Law, passed in 1937, specifically exempted control of mining operations. In 1945, the law was amended to disallow pollution from active mines located on clean streams. Lack of proper funding delayed effective implementation of this amendment for several years. By that time, Muddy Run was not considered a "clean stream", so mining was allowed essentially without restriction. The technical requirements developed under this law were also weak (complete strip mine restoration and effective mine sealing were seldom required). It was not until 1963 that control of active surface mines was effectively strengthened, and not until 1965 that active deep mines were required to control pollution regardless of the quality of the receiving streams.

Historical Permits

Permit	Site Status	Site Name	Type
1002596	Active	Buterbaugh 1 mine	post mining trmt
1002596	Active	Buterbaugh 1 mine	discharge point
11000101	Stage 2 approved	Mulhollen opr	surface mine
11020102	Stage 2 eligible	Hommer opr	surface mine
1179101	Reclamation complete	Cambria 18	surface mine
1179106	Bond forfeited	Hommer opr 2	surface mine
11810106	Reclamation complete	Glasgow	surface mine
11813021	Bond forfeited	Glasgow	surface mine
11840112	Reclamation complete	C & k mine 46	surface mine
11850106	Bond forfeited - passive treatment	Cambria 51 mine	surface mine
11860105	Bond forfeited	Marion 1 mine	surface mine
11960101	Stage 2 approved	Lewis 1	surface mine
17000105	Reclamation complete	Alexa jean mine	surface mine
17010109	Reclaimed/passive treatment	Buterbaugh 2 mine	surface mine
17030120	Active	Kitko mine	surface mine
17040102	Stage 2 approved	Shaffer mine	surface mine
17040109	Stage 2 approved	Banian no 3 mine	surface mine

Permit	Site Status	Site Name	Type
17070104	Stage 2 approved	Smith mine	surface mine
17080102	Active	Goodyear #1 mine	surface mine
17080115	Not started	Kitko #2 mine	surface mine
17793090	Reclamation complete	Oshall 1 mine	surface mine
17810121	Inactive	Zendek mine	surface mine
17813153	Reclamation complete	Muddy run 1 mine	surface mine
17840120	Reclamation complete	Belin mine	surface mine
17840130	Stage 2 approved	Mo valley 2 mine	surface mine
17870109	Inactive	Heverly mine soap 318	surface mine
17870118	Reclamation complete	Camp mine	surface mine
17880123	Stage 2 approved	Mine 56	surface mine
17900109	Reclamation complete	Priselac mine	surface mine
17900138	Reclamation complete	Camp 2 mine	surface mine
17910102	Stage 2 approved	Kitko mine	surface mine
17910127	Stage 1/regraded	Kitko 1 mine	surface mine
17910129	Stage 1/regraded	Cambria 55 mine	surface mine
17910132	Reclamation complete	Muddy run 2	surface mine
17920104	Reclamation complete	Duncan 1 mine	surface mine
17940101	Stage 2 approved	Buterbaugh mine 57 job	surface mine
17940115	Stage 2 eligible	Buterbaugh mine	surface mine
17941601	Active	Forcey tipple	mineral preparation plant
17960108	Stage 2 approved	Scott anthony	surface mine
17960112	Reclamation complete	Lowe 1 mine	surface mine
17960122	Stage 1/regraded	Banian 2 mine 68 job	surface mine
17960125	Reclamation complete	Oshall 1 mine	surface mine
17970112	Stage 1/regraded	Sean michael 1 mine	surface mine
17970115	Stage 2 eligible	Tana rae 1 mine	surface mine
17970119	Reclamation complete	Smith 1 mine	surface mine
17980113	Stage 2 approved	Ramey 2 mine	surface mine
17990109	Active	Ettari opr mine	surface mine
17990112	Reclaimed/passive treatment	Buterbaugh 1 mine	surface mine
17990119	Reclamation complete	Kitko mine	surface mine
17990119	Reclamation complete	Kitko mine	surface mine
17990124	Stage 1/regraded	Beyer mine	surface mine
17990124	Stage 1/regraded	Beyer mine	coal-aboveground storage tank
11783035		Cambria Coal Co, Mine #30	
11823023		Swistock Assoc. Coal Corp	
1187106		Black Oak Development, Black Oak	
17813179/17810103		Arts Minds Coal, Allemans	
17960124 (SOAP 1122)		Penn Grampian, Oshall #1	
4275SM5		EP Bender, Glasgow	

Permit	Site Status	Site Name	Type
4377SM11		Fran Contracting, Rudzinski, No.1	
SOAP 658		Beverly Hill Coal, Ashville	
SOAP 769		Cusisk Construction, Depto	
22671	Active	Cambria 51 mine	discharge point
22672	Active	Cambria 51 mine	post mining trmt
22673	Active	Cambria 51 mine	discharge point
4274SM21	Reclamation complete	Blandburg	surface mine
4277SM1	Bond forfeited	Hommer	surface mine
4277SM10	Reclamation complete	Cambria 26	surface mine
4375SM1	Inactive	Shedlock mine	surface mine
4376SM16	Reclamation complete	Davis mine	surface mine
PA0079545	Reclamation complete	Cambria 18	NPDES discharge point
PA0099392	Bond forfeited	Hommer opr 2	NPDES discharge point
PA0124389	Bond forfeited	Hommer	NPDES discharge point
PA0125326	Bond forfeited	Glasgow	NPDES discharge point
PA0125326	Reclamation complete	Glasgow	NPDES discharge point
PA0206750	Stage 1/regraded	Kitko 1 mine	NPDES discharge point
PA0206776	Stage 1/regraded	Cambria 55 mine	NPDES discharge point
PA0206814	Reclamation complete	Muddy run 2	NPDES discharge point
PA0213276	Stage 2 approved	Lewis 1	NPDES discharge point
PA0219746	Stage 2 approved	Buterbaugh mine 57 job	NPDES discharge point
PA0219894	Stage 2 eligible	Buterbaugh mine	NPDES discharge point
PA0220337	Stage 1/regraded	Scott anthony	NPDES discharge point
PA0220370	Stage 2 approved	Lowe 1 mine	NPDES discharge point
PA0220493	Stage 1/regraded	Banian 2 mine 68 job	NPDES discharge point
PA0220680	Stage 1/regraded	Sean michael 1 mine	NPDES discharge point
PA0235261	Stage 2 approved	Mulhollen opr	NPDES discharge point
PA0237876	Reclamation complete	Smith 1 mine	NPDES discharge point
PA0238040	Stage 2 approved	Ramey 2 mine	NPDES discharge point
PA0238325	Stage 2 approved	Ettari opr mine	NPDES discharge point
PA0242802	Stage 1/regraded	Beyer mine	NPDES discharge point
PA0242926	Reclamation complete	Alexa jean mine	NPDES discharge point
PA0243663	Active	Kitko mine	NPDES discharge point
PA0243710	Stage 2 approved	Shaffer mine	NPDES discharge point
PA0243841	Stage 2 approved	Banian no 3 mine	NPDES discharge point
PA0249220	Stage 2 eligible	Hommer opr	NPDES discharge point
PA0256501	Stage 2 approved	Smith mine	NPDES discharge point
PA0256960	Not started	Kitko #2 mine	NPDES discharge point
PA0597309	Bond forfeited - passive treatment	Cambria 51 mine	NPDES discharge point
PA0597759	Bond forfeited	Marion 1 mine	NPDES discharge point
PA0607380	Reclamation complete	C & k mine 46	NPDES discharge point
PA0610089	Stage 2 approved	Mo valley 2 mine	NPDES discharge point

Scarlift Report:

An extensive study of the assessment area was completed by Skelly and Loy (1971). The report is located at http://www.amrclearinghouse.org/Sub/SCARLIFTReports/.

AML

Page A-8 shows the extent of the remaining catalogued highwalls and spoil areas within the Muddy Run Watershed. Several of the AML within the watershed border the main stem of Muddy Run and pose a public safety hazard. Not only are the spoil piles and highwalls ruining the beauty of the landscape, but they are also contributing a source of additional acid runoff to the stream. Some of the AML has very steep slopes and poses a safety threat to outdoorsmen who hunt, hike, and ride ATVs in the area.

Many discharges are associated with priority reclamation areas within the Muddy Run watershed. Some of the reclamation areas create more than one discharge and further survey work and investigation is recommended to determine the overall restoration strategy. The AML's are a major source of pollution in the watershed. Reclamation of these areas will have a large impact on the overall water quality within the watershed. Some of these AML's are spoil piles and potentially contain material that could be used in COGEN plants. Prior investigation has shown that energy potential is limited in these AML areas and most will just need backfilled and seeded.

Data Collection

Field Reconnaissance

The Clearfield Creek Watershed Association (CCWA), members of the Clearfield County and Cambria County Conservation districts, and NMBS representatives initially walked the streams in the spring and summer of 2008 in the first stage of the assessment. Discharges were located, flagged and inspected for flow devices. Field measurements such as pH, conductivity, and temperature were also collected at each reconnaissance point. Over 50 areas were flagged during field reconnaissance. Twenty eight of these sites were chosen for monthly sampling, while seven stream sites were chosen to be monitored on a quarterly basis. The remaining reconnaissance points were considered non-significant, thus, they were not included in the monitoring plan on either a monthly or quarterly sampling schedule. Weirs were built and installed by members of the CCWA and the CCCD. The weirs were installed in the Fall of 2008 and sampling began in December 2008. Representatives from the CCWA collected the monthly samples after being trained by the CCWA tech committee and other experienced volunteers.

Of all of the discharges that were identified and flagged during the various stream walks, 28 monitoring points were established along with some grab samples. All but site MUE-5R were sampled monthly, twelve times over the period of a year. For a few of the sample points, one or more sets of field data showed conflicting or ambiguous results, so fewer than 12 samples are considered valid. These monitoring points, their descriptions, latitude and longitude, and number of times validly sampled can be found in Table 1.

Historical Data

Historical mining permits were researched as part of the completed Clearfield Creek Assessment. The historical water quality data, from these permits and previous studies, was used to evaluate discharges over time. Follow links on the accompanying CD or see page B-1 for more information on how to access this information.

Documentation of Problem Areas

Table 1 represents the sampling locations on in the Muddy Run Watershed. The number of times each location was sampled is included in the table. The table contains the monitoring point, sample description and latitude and longitude. Pages A-14 to A-16 display the sample locations. Some additional points were sampled once or twice. These values are not summarized here, but can be found in the data on the CD.

Table 1: Sampling Plan

Monthly Sampling

Monitoring Point	Description	Latitude	Longitude	Times sampled
A-101	A discharge is located just north of an electrical substation on the east side of PA 453 about ½ mile south of Madera	40.82085	-78.436737	11
BW-01	A discharge from the Brookwood Shaft, which drains the abandoned Brookwood Mine on the Lower Kittanning coal.	40.787546	-78.415240	13
BW-02	A discharge from a shaft to a coal above the L. Kittanning coal; the discharge flows about 100 feet into a small stream, which heads near Ramey.	40.794057	-78.409247	12
BW-03	A discharge from an apparent underground working within a strip cut.	40.786895	-78.415240	12
CB-10L	This sampling point is the outflow of about 20 acres of surface mining on a small tributary to Muddy Run (the tributary heads near Utahville).	40.7412	-78.45333	12
CM-3R	A discharge located about 50 yards south of PA 253, about 0.5 mile toward Glasgow from Muddy Run.	40.71138	-78.43067	12
CRD-05	Curtis Run at PA 253; measures several discharges which contribute to this flow, but which are within a private fenced game preserve.	40.720211	-78.413582	12
CRD-1R	The outflow of a large seepage area into Curtis Run just downhill to the NW from PA 253 and about 2000 feet N of the former C&K Glasgow Treatment .	40.72184	-78.42572	12

Monitoring Point	Description	Latitude	Longitude	Times sampled
CRD-2R	The outflow of a large seepage area draining to Curtis Run from the south, on the NW side of PA253.	40.721432	-78.421227	11
DER-2T	This discharge is from the C&K Glasgow treatment system.	40.7159	-78.42294	10
EU01	A large flow of severe acid mine drainage emerges from a shaft from the Eureka-29 underground mine on the L. Kittanning coal.	40.75705	-78.4482	12
MCC-01L	This discharge emerges from an apparent abandoned shaft on the east side of Muddy Run south of Beccaria.	40.76102	-78.4455	11
MUC-10R	. Discharge from a beaver dam draining an extensive area of surface mining.	40.72715	-78.434998	12
MUC-11R	This discharge is from the Miller Mine, a very large abandoned underground mine on the Lower Kittanning coal.	40.725349	-78.435051	12
MUC-9R	At this site, water drains from an entry to an underground mine, possibly the Black Oak #5 mine, on the Lower Freeport coal..	40.754341	-78.450917	12
MUE-1L	This site is a small stream in a gully entering Muddy Run upstream about 1000 ft. upstream from the mouth of Curtis Run. The source of this small flow is somewhat ambiguous.	40.723956	-78.429798	12
MUE-2L	This site is the outflow of a large area of seepage on the NW (downhill) side of PA 253. It is located about 1000 feet N of the C&K Glasgow treatment system.	40.718899	-78.424263	12
MUE-2R	This site is a small stream draining a wetland area of about 1 acre.	40.721135	-78.427229	12
MUE-5R	This site is located on the west side of Muddy Run about 100 feet upstream from a road crossing Muddy Run in a cleared zone.	40.710250	-78.417270	9
MUE-6R	This sampling point is a small flow entering Muddy Run about 500 feet upstream from a well of the Reade Township Water Authority	40.705898	-78.414848	12
MUEA-1L	The weir for this discharge is located on the east side of stream MUEA about 100 ft. downstream from Sportsman Road.	40.709750	-78.423927	12
MUEA-2R	This weir is located on the west side of stream MUEA about 100 ft downstream from Sportsman Road	40.710050	-78.424190	12
MUEA-3L	This site has also been called the Pumphouse discharge, and is located on the McCartney Property north of Mountaindale.	40.69886	-78.425072	12
MUEA-3R	The weir for this discharge is located in a ditch along the uphill side of Sportsman Road on the west side of stream.	40.70892	-78.42494	12
MUEA-6R	This discharge forms the headwaters of the MUEA tributary of Muddy Run, and is located just uphill from the Mountaindale village	40.6912	-78.42598	12
MUEC	This discharge drains a large area of surface mining about 1500 ft. NW of Blandburg. The weir lies about 100 feet upstream from a private road into the Ryan cabin.	40.691195	-78.408961	12
MUED-1R	This discharge is derived from a several acre seepage area and kill zone downslope from the Ryan cabin	40.695122	-78.40889	12
MUED-3	This small stream drains another part of the large area of surface mining east of Blandburg. The stream emerges within the mine spoil and forms the headwaters and main source of stream MUED.	40.6917	-78.403877	12

Quarterly Points

Monitoring Point	Description	Latitude	Longitude	Times sampled
BRQ-10	Mouth of Banian Run above Madera.	40.81401	-78.43992	4
LMQ-10	Mouth of Little Muddy Run above Smoke Run. Off of railroad grade…	40.79322	-78.4285	3
MRQ-10	Mouth of Muddy Run above bridge on Chesterfield Rd TR891.	40.81963	-78.43687	4
MRQ-20	Muddy Run, just above Little Muddy Run.	40.79336	-78.42911	2
MRQ-30	Muddy Run, downstream at bridge in Beccarria.	40.76912	-78.44735	4
MRQ-40	Muddy Run downstream at bridge on Wippers Rd.	40.7333	-78.43449	2
MRQ-50	Muddy Run, downstream of SR 253.	40.71615	-78.4234	4

Permission

Access was granted by various property owners to conduct the water quality sampling. Each landowner was contacted by mail, and permission was obtained for the installation of the weirs and for the monthly sampling. Signed agreements will be obtained for all construction projects. A list of potentially impacted landowners in the watershed were obtained during the beginning stage of the assessment; this list can be found on the CD.

Development of Monitoring Plan

CCWA devised a monitoring plan after the initial reconnaissance and after having reviewed historical reports and data. Arthur Rose visited all significant discharges recorded in the stream-walking phase. NMBS representatives recommended that the sampling plan focus on the severe mine drainage discharges that were moderate flow or higher and contained significant acidity, iron or aluminum loads. Stream sample locations were established throughout the assessment area to determine impacts of combined areas; this helped in determining the priority areas. See Table 1 for the list of sampling points and the number of times the samples were collected. Other sources of hydrology were considered to have minimal impact on overall water quality and were, therefore, not monitored.

Sampling Methodology

NMBS provided suggestions to the CCWA technical committee as to how to complete sampling and ensure that data quality was managed and maintained. Training of CCWA members who were to complete the monthly sampling was done by the CCWA technical committee. They were trained to conduct field chemistry tests, collect water samples, and measure flow rates. Most volunteers had worked on previous assessments conducted by CCWA. Samplers were trained to collect pH, conductivity, and temperature measurements in the field. Training included a review of proper use, care, and maintenance of each of the pieces of equipment required for these measurements. A NMBS representative provided suggestions to the CCWA technical committee who then took volunteer samplers into the field and identified the points that were selected for monitoring and reviewed proper sampling methods with samplers at each of these sites.

The sampling methods used require that samples be taken as close to the source as possible. Samplers were directed to take samples in a section of the stream or discharge where flow is concentrated and flowing to provide the best representation of the chemical properties and to avoid sampling in pooled backwater areas or areas that are littered with decaying organic matter. Samplers were also directed to avoid areas that contain heavy concentrations of aquatic vegetation.

Samplers were taught to collect water samples in a manner that would prevent contamination. These steps included the exclusive use of bottles supplied by the lab and the technique of field rinsing equipment. Field rinsing was used to equilibrate the equipment to the sample environment; this was also done to ensure that all cleaning solution residues had been removed before sampling began.

Samplers were taught to rinse and then fill bottles in a manner that minimizes contact with the air. Samplers were instructed to keep bottles cool as soon as possible. Provisions were made as part of the sampling plan to ensure prompt delivery of samples to the lab. Each sampler had a cooler in their vehicle for temporary storage of the samples.

Samplers were taught to use a water resistant field book to record sampling information in the field. The sampling information includes date, sample name, field pH, field conductivity, flow, temperature, and weather conditions. Samplers were also directed to always be aware of and record potential sources of contamination at any field site.

Samplers were instructed to properly label bottles. These labels were the same as those recorded on the chain of custody that was sent with the bottles to the lab. A CCWA representative maintained responsibility for filling out the chain of custody and any additional lab paperwork that was required. Several data quality issues were noted when NMBS reviewed the field books against lab results. NMBS attempted to extract the best quality data available from the different sources of data. The data used for analysis is the result of substantial review of the source documents by both NMBS representatives and CCWA technical committee members.

Data Quality

NMBS did not participate in the monthly review of field books, sampling practices, and data management. Values which were sent to NMBS were logged in NMBS WaMP for later use in reporting and conceptual design development. In the post sampling review of the data by both CCWA and NMBS representatives, a number of data issues were discovered. Efforts were made to ensure that these issues are either noted in this document or the data was just discarded as unreliable.

In some cases, values which are identifiable as estimates have been included for informational purposes only. These values have been flagged as “E” and were not used in the aggregate calculations which were used for system design. In several cases these estimates represent very high flows exceeding the weir capacity.

In other cases, confusion exists as to which site was sampled. These results were either interpreted and assigned by a CCWA representative, or were just discarded as unreliable. Many instances of this were considered to be handwriting issues and the most reasonable sample name was assigned (e.g., lab results are for sample "CB1DL" or "CBY0L" but were assigned to "CB10L"). For several months, field samplers appear to have been confused about the name of a site; this happened for a number of months on the sites A-101 and MCC-01L. Art Rose of the CCWA researched these results and believes that the current values are correctly assigned. Note that the data presented here differ from lab results sheets for the sampling events dated 3/3/2009, 3/22/2009, 4/19/2009, and 5/17/2009.

Flow data on the lab sheets should have been transferred from the chain of custody sheets. A NMBS representative referred back to the field books and extracted all available flow data. This data was then reviewed by both NMBS and CCWA repeatedly to obtain the information which has been reported here. All values that remain are either ones which we feel are reliable or are flagged with the "E" flag and were then not include in aggregate calculations.

Water Quality Measurements

Water samples were analyzed for mine drainage parameters. The pH, conductivity, and temperature were measured in the field. The pH and conductivity were measured using hand held pHTestr's by Oakton and temperature was measured by the pHTestr. The meters were calibrated with buffer solutions prior to each use.

Iron, aluminum, manganese, acidity, alkalinity, lab pH, lab conductivity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and sulfate were measured at Mahaffey Laboratory, Ltd. using standard methods. Samples for metals were preserved in the field by collection into vials containing five drops of nitric acid. None of the samples were filtered, so they represent total metal concentrations.

Flow Rate:

Several types of flow devices and methods were used to collect flow data during the assessment. V-notch or H-notch weirs were installed at most sampling locations. The water flow height over the weir was measured and gallons per minute (gpm) were calculated. In-Stream flow measurements were taken by a conservation district representative using a flow meter.

Standard weir formulas were used to calculate flow results in gpm. These are:

Formula:

V notch: $2.5 * ((h / 12)^{2.5}) * 60 * 7.5$

H notch: $3.33 * (L - 0.2 * (h / 12)) * ((h / 12)^{1.5}) * 60 * 7.5$

Where

h represents the water height over the weir as measured in inches

L = represents the length of weir opening in feet

Both adjust from ft^3/sec to gal/min by using 60 sec/min and 7.5 gal/ ft^3

Mapping

Maps were created to show the location of the watershed, the stream quality, the sampling that has been done for this assessment, historical mining activities within the watershed through research in the Moshannon and Ebensburg District office, the location of wetlands, the location of mining activities and reclamation priorities from online BAMR files, the soils in the watershed, and the geology of the watershed. A description of each of these maps appears on page A-1.

Location maps

The location of the watershed can be found on page A-3. This map displays Pennsylvania and the location of the watershed within the Commonwealth as well as within the surrounding municipalities.

For reference, a map also is provided to illustrate which USGS 7.5 minute topographic quadrants included the area in question. This map can be found on page A-4.

Monitoring Program

Pages A-14 through A-16 represents the sampling plan for Muddy Run. Sampling points for both monthly and quarterly sampling are displayed once within the watershed, and once on a representation of the 7.5 minute topographic maps within the watershed.

Stream Quality

Page A-6 displays the impaired streams that DEP has identified. Page A-7 displays a color coded version of the stream quality in the watershed from the current sampling results. The variation in color describes the water quality moving downstream from the headwaters region. Some variances in the two may be noted which are due either to criteria used in the assessment (e.g., this document only assesses mine drainage impacts) and/or changes over time.

Data Analysis

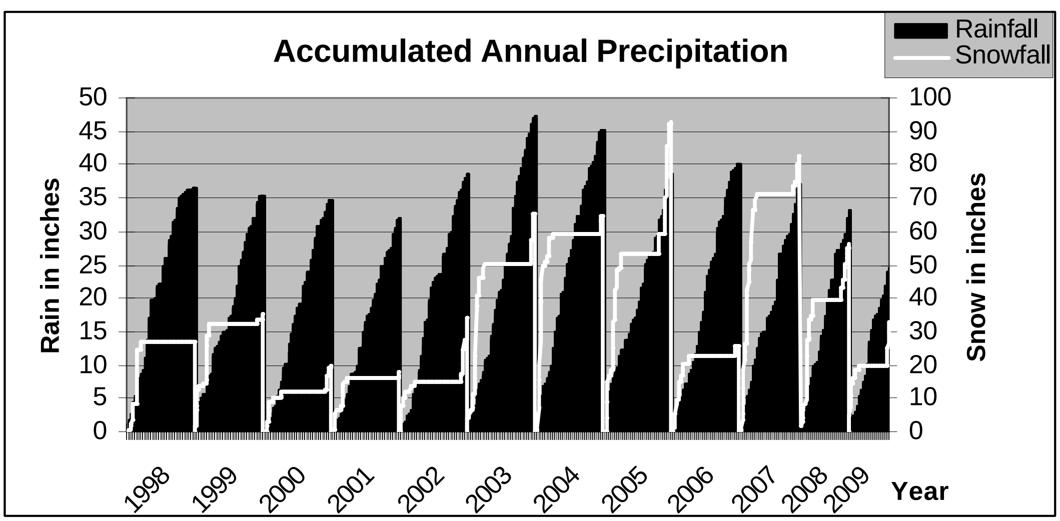
Precipitation during Sampling Period

We tried to obtain reliable precipitation data from a number of sources. Ultimately, all data seemed to have gaps. We are unsure whether these gaps simply represent dry days or intervals in which no-one was able to check the gauge. Presumably, especially for rainfall, the worst that these gaps would represent is cumulative rainfall within the specified time frame. Since we are more interested in aggregate numbers than specific daily values, this possible discrepancy is considered acceptable.

The impact that snowfall has on the water table is difficult to assess since the water content of snow varies. However, in order to ascertain general trends, these values are displayed and reviewed here.

The data used for this analysis came from the Pennsylvania State Climatologist website at climate.met.psu.edu. For this assessment, values were taken from the PGLP1- PRINCE GALLITZIN STATE PARK station. This weather station is found in Cambria County at a latitude of approximately 40.65° N and a longitude of approximately 78.55° W.

Sampling took place for the assessment from December 2008 through November2009. During this period, approximately 26 inches of rain fell. Average annual rainfall at this station over the period of 1998-2009 was approximately 37 inches. Approximately 24 inches of snow fell during the sampling period. Average annual snowfall at this station over the period of 1998-2009 was approximately 46 inches. To review the annual precipitation trends, see the below graph entitled "Accumulated Annual Precipitation."



This graph displays the cumulative total rainfall and total snowfall within a calendar year. The graph starts at zero each January 1 and adds all precipitation over the course of the entire year and displays this progression for visual comparison. For example, the most rain fell in 2003, but the most snow fell in 2005. In 2005, most of the snow fell in the first few months, and somewhere near the first of December, but rainfall was fairly evenly distributed. Rainfall in 1998, however, spiked significantly around April and then leveled off to a more consistent rate.

It can be concluded that the sampling period was a relatively dry period. The prior year may also have been a drier than normal year, though not as significantly. Rainfall was slightly lower than average, but snowfall for 2008 was slightly higher than average. On an annual basis, 2009 had 24.56 inches of rain and 32.7 inches of snow; 2008 had 33.161 inches of rain and 56.3 inches of snow.

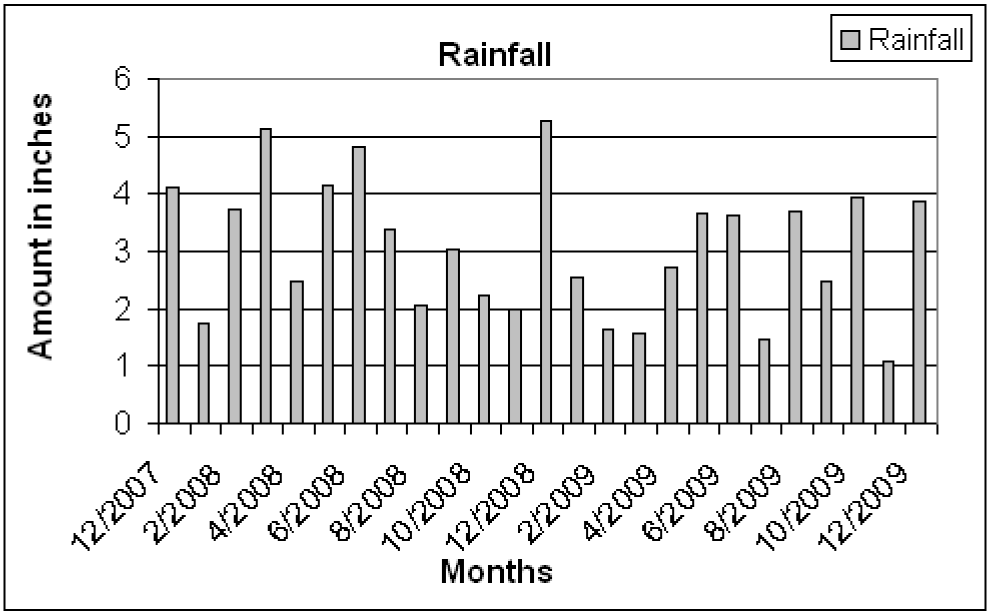
	Rainfall	**Snowfall**
Ave	37.0	46.2
2008	33.2	56.3
2009	24.5	32.7

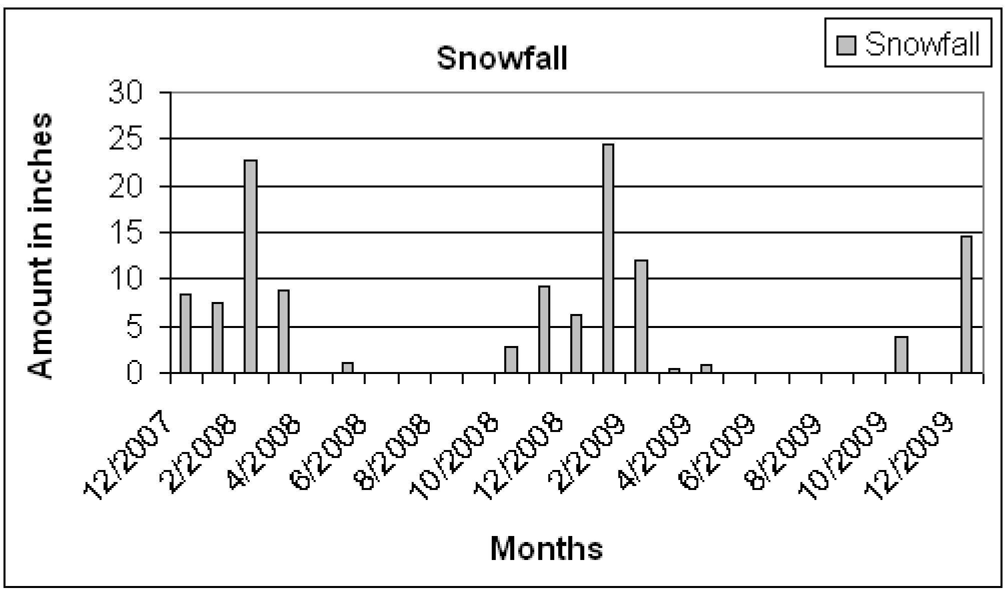
The exact impact of this precipitation on water tables and underground mine pools is difficult to ascertain. Although values should have been close to base line in the beginning of the sampling period, an argument can be made that levels diminished somewhat over the course of 2009. Streams were observed to be very low during much of the sampling period.

Drought years versus high water years can affect flow rates and may change the overall design of the treatment systems. These factors should be reviewed and additional sampling should be done prior to creation of final system designs. The conceptual recommendations made in this document were analyzed based upon the data obtained during the sampling period.

As part of the sampling event, temperature and weather conditions were recorded in the field books. Precipitation events can affect the chemistry of the samples either by dilution or causing flush events. These conditions were considered in the final site evaluations.

The following graphs illustrate the total precipitation for each month during the sampling period and the year prior to the sampling period.





Description of Data

The sampling data for each sample location can be found in the following sections. Flow values at each point were collected and samples were analyzed for pH, conductivity, acidity, aluminum, iron, manganese, and sulfate. The loadings for acidity and iron are calculated and included as columns in each table. Each table contains not only the raw water data, but also an average value for each parameter, the maximum value, the minimum value, and the 75% and 90% confidence intervals for each parameter.

NOTE: In all of the data tables which follow, qualified values are not included in aggregate numbers. (e.g., "<5" or "E5" would not include a value of 5 in the calculation of the average.)

Discharge Areas/Water Quality Data

A-101

This discharge is located just north of an electrical substation on the east side of PA 453 about 0.75 mile south of Madera. The water apparently flows from the abandoned Banion #1 underground mine on the Clarion-Brookville coal under the hill to the east. Small amounts of coal refuse and spoil are evident up the slope from the weir site, near where the water emerges. Appreciable Fe is precipitating from the water along the small stream. The flow crosses the highway and into Muddy Run about 300 feet below the highway.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
01/26/2009	422	5.7	1270	28.0	141.7	128.0	647.7	66.9	338.5	8.6	1.7	589.0
03/03/2009	E477	5.7	1180	16.0		152.0		63.3		7.5	2.4	623.0
03/22/2009	E199	5.6	1240	21.0		128.0		68.7		8.8	2.2	596.0
04/19/2009	477	5.8	1130	23.0	131.6	114.0	652.0	60.8	347.8	8.1	1.9	595.0
05/17/2009	477	5.9	1190	25.0	143.0	120.0	686.4	67.1	383.8	6.5	2.3	551.0
06/21/2009	383	5.7	1100	30.0	137.8	115.0	528.1	64.4	295.8	7.1	1.8	583.0
07/20/2009	409	5.7	1180	27.0	132.4	125.0	613.0	64.4	315.8	7.2	2.1	549.0
08/16/2009	477	5.7	1090	32.0	183.0	118.0	674.9	61.6	352.3	7.1	1.6	569.0
09/18/2009	477	5.7	1150	33.0	188.8	137.0	783.6	62.0	354.6	7.1	1.5	621.0
10/18/2009	293	5.9	1180	34.0	119.5	115.0	404.0	64.2	225.6	7.0	1.1	609.0
11/15/2009	318	5.8	1240	34.0	129.6	122.0	465.2	70.7	269.6	7.8	1.4	649.0
Average	415	5.7	1177	27.5	145.3	124.9	606.1	64.9	320.4	7.5	1.8	594.0
Min	293	5.6	1090	16.0	119.5	114.0	404.0	60.8	225.6	6.5	1.1	549.0
Max	477	5.9	1270	34.0	188.8	152.0	783.6	70.7	383.8	8.8	2.4	649.0
90% CI	454	5.8	1206	30.4	158.5	130.6	671.4	66.5	347.5	7.9	2.0	609.3
75% CI	442	5.8	1197	29.6	154.5	128.9	651.7	66.0	339.3	7.8	1.9	604.7
StdDev	71	0.1	58	5.9	24.1	11.4	119.0	3.1	49.4	0.7	0.4	30.8

BW-01

This site datadescription is the discharge of the Brookwood Shaft, which drains the abandoned Brookwood Mine on the Lower Kittanning coal. The mine has an area of about 3 square miles up dip to the east, and connects to a series of surface mines on the outcrop of the coal in the Moshannon Creek drainage. The water emerges into the bottom of a pond about ¼ mile long and 100 ft wide. The pond is reddish in places and gray in others, indicating the precipitation of Fe and Al. Mine spoil surrounds the pond, apparently derived by surface mining of the Lower and Upper Freeport coals . A small stream heading near Ramey and receiving the alkaline BW-02 discharge flows near the north side of the pond near its outlet. The BW-01 water joins this flow and enters a large wetland, then flows under a bridge in an abandoned railroad grade and into Little Muddy Run. Repeated beaver damming resulted in the weir being submerged on most sample dates, so only 1 valid flow, taken with a flowmeter, is reported. At some dates, the small stream from Ramey flowed into the BW-01 pond.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008		5.9	2110	86.0		3.0		29.4		7.4	0.8	1179.0
01/25/2009		6.2	1550	104.0		-48.0		18.3		5.4	0.4	814.0
03/01/2009		6.2	1500	93.0		-36.0		18.4		5.3	0.5	801.0
03/22/2009		6.0	2500	86.0		19.0		31.6		9.7	0.9	1315.0
04/19/2009		6.0	2450	78.0		25.0		40.9		12.6	0.9	1536.0
05/17/2009		6.0	2590	74.0		22.0		40.9		12.1	1.4	1577.0
06/21/2009		6.0	1480	73.0		-20.0		20.0		5.8	0.7	754.0
07/20/2009		6.0	1950	94.0		-13.0		25.0		7.6	0.5	1112.0
08/16/2009		5.9	2010	93.0		5.0		34.8		10.1	0.9	1293.0
09/18/2009		5.8	2300	87.0		39.0		40.7		12.2	0.8	1576.0
10/18/2009		6.1	2370	88.0		28.0		40.0		11.6	0.7	1527.0
10/20/2009	870	6.1	2390	93.0	970.2	24.0	250.4	36.5	380.8	10.6	0.7	1485.0
11/15/2009		6.2	2320	91.0		20.0		37.0		11.2	0.6	1505.0
Average		6.0	2117	87.7		5.2		31.8		9.3	0.7	1267.2
Min		5.8	1480	73.0		-48.0		18.3		5.3	0.4	754.0
Max		6.2	2590	104.0		39.0		40.9		12.6	1.4	1577.0
90% CI		6.1	2296	91.7		17.4		35.8		10.6	0.9	1408.8
75% CI		6.1	2242	90.5		13.8		34.6		10.2	0.8	1366.2
StdDev		0.1	392	8.7		26.8		8.8		2.7	0.3	310.4

BW-02

The flow at this site emerges from a shaft which most likely accesses the Lower Freeport coal at a relatively shallow depth. The water flows about 100 feet into a small stream, which heads near Ramey. During dryer periods in the summer and fall, the BW-02 flow makes up all of the flow in this small stream.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	E650	6.6	756	141.0		-117.0		1.8		0.4	<0.05	243.0
01/25/2009	1134	6.5	712	131.0	1781.3	-106.0	-1441.4	1.2	16.6	0.2	<0.05	223.0
03/01/2009	1295	6.6	659	114.0	1770.2	-91.0	-1413.1	0.2	2.6	0.1	<0.05	215.0
03/22/2009	1295	6.6	773	114.0	1770.2	-85.0	-1319.9	0.2	3.1	0.1	<0.05	217.0
04/19/2009	1351	6.7	697	122.0	1976.4	-100.0	-1620.0	0.2	3.7	0.1	<0.05	215.0
05/17/2009	1295	6.8	719	130.0	2018.7	-107.0	-1661.5	0.4	5.9	0.2	0.1	220.0
06/21/2009	930	6.6	702	125.0	1394.0	-99.0	-1104.0	1.0	11.6	0.3	0.1	208.0
07/20/2009	833	6.6	733	128.0	1278.5	-102.0	-1018.8	1.0	10.1	0.3	<0.05	435.0
08/16/2009	786	6.5	709	133.0	1253.5	-108.0	-1017.9	0.8	7.7	0.3	<0.05	230.0
09/18/2009	564	6.3	742	139.0	940.0	-93.0	-629.0	1.2	8.0	0.4	<0.05	233.0
10/18/2009	482	6.7	729	137.0	791.8	-109.0	-630.0	2.4	14.0	0.3	<0.05	266.0
11/15/2009	263	6.6	743	137.0	432.0	-107.0	-337.4	1.2	3.8	0.4	<0.05	251.0
Average	930	6.6	723	129.3	1400.6	-102.0	-1108.5	1.0	7.9	0.3	0.1	246.3
Min	263	6.3	659	114.0	432.0	-117.0	-1661.5	0.2	2.6	0.1	0.1	208.0
Max	1351	6.8	773	141.0	2018.7	-85.0	-337.4	2.4	16.6	0.4	0.1	435.0
90% CI	1117	6.7	737	133.6	1657.8	-97.8	-893.1	1.3	10.3	0.3	0.1	275.7
75% CI	1061	6.6	733	132.3	1580.4	-99.0	-957.9	1.2	9.6	0.3	0.1	266.8
StdDev	378	0.1	30	9.1	518.6	8.9	434.2	0.7	4.7	0.1	0.0	61.8

BW-03

This flow emerges from an apparent underground working within a strip cut near BW-01. The strip cut extracted probable Upper Freeport coal. The water flows along the cut and enters Little Muddy Run where minor iron staining can be seen.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	E482	6.7	586	106.0		-81.0		0.3		0.0	0.1	166.0
01/25/2009	367	6.8	724	152.0	668.9	-124.0	-545.7	<0.05		<0.02	<0.05	219.0
03/01/2009	523	7.0	625	137.0	859.2	-117.0	-733.7	<0.05		<0.02	<0.05	190.0
03/22/2009	482	7.0	833	148.0	855.4	-120.0	-693.6	0.1	0.3	<0.02	<0.05	181.0
04/19/2009	482	7.2	653	142.0	820.7	-117.0	-676.2	<0.05		<0.02	<0.05	180.0
05/17/2009	443	7.1	730	162.0	860.5	-141.0	-749.0	<0.05		<0.02	<0.05	192.0
06/21/2009	331	6.7	819	182.0	722.4	-151.0	-599.3	0.1	0.3	<0.02	<0.05	225.0
07/20/2009	200	6.9	809	181.0	434.1	-158.0	-378.9	<0.05		<0.02	<0.05	230.0
08/16/2009	263	6.8	753	163.0	514.0	-137.0	-432.0	<0.05		<0.02	<0.05	219.0
09/18/2009	144	6.5	819	183.0	316.0	-148.0	-255.6	<0.05		<0.02	<0.05	233.0
10/18/2009	144	7.1	800	180.0	310.8	-159.0	-274.5	<0.05		<0.02	<0.05	272.0
11/15/2009	144	7.0	772	170.0	293.5	-142.0	-245.2	<0.05		<0.02	<0.05	
Average	320	6.9	744	158.8	605.0	-132.9	-507.6	0.1	0.3			209.7
Min	144	6.5	586	106.0	293.5	-159.0	-749.0	0.1	0.3			166.0
Max	523	7.2	833	183.0	860.5	-81.0	-245.2	0.3	0.3			272.0
90% CI	394	7.0	783	169.9	722.6	-122.3	-409.5	0.2	0.3			225.1
75% CI	372	7.0	771	166.5	687.2	-125.5	-439.0	0.2	0.3			220.4
StdDev	149	0.2	83	23.2	237.0	22.3	197.8	0.1	0.0			30.9

CB-10L

This sampling point is the outflow of about 20 acres of surface mining on a small tributary to Muddy Run (the tributary heads near Utahville). The weir is located at 40.7412N, 78.45333W. The mine is largely reclaimed and has several sediment ponds along its lower edge. At the sample point, there is no pond but an area of cattails along a channel leading to the weir. Coal mined here is Lower and Upper Freeport.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	E70	7.0	972	384.0		-354.0		1.2		1.7	<0.05	148.0
01/25/2009	39	6.9	869	335.0	155.8	-309.0	-143.7	1.2	0.6	1.5	<0.05	136.0
03/01/2009	111	7.0	803	304.0	404.5	-282.0	-375.2	1.3	1.7	1.6	<0.05	124.0
03/22/2009	126	6.9	930	303.0	458.9	-276.0	-418.0	1.2	1.7	1.5	<0.02	126.0
04/19/2009	97	7.0	851	308.0	356.5	-284.0	-328.7	1.1	1.3	1.4	<0.05	134.0
05/17/2009	90	7.1	897	318.0	344.0	-290.0	-313.7	1.3	1.4	1.6	<0.05	146.0
06/21/2009	118	6.9	945	347.0	491.7	-318.0	-450.6	1.1	1.6	1.5	<0.05	142.0
07/20/2009	104	7.0	948	347.0	431.7	-323.0	-401.8	1.2	1.5	1.6	<0.05	143.0
08/16/2009	97	6.9	932	346.0	400.5	-322.0	-372.7	1.3	1.4	1.6	<0.05	153.0
09/18/2009	97	6.6	984	367.0	424.8	-326.0	-377.3	1.3	1.4	1.7	<0.05	152.0
10/18/2009	97	7.0	927	369.0	427.1	-346.0	-400.5	1.3	1.5	1.7	<0.05	140.0
11/15/2009	72	6.9	950	365.0	315.9	-344.0	-297.7	1.3	1.2	1.7	<0.05	185.0
Average	95	6.9	917	341.1	382.8	-314.5	-352.7	1.2	1.4	1.6		144.1
Min	39	6.6	803	303.0	155.8	-354.0	-450.6	1.1	0.6	1.4		124.0
Max	126	7.1	984	384.0	491.7	-276.0	-143.7	1.3	1.7	1.7		185.0
90% CI	107	7.0	943	354.2	428.0	-301.9	-311.6	1.3	1.5	1.6		151.6
75% CI	103	7.0	935	350.3	414.4	-305.7	-324.0	1.2	1.5	1.6		149.3
StdDev	24	0.1	53	27.7	91.0	26.6	83.0	0.1	0.3	0.1		15.8

CM-3R

This sample site is located about 50 yards south of PA 253, about 0.5 miles toward Glasgow from Muddy Run. The site is a small stream in a wooded area carrying the runoff from a moderate size strip mine on Lower Kittanning coal to the south and west. This discharge contributes acid and metals to a small stream extending about 2500 feet to the north, where it joins Muddy Run very close to site MUE-2R.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/22/2008	28	4.2	1470	3.0	1.0	46.0	15.4	0.5	0.2	16.5	0.6	828.0
01/26/2009	17	4.2	1700	3.0	0.6	55.0	11.3	0.6	0.1	25.0	0.5	1099.0
02/27/2009	E48	4.1	1490	2.0		49.0		0.4		20.8	0.4	853.0
03/20/2009	28	4.2	1760	3.0	1.0	48.0	16.1	0.3	0.1	21.9	0.4	992.0
04/20/2009	43	4.1	1590	2.0	1.0	47.0	24.4	0.3	0.2	20.6	0.4	996.0
05/15/2009	23	4.0	1700	0.0	0.0	45.0	12.2	0.4	0.1	21.4	0.4	1042.0
06/20/2009	E340	4.0	1120	0.0		39.0		1.6		11.5	0.3	510.0
07/17/2009	23	3.7	1930	0.0	0.0	67.0	18.1	1.9	0.5	24.8	0.2	1211.0
08/16/2009	20	3.7	2020	0.0	0.0	75.0	17.8	2.9	0.7	26.0	0.2	1271.0
09/18/2009		3.8	1950	0.0		77.0		1.8		23.0	0.2	1186.0
10/18/2009	28	4.1	1590	2.0	0.7	46.0	15.4	1.0	0.3	20.6	0.2	941.0
11/15/2009	23	4.1	1730	3.0	0.8	52.0	14.1	0.8	0.2	21.9	0.2	1047.0
Average	26	4.0	1671	1.5	0.6	53.8	16.1	1.0	0.3	21.2	0.3	998.0
Min	17	3.7	1120	0.0	0.0	39.0	11.3	0.3	0.1	11.5	0.2	510.0
Max	43	4.2	2020	3.0	1.0	77.0	24.4	2.9	0.7	26.0	0.6	1271.0
90% CI	30	4.1	1788	2.2	0.8	59.7	18.2	1.4	0.4	23.0	0.4	1095.2
75% CI	29	4.1	1753	2.0	0.7	57.9	17.6	1.3	0.3	22.5	0.4	1066.0
StdDev	8	0.2	247	1.4	0.5	12.4	3.9	0.8	0.2	4.0	0.1	204.7

CRD-05

This weir measures the flow of Curtis Run upstream from PA 253. Several discharges contribute to this flow, but they are within a private fenced game preserve into which access was difficult, so only the sum of the several sources could be sampled routinely.

