Watershed Based Plan for Roaring Creek of the Tygart Valley River

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The West Virginia Water Research Institute
and
Trout Unlimited
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1 Executive Summary

1.1 Project Background

This document is a comprehensive watershed-based plan for Roaring Creek, a tributary of the Tygart Valley River located west of the town of Elkins in Randolph County, West Virginia. This project originated as a unique partnership between academia, state agencies, and a non-profit group. It was funded by a grant from the West Virginia Department of Environmental Protection (WVDEP). Development of the plan was provided by the WVDEP Division of Water and Waste Management, the West Virginia Water Research Institute (WVWRI), and the Mountaineer Chapter of Trout Unlimited (MCTU).

This project was prompted by anecdotal evidence of native trout populations in the headwaters of Roaring Creek. MCTU performed an informal watershed survey to determine the range of current trout populations. At the same time, WVWRI and WVDEP-DWWM performed water sampling throughout the watershed to ascertain the chemistry of the stream. This initial sampling determined that the headwaters of the stream were of good quality while the lower section, particularly downstream of Kittle Hollow, was impacted by acid mine drainage. It was also determined that once Kittle Hollow was remediated, Roaring Creek could likely be removed from the 303 (d) list of Impaired Streams.

Very little reclamation work had been previously constructed in the creek. Because of this, Roaring Creek is still a large contributor of acidity and metals to the Tygart Valley River TMDL.

1.2 Partnership Mission and Project Goals

The mission of the partnership formed for this project is to restore Roaring Creek as a viable trout fishery throughout its length. The goals of this plan are to develop a set of recommendations that will improve water quality and stream habitat, enable greater use of the creek for recreation, and help stakeholders to implement the objectives of the Tygart Valley River TMDL.

1.3 Project Overview

This project began in the winter of 2009. WVWRI, MCTU, and the WVDEP developed a sampling plan, took water and benthic macroinvertebrate samples four times, and collaborated with one another to write the plan. WVWRI compiled existing source data and integrated historic data with data collected in 2009 and 2010.

As part of the planning process, the partners developed a plan for the watershed, including goals and objectives to measure progress. MCTU volunteers helped with stream monitoring and developing management recommendations. Feasibility and performance of each recommended improvement were assessed by all project partners. This WBP summarizes the results of this partnership. It includes a prioritized implementation plan, estimated costs, and a monitoring plan.

1.4 Existing Conditions

Roaring Creek is a direct draining tributary to the Tygart Valley River. It is nearly entirely rural, with two small towns (Coalton and Mabie) within the watershed. The headwater and upper tributaries of the creek have evidence of trout in them, while the lower section of the watershed is impacted by acid mine drainage. Both the chemical and macroinvertebrate sampling showed that water quality was negatively affected by mine drainage. This is due to the large amount of abandoned coal mines within the lower part of the watershed. High concentrations of iron and aluminum from abandoned mines were found in several areas of the watershed. Other nonpoint sources of pollution, including sediment and bacteria, amy be masked due to the heavy AMD contamination.

1.5 Improvement Plan and Analysis

A list of possible sites to be reclaimed was based on field and laboratory analyses. Reclamation project sites will be reclaimed in the order of upstream to downstream so that constructed projects do not interfere with one another. A total of eight reclamation project sites were considered. Conceptual designs, complete with cost information, were created for each project as an estimate of final water treatment. The goal of each reclamation project is an 80% reduction in metal and acidity loads.

1.6 Quantitative Assessment and Results

One of the main goals of the implementation of this plan is improvement in water quality. Performance of the reclamation projects will be assessed using WV state water quality standards as well as the 80% reduction benchmark mentioned previously. These metrics will provide the best quantitative measurement of project results.

A second goal of plan implementation is an improvement in aquatic life populations. This will be measured by identification of benthic macroinvertebrate organisms as well as the extension of trout range throughout the watershed. Fish shocking will be used to determine changes in fish population. An overall picture of the aquatic life within the watershed will be determined from these two measurements.

1.7 Implementation, Projected Costs and Funding

Implementation of this plan will require the aid of all stakeholders of the Roaring Creek watershed. Of particular importance are those entities that hold NPDES permits within the watershed. However, the continued partnership of agencies, academia, and NGOs will ensure that the implementation of this plan is a success.

The recommended improvements include structural control structures. These may include: limestone leach beds, limestone channels, steel slag leach beds, and wetlands, among others.

The next major step for this plan is to obtain funding for the first reclamation project. This funding has been applied for and could be received in 2012. Acceptance of this plan will make Roaring Creek eligible for Clean Water Act Section 319 funding, which is the most significant source of funding available for projects of this type in West Virginia. WVWRI and WVDEP-DWWM intend to lead implementation of this plan and offer technical and administrative assistance to watershed stakeholders.

2 Introduction

2.1 Document Overview

A watershed-based plan (WBP) is a document that describes all major environmental impacts within a watershed, and details possible remediation solutions for these impacts. WBPs are used in conjunction with Total Maximum Daily Load (TMDL) plans to guide the remediation of environmental issues within a watershed. These plans are also written to aid in obtaining funding for construction of remediation projects.

A WBP covers all environmental aspects of a watershed. The first section of the plan is a description of the watershed, including such features as hydrology, climate, topography, geology, and vegetation, among others. The watershed description also includes land use and demographic data.

The next section of the WBP refers to watershed conditions. These include water quality standards, available water quality data, and flow data. A pollutant assessment is also performed as part of the WBP. This assessment includes both point and nonpoint sources of pollution. Pollutant loads are then linked to water quality by establishing current water quality conditions and estimating future conditions.

The goals and objectives of the plan are then discussed with a specific focus on pollutant load reductions and management objectives. Current management strategies are detailed, along with plans for future pollutant management. Finally, the implementation program design is discussed. This section includes, among others: schedule of activities, milestones, and education of the watershed community. There may also be appendices which have raw water quality data in them.

This specific WBP is for the Roaring Creek watershed, which is a tributary of the Tygart Valley River and is located in central West Virginia. In 2001, the final TMDL for the Tygart Valley River was approved by EPA Region 3. Recently, interest in restoring Roaring Creek has grown due to an active chapter of Trout Unlimited (TU) in the watershed. This provided the impetus for the baseline water sampling detailed in this report to be accomplished. After the approval of this watershed-based plan, projects will be constructed to mitigate the problem areas in Roaring Creek. In the Tygart Valley River TMDL, Roaring Creek was listed as impaired by pH, iron, aluminum, and manganese. Because of this, this watershed-based plan will focus on these issues.

2.2 Watershed Management Plan Purpose and Process Used

The purpose of this plan is to document the existing characteristics and conditions within the Roaring Creek watershed, and identify problem areas for restoration. This was done by first compiling all existing water quality data. However, very few historic water quality data were found. Some of these historic data included: data from TMDL development and data collected by the WV Abandoned Mine Lands Program.

Watershed characteristics were also compiled. This included GIS data such as aerial photography, digital elevation models, and topographic maps. From this data, it was determined that the most prevalent problem within the watershed is Acid Mine Drainage (AMD) and its impacts upon aquatic life. The West Virginia Water Research Institute (WVWRI) worked collaboratively with the Mountaineer Chapter of Trout Unlimited (TU) to complete an intensive field survey of the watershed to verify the existing data and collect additional data. Two types of water quality samples were collected:

 AMD: Very little baseline water quality data has been collected on Roaring Creek. As such, WVWRI and TU grabbed water quality samples at several points on the mainstem of Roaring Creek, as well as the mouths of the major tributaries of Roaring Creek. This baseline sampling showed that all of the AMD was coming from one tributary called Kittle Hollow. Further sampling was performed on Kittle Hollow at specific mine drainage sources. A stream walk encompassing the entire length of Kittle Hollow was completed to account for all mine drainage sources. Local residents were also asked for information regarding the watershed's mining history. In all, 49 sites were located and sampled in accordance with EPA standard procedures (appendix A).

 Benthic Macronivertebrate: Benthic macroinvertebrate samples were collected twice (April and October) over the time period of a year. Samples were collected at the most of the same points as the AMD samples. Local residents were also asked for information regarding possible sites where trout populations were found. No sites beyond the 49 sampled for AMD were found by either local residents or the rest of the sampling group.

2.2.1 Watershed Management Team

This watershed plan was prepared as a joint effort by the project team including:

- Ben Mack: Research Associate, at West Virginia Water Research Institute (WVWRI);
- Brady Gutta: Senior Program Coordinator, West Virginia Water Research Institute (WVWRI);
- Lou Schmidt, Basin Coordinator, West Virginia Department of Environmental Protection (WVDEP);
- Trout Unlimited volunteers (TU).

The project team also consulted with the WVDEP and local watershed residents.

2.2.2 Public Participation

Trout Unlimited is a 501 (c) (3) organization dedicated to the conservation, protection, and restoration of North America's coldwater fisheries and their watersheds. It advocates an integrated watershed management approach, which includes protecting headwater areas and reconnecting them to restored sections of the watershed downstream. It also sustains its successes over time so that a new generation of anglers may enjoy the watershed.

3 Watershed Description

3.1 Physical and Natural Features

Roaring Creek is a direct drain to the Tygart Valley River south-southeast of Norton, WV (Figure 1). This 29 mi^2 watershed is located entirely within Randolph County.