Based on observations during the reconnaissance stage, one discrete source is at recon point CRD-6L (40.71904N, 78.40662W) which flows down from the middle of an old reclaimed surface mine on Clarion-Brookville coal. This flow emerges from spoil at approximately the same location as discharge 116 of the Scarlift survey (Skelly and Loy, 1971), and is probably an old underground entry. Additional acidity enters Curtis Run from tributaries at 40.71597N, 78.40137W. These acidic flows appear to seep from the overburden at various places up the hill, and probably represent, at least in part, the flow that infiltrates the surface near 40.7120N, 78.39869W. Sampling of the outflow of the small dam at 40.72254N, 78.39825W shows conductance 50 uS/cm, so no significant sources upstream of this point are indicated, in contrast to the Scarlift report. Areas to the south are clearly generating acidity.

CRD-05 (cont)

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/22/2008	927	4.1	287	2.0	22.2	68.0	755.9	0.2	2.6	3.4	6.9	147.0
01/23/2009	180	4.1	307	2.0	4.3	72.0	155.4	0.3	0.5	3.5	8.1	142.0
02/27/2009	707	4.2	355	2.0	17.0	70.0	593.4	0.3	2.3	3.9	9.1	155.0
03/20/2009	415	4.1	410	2.0	10.0	73.0	363.3	0.3	1.3	4.3	10.5	176.0
04/20/2009	1045	4.1	337	2.0	25.1	60.0	751.8	0.5	5.9	3.9	8.7	132.0
05/15/2009	415	4.0	344	0.0	0.0	61.0	303.6	0.3	1.3	3.9	9.1	149.0
06/20/2009	E5000	4.3	217	3.0		43.0		2.8		1.8	4.3	52.0
07/17/2009	117	3.9	377	0.0	0.0	64.0	89.8	0.3	0.5	4.1	7.8	144.0
08/16/2009	64	3.8	400	0.0	0.0	61.0	46.8	0.4	0.3	4.2	6.8	151.0
09/18/2009	23	3.9	387	0.0	0.0	61.0	16.8	0.4	0.1	4.5	5.8	167.0
10/18/2009	251	4.1	350	1.0	3.0	53.0	159.5	0.4	1.3	4.1	5.1	153.0
11/15/2009	89	4.1	396	2.0	2.1	68.0	72.6	0.4	0.4	5.1	8.1	169.0
Average	385	4.1	347	1.3	7.6	62.8	300.8	0.5	1.5	3.9	7.5	144.8
Min	23	3.8	217	0.0	0.0	43.0	16.8	0.2	0.1	1.8	4.3	52.0
Max	1045	4.3	410	3.0	25.1	73.0	755.9	2.8	5.9	5.1	10.5	176.0
90% CI	563	4.1	374	1.8	12.3	66.9	439.6	0.9	2.3	4.3	8.4	159.8
75% CI	509	4.1	366	1.7	10.9	65.7	397.8	0.8	2.1	4.1	8.1	155.3
StdDev	359	0.1	56	1.1	9.5	8.5	279.8	0.7	1.7	0.8	1.8	31.7

CRD-1R

This monitoring point is the outflow of a large seepage area just downhill to the NW from PA 53 and about 2000 feet N of the former C&K Glasgow Treatment System. The seepage appears to be derived from the large area of Lower Kittanning coal strip-mined uphill from PA 253, fed by flow under the highway through the unconsolidated overburden. The outflow of this large seepage area discharges into Curtis Run through a small channel where the flow was sampled.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/22/2008	23	3.2	1590	0.0	0.0	280.0	75.7	5.0	1.3	56.4	14.8	929.0
01/26/2009	28	3.1	1960	0.0	0.0	294.0	98.6	7.1	2.4	64.9	16.5	988.0
02/27/2009	143	3.1	1700	0.0	0.0	237.0	405.1	9.4	16.0	53.0	16.6	857.0
03/20/2009	35	3.2	1870	0.0	0.0	253.0	106.7	5.8	2.4	49.6	15.4	923.0
04/20/2009	E269	3.0	1960	0.0		271.0		8.1		59.0	15.9	1023.0
05/15/2009	72	3.0	2040	0.0	0.0	281.0	243.2	7.9	6.8	56.0	16.0	1011.0
06/20/2009	E450	3.1	1670	0.0		190.0		5.3		30.8	8.9	593.0
07/17/2009	28	3.0	2100	0.0	0.0	305.0	102.3	14.6	4.9	73.7	9.7	1148.0
08/16/2009	23	2.9	2210	0.0	0.0	318.0	86.0	18.4	5.0	91.2	9.3	1150.0
09/18/2009	28	2.9	2490	0.0	0.0	391.0	131.1	15.4	5.2	109.0	11.0	1376.0
10/18/2009	97	3.0	2010	0.0	0.0	321.0	371.5	8.9	10.3	71.2	15.5	1146.0
11/15/2009	32	3.1	2210	0.0	0.0			8.9	3.4	83.7	14.7	1231.0
Average	51	3.1	1984	0.0	0.0	285.5	180.0	9.5	5.8	66.5	13.7	1031.3
Min	23	2.9	1590	0.0	0.0	190.0	75.7	5.0	1.3	30.8	8.9	593.0
Max	143	3.2	2490	0.0	0.0	391.0	405.1	18.4	16.0	109.0	16.6	1376.0
90% CI	72	3.1	2106	0.0	0.0	311.2	250.3	11.6	8.1	76.5	15.1	1126.9
75% CI	65	3.1	2069	0.0	0.0	303.5	229.2	11.0	7.4	73.5	14.7	1098.1
StdDev	40	0.1	257	0.0	0.0	51.7	128.2	4.3	4.4	20.9	3.0	201.5

CRD-2R

This monitoring point is located on a small stream entering Curtis Run from the south, on the NW side of PA253. The site is about 2000 feet NW of the C&K Glasgow treatment system (40.71593N, 78.42295W). The flow is derived from a large seepage area between the site and PA 253. This seepage probably is derived by flow through the unconsolidated zone from the large area of Lower Kittanning coal mined by C&K Coal on the SE side of PA 253. Site MUE2L and CRD01R are also derived in this manner.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/22/2008	13	4.2	467	3.0	0.5	40.0	6.1	0.2	0.0	4.3	3.2	405.0
01/26/2009	7	4.2	680	3.0	0.3	76.0	6.6	0.2	0.0	8.0	7.6	342.0
02/27/2009	43	4.3	587	4.0	2.1	52.0	27.0	0.1	0.1	5.9	5.5	266.0
03/20/2009	17	4.3	662	4.0	0.8	51.0	10.5	0.2	0.0	7.1	6.1	288.0
04/20/2009	51	4.2	593	3.0	1.8	53.0	32.7	0.2	0.1	7.1	6.3	262.0
05/15/2009	17	4.1	571	2.0	0.4	45.0	9.2	0.3	0.1	5.6	4.6	253.0
06/20/2009	E360	4.4	198	4.0		32.0		1.5		1.2	1.2	47.0
07/17/2009	4	3.6	652	0.0	0.0	61.0	2.6	3.7	0.2	8.5	0.6	287.0
08/16/2009	4	3.6	668	0.0	0.0	65.0	2.8	13.6	0.6	7.3	3.2	265.0
09/09/2009	0											
10/18/2009	28	4.0	500	0.0	0.0	44.0	14.8	0.7	0.2	5.3	3.3	228.0
11/15/2009	4	4.2	607	3.0	0.1	58.0	2.5	3.1	0.1	7.9	0.5	289.0
Average	17	4.1	562	2.4	0.6	52.5	11.5	2.2	0.1	6.2	3.8	266.5
Min	0	3.6	198	0.0	0.0	32.0	2.5	0.1	0.0	1.2	0.5	47.0
Max	51	4.4	680	4.0	2.1	76.0	32.7	13.6	0.6	8.5	7.6	405.0
90% CI	28	4.2	631	3.2	1.0	58.6	16.9	4.1	0.2	7.2	5.0	309.8
75% CI	25	4.2	610	2.9	0.9	56.7	15.3	3.5	0.2	6.9	4.7	296.8
StdDev	17	0.3	139	1.6	0.8	12.3	10.5	4.0	0.2	2.1	2.4	87.3

DER-2T

This discharge is from the C&K Glasgow treatment system. The flow treated here represents part of the flow from the large area surface mined on the Lower Kittanning coal by C& K Coal Co. During the sampling period, most of the flow to the system was being partially treated in the passive system. After July 2009, the flow was bypassed without treatment. Since January 2010 the renovated system has been treating this discharge, and an active treatment system funded by the bond forfeiture fund will treat flows greater than 40 gal/min, so that this discharge is expected to be net alkaline and contribute appreciable alkalinity to Muddy Run.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/22/2008	35	5.1	1390	8.0	3.4	76.0	31.9	0.6	0.3	29.0	2.9	791.0
01/26/2009	40	4.0	2480	1.0	0.5	314.0	150.6	2.1	1.0	74.7	27.0	1715.0
02/27/2009	60	3.9	2380	0.0	0.0	318.0	228.8	2.1	1.5	82.1	38.6	1635.0
03/20/2009	60	4.0	2990	0.0	0.0	350.0	251.8	5.6	4.0	82.7	30.2	1915.0
04/20/2009	150	3.7	2800	0.0	0.0	380.0	683.5	5.5	9.9	85.8	32.2	2032.0
05/15/2009	50	3.5	2950	0.0	0.0	357.0	214.0	6.8	4.1	92.4	32.7	1956.0
06/20/2009	110	3.5	2660	0.0	0.0	308.0	406.3	3.4	4.4	67.0	28.3	1495.0
07/17/2009	60	3.3	3300	0.0	0.0	426.0	306.5	7.7	5.5	100.0	33.0	2129.0
08/16/2009	30	4.8	3140	9.0	3.2	184.0	66.2	2.0	0.7	87.2	7.8	1928.0
11/15/2009	4	3.7	2810			320.0	15.3				24.9	1972.0
Average	60	4.0	2690	2.0	0.8	303.3	235.5	4.0	3.5	77.9	25.8	1756.8
Min	4	3.3	1390	0.0	0.0	76.0	15.3	0.6	0.3	29.0	2.9	791.0
Max	150	5.1	3300	9.0	3.4	426.0	683.5	7.7	9.9	100.0	38.6	2129.0
90% CI	82	4.3	2969	4.0	1.6	356.0	339.7	5.3	5.2	89.2	31.7	1959.9
75% CI	75	4.2	2885	3.4	1.3	340.2	308.4	4.9	4.7	85.8	29.9	1898.8
StdDev	42	0.6	536	3.7	1.4	101.4	200.4	2.5	3.0	20.6	11.5	390.5

EU01

At this site, a large flow of severe acid mine drainage, the top acid load producer in the watershed, emerges from a shaft and flows across a cattail wetland a few hundred yards to Muddy Run. The flow is from the Eureka-29 underground mine on the Lower Kittanning coal. This mine, with the connecting Eureka 28 and Viola 1 mines, underlies an area of about 3-4 square miles in the area up-dip to the east. In addition, flow from surface mines near the junction of PA 453 and PA 253 was captured and diverted down wells into the Eureka mine by PA BAMR in order to improve water in the Janesville dam. Considerable mine refuse is present in the vicinity of the outflow.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	695	3.5	1050	0.0	0.0	89.0	741.7	10.6	88.3	10.2	6.4	498.0
01/25/2009	970	3.5	1030	0.0	0.0	87.0	1011.9	9.4	109.7	8.7	5.8	495.0
03/01/2009	1295	3.4	1050	0.0	0.0	93.0	1444.1	11.0	170.8	9.4	7.4	498.0
03/22/2009	1351	3.5	1230	0.0	0.0	100.0	1620.0	9.4	152.9	9.0	7.4	493.0
04/19/2009	1351	3.4	1080	0.0	0.0	94.0	1522.8	10.3	166.9	9.8	8.7	511.0
05/17/2009	1407	3.4	1110	0.0	0.0	95.0	1602.8	10.4	175.5	9.5	8.3	528.0
06/21/2009	980	3.4	1270	0.0	0.0	98.0	1151.6	11.1	130.4	8.3	7.6	507.0
07/20/2009	930	3.4	1210	0.0	0.0	97.0	1081.7	12.7	141.6	9.9	8.1	501.0
08/16/2009	930	3.4	1150	0.0	0.0	98.0	1092.9	13.2	147.2	10.4	8.4	532.0
09/18/2009	740	3.6	1060	0.0	0.0	116.0	1029.3	13.9	123.3	11.4	8.5	531.0
10/18/2009	740	3.4	1070	0.0	0.0	91.0	807.5	12.2	108.3	10.1	7.1	523.0
11/15/2009	740	3.6	1130	0.0	0.0	87.0	772.0	12.6	111.8	11.2	7.5	509.0
Average	1011	3.5	1120	0.0	0.0	95.4	1156.5	11.4	135.6	9.8	7.6	510.5
Min	695	3.4	1030	0.0	0.0	87.0	741.7	9.4	88.3	8.3	5.8	493.0
Max	1407	3.6	1270	0.0	0.0	116.0	1620.0	13.9	175.5	11.4	8.7	532.0
90% CI	1139	3.5	1158	0.0	0.0	99.1	1308.0	12.1	148.9	10.3	8.0	517.4
75% CI	1101	3.5	1146	0.0	0.0	98.0	1262.4	11.9	144.9	10.1	7.9	515.3
StdDev	270	0.1	79	0.0	0.0	7.8	319.0	1.5	28.1	0.9	0.9	14.5

MCC-01L

This discharge emerges from an apparent abandoned mine shaft on the east side of Muddy Run south of Beccaria. Information on the depth and geology of this shaft has not been found, but very likely it is connected to a mine on the Lower Freeport or underlying coal. Water from the shaft flows into a small pond and before it discharges to Muddy Run. Some red precipitate is evident.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
01/26/2009	147	6.6	1100	260.0	458.3	-232.0	-408.9	0.2	0.4	0.3	0.1	352.0
03/03/2009	123	7.0	1100	284.0	418.9	-261.0	-384.9	0.2	0.3	0.3	0.1	334.0
03/22/2009	115	6.7	1270	288.0	397.1	-260.0	-358.5	0.1	0.2	0.3	0.1	326.0
04/19/2009	131	6.8	1090	280.0	439.8	-254.0	-399.0	1.0	1.6	0.3	0.1	326.0
05/17/2009	115	6.9	1120	270.0	372.3	-236.0	-325.4	0.2	0.2	0.4	0.1	336.0
06/21/2009	100	6.4	960	171.0	205.0	-142.0	-170.3	0.5	0.6	1.2	0.2	310.0
07/20/2009	100	6.6	1090	228.0	273.4	-195.0	-233.8	0.2	0.2	0.4	0.1	336.0
08/16/2009	100	6.6	1030	213.0	255.4	-181.0	-217.0	0.2	0.2	0.3	0.1	338.0
09/18/2009	131	6.4	1090	212.0	333.0	-174.0	-273.3	0.2	0.2	0.4	0.1	374.0
10/18/2009	85	6.6	1190	245.0	249.7	-221.0	-225.3	0.3	0.3	0.7	<0.05	444.0
11/15/2009	71	6.5	1160	231.0	196.7	-204.0	-173.7	0.5	0.4	0.8	<0.05	400.0
Average	111	6.6	1109	243.8	327.2	-214.5	-288.2	0.3	0.4	0.5	0.1	352.4
Min	71	6.4	960	171.0	196.7	-261.0	-408.9	0.1	0.2	0.3	0.1	310.0
Max	147	7.0	1270	288.0	458.3	-142.0	-170.3	1.0	1.6	1.2	0.2	444.0
90% CI	122	6.7	1149	262.0	374.6	-195.3	-243.4	0.5	0.6	0.6	0.1	371.8
75% CI	118	6.7	1137	256.6	360.4	-201.1	-256.8	0.4	0.6	0.6	0.1	366.0
StdDev	22	0.2	81	36.7	95.5	38.9	90.4	0.3	0.4	0.3	0.0	39.2

MUC-10R

This sampling point is located on a small stream at the crossing of an abandoned road at 40.72715N, 78.4350W. A 5-ft high beaver dam holding up a several acre pond lies just above the road, and a notch through mine spoil channels the stream to Muddy Run below the sample point. Several small streams flow into the pond to generate the outflow. The Lower, Middle and Upper Kittanning seams have been surface mined in this small watershed, and the slopes are composed largely of spoil. Small underground mines may be present. A weir was installed essentially on the road, but was removed by unknown persons before the first sample date, and a better location could not be found between the beaver dam and Muddy Run.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	E400	6.4	461	32.0		-12.0		1.9		0.7	0.5	176.0
01/25/2009	E506	6.5	896	74.0		-49.0		1.1		1.1	0.1	386.0
03/01/2009	E707	6.5	786	54.0		-35.0		2.5		1.2	0.1	361.0
03/22/2009	E927	6.8	786	65.0		-37.0		0.9		0.5	<0.05	286.0
04/19/2009	E927	6.7	832	58.0		-30.0		1.7		1.5	<0.05	368.0
05/17/2009	E1166	6.8	797	52.0		-30.0		1.6		1.6	0.1	348.0
06/21/2009	E3970	6.3	357	24.0		5.0		3.2		0.9	0.8	124.0
07/20/2009	E3970	6.7	950	76.0		-52.0		0.9		1.4	<0.05	391.0
08/16/2009		6.5	966	71.0		-43.0		1.9		2.2	0.1	445.0
09/18/2009												
10/18/2009		6.7	932	69.0		-46.0		1.5		1.8	<0.05	422.0
11/15/2009		6.8	924	78.0		-50.0		2.3		1.7	<0.05	393.0
Average		6.6	790	59.4		-34.5		1.8		1.3	0.3	336.4
Min		6.3	357	24.0		-52.0		0.9		0.5	0.1	124.0
Max		6.8	966	78.0		5.0		3.2		2.2	0.8	445.0
90% CI		6.7	889	68.2		-25.8		2.1		1.6	0.5	386.7
75% CI		6.7	859	65.5		-28.4		2.0		1.5	0.4	371.5
StdDev		0.2	201	17.8		17.5		0.7		0.5	0.3	101.4

MUC-11R

This site is a discharge from the Miller Mine, a very large abandoned underground mine on the Lower Kittanning coal. According to a map in the Scarlift Report, this mine extends almost to Mountaindale, a distance of nearly 3 miles. The flow emerges in a recess in the hillside on the west side of Muddy Run and flows down about 500 feet, crossing an unimproved mine road, before entering the stream.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	182	3.3	1390	0.0	0.0	111.0	242.2	15.4	33.6	8.1	6.6	758.0
01/25/2009	239	3.3	1530	0.0	0.0	102.0	292.3	16.0	45.9	8.4	6.8	804.0
03/01/2009	279	3.4	1450	0.0	0.0	98.0	327.9	13.2	44.2	7.0	6.2	738.0
03/22/2009	300	3.5	1710	0.0	0.0	98.0	352.5	0.1	0.3	0.0	<0.02	771.0
04/19/2009	300	3.4	1510	0.0	0.0	105.0	377.7	13.8	49.6	7.6	6.1	791.0
05/17/2009	239	3.3	1530	0.0	0.0	100.0	286.6	13.2	37.8	6.9	5.7	810.0
06/21/2009	365	3.3	1570	0.0	0.0	103.0	450.8	13.4	58.6	7.1	5.8	696.0
07/20/2009	321	3.2	1700	0.0	0.0	106.0	408.0	16.6	63.9	8.1	6.2	795.0
08/16/2009	259	3.2	1550	0.0	0.0	108.0	335.4	18.6	57.8	7.9	6.2	853.0
09/18/2009	219	3.3	1600	0.0	0.0	141.0	370.3	19.1	50.2	7.6	6.2	873.0
10/18/2009	201	3.2	1550	0.0	0.0	105.0	253.1	17.7	42.7	7.8	5.9	803.0
11/15/2009	201	3.4	1610	0.0	0.0	112.0	269.9	16.4	39.5	8.0	6.1	792.0
Average	259	3.3	1558	0.0	0.0	107.4	330.6	14.5	43.7	7.0	6.2	790.3
Min	182	3.2	1390	0.0	0.0	98.0	242.2	0.1	0.3	0.0	5.7	696.0
Max	365	3.5	1710	0.0	0.0	141.0	450.8	19.1	63.9	8.4	6.8	873.0
90% CI	285	3.4	1602	0.0	0.0	112.9	361.2	16.8	51.4	8.1	6.3	812.8
75% CI	277	3.3	1589	0.0	0.0	111.2	351.9	16.1	49.1	7.8	6.3	806.0
StdDev	56	0.1	91	0.0	0.0	11.5	64.4	5.0	16.4	2.3	0.3	47.3

MUC-9R

At this site, water drains from an entry to an underground mine, possibly the Black Oak #5 mine, on the Lower Freeport coal. Within the opening, two diverging passages are evident. The site is within an area of unreclaimed surface mining, and the water flows from the entry toward Muddy Run in a channel through the mine spoil. Considerable trash has been dumped into the area. No information has been found on the size of this mine, though the water flow is considerable.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	E2385	7.0	847	213.0		-189.0		0.3		0.0	0.1	229.0
01/25/2009	E486	6.8	866	164.0		-139.0		0.1		0.0	<0.05	233.0
03/01/2009	1176	6.9	701	150.0	2115.2	-128.0	-1805.0	0.1	1.3	0.0	<0.05	222.0
03/22/2009	1176	6.9	808	143.0	2016.5	-114.0	-1607.6	0.1	1.1	0.0	<0.02	193.0
04/19/2009	E2098	7.0	700	148.0		-124.0		0.1		0.0	<0.05	204.0
05/17/2009	1166	7.1	699	142.0	1985.4	-122.0	-1705.7	0.1	1.8	0.0	<0.05	197.0
06/21/2009	870	6.8	803	169.0	1763.0	-145.0	-1512.7	0.2	1.7	0.0	0.1	218.0
07/20/2009	460	6.9	807	185.0	1020.4	-158.0	-871.5	0.1	0.7	0.1	<0.05	227.0
08/16/2009	707	6.8	809	199.0	1687.0	-163.0	-1381.9	1.9	16.4	0.1	0.2	233.0
09/18/2009	329	6.5	900	203.0	800.8	-171.0	-674.6	0.2	0.6	0.1	<0.05	246.0
10/18/2009	214	7.1	876	220.0	564.5	-198.0	-508.1	0.1	0.3	0.0	<0.05	280.0
11/15/2009	371	6.9	885	221.0	983.2	-194.0	-863.0	0.1	0.6	0.1	<0.05	264.0
Average	719	6.9	808	179.8	1437.3	-153.8	-1214.4	0.3	2.7	0.0	0.1	228.8
Min	214	6.5	699	142.0	564.5	-198.0	-1805.0	0.1	0.3	0.0	0.1	193.0
Max	1176	7.1	900	221.0	2115.2	-114.0	-508.1	1.9	16.4	0.1	0.2	280.0
90% CI	934	7.0	843	194.4	1762.4	-139.7	-947.7	0.5	5.5	0.1	0.2	241.0
75% CI	869	6.9	833	190.0	1664.6	-143.9	-1028.0	0.5	4.7	0.0	0.2	237.4
StdDev	393	0.2	73	30.7	592.7	29.6	486.5	0.5	5.1	0.0	0.1	25.7

MUE-1L

This site is a small channel in a gully entering Muddy Run about 1000 ft. upstream from the mouth of Curtis Run. Note that the mouth of Curtis Run is farther downstream than shown on the USGS quadrangle map. The source of this small flow is somewhat ambiguous. During periods of lower flow, it appears to be derived from seepage in a zone a few hundred yards upstream, perhaps from the same groundwater plume as the CRD-1R and MUE-2L flows. However, on one very high flow occasion (6/20/09 with flow estimated at 3200 gal/min), the stream was observed to be a branch of Muddy Run, with the water overflowing the banks of Muddy Run and into this channel a few hundred yards upstream.

MUE-1L (cont)

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/22/2008	13	4.3	630	3.0	0.5	58.0	8.8	0.3	0.1	20.4	2.9	324.0
01/26/2009	3	4.4	569	4.0	0.1	62.0	2.0	0.3	0.0	20.4	1.7	282.0
02/27/2009	14	4.5	487	4.0	0.7	44.0	7.6	0.1	0.0	16.7	1.5	224.0
03/20/2009	9	4.4	555	5.0	0.5	43.0	4.7	0.1	0.0	16.8	1.5	244.0
04/20/2009	23	4.4	481	4.0	1.1	36.0	9.7	0.1	0.0	15.7	1.6	214.0
05/15/2009	13	4.3	495	3.0	0.5	34.0	5.1	0.1	0.0	11.7	1.1	219.0
06/20/2009	E3600	4.2	343	2.0		42.0		3.2		5.1	2.6	120.0
07/17/2009	2	4.0	471	0.0	0.0	45.0	1.0	0.3	0.0	13.8	1.0	210.0
08/16/2009	3	3.9	523	0.0	0.0	46.0	1.5	0.4	0.0	16.1	0.9	223.0
09/18/2009	4	3.8	507	0.0	0.0	54.0	2.3	0.4	0.0	14.6	0.6	209.0
10/18/2009	35	4.1	778	1.0	0.4	74.0	31.2	1.0	0.4	33.1	1.5	450.0
11/15/2009	13	4.1	614	2.0	0.3	53.0	8.0	0.3	0.1	20.9	1.2	313.0
Average	12	4.2	538	2.3	0.4	49.3	7.5	0.6	0.1	17.1	1.5	252.7
Min	2	3.8	343	0.0	0.0	34.0	1.0	0.1	0.0	5.1	0.6	120.0
Max	35	4.5	778	5.0	1.1	74.0	31.2	3.2	0.4	33.1	2.9	450.0
90% CI	17	4.3	588	3.2	0.5	54.7	11.7	1.0	0.1	20.3	1.8	291.7
75% CI	15	4.3	573	2.9	0.5	53.1	10.4	0.8	0.1	19.3	1.7	279.9
StdDev	10	0.2	106	1.8	0.3	11.5	8.5	0.9	0.1	6.6	0.7	82.2

MUE-2L

This site is the outflow of a large area of seepage on the NW (downhill) side of PA 253. It is located about 1000 feet N of the C&K Glasgow treatment system. As with CRD-2R and CRD-1R, the seepage is interpreted to be derived from the large area of Lower Kittanning coal strip mined by C&K uphill on the SE side of PA 253. The seepage flows into Muddy Run through a small channel where the sample point and weir are located.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	6	3.1	2400	0.0	0.0	445.0	33.7	11.6	0.9	93.6	29.3	1521.0
01/26/2009	17	3.0	2950	0.0	0.0	526.0	108.1	27.5	5.7	104.0	36.4	1784.0
02/27/2009	61	3.1	2380	0.0	0.0	411.0	302.3	23.3	17.1	83.7	40.5	1381.0
03/20/2009	28	3.0	3030	0.0	0.0	492.0	165.0	24.3	8.1	98.4	34.1	1546.0
04/20/2009	104	2.9	2890	0.0	0.0	505.0	628.2	19.8	24.6	87.0	32.8	1806.0
05/15/2009	28	2.8	3280	0.0	0.0	495.0	166.0	22.5	7.5	105.0	36.8	1873.0
06/20/2009	E335	2.9	2210	0.0		315.0		11.0		52.0	18.8	939.0
07/17/2009	20	2.8	3300	0.0	0.0	577.0	137.3	40.4	9.6	99.5	28.0	1892.0
08/16/2009	E10	2.7	3270	0.0		800.0		48.7		100.0	24.2	1725.0
09/18/2009	E8	2.8	3500	0.0		676.0		36.3		126.0	39.4	2022.0
10/18/2009	43	2.9	2720	0.0	0.0	454.0	235.7	18.9	9.8	98.1	33.7	1651.0
11/15/2009	23	3.1	2970	0.0	0.0	451.0	122.0	20.4	5.5	111.0	35.1	1894.0
Average	37	2.9	2908	0.0	0.0	512.3	210.9	25.4	9.9	96.5	32.4	1669.5
Min	6	2.7	2210	0.0	0.0	315.0	33.7	11.0	0.9	52.0	18.8	939.0
Max	104	3.1	3500	0.0	0.0	800.0	628.2	48.7	24.6	126.0	40.5	2022.0
90% CI	53	3.0	3103	0.0	0.0	572.2	306.4	30.8	13.7	105.0	35.4	1809.4
75% CI	48	3.0	3045	0.0	0.0	554.2	277.7	29.1	12.6	102.4	34.5	1767.3
StdDev	30	0.1	411	0.0	0.0	126.3	174.1	11.3	7.0	17.8	6.3	294.6

MUE-2R

This site is a small channel draining a wetland area of about 1 acre. Precipitation of Fe is evident in the channel. The water flows into Muddy Run just downstream from the weir location. The source is seepage, probably from a large area of abandoned Lower Kittanning strip mining uphill to the west. A second stream, designated MUE-1R during the reconnaissance phase, enters Muddy Run about 25 ft downstream from this site. The acidity and metals flowing to MUE-1R is nearly all from discharge CM-3R, so the latter discharge was sampled monthly.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	28	4.6	807	5.0	1.7	31.0	10.4	2.2	0.7	6.1	0.9	369.0
01/26/2009	E15	5.1	1010	7.0		33.0		2.1		8.3	0.9	531.0
02/27/2009	35	4.5	832	5.0	2.1	23.0	9.7	1.7	0.7	6.4	0.9	387.0
03/20/2009	23	4.7	985	6.0	1.6	25.0	6.8	1.0	0.3	6.0	1.0	446.0
04/20/2009	51	4.3	490	4.0	2.5	24.0	14.8	1.0	0.6	5.3	1.0	479.0
05/15/2009	28	4.3	1010	3.0	1.0	23.0	7.7	1.2	0.4	6.3	0.9	519.0
06/20/2009												
07/17/2009	E10	4.4	1170	4.0		28.0		1.1		9.1	0.6	637.0
08/16/2009	14	5.4	1180	9.0	1.6	35.0	6.1	4.2	0.7	11.0	0.4	678.0
09/18/2009	9	5.0	1420	7.0	0.8	44.0	4.8	4.4	0.5	13.7	0.4	827.0
10/18/2009	35	5.3	1030	8.0	3.4	23.0	9.7	2.7	1.1	8.0	0.5	529.0
11/15/2009	14	5.3	1190	10.0	1.7	29.0	5.0	1.0	0.2	8.2	5.0	642.0
Average	26	4.8	1011	6.2	1.8	28.9	8.3	2.1	0.6	8.0	1.1	549.5
Min	9	4.3	490	3.0	0.8	23.0	4.8	1.0	0.2	5.3	0.4	369.0
Max	51	5.4	1420	10.0	3.4	44.0	14.8	4.4	1.1	13.7	5.0	827.0
90% CI	34	5.0	1133	7.3	2.2	32.2	10.1	2.7	0.7	9.3	1.8	617.1
75% CI	32	5.0	1096	7.0	2.1	31.2	9.5	2.5	0.7	8.9	1.6	596.8
StdDev	13	0.4	245	2.2	0.8	6.6	3.2	1.2	0.3	2.5	1.3	136.4

MUE-5R

This site is located on the west side of Muddy Run about 100 feet upstream from a road crossing Muddy Run in a cleared zone. Currently a gate blocks travel up the valley at this point. The source of this water is probably the same zone of reclaimed surface mining on the Clarion-Brookville coal up the hill that supplies the MUE-6R discharge.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
03/21/2009	13	4.2	381	3.0	0.5	61.0	9.5	0.3	0.0	5.7	6.6	172.0
04/19/2009	23	4.1	328	2.0	0.6	52.0	14.3	0.2	0.1	4.9	5.8	130.0
05/17/2009	23	4.0	384	0.0	0.0	60.0	16.5	0.3	0.1	5.8	6.5	168.0
06/21/2009	178	4.2	221	2.0	4.3	37.0	79.0	0.2	0.4	2.3	2.5	74.0
07/20/2009	13	4.0	395	0.0	0.0	52.0	8.1	1.0	0.1	5.6	4.6	157.0
08/16/2009	4	3.9	385	0.0	0.0	51.0	2.4	1.5	0.1	6.6	5.2	153.0
09/20/2009	4	4.1	368	2.0	0.1	54.0	2.6	1.9	0.1	6.0	3.4	152.0
10/18/2009	35	3.9	523	0.0	0.0	74.0	31.1	0.6	0.3	8.5	6.6	274.0
11/22/2009	23	4.0	404	1.0	0.3	61.0	16.8	0.5	0.1	7.0	7.0	185.0
Average	35	4.0	377	1.1	0.6	55.8	20.0	0.7	0.1	5.8	5.4	162.8
Min	4	3.9	221	0.0	0.0	37.0	2.4	0.2	0.0	2.3	2.5	74.0
Max	178	4.2	523	3.0	4.3	74.0	79.0	1.9	0.4	8.5	7.0	274.0
90% CI	65	4.1	420	1.8	1.4	61.3	33.1	1.1	0.2	6.8	6.2	191.6
75% CI	56	4.1	407	1.6	1.2	59.6	29.2	1.0	0.2	6.5	6.0	183.0
StdDev	55	0.1	79	1.2	1.4	10.1	23.8	0.6	0.1	1.7	1.6	52.7

MUE-6R

This sampling point is a small flow entering Muddy Run about 500 feet upstream from a well of the Reade Township Water Authority. The flow is apparently downslope seepage from a strip of reclaimed surface mining on the Clarion-Brookville coal a few hundred feet up the hill to the west.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	243	4.1	387	2.0	5.8	46.0	133.9	0.1	0.2	4.7	5.0	155.0
01/24/2009	72	3.8	1040	0.0	0.0	139.0	120.3	0.2	0.1	14.9	14.8	383.0
02/28/2009	220	2.9	1650	0.0	0.0	230.0	607.1	0.1	0.2	10.2	11.0	747.0
03/21/2009	97	3.9	746	0.0	0.0	118.0	136.6	0.2	0.2	12.1	12.8	356.0
04/19/2009	126	3.8	606	0.0	0.0	91.0	137.8	0.1	0.2	10.9	11.4	260.0
05/17/2009	126	3.8	697	0.0	0.0	102.0	154.5	0.2	0.2	10.9	11.9	321.0
06/21/2009	292	4.0	400	0.0	0.0	53.0	185.8	0.1	0.3	4.3	4.5	159.0
07/20/2009	84	3.6	944	0.0	0.0	154.0	154.9	0.3	0.3	17.9	17.0	426.0
08/16/2009	84	3.5	911	0.0	0.0	145.0	145.9	0.3	0.3	17.8	16.6	439.0
09/20/2009	72	3.5	1010	0.0	0.0	182.0	157.5	0.4	0.3	22.7	21.0	501.0
10/18/2009	84	3.6	805	0.0	0.0	120.0	120.7	0.2	0.2	16.0	13.1	429.0
11/22/2009	72	3.7	805	0.0	0.0	122.0	105.6	0.5	0.5	15.7	15.8	420.0
Average	131	3.7	833	0.2	0.5	125.2	180.0	0.2	0.3	13.2	12.9	383.0
Min	72	2.9	387	0.0	0.0	46.0	105.6	0.1	0.1	4.3	4.5	155.0
Max	292	4.1	1650	2.0	5.8	230.0	607.1	0.5	0.5	22.7	21.0	747.0
90% CI	167	3.8	992	0.4	1.3	149.5	244.7	0.3	0.3	15.7	15.2	458.3
75% CI	156	3.8	944	0.4	1.0	142.2	225.2	0.3	0.3	15.0	14.5	435.7
StdDev	77	0.3	334	0.6	1.7	51.3	136.1	0.1	0.1	5.4	4.7	158.6

MUEA-1L

The weir for this discharge is located on the east side of stream MUEA about 100 ft. downstream from Sportsman Road. The water upwells forming a wetland area precipitating Fe as it flows to the stream. The source of this water is not clear. It could be a small shaft or drillhole, or it could be seepage from a source on the uphill side of Sportsman Road, traveling through the unconsolidated zone to the site of emergence.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	35	6.5	392	50.0	21.0	-27.0	-11.3	1.8	0.8	0.9	<0.05	178.0
01/24/2009	13	6.4	543	50.0	7.8	-23.0	-3.6	3.9	0.6	0.9	<0.05	169.0
02/28/2009	4	6.7	428	50.0	2.4	-28.0	-1.3	3.1	0.2	1.0	<0.05	171.0
03/21/2009	13	6.7	466	52.0	8.1	-24.0	-3.7	4.3	0.7	0.9	<0.05	171.0
04/19/2009	23	6.9	436	51.0	14.1	-29.0	-8.0	3.1	0.9	0.9	<0.05	164.0
05/17/2009	13	7.0	436	50.0	7.8	-31.0	-4.8	2.0	0.3	0.8	<0.05	163.0
06/21/2009	35	6.5	454	50.0	21.0	-30.0	-12.6	2.6	1.1	1.0	<0.05	166.0
07/20/2009	35	6.7	450	51.0	21.4	-29.0	-12.2	2.6	1.1	1.1	<0.05	171.0
08/16/2009	35	6.6	443	53.0	22.2	-31.0	-13.0	3.5	1.5	1.1	<0.05	171.0
09/20/2009	4	6.1	465	52.0	2.5	-20.0	-1.0	5.0	0.2	1.1	<0.05	171.0
10/18/2009	35	6.7	422	48.0	20.1	-28.0	-11.8	1.9	0.8	1.0	<0.05	184.0
11/22/2009	35	6.7	435	48.0	20.1	-27.0	-11.3	1.8	0.8	1.0	<0.05	182.0
Average	23	6.6	448	50.4	14.0	-27.3	-7.9	3.0	0.7	1.0		171.8
Min	4	6.1	392	48.0	2.4	-31.0	-13.0	1.8	0.2	0.8		163.0
Max	35	7.0	543	53.0	22.2	-20.0	-1.0	5.0	1.5	1.1		184.0
90% CI	30	6.7	465	51.1	17.8	-25.7	-5.7	3.5	0.9	1.0		174.9
75% CI	28	6.7	459	50.9	16.6	-26.1	-6.3	3.3	0.9	1.0		173.9
StdDev	13	0.2	36	1.5	7.8	3.4	4.7	1.0	0.4	0.1		6.6

MUEA-2R

This weir is located on the west side of stream MUEA about 100 ft downstream from Sportsman Road. The water seeps out between the stream and Mountaindale Road, probably derived from the abandoned Lower Kittanning surface mine on the west side of Mountaindale Road.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	35	3.9	702	0.0	0.0	44.0	18.5	1.4	0.6	7.0	1.8	351.0
01/24/2009	13	4.0	1130	0.0	0.0	44.0	6.9	1.5	0.2	10.3	2.3	460.0
02/28/2009	35	4.1	784	2.0	0.8	39.0	16.4	0.8	0.3	7.1	2.2	373.0
03/21/2009	4	4.1	909	2.0	0.1	50.0	2.4	1.3	0.1	10.5	2.5	421.0
04/19/2009	13	4.0	880	0.0	0.0	42.0	6.5	1.1	0.2	8.8	2.2	436.0
05/17/2009	13	3.9	950	0.0	0.0	44.0	6.9	1.7	0.3	9.7	2.0	459.0
06/21/2009	65	4.0	643	0.0	0.0	35.0	27.3	1.3	1.0	5.3	0.9	282.0
07/20/2009	13	3.6	1030	0.0	0.0	56.0	8.7	3.6	0.6	10.8	1.3	474.0
08/16/2009	4	3.5	982	0.0	0.0	58.0	2.8	9.5	0.5	10.6	0.6	482.0
09/20/2009	4	3.9	1030	0.0	0.0	72.0	3.5	9.5	0.5	13.3	0.8	528.0
10/18/2009	49	3.7	933	0.0	0.0	48.0	28.2	2.5	1.5	9.3	2.2	434.0
11/22/2009	4	3.8	974	0.0	0.0	47.0	2.3	3.8	0.2	12.4	1.9	487.0
Average	21	3.9	912	0.3	0.1	48.3	10.8	3.2	0.5	9.6	1.7	432.3
Min	4	3.5	643	0.0	0.0	35.0	2.3	0.8	0.1	5.3	0.6	282.0
Max	65	4.1	1130	2.0	0.8	72.0	28.2	9.5	1.5	13.3	2.5	528.0
90% CI	31	4.0	979	0.7	0.2	53.0	15.3	4.6	0.7	10.7	2.0	464.5
75% CI	28	3.9	959	0.6	0.2	51.5	14.0	4.2	0.6	10.4	1.9	454.8
StdDev	20	0.2	141	0.8	0.2	9.9	9.4	3.1	0.4	2.3	0.6	67.9