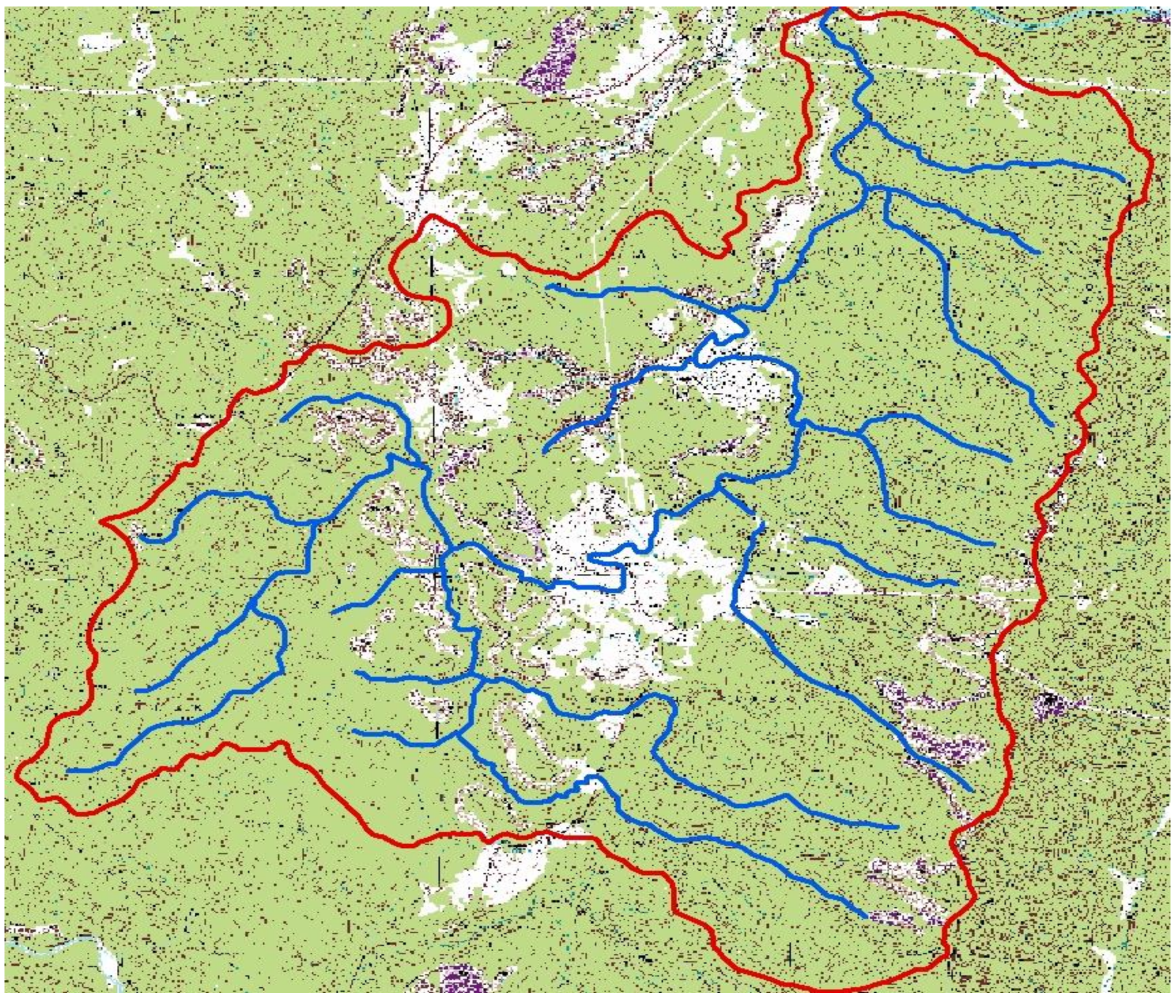

Figure 1. Map of the Roaring Creek watershed.

3.1.1 Watershed Boundaries

Roaring Creek is a direct drain into the Tygart Valley River. Although it is a fairly large subwatershed of the Tygart Valley River, it is not subdivided into smaller subwatersheds. The 12 digit Hydrologic Unit Code (HUC) for Roaring Creek is 050200010406. Because

Roaring Creek is not subdivided into smaller subwatersheds, Figure 1 is representative of the watershed boundary of Roaring Creek.

3.1.2 Hydrology

Roaring Creek is an ungauged, direct drain tributary to the Tygart Valley River. Because it is ungauged, no continuous flow data, including base flow, storm flow, or flashiness, currently exist. However, stream flow was measured during the four sampling events that were performed by WVWRI and TU. These data will be reviewed later in this report. The research team also talked to members of local communities within the watershed to determine hydrologic characteristics. No drastic changes in water quantity from current conditions were found to have existed as a result of these community interviews.

The mainstem of Roaring Creek can be described as a moderately entrenched stream with low to moderate channel sinuosity. Sinuosity decreases from the headwaters to the mouth. The upper region has a very well defined floodplain. The channel slope is highest in the headwaters (approx. 6.4%), as the stream begins in a mountainous region. Moving downstream, the slope decreases to the mouth. At the mouth, the slope is roughly 1.2%. Frequently, this low gradient section of Roaring Creek is back flooded by the Tygart Valley River.

The creek bed is predominately cobbles and sediment. However, as the stream approaches its confluence with the Tygart Valley River, larger rocks and boulders are often found within the stream channel. This is especially true at the mouth of Roaring Creek. There is very little visible bedrock exposed anywhere within the watershed.

Although the overwhelming majority of the Roaring Creek has similar physical characteristics, water chemistry varies significantly, specifically in the subtributary of Kittle Hollow. Nearly all of the impacts from legacy coal mining are found within this subwatershed. Kittle Hollow will be discussed in more detail later in this report.

There are no navigable waterways on Roaring Creek or any of its tributaries. However, one dam does exist on the mainstem of Roaring Creek. The dam is located near the town of Coalton and was used to provide drinking water for the town. Coalton now receives its drinking water from the Tygart Valley River, which means that the dam is no longer used for its intended purpose. Although the dam does cause Roaring Creek to back up, some water now flows over the dam as well. It is possible that this dam could impede future fish movement within the watershed. Currently, there are no fish to be found below the dam due to mine drainage impacts.

3.1.3 Climate and Precipitation

Typically, the weather in the east-central region of West Virginia has a strongly seasonal pattern. Roughly half of the precipitation (22 inches) falls in the summer months of May-September. October is generally the driest month of the year, while July is the wettest.

Due to the mountainous character of this area, this watershed often receives greater amounts of precipitation than areas west of the watershed. The Roaring Creek watershed receives on average 46 inches per year of precipitation. The average high temperature of the watershed is 62 degrees F and the average low temperature is 38 degrees F (National Oceanic and Atmospheric Administration, 2010).

3.1.4 Surface Water Resources

Surface water resources within the Roaring Creek watershed consist of Roaring Creek and its tributaries. There are no natural lakes within the watershed. However, there are approximately 15 man-made ponds that were used in the mining industry as settling ponds. An old reservoir/impoundment also exists at the site of the Coalton drinking water dam. However, Coalton now receives its drinking water from the Tygart Valley River. The dam continues to impound Roaring Creek, although some of the stream overtops the dam. A swampy area, as evidenced by wetland vegetation, has also formed in a low gradient area within the Kittle Hollow subwatershed. However, this swampy area is highly impacted by mine drainage and is of very poor quality.

There are currently no surface water intakes within the watershed. Some areas of the watershed (especially from the town of Coalton north to the mouth of Roaring Creek) use the Tygart Valley River for their water supply. The southern part of the watershed uses private groundwater wells.

3.1.5 Ground Water Resources

There are no documented springs within the watershed. However, undocumented springs may exist. There are also no large groundwater intakes within the Roaring Creek watershed that serve a large population. However, a majority of the residents of the watershed rely on private groundwater wells for their drinking water. Groundwater in the headwaters of the watershed has fewer potential impacts on their groundwater wells. This is because most coal mining occurred in the Kittle Hollow subwatershed near Coalton. It is likely that groundwater in this area of the watershed has a greater chance of being contaminated due to this historic mining. Higher concentrations of metals and lower pH values may be found in this mining-impacted groundwater.

3.1.6 Flood Plains

There are three designated flood zones in the Roaring Creek watershed (Figure 2).
The flood zone along the mainstem is designated zone A, which is the estimated 100 year floodplain, and has a 26% chance of flooding over the life of a 30-year mortgage. This is considered a special hazard risk area (SFHA). The area of the confluence of Roaring Creek and the Tygart Valley River is also designated Flood Zone A (West Virginia GIS Technical Center, 2008).