MUEA-3L

This site has also been called the Pumphouse discharge, and is located on the McCartney Property north of Mountaindale. The weir for this site is located adjacent to stream MUEA, but two sources feed this weir. One source is what appears to be a large prospecting pit for coal. This source is located about 100 feet uphill from the weir. The water seeps from the head of this pit and precipitates appreciable Fe on the seepage area and in the pond. The second source, of volume about equal to the first, is derived about 1000 ft. up the hill to the east at 40.69738N, 78.42213W. At the latter location, two small spring-house-type sheds form the source of an acid, Fe-bearing flow. Electrical wiring in the northern shed suggests that a pump was once here, though no power line currently is evident. The water-filled interior of this shed suggests that it might be a shaft. A small amount of spoil is present downhill. The McCartney family reports that they pumped water from this site at one time, but that the water turned acid and Fe-bearing when coal was mined on the east side of the same hill.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	71	3.4	722	0.0	0.0	109.0	92.8	4.0	3.4	13.4	6.9	310.0
01/24/2009	25	3.2	2000	0.0	0.0	302.0	90.5	9.2	2.8	37.2	19.6	767.0
02/28/2009	9	3.4	946	0.0	0.0	154.0	16.6	4.1	0.4	22.7	15.1	421.0
03/21/2009	9	3.3	1380	0.0	0.0	229.0	24.7	5.3	0.6	32.7	18.1	651.0
04/19/2009	9	3.1	1240	0.0	0.0	194.0	20.9	5.4	0.6	29.8	15.0	554.0
05/17/2009	9	3.1	1330	0.0	0.0	197.0	21.3	4.6	0.5	28.4	14.8	544.0
06/21/2009	100	3.2	974	0.0	0.0	133.0	159.5	3.0	3.6	14.4	8.4	280.0
07/20/2009	25	2.8	2430	0.0	0.0	481.0	144.2	13.9	4.2	60.8	30.8	1199.0
08/16/2009	9	2.8	2580	0.0	0.0	524.0	56.5	21.2	2.3	66.5	33.1	1320.0
09/20/2009	9	2.8	2730	0.0	0.0	751.0	81.0	31.9	3.4	83.4	54.3	1598.0
10/18/2009	9	2.9	1860	0.0	0.0	371.0	40.0	13.9	1.5	47.2	27.7	961.0
11/22/2009	9	2.9	2250	0.0	0.0	455.0	49.1	22.3	2.4	60.3	40.4	1267.0

MUEA-3L (cont)

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	24	3.1	1704	0.0	0.0	325.0	66.4	11.6	2.1	41.4	23.7	822.7
Min	9	2.8	722	0.0	0.0	109.0	16.6	3.0	0.4	13.4	6.9	280.0
Max	100	3.4	2730	0.0	0.0	751.0	159.5	31.9	4.2	83.4	54.3	1598.0
90% CI	39	3.2	2033	0.0	0.0	417.8	89.4	16.0	2.8	51.9	30.3	1030.5
75% CI	34	3.2	1934	0.0	0.0	389.9	82.5	14.7	2.6	48.8	28.3	968.0
StdDev	30	0.2	693	0.0	0.0	195.5	48.3	9.3	1.4	22.2	14.0	437.7

MUEA-3R

The weir for this discharge is located in a ditch along the uphill side of Sportsman Road on the west side of stream MUEA. The water emerges from a large wetland area between Mountaindale Road and the stream. It is possible that this water is derived from an area of surface mining on the Lower Kittanning coal on the west side of Mountaindale Road.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	17	3.8	814	0.0	0.0	61.0	12.5	1.5	0.3	8.7	3.0	36.0
01/24/2009	13	3.6	1310	0.0	0.0	80.0	12.1	2.5	0.4	13.8	4.9	521.0
02/28/2009	1	3.9	823	0.0	0.0	48.0	0.5	1.2	0.0	8.1	3.1	346.0
03/21/2009	13	3.7	1140	0.0	0.0	80.0	12.1	8.0	1.2	13.9	5.4	525.0
04/19/2009	13	3.6	1050	0.0	0.0	74.0	11.2	2.0	0.3	11.8	4.2	509.0
05/17/2009	9	3.5	1110	0.0	0.0	72.0	7.8	3.1	0.3	13.2	4.2	527.0
06/21/2009	35	3.7	742	0.0	0.0	51.0	21.5	1.3	0.5	6.1	1.9	299.0
07/20/2009	9	3.3	1180	0.0	0.0	94.0	10.2	5.3	0.6	13.7	3.6	527.0
08/16/2009	4	3.3	1190	0.0	0.0	92.0	4.0	6.4	0.3	13.0	2.8	559.0
09/20/2009	4	3.4	1240	0.0	0.0	106.0	4.6	5.2	0.2	14.1	3.6	608.0
10/18/2009	28	3.8	786	0.0	0.0	49.0	16.4	1.9	0.6	7.5	2.3	390.0
11/22/2009	6	3.6	1010	0.0	0.0	69.0	5.2	3.4	0.3	14.0	4.2	501.0
Average	13	3.6	1033	0.0	0.0	73.0	9.8	3.5	0.4	11.5	3.6	445.7
Min	1	3.3	742	0.0	0.0	48.0	0.5	1.2	0.0	6.1	1.9	36.0
Max	35	3.9	1310	0.0	0.0	106.0	21.5	8.0	1.2	14.1	5.4	608.0
90% CI	17	3.7	1126	0.0	0.0	81.9	12.6	4.5	0.6	12.9	4.1	520.6
75% CI	16	3.7	1098	0.0	0.0	79.2	11.8	4.2	0.5	12.5	3.9	498.0
StdDev	10	0.2	196	0.0	0.0	18.7	5.8	2.2	0.3	3.0	1.0	157.8

MUEA-6R

This discharge forms the headwaters of the MUEA tributary of Muddy Run, and is located just uphill from the Mountaindale village. This discharge was discussed in the Scarlift report as discharge 117. The flow emerges from an unreclaimed surface mine on the Middle Kittanning coal. Extensive piles of coal refuse suggest that an underground mine may have also been located in this vicinity, perhaps on the Lower Kittanning coal. The pile has been tested and contains low BTU values. The small stream flows down through the yard of the McAndrews residence, and parallels Mountaindale Road on the east for some distance.

MUEA-6R (cont)

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	99	2.8	1700	0.0	0.0	275.0	326.5	10.3	12.2	5.5	17.8	756.0
01/24/2009	65	2.9	1750	0.0	0.0	273.0	212.8	9.4	7.3	7.8	21.5	840.0
02/28/2009	99	4.0	607	0.0	0.0	84.0	99.7	9.0	10.7	7.2	21.8	305.0
03/21/2009	99	3.0	1900	0.0	0.0	255.0	302.7	10.7	12.7	8.3	22.5	803.0
04/19/2009	99	2.9	1770	0.0	0.0	262.0	311.0	12.5	14.8	8.2	24.5	820.0
05/17/2009	81	2.9	1910	0.0	0.0	267.0	259.3	13.7	13.3	8.3	25.5	874.0
06/21/2009	99	2.8	2230	0.0	0.0	267.0	317.0	11.4	13.5	6.1	21.8	724.0
07/20/2009	35	2.8	2130	0.0	0.0	342.0	143.5	16.9	7.1	8.6	31.5	964.0
08/16/2009	23	2.8	2200	0.0	0.0	356.0	98.2	17.7	4.9	8.5	33.1	1093.0
09/20/2009	13	2.7	2380	0.0	0.0	441.0	68.7	21.7	3.4	9.8	42.3	1175.0
10/18/2009	23	2.7	2230	0.0	0.0	385.0	106.2	18.9	5.2	8.4	39.1	1093.0
11/22/2009	35	2.7	2320	0.0	0.0	393.0	164.9	24.6	10.3	10.6	48.4	1182.0
Average	64	2.9	1927	0.0	0.0	300.0	200.9	14.7	9.6	8.1	29.2	885.8
Min	13	2.7	607	0.0	0.0	84.0	68.7	9.0	3.4	5.5	17.8	305.0
Max	99	4.0	2380	0.0	0.0	441.0	326.5	24.6	14.8	10.6	48.4	1182.0
90% CI	81	3.1	2154	0.0	0.0	344.0	247.7	17.2	11.5	8.8	33.8	1001.8
75% CI	76	3.0	2086	0.0	0.0	330.7	233.6	16.4	10.9	8.6	32.4	966.9
StdDev	36	0.4	478	0.0	0.0	92.6	98.7	5.1	3.9	1.4	9.7	244.4

MUEC

This discharge is located northwest of Blandburg approximately 100 feet upstream from a private road into the Ryan cabin. This discharge emanates from a large surface mine site east of Blandburg. The Clarion-Brookville and Lower Kittanning coals were surface mined in this area. The discharge channel is the outflow of a pond about an acre in size within the mine spoil. Examination of this pond suggests that much of the flow is derived from a probable caved underground entry on the middle of the southeast side of the pond.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	157	3.3	1400	0.0	0.0	310.0	583.6	8.6	16.2	29.0	24.6	758.0
01/24/2009	99	3.2	1450	0.0	0.0	345.0	409.6	8.3	9.9	36.8	36.8	798.0
02/28/2009	157	3.3	1330	0.0	0.0	293.0	551.6	5.6	10.5	27.9	35.0	739.0
03/21/2009	137	3.3	1600	0.0	0.0	340.0	558.5	6.8	11.2	34.8	33.8	811.0
04/19/2009	137	3.2	1470	0.0	0.0	312.0	512.5	6.7	11.0	33.1	36.5	807.0
05/17/2009	157	3.2	1520	0.0	0.0	291.0	547.8	6.8	12.8	34.0	38.0	781.0
06/21/2009	157	3.4	1470	0.0	0.0	250.0	470.6	7.2	13.5	24.7	25.4	592.0
07/20/2009	99	3.2	1490	0.0	0.0	330.0	391.7	9.6	11.3	36.9	35.4	761.0
08/16/2009	65	3.2	1460	0.0	0.0	291.0	226.8	7.4	5.7	29.3	28.6	766.0
09/20/2009	49	3.2	1510	0.0	0.0	359.0	210.9	8.6	5.1	33.4	33.1	837.0
10/18/2009	81	3.3	1160	0.0	0.0	236.0	229.2	7.5	7.2	24.9	21.9	605.0
11/22/2009	81	3.1	1430	0.0	0.0	289.0	280.7	10.0	9.7	37.2	42.3	794.0
Average	115	3.2	1441	0.0	0.0	303.8	414.5	7.7	10.3	31.8	32.6	754.1
Min	49	3.1	1160	0.0	0.0	236.0	210.9	5.6	5.1	24.7	21.9	592.0
Max	157	3.4	1600	0.0	0.0	359.0	583.6	10.0	16.2	37.2	42.3	837.0
90% CI	134	3.3	1493	0.0	0.0	321.4	482.9	8.4	11.9	34.0	35.5	790.9
75% CI	128	3.3	1477	0.0	0.0	316.1	462.3	8.2	11.4	33.3	34.7	779.8
StdDev	40	0.1	110	0.0	0.0	36.9	144.0	1.3	3.2	4.5	6.2	77.5

MUED-1R

This discharge is derived from a several acre seepage area and kill zone downslope from the Ryan cabin. The source of the seepage appears to be from the unconsolidated zone from the large surface mined area that also furnishes discharges MUEC and MUED-3.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	35	3.6	831	0.0	0.0	132.0	55.7	1.6	0.7	19.8	11.5	398.0
01/24/2009	13	3.5	1090	0.0	0.0	201.0	30.4	1.4	0.2	23.8	16.1	523.0
02/28/2009	28	3.6	950	0.0	0.0	160.0	53.7	1.4	0.5	21.6	16.2	468.0
03/21/2009	9	3.6	1180	0.0	0.0	184.0	19.9	1.9	0.2	28.6	18.9	568.0
04/19/2009	9	3.5	1080	0.0	0.0	175.0	18.9	1.7	0.2	28.1	16.8	557.0
05/17/2009	23	3.3	1220	0.0	0.0	195.0	52.7	2.7	0.7	29.7	19.6	596.0
06/21/2009	23	3.4	1030	0.0	0.0	112.0	30.3	1.8	0.5	19.5	5.8	361.0
07/20/2009	17	3.2	1110	0.0	0.0	120.0	24.7	2.9	0.6	23.0	3.8	446.0
08/16/2009	2	3.2	1080	0.0	0.0	113.0	2.4	3.2	0.1	23.3	3.1	454.0
09/20/2009	4	3.3	1110	0.0	0.0	140.0	6.1	2.9	0.1	26.6	3.4	489.0
10/18/2009	28	3.5	897	0.0	0.0	93.0	31.2	1.4	0.5	22.5	4.5	405.0
11/22/2009	13	3.5	889	0.0	0.0	100.0	15.1	1.5	0.2	27.6	6.3	424.0
Average	17	3.4	1039	0.0	0.0	143.8	28.4	2.0	0.4	24.5	10.5	474.1
Min	2	3.2	831	0.0	0.0	93.0	2.4	1.4	0.1	19.5	3.1	361.0
Max	35	3.6	1220	0.0	0.0	201.0	55.7	3.2	0.7	29.7	19.6	596.0
90% CI	22	3.5	1097	0.0	0.0	161.8	36.9	2.3	0.5	26.2	13.6	509.2
75% CI	20	3.5	1079	0.0	0.0	156.4	34.4	2.2	0.4	25.7	12.7	498.7
StdDev	10	0.1	122	0.0	0.0	38.0	17.9	0.7	0.2	3.5	6.6	74.0

MUED-3

This small stream drains from another part of the large area of surface mining east of Blandburg. The stream emerges within the mine spoil and forms the headwaters and main source of stream MUED. It is a short distance upstream from the private road passing by the Ryan cabin. The source area contained the Clarion-Brookville and Lower Kittanning coals.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
12/21/2008	201	3.7	624	0.0	0.0	91.0	219.3	0.1	0.2	6.2	7.0	233.0
01/24/2009	25	3.5	1050	0.0	0.0	205.0	61.5	0.2	0.1	21.7	19.5	517.0
02/28/2009	71	3.5	937	0.0	0.0	147.0	125.2	0.3	0.2	19.3	18.4	457.0
03/21/2009	9	3.6	1020	0.0	0.0	152.0	16.4	0.2	0.0	21.4	17.5	464.0
04/19/2009	47	3.5	936	0.0	0.0	161.0	90.7	0.3	0.2	20.7	17.5	458.0
05/17/2009	25	3.5	1220	0.0	0.0	152.0	45.6	0.3	0.1	21.2	19.1	471.0
06/21/2009	100	3.5	842	0.0	0.0	111.0	133.1	0.2	0.2	12.4	11.3	335.0
07/20/2009	25	3.5	1130	0.0	0.0	191.0	57.3	0.3	0.1	22.6	18.8	550.0
08/16/2009	9	3.5	951	0.0	0.0	156.0	16.8	0.2	0.0	17.7	15.3	467.0
09/20/2009	9	3.5	1020	0.0	0.0	212.0	22.9	0.3	0.0	22.2	19.4	506.0
10/18/2009	9	3.6	701	0.0	0.0	103.0	11.1	0.2	0.0	12.6	10.4	345.0
11/22/2009	9	3.5	889	0.0	0.0	148.0	16.0	0.2	0.0	20.1	20.2	457.0
Average	45	3.5	943	0.0	0.0	152.4	68.0	0.2	0.1	18.2	16.2	438.3
Min	9	3.5	624	0.0	0.0	91.0	11.1	0.1	0.0	6.2	7.0	233.0
Max	201	3.7	1220	0.0	0.0	212.0	219.3	0.3	0.2	22.6	20.2	550.0
90% CI	72	3.6	1023	0.0	0.0	170.5	98.3	0.2	0.1	20.6	18.2	480.9
75% CI	64	3.6	999	0.0	0.0	165.0	89.2	0.2	0.1	19.9	17.6	468.1
StdDev	57	0.1	167	0.0	0.0	38.0	63.8	0.1	0.1	5.1	4.3	89.7

BRQ-10

Mouth of Banian Run above Smoke Run.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
01/06/2009	802	6.7	722	42.0	403.9	-22.0	-211.6	0.2	2.0	0.4	0.4	350.0
04/08/2009	880	6.8	595	37.0	390.4	-17.0	-179.4	0.2	2.1	0.2	0.3	268.0
06/01/2009		6.7	722	42.0		-22.0		0.2		0.4	0.4	350.0
08/31/2009	49	6.9	791	57.0	33.5	-28.0	-16.5	1.2	0.7	0.8	1.2	348.0
Average	577	6.8	708	44.5	275.9	-22.3	-135.8	0.5	1.6	0.4	0.6	329.0
Min	49	6.7	595	37.0	33.5	-28.0	-211.6	0.2	0.7	0.2	0.3	268.0
Max	880	6.9	791	57.0	403.9	-17.0	-16.5	1.2	2.1	0.8	1.2	350.0
90% CI	1013	6.9	775	51.6	475.5	-18.5	-36.5	0.9	2.4	0.7	0.9	362.5
75% CI	882	6.8	755	49.5	415.4	-19.7	-66.3	0.7	2.1	0.6	0.8	352.4
StdDev	459	0.1	82	8.7	210.1	4.5	104.6	0.5	0.8	0.3	0.4	40.7

LMQ-10

Mouth of Little Muddy Run above Smoke Run.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
01/06/2009		6.6	743	49.0		-27.0		4.5		2.1	0.1	349.0
04/08/2009	9820	6.7	717	39.0	4592.3	-13.0	-1530.8	4.8	566.4	2.1	0.1	326.0
06/01/2009		6.6	684	49.0		-27.0		4.5		2.1	0.1	349.0
Average		6.6	715	45.7		-22.3		4.6		2.1	0.1	341.3
Min		6.6	684	39.0		-27.0		4.5		2.1	0.1	326.0
Max		6.7	743	49.0		-13.0		4.8		2.1	0.1	349.0
90% CI		6.7	743	51.2		-14.7		4.8		2.1	0.1	353.9
75% CI		6.7	734	49.5		-17.0		4.7		2.1	0.1	350.2
StdDev		0.1	30	5.8		8.1		0.2		0.0	0.0	13.3

MRQ-10

Mouth of Muddy Run above bridge on Chesterfield Rd TR891.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
01/06/2009	25568	6.8	677	56.0	17168.8	-33.0	-10117.3	2.5	760.3	2.8	1.3	310.0
04/08/2009	26237	6.9	621	46.0	14472.0	-22.0	-6921.4	2.0	632.4	2.3	1.2	261.0
06/01/2009		6.8	677	56.0		-33.0		2.5		2.8	1.3	310.0
08/31/2009	7936	6.9	1150	64.0	6090.3	-32.0	-3045.1	1.7	159.9	5.8	<0.05	577.0
Average	19914	6.9	781	55.5	12577.0	-30.0	-6694.6	2.2	517.5	3.4	1.2	364.5
Min	7936	6.8	621	46.0	6090.3	-33.0	-10117.3	1.7	159.9	2.3	1.2	261.0
Max	26237	6.9	1150	64.0	17168.8	-22.0	-3045.1	2.5	760.3	5.8	1.3	577.0
90% CI	29770	6.9	985	61.6	18063.9	-25.6	-3331.1	2.5	817.9	4.7	1.3	482.6
75% CI	26804	6.9	923	59.7	16412.8	-26.9	-4343.2	2.4	727.5	4.3	1.3	447.0
StdDev	10378	0.1	247	7.4	5777.2	5.4	3541.5	0.4	316.3	1.6	0.0	143.5

MRQ-20

Muddy Run, downstream of Little Muddy Run.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
04/16/2009		6.7	660	40.0		-15.0		1.5		5.1	3.0	342.0
08/31/2009		6.8	873	56.0		-23.0		0.2		6.5	0.1	402.0
Average		6.8	767	48.0		-19.0		0.9		5.8	1.5	372.0
Min		6.7	660	40.0		-23.0		0.2		5.1	0.1	342.0
Max		6.8	873	56.0		-15.0		1.5		6.5	3.0	402.0
90% CI		6.8	942	61.2		-12.4		1.9		6.9	3.9	421.4
75% CI		6.8	889	57.2		-14.4		1.6		6.6	3.2	406.5
StdDev		0.1	151	11.3		5.7		0.9		1.0	2.1	42.4

MRQ-30

Muddy Run, downstream from bridge in Beccaria.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
01/06/2009		6.6	684	58.0		-29.0		1.6		4.5	2.9	314.0
04/08/2009		6.7	625	43.0		-16.0		1.7		4.2	3.0	272.0
06/01/2009		6.6	684	58.0		-29.0		1.6		4.5	2.9	314.0
08/31/2009	3245	6.6	892	50.0	1945.5	-11.0	-428.0	1.6	61.1	7.8	0.2	479.0
Average		6.6	721	52.3		-21.3		1.6		5.3	2.3	344.8
Min		6.6	625	43.0		-29.0		1.6		4.2	0.2	272.0
Max		6.7	892	58.0		-11.0		1.7		7.8	3.0	479.0
90% CI		6.7	818	58.2		-13.7		1.7		6.7	3.4	420.1
75% CI		6.7	789	56.4		-16.0		1.6		6.2	3.1	397.5
StdDev		0.0	117	7.2		9.2		0.0		1.7	1.4	91.7

MRQ-40

Muddy Run downstream at bridge on Wippers Rd.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
04/16/2009	6759	4.2	604	3.0	243.1	59.0	4781.8	0.9	75.4	7.3	6.4	361.0
08/31/2009		3.7	1040	0.0		77.0		2.4		15.4	6.6	488.0
Average		4.0	822	1.5		68.0		1.6		11.4	6.5	424.5
Min		3.7	604	0.0		59.0		0.9		7.3	6.4	361.0
Max		4.2	1040	3.0		77.0		2.4		15.4	6.6	488.0
90% CI		4.4	1181	4.0		82.8		2.8		18.0	6.7	529.0
75% CI		4.2	1073	3.2		78.4		2.5		16.0	6.6	497.5
StdDev		0.4	308	2.1		12.7		1.0		5.7	0.1	89.8

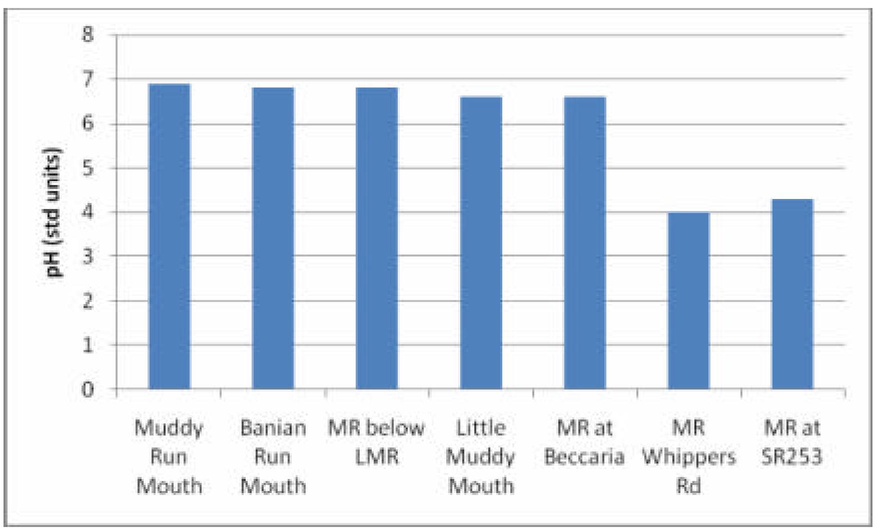
MRQ-50

Muddy Run, downstream of SR 253.

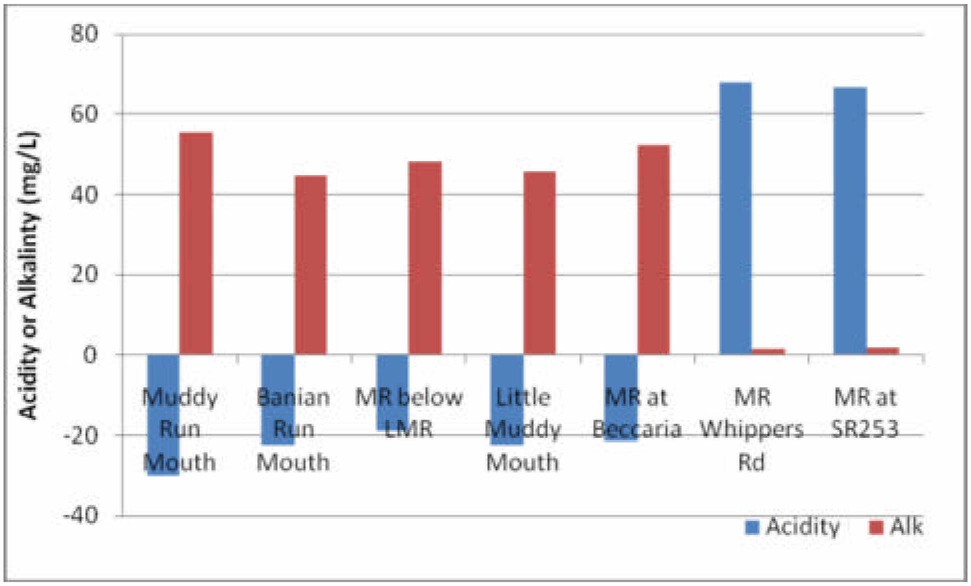
Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
01/06/2009	2087		486	1.0	25.0	71.0	1776.8	0.7	17.0	7.7	8.0	267.0
04/08/2009	3662	4.2	439	2.0	87.8	54.0	2371.2	0.4	17.6	5.9	5.6	207.0
06/01/2009			486	1.0		71.0		0.7		7.7	8.0	267.0
08/31/2009		4.3	644	3.0		70.0		0.3		10.7	5.9	340.0
Average	2875	4.3	514	1.8	56.4	66.5	2074.0	0.5	17.3	8.0	6.9	270.3
Min	2087	4.2	439	1.0	25.0	54.0	1776.8	0.3	17.0	5.9	5.6	207.0
Max	3662	4.3	644	3.0	87.8	71.0	2371.2	0.7	17.6	10.7	8.0	340.0
90% CI	4170	4.3	587	2.5	108.1	73.4	2562.9	0.7	17.7	9.6	8.0	315.0
75% CI	3780	4.3	565	2.3	92.5	71.3	2415.8	0.6	17.6	9.1	7.6	301.5
StdDev	1114	0.1	90	1.0	44.4	8.3	420.3	0.2	0.4	2.0	1.3	54.4

Comparison of Quarterly Stream Samples

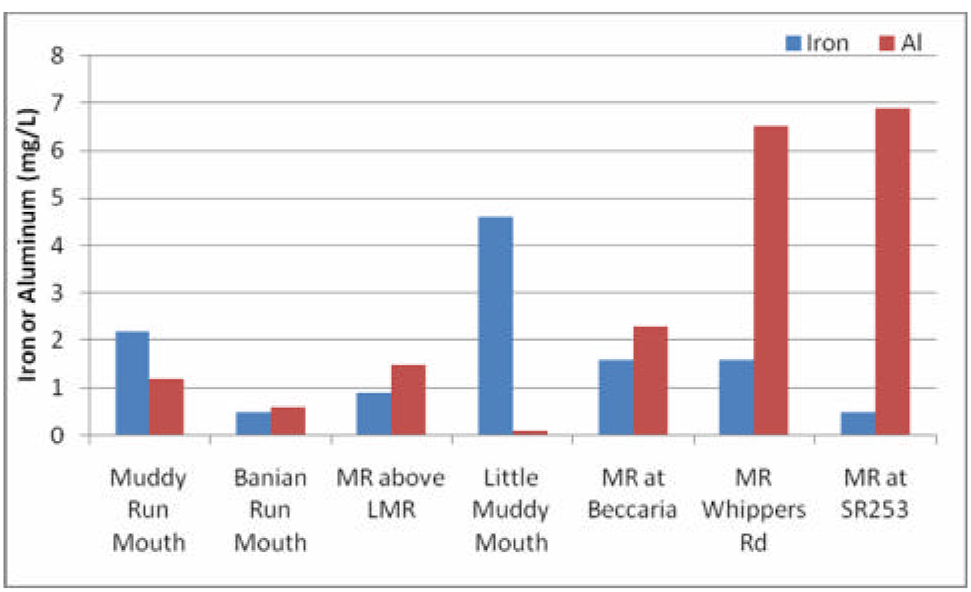
The graphs below represent stream water quality throughout the watershed which was collected on a quarterly basis. The mouth of Muddy Run is almost neutral pH as are the mouths of Little Muddy Run and Banian Run. The upper reaches of Muddy Run are degraded and showing pH’s around 4.0. It is evident from the data that Little Muddy Run acts to neutralize and increase the pH of the main stem as is seen in at Muddy Run below Little Muddy Run (MRQ-20).



The graph below represents acidity and alkalinity concentrations of stream water throughout the watershed. The upper reaches of the watershed are acidic in nature with 60 to 70 mg/L of acidity. This headwaters reach shows the impact of past mining practices and the importance of implementing restoration projects to restore the fishery potential in this area. In the lower reaches of the watershed, Little Muddy Run has entered and improved the water quality to alkaline levels ranging from 40 to 60 mg/L.



The graph below represents iron and aluminum concentrations of stream water throughout the watershed. The upper reaches of the watershed have average aluminum concentrations of 6 to 7 mg/L, while the lower reaches are typically less than 2 mg/L. The average stream iron concentrations throughout the watershed are less than 2 mg/L, with the exception of the mouth of Little Muddy Run. The average iron concentration here is 4.5 mg/L on average and is being affected by the Brookwood mines. These metal concentrations are not severe in the main stem and are encouraging that Muddy Run itself can be restored through treatment of the most significant discharges in the watershed. During sampling, it was observed that aluminum and iron sediments are covering the bottom of the stream and diminishing aquatic habitat. Treatment will help rectify this issue, along with completing habitat projects.



Macroinvertebrate Data

An aquatic macroinvertebrate investigation of Muddy Run and four of its tributaries was conducted on May 14 and 15, 2009, to determine baseline aquatic conditions prior to implementation of the restoration projects within the watershed. The following is taken from and summarizes the results in that report. To view the full report, see Appendix E.

The kick samples conform to the Pennsylvania Department of Environmental Protection Agency (PA DEP) standards for determining the index of biological integrity (IBI) for benthic macroinvertebrate communities in wadeable freestone Pennsylvania streams (Chalfont 2007). This index measures the ability of the stream to support and maintain balanced species diversity, taxa richness, and functional organization comparable to natural non-polluted streams in that region. The highest possible score for the IBI is 100, the higher the score the better the water quality, macroinvertebrate species diversity and taxa richness. A score of 80.0 to 63.0 indicates declining but still functional water quality conditions. A score below 63.0 indicates severely degraded water quality.

Habitat analysis was also conducted at each sampling site using standard protocol. The substrate varied from few boulders, cobblestones, to sand and gravel. In most of the sites silt has been deposited among the substrate leaving few rock edges exposed to the current. This limits the habitat for macroinvertebrates. All collection locations had riparian vegetation consisting of trees and shrubs.

Kick samples were taken from 10 sites with only 4 sites yielding organisms which represented 18 different genera. Chironomidae were keyed to family level with more than one genera present. The site on Little Muddy Run below Janesville Dam (LMR-JD) had the highest taxa count of 90, while Little Muddy Run at Boy Scout Camp (LMR-BS) had the fewest of 15. Low diversity and low IBI scores indicate degraded water quality conditions at all four sampling sites. Poor habitat also contributed to the relatively low total numbers of organisms. Due to the low number of individuals, all individuals were used for this report. Additional sites at MRQ-10, MRQ-20, Banian Run (BRQ-H), Muddy Run at Kitko’s (MR-KIT), MRQ-30, and a tributary at Utahville (TRIB-UT) were investigated but no aquatic organisms were found. A map of the study sites can be found on A-17.

The limited taxa richness, low total number of organisms, and low IBI scores at all stations on Muddy Run confirm the impaired status of these stream segments. Conditions were improved in Little Muddy Run and the upper part of this tributary is fully capable of supporting fish. Curtis Run and both Little Muddy Run sites had IBI scores that fall into the cold water fishery category. Severely degraded water quality conditions prevailed in the acidic, iron precipitate covered section Muddy Run at SR253 (MRQ-50) where the macroinvertebrate fauna was extremely reduced in taxa richness and numbers of organisms.

	Modified Becks	EPT Taxa Richness	Total Taxa Richness	Shannon Diversity Index	Hilsenhoff Biotic Index	Percent Intolerant Individuals	IBI Score
LMR-BS	0.49	0.61	0.26	0.57931	0.912409	0.858378	**61.83**
MRQ-50	0	0	0.03	0	0.49	0	**8.67**
Curtis Run	0.95	0.91	0.11	0.16	1	1	**68.83**
LMR-JD	1	1	0.26	0.36	0.88	0.84	**72.33**

AMD Treatment Methods:

Through the years, many treatments have been developed for AMD remediation. Currently there are a number of organized efforts in Pennsylvania using both active and passive treatment methods on a watershed scale. Active treatment methods incorporate the use of mechanized procedures for the addition of alkaline materials and require constant monitoring and maintenance. Basic chemicals are used as additives to increase the pH and cause the precipitation of metals, such as Fe, Mn, and Al. The chemicals commonly used are $Ca(OH)_2$ (hydrated lime), NaOH (caustic soda), NH_3 (ammonia), CaO (pebble quicklime) and Na_2CO_3 (soda ash) (Robb and Robinson, 1995). The chemicals used on a particular site depend on mine drainage characteristics and site accessibility. Hydrated lime is commonly used, but is hydrophobic and requires mixing. Pebble quicklime (CaO) is utilized at sites where it is usually dissolved by a water wheel arrangement. Soda ash, in the form of briquettes, is used in remote areas with low flows and low acidity. Caustic soda is also used in remote areas with low flows. Liquid caustic soda is capable of treating high acidity and high Mn because it raises the pH quickly, but it is expensive and dangerous to handle. Another potentially dangerous chemical used less frequently is ammonia. It must be handled carefully and is stored as a liquid. Ammonia can raise the pH above 9.2, but may have direct negative impacts on the biota of the receiving streams (Skousen and Ziemkiewicz, 1995).

Other active treatment methods include dissolved air flotation and ion exchange devices, flocculants, coagulants, and oxidants (Skousen and Ziemkiewicz, 1995). Active methods are successful, but expensive. It is not uncommon for water treatment costs to exceed $200,000 per year at AMD sites using active treatment. Another concern is the large volume of sludge produced from the rapid precipitation of metals. Disposal costs for the sludge add to the cost of chemical treatment. Active methods may also cause environmental damage because potentially harmful chemicals are used. The high cost and possible side effects of active treatment can be avoided by the use of passive treatment systems.

Passive treatment systems, which require only limited maintenance, are the alternative approach to active treatment methods. They require no input of manufactured chemicals and have a lower operation and maintenance cost. A downside is that they do require longer retention times and larger treatment areas (Hedin et al., 1994). Page D-1 shows the evolution of passive treatment technology since the early 1980s. Passive treatment systems were first designed after it was observed that natural wetland systems in the path of AMD had some positive effects. The first passive systems described were natural *Sphagnum* wetlands that were improving AMD as discharges flowed through them. The first constructed wetlands were small and planted with cattails (*Typha latifolia)*. They were designed to encourage oxidation processes to precipitate unwanted metals (Robb and Robinson, 1995). Constructed wetlands function by precipitating metal hydroxides, forming metal sulfides, and adsorbing small amounts of metals to the plant community (Skousen and Ziemkiewicz, 1995).

WETLANDS

Two types of constructed wetlands are aerobic and anaerobic. Aerobic wetland systems are designed to encourage metal precipitation through oxidation processes and are therefore normally shallow, vegetated, and have surface flow predominating (Robb and Robinson, 1995). Anaerobic wetland systems require that the mine water flow through or interact with an organic layer under anaerobic conditions. The organic material most commonly used is spent mushroom compost. This organic material must contain sulfate-reducing bacteria for metal sulfide precipitates to form (Robb and Robinson, 1995).

Both vegetation and bacteria are vital to wetland treatment success. Wetland plant species have many roles in mine drainage treatment. They include substrate consolidation, metal accumulation, stimulation of microbial activity and improving the aesthetics of the site. Constructed wetlands can also provide valuable wildlife habitat, for animals such as reptiles and amphibians. Plants may also serve as a food source. Sulfate reducing bacteria, such as *Desulfovibrio* and *Desulfotomaculum,* play a major role by increasing the pH and encouraging metal precipitation. It has been shown that *Desulfovibrio* are most effective at a pH > 4.5 so an important aspect of anaerobic wetland treatment is maintaining the pH within the organic layer (Nawrot and Klimstra, 1990). Sulfate reducers exist in the absence of oxygen and are only found in the deeper parts of the organic layer where they are able to perform their function of sulfate reduction and alkalinity production. Treatment efficiencies of these microbial dependent wetlands show trends of seasonal variation. The decrease in treatment efficiency may be due to biological functions slowing with decreasing temperatures (Kepler, 1990).

These bacteria utilize the organic substrate as a carbon source and use sulfate as an electron acceptor in the following reactions:

$SO_4^{2-} + 2\ CH_2CHOHCOO^- + 4\ H^+ \rightarrow H_2S + 2\ CH_3COOH + 2\ H_2CO_3$ (1)

$SO_4^{2-} + CH_3OO^- + 3\ H^+ \rightarrow H_2S + 2\ H_2CO_3$ (2)

$SO_4^{2-} + 2\ CH_3CHOHCOO^- + 3\ H^+ \rightarrow 3H_2S + 6\ H_2CO_3$ (3)

Sulfate reducing bacteria cannot break down complex organic substrates so they rely mainly on fermenting bacteria to provide substrates like acetate and lactate from larger organic molecules (Cork and Cusanovich, 1979). Plants aid in maintaining these bacterial communities by providing attachment sites and a continual supply of organic matter (Skousen and Ziemkiewicz, 1995).

ANOXIC LIMESTONE DRAINS

Another type of passive treatment technology is an anoxic limestone drain (ALD). The Tennessee Division of Water Pollution Control in 1988 first built prototype ALDs. At the same time, the Tennessee Valley Authority (TVA) personnel found that AMD from a coal refuse dam was being neutralized by calcium carbonate (limestone) in an old road buried beneath the dam (Brodie et al., 1993). In an ALD, alkalinity is produced when AMD contacts limestone in an anoxic environment producing bicarbonate alkalinity. ALDs consist of a shallow limestone filled trench, sealed from the atmosphere, through which the AMD is channeled. Limestone with greater than 90% $CaCO_3$ is used to produce the greatest amount of alkalinity (Brodie et al., 1993). The limestone layer is often covered with plastic or geotextile fabric. Clay soil is then placed over the plastic or fabric followed by a covering of a heavy soil, then vegetated. The amount of limestone used is determined by the flow and loading of the AMD and desired longevity for the system. Usually, extra limestone is employed to ensure a comfortable safety factor for longevity. An oxidation basin immediately after the ALD allows for precipitation of the metals (Brodie et al., 1993).

Three other criteria are followed when constructing ALDs. The first is to keep out any organic matter that may allow microorganisms to grow and coat the limestone. The second is that larger limestone (1"-6") should be used to maintain flow in case plugging occurs due to metal precipitation. Finally, oxygen should be kept out of the drain to deter metal precipitates from forming (Skousen and Ziemkiewicz, 1995). ALDs have been found to raise pH and introduce as much as 300 mg/l of bicarbonate alkalinity as shown by the following equations:

$CaCO_3\ (s) + 2\ H^+ \leftrightarrow Ca^{2+} + H_2CO_3^-$ (4)

$CaCO_3\ (s) + H_2CO_3^- \leftrightarrow Ca^{2+} + 2\ HCO_3^-$ (5)

$CaCO_3\ (s) + H_2O \leftrightarrow Ca^{2+} + HCO_3^- + OH^-$ (6)

The rate of calcium dissolution is dependent on carbon dioxide partial pressure. Generally, the rate of calcium dissolution will increase as the partial pressure increases (Plummer et al., 1979). Also, the amount of alkalinity in the effluent increases with increasing influent CO_2.

As the water leaves the ALD and is exposed to oxygen, the increased pH promotes metal precipitation and the bicarbonate alkalinity neutralizes the acidity produced by metal hydrolysis (Hedin and Watzlaf, 1994). Dissolved oxygen (DO) concentration is a limiting factor in the utility of ALDs. A DO level of less than 1.0 mg/l is recommended to ensure that Fe^{3+} will not precipitate, coating the limestone or clogging the system (Kepler and McCleary, 1994). Al^{3+}, however, can precipitate at a pH > 4.5 in the absence of oxygen, therefore clogging the system even in the absence of oxygen (Kepler and McCleary, 1994). ALDs are often used in combination with anaerobic constructed wetlands and vertical flow wetlands, which are also called successive alkalinity producing systems (SAPS) in the literature.

VERTICAL FLOW WETLANDS

Vertical flow wetlands are being used on mine sites for the treatment of acidic AMD (page D-2 and D-3). It is a newer technology that has shown great success. Vertical flow wetlands combine ALDs and anaerobic wetlands into one integrated system. Vertical flow is promoted through rich organic wetland substrates followed by a limestone bed (Kepler and McCleary, 1994). Most systems are constructed as ponds lined with 65-85 cm of limestone on which approximately 25 to 65 cm of spent mushroom compost is spread. To maintain reducing conditions within the organic layer, at least 85 cm of compost is recommended (Demchak, et al. 2001). On top of the compost layer is freestanding water with a depth of 40-255 cm (Skousen and Ziemkiewicz, 1995). Perforated pipes under the limestone layer collect the flow. Various piping patterns are used from a minimal approach where only 2-3 pipes are placed lengthwise through the system, to a maximal approach where piping is placed in a grid-like pattern on 5' or 10' centers. Demchak et al. (2001) recommends the use of increased piping to insure preferential flow does not occur.

Vertical flow wetlands add alkalinity both through bacterial sulfate reduction and limestone dissolution. Bacterial-mediated sulfate reduction occurs in the organic layer. Bacteria oxidize organic compounds using sulfate and release hydrogen sulfide and bicarbonate. The sulfate reduction directly affects concentrations of dissolved metals by raising alkalinity and providing the conditions necessary for precipitating them as metal sulfides (Skousen and Ziemkiewicz, 1995). Metals precipitating in the system may decrease the lifespan. Flushing the wetlands may be a solution to increasing the treatment success and may aid in the prevention of clogging. Acidic conditions may also be created from reactions involving H_2S, including $H_2S \rightarrow H^+ + HS^-$ and $Fe^{2+} + HS^- \rightarrow FeS + H^+$. When the mine water enters the organic layer containing dissolved Fe^{3+}, dissolved O_2, or precipitated Fe and Mn oxides, the H_2S is oxidized and mineral acidity is affected

(Hedin et al., 1994). As the H_2S levels increase, the acidity decreases raising pH levels. The amount of H_2S produced can be qualitatively detected by both the odor of the gas and the rich black color of the organic layer which can be an indicator of successful treatment within the wetland (Nawrot and Klimstra, 1990).