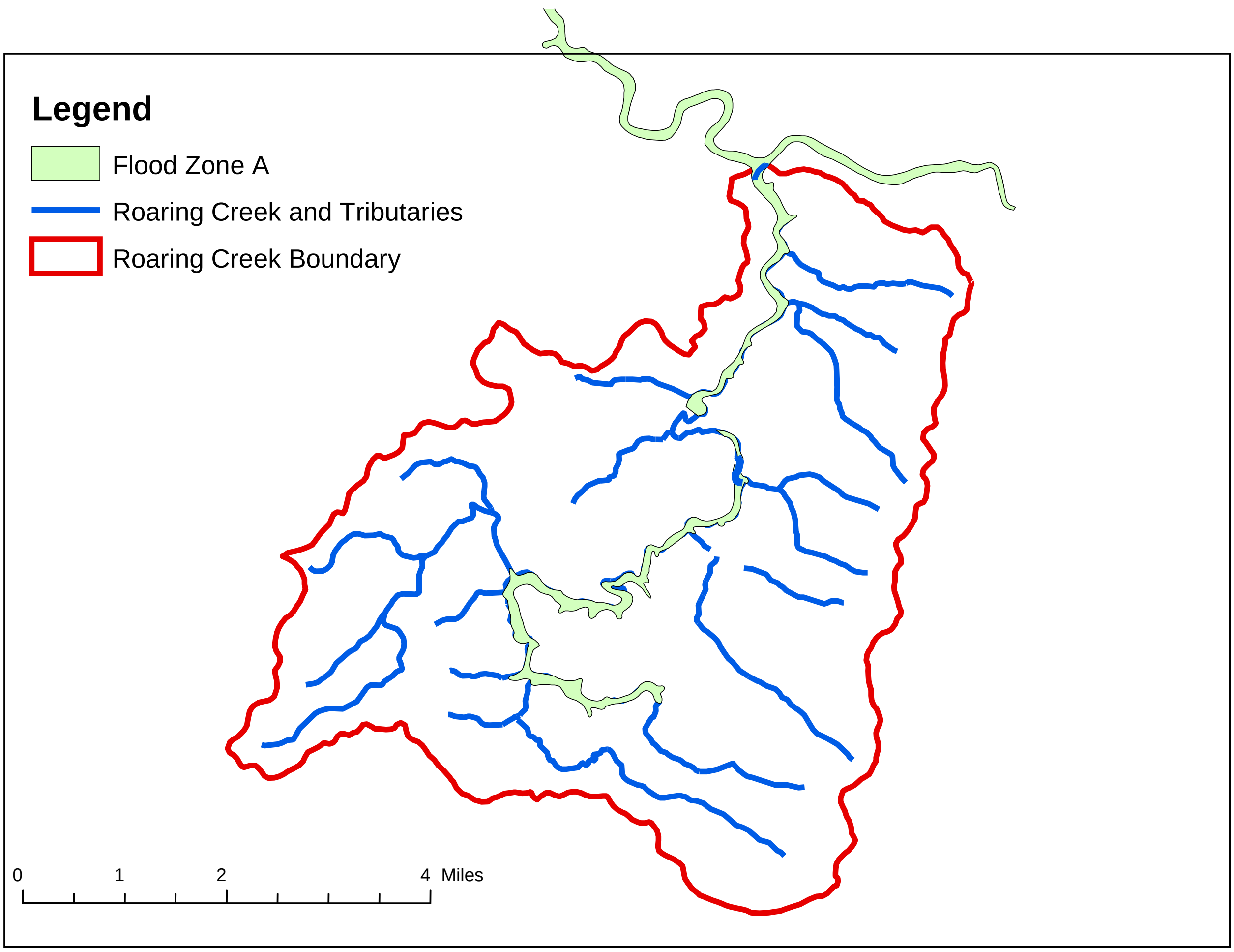

Figure 2. FEMA Flood Hazard Risk in Roaring Creek. Areas in blue are the mainstem of Roaring Creek and its tributaries. Areas shaded green are the estimated 100 year flood plain.

3.1.7 Navigation Channels, Ports, and Harbors

There are no navigation channels, ports, or harbors within the Roaring Creek watershed.

3.1.8 Dams

There are currently no functioning dams within the Roaring Creek watershed. However, an abandoned dam is still in place on the mainstem of Roaring Creek near the town of Coalton. This dam once created a reservoir that provided drinking water to the town of Coalton. Since Coalton residents currently receive their potable water from a mixture of private groundwater wells and the Tygart Valley River, the dam is no longer used for its original purpose. Although the dam still slightly impounds Roaring Creek, water also flows over the top of the dam. It is possible that the dam may act as a fish passage barrier once the stream has been restored to the point where a viable fish population has been established.

3.1.9 Topography/Elevation

Roaring Creek originates at an elevation of 3,200 ft mean sea level (msl) and drops approximately 1,325 ft to enter the Tygart Valley River at an elevation of 1,875 ft msl (Figure 3). Topography data was obtained from the West Virginia GIS Technical Center (2005).

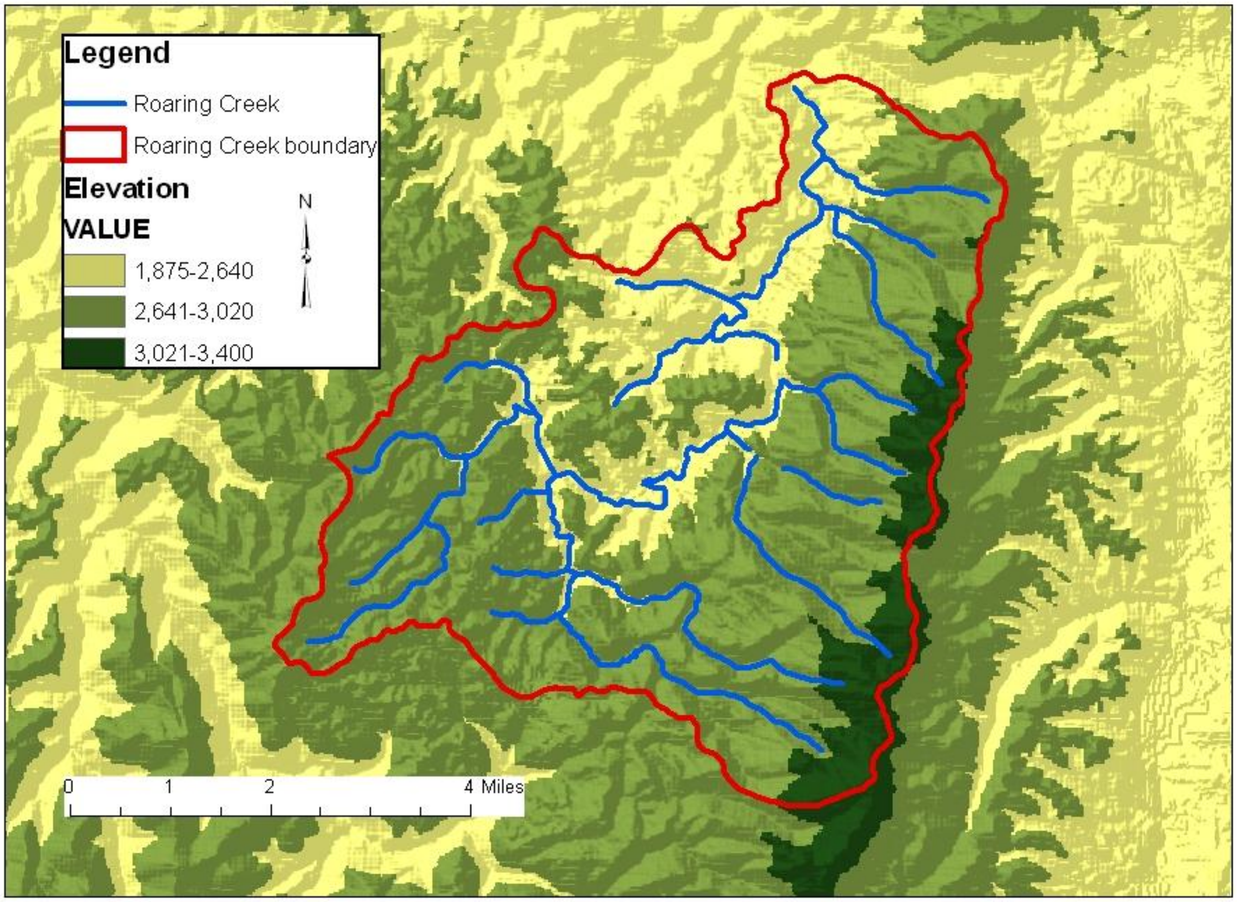

Figure 3. Digital Elevation Model of the Roaring Creek watershed. High elevations are shown in dark green and low elevations are shown in light green/yellow. Elevation values are given in feet.

3.1.10 Geology and Soils

The majority of the rocks that outcrop in West Virginia are Paleozoic in age. In the Roaring Creek watershed, the rocks that outcrop all belong to one system and period (Carboniferous and Pennsylvanian). Roughly 80% of the outcrops are classified in the Kanawha Series of the Pottsville Group, >19% are classified in the Allegheny Series (particularly along the eastern and western edges of the watershed at higher elevations), while the remainder of the geology consists of alluvium deposits from the Quaternary System found around the population centers in the watershed. The oldest formation documented in the watershed is the Lower Kittanning coal. The youngest formation documented is the Allegheny formation (Reger, 1931).

Two coal seams are found within the Roaring Creek watershed. These are the Middle/Lower Kittanning and the Upper Mercer coal seams. The Middle/Lower Kittanning coal seam is detailed as one seam because they were typically mined together and only had a very thin parting of shale between them. This coal seam is found within the deeper depths of the Allegheny Series. The Middle/Lower Kittanning seam was the principally mined seam in the watershed and the most valuable mineral resource within the watershed. This coal is 8-10 ft thick across the region (Reger, 1931).