Another source of bicarbonate in vertical flow wetlands is attributed to dissolution of the limestone, $CaCO_3 + H^+ \rightarrow Ca^{2+} + HCO_3^-$. The dissolution rate and concomitant alkalinity generation are greatly affected by the partial pressure of CO_2. Anaerobic mine water increases CO_2 partial pressures due to decomposing organic matter and precipitation of metal sulfides. The dissolved CO_2 is a weak diprotic acid and continues to react with limestone, producing more Ca^{2+} and HCO_3^-. When highly acidic water contacts limestone, the first reaction is neutralization of proton acidity. The reaction increases pH and decreases metal solubility. As pH rises above 4.5, bicarbonate accumulates, further decreasing the solubility of metals (Hedin et al., 1994a). It has been stated that limestone dissolution requires a 12-hour contact time for maximum alkalinity production (Kepler and McCleary, 1994),but in general these systems should be designed based on a maximum acidity load of 35 g/m^2d (Rose, 2004, 2010). In vertical flow wetlands, through a combination of bacterial mediated sulfate reduction and limestone dissolution, alkalinity is produced. The increased pH results in the precipitation of metals when the discharged water is exposed to oxygen.

LIMESTONE PONDS, FLUSHED LIMESTONE BEDS

Passive treatment technology is undergoing rapid development because of the importance of developing remediation methods for AMD at a low cost. Other systems are being studied to determine if they can be successfully used as cost-efficient systems, either alone or in combination with other systems. One such system is a limestone pond. The pond is constructed on an upwelling of an AMD seep or underground discharge point. Limestone is placed on the bottom of the pond and water flows up through it. They are normally constructed with 1-3 m of water, 0.3-1.0 m of limestone, and have a retention time of 1-2 days. The drainage requires a low DO, and should contain minimal Fe^{3+} and Al^{3+}, so clogging does not occur (Skousen and Ziemkiewicz, 1995). If higher concentrations of metals are present, a flushing system can be added.

Recently, it has been shown that AMD with high Fe and/or Al can be partially treated with a flushed limestone pond or bed (Hedin Environmental, 2009). The flushing can remove 50% or more of the accumulated Fe and Al precipitate. Eventually the limestone bed must be cleaned by agitating, stirring and washing it, but this can be done at low cost. Typically such a flushed bed would be followed by a settling pond, and then by some other type of treatment system, such as a vertical flow wetland.

OPEN LIMESTONE CHANNELS, LIMESTONE SAND

Another technique involves the use of open limestone channels. They add alkalinity to acidic water in open channels or ditches lined with limestone. The channel should contain a slope greater than 20% to maintain flow velocities that keep precipitates in suspension (Skousen and Ziemkiewicz, 1995).

Direct addition of limestone sand to streams is another technique being used. The sand is placed in the headwaters of a stream and during high flows the sand moves downstream and mixes with natural sediments. No harmful effects have been seen. An increase in pH and calcium levels has been observed along with a decrease in toxic aluminum species. A careful selection of particle size, purity and mass of the limestone is important for treatment success (Downey et al., 1994).

DIVERSION WELLS

Diversion wells have been used in Scandinavia to treat small acidic streams since the late 1970's (Sverdrup, 1983). The first full-sized wells were implemented in Sweden in 1980 and were first used in Lebanon County, Pennsylvania in 1986. Diversion wells are constructed from a cylinder or vertical tank made of either concrete or metal. They are 1.5-1.8 m in diameter, 2.0-2.5 m deep and filled with limestone. They contain a large pipe that extends vertically down the center of the well. Water is fed from the stream into the pipe that exits near the bottom through a nozzle. Water then flows up through the limestone, fluidizing it. Grinding and dissolution of the limestone occurs creating alkalinity. Due to the high pressure created within the wells, floc is removed at a consistent rate, so limestone coating is not a concern. Diversion wells are not entirely passive in that limestone must be added on a monthly basis and sometimes even daily. They work best where metal concentrations are low since there are no settling ponds employed.

BIOREMEDIATION

Bioremediation is another passive treatment technique being used. Seeded microbes are used to convert metals to their less harmful species. Metal oxidation and precipitation are promoted through hydroxide formation, as is metal reduction and precipitation through sulfide formation. One example is the use of metal oxidizing beds for the treatment of both Mn and Fe (Skousen and Ziemkiewicz, 1995). Mn is difficult to remove because of the high pH required to precipitate it (> 9.0) and competition with Fe precipitation when Fe is present in high concentration. These beds have been in use for approximately 10 years, with the first being constructed in Pennsylvania in 1994.

Treatment, Operation, and Maintenance

Operation and Maintenance

Through discussions with the various project partners, CCWA and the local conservation districts, long term maintenance of the constructed treatment systems will be conducted through a coordinated effort. The partners are willing to do the field work associated with maintenance of the treatment cells. An operation and maintenance plan should be developed for each treatment project as it enters final design.

Wetlands require minimal maintenance. Visual inspections are necessary to insure muskrats and beavers are not impacting inlet/outlet structures or destroying vegetation. Vertical flow wetlands require regular flushing to insure plugging does not occur, but automatic flushing systems using solar power are fairly common. This flushing frequency will vary depending on the size of the system and metal loading entering the system. The flushing is similar on limestone ponds. The primary maintenance issue is with solids removal in the settling ponds. The purpose of the settling pond is to collect precipitated metals. These solids accumulate over time and will eventually need to be removed. Ponds are typically designed to operate for 10 years or more before needing to be cleaned out.

If active treatment is chosen to treat the more severe discharges, increased O&M will be necessary. The active system recommended is Swedish Lime Dosers which require no electricity, but do need silo bins filled which requires coordination for delivery. These dosers would be placed directly on the mine discharge and would include settling basins to protect the habitat within the stream channels.

Prioritization of Treatment Areas

The prioritization of treatment areas was based on a variety of criteria including loading rates for acidity and iron, location, stream-mile restoration, area available for treatment and cost effectiveness. Treatment areas are located throughout the watershed on property owned by individual landowners. Permission will need to be obtained when submitting grants in order to complete the design/permitting phase, along with construction of the projects. All landowners were contacted before the assessment began for permission to install flow devices on their property and conduct monthly sampling. Most landowners in the watershed are cooperative with the CCWA and its efforts to restore Muddy Run.

Twenty four treatment systems are being recommended for construction to improve water quality in the watershed and allow for repopulation of trout throughout the watershed. We will, however, address quality of each sample location and give a brief justification for our decision to treat or not treat each location.

Each priority area and its conceptual treatment design are presented below. All are conceptual designs and will most likely change during the design and permitting phase of each individual project as more information is gathered. Cost estimates are also given for each project. The cost estimates were obtained using current component pricing using the computer program AMDtreat of the US Office of Surface Mining.

The water quality throughout the watershed is varied and will need varying technologies to treat, ranging from passive to active systems. Due to the size of the assessment area and the varying water quality, the stream has been divided into two "AREAS" of treatment, along with "SUB-AREAS", rather than strict prioritization. Certain sites within the watershed are being influenced by abandoned mine lands, so some of the projects will include a reclamation component in conjunction with treatment systems for the discharges themselves.

Appendix C contains tables of "rankings". Due to the size of the watershed and the need for reclamation, prioritization was difficult. It was determined that breaking the watershed into areas and prioritizing from the headwaters of those sections downstream was the most logical and that is what is presented in this restoration plan. The ranking tables in Appendix C, also show priorities based on both acid and iron loads and are ranked strictly from highest to lowest. This is another approach that may be taken in implementing the restoration plan. By starting with the highest acid load, the largest removal of acid on a lbs/day basis would be obtained, however direct restoration of stream miles may not be achieved. This approach would be recommended if the goal would be to remove acid loadings from both the overall Muddy Run Watershed and subsequently the West Branch of the Susquehanna.

Many of the discharges are associated with abandoned highwalls and/or spoil piles and that is where restoration efforts should begin. Through restoration efforts a decrease in flow rates and increase in water quality should be seen which would decrease the number of treatment systems necessary to restore the watershed. Many sites may also combined for treatment after future investigation occurs and the feasibility of combining their flow is determined. Therefore, the 24 treatment system recommendations made below, may be altered upon further investigation at each individual site or area.

The restoration plan makes recommendations of each treatment area based on restoration of stream miles and restoring a fishery to this watershed. The conceptual designs presented below can be easily adjusted as deemed necessary to insure successful implementation of this plan an eventual restoration of Muddy Run Watershed.

Area #1: Lower Muddy and Little Muddy Runs

Priority #1-1: EU-01

Site Description:

At this site, a large flow of severe acid mine drainage, the top acid load producer in the watershed, emerges from a shaft and flows across a cattail wetland a few hundred yards to Muddy Run. The flow is from the Eureka-29 underground mine on the Lower Kittanning coal. This mine with the connecting Eureka 28 and Viola 1 mines, underlies an area of about 3-4 square miles in the area up-dip to the east. In addition, flow from surface mines near the junction of PA 453 and PA 253 was captured and diverted down wells into the Eureka mine by PA BAMR in order to improve water in the Janesville dam. Considerable mine refuse is present in the vicinity of the outflow.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	1011	3.5	1120	0.0	0.0	95.4	1156.5	11.4	135.6	9.8	7.6	510.5
Min	695	3.4	1030	0.0	0.0	87.0	741.7	9.4	88.3	8.3	5.8	493.0
Max	1407	3.6	1270	0.0	0.0	116.0	1620.0	13.9	175.5	11.4	8.7	532.0
90% CI	1139	3.5	1158	0.0	0.0	99.1	1308.0	12.1	148.9	10.3	8.0	517.4
75% CI	1101	3.5	1146	0.0	0.0	98.0	1262.4	11.9	144.9	10.1	7.9	515.3
StdDev	270	0.1	79	0.0	0.0	7.8	319.0	1.5	28.1	0.9	0.9	14.5

Recommendations:

The design chemistry for this site is a flow rate of 1150 gpm, pH of 3.5, acidity of 100 mg/L, Fe of 12 mg/l, Al of 8 mg/L and Mn of 10 mg/L.

The Eureka 29 discharge was studied extensively in an investigation of sites that might provide additional water to the Susquehanna during low flow periods (GAI Consultants, 2007). The following is taken from this report.

The Eureka 29 discharge flows from a shaft on the south side of Muddy Run about 1.5 miles upstream from Beccaria. The shaft is the outflow of the Eureka 29 mine underlying about 1571 acres to the northeast of the outflow. In addition, the Viola No. 1 mine underlies 469 acres to the southeast of the Eureka 29, and is connected to it. The mines extracted the Lower Kittanning (B) coal. The mine pool underlies about 953 acres containing about 413 M-gal of water, plus an unsaturated area of 1032 acres. An additional major inflow enters the mines from a dewatering system along the north side of Little Muddy Run. Attempts to balance the flow into the system suggest that about 1000 gal/min of water with about 200 mg/L acidity enters the mines from this source. The 200 mg/L acidity estimate is derived from a sample collected from a manhole into the dewatering system on 4/20/07.

Data on the chemistry and flow of the Eureka 29 discharge are available from 2006 sampling (GAI Consultants, 2007) plus the current study, plus sparse prior samples. For the 2006 study, the average flow of 1027 gal/min (1.48 M-gal/day) has pH 3.43, acidity 86 mg/L $CaCO_3$, 13.5 mg/L Fe, 6.7 mg/L Al, 8.9 mg/L Mn and 511 mg/L SO_4. Acidity load is 1063 lbs/day. The 2006 samples show ferrous Fe essentially equal to total Fe, indicating essentially all ferrous Fe. Averages are 91 mg/L Ca, 55 mg/L Mg and 11 mg/L suspended sediment.

The GAI report suggests that a treatment plant might be located just upstream from the discharge, near the Township Road. Calculations show that the mine could be pumped at 2.8 M-gal/min for 4 months, followed by 8 months of recovery at 0.9 M-gal/min (63% of the natural discharge rate). Under these conditions, nearly all the pool would be removed to the pump elevation of 1320 ft at maximum drawdown. The 120-day withdrawal rate is limited by the size of the mine pool rather than by the recharge rate.

The acidity calculations show a high rate of acidity generation per unit area and a large increase in acidity during drawdown, from 86 to 112 mg/L. The calculations are clearly only approximations because of the uncertainty in the dewatering inflow. Additional data are required to obtain a correct appraisal of drawdown effects at this discharge. The Eureka mine was not selected as a priority site because of the increased acidity and limited amount of low flow water it could furnish, though it remains of interest for this purpose.

The flow and chemistry on Muddy Run were sampled in 2006 at a weir upstream from the Eureka 29. Flow data are limited because one weir was stolen, and another was washed out. Based on sampling for 5 dates between 10/3/06 and 12/19/06, the average flow of Muddy Run is 2741 gal/min. An additional 5 flows in 2007 lead to an average of 3750 gal/min to 3/12/07. The stream chemistry is very contaminated, with an average for 13 samples of field pH 5.58, acidity 31 mg/L $CaCO_3$, alkalinity 11 mg/L $CaCO_3$, Fe 0.54 mg/L, Al 3.8 mg/L, Mn 7.7 mg/L, SO_4 291 mg/L and suspended sediment 12 mg/L. The stream is commonly grey from suspended Al precipitate.

The acidity load of the stream at CR101 is 1032 lbs/day, which is substantial, and similar to the 1063 lbs/day acid load from the Eureka 29 discharge. Removal of the Eureka load would decrease the downstream load to about 50% of its current value. If the treatment plant discharge had a significant net alkalinity, the stream would be further improved. However, it would remain net acid with considerable suspended Al precipitate, similar to the upstream character. The removal of the Eureka 29 load of acidity, Fe and Al would also decrease loadings into Clearfield Creek. Treatment of the Eureka 29 discharge would be a major and necessary step in recovery of Muddy Run. Several additional inflows would require treatment for complete recovery.

As an alternative to the above active treatment, the mixing of EU-01 water with alkaline water from the nearby MUC-9R discharge is attractive. The MUC-9R discharge is only about 1200 ft from EU-01, and appears to be slightly higher, though this feature requires surveying of relative elevations. The average acidity load from the MUC-9R discharge is **negative** 1215 lbs/day (i.e., strongly alkaline), and on average would approximately balance the acidity load of EU-01. The MUC-9R water could be flowed to the EU-01 shaft in either a surface ditch or a buried pipeline and mixed with the EU-01 water. A settling pond would capture the resulting Fe and Al precipitate. Possibly during some seasons the flow from MUC-9R would be low, and the balance could not be completely achieved this way. Further study of this aspect is needed.

The cost of this alternative, as estimated by AMDTreat, is approximately $90,000, based on a 1200 ft ditch lined with 0.2 ft of limestone to add a little more alkalinity ($11,670), and a 24-hour settling pond with dimensions of 350 x 180 ft ($48,600), plus $30,000 engineering. This treatment approach would be very cost-efficient in removing acidity ($20/ton of acid removed). Some additional cost might be needed to treat periods with large flow from EU-01 and low flows from MUC-9R

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the EU-01 discharge is designed to remove 1063 lbs/day of acidity, 147 lbs/day of iron and 98 lbs/day of aluminum. This treatment is expected to decrease the acidity load to downstream Muddy Run by about 50%, with larger decreases in Fe and Al load.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #1-2: A1-01

Site Description:

This discharge is located just north of an electrical substation on the east side of PA 453 about ½ mile south of Madera. The water apparently flows from the abandoned Banion #1 underground mine on the Clarion-

Brookville coal under the hill to the east. Small amounts of coal refuse and spoil are evident up the slope from the weir site, near where the water emerges. Appreciable Fe is precipitating from the water along the small stream. The flow crosses the highway and into Muddy Run about 300 feet below the highway.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	415	5.7	1177	27.5	145.3	124.9	606.1	64.9	320.4	7.5	1.8	594.0
Min	293	5.6	1090	16.0	119.5	114.0	404.0	60.8	225.6	6.5	1.1	549.0
Max	477	5.9	1270	34.0	188.8	152.0	783.6	70.7	383.8	8.8	2.4	649.0
90% CI	454	5.8	1206	30.4	158.5	130.6	671.4	66.5	347.5	7.9	2.0	609.3
75% CI	442	5.8	1197	29.6	154.5	128.9	651.7	66.0	339.3	7.8	1.9	604.7
StdDev	71	0.1	58	5.9	24.1	11.4	119.0	3.1	49.4	0.7	0.4	30.8

Recommendations:

The discharge emanates from an underground mine area channelizing through spoil material. Investigation into the size of the mine and potential sealing or remining is recommended. The design chemistry of this discharge is 450 gpm with a pH of 5.8, acidity of 130 mg/L, alkalinity of 30 mg/L, iron of 66 mg/L, aluminum of 2 mg/L and manganese of 8 mg/L This discharge will be difficult to treat passively due to the high flow rate producing high metal loads. Since the discharge emanates from an abandoned mine area, the first phase of this project would be site reclamation or potential remining efforts. Surveying needs to be completed at this site to determine the extent of reclamation needed or the potential of coal remaining to make it economically feasible to remine. Through reclamation efforts, the discharge should decrease in quantity and increase in quality.

Passive treatment was investigated to be used at this site, however, it was deemed not feasible to treat this discharge passively. If aerobic wetlands were to be used, 18 acres are needed. If a bioreactor was used, it would cost approximately $1.2 million dollars. The best option would be to treat this discharge chemically to maintain pH levels and precipitate the high load iron loads of 356 lbs/day. Swedish lime dosers could be used with pebble quicklime followed by settling basins to protect habitat within Muddy Run. Approximately 130 tons/yr of pebble quicklime would be needed.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the A1-01 discharge is designed to remove 630 lbs/day of acidity, 320 lbs/day of iron and 9 lbs/day of aluminum.

Other:

A final O&M plan will be developed after reclamation and construction is complete. If active treatment is deemed necessary, yearly chemical costs will be necessary along with coordination activities for delivery and system checks. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #1-3: BW01

Site Description:

This site is the discharge of the Brookwood Shaft, which drains the abandoned Brookwood underground mine on the Lower Kittanning coal. The mine has an area of about 3 square miles up dip to the east, and connects to a series of surface mines on the outcrop of the coal in the Moshannon Creek drainage. The water emerges into the bottom of a pond about 1000 feet long and 100 ft wide. The pond is reddish in places and gray in others, indicating the precipitation of Fe and Al. Mine spoil surrounds the pond. A small stream heading near Ramey and receiving the alkaline BW-02 discharge flows near the north side of the pond near its outlet. The BW-01 water joins this flow and enters a large wetland, then flows under a bridge in an abandoned railroad grade and into Little Muddy Run.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average		6.0	2117	87.7		5.2		31.8		9.3	0.7	1267.2
Min		5.8	1480	73.0		-48.0		18.3		5.3	0.4	754.0
Max		6.2	2590	104.0		39.0		40.9		12.6	1.4	1577.0
90% CI		6.1	2296	91.7		17.4		35.8		10.6	0.9	1408.8
75% CI		6.1	2242	90.5		13.8		34.6		10.2	0.8	1366.2
StdDev		0.1	392	8.7		26.8		8.8		2.7	0.3	310.4

Recommendations:

An accurate set of flow values could not be collected from this discharge because of repeated beaver damming about 25 ft downstream from the weir, very little stream gradient, and periodic flow of the stream from Ramey and BW-02 into the pond. One good measuurement of 870 gpm was measured on 10/20/09 by a flowmeter . Four valid measurements were obtained in the 2006 SRBC study: 4041, 2784, 2550, and 1686 gpm during April thru July 2006. The average of the 5 flows is 2386 gpm. Based on these 5 flows the average is taken as 2000 gpm. Most flows were measured during the spring high-flow period, skewing the average. Attempts to measure accurate flows are underway and are necessary to design an appropriate treatment system.

Given an average flow of 2000 gpm and an average acidity of 5 mg/l, the acid load is 120 lbs/day. The Fe load is 800 lbs/day, and the Al load is 17 lbs/day.

An efficient treatment for the BW-01 discharge is possible using mixing with nearby alkaline water, as for the EU-01 discharge. At site BW-03, about 400 ft in a straight line from BW-01, alkaline water with negative acidity load of 508 lbs/day emerges at 320 gpm from an abandoned underground mine exposed in a strip cut on the Upper Freeport coal. This negative acidity load exceeds the acidity of the BW-01 discharge, and could be used to neutralize it and cause the Fe to precipitate in the BW-01 pond. The elevation of BW-03 is several tens of feet higher than BW-01.

Transporting the BW-03 water to the BW-01 pond could be done with a drillhole or a cut through the spoil separating the discharges, or by a considerably longer channel along the topography. A cut through the spoil is probably simplest. An approximate cost, assuming a 200 ft cut through spoil, 20 ft deep, with riprapped bottom, is $100,000, including $30,000 for engineering. If the pond averages 8 ft deep, 1000 ft long and 100 ft wide, the retention time for the combined flow is 40 hours, so this pond seems adequate in size for settling. A baffle might improve settling. A natural wetland currently exists between the pond and Little Muddy Run.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the BW-01 discharge is designed to remove 120 lbs/day of acidity, 800 lbs/day of iron and 17 lbs/day of aluminum. The BW-01 discharge is the largest acid-producer entering Little Muddy Run. This treatment, in combination with treatment of BW-02, should lead to recovery of all of the contaminated 0.75 mile of Little Muddy Run to its junction with Muddy Run at Smoke Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #1-4: BW02

Site Description:

The flow at this site emerges from a shaft which most likely accesses the Lower Freeport coal at a relatively shallow depth. The water flows about 100 feet into a small stream, which flows from Ramey. During drier periods in the summer and fall, the BW-02 flow makes up all of the flow in this small stream.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	930	6.6	723	129.3	1400.6	-102.0	-1108.5	1.0	7.9	0.3	0.1	246.3
Min	263	6.3	659	114.0	432.0	-117.0	-1661.5	0.2	2.6	0.1	0.1	208.0
Max	1351	6.8	773	141.0	2018.7	-85.0	-337.4	2.4	16.6	0.4	0.1	435.0
90% CI	1117	6.7	737	133.6	1657.8	-97.8	-893.1	1.3	10.3	0.3	0.1	275.7
75% CI	1061	6.6	733	132.3	1580.4	-99.0	-957.9	1.2	9.6	0.3	0.1	266.8
StdDev	378	0.1	30	9.1	518.6	8.9	434.2	0.7	4.7	0.1	0.0	61.8

Recommendations:

The design chemistry of this discharge is 1120 gpm with a pH of 6.7, acidity of -98 mg/L, alkalinity of 133 mg/L, iron of 1.3 mg/L, aluminum of 0.1 mg/L and manganese of 0.3 mg/L. An aerobic wetland should be constructed to precipitate the iron load from this discharge and protect the stream channel. Based on the 5 g/m^2/day iron removal rate, a wetland approximately 192 ft by 100 ft should sufficiently treat the discharge.

It would also be possible to divert the stream into the BW-01 pond, and capture the Fe precipitate there. However, this would appreciably decrease the retention time for BW-01.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the BW-02 discharge is designed to remove 15 lbs/day of iron.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed

Priority #1-5: BW03

Site Description:

This flow emerges from an apparent underground working within a strip cut. The strip cut extracted probable Upper Freeport coal. The water flows along the cut and enters Little Muddy Run where minor iron staining can be seen.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	320	6.9	744	158.8	605.0	-132.9	-507.6	0.1	0.3			209.7
Min	144	6.5	586	106.0	293.5	-159.0	-749.0	0.1	0.3			166.0
Max	523	7.2	833	183.0	860.5	-81.0	-245.2	0.3	0.3			272.0
90% CI	394	7.0	783	169.9	722.6	-122.3	-409.5	0.2	0.3			225.1
75% CI	372	7.0	771	166.5	687.2	-125.5	-439.0	0.2	0.3			220.4
StdDev	149	0.2	83	23.2	237.0	22.3	197.8	0.1	0.0			30.9

Recommendations:

See the discussion of BW-01. The strongly alkaline water of this discharge should be mixed into the BW-01 pond to neutralize the BW-01 outflow. A small amount of Fe from the BW-03 water would be captured in the pond.

Priority #1-6: MUC-9R

Site Description:

At this site, water drains from an entry to an underground mine, possibly the Black Oak #5 mine, on the Lower Freeport coal. Within the opening, two diverging passages are evident. The site is within an area of unreclaimed surface mining, and the water flows from the entry toward Muddy Run in a channel through the mine spoil. Considerable trash has been dumped into the area. No information has been found on the size of this mine, though the water flow is considerable. This discharge has been placed in this section because it is only 1000 ft away from EU-01.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	719	6.9	808	179.8	1437.3	-153.8	-1214.4	0.3	2.7	0.0	0.1	228.8
Min	214	6.5	699	142.0	564.5	-198.0	-1805.0	0.1	0.3	0.0	0.1	193.0
Max	1176	7.1	900	221.0	2115.2	-114.0	-508.1	1.9	16.4	0.1	0.2	280.0
90% CI	934	7.0	843	194.4	1762.4	-139.7	-947.7	0.5	5.5	0.1	0.2	241.0
75% CI	869	6.9	833	190.0	1664.6	-143.9	-1028.0	0.5	4.7	0.0	0.2	237.4
StdDev	393	0.2	73	30.7	592.7	29.6	486.5	0.5	5.1	0.0	0.1	25.7

Recommendations:

Further investigation should occur at this site. The Black Oak #5 maps should be located and the potential for mine sealing or remining should be investigated. Since the discharge flows through exposed spoil material near the site, the first phase of this project would be site reclamation. Surveying needs to be completed at this site to determine the extent of reclamation needed. Through reclamation efforts, the discharge should decrease in quantity and increase in quality. Samples will be collected on the spoil material to determine the BTU values, if they are low or if there is not sufficient material to be valuable to a COGEN plant, the area will be regraded with lime addition and soil amendments.

Another possibility is to use this net alkaline water to mix with the net acid water of the nearby EU-01 water. The MUC-9R water has negative 1200 lbs/day acidity, and the EU-01 water is net acid with 1200 lbs/day acidity, so mixing the two waters should approximately lead to near-neutral effluent. See the discussion under EU-01. Careful surveying is needed to establish whether the MUC-9R water can flow to EU-01 by gravity – field evaluation indicates that it can. If necessary, the MUC-9R water might be dammed up a few feet.

This discharge is a low priority due to its alkaline nature and low concentrations of metals. If a system were to be designed here, based on data collected during the development of the restoration plan, it would have a design discharge 900 gpm with a pH of 7, acidity of -139 mg/L, alkalinity of 194 mg/L, iron of 0.5 mg/L, aluminum of 0.2 mg/L and manganese of 0.1 mg/L. Based on the water quality collected during the assessment, an aerobic wetland 160 ft by 85 ft would be needed to precipitate the metals. The wetland will be constructed with a substrate of a 1:1 ratio of organic matter and limestone to maintain the pH as the iron precipitates. Different sizes and depths of wetlands will be established to increase contact time and allow for greater precipitation of the iron. The cost of the constructed wetland with design and permitting would be approximately $150,000.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUC-9R discharge is designed to remove 5 lbs/day of iron and 2 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run. If the water is mixed with EU-01, the combined effect would be much larger, as discussed in EU-01.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Area #2: Headwaters Region of Muddy Run

Area #2A: Upper Reaches of Muddy Run, East Side

Priority #2A-1: MUEC

Site Description:

This discharge is located northwest of Blandburg approximately 100 feet upstream from a private road into the Ryan cabin. This discharge emanates from a large surface mine (0.5 mi^2) east of Blandburg. The Clarion-Brookville and Lower Kittanning coals were surface mined in this area. The discharge channel is the outflow of a pond about an acre in size within the mine spoil. Examination of this pond suggests that much of the flow is derived from a probable caved underground entry on the middle of the southeast side of the pond.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	115	3.2	1441	0.0	0.0	303.8	414.5	7.7	10.3	31.8	32.6	754.1
Min	49	3.1	1160	0.0	0.0	236.0	210.9	5.6	5.1	24.7	21.9	592.0
Max	157	3.4	1600	0.0	0.0	359.0	583.6	10.0	16.2	37.2	42.3	837.0
90% CI	134	3.3	1493	0.0	0.0	321.4	482.9	8.4	11.9	34.0	35.5	790.9
75% CI	128	3.3	1477	0.0	0.0	316.1	462.3	8.2	11.4	33.3	34.7	779.8
StdDev	40	0.1	110	0.0	0.0	36.9	144.0	1.3	3.2	4.5	6.2	77.5

Recommendations:

The discharge emanates from a pond forming a discrete channel. The design chemistry of this discharge is 150 gpm with a pH of 3.3, acidity of 325 mg/L, alkalinity of 0 mg/L, iron of 10 mg/L, aluminum of 36 mg/L and manganese of 35 mg/L. This discharge will be difficult to treat passively due to the high flow rate producing high metal loads. Since the discharge emanates from an abandoned mine area, the first phase of this project would be site reclamation. Surveying needs to be completed at this site to determine the extent of reclamation needed. Through reclamation efforts, the discharge should decrease in quantity and increase in quality. It will be regraded with lime addition and soil amendments. The area has also been used as a garbage dump and reclamation efforts would not only improve the quality of the discharge, but improve the aesthetics of the area.

If passive treatment is to be used at this site, a sacrificial cell (flushed limestone bed) should be placed in the front of the treatment train. The cell should contain 600 tons of limestone in a wedge shaped cell. The cell should be followed by an equalization basin, leading to a VFW with 2900 tons of limestone, followed by a settling basin and another VFW with an additional 2900 tons of limestone and a final settling basin. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging.

Another option for this site may be to use a Bioreactor due to the severity of the metals. A bioreactor consists of 3 ft of a substrate mixture containing organic matter and limestone. It works to remove metals and increase alkalinity through bacterially mediated processes. The systems have shown great promise with severe water quality. The bio-mixture should contain 233 tons of manure, 180 tons of hay, 3800 tons of limestone and 1400 tons of wood chips. It would be approximately 370 ft by 195 ft at the top of freeboard.

A third option may be the need to treat chemically to insure success of treatment. Swedish lime dosers could be used with pebble quicklime. Approximately 64 tons/yr of pebble quicklime would be needed.

A fourth possibility is that the existing pond can be used for some treatment of the AMD entering from the east bank, or that the flushed limestone pond can be installed in the existing pond.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of treating this discharge will vary depending on the area to be reclaimed and the ultimate course of action to be taken.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUEC discharge is designed to remove 525 lbs/day of acidity, 16 lbs/day of iron and 58 lbs/day of aluminum. This will restore water chemistry in about 0.7 mi. of stream MUEC, and considerably improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. . Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2A-2: MUE-6R

Site Description:

This sampling point is a moderate flow entering Muddy Run about 500 feet upstream from a well of the Reade Township Water Authority. The flow is apparently downslope seepage from a strip of reclaimed surface mining on the Clarion-Brookville coal a few hundred feet up the hill to the west.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	131	3.7	833	0.2	0.5	125.2	180.0	0.2	0.3	13.2	12.9	383.0
Min	72	2.9	387	0.0	0.0	46.0	105.6	0.1	0.1	4.3	4.5	155.0
Max	292	4.1	1650	2.0	5.8	230.0	607.1	0.5	0.5	22.7	21.0	747.0
90% CI	167	3.8	992	0.4	1.3	149.5	244.7	0.3	0.3	15.7	15.2	458.3
75% CI	156	3.8	944	0.4	1.0	142.2	225.2	0.3	0.3	15.0	14.5	435.7
StdDev	77	0.3	334	0.6	1.7	51.3	136.1	0.1	0.1	5.4	4.7	158.6

Recommendations:

The discharge creates a large channel from the surface mine above. The design chemistry of this discharge is 175 gpm with a pH of 3.8, acidity of 150 mg/L, alkalinity of 0 mg/L, iron of 0.3 mg/L, aluminum of 16 mg/L and manganese of 16mg/L. There is minimal iron at this site, so a flushed limestone cell can be used to treat the discharge. It will be difficult to treat, however, due to the high flow rates and moderate concentrations of aluminum. The treatment train will consist of a series of limestone cells with flushing devices followed by settling basins. A total of 2400 tons of limestone is needed through the series of cells. The first cell should be a wedge shaped sacrificial cell with 600 tons of limestone, followed by an equalization basin. This basin will be followed by a flushing limestone cell with 1800 tons of limestone, followed by a settling basin.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of constructing the treatment train is $325,000. The design and permitting phase of the project would be at a cost of $50,000. The overall design and construction cost of MUE-6R is $375,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUE-6R discharge is designed to remove 280 lbs/day of acidity, 0.5 lbs/day of iron and 30 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2A-3: MUED-3

Site Description:

This small stream drains from another part of the large area of surface mining east of Blandburg. The stream emerges within the mine spoil and forms the headwaters and main source of stream MUED. It is a short distance upstream from the private road passing by the Ryan cabin. The source area contained the Clarion-Brookville and Lower Kittanning coals.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	45	3.5	943	0.0	0.0	152.4	68.0	0.2	0.1	18.2	16.2	438.3
Min	9	3.5	624	0.0	0.0	91.0	11.1	0.1	0.0	6.2	7.0	233.0
Max	201	3.7	1220	0.0	0.0	212.0	219.3	0.3	0.2	22.6	20.2	550.0
90% CI	72	3.6	1023	0.0	0.0	170.5	98.3	0.2	0.1	20.6	18.2	480.9
75% CI	64	3.6	999	0.0	0.0	165.0	89.2	0.2	0.1	19.9	17.6	468.1
StdDev	57	0.1	167	0.0	0.0	38.0	63.8	0.1	0.1	5.1	4.3	89.7

Recommendations:

Since the discharge emanates from an abandoned mine area with exposed spoil material, the first phase of this project would be site reclamation. Surveying needs to be completed at this site to determine the extent of reclamation needed. Through reclamation efforts, the discharge should decrease in quantity and increase in quality.   It will be regraded with lime addition and soil amendments.

The design chemistry of this discharge is 75 gpm with a pH of 3.6, acidity of 175 mg/L, alkalinity of 0 mg/L, iron of 0.2 mg/L, aluminum of 18 mg/L and manganese of 21 mg/L. There is minimal iron at this site, so limestone cells can be used to treat the discharge. It will be difficult to treat, however, due to the moderate flow rates and moderate concentrations of aluminum. The treatment train will consist of a series of limestone cells with flushing devices followed by settling basins. A total of 2200 tons of limestone is needed through the series of cells. The first cell should be a flushed cell with 600 tons of limestone, followed by an equalization basin. This basin will be followed by a limestone cell with 1600 tons of limestone, followed by a settling basin.

Another option may be to combine this discharge with the potential active treatment at MUEC. During reclamation of the area, investigation will occur to determine the possibilities of combining the flows into one treatment system if topography would allow.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of constructing the passive treatment train is $225,000. The design and permitting phase of the project would be at a cost of $50,000. The overall design and construction cost of MUED-3 is $275,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUED-3 discharge is designed to remove 140 lbs/day of acidity, 0.2 lbs/day of iron and 14 lbs/day of aluminum. This will largely restore water chemistry in 0.5 mi of tributary MUED, and improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2A-4: MUED-1R

Site Description:

This discharge is derived from a several acre seepage area and kill zone located downslope from the Ryan cabin. The source of the seepage appears to be from seepage through the unconsolidated zone from the large surface mined area that also furnishes discharges MUEC and MUED-3.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	17	3.4	1039	0.0	0.0	143.8	28.4	2.0	0.4	24.5	10.5	474.1
Min	2	3.2	831	0.0	0.0	93.0	2.4	1.4	0.1	19.5	3.1	361.0
Max	35	3.6	1220	0.0	0.0	201.0	55.7	3.2	0.7	29.7	19.6	596.0
90% CI	22	3.5	1097	0.0	0.0	161.8	36.9	2.3	0.5	26.2	13.6	509.2
75% CI	20	3.5	1079	0.0	0.0	156.4	34.4	2.2	0.4	25.7	12.7	498.7
StdDev	10	0.1	122	0.0	0.0	38.0	17.9	0.7	0.2	3.5	6.6	74.0

Recommendations:

Since the discharge emanates from an abandoned mine area with exposed spoil material and appears to be related to two other seeps in the area, the first phase of this project would be site reclamation. Surveying needs to be completed at this site to determine the extent of reclamation needed. Through reclamation efforts, the discharge should decrease in quantity and increase in quality. It will be regraded with lime addition and soil amendments.

The design chemistry of this discharge is 25 gpm with a pH of 3.5, acidity of 162 mg/L, alkalinity of 0 mg/L, iron of 3 mg/L, aluminum of 14 mg/L and manganese of 26 mg/L. The treatment train will consist of an equalization basin, followed by a VFW with 600 tons of limestone and a settling basin. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging.

Another option may be to combine this discharge with the potential active treatment at MUEC. During reclamation of the area, investigation will occur to determine the possibilities of combining the flows into one treatment system if topography would allow.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of constructing the passive treatment train is $100,000. The design and permitting phase of the project would be at a cost of $50,000. The overall design and construction cost of MUED-1R is $150,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUED-1R discharge is designed to remove 43 lbs/day of acidity, 0.8 lbs/day of iron and 3.7 lbs/day of aluminum. Along with treatment of MUED-3, this will restore the water chemistry in 0.5 miles of the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2A-5: MUE-5R

Site Description:

This site is located on the west side of Muddy Run about 100 feet upstream from a road crossing Muddy Run in a cleared zone. Currently a gate blocks travel up the valley at this point. The source of this water is probably the same zone of reclaimed surface mining up the hill that supplies the MUE-6R discharge.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	35	4.0	377	1.1	0.6	55.8	20.0	0.7	0.1	5.8	5.4	162.8
Min	4	3.9	221	0.0	0.0	37.0	2.4	0.2	0.0	2.3	2.5	74.0
Max	178	4.2	523	3.0	4.3	74.0	79.0	1.9	0.4	8.5	7.0	274.0
90% CI	65	4.1	420	1.8	1.4	61.3	33.1	1.1	0.2	6.8	6.2	191.6
75% CI	56	4.1	407	1.6	1.2	59.6	29.2	1.0	0.2	6.5	6.0	183.0
StdDev	55	0.1	79	1.2	1.4	10.1	23.8	0.6	0.1	1.7	1.6	52.7

Recommendations:

The design chemistry of this discharge is 65 gpm with a pH of 4.1, acidity of 60 mg/L, alkalinity of 0 mg/L, iron of 1 mg/L, aluminum of 7 mg/L and manganese of 7 mg/L. The treatment train will consist of an equalization basin, followed by a VFW with 1200 tons of limestone and a settling basin. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging.

Another option for this site may be to use a Bioreactor. A bioreactor consists of 3 ft of a substrate mixture containing organic matter and limestone. It works to remove metals and increase alkalinity through bacterially mediated processes. The bio-mixture should contain 100 tons of manure, 78 tons of hay, 1650 tons of limestone and 620 tons of wood chips. It would be approximately 250 ft by 140 ft at the top of freeboard.

Another option may be to combine this discharge with the related MUE-6R. Investigation should occur to determine the possibilities of combining the flows into one treatment system if topography would allow.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of constructing the passive treatment train is $125,000 for the VFW or $210,000 for the bioreactor. The design and permitting phase of the project would be at a cost of $50,000. The overall design and construction cost of MUE-5R is $175,000 or $265,000 depending on the treatment option.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUED-5R discharge is designed to remove 42 lbs/day of acidity, 0.7 lbs/day of iron and 4.9 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Area #2B: Upper Reaches of Muddy Run, West Side

Priority #2B-1: MUEA-6R

Site Description:

This discharge forms the headwaters of the MUEA tributary of Muddy Run, and is located just uphill from the Mountaindale village. This discharge was discussed in the Scarlift report as site 117. The flow emerges from an unreclaimed surface mine on the Middle Kittanning coal. Extensive piles of coal refuse suggest that an underground mine may have also been located in this vicinity, perhaps on the Lower Kittanning coal. The pile has been tested and contains low BTU values. The small stream flows down through the yard of the McAndrews residence, and parallels Mountaindale Road on the east for some distance.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	64	2.9	1927	0.0	0.0	300.0	200.9	14.7	9.6	8.1	29.2	885.8
Min	13	2.7	607	0.0	0.0	84.0	68.7	9.0	3.4	5.5	17.8	305.0
Max	99	4.0	2380	0.0	0.0	441.0	326.5	24.6	14.8	10.6	48.4	1182.0
90% CI	81	3.1	2154	0.0	0.0	344.0	247.7	17.2	11.5	8.8	33.8	1001.8
75% CI	76	3.0	2086	0.0	0.0	330.7	233.6	16.4	10.9	8.6	32.4	966.9
StdDev	36	0.4	478	0.0	0.0	92.6	98.7	5.1	3.9	1.4	9.7	244.4

Recommendations:

Since the discharge emanates from an abandoned mine area with exposed spoil material the first phase of this project would be site reclamation. Surveying needs to be completed at this site to determine the extent of reclamation needed. Through reclamation efforts, the discharge should decrease in quantity and increase in quality. Samples have been collected which show low BTU values of the spoil material, therefore, it will be regraded with lime addition and soil amendments.

The design chemistry of this discharge is 80 gpm with a pH of 3.1, acidity of 344 mg/L, alkalinity of 0 mg/L, iron of 18 mg/L, aluminum of 34 mg/L and manganese of 9 mg/L. The treatment train will consist of a pre-treatment flushed limestone cell containing 600 tons of limestone. This will be followed by an equalization basin, followed by a VFW with 1650 tons of limestone and a settling basin, followed by an additional VFW with 1650 tons of limestone and a final settling basin. The VFWs will consist of 3 feet of limestone and two feet of organic matter. They will have a grid like piping system which will also act to flush the system to limit aluminum plugging. The system will decrease in size after reclamation has improved water quality and decreased flow.

The approximate cost of constructing the passive treatment train is $450,000 for the VFWs. The design and permitting phase of the project would be at a cost of $50,000. The overall design and construction cost of MUEA-6R is $500,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUEA-6R discharge is designed to remove 309 lbs/day of acidity, 16 lbs/day of iron and 30 lbs/day of aluminum. This will restore the water chemistry in about 0.7 miles of the MUEA tributary of Muddy Run, as well as improvement of downstream segments.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2B-2: MUEA-3L

Site Description:

This site has also been called the Pumphouse discharge, and is located on the McCartney Property north of Mountaindale. The weir for this site is located adjacent to stream MUEA, but two sources feed this weir. One source is what appears to be a large prospecting pit for coal. This source is located about 100 feet uphill from the weir. The water seeps from the head of this pit and precipitates appreciable Fe on the seepage area and in the pond. The second source, of volume about equal to the first, is derived about 1000 ft. up the hill to the east at 40.69738N, 78.42213W. At the latter location, two small spring-house-type sheds form the source of an acid, Fe-bearing flow. Electrical wiring in the northern shed suggests that a pump was once here, though no power line currently is evident. The water-filled interior of this shed suggests that it might be a shaft. A small amount of spoil is present downhill. The McCartney family reports that they pumped water from this site at one time, but that the water turned acid and Fe-bearing when coal was mined on the east side of the same hill.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	24	3.1	1704	0.0	0.0	325.0	66.4	11.6	2.1	41.4	23.7	822.7
Min	9	2.8	722	0.0	0.0	109.0	16.6	3.0	0.4	13.4	6.9	280.0
Max	100	3.4	2730	0.0	0.0	751.0	159.5	31.9	4.2	83.4	54.3	1598.0
90% CI	39	3.2	2033	0.0	0.0	417.8	89.4	16.0	2.8	51.9	30.3	1030.5
75% CI	34	3.2	1934	0.0	0.0	389.9	82.5	14.7	2.6	48.8	28.3	968.0
StdDev	30	0.2	693	0.0	0.0	195.5	48.3	9.3	1.4	22.2	14.0	437.7

Recommendations:

Since one of the discharges emanates from an abandoned test pit area, along with additional exposed spoil material near the site, the first phase of this project would be site reclamation. Surveying needs to be completed at this site to determine the extent of reclamation needed. Restoration to approximate original contour and mixing with limestone should largely remediate this water. Through reclamation efforts, the discharge should decrease in quantity and increase in quality.