The Upper Mercer coal seam is found within the Pottsville Group. This coal seam is often patchy and does not always obtain minable thickness due to a large amount of slate and bony coal found within the coal seam. In the area of Roaring Creek, the Upper Mercer seam is 1-3 ft thick (Reger, 1931).

Sixteen different soil types are represented in the Roaring Creek watershed (Table 1). Of these, the Buchanan-Ernest, Cookport, Dekalb, Ernest, Gilpin, Lily, and Udorthent soil families are the most prevalent. The majority of these soils are either a type of loam or a stony soil. The Udorthents are the main exception to this trend, as they are mostly made up of weathered mudstone.

There are also two major associations of different soil types within the watershed. The Gilpin-Dekalb-Lily association covers the entire watershed with the exception of the eastern edge of Roaring Creek. In this area, the terrain is steeper and the dominant soil association is the Gilpin-Dekalb-Buchanan. Both of these soil groups are well-drained acid soils that are gently sloping to very steep. Figure 4 is a general soil map of Randolph County. The Roaring Creek watershed is located in the northwest corner of the map.

Table 1. Soil types represented in the Roaring Creek watershed.

Soil Series	**Percent coverage in watershed (%)**
Buchanan and Ernest	18.9
Cookport	5.2
Dekalb	21.7
Ernest	4.3
Gilpin	8.9
Gilpin-Dekalb	25
Lily	8.6

Udorthents	7.4
Water	0

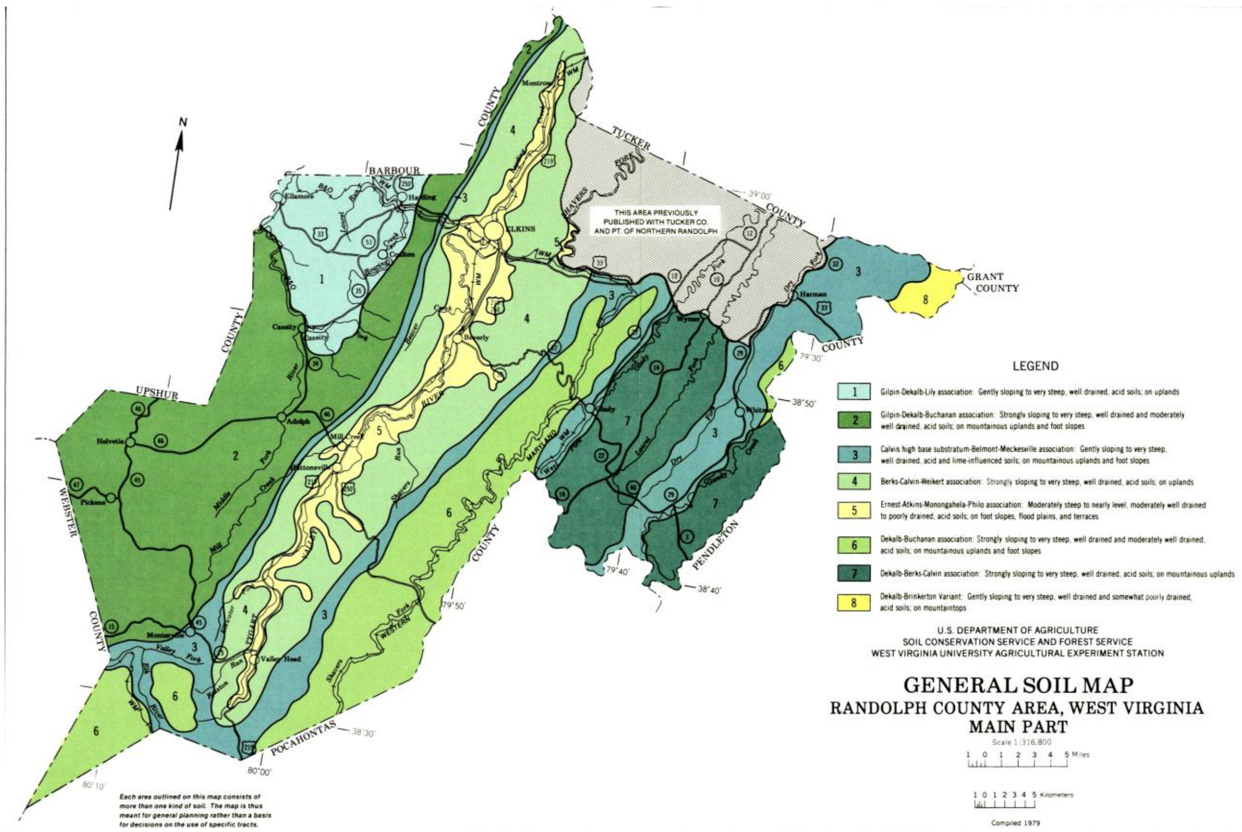

Figure 4. General soil map of Randolph County, WV. Roaring Creek is in the light blue section in the northwestern corner of the map.