The design chemistry of the uphill discharge is 30 gpm with a pH of 3.2, acidity of 420 mg/L, alkalinity of 0 mg/L, iron of 16 mg/L, aluminum of 30 mg/L and manganese of 52 mg/L. This is a moderate flow discharge, but contains high metal concentrations. A pre-treatment flushing limestone cell containing 600 tons of limestone is necessary to maintain the integrity of the remaining treatment train. This will be followed by an equalization basin and a VFW containing 1500 tons of limestone. A small concern is the managanese concentration and is considered a low priority, but if treatment is wanted a Mn removal bed will be placed after the settling basin and will contain 850 tons of limestone for 24 hours of detention time. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of constructing the passive treatment train is $350,000 for the VFW. The design and permitting phase of the project would be at a cost of $50,000. The overall design and construction cost of MUEA-3L is $400,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUEA-3L discharge is designed to remove 180 lbs/day of acidity, 7 lbs/day of iron and 13 lbs/day of aluminum. In combination with treatment of MUEA-6R, this will restore the water chemistry of 1.2 miles of tributary MUEA, and improve the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2B-3: MUEA-2R

Site Description:

This weir is located on the west side of stream MUEA about 100 ft downstream from Sportsman Road. The water seeps out between the stream and Mountaindale Road, probably derived from the abandoned Lower Kittanning surface mine on the west side of Mountaindale Road.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	21	3.9	912	0.3	0.1	48.3	10.8	3.2	0.5	9.6	1.7	432.3
Min	4	3.5	643	0.0	0.0	35.0	2.3	0.8	0.1	5.3	0.6	282.0
Max	65	4.1	1130	2.0	0.8	72.0	28.2	9.5	1.5	13.3	2.5	528.0
90% CI	31	4.0	979	0.7	0.2	53.0	15.3	4.6	0.7	10.7	2.0	464.5
75% CI	28	3.9	959	0.6	0.2	51.5	14.0	4.2	0.6	10.4	1.9	454.8
StdDev	20	0.2	141	0.8	0.2	9.9	9.4	3.1	0.4	2.3	0.6	67.9

Recommendations:

The design chemistry of this discharge is 30 gpm with a pH of 4, acidity of 55 mg/L, alkalinity of 0.2 mg/L, iron of 5 mg/L, aluminum of 2 mg/L and manganese of 11 mg/L. Space for construction is limited at this site due to the discharge location, along with potential wetland impacts. The treatment train will consist of a small VFW with 550 tons of limestone followed by a settling basin. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of constructing the passive treatment train is $100,000 for the VFW. The design and permitting phase of the project would be at a cost of $50,000. The overall design and construction cost of MUEA-2R is $150,000.

Predicted Effect of System on Receiving Stream:

Treatment of the MUEA-2R discharge is designed to remove 17.8 lbs/day of acidity, 1.6 lbs/day of iron and 0.6lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2B-4: MUEA-3R

Site Description:

The weir for this discharge is located in a ditch along the uphill side of Sportsman Road on the west side of stream MUEA. The water emerges from a large wetland area between Mountaindale Road and the stream. It is possible that this water is derived from an area of surface mining on the Lower Kittanning coal on the west side of Mountaindale Road.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	13	3.6	1033	0.0	0.0	73.0	9.8	3.5	0.4	11.5	3.6	445.7
Min	1	3.3	742	0.0	0.0	48.0	0.5	1.2	0.0	6.1	1.9	36.0
Max	35	3.9	1310	0.0	0.0	106.0	21.5	8.0	1.2	14.1	5.4	608.0
90% CI	17	3.7	1126	0.0	0.0	81.9	12.6	4.5	0.6	12.9	4.1	520.6
75% CI	16	3.7	1098	0.0	0.0	79.2	11.8	4.2	0.5	12.5	3.9	498.0
StdDev	10	0.2	196	0.0	0.0	18.7	5.8	2.2	0.3	3.0	1.0	157.8

Recommendations:

The design chemistry of this discharge is 20 gpm with a pH of 3.7, acidity of 82 mg/L, alkalinity of 0 mg/L, iron of 5 mg/L, aluminum of 4 mg/L and manganese of 13 mg/L. This is a low flow, low priority discharge, but it does contribute a small metal load to the stream. Space for construction is limited at this site due to the discharge location, along with potential wetland impacts. One option may be to expand the existing wetland for treatment or to pre-treat the discharge with limestone before it enters the existing wetland to allow for metal precipitation. A second option would be to construct a small VFW with 400 tons of limestone followed by a settling basin. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging.

Another possibility is to combine treatment of this discharge with MUEA-2R which is only about 100 ft downstream.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of constructing the passive treatment train is $100,000 for the VFW. The design and permitting phase of the project would be at a cost of $50,000. The overall design and construction cost of MUEA-3R is $150,000.

Predicted Effect of System on Receiving Stream:

Treatment of the MUEA-3R discharge is designed to remove 17.6 lbs/day of acidity, 1 lbs/day of iron and 1 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2B-5: MUEA-1L

Site Description:

The weir for this discharge is located on the east side of stream MUEA about 100 ft. downstream from Sportsman Road. The water upwells forming a wetland area precipitating Fe as it flows to the stream. The source of this water is not clear. It could be a small shaft or drillhole, or it could be seepage from a source on the uphill side of Sportsman Road, traveling through the unconsolidated zone to the site of emergence.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	23	6.6	448	50.4	14.0	-27.3	-7.9	3.0	0.7	1.0		171.8
Min	4	6.1	392	48.0	2.4	-31.0	-13.0	1.8	0.2	0.8		163.0
Max	35	7.0	543	53.0	22.2	-20.0	-1.0	5.0	1.5	1.1		184.0
90% CI	30	6.7	465	51.1	17.8	-25.7	-5.7	3.5	0.9	1.0		174.9
75% CI	28	6.7	459	50.9	16.6	-26.1	-6.3	3.3	0.9	1.0		173.9
StdDev	13	0.2	36	1.5	7.8	3.4	4.7	1.0	0.4	0.1		6.6

Recommendations:

This is a low priority site due to the water quality and potential wetland impacts in order to construct treatment. The design chemistry of this discharge is 30 gpm with a pH of 6.7, acidity of -25 mg/L, alkalinity of 51 mg/L, iron of 4 mg/L, and manganese of 1 mg/L. A small aerobic wetland is needed for treatment at this site. Based on a removal rate of 5 $g/m^2/day$, a wetland with a top of freeboard size of 95 ft by 50 ft is needed. The wetland will be constructed with a substrate of a 1:1 ratio of organic matter and limestone to maintain the pH as the iron precipitates. Different sizes and depths of wetlands will be established to increase contact time and allow for greater precipitation of the iron.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of constructing the aerobic wetland is $50,000, along with the design and permitting phase of the project costing an additional $50,000. The overall design and construction cost of MUEA-1L is $100,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUEA-1L discharge is designed to remove 1 lbs/day of iron. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Area #2C: Muddy Run after confluence of upper headwaters tributaries

Priority #2C-1: MUC-11R

Site Description:

This site is a discharge from the Miller Mine, a very large abandoned underground mine on the Lower Kittanning coal. According to a map in the Scarlift Report (see page A-22), this mine extends almost to Mountaindale, a distance of nearly 3 miles. The flow emerges in a recess in the hillside on the west side of Muddy Run and flows down about 500 feet, crossing an unimproved mine road, before entering the stream.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	259	3.3	1558	0.0	0.0	107.4	330.6	14.5	43.7	7.0	6.2	790.3
Min	182	3.2	1390	0.0	0.0	98.0	242.2	0.1	0.3	0.0	5.7	696.0
Max	365	3.5	1710	0.0	0.0	141.0	450.8	19.1	63.9	8.4	6.8	873.0
90% CI	285	3.4	1602	0.0	0.0	112.9	361.2	16.8	51.4	8.1	6.3	812.8
75% CI	277	3.3	1589	0.0	0.0	111.2	351.9	16.1	49.1	7.8	6.3	806.0
StdDev	56	0.1	91	0.0	0.0	11.5	64.4	5.0	16.4	2.3	0.3	47.3

Recommendations:

Further investigation should occur at this site. The Miller Mine maps should be located and the potential for mine sealing or remining should be investigated. The high flow rates at this site make it difficult to treat passively.

The design chemistry of this discharge is 285 gpm with a pH of 3.4, acidity of 115 mg/L, alkalinity of 0 mg/L, iron of 17 mg/L, aluminum of 7 mg/L and manganese of 8 mg/L. The acidity load is about 400 lbs/day. A cost-effective treatment system at this site would be to mix this flow with the flow from the nearby MUC-10R site. The latter water is net alkaline, with an average acidity load of negative 100 to 200 lbs/day based on fragmentary flow data of 200 to 400 gpm. Mixing this water with the Miller mine water would neutralize 25 to 50% of the Miller Mine acidity. More accurate flow values for MUC-10R should be obtained before this design is implemented, as well as careful surveying to determine whether the alkaline water can flow by gravity.

The remaining acidity and metal content can be treated with two parallel VFP systems, preceded by the above mixing pond, a flushing limestone bed and a settling pond. At a loading rate of 30 g/m2/d. and assuming that half of the acidity is removed in the limestone bed, two VFP's with dimensions of about 110 ft square should treat the water. A settling pond should follow the VFP's. The total cost of this system is estimated as $450,000

This parallel configuration would allow for systems to be "shut off" during low flow conditions to maintain integrity within the cells, and would allow more effective placement of two smaller systems.. The VFWs will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging. This treatment train would cost approximately $450,000 with design and permitting. A possible problem with this design is the limited space near this discharge.

A second option for this site is to build a large bioreactor or again split the flow into two parallel bioreactors. The total volume of medium would consist of 443 tons of manure, 342 tons of hay, 7230 tons of limestone, and 2720 tons of wood chips. One large cell would be 500 ft by 260 ft at top of freeboard and the approximate cost would be $790,000, a large investment.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUC-11R discharge is designed to remove 350 lbs/day of acidity, 52 lbs/day of iron and 21 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2C-2: CM-3R

Site Description:

This sample site is located about 50 yards south of PA 253, about 0.5 mile toward Glasgow from Muddy Run. The site is a small stream in a wooded area carrying the runoff from a moderate size strip mine on Lower Kittanning coal to the south and west. This discharge contributes acid and metals to a small stream extending about 2500 feet to the north, where it joins Muddy Run very close to site MUE-2R.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	26	4.0	1671	1.5	0.6	53.8	16.1	1.0	0.3	21.2	0.3	998.0
Min	17	3.7	1120	0.0	0.0	39.0	11.3	0.3	0.1	11.5	0.2	510.0
Max	43	4.2	2020	3.0	1.0	77.0	24.4	2.9	0.7	26.0	0.6	1271.0
90% CI	30	4.1	1788	2.2	0.8	59.7	18.2	1.4	0.4	23.0	0.4	1095.2
75% CI	29	4.1	1753	2.0	0.7	57.9	17.6	1.3	0.3	22.5	0.4	1066.0
StdDev	8	0.2	247	1.4	0.5	12.4	3.9	0.8	0.2	4.0	0.1	204.7

Recommendations:

This is a low priority in the watershed due to the small loads being discharged to the stream, however, treatment would remove approximately 20 lbs/day of acid from the watershed along with treating a moderate level of manganese. The design chemistry of this discharge is 30 gpm with a pH of 4.1, acidity of 60 mg/L, alkalinity of 0 mg/L, iron of 2 mg/L, aluminum of 1 mg/L and manganese of 53 mg/L. A small VFW containing 550 tons of limestone will be followed by a settling basin. A manganese removal bed with 600 tons of limestone for 24 hour detention may be placed after the settling basin if manganese treatment is desired. This would also add to the alkalinity boost in this stream reach. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging. This treatment train with design and permitting would cost approximately $125,000 to construct.

A second option would be to construct a bioreactor for metal removal. The medium would consist of 46 tons of manure, 36 tons of hay, 760 tons of limestone and 286 tons of wood chips. The bioreactor would cost approximately $110,000 to construct.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the CM-3R discharge is designed to remove 20 lbs/day of acidity, 0.6 lbs/day of iron and 0.2 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2C-3: MUE-2R

Site Description:

This site is a small channel draining a wetland area of about 1 acre. Precipitation of Fe is evident in the channel. The water flows into Muddy Run just downstream from the weir location. The source is seepage, probably from a large area of abandoned Lower Kittanning strip mining uphill to the west. A second stream, designated MUE-1R during the reconnaissance phase, enters Muddy Run about 25 ft downstream from this site. MUE-1R is treated by the CM-3R system, which represents the source of nearly all of this discharge.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	26	4.8	1011	6.2	1.8	28.9	8.3	2.1	0.6	8.0	1.1	549.5
Min	9	4.3	490	3.0	0.8	23.0	4.8	1.0	0.2	5.3	0.4	369.0
Max	51	5.4	1420	10.0	3.4	44.0	14.8	4.4	1.1	13.7	5.0	827.0
90% CI	34	5.0	1133	7.3	2.2	32.2	10.1	2.7	0.7	9.3	1.8	617.1
75% CI	32	5.0	1096	7.0	2.1	31.2	9.5	2.5	0.7	8.9	1.6	596.8
StdDev	13	0.4	245	2.2	0.8	6.6	3.2	1.2	0.3	2.5	1.3	136.4

Recommendations:

The design chemistry of this discharge is 35 gpm with a pH of 5, acidity of 35 mg/L, alkalinity of 7 mg/L, iron of 3 mg/L, aluminum of 2 mg/L and manganese of 10 mg/L. This discharge will be treated with a vertical flow wetland containing 650 tons of limestone. This system would cost approximately $125,000 including design and permitting.

A second option would be to construction a bioreactor for metal removal. The medium would consist of 54 tons of manure, 42 tons of hay, 890 tons of limestone and 334 tons of wood chips. The bioreactor cost approximately $125,000 to construct.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUE-2R discharge is designed to remove 13 lbs/day of acidity, 1 lbs/day of iron and 0.7 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2C-4: MUC-10R

Site Description:

This sampling point is located on a small stream at the crossing of an abandoned road at 40.72715N, 78.4350W. A 5-ft high beaver dam holding up a several acre pond lies just above the road, and a notch through mine spoil channels the stream to Muddy Run below the sample point. Several small streams flow into the pond to generate the outflow. The Lower, Middle and Upper Kittanning seams have been surface mined in this small watershed, and the slopes are composed largely of spoil. Small underground mines may be present. A weir was installed essentially on the road, but was removed by unknown persons before the first sample date, and a better location could not be found between the beaver dam and Muddy Run.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average		6.6	790	59.4		-34.5		1.8		1.3	0.3	336.4
Min		6.3	357	24.0		-52.0		0.9		0.5	0.1	124.0
Max		6.8	966	78.0		5.0		3.2		2.2	0.8	445.0
90% CI		6.7	889	68.2		-25.8		2.1		1.6	0.5	386.7
75% CI		6.7	859	65.5		-28.4		2.0		1.5	0.4	371.5
StdDev		0.2	201	17.8		17.5		0.7		0.5	0.3	101.4

Recommendations:

Since some of the flow making up this discharge emanates exposed spoil material near the site, the first phase of this project would be site reclamation. Surveying needs to be completed at this site to determine the extent of reclamation needed. Through reclamation efforts, the discharge should decrease in quantity and increase in quality.The area will be regraded with lime addition and soil amendments.

There is no good flow data for this site. In order to have a conceptual design, the estimated flows were evaluated and a design discharge is 1500 gpm were used. The design chemistry is pH of 6.7, acidity of -26 mg/L, alkalinity of 68 mg/L, iron of 2.1 mg/L, aluminum of 0.5 mg/L and manganese of 1.6 mg/L. This is a high flow alkaline discharge, but it contains small concentrations of metals.

The preferred plan for this discharge is to convey the water about 1000 ft to the MUC-11R discharge and mix it to at least partly neutralize that flow, as discussed in the section on MUC-11R.   Precipitate from this treatment would accumulate in a settling pond and wetland, if space can be found.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUC-10R discharge is designed to remove 42 lbs/day of iron and 8 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Area #2D: Curtis Run and Vicinity

Priority #2D-1: CRD-05

Site Description:

This weir measures the flow of Curtis Run upstream from PA 253. Several discharges contribute to this flow, but they are within a private fenced game preserve into which access was difficult, so only the sum of the several sources could be sampled routinely.

Based on observations during the reconnaissance stage, one discrete source is at recon point CRD-6L (40.71904N, 78.40662W) which flows down from the middle of an old reclaimed surface mine on Clarion-Brookville coal. This flow emerges from spoil at approximately the same location as discharge 116 of the Scarlift survey (Skelly and Loy, 1971), and is probably an old underground entry. Additional acidity enters Curtis Run from tributaries at 40.71597, 78.40137. These acidic flows appear to seep from the overburden at various places up the hill, and probably represent, at least in part, the flow that infiltrates the surface near 40.7120N, 78.39869W. Sampling of the outflow of the small dam at 40.72254N, 78.39825 shows conductance 50 uS/cm, so no significant sources upstream of this point are indicated, in contrast to the Scarlift report. Areas to the south are clearly generating acidity.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	385	4.1	347	1.3	7.6	62.8	300.8	0.5	1.5	3.9	7.5	144.8
Min	23	3.8	217	0.0	0.0	43.0	16.8	0.2	0.1	1.8	4.3	52.0
Max	1045	4.3	410	3.0	25.1	73.0	755.9	2.8	5.9	5.1	10.5	176.0
90% CI	563	4.1	374	1.8	12.3	66.9	439.6	0.9	2.3	4.3	8.4	159.8
75% CI	509	4.1	366	1.7	10.9	65.7	397.8	0.8	2.1	4.1	8.1	155.3
StdDev	359	0.1	56	1.1	9.5	8.5	279.8	0.7	1.7	0.8	1.8	31.7

Recommendations:

It is recommended that samples need to be collected at the source of the discharges. The high flow rate at this tributary will make it difficult to treat the combined flow. If it is not possible to obtain landowner permission to sample the discharges at their source, it is recommended that partial flow be pulled from the stream and treated through limestone cells. The iron is minimal, less than 1 mg/L, and the focus of treatment should be on the removal of aluminum. The design chemistry is 100 gpm with a pH of 4.1, acidity of 70 mg/L, alkalinity of 1.8 mg/L, iron of 1 mg/L, aluminum of 10 mg/L and manganese of 5 mg/L. This flow is 20% of the total flow of the stream. The treatment train would consist of a series of limestone ponds and settling basins. An equalization basin will discharge water into the first limestone cell containing 1000 tons of limestone, followed by a settling basin and then another limestone cell with an additional 1000 tons of limestone and a finally settling basin before discharging back into the stream. The treatment train should be in a “U” shaped pattern to minimize stream length impact. This system with design and permitting will cost approximately $225,000.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment.

The approximate cost of treating this discharge will vary depending on the area to be reclaimed and the ultimate course of action to be taken.

Predicted Effect of System on Receiving Stream:

Treatment of 20% of the CRD-05 tributary is designed to remove 17 lbs/day of acidity, 0.24 lbs/day of iron and 2.4 lbs/day of aluminum. Additional metal removal will occur in the stream channel when the alkaline water mixes back in.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices.. Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2D-2: MUE-2L

Site Description:

This site is the outflow of a large area of seepage on the NW (downhill) side of PA 253. It is located about 1000 feet N of the C&K Glasgow treatment system. As with CRD-2R and CRD-1R, the seepage is interpreted to be derived from the large area of Lower Kittanning coal strip mined by C&K uphill on the SE side of PA 253. The seepage flows into Muddy Run through a small channel where the sample point and weir are located.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	37	2.9	2908	0.0	0.0	512.3	210.9	25.4	9.9	96.5	32.4	1669.5
Min	6	2.7	2210	0.0	0.0	315.0	33.7	11.0	0.9	52.0	18.8	939.0
Max	104	3.1	3500	0.0	0.0	800.0	628.2	48.7	24.6	126.0	40.5	2022.0
90% CI	53	3.0	3103	0.0	0.0	572.2	306.4	30.8	13.7	105.0	35.4	1809.4
75% CI	48	3.0	3045	0.0	0.0	554.2	277.7	29.1	12.6	102.4	34.5	1767.3
StdDev	30	0.1	411	0.0	0.0	126.3	174.1	11.3	7.0	17.8	6.3	294.6

Recommendations:

The design chemistry of this discharge is 50 gpm with a pH of 3.0, acidity of 575 mg/L, alkalinity of 0 mg/L, iron of 31 mg/L, aluminum of 35 mg/L and manganese of 105 mg/L. This discharge will be difficult to treat passively due to the moderate flow rates and high metal concentrations.

If passive treatment is to be used at this site, a flushing limestone cell cell should be placed in the front of the treatment train. The cell should contain 600 tons of limestone in a wedge shaped cell.. The cell should be followed by an equalization basin, leading to a VFW with 1200 tons of limestone, followed by a settling basin and another VFW with an additional 1200 tons of limestone and a final settling basin. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging. Due to the high manganese concentration, it would be advantageous to include a manganese treatment bed consisting of 1055 tons of limestone to insure a 24 hour detention time.

Another possible approach for this site is to capture the AMD on the uphill side of PA 253 and route it to a treatment system in the vicinity of the existing C&K Glasgow system. The AMD might be captured in a large French drain at the toe of the stripped area, which also furnishes the water treated in the DER-2T discharge. Treatment would probably have to be at least partly active, as is the case at the current C&K Glasgow system.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment. It may be possible to combine related discharges at this site if topography allows and installing an active treatment system to better handle the loads emanating from this reclaimed mine site.

The cost of treating this discharge with design and permitting included should be approximately $500,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the MUE-2L discharge is designed to remove 310 lbs/day of acidity, 16 lbs/day of iron and 18 lbs/day of aluminum.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. . Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2D-3: CRD-1R

Site Description:

This monitoring point is the outflow of part of a large seepage area just downhill to the NW from PA 53 and about 2000 feet N of the former C&K Glasgow Treatment System. Discharges CRD-2R and MUE-2L also flow from this seepage area. The seepage appears to be derived from the large area of Lower

Kittanning coal strip-mined uphill from PA 253, fed by flow under the highway through the unconsolidated overburden. The outflow of this large seepage area discharges into Curtis Run through a small channel where the flow was sampled.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	51	3.1	1984	0.0	0.0	285.5	180.0	9.5	5.8	66.5	13.7	1031.3
Min	23	2.9	1590	0.0	0.0	190.0	75.7	5.0	1.3	30.8	8.9	593.0
Max	143	3.2	2490	0.0	0.0	391.0	405.1	18.4	16.0	109.0	16.6	1376.0
90% CI	72	3.1	2106	0.0	0.0	311.2	250.3	11.6	8.1	76.5	15.1	1126.9
75% CI	65	3.1	2069	0.0	0.0	303.5	229.2	11.0	7.4	73.5	14.7	1098.1
StdDev	40	0.1	257	0.0	0.0	51.7	128.2	4.3	4.4	20.9	3.0	201.5

Recommendations:

The design chemistry of this discharge is 75 gpm with a pH of 3.1, acidity of 315 mg/L, alkalinity of 0 mg/L, iron of 12 mg/L, aluminum of 15 mg/L and manganese of 76 mg/L. This discharge will be difficult to treat passively due to the high flow rates and moderate metal concentrations.

If passive treatment is to be used at this site, a flushed limestone bed should be placed in the front of the treatment train. The cell should contain 600 tons of limestone in a wedge shaped cell. The bed will gradually plug and will have to be reworked, but will greatly reduce the load to the downstream components. The cell should be followed by a settling and equalization basin, leading to a VFW with 1200 tons of limestone, followed by a settling basin and another VFW with an additional 1200 tons of limestone and a final settling basin. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging. Due to the high manganese concentration, it would be advantageous, but not necessary, to include a manganese treatment bed consisting of 1580 tons of limestone to insure a 24 hour detention time.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment. It may be possible to combine related discharges at this site if topography allows and installing an active treatment system to better handle the loads emanating from this reclaimed mine site.

The approximate cost of treating this discharge will vary depending on the area to be reclaimed and the ultimate course of action to be taken.

The cost of treating this discharge with design and permitting included should be approximately $525,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the CRD-1R discharge is designed to remove up to 255 lbs/day of acidity, 10 lbs/day of iron and 60 lbs/day of aluminum. This will improve the water chemistry in the headwaters segment of Muddy Run.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. . Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Priority #2D-4: CRD-2R

Site Description:

This monitoring point is located on a small stream entering Curtis Run from the south, on the NW side of PA253. The site is about 2000 feet NW of the C&K Glasgow treatment system (40.71593N, 78.42295W). The flow is derived from a large seepage area between the site and PA 253. This seepage probably is derived by flow through the unconsolidated zone from the large area of Lower Kittanning coal mined by C&K Coal on the SE side of PA 253. Site MUE2L and CRD01R are also derived in this manner,

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	19	4.1	562	2.4	0.6	52.5	11.5	2.2	0.1	6.2	3.8	266.5
Min	4	3.6	198	0.0	0.0	32.0	2.5	0.1	0.0	1.2	0.5	47.0
Max	51	4.4	680	4.0	2.1	76.0	32.7	13.6	0.6	8.5	7.6	405.0
90% CI	28	4.2	631	3.2	1.0	58.6	16.9	4.1	0.2	7.2	5.0	309.8
75% CI	25	4.2	610	2.9	0.9	56.7	15.3	3.5	0.2	6.9	4.7	296.8
StdDev	17	0.3	139	1.6	0.8	12.3	10.5	4.0	0.2	2.1	2.4	87.3

Recommendations:

The design chemistry of this discharge is 30 gpm with a pH of 4.2, acidity of 60 mg/L, alkalinity of 3 mg/L, iron of 4 mg/L, aluminum of 5 mg/L and manganese of 7 mg/L.

The treatment train should consist of an equalization basin, leading to a VFW with 550 tons of limestone, followed by a settling basin. The VFW will consist of 3 feet of limestone and two feet of organic matter. It will have a grid like piping system which will also act to flush the system to limit aluminum plugging.

As with all study sites, additional research and investigation needs to be done to determine the best course of action. These recommendations are based on information obtained during the assessment. It may be possible to combine related discharges at this site if topography allows and installing an active treatment system to better handle the loads emanating from this reclaimed mine site.

The cost of treating this discharge with design and permitting included should be approximately $125,000.

Predicted Effect of System on Receiving Stream:

Reclamation and treatment of the CRD-2R discharge is designed to remove 20 lbs/day of acidity, 1.2 lbs/day of iron and 1.6 lbs/day of aluminum.

Other:

A final O&M plan will be developed after reclamation and construction is complete. Limited maintenance should be necessary, due to the use of automatic flushing devices. . Visual checks of the system will be made monthly to insure that wildlife or other natural processes are not affecting the integrity of the system. A field monitoring plan will be established to determine the overall effects of the project on water quality.

Permits will need to be obtained for the construction of the project. A field meeting with PADEP, PGC, PFBC, Army Corp of Engineers, and the Conservation District will occur to insure all permitting issues are addressed.

Other Sites:

Additional sites collected during the assessment, but were not deemed significant and no treatment is necessary.

CB-10L

This sampling point is the outflow of about 20 acres of surface mining on a small tributary to Muddy Run (the tributary heads near Utahville). The mine is largely reclaimed and has several sediment ponds along its lower edge. At the sample point, there is no pond but an area of cattails along a channel leading to the weir. Coal mined here is Lower and Upper Freeport.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	95	6.9	917	341.1	382.8	-314.5	-352.7	1.2	1.4	1.6	<0.5	144.1
Min	39	6.6	803	303.0	155.8	-354.0	-450.6	1.1	0.6	1.4	<0.5	124.0
Max	126	7.1	984	384.0	491.7	-276.0	-143.7	1.3	1.7	1.7	<0.5	185.0
90% CI	107	7.0	943	354.2	428.0	-301.9	-311.6	1.3	1.5	1.6	<0.5	151.6
75% CI	103	7.0	935	350.3	414.4	-305.7	-324.0	1.2	1.5	1.6	<0.5	149.3
StdDev	24	0.1	53	27.7	91.0	26.6	83.0	0.1	0.3	0.1	<0.5	15.8

Recommendations:

This site is not a priority based on the loading rates to the stream and does not need a treatment system.

DER-2T

This discharge is from the C&K Glasgow treatment system. The flow treated here represents part of the flow from the large area surface mined on the Lower Kittanning coal by C& K Coal Co. During the sampling period, most of the flow to the system was being partially treated in the passive system. After July 2009, the flow was bypassed without treatment. Since January 2010 the renovated system has been treating this discharge, and an active treatment system funded by the bond forfeiture fund will treat flows greater than 40 gal/min, so that this discharge is expected to be net alkaline and contribute appreciable alkalinity to Muddy Run.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	60	4.0	2690	2.0	0.8	303.3	235.5	4.0	3.5	77.9	25.8	1756.8
Min	4	3.3	1390	0.0	0.0	76.0	15.3	0.6	0.3	29.0	2.9	791.0
Max	150	5.1	3300	9.0	3.4	426.0	683.5	7.7	9.9	100.0	38.6	2129.0
90% CI	82	4.3	2969	4.0	1.6	356.0	339.7	5.3	5.2	89.2	31.7	1959.9
75% CI	75	4.2	2885	3.4	1.3	340.2	308.4	4.9	4.7	85.8	29.9	1898.8
StdDev	42	0.6	536	3.7	1.4	101.4	200.4	2.5	3.0	20.6	11.5	390.5

Recommendations:

This site is already being addressed by the Glasgow Treatment System and does not need additional treatment.

MCC-01L

This discharge emerges from an apparent abandoned mine shaft on the east side of Muddy Run south of Beccaria. Information on the depth and geology of this shaft has not been found, but very likely it is connected to a mine on the Lower Freeport or underlying coal. Water from the shaft flows into a small pond and before it discharges to Muddy Run. Some red precipitate is evident.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	111	6.6	1109	243.8	327.2	-214.5	-288.2	0.3	0.4	0.5	0.1	352.4
Min	71	6.4	960	171.0	196.7	-261.0	-408.9	0.1	0.2	0.3	0.1	310.0
Max	147	7.0	1270	288.0	458.3	-142.0	-170.3	1.0	1.6	1.2	0.2	444.0
90% CI	122	6.7	1149	262.0	374.6	-195.3	-243.4	0.5	0.6	0.6	0.1	371.8
75% CI	118	6.7	1137	256.6	360.4	-201.1	-256.8	0.4	0.6	0.6	0.1	366.0
StdDev	22	0.2	81	36.7	95.5	38.9	90.4	0.3	0.4	0.3	0.0	39.2

Recommendations:

This site is not a priority based on the loading rates to the stream and does not need a treatment system.

Priority #2D-4: MUE-1L

Site Description:

This site is a small channel in a gully entering Muddy Run about 1000 ft. upstream from the mouth of Curtis Run. Note that the mouth of Curtis Run is farther downstream than shown on the USGS quadrangle map. The source of this small flow is somewhat ambiguous. During periods of lower flow, it appears to be derived from seepage in a zone a few hundred yards upstream, perhaps from the same groundwater plume as the CRD-1R and MUE-2L flows. However, on one very high flow occasion (6/20/09 with flow estimated at 3600 gal/min), the stream was observed to be a branch of Muddy Run, with the water overflowing the banks of Muddy Run and into this channel a few hundred yards upstream.

Date	Flow (gpm)	pH (SU)	Cond	Alk	Alk load (lbs/day)	Acidity (mg/l)	Acid load (lbs/day)	Iron	Iron load (lbs/day)	Mn	Al	Sulfate
Average	12	4.2	538	2.3	0.4	49.3	7.5	0.6	0.1	17.1	1.5	252.7
Min	2	3.8	343	0.0	0.0	34.0	1.0	0.1	0.0	5.1	0.6	120.0
Max	35	4.5	778	5.0	1.1	74.0	31.2	3.2	0.4	33.1	2.9	450.0
90% CI	17	4.3	588	3.2	0.5	54.7	11.7	1.0	0.1	20.3	1.8	291.7
75% CI	15	4.3	573	2.9	0.5	53.1	10.4	0.8	0.1	19.3	1.7	279.9
StdDev	10	0.2	106	1.8	0.3	11.5	8.5	0.9	0.1	6.6	0.7	82.2

Recommendations:

This is a low priority in the watershed due to the small loads being discharged to the stream, however, treatment would remove approximately 12 lbs/day of acid from the watershed along with treating a moderate level of manganese.

FUNDING OF THE PROJECT

The Muddy Run Assessment Project was funded by a Growing Greener grant of $49,000 to Clearfield Creek Watershed Association from the Pennsylvania Department of Environmental Protection. The start date of the grant was June 2008 with completion in June 2010. The CCWA is very grateful for the continued support from both the Moshannon and Ebensburg District Offices in their continued restoration efforts within the Clearfield Creek Watershed.

CONCLUSION

The Muddy Run watershed is located in northern Cambria and southern Clearfield Counties, Pennsylvania. Towns in the watershed include Blandburg in the headwaters, Beccaria and Ramey in the central region, and Madera at the confluence with Clearfield Creek. The watershed has an area of 37 square miles.

As a result of extensive underground and surface coal mining, the stream is severely contaminated with acidic mine drainage containing elevated Fe, Al and Mn. The purpose of this investigation was to acquire good data on the sources of acid mine drainage (AMD) and to develop initial plans for remediating the AMD effects. The project has been conducted under a Growing Greener Grant from the State of Pennsylvania to Clearfield Creek Watershed Association. The project was accomplished in the period March 2008 to June 2010. Much of the field work was done by members of the CCWA as volunteers. Technical and reporting responsibilities have been contracted to New Miles of Blue Streams. The Clearfield and Cambria County Conservation Districts have contributed as both paid and unpaid organizations.

In order to accomplish the project, volunteers from the Clearfield Creek Watershed Association first walked all the streams in the watershed, recording pH, conductance and estimated flow of all significant discharges. Based on this information, 28 discharges were selected for sampling, and weirs were installed for flow measurement. The 28 sites were then sampled monthly for a year. At each sampling date, the pH, conductance, temperature and flow were measured in the field, and the pH, alkalinity, acidity, conductance, Fe, Mn, Al, SO_4, total suspended sediments and total dissolved solids were measured by Mahaffey Labs of Curwensville, PA.

The total acidity loading from the 28 discharges into the watershed is about 4500 lbs/day, and the total Fe loading is 740 lbs/day. The largest acidity sources are the Eureka 29 abandoned underground mine (1230 lbs/day), discharges MUEC and MUEA-6R in the headwaters near Blandburg (525 and 309 lbs/day), a large seepage area just north of PA 253 near Muddy Run (discharges MUE-2L, CRD-1R and CRD-2R, 580 lbs/day), the Miller Mine near Glasgow (350 lbs/day) and discharge A1-01 near Madera (525 lbs/day). In general, Muddy Run in the upper 1/3 of the watershed is strongly acid and metal-bearing, but by influx of water from the upper coal seams and associated rocks, becomes near neutral in the lower half, though with high levels of suspended Al and Fe precipitate.

For most sites, various combinations of passive treatment systems are proposed, including wetlands, flushed limestone beds, vertical flow wetlands and settling ponds, though some of the larger sites might be candidates for active treatment. At the large Eureka, Brookwood and Miller mines, it appears that the acidity and metals can be completely or largely removed by mixing the AMD with strongly alkaline waters of nearby discharges from the upper coal seams of the area. These sites are suggested for first priority treatment. As a second priority, treatment of the MUEC, MUED-3 and MUEA-6R discharges in the headwaters near Blandburg can largely clean up several miles of the headwaters area. Other localities would be a third priority. A few discharges are so small and poor in acidity and metals that not treatment is recommended.

During future years, the CCWA will seek funding for the treatment systems and oversee their construction.

Appendix A: Maps

The following outlines the maps which can be found in this appendix.

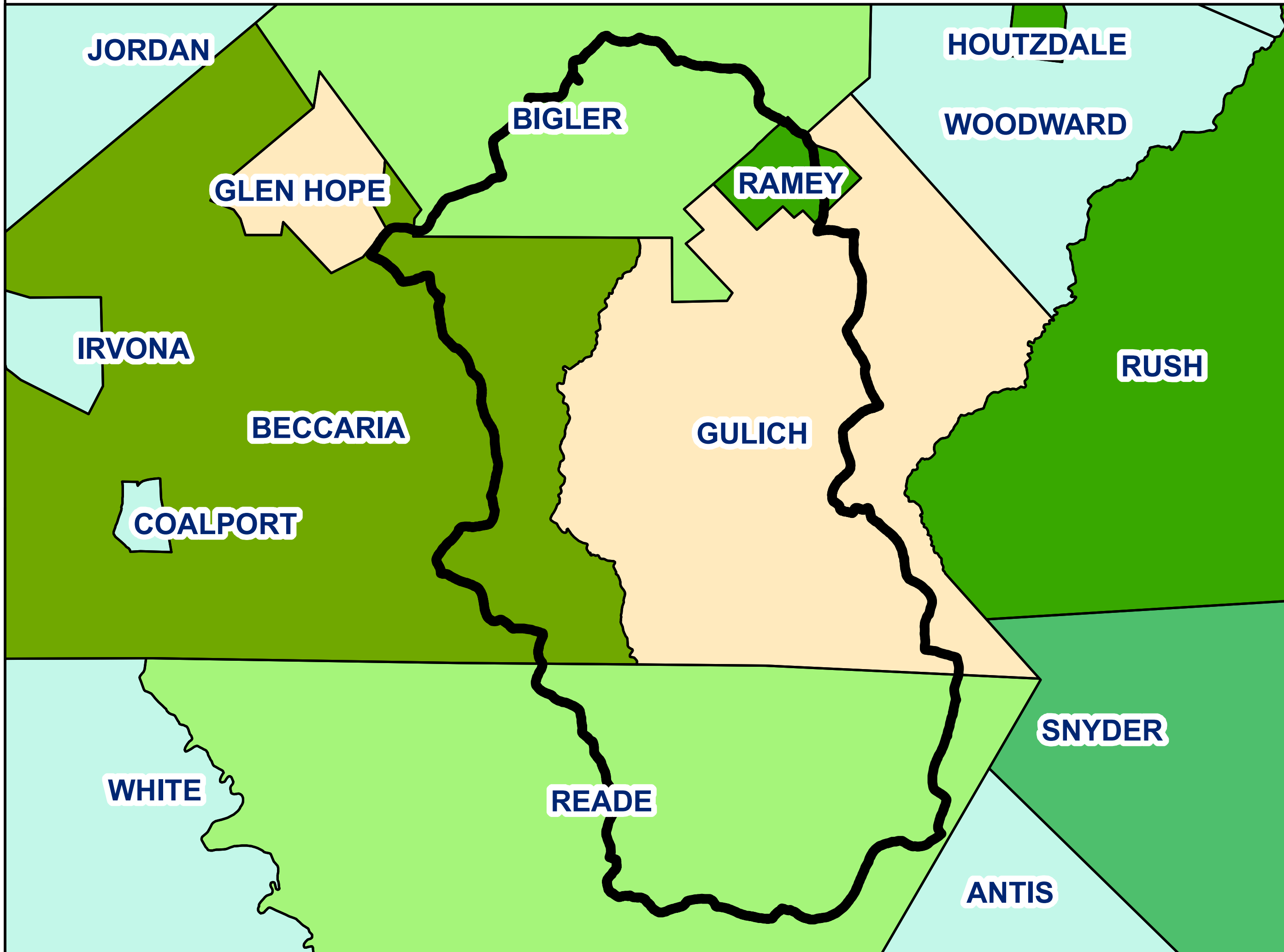
A-3	Watershed in PA	This displays the location of the watershed in Pennsylvania as well as the nearby civil boundaries.
A-4	Topographic Quads containing Assessment Area	This displays the watershed within the USGS 7.5 Minute Series topographic quadrangles. The boundaries of the quadrangles are displayed and quadrangle name is identified.
A-5	Sub Watersheds	This displays an identification of the sub watersheds within the assessment area.
A-6	Impaired Streams	This identifies streams within the specified assessment area and whether the streams are currently considered impaired by DEP.
A-7	Stream Quality	This displays a color coded version of the watershed. The variation in color describes the quality of the stream as it runs from headwaters to mouth based upon the sampling performed.
A-8	AML priorities	This displays AML priorities in and near the watershed as determined and reported by the Bureau of Abandoned Mine Reclamation in 2008.
A-9	Soil survey	This displays the soils of the area as reported by NRCS in 2005. Some differences will appear on this map as compared to the last published soil survey report. The data used to create this map was considered more recent, and thereby more appropriate to report.
A-10	Geology	This displays the regional bedrock within and near the watershed. Data was provided by DCNR (see http://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspx) which digitized data from the 1980 map published by the Bureau of Topographic and Geologic Survey.
A-11 & A-12	Wetlands/NWI	This displays the NWI wetland areas within the watershed (as identified by US Fish & Wildlife). To make the areas somewhat visible, this was split over two pages.
A-13	Treatment sub Areas	This displays an overview of the areas in which treatment is being recommended. These areas correspond to treatment areas mentioned in the discussion.

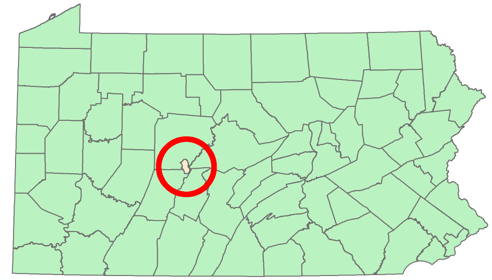
A-14	Monthly Sampling	This displays the monthly sampling points within the watershed.
A-15	Monthly Sampling on Topo	This displays the same data as is seen above, but relevant portions of USGS quad maps are also displayed to provide context and area topography.
A-16	Quarterly Sampling (on topo)	This displays the points at which quarterly sampling occurred; relevant portions of USGS quad maps are displayed to provide context and area topography.
A-17	Macroinvertebrate Sampling	This displays the points at which macroinvertebrate sampling occurred.
A-18	Permits	Approximate location of permits within watershed
A-19	Mine maps	Approximate location of historic mine maps within watershed
	Scarlift maps	Although portions of some Scarlift maps appear below, this document does not reprint the four Scarlift maps for Muddy Run. Instead, an interested reader can access these maps from the following web link: http://www.amrclearinghouse.org/Sub/SCARLIFTReports/MuddyRun/MuddyRun.htm.
A-20	Brookwood Mine	This appears to be a portion of a Scarlift map which focuses on the Brookwood Mine
A-21	Eureka Mine	This appears to be a portion of a Scarlift map which focuses on the Eureka Mine(s).
A-22	Miller Mine	This appears to be a portion of a Scarlift map which focuses on the Miller Mine(s).
A-23	Seepage aerial	Seepage area feeding CRD-2R, CRD-1R and MUE-2L, and nearby sites.

Maps should be used as reference only. Exact precision is neither implied nor guaranteed.

Watershed in PA

N





Assessment Area within State of Pennsylvania

Legend

Watershed Bounds

Civil bounds

Civil boundary and watershed boundaries Accessed from PASDA

Assessment area within surrounding civil bounds

1:120,000

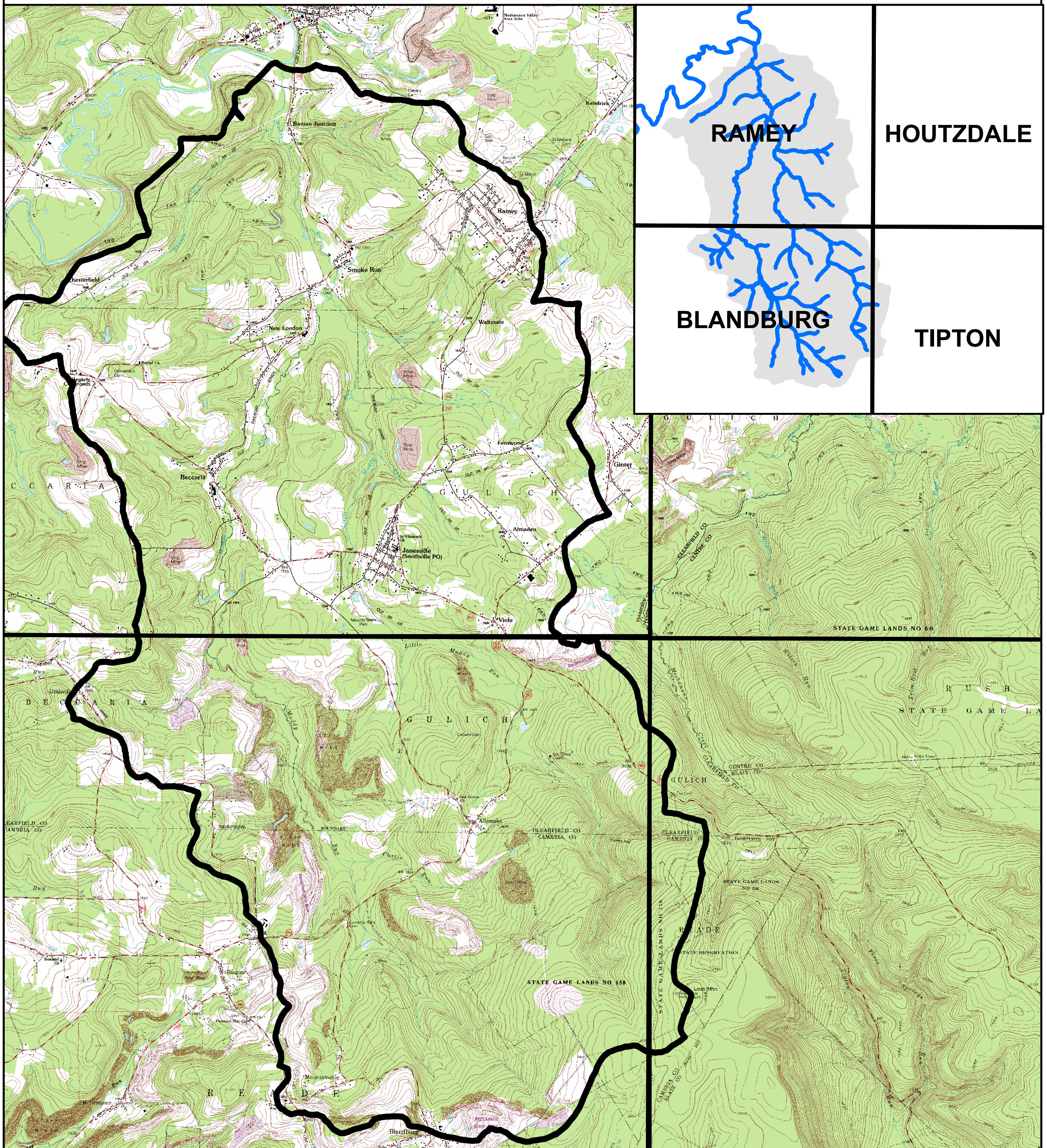
0 1,300 2,600 5,200 7,800 10,400 Meters

Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NMBS NEW MILES OF BLUE STREAM

Topographic Quads containing Assessment Area

N



0 750 1,500 3,000 4,500 6,000
Meters

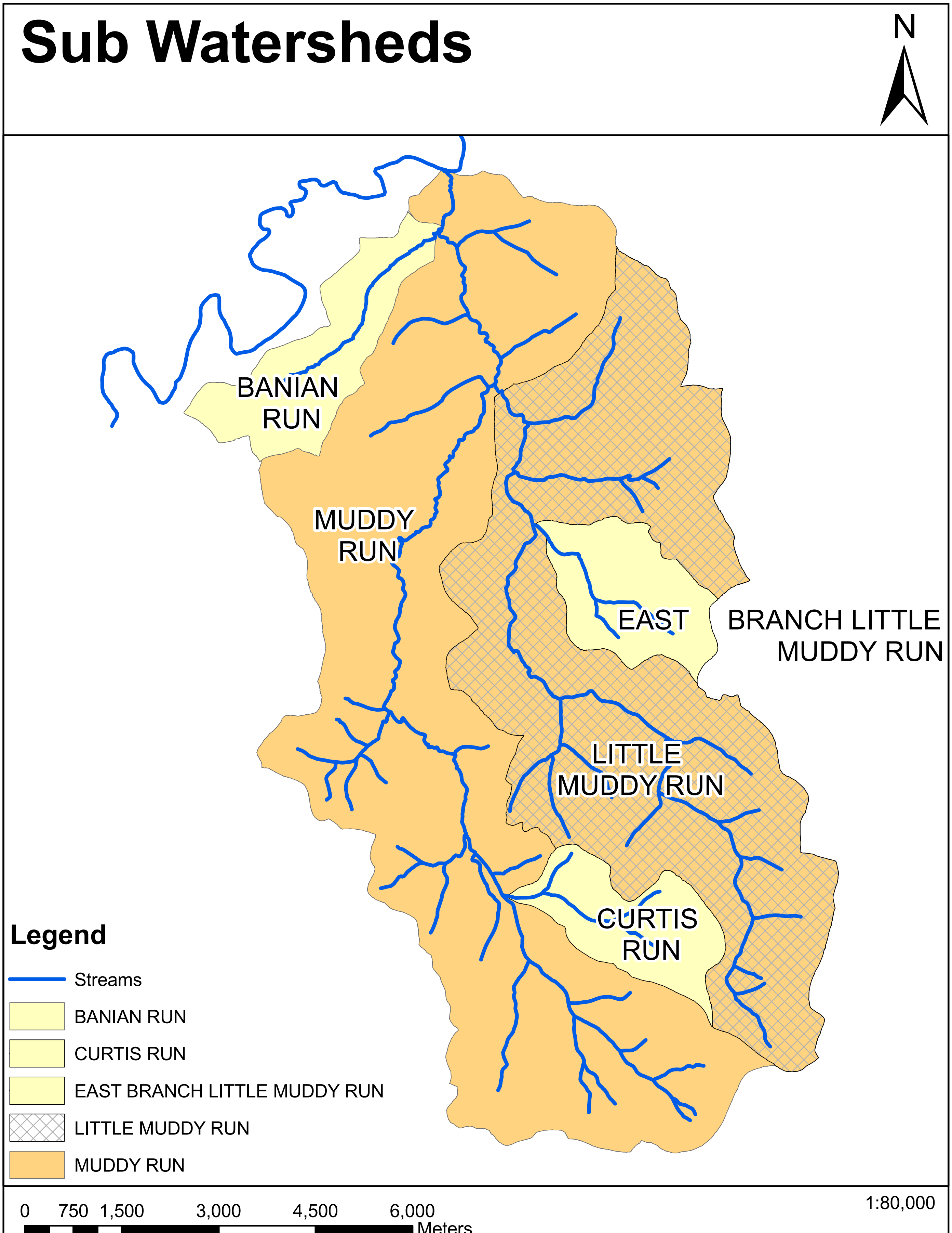
1:80,000

7.5 minute quadrangle outlines and
7.5 minute Raster graphics
Accessed from PASDA

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Sub Watersheds



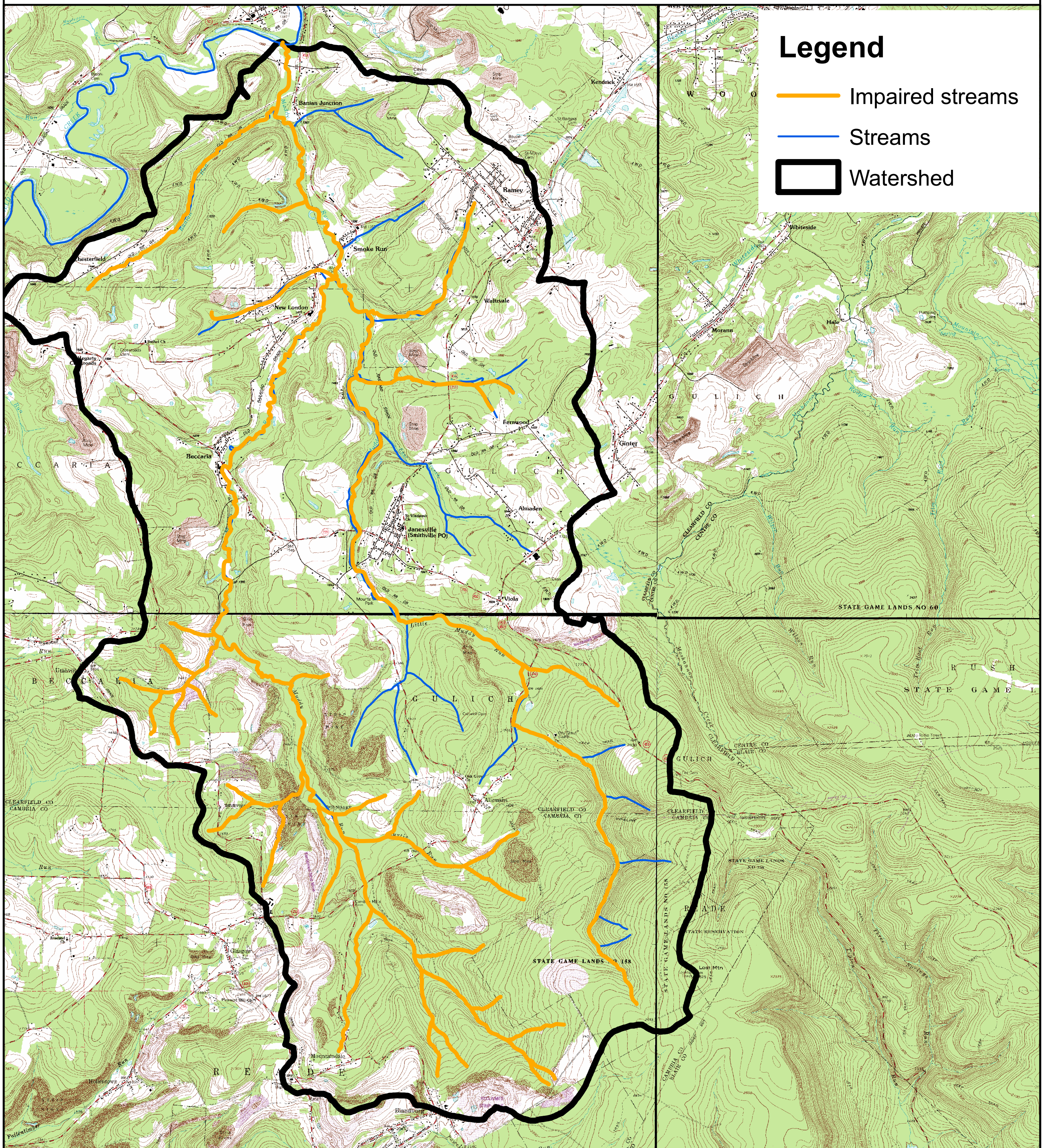
Stream outlines provided by USGS, EPA, USDA Forest Service, and other agencies. Watershed boundaries Accessed from PASDA

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NEW MILES OF BLUE STREAM

Impaired Streams (DEP)

N



0 750 1,500 3,000 4,500 6,000
Meters

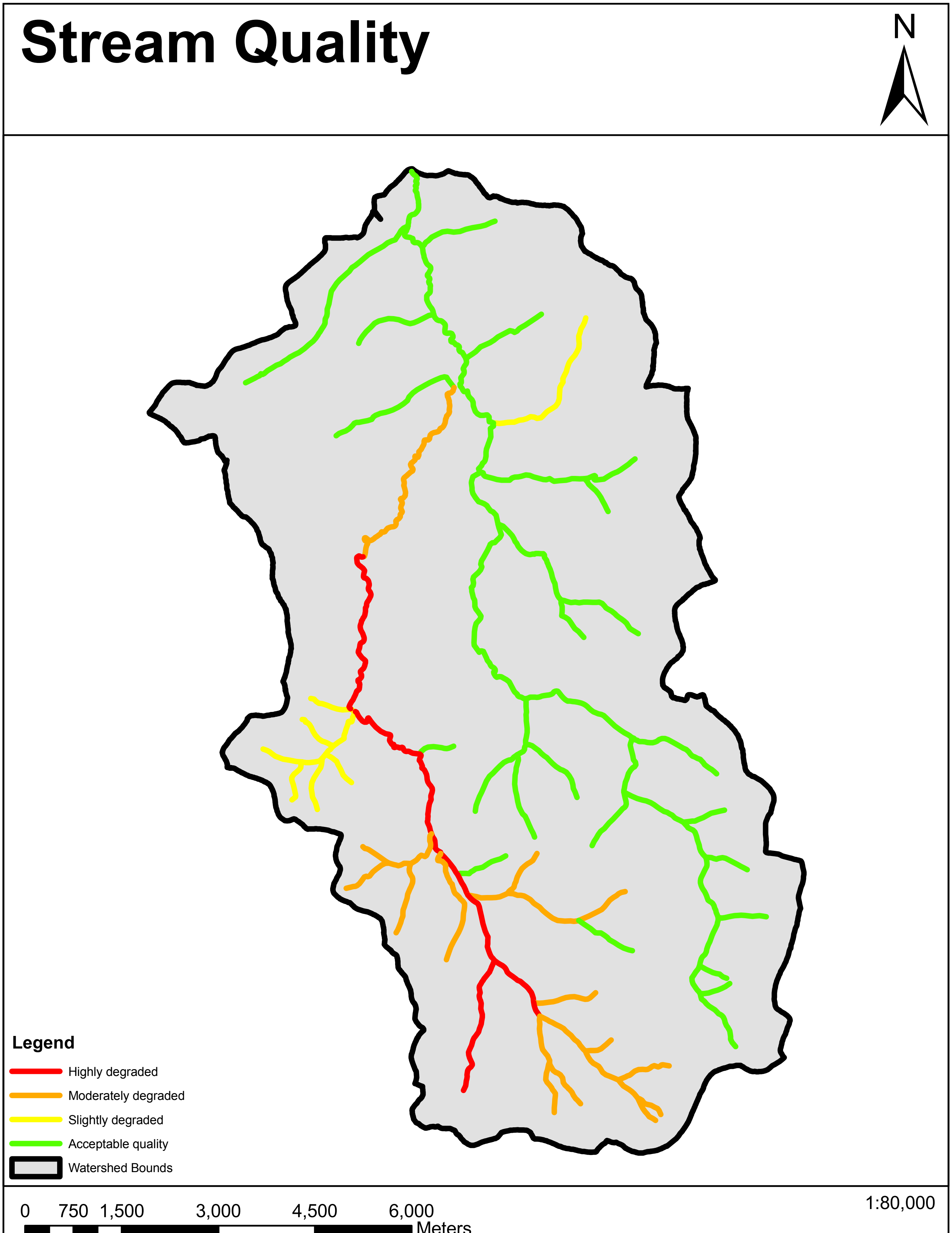
1:80,000

Stream outlines provided by USGS, EPA, USDA Forest Service, and other agencies.
Impaired stream data provided by PA DEP (2009 data)
Accessed from PASDA

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Stream Quality



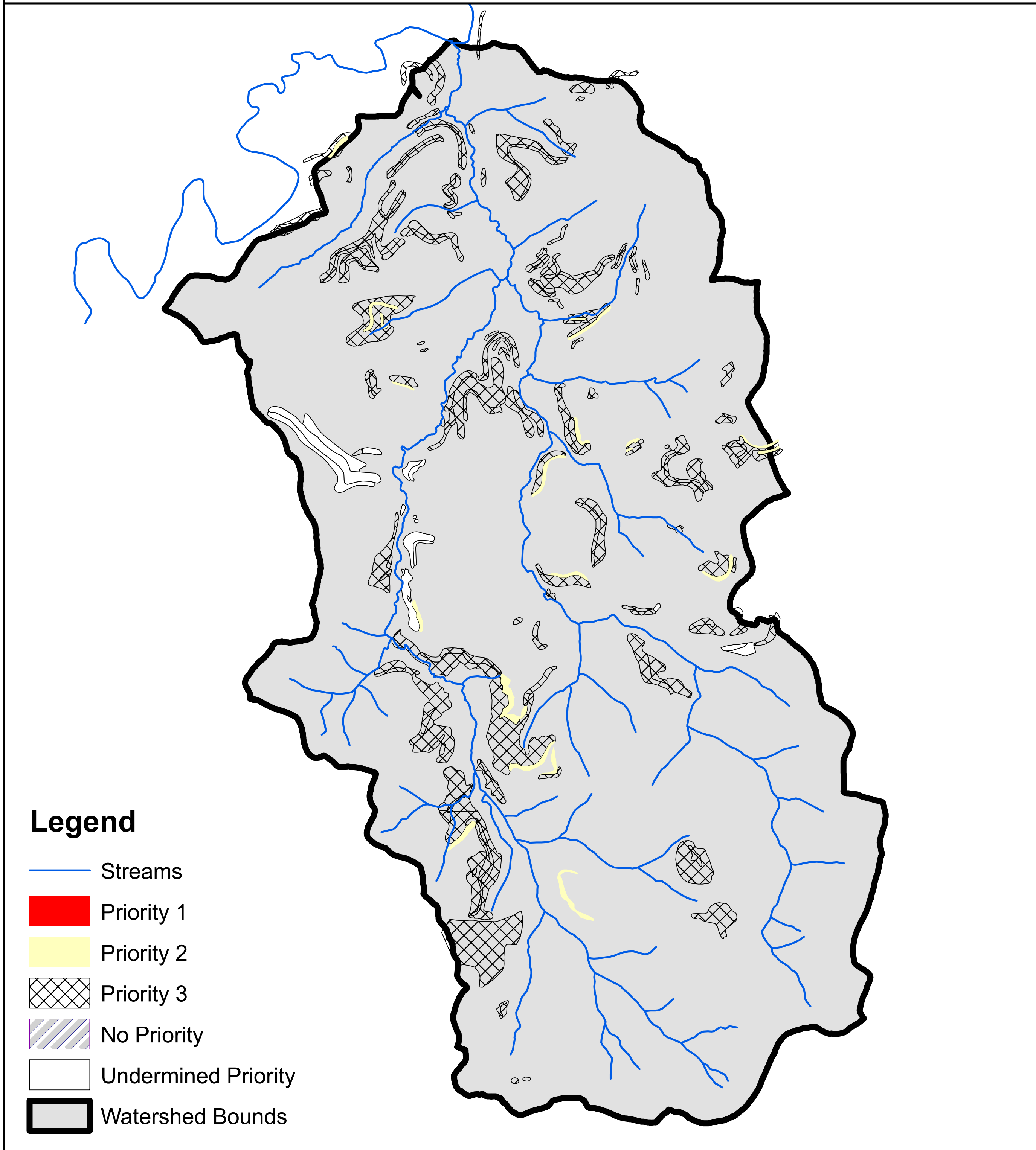
Stream outlines and watershed boundaries
Accessed from PASDA
Stream quality representation based upon results of this assessment

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Identified AML Areas

N



0 750 1,500 3,000 4,500 6,000 Meters

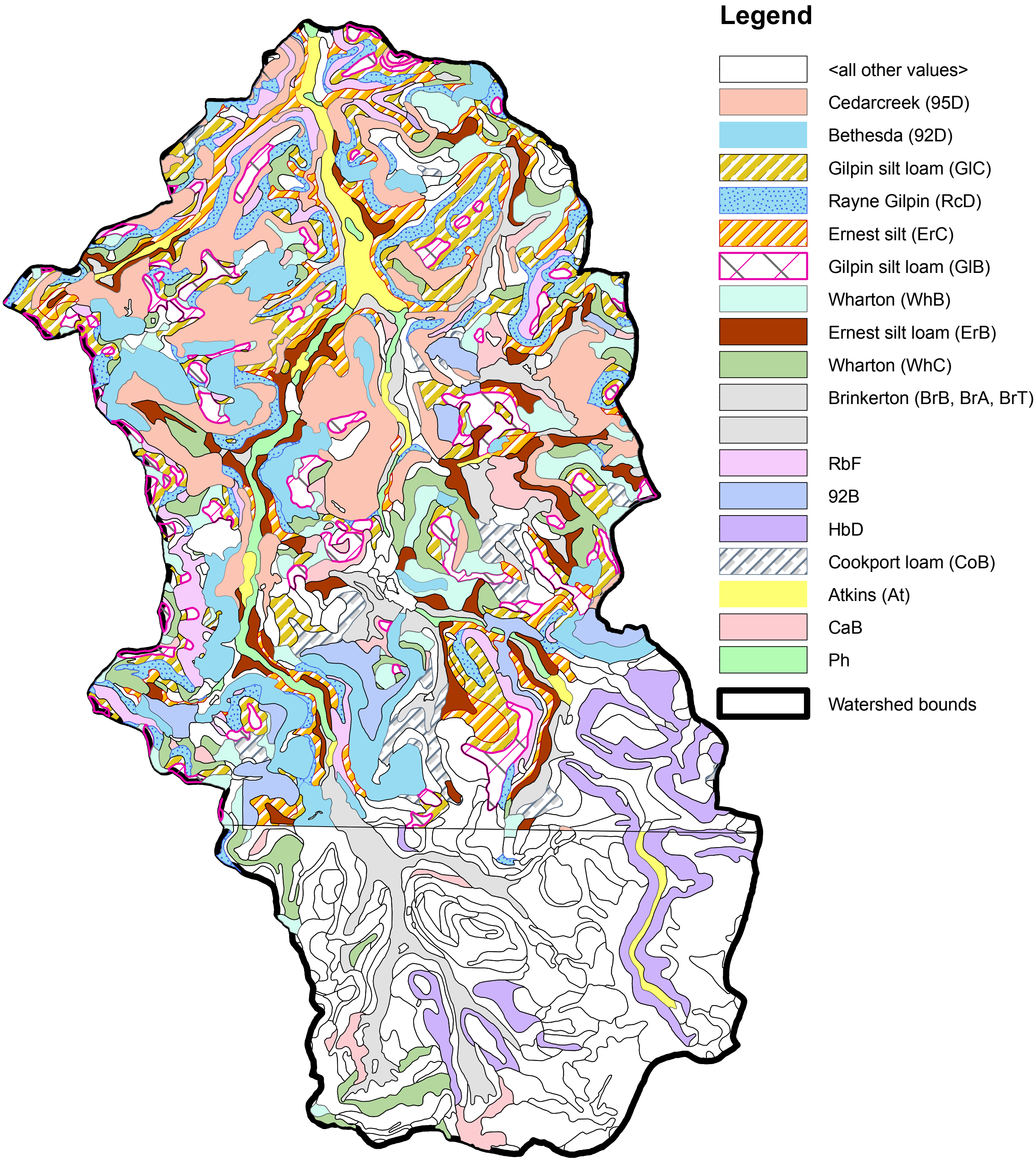
1:80,000

Stream outlines provided by USGS, EPA, USDA Forest Service, and other agencies. AML Data from DEP 2008 list Accessed from PASDA

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

Soils

N



0 800 1,600 3,200 4,800 6,400 Meters

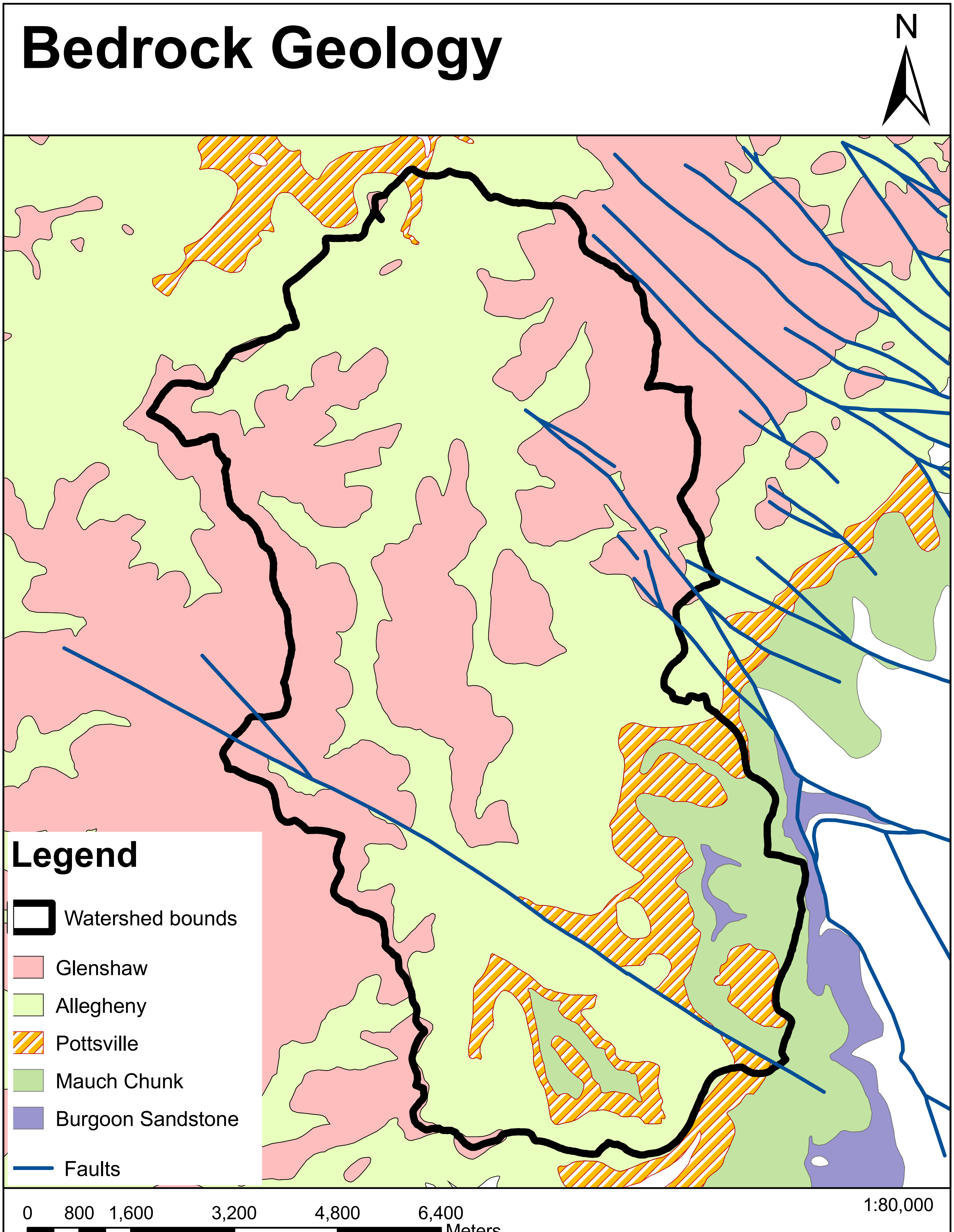
1:80,000

Soil data provided by NRCS

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS NEW MILES OF BLUE STREAM

Bedrock Geology



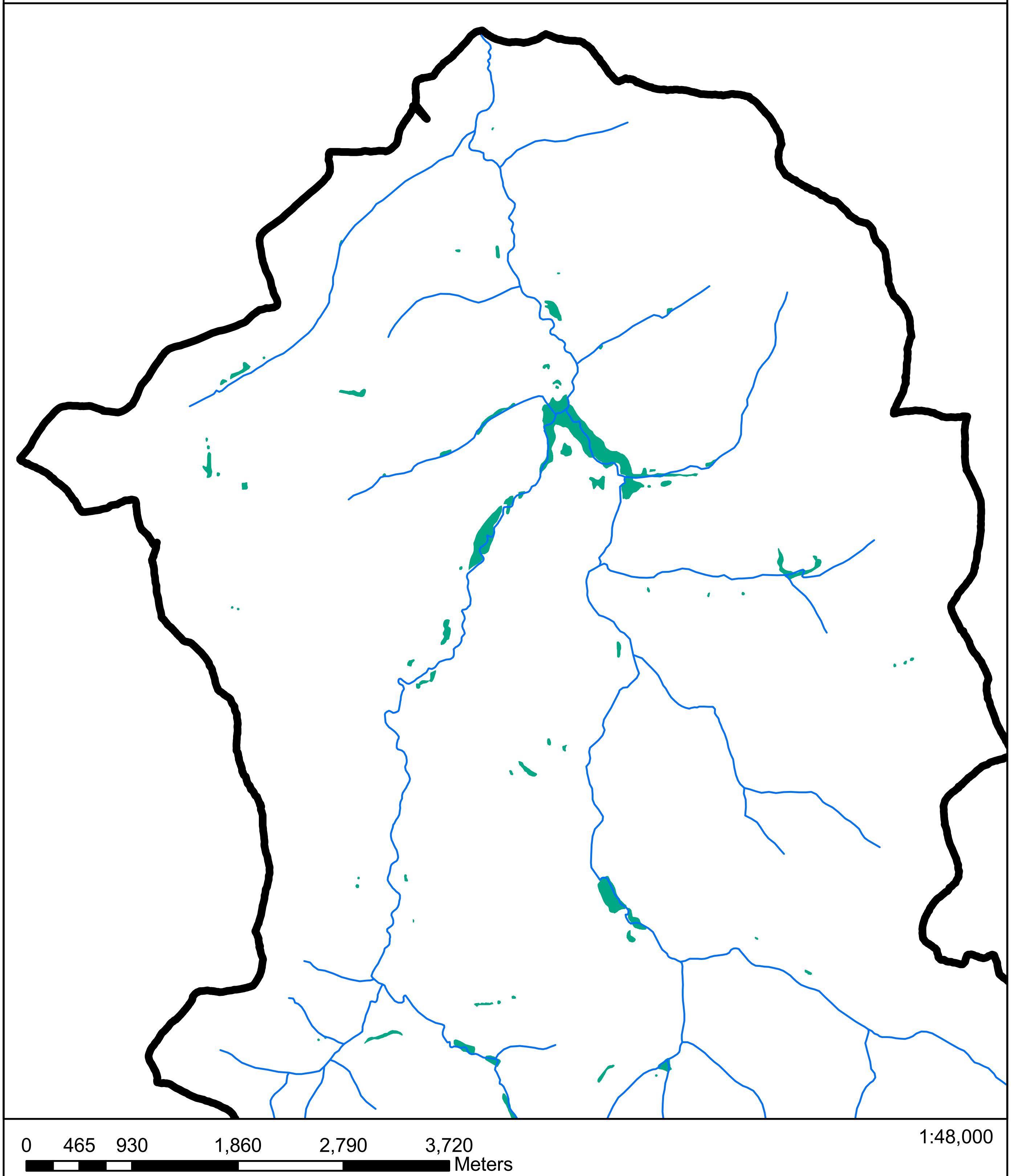
Geology data from the PA Bureau of Topographic & Geologic Survey, Dept. of Conservation & Natural Resources

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Wetlands locations (NWI catalog)

upper half of Muddy Run



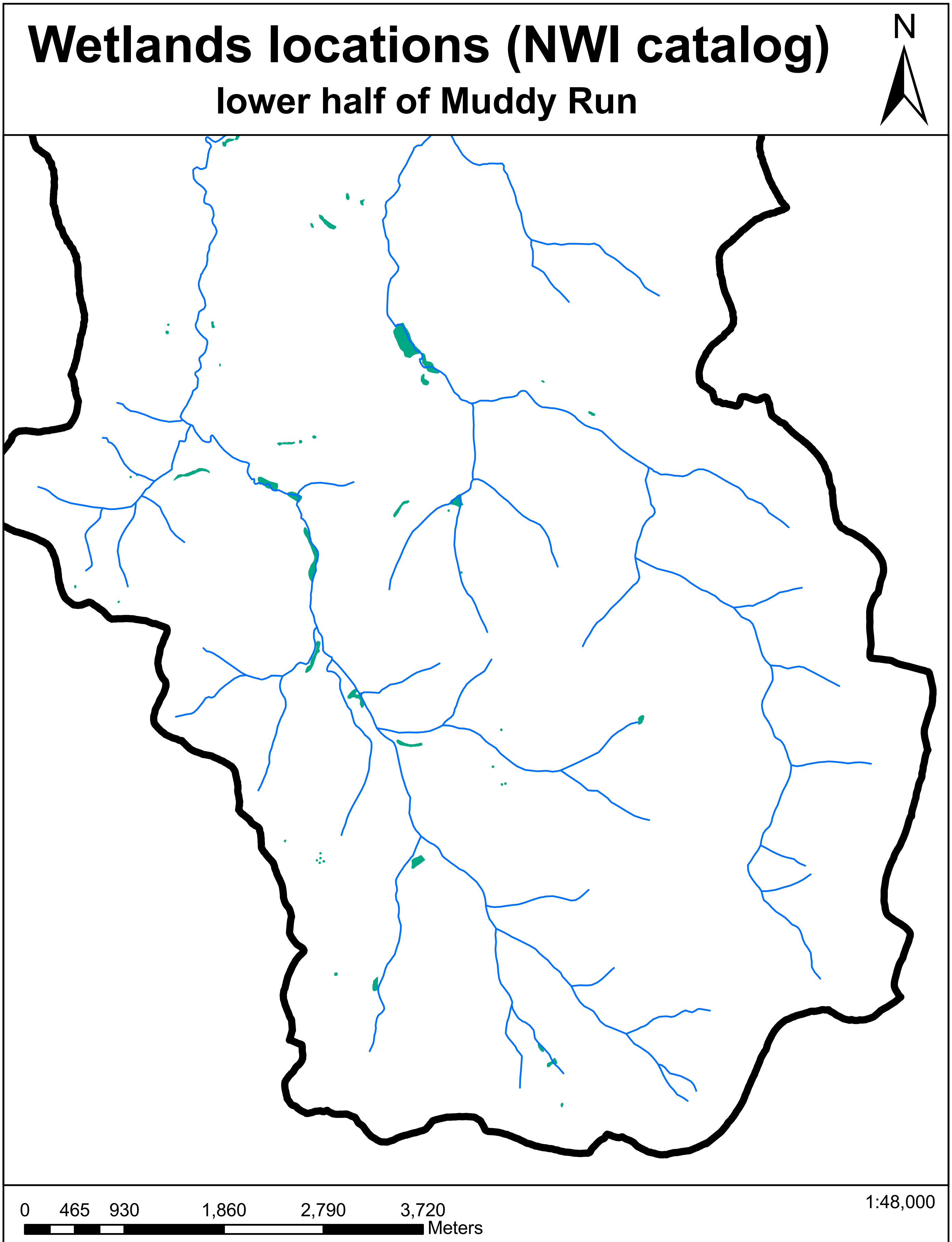
Waterhsed boundary and stream shapes provided by PASDA
NWI shapes provided by US Fish & Wildlife Service National Wetlands Inventory

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Wetlands locations (NWI catalog)

lower half of Muddy Run

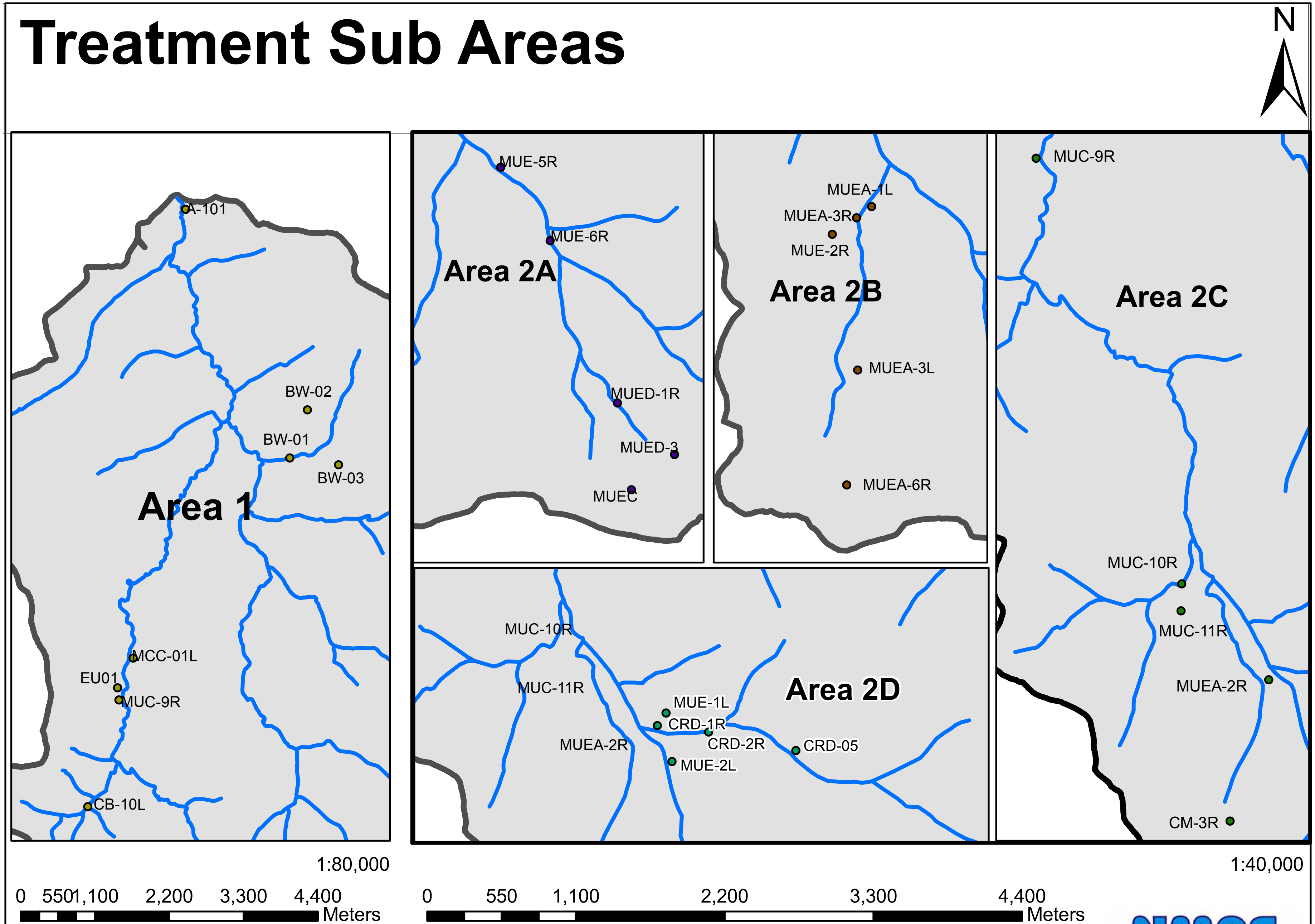


Waterhsed boundary and stream shapes provided by PASDA
NWI shapes provided by US Fish & Wildlife Service National Wetlands Inventory

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Treatment Sub Areas



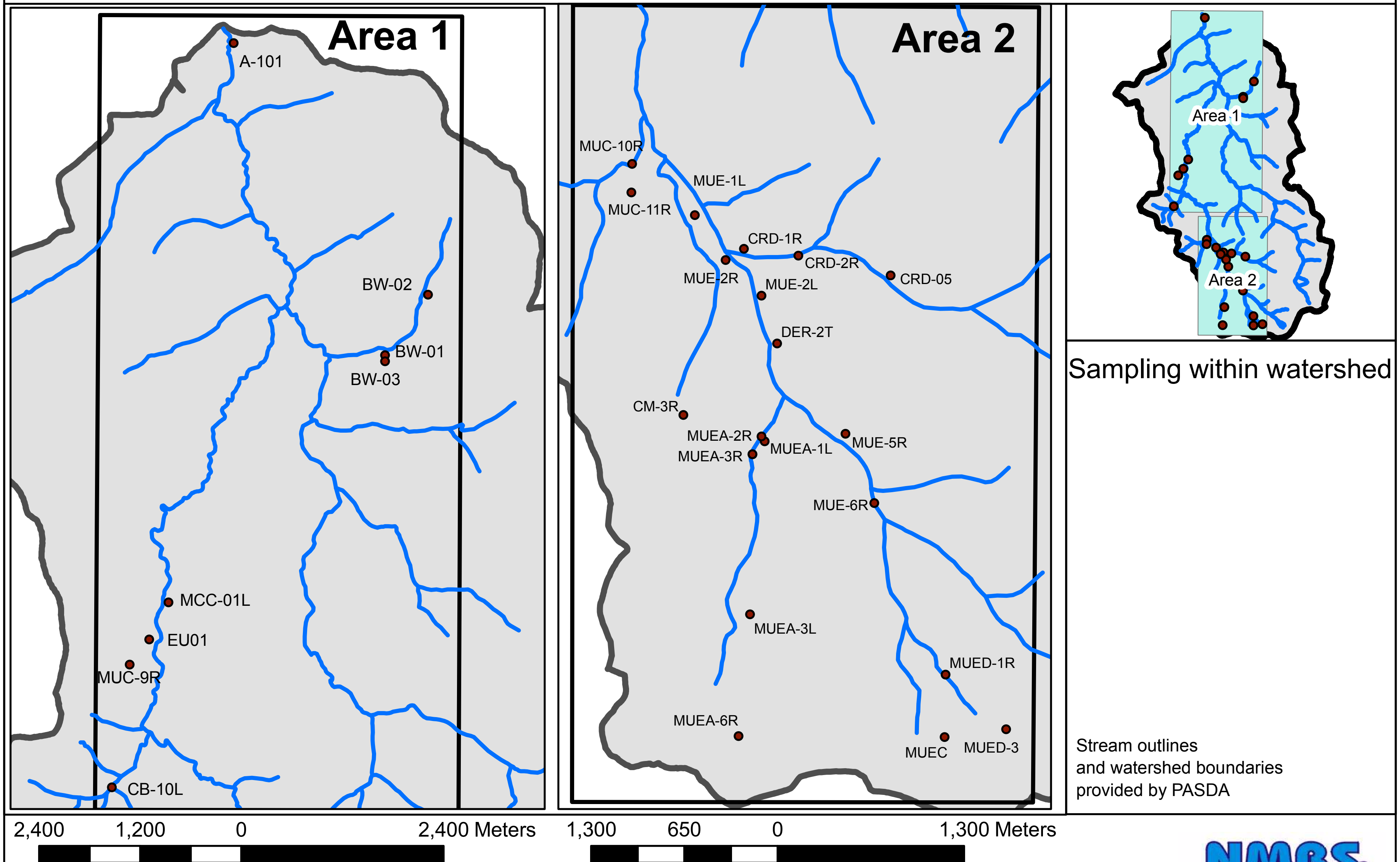
Stream outlines and watershed boundaries provided by PASDA

Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Monthly Sampling points

N

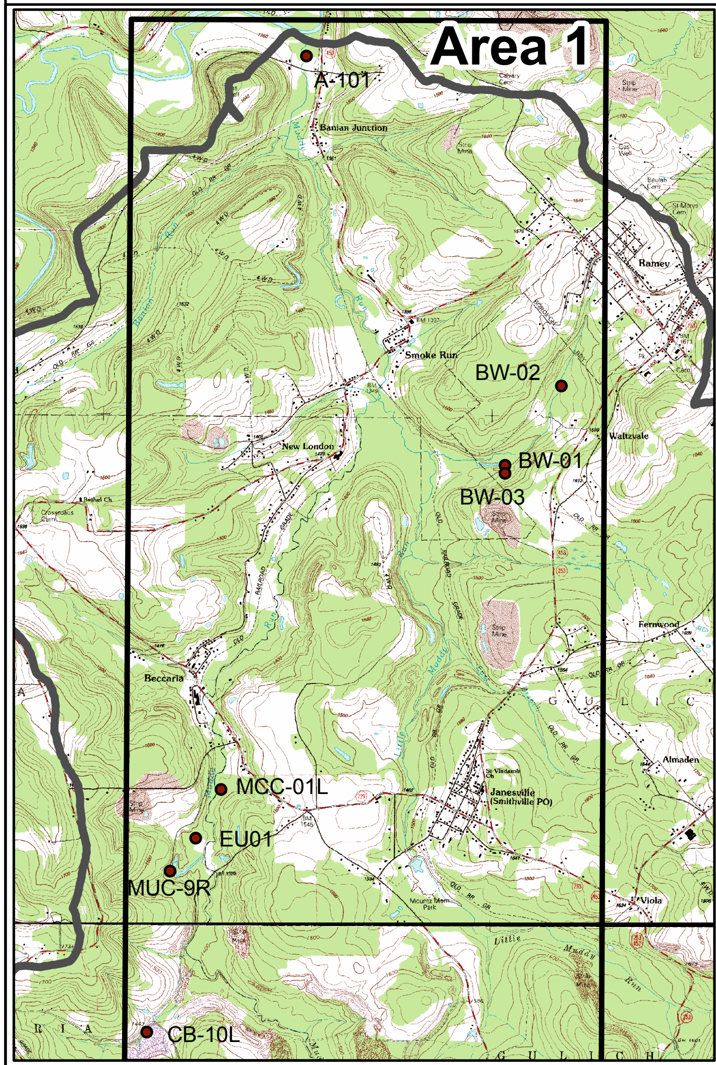


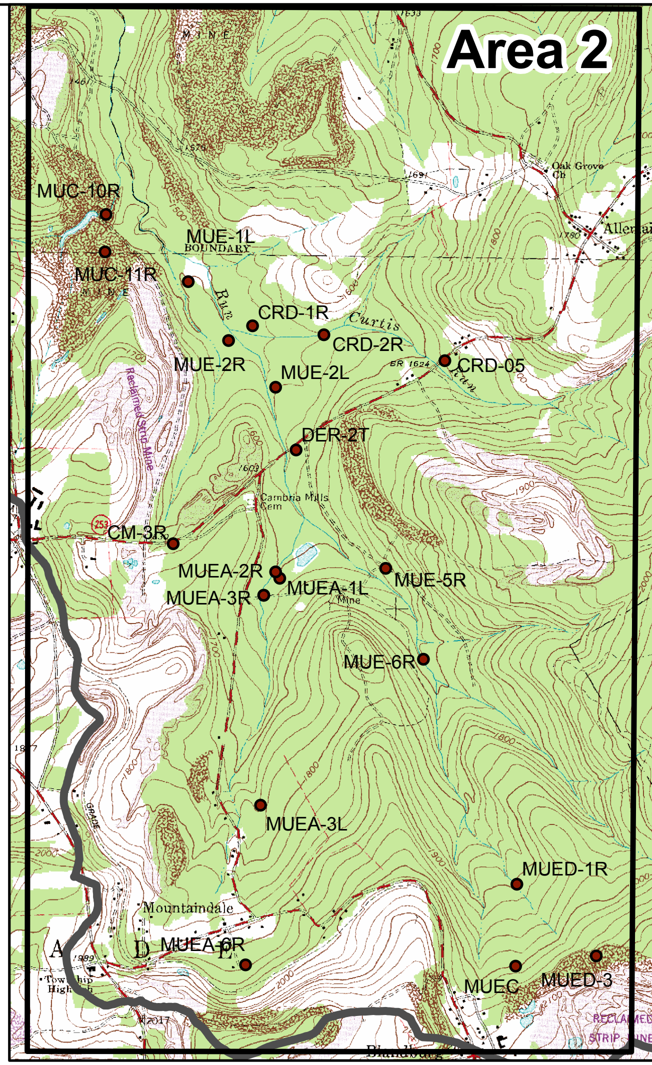
Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

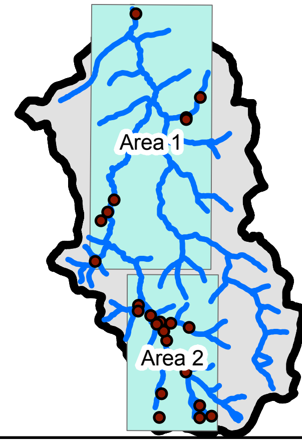
NEW MILES OF BLUE STREAM

Monthly Sampling points on topo maps

N







Sampling within watershed

Stream outlines
and watershed boundaries
provided by PASDA

2,400 1,200 0 2,400 Meters

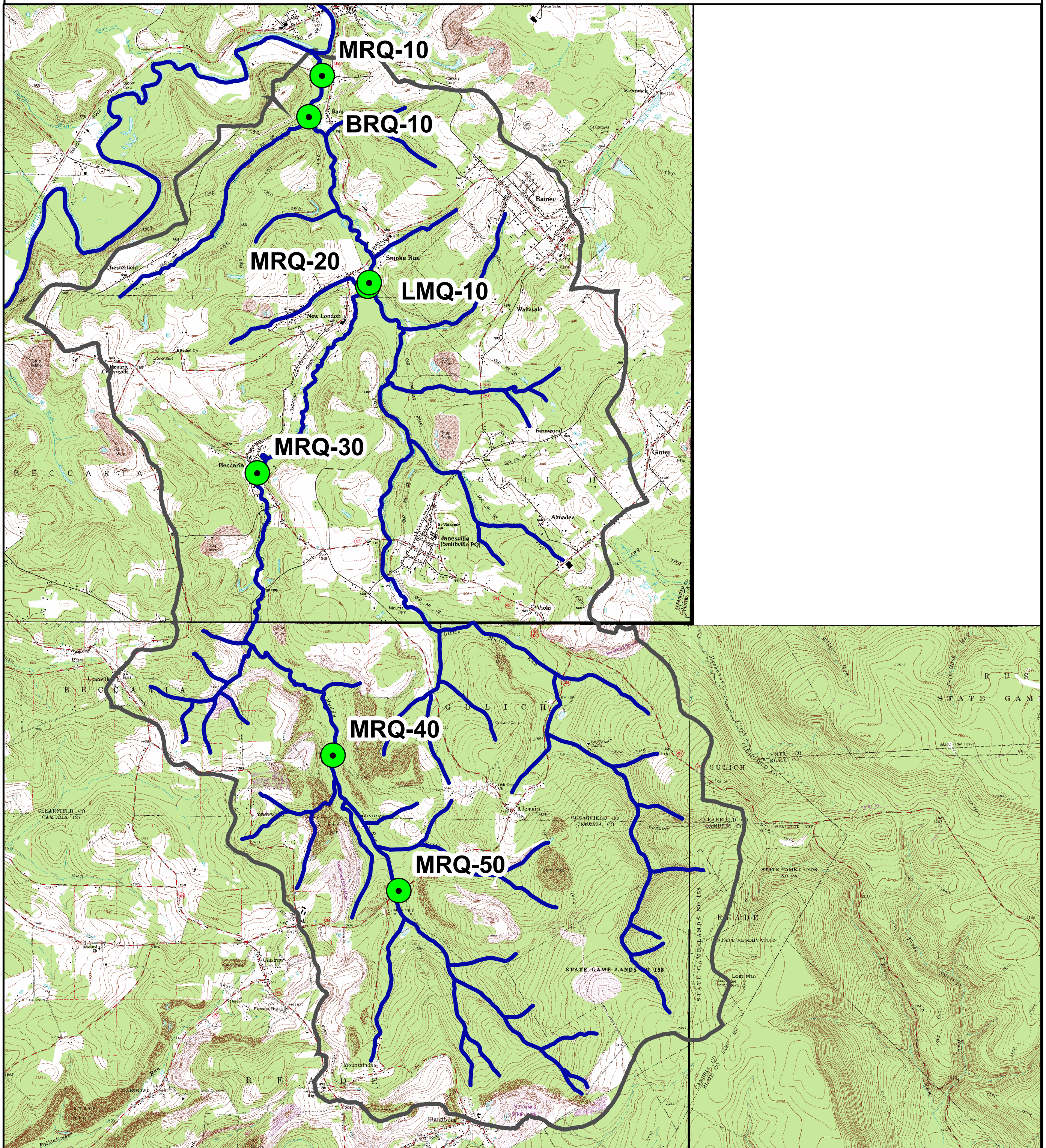
1,300 650 0 1,300 Meters

A-15

Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Muddy Run Quarterly Points



0 750 1,500 3,000 4,500 6,000 Meters

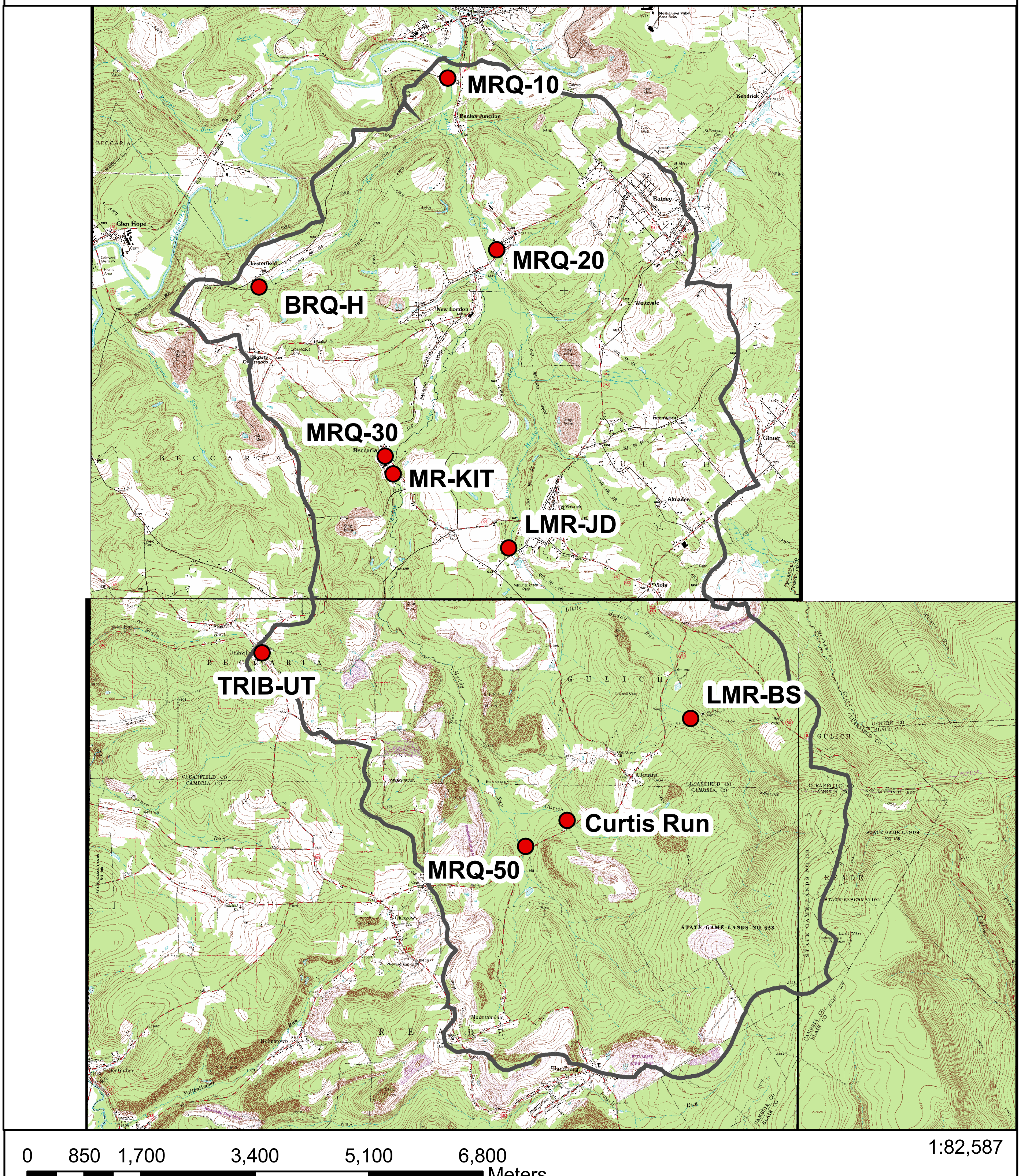
1:80,130

Topographic Map: 7.5 minute Raster graphics
Provided by PASDA

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NEW MILES OF BLUE STREAM

Macro-invertebrate sampling points



Topographic Map: 7.5 minute Raster graphics
Provided by PASDA

Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS
NEW MILES OF BLUE STREAM

Approximate Permit locations

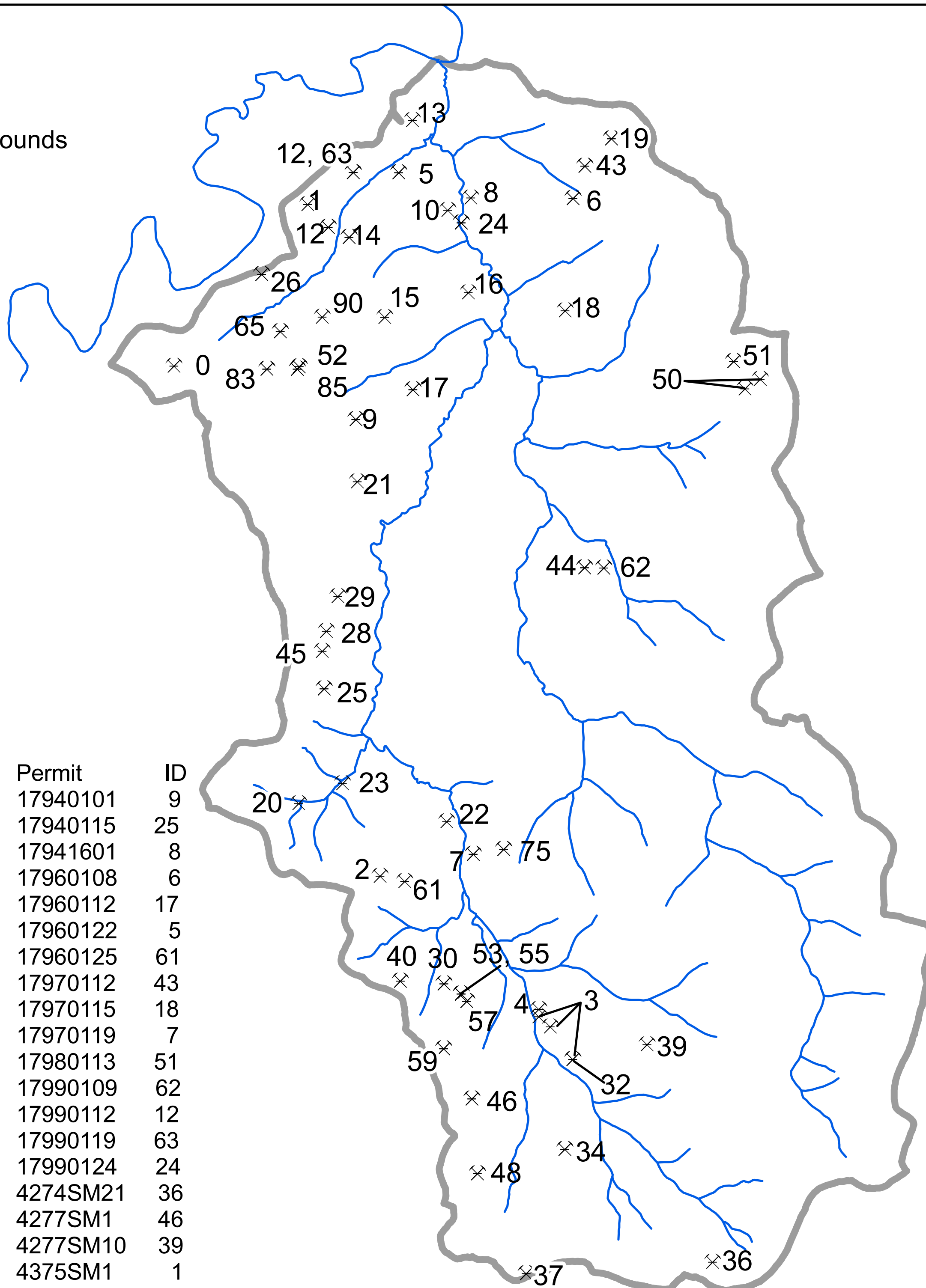
N

Legend

Streams

Watershed Bounds

Permit



Permit	ID
1179101	37
1179106	48
11000101	57
11020102	59
11810106	55
11813021	53
11840112	34
11850106	3
11860105	40
11960101	30
17000105	44
17010109	13
17030120	83
17040102	26
17040109	14
17070104	65
17080102	90
17080115	85
17793090	22
17810121	0
17813153	21
17840120	20
17840130	19
17870109	2
17870118	28
17880123	10
17900109	15
17900138	29
17910102	23
17910127	52
17910129	50
17910132	75
17920104	16

Permit	ID
17940101	9
17940115	25
17941601	8
17960108	6
17960112	17
17960122	5
17960125	61
17970112	43
17970115	18
17970119	7
17980113	51
17990109	62
17990112	12
17990119	63
17990124	24
4274SM21	36
4277SM1	46
4277SM10	39
4375SM1	1
4376SM16	45

0 750 1,500 3,000 4,500 6,000 Meters

A-8

1:80,000

Stream outlines provided by USGS, EPA, USDA Forest Service, and other agencies.
Permit data provided by DEP through 2010. Some permits are missing from this representation.

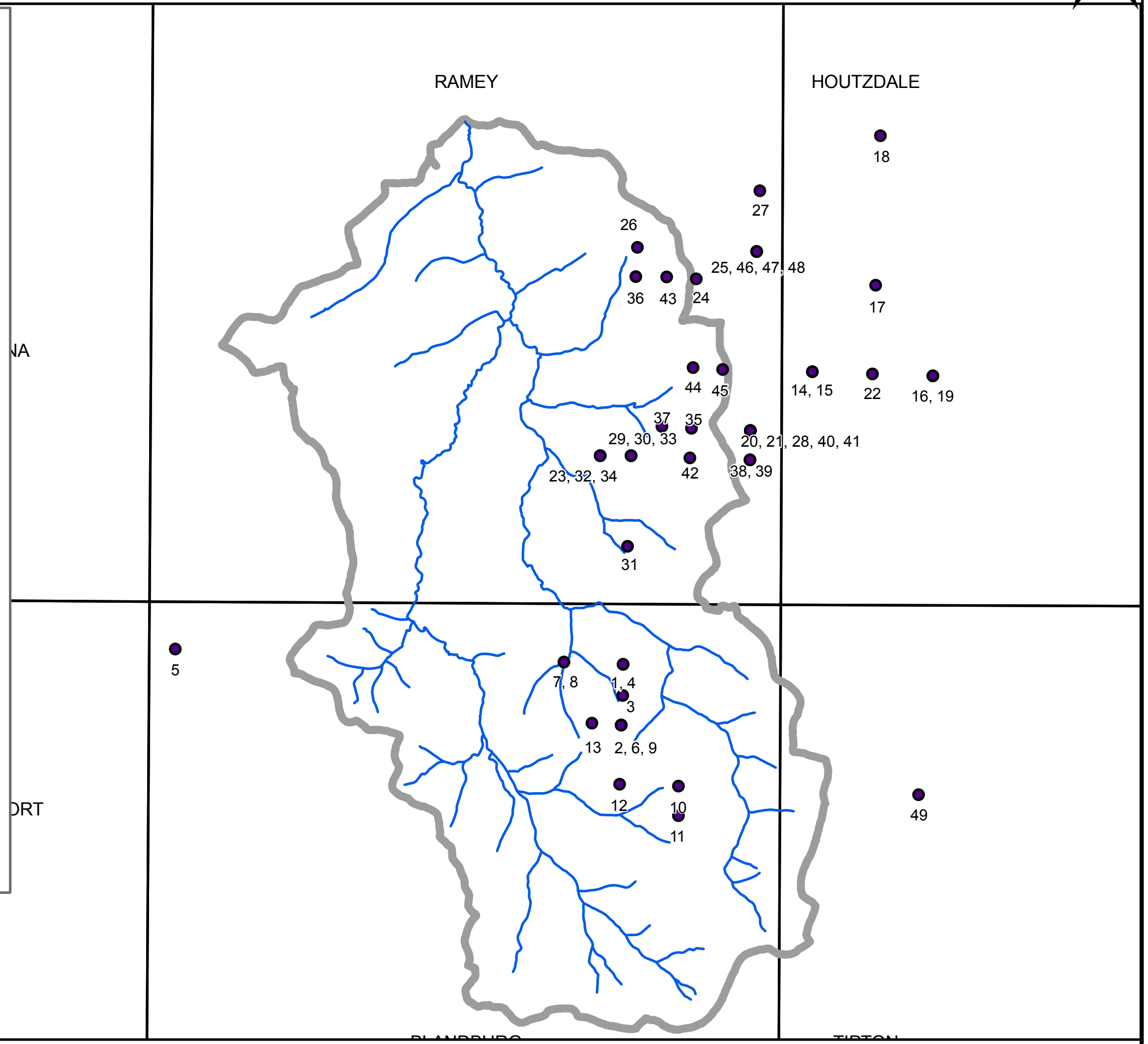
Map is intended as representational.
Size and position of map elements are not guaranteed in size or placement.

NMBS NEW MILES OF BLUE STREAM

Approximate location of mines in mine maps

N

ID	DOCUMENT #	ID	DOCUMENT #
1	303254	27	325481
2	304091	28	303117
3	304141	29	303181
4	306866	30	303186
5	314594	31	303203
6	316131	32	303205
7	318606	33	303218
8	318607	34	303224
9	325055	35	303234
10	325497	36	303280
11	325549	37	304086
12	349599	38	307408
13	358363	39	319328
14	302622	40	319391
15	303086	41	319395
16	303184	42	324546
17	303187	43	325481
18	306570	44	325599
19	318530	45	358342
20	319391	46	371702
21	319395	47	371703
22	325479	48	371716
23	325481	49	349647
24	325481		
25	325481		
26	325481		



Reported location of mine maps by file name

1:125,697

0 1,375 2,750 5,500 8,250 11,000 Meters

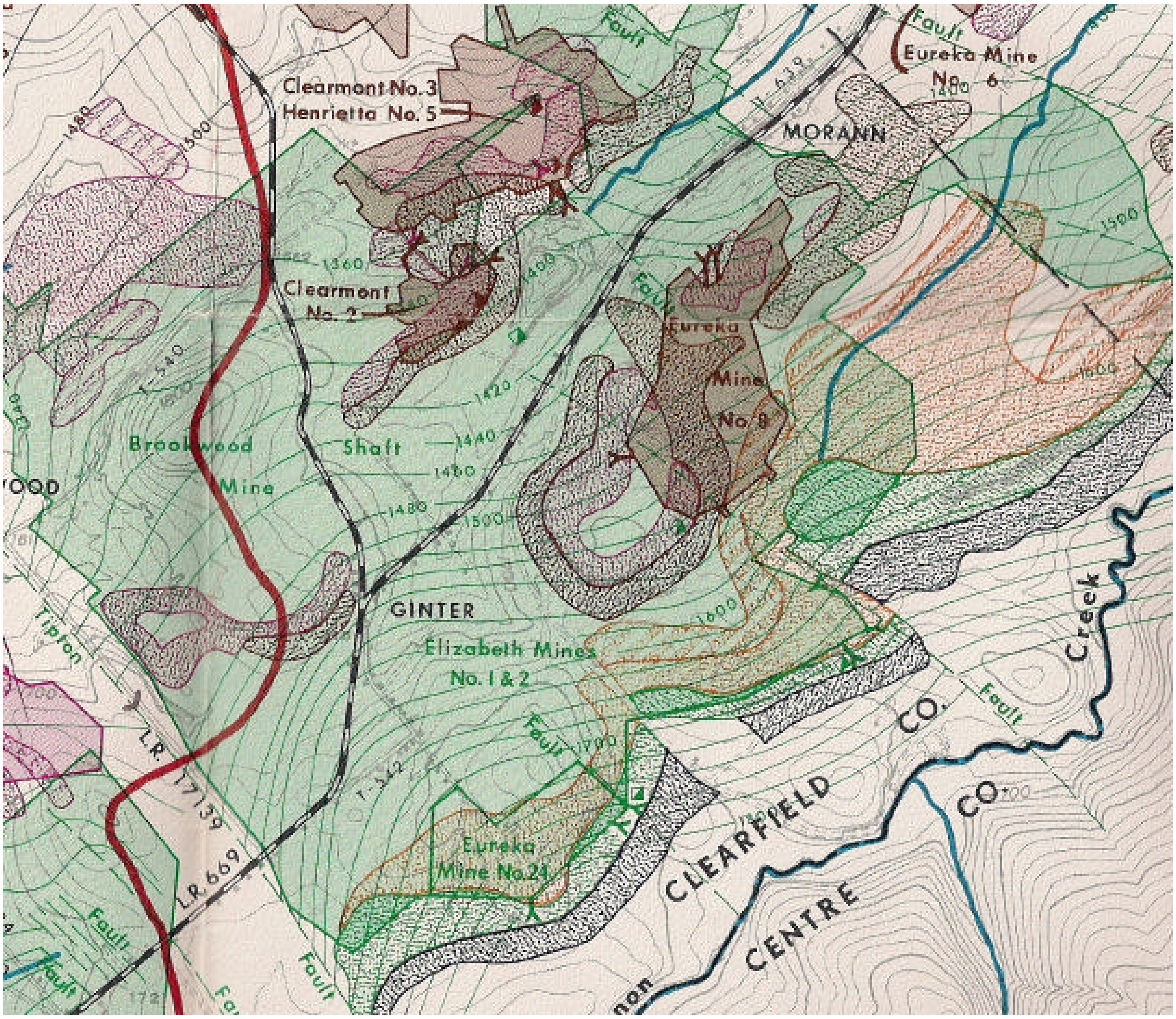
Watershed & civil boudaries provided by PASDA. Mine map locations derived from data provided by the Bureau of Mines.
Map is intended as representational. Size and position of map elements are not guaranteed in size or placement.

NEW MILES OF BLUE STREAM

Brookwood Mine

This image has been cropped for display. Find the original file and other maps under the "Mine maps" section on the CD.

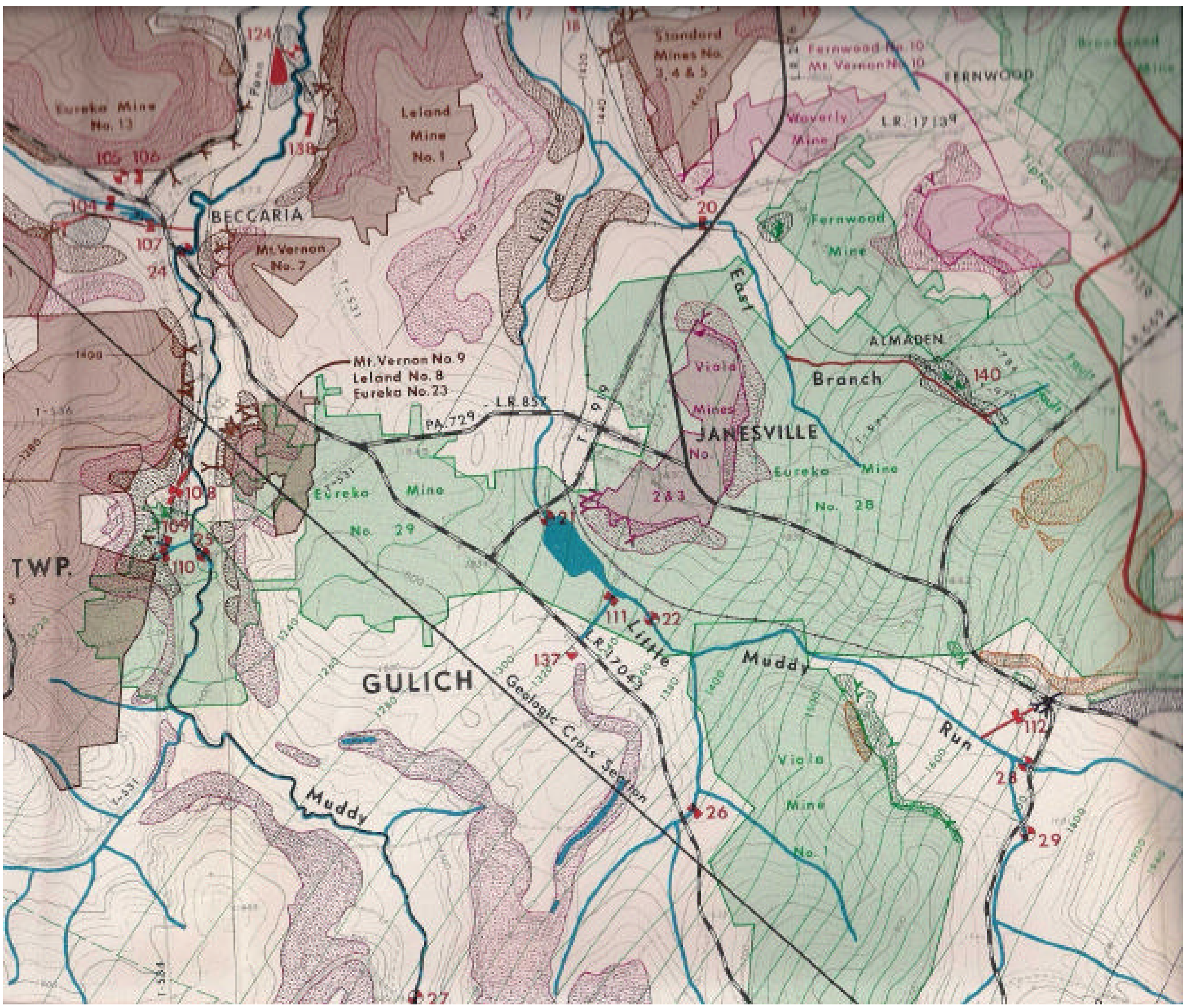
This image was submitted by CCWA for inclusion in this document. It appears to be a portion of the Scarlift map. Scarlift maps can be found at http://www.amrclearinghouse.org /Sub/SCARLIFTReports/ MuddyRun/MuddyRun.htm.



Eureka Mine

This image has been reduced for display. Find the original file and other maps under the "Mine maps" section on the CD.

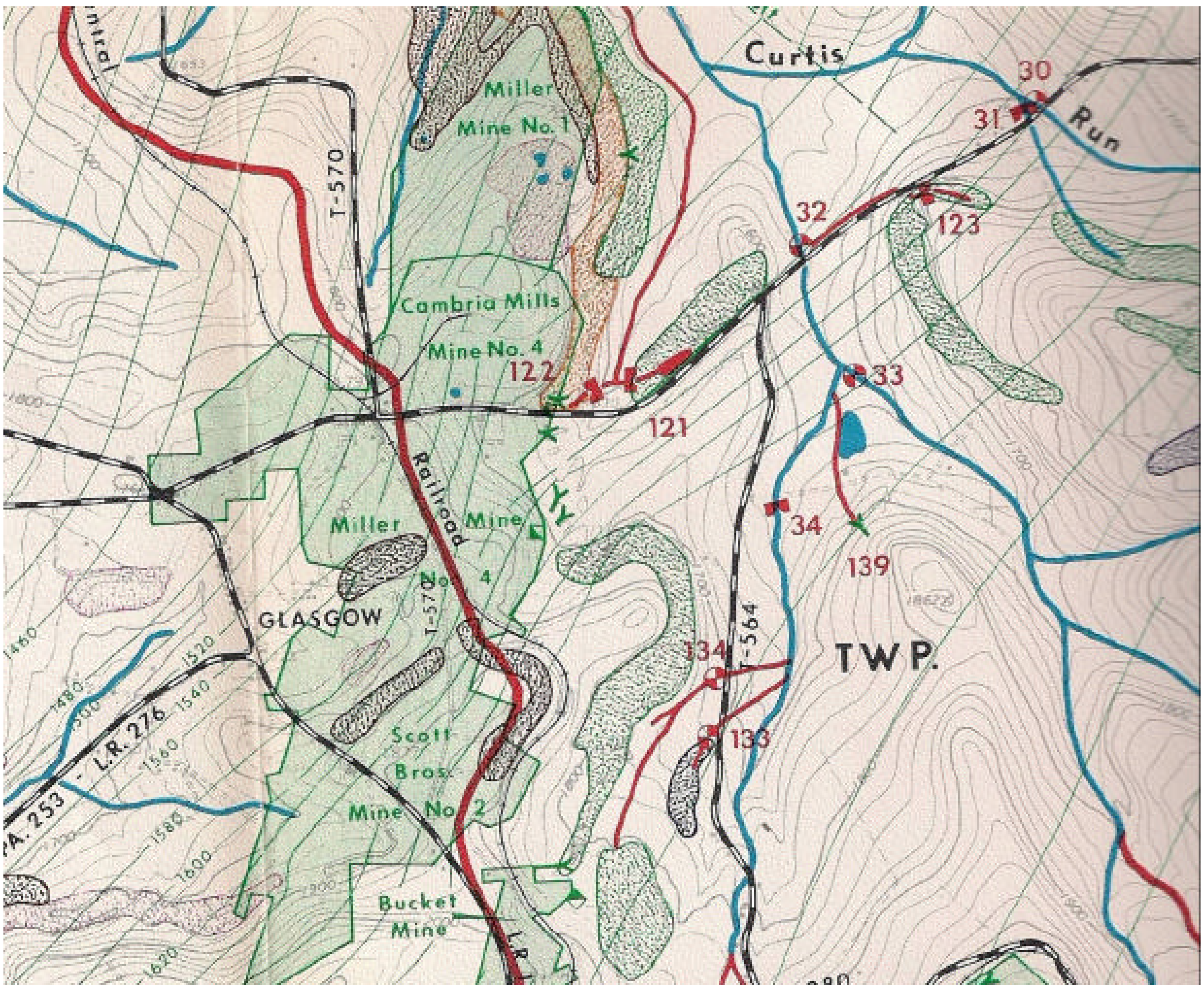
This image was submitted by CCWA for inclusion in this document. It appears to be a portion of the Scarlift map. Scarlift maps can be found at http://www.amrclearinghouse.org /Sub/SCARLIFTReports/ MuddyRun/MuddyRun.htm.



Miller Mine

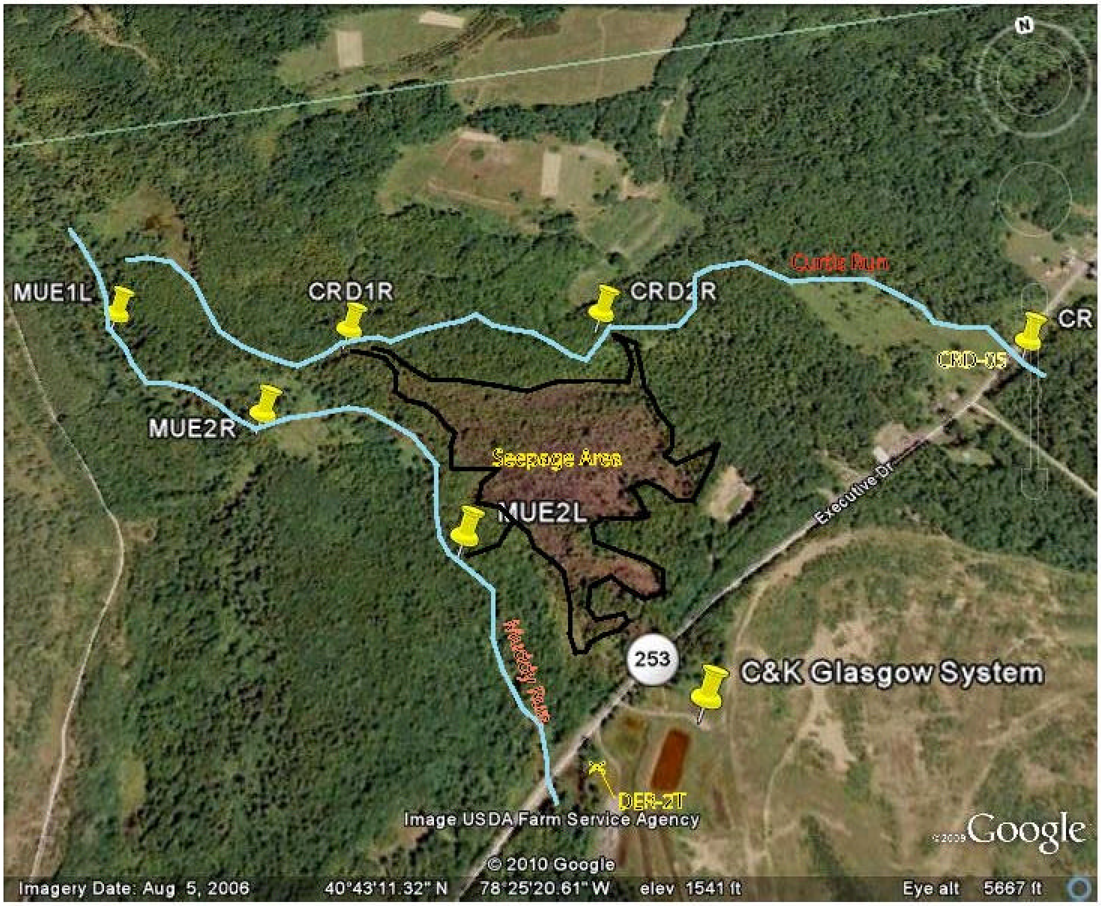
This image has been cropped for display. Find the original file and other maps under the "Mine maps" section on the CD.

This image was submitted by CCWA for inclusion in this document. It appears to be a portion of the Scarlift map. Scarlift maps can be found at http://www.amrclearinghouse.org /Sub/SCARLIFTReports/ MuddyRun/MuddyRun.htm.



Seepage Area

This image was provided by the Clearfield Creek Watershed Association technical committee and was identified as illustrating the seepage area feeding CRD-2R, CRD-1R and MUE-2L, and nearby sites.



Appendix B: Associated files

The following table lists the files which were collected during the process of developing this assessment. These files can be found on the accompanying CD. To access associated information on the CD, open the file “index.html.” A copy of the CD will be available for some period of time at http://www.newmilesofbluestream/assess/muddy/index.html

Assessment Data

The assessment data is available on the CD. It is in a CSV file format (text). A definition of the data included is also included. The reference for the data files and the definition of the fields are both available under the menu option “Data.”

Images

Pictures taken during the assessment are catalogued and made available on the CD. To access pictures, select “View Pictures” from the menu.

Landowners

A list of landowner information that was obtained during the research prior to starting the assessment is available. This list is dated and is likely to not be completely correct even when this document is initially published.

Mine Maps

Mine maps for the assessment area were obtained from the OSM Bureau of Mines. These are catalogued by USGS quadrant. A catalogue of the available mine maps is available under the menu option “Mine maps.”

Penn State TMDL

The objective of this study completed by Penn State students was to develop TMDLs for the Muddy Run watershed. At each of the sampling points, stream flow data was collected to determine the stream flow rate. Water quality measurements were taken to determine the pH, conductivity, temperature and total dissolved solids (TDS) in the stream. Samples were also collected and analyzed in a lab to determine the acidity, alkalinity, total suspended solids (TSS) and turbidity of the water.

Sulfate and metals analysis were also conducted in the lab. In displaying and analyzing the collected data, this report serves as an aid to locate significant problem sources and identify any unknown pollutants or issues. Evaluation of pollutant loads helps to quantify reductions needed to achieve the PADEP water quality criteria.

Unsuitable for Mining Report

This report contains information and comments as determined by the PA Environmental Quality Board in reference to a submission to make areas unsuitable for mining in the Muddy Run Watershed.

Appendix C: Alternate Ranking Orders

Stream miles

The below ranking is based on the criteria for prioritization within the restoration plan. It is based on sub-areas moving from the headwaters of those sections downstream to maximize stream miles restored. Due to the size of the watershed and the number of treatment systems necessary for restoration, the area was broken into smaller segments to focus restoration efforts. By focusing on each area beginning in the headwaters of that area, stream miles can be recovered and a fishery can begin to be restored. This is presented as Option #1 for restoration efforts and is being put forth as the recommendation for priority treatment systems and reclamation areas. The loads presented represent 90% of the design chemistry loads. Each system is designed to treat 100% of the design chemistry, but as a safety factor, 90% load removal is reported for system effectiveness.

Area	Site	Reclamation Yes or No	Potential Active Yes or No	Acid Load lbs/day	Iron Load lbs/day	Aluminum Load lbs/day
#1	EU-01	No	Yes	1230	147	98
#1	BW-01	No	Yes	183	388	9
#1	BW-02	No	No		15	
#1	BW-03	No	No			
#1	A1-01	Yes	Yes	630	320	9
#2A	MUEC	Yes	Yes	525	16	58
#2A	MUE-6R	No	No	280	0.5	30
#2A	MUED-3	Yes	No	140	0.2	14
#2A	MUED-1R	Yes	No	43	0.8	3.7
#2A	MUE-5R	No	No	42	0.7	4.9
#2B	MUEA-6R	Yes	No	309	16	30
#2B	MUEA-3L	Yes	No	180	7	13
#2B	MUEA-2R	No	No	18	1.6	0.6
#2B	MUEA-3R	No	No	18	1	1
#2B	MUEA-1L	No	No		1	
#2C	MUC-11R	No	No	350	52	21
#2C	CM-3R	No	No	20	0.6	0.2
#2C	MUE-2R	No	No	13	1	0.7
#2C	MUC-10R	Yes	No		42	8
#2C	MUC-9R	Yes	No		5	2

Area	Site	Reclamation Yes or No	Potential Active Yes or No	Acid Load lbs/day	Iron Load lbs/day	Aluminum Load lbs/day
#2D	CRD-05	No	Yes	17	0.24	2.4
#2D	MUE-2L	No	No	310	16	18
#2D	CRD-1R	No	No	255	10	60
#2D	MUE-1L	No	No	12	0.2	0.4
#2D	CRD-2R	No	No	0	1.2	1.6

**The load removals for CRD-05 are for partial treatment

Acid Load

The below ranking is based solely on acid load entering Muddy Run. This ranking would not necessarily allow for the restoration of stream miles, but would remove acid load from both the Muddy Run Watershed and subsequently the West Branch of the Susquehanna. Because most of Muddy Run is on the “tipping point” for restoration, by focusing on the largest inputs of acid and metal loadings may allow for a “quicker” restoration to the main stem. This is presented as Option #2 for restoration efforts and should be considered by the project partners.

Area	Site	Reclamation Yes or No	Potential Active Yes or No	Acid Load lbs/day	Iron Load lbs/day	Aluminum Load lbs/day
#1	EU-01		Yes	1230	147	98
#2A	MUEC	Yes	Yes	525	16	58
#1	A1-01	Yes	Yes	630	320	9
#2C	MUC-11R	No	No	350	52	21
#2D	MUE-2L	No	No	310	16	18
#2B	MUEA-6R	Yes	No	309	16	30
#2A	MUE-6R	No	No	280	0.5	30
#2D	CRD-1R	No	No	255	10	60
#1	BW-01		Yes	183	388	9
#2B	MUEA-3L	Yes	No	180	7	13
#2A	MUED-3	Yes	No	140	0.2	14
#2A	MUED-1R	Yes	No	43	0.8	3.7
#2A	MUE-5R	No	No	42	0.7	4.9
#2B	MUEA-2R	No	No	18	1.6	0.6
#2B	MUEA-3R	No	No	18	1	1
#2C	CM-3R	No	No	20	0.6	0.2
#2D	CRD-2R	No	No	20	1.2	1.6

Area	Site	Reclamation Yes or No	Potential Active Yes or No	Acid Load lbs/day	Iron Load lbs/day	Aluminum Load lbs/day
#2D	CRD-05	No	Yes	17	0.24	2.4
#2C	MUE-2R	No	No	13	1	0.7
#2D	MUE-1L	No	No	12	0.2	0.4
#2C	MUC-10R	Yes	No		42	8
#2C	MUC-9R	Yes	No		5	2
#1	BW-02	No			15	
#1	BW-03	No				
#2B	MUEA-1L	No	No		1	

Iron Load

The below ranking is based solely on iron load entering Muddy Run. This ranking would not necessarily allow for the restoration of stream miles, but would remove iron load from both the Muddy Run Watershed and subsequently the West Branch of the Susquehanna. Because most of Muddy Run is on the "tipping point" for restoration, by focusing on the largest inputs of metal loadings may allow for a "quicker" restoration to the main stem. This is presented as Option #3 for restoration efforts and should be considered by the project partners.

Area	Site	Reclamation Yes or No	Potential Active Yes or No	Acid Load lbs/day	Iron Load lbs/day	Aluminum Load lbs/day
#1	BW-01		Yes	183	388	9
#1	A1-01	Yes	Yes	630	320	9
#1	EU-01		Yes	1230	147	98
#2C	MUC-11R	No	No	350	52	21
#2C	MUC-10R	Yes	No		42	8
#2A	MUEC	Yes	Yes	525	16	58
#2D	MUE-2L	No	No	310	16	18
#2B	MUEA-6R	Yes	No	309	16	30
#1	BW-02	No			15	
#2D	CRD-1R	No	No	255	10	60
#2B	MUEA-3L	Yes	No	180	7	13
#2C	MUC-9R	Yes	No		5	2
#2B	MUEA-2R	No	No	18	1.6	0.6
#2D	CRD-2R	No	No	20	1.2	1.6
#2B	MUEA-3R	No	No	18	1	1

Area	Site	Reclamation Yes or No	Potential Active Yes or No	Acid Load lbs/day	Iron Load lbs/day	Aluminum Load lbs/day
#2B	MUEA-1L	No	No		1	
#2C	MUE-2R	No	No	13	1	0.7
#2A	MUED-1R	Yes	No	43	0.8	3.7
#2A	MUE-5R	No	No	42	0.7	4.9
#2C	CM-3R	No	No	20	0.6	0.2
#2A	MUE-6R	No	No	280	0.5	30
#2A	MUED-3	Yes	No	140	0.2	14
#2D	CRD-05	No	Yes	17	0.24	2.4
#2D	MUE-1L	No	No	12	0.2	0.4
#1	BW-03	No				

Appendix D: Soil Descriptions

The following text describes the dominant soil types in the watershed. Differences exist by county in how some of the soils are identified and grouped, so names will vary between each county. The analysis completed for this document attempted to reasonably aggregate similarly identified soil groupings.

Atkins silt loam (At)

This soil is nearly level, deep, poorly drained and found on flood plains which are frequently flooded. Slopes range from zero to three percent. The permeability is slow to moderate in the subsoil and moderately slow to rapid in the substratum. The available water capacity is high and runoff is very slow. Reaction in un-limed areas is strongly to very strongly acid. The seasonal high water table of this soil unit is between the surface and a depth of 1 foot; a slight hazard of erosion exists. This soil is considered hydric and is also included on the list of Statewide Important Farmland Soils of Clearfield County, Pennsylvania; however, much of the soil surrounding this stream has been disturbed by surface mining. This soil unit belongs to Hydrologic Group D with very brief, frequent flooding from September through July. Frequent flooding and the high water table limit the use of this soil for most non-farm uses. It is especially unsuited to onsite waste disposal. According to the soil survey, Atkins silt loam is fairly well to well suited for wetland plants, openland, woodland, and wetland wildlife.

Bethesda very channery silt loam, 0 to 8 percent slopes (92B)

Bethesda soils were formerly mapped as mine spoils. They have no diagnostic horizons. The Bethesda series consists of very deep; well drained soils formed primarily in Pennsylvanian-age acid regolith from surface mine operations. Bethesda soils are on nearly level to gently sloping interfluves, base slopes, head slopes and benches to very steep nose slopes and side slopes. These soils occur on human-modified hills. They are moderately deep to a root restrictive, compacted layer. Reaction ranges from strongly acid to extremely acid except for surface layers that have been reclaimed. Rock fragments include shale, sandstone, siltstone, and coal. Bethesda soils are well drained. Index surface runoff class is low to very high. Permeability is moderate in the upper part and slow or moderately slow in the lower part. The dominant use is wildlife habitat and recreational areas. Most reclaimed areas have been seeded to grasses and some trees. Some of the reclaimed areas are used for hay and pasture.

Bethesda very channery silt loam, 8 to 25 percent slopes (92D)

This soil is very deep, well drained soil formed primarily in Pennsylvanian-age acid regolith from surface mine operations. Bethesda soils are on nearly level to gently sloping interfluves, base slopes, head slopes and benches to very steep nose slopes and side slopes. These soils occur on human-modified hills. The regolith is a mixture of partially weathered fine earth and fragments of bedrock from surface mine operations. Fragments of rock consist mainly of acid shale, siltstone, coal, and medium and fine-grained sandstone. They are moderately deep to a root restrictive, compacted layer. Reaction ranges from strongly acid to extremely acid except for surface layers that have been reclaimed. Rock fragments include shale, sandstone, siltstone, and coal. They range mostly from 2 mm to 25 cm but include stones and boulders. The fine-earth fraction of the control section averages 18 to 35 percent clay. Bethesda soils are well drained. Permeability is moderate in the upper part and slow or moderately slow in the lower part. The dominant use is wildlife habitat and recreational areas. Most reclaimed areas have been seeded to grasses and some trees. Some of the reclaimed areas are used for hay and pasture.

Brinkerton silt loam, 3 to 8 percent slopes (BrB)

This soil unit is gently sloping, deep, and poorly drained. It is found on uplands. Permeability is moderate above the firm part of the subsoil and moderately slow to slow in the firm part, and runoff is slow. Reaction in un-limed areas is medium acid to very strongly acid. The seasonal high water table is from the surface to a depth of six inches, and the erosion hazard is moderate. Most areas of this soil type are in woodland. The soil is also suited to some crops that tolerate seasonal wetness, pasture, and trees. Non-farm uses of this soil are limited by the high water table and permeability. Within the headwaters of Muddy Run, Brinkerton silt loam is found in small areas along some of the tributaries. This soil is listed as a hydric soil.

Cavode silt loam, 3 to 8 percent slopes (CaB)

Cavode soils make up 85 percent of the map unit. This map unit is Farmland of Statewide Importance. The runoff class is very high. The depth to a restrictive feature is 40 to 72 inches to bedrock. It is somewhat poorly drained. The slowest permeability within 60 inches is slow. Available water capacity is moderate and shrink swell potential is moderate. This soil is not subject to flooding and is not ponded. The top of the seasonal high water table ranges from 6 to 18 inches. Major component is not a hydric soil.

Cedarcreek extremely channery loam, moderately steep (95D)

The Cedarcreek series consists of very deep well drained soils with moderate or moderately rapid permeability. These soils formed in acid regolith from the surface mining of coal. The regolith is a mixture of partially weathered fine earth and fragments of bedrock. Rock fragments consist mainly of acid sandstone and siltstone with small amounts of shale and coal. Cedarcreek soils are on nearly level to gently sloping benches, gently sloping to strongly sloping hillslopes, and steep to very steep outslopes. These soils formed in regolith from surface coal mine operations. The regolith is a mixture of partially weathered fine earth and fragments of bedrock. The fine earth material is from fragments of bedrock which have been crushed by machinery and weathered. Depth to bedrock is greater than 5 feet. Reaction ranges from strongly acid to extremely acid except for surface layers that have been limed. Clay content ranges from 18 to 27 percent. Most pedons have red, brown, yellow, or gray lithochromic mottles in some or all horizons.

Cookport channery loam, 3 to 8 percent slopes (CoB)

This soil unit is gently sloping, deep, and moderately well drained. It is found on uplands and is listed as a Prime Farmland of Clearfield County. Permeability is moderate above the firm part of the soil, slow in the firm part, and moderately slow in the substratum. The available water capacity is moderate, and runoff is medium. The reaction in un-limed areas is strongly acid to extremely acid. The high water table is between 18 to 30 inches, and the erosion hazard is moderate. Most areas of this soil are in woodland, and it is also well suited to cultivate crops, pasture, and tree production. Non-farm uses are limited by the high water table and the slow permeability. Within the headwaters of Muddy Run, this soil unit is found in sections throughout the watershed, mainly on the Clearfield County side of the stream.

Ernest silt loam, 3 to 8 percent slopes (ErB)

This soil unit is described as gently sloping, deep, and moderately well drained. It is listed as a Statewide Important Farmland and contains hydric inclusions. The permeability is moderate above the firm part of the subsoil and moderately slow to slow in the firm part and substratum. The available water capacity is moderate, and the runoff is medium. The reaction in un-limed areas is strongly acid or very strongly acid. The high water table is at a depth of 18 to 36 inches, and the erosion hazard is moderate. Most areas are in woodland. This soil unit is suited to cultivated crops, pasture, and trees. Non-farm uses are limited by the high water table and the permeability in the firm part of the subsoil. Within the headwaters of Muddy Run, this soil unit is found in the headwaters of some tributaries.

Ernest silt loam, 8 to 15 percent slopes (ErC)

Ernest silt loam, 8 to 15 percent slopes, is sloping, deep, and moderately well drained. It has moderately-slow to slow permeability and a moderate available water capacity. Runoff is medium, and the erosion hazard of this soil unit is severe. The reaction in un-limed areas is strongly to very strongly acid. The seasonal high water table is 18 to 36 inches. Ernest silt loam, 8 to 15 percent slopes is listed as a Farmland of Statewide Importance. Most areas of this soil are in woodland, but it is also suited to cropland and pasture. Non-farm uses are limited by the high water table and permeability. This soil type is found in the extreme headwater areas of some tributaries.

Gilpin channery silt loam, 3 to 8 percent slopes (GlB)

This soil is gently sloping, moderately deep, and well drained. They are found on uplands. Slopes generally are smooth, and convex, and 200 to 600 feet long. The areas of this soil are irregular in shape and range from about 4 to 50 acres. Permeability is moderate. Available water capacity is moderate. Runoff is medium. Reaction in un-limed areas is strongly acid to extremely acid throughout. The hazard of erosion is moderate. Most areas of this soil are in native vegetation or woodland. Some areas are used for pasture or cultivated areas. This soil is suited for trees.

Gilpin channery silt loam, 8 to 15 percent slopes (GlC)

These soils are sloping, moderately deep, and well drained. They are on uplands. Slopes generally are smooth, and convex, and 100 to 500 feet long. The areas of this soil are irregular in shape and range from about 4 to 50 acres. Permeability is moderate. Available water capacity is moderate; runoff is medium. Reaction in un-limed areas is strongly acid to extremely acid throughout. The hazard of erosion is moderate. Most areas of this soil are in woodland, cultivated, or pasture. Some areas are used for pasture or are in native vegetation. This soil is suited for trees.

Hazleton very stony loam, 8 to 25 percent slopes (HbD)

Hazleton soils make up 95 percent of the map unit. Not classified as Prime or Statewide Important Farmland. The runoff class is low. The depth to a restrictive feature is 40 to 80 inches to bedrock. It is well drained. The slowest permeability within 60 inches is moderately rapid. Available water capacity is low and shrink swell potential is low. This soil is not subject to flooding and is not ponded. The seasonal high water table is at a depth of more than 6 feet. Major component is not a hydric soil.

Philo silt loam (Ph)

Philo soils make up 90 percent of the map unit. This map unit is Prime Farmland. The runoff class is low. The depth to a restrictive feature is 40 inches bedrock. It is moderately well drained. The slowest permeability within 60 inches is moderate. Available water capacity is moderate and shrink swell potential is low. This soil is subject to occasional flooding and is not ponded. The top of the seasonal high water table ranges from 18 to 36 inches. Major component is not a hydric soil.

Rayne-Gilpin complex, 15 to 25 percent slopes (RcD)

These soils are moderately steep and well drained. They are found on uplands. Slopes generally are smooth, and convex, and 100 to 300 feet long. The areas of this soil are irregular in shape and range from about 4 to 100 acres. They are about 60 percent deep Rayne soils, 30 percent moderately deep Gilpin soils, and 10 percent other soils. Rayne permeability is moderate and available water capacity is moderate to high. Runoff is rapid with a severe hazard of erosion. Reaction in un-limed areas is very strongly acid or strongly acid. Gilpin permeability is moderate and available water capacity is high. Runoff is rapid with a severe hazard of erosion. Reaction in un-limed areas is very strongly acid to extremely acid. Most areas of this unit are in woodland. Some areas are used for are hay, pasture, or native vegetation. This soil is suited for trees and potential productivity is high.

Rayne channery silt loam, 25 to 65 percent slopes (RbF)

Rayne soils make up 90 percent of the map unit. Not classified as Prime or Statewide Important Farmland. The runoff class is high. The depth to a restrictive feature is 40 to 72 inches to bedrock. It is well drained. The slowest permeability within 60 inches is moderate. Available water capacity is moderate and shrink swell potential is low. This soil is not subject to flooding and is not ponded. The seasonal high water table is at a depth of more than 6 feet. Major component is not a hydric soil.

Wharton silt loam, 3 to 8 percent slopes (WhB)

This soil is gently sloping, deep and very deep, moderately well drained soils formed in residuum from interbedded clay, shale, siltstone, and fine-grained sandstone. They are on uplands. Slopes generally are smooth, slightly concave or convex, and 100 to 300 feet long. The areas of this soil are oval, oblong, or irregular in shape and range from about 2 to 40 acres. Permeability is slow or moderately slow in the subsoil and substratum. Available water capacity is high. Runoff is medium. Reaction in un-limed areas is very strongly acid or strongly acid. A seasonal high water table is at a depth of 18 to 36 inches. The hazard of erosion is moderate. Most areas of this soil are in woodland, cultivated, or are in permanent hay.

Wharton silt loam, 8 to 15 percent slopes (WhC)

This soil is sloping, deep, and moderately well drained. It is typically found on uplands. Slopes generally are smooth, slightly concave or convex, and 100 to 300 feet long. The areas of this soil are oval, oblong, or irregular in shape and range from about 4 to 40 acres. Permeability is slow or moderately slow in the subsoil and substratum. Available water capacity is high; runoff is medium. Reaction in un-limed areas is very strongly acid or strongly acid. A seasonal high water table is at a depth of 18 to 36 inches. The hazard of erosion is severe. Most areas of this soil are in woodland, cultivated, or are in permanent hay. Some areas are used for pasture, have remained in native vegetation, and are suited for trees.

Appendix E: Macroinvertebrate Study

An aquatic macroinvertebrate investigation of Muddy Run and four of its tributaries was conducted on May 14th and 15th, 2009 to determine baseline aquatic conditions prior implementing restoration projects in the watershed. Personnel obtaining the kick samples were Michael Shipman with Jennifer Demchak.

The Muddy Run watershed encompasses 37 square miles in 4 townships in Cambria and Clearfield Counties, Pennsylvania. Nearly all of the tributaries within the watershed are acid in nature. At the time of the Scarlift study, Muddy Run was contributing approximately 16,000 lbs/day of acid to Clearfield Creek. The acid nature of the tributaries and Muddy Run itself is due to the large and extensive deep mining and surface mining that has taken place in the watershed. Deep mining began in the early 1860s and expanded as coal became the preferred energy source over wood. This unregulated mining activity drastically altered the natural hydrology of the watershed. The Lower Freeport, Clarion, and Lower Kittanning coal seems were the first and most extensively mined because of their high quality and large quantity. As they began to dwindle, mining began to spread to the thinner seams. In the early 1940s, surface mining began to replace deep mining and it has continued until the present time. At the time of the Scarlift report, active deep mines on the Lower Kittanning seem were still being performed. Surface mining continues in the Muddy Run watershed at several sites. These sites along with past mining sites will be addresses in the assessment and restoration plan of Muddy Run.

The headwaters of Muddy Run and associated tributaries begin in the northeast corner of Cambria County, Pennsylvania near Blandburg . The main stream then flows in a northern direction into the southeast corner of Clearfield County until its confluence with Clearfield Creek near the town of Madera. The headwaters of Little Muddy Run and some other tributaries are believed to be high quality. The watershed area is located on the Ramey and Blandburg USGS 7.5-minute series topographic maps. The watershed encompasses parts of Beccaria, Bigler, Gulich, and Reade Townships, and flows through the small communities of Madera, Janesville, and Blandburg.

Methods

Sample Collection and Identification

The kick samples conform to the Pennsylvania Department of Environmental Protection Agency (PA DEP) standards for determining the index of biological integrity (IBI) for benthic macroinvertebrate communities in wadeable freestone Pennsylvania streams (Chalfont 2007). This index measures the ability of the stream to support and maintain balanced species diversity, taxa richness, and functional organization comparable to natural non-polluted streams in that region. The highest possible score for the IBI is 100, the higher the score the better the water quality, macroinvertebrate species diversity and taxa richness. A score of 80.0 to 63.0 indicates declining but still functional water quality conditions. A score below 63.0 indicates severely degraded water quality.

Kick samples were collected with a 500 micron D frame net. Six one minute kick samples were collected in riffles within a 100 meter stream reach. The substrate was disturbed to a depth of four inches where possible one meter upstream of the net. The six samples were combined and preserved in lab grade formaldehyde for four days and then the samples were stored in 95% ethanol. In the lab each sample, one at a time, were dumped into a white 9x13 inch sorting pan. Due to the low numbers of each sample every macroinvertebrate was identified and counted. A dissecting microscope was used to view the samples. The dichotomous key in Merritt, Cummings and Berg fourth edition of Aquatic Insects of North America used to identify the insects.

Pollution Tolerance Values

The pollution values listed come from appendix F of " A Benthic Index of Biotic Integrity for Wadeable Freestone Riffle-Run Streams in Pennsylvania Draft April 2009". Pollution tolerance values are on a scale of 0 to 10 with 0 indicating the least pollution tolerant and 10 indicating the most pollution tolerant.

Metrics

To develop a Pennsylvania IBI, six metrics are used.

- **Modified Beck's Index:** This taxonomic composition metric is a weighted count of taxa with pollution tolerance values of 0, 1, or 2. This metric reflects the loss of pollution sensitive taxa is expected to decrease in value with increasing stress to a stream ecosystem.

- **Ephemeroptera + Plecoptera + Tricoptera (EPT) Taxa Richness:** The number of taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Tricoptera (caddis flies) determines the community structure composition within the sample. Within these orders the immature instars are generally considered more sensitive to or intolerant of pollution. This metric is expected to decrease in value with increasing stress in a stream ecosystem resulting in the loss of taxa from these largely pollution sensitive orders.

- **Total Taxa Richness:** This community structure metric is a count of the total number of taxa in a sample. This metric is expected to decrease with increasing stress in a stream ecosystem resulting in a loss of taxa and increasing dominance of a few pollution tolerant taxa.

- **Shannon Diversity Index:** This taxonomic composition metric measures the taxonomic richness and evenness of individuals across taxa of a sample. This metric is expected to decrease values with increasing stress in a stream ecosystem resulting in a loss of pollution sensitive taxa and increasing dominance of a few pollution tolerant taxa.

- **Hilsenhoff Biotic Index (HBI):** This taxonomic composition metric is calculated as a mean pollution tolerance value weighted by the number of individuals of each taxa within the sample. This index generally increases with increasing stream ecosystem stress.

- **Percent Intolerant Individuals:** This taxonomic composition metric is the mean of individuals with pollution tolerance values of five of less within a sample and is expected to decrease in value with increasing stream ecosystem stress.

The adjusted standardized metric values for the six core metrics were averaged and multiplied by 100 to produce an index score ranging from 0 to 100. This number represents the multimetric index of biological integrity (IBI) score for a sample (Chalfont 2007).

Results

Habitat

The substrate in the sampling locations varied from few boulders and cobblestones, to sand and gravel. In most of the sites silt has been deposited among the substrate leaving few rock edges exposed to the current. This limits the habitat for macroinvertebrates. In a freestone stream the desired habitat riffle to run ratio is 1:1. Most riffles at the collection sites were well defined and had a good riffle to run ratio. All collection locations had riparian vegetation consisting of trees and shrubs.

Macroinvertebrates

Kick samples were taken from 10 sites yielding 18 different genera. Chironomidae were keyed to family level with more than one genera present. The site on Little Muddy Run below Janesville Dam (LMR-JD) had the highest taxa count of 90, while Little Muddy Run at Boy Scout Camp (LMR-BS) had the fewest of 15.

Little Muddy Run at Boy Scout Camp (LMR-BS)

The sampling site was directly downstream of where the stream begins. This area has been affected by man as several dams have been built to make ponded areas. The vegetation was dense and shading the stream. The substrate was small cobble and platy stones. The PTV's ranged from 0 to 8 with 9 genera containing 15 individuals. The macroinvertebrate fauna was depressed with a taxa richness of 0.26 and an EPT score of 0.61. The Shannon Diversity Index score very high at 0.58. The Hilsenhoff Index was 0.91. The IBI score was 61.83.

LMR-BS				
Order	**Family**	**Genera**	**Quantity**	**Pollution Tolerance #**
Ephemeropta	Baetidae	Baetodes	1	2.5
	Siphlonuridae	Siphlonurus	1	7
	Neoephemeridae	Neoephemera	3	3
Plecoptera	Leuctridae	Leuctra	4	0
	Perlodidae	Isoperla	1	2
	Nemouridae	Nemoura	2	1
Tricoptera	Polycentropodidae	Cyrnellus	1	8
		Polycentropus	1	6
Diptera	Athericidae	Atherix	1	2

LMR-BS				
Metric	**Standard Equation**	**Observed Metric Value**	**Standard Metric Score**	**Adjusted Standard Metric Score Maximum = 100**
Modified Becks	val /39	19	0.49	0.49
EPT Taxa Richness	val /23	14	0.61	0.61
Total Taxa Richness	val /35	9	0.26	0.26
Shannon Diversity Index	val /2.90	1.68	0.58	0.58
Hilsenhoff Biotic Index	(10 - val) / (10 - 1.78)	2.5	0.91	0.91
% Intolerant Individuals	val /92.5	79.4	0.86	0.86
				3.71
IBI Score				61.83

Muddy Run at SR-253 (MRQ-50)

This site was about 130 feet below the bridge at the beginning of the wooded riparian zone. The channel was about 17 ft wide and 1 foot deep in the riffles. The pools were about 3 to 4 ft deep. The grade was a very gentle slope with very little distinction between pools and riffles. The substrate was small to large platy stones with few cobble. The riffle stones were covered in moss and iron precipitate. There was 1 family, Chironomidae consisting of 20 individuals with PTV score of 6. The macroinvertebrate fauna was depressed with a taxa richness of 0.03 and an EPT score of 0.00. The Shannon Diversity Index score was high at 0.00. The Hilsenhoff Index was 0.49. The IBI score of 8.67 is the lowest score for all sites sampled.

MRQ-50				
Order	**Family**	**Genera**	**Quantity**	**Pollution Tolerance #**
Diptera	Chironomidae		20	6

MRQ-50				
Metric	Standard Equation	Observed Metric Value	Standard Metric Score	Adjusted Standard Metric Score Maximum = 100
Modified Becks	val /39	0	0.00	0.00
EPT Taxa Richness	val /23	0	0.00	0.00
Total Taxa Richness	val /35	1	0.03	0.03
Shannon Diversity Index	val /2.90	0	0.00	0.00
Hilsenhoff Biotic Index	(10 - val) / (10 - 1.78)	6.00	0.49	0.49
% Intolerant Individuals	val /92.5	0.00	0.00	0.00
				0.52
IBI Score				8.67

Curtis Run

This site is directly downstream from a large sluice pipe under SR-253. Looking downstream the riparian buffer is unaffected on both sides of the channel. This stream channel is about 6 feet wide and about 1 foot deep but frequently varies. It has a healthy pool riffle ratio. The substrate is composed of large cobble and platy stones with little to no deposition. The PTV's ranged from 0 to 6 with 4 species containing 22 individuals. The macroinvertebrate fauna was depressed with a taxa richness of 0.11 and an excellent EPT score of 0.91. The Shannon Diversity Index score very high at 0.16. The Hilsenhoff Index was high at 1.00. The IBI score of 68.83 and was the second highest of all sites sampled.

Curtis Run				
Order	Family	Genera	Quantity	Pollution Tolerance #
Plecoptera	Leuctridae	Leuctra	3	0
	Capniidae	Capnura	14	1
Tricoptera	Hydropsychidae	Hydropsyche	4	5
Diptera	Chironomidae		1	6

Curtis Run				
Metric	**Standard Equation**	**Observed Metric Value**	**Standard Metric Score**	**Adjusted Standard Metric Score Maximum = 100**
Modified Becks	val /39	37	0.95	0.95
EPT Taxa Richness	val /23	21	0.91	0.91
Total Taxa Richness	val /35	4	0.11	0.11
Shannon Diversity Index	val /2.90	0.47	0.16	0.16
Hilsenhoff Biotic Index	(10 - val) / (10 - 1.78)	1.82	1.00	1.00
Percent Intolerant Individuals	val /92.5	95.45	1.03	1.00
				4.13
IBI Score				68.83

Little Muddy Run Below Janesville Dam (LMR-JD)

The substrate was a mix of cobble and platy stones. This main channel is twenty feet wide and about one foot deep. Nine species were found consisting of 90 individuals with PTV ranges of 0 to 6; EPT and Diptera were the families present. This suggests that the site has good water quality. From the bridge at the dam trout and bass could be seen in the spillway. The macroinvertebrate fauna was depressed with a taxa richness of 0.26 and an excellent EPT score of 1.0. The Shannon Diversity Index score was 0.36. The Hilsenhoff Index was 0.88. The IBI score of 72.33 was the highest site sampled.

LMR-JD					
Order	**Family**	**Subfamily**	**Genera**	**Quantity**	**Pollution Tolerance #**
Ephmereoptera	Isonychiidae		Isonychia	5	3
	Heptageniidae		Maccafferetium	25	3
			Epeorus	13	0
Plecoptera	Leuctridae		Leuctra	1	0
Tricoptera	Hydropsychidae		Hydropsyche	8	5
	Philopotamidae		Dolophilodes	18	0
Diptera	Chironomidae	Tanypodine		17	6
				2	6
	Nymphomyiidae		Nymphomyia	1	6

LMR-JD				
Metric	**Standard Equation**	**Observed Metric Value**	**Standard Metric Score**	**Adjusted Standard Metric Score Maximum = 100**
Modified Becks	val /39	96	2.46	1.00
EPT Taxa Richness	val /23	70	3.04	1.00
Total Taxa Richness	val /35	9	0.26	0.26
Shannon Diversity Index	val /2.90	1.05	0.36	0.36
Hilsenhoff Biotic Index	(10 - val) / (10 - 1.78)	2.78	0.88	0.88
Percent Intolerant Individuals	val /92.5	77.78	0.84	0.84
				4.34
IBI Score				72.33

Additional sites were investigated throughout the watershed, but no aquatic organisms were found. The following is a list of those sites and a short description.

MRQ-10: The pH of this site was 5.8, but there were large amounts of iron precipitate coating the stream bottom.

MRQ-20: This is at the bridge in Smoke Run. The pH was 6.5, but there was iron sediment on the bottom of the stream, creating an extremely soft bottom.

Banian Run (BRQ-H): At the headwaters of this tributary, it was a large swamp area that kick nets could not be conducted. At the mouth of Banian Run, the stream was dry.

Muddy Run at Kitko's Sawmill (MR-KIT): The pH was 6.8, but there were large amounts of sediment on the bottom of the stream, along with grasses. No organisms were found.

Muddy Run Trib at Utahville (TRIB-UT): This was a stream sample near the headwaters area of Muddy Run which contained less sediment and good riparian cover. The stream is intermittent here and few organisms were found.

MRQ-30: The pH of the stream here is 4.0 and iron precipitate is on the stream bottom.

As part of the aquatic study, habitat sheets were also completed and the summary table is located below. The total possible score is 240 points. The higher the total score, the better the habitat. Once restoration activities have improved water chemistry, habitat issues will need to be addressed.

Station Name	Instream Cover	Epifaual Substrate	Embeddedness	Velocity / Depth Regimes	Channel Alteration	Sediment Depostion	Frequency of riffles	Channel Flow Staus	Condition of banks	Bank vegetative protection	Grazing / other disruptive pressure	Riparian Vegetative zone width	Total
MRQ-10	12	11	17	16	19	16	9	16	14	20	20	20	190
MRQ-20	9	7	7	7	9	4	4	17	14	14	14	10	116
MRQ-30	4	2	2	6	3	5	4	19	14	19	15	5	98
TRIB-UT	18	15	17	20	20	16	16	19	16	20	20	20	217
BRQ-H	12	11	9	17	15	13	9	18	11	17	19	11	162
Curtis Run	18	16	19	18	16	18	17	20	17	20	19	15	213
MRQ-50	15	11	16	17	18	11	12	19	13	15	18	17	182
LMR-BS	10	8	12	14	7	10	6	18	19	20	20	20	164
LMR-JD	16	18	19	19	17	20	20	19	17	17	17	17	216

Discussion

The Pennsylvania Department of Environmental Protection's 2008 Integrated Water Quality Monitoring and Assessment Report states that 26.71 miles of the main stem of Muddy Run are degraded from abandoned mine drainage, along with 0.90 miles of Curtis Run (Pennsylvania Department of Environmental Protection 2008). Little Muddy Run is not listed in the PA DEP report as being impaired. The results of this aquatic investigation concur with the PA DEP assessment.

The low diverse macroinvertebrate fauna and low IBI scores indicate degraded water quality conditions at all four sampling sites. The pH, iron, and aluminum levels, along with poor habitat, contribute to the relatively low total numbers of organisms. Due to the low number of individuals all individuals were used for this report. A grid sorting system was not used.

The limited taxa richness, low total number of organisms, and low IBI scores at all stations confirm the impaired status of these stream segments. Curtis Run and both Little Muddy Run sites had IBI scores that fall into the cold water fishery category. Severely degraded water quality conditions prevailed in the acidic, iron precipitate covered section Muddy Run at SR-253 (MRQ-50) where the macroinvertebrate fauna was extremely reduced in taxa richness and numbers of organisms and IBI scores were very low.

Restoration Potential

The effects of mine drainage on a receiving stream are dependent on the pH, acidity, and concentrations of dissolved metals in the discharge; generally the lower the pH and higher the metals concentrations the more severe the impairment. Iron precipitate in combination with low pH can cause significant reduction in numbers and diversity of macroinvertebrates, as is the case in Muddy Run watershed. At higher pH, iron precipitate can adversely affect macroinvertebrates by filling in crevices in rocks that provide attachment places and by smothering organisms.

Present in-stream conditions may help show the potential for restoration success after treatment of mine discharges. The diverse macroinvertebrate fauna at Little Muddy Run below Janesville Dam (LMR-JD) shows that the streams in the watershed are capable of supporting macroinvertebrate life. Restoration of the macroinvertebrate fauna downstream in the other areas may be more difficult to achieve because of the presence of iron precipitate; however, even partial removal of the iron precipitate and increase in pH to above 6.0 should result in improvements in the macroinvertebrate fauna.

Literature Cited

Chalfont, B. 2007. A benthic index of biological integrity for wadeable freestone streams in Pennsylvania. Available online at http://www.depweb.state.pa.us/watersupply/lib/watersupply/ibi_rifflerun.pdf www.

Pennsylvania Department of Environmental Protection. 2008. Pennsylvania Integrated Water Quality Monitoring and Assessment Report. Available online at http://www.depweb.state.pa.us/watersupply/cwp/view.asp?a=1261&q=535678

Bibliography

Brodie, G.A., C.R. Britt, and T.M. Tomasczewski, H.N. Taylor. 1993. Anoxic limestone drains to enhance performance of aerobic acid drainage treatment wetlands-experiences of the Tennessee Valley Authority.

Chalfont, B. 2007. " A benthic index of biological integrity for wadeable freestone streams in Pennsylvania". Available online at http://www.depweb.state.pa.us/watersupply/lib/watersupply/ibi_rifflerun.pdf

Cork, D.J. and Cusanovich, M.A. 1979. Continuous disposal of sulfate by bacterial mutualism. Microbiology. 20: 591-602.

Demchak, J., T. Morrow, and J. Skousen. 2001. Treatment of Acid Mine Drainage by Four Vertical Flow Wetlands in Pennsylvania. Geochemistry: Exploration, Environment, Analysis. 1: 71-80.

Dunlap, R. and Detar, J. 2010. West Branch Susquehanna Recovery Benchmark Project: A Synopsis of Water Quality and Fishery Improvements (abst.) Fifth West Branch Susquehann Restoration Symposium.

EPA. 1997. A Citizen's Handbook to Address Contaminated Coal Mine Drainage. #EPA-903-K-97-003.

Faill, R.T., Glover, A.D. and Way, J.H. 1989. Geology and Mineral Resources of the Blandburg, Tipton, Altoona and Bellwood Quadrangles, Blair, Cambria, Clearfield and Centre Counties, PA. Pennsylvania Geological Survey Atlas 86. 209 p.

GAI Consultants. 2007. Phase I SRB Low Flow Mine Storage and Treatment Project Evaluation. Report to PA Bureau of Abandoned Mine Reclamation. 3 volumes.

Hainly, R.A. and Barker, J.L. 1993. Water quality of the Upper West Branch Susquehanna River and tributary streams between Curwensville and Renovo, Pennsylvania, May and Jult 1984. U.S. Geological Survey, Water Resources Investigation Report 90-4011.

Hedin Environmental. 2009. Optimizing the design and operation of self-flushing limestone systems for mine drainage treatment. Report on Hedin Environmental website: www.hedinenv.com/pdf/flushing_final_report.pdf

Hedin, Robert S., Robert W. Nairn, and Robert L.P. Kleinmann. 1994. Passive treatment of coal mine drainage. Bureau of Mine Information Circular, US Dept. of the Interior.

Hedin, Robert. S., and George R. Watzlaf. 1994. The effects of anoxic limestone drains on mine water chemistry. Proceedings of International Land Reclamation and Mine Drainage Conference and the Third International Conference on Abatement of Acidic Drainage, Pittsburgh, PA. pp. 185-194.

Kepler, Douglas A. and Eric C. McCleary. 1994. Successive alkalinity producing systems (SAPS) for the treatment of acidic mine drainage. Proceedings of International Land Reclamation and Mine Drainage Conference and the Third International Conference on Abatement of Acidic Drainage, Pittsburgh, PA.

Nawrot, Jack R. and Willliam B. Klimstra. 1990. Biochemical treatment of mine drainage through a reedgrass wetland. Proceedings of Mining and Reclamation Conference and Exhibition, Charleston, WV.

PADEP, 2001, "*Little Muddy Run Watershed TMDL*".

Plummer, L.N., Parkhurst, D.L., and Wigley, M.L. 1979. Critical review of the kinetics of calcite dissolution and precipitation. In chemical modeling in aqueous systems-speciation, sorption, solubility, and kinetics (ed. E. A. Jenne). American Chemical Society Symposium, Series 93.

Robb, Gordon A. and James D.F. Robinson. 1995. Acid drainage from mines. The Geographical Journal. 161: 47-54.

Skelly and Loy. 1971. Muddy Run Mine Drainage Pollution Abatement Project, Operation SCARLIFT. 239 p + 4 maps.

Skousen, Jeffrey G. and Paul F. Ziemkiewicz. 1995. Acid Mine Drainage: Control and Treatment. National Mine Land Reclamation Center, West Virginia University.

Sverdrup, H.U. 1983. "The Limestone Wells at Piggeboda." Translation from the Symposium Proceeding "Kalkining av rinnende vatten." Alvesta, Sweden. pp. 11.

USEPA, 2008, "Decision Rationale Total Maximum Daily Loads Little Muddy Run Watershed For Acid Mine Drainage Affected Segments"

West Branch Susquehanna River Task Force, 2005. West Branch Susquehanna River Watershed: State of the Watershed Report. PA Dept. of Environmental Protection, 19 p.

Glossary

Acidic: a condition where the concentration of positively charged hydrogen ions is high, and the pH is less than 7.0.

Aerobic: a condition existing or process conducted in the presence of oxygen

Alkalinity: a measure of the ability of a solution to absorb positively charged hydrogen ions without a significant change in pH. Also referred to as buffering capacity. Alkaline solutions have a pH greater than 7.0.

Aluminum: a common metal element found in mine drainage that oxidizes as a whitish precipitate at pH levels greater than 4.5.

Anaerobic: a condition existing or process conducted in the absence of oxygen.

Appalachian Clean Streams Initiative: a program sponsored by OSM to coordinate and focus mine drainage cleanup projects in the United States.

BAMR: Bureau of Abandoned Mine Reclamation. Part of the Pennsylvania DEP.

Basic: a condition where the concentration of negatively charged hydroxide ions is high, and the pH is greater than 7.0 (alkaline)

CCCD: Clearfield County Conservation District

CCWA: Clearfield Creek Watershed Association

DCNR: (Pennsylvania) Department of Conservation and Natural Resources

DEP: (Pennsylvania) Department of Environmental Protection

Dissolved Oxygen (D.O.): the amount of oxygen that is dissolved in a solution. DO can cause armoring on limestone by oxidizing iron compounds in mine drainage to form iron hydroxide.

Dissolved Solids: compounds in a solution that can be precipitated through chemical processes into solids.

Effluent: the solution that flows out of a basin, pond, tank, wetland, ditch, pipe, or other containment.

Environmental Protection Agency (EPA): the federal agency created by executive order in 1970 to coordinate efforts to protect human health and biological communities form environmental pollutants.

Ferric hydroxide: an iron compound that forms when dissolved iron in mine drainage is oxidized, and appears as a rusty, reddish-orange residue. It is often called yellowboy.

Flow Rate: the rate a solution moves through a ditch, wetland, pond, or stream defined in terms of quantity of mine drainage per unit time (i.e., 150 gallons per minute)

gpm: gallons per minute. See “Flow Rate”

Hydroxide: a compound containing the OH- molecule

Iron: a common metal contained in mine rocks in the form of iron sulfide that oxidizes as a reddish colored hydroxide solid.

Manganese: a metal found in mine drainage that oxidizes as a blackish stain.

Metal: elements that are solids, have few electrons in the outer shell, and lose electrons easily to form cations. Metals of concern in mine drainage are iron, aluminum, manganese, and sometimes lead, mercury, copper and zinc.

Neutral: a condition where the concentration of hydrogen ions equals the concentration of hydroxide ions, resulting in a solution that is neither acidic nor basic and has a pH of 7.0.

Neutralize: to cause a solution to move toward a pH reading of 7.0 through chemical or biological processes.

NMBS: The name of the company that prepared this document. See www.newmilesofbluestream.com for more information.

NMBS WaMP: A Watershed Management Program (software) used to retain and track data for this assessment.

O & M: Operations and Maintenance

Office of Surface Mining (OSM): the federal agency charged with enforcing SMCRA and dealing with health, safety and resource protection issues related to active mining and abandoned mine problems.

OSM: Office of Surface Mining

Overburden: the layers of rock and soil found above coal bed deposits. Overburden rocks often contain acid forming materials in the form of iron sulfide and other compounds that can form dissolved metals and sulfates.

Oxidation: a reaction in which a substance losses electrons. In the case of mine drainage metals oxidation, the oxidizing agent is gaseous oxygen. Metal oxides are formed in the process.

PADEP: Pennsylvania Department of Environmental Protection

Permeability: a measure of the rate of water movement through soil or other substance.

PFBC: Pennsylvania Fish & Boat Commission

pH: a value, expressed as standard units on a scale of 0-14 that uses a logarithmic measure to express concentrations of hydrogen ions. pH readings below 7.0 are said to be acidic, and readings above 7.0 are basic or alkaline.

Porosity: the ration of volume of voids to the total volume of material. Used to describe the ability of a fluid to move through crushed rocks or other material.

Pre Act mining: mining that occurred prior to the passing of SMCRA in 1977.

Pyrite: the iron sulfide mineral, often called "fools gold" that is found in earthen and rock layers near coal seams. Pyrite is the usual source of the sulfur that binds with hydrogen and oxygen in rain water to form the sulfuric acid component of mine drainage.

Reduction: a reaction in which a substance gains electrons. In mine drainage treatment, reduction usually involves stripping away of oxygen atoms from sulfate or metal compounds.

Residence Time: the length of time that mine drainage remains in a treatment pond, wetland, or other structure. Designed residence times depend on incoming flow rate, the rate of treatment process in the structure, the contaminants in the mine drainage to be treated, the size of the structure, and the settling rates of solids in the discharge.

Sedimentation: the process whereby particles settle out of solutions. Sedimentation produces a sludge or other layer of solids at the bottom of a sedimentation or settling pond.

SGL: State Game Lands

Sludge: the layer of solids that settle from a solution, including suspended silt and soil particles and precipitates formed by chemical processes.

Solubility: the amount of material that can dissolve in a given amount of water or other solvent at a given temperature to produce a stable solution. Highly soluble substances dissolve quickly. Soluble products will not settle out of a solution unless they are precipitated.

Substrate: the rich, organic layer of compost or other material found at the bottom of wetlands.

Sulfates: compounds containing sulfur and oxygen. Elevated sulfate levels are common in mine drainage. Sulfates can bond with hydrogen ions to form sulfuric acid or bind to calcium atoms to form a gypsum solid.

Surface Mining Control Act of 1977 (SMCRA): the federal law that requires mining operations to prevent water pollution, reclaim mine lands and protect other sources.

Suspended Solids: solid particles that are suspended in solution. Suspended solids in mine drainage can include oxidized metals, silt or soil and other tiny debris particles.

TDS: Total Dissolved Solids

TMDL : Total Maximum Daily Load

Topographical Map: a map that shows land elevations by use of lines that connect points of equal elevation, water bodies, streams, buildings, mine sites, roads, and other land features.

TSS: Total Suspended Solids

UT: Unnamed Tributary

Vertical Flow Wetland (VFW): specialized mine drainage treatment ponds that make use of chemical and biological processes to treat the acid, metals, and sulfate found in mine drainage.

VFW: See Vertical Flow Wetland

Watershed: an area of land from which water drains toward a single channel.

WPA: Works Progress Administration