3.1.11 Vegetation

The majority of the Roaring Creek watershed (>95%) is deciduous forest. Along the mainstem of Roaring Creek, some areas of evergreen forest exist. The rest of the watershed consists of pastureland, cultivated cropland, and small areas of bare land. The bare land is likely mining-impacted.

3.1.12 Exotic/Invasive Species

Several non-native invasive species are found in West Virginia. These include garlic mustard, Japanese honeysuckle, kudzu, purple loosestrife, mile-a-minute, Japanese knotweed, sachaline knotweed, spotted knapweed, barren brome, and tree of heaven. It is likely that many of these could be found in the Roaring Creek watershed. However, a detailed survey of invasive species within Roaring Creek has never been performed.

3.1.13 Wildlife

West Virginia is home to more than 57 species of amphibians and reptiles; 70 wild mammals; 178 species of fish and nearly 300 species of birds (WVDNR, 2003a). Many of these species can be found in the Roaring Creek watershed. Some species of note within the watershed include: white-tailed deer, various species of trout, coyotes, black bears, and wild turkeys. This is just a small sampling of the possible wildlife diversity within the watershed.

3.1.14 Protected Species

Eleven species of animals and four species of plants found in West Virginia are listed as endangered. Of these endangered species, only the Northern Flying Squirrel, Indiana bat, and Virginia Big-Eared Bat are found in Randolph County (WVDNR, 2003b). The Indiana Bat and the Virginia Big-Eared Bat may be found in open, abandoned mines within the Roaring Creek watershed. However, a bat survey has never been completed.

In addition, four species of animals and two species of plants are listed as threatened. One of these (the Cheat Mountain Salamander) can be found in Randolph County (WVDNR, 2003b).

3.1.15 Sensitive Areas

There is a potential for two endangered species to be found in the Roaring Creek watershed. Both the Indiana bat and the Virginia Big-Eared bat could be found in abandoned mines or caves. Special care would need to be taken to ensure the survival of these species if they reside in a mine that needed to be reclaimed. A bat survey would be completed before mine reclamation would take place. If a bat population was found, a bat gate would be installed to allow the bats to enter and exit the mine.

The headwaters of Roaring Creek are also a sensitive area. Trout have already been seen in the headwaters. Most of the needed stream structure and productivity requirements for trout already exist in this area. This area of the watershed is currently entirely rural and will likely remain that way for some time. The residents of this area of the watershed have preserved the integrity of the local environment because they use the land for fishing and hunting. Because of this, it is unlikely that the headwaters will need further protection than they already receive.

3.1.16 Cultural Resources

No cultural resources are known to exist within the watershed at this time.

3.2 Land Use and Land Cover

Land use and land cover data were obtained from the USGS Land Cover Analysis Tool. Data used in this report were based off of the 2001 revision of the National Land Cover Database. The primary land use in the Roaring Creek watershed is deciduous forest (Table 2). At the time of this study, only 1.10% of the watershed is developed (Low and medium intensity urban areas).

Table 2. Land use categories within the Roaring Creek watershed.

Land Use Type	% of total land use
Deciduous Forest	81.00%
Open Space	5.70%
Cultivated Crops	3.57%
Pasture/Hay	3.14%
Barren Land (Rock, Mining)	2.50%
Open Water	2.00%
Low Intensity Urban	0.87%
Mixed Forest	0.56%
Evergreen Forest	0.37%
Medium Intensity Urban	0.23%
Emergent Herbaceous Wetlands	0.06%

TOTAL	100.00%

3.2.1 Open Space

With the exception of the small towns of Coalton and Mabie, the Roaring Creek watershed has remained almost entirely rural in nature. According to Table 2, 5.7% of the watershed is open space. However, other areas such as stream corridors, also are counted as open space, even though they are in a separate category in Table 2 (open water). Development has occurred very slowly in this watershed, with this trend likely to continue. It is anticipated that the amount of open space in the watershed will remain constant or decrease slightly in the near future.

3.2.2 Wetlands

Emergent wetlands only make up 0.06% of the land area in the Roaring Creek watershed. However, there is another type of wetland that occurs within the watershed, called a forested/shrub wetland. Several wetlands within the watershed (as cataloged by the US Fish and Wildlife Service) are near the town of Coalton. Of these wetlands, roughly 50% of them are emergent and 50% are forested/shrub wetlands. Four forested/shrub wetlands are also found near the town of Mabie.

3.2.3 Forested Areas

Roughly 82% of the land area within the Roaring Creek watershed is forested, with only 1% of the forested area being evergreen forest. The deciduous forest is dominated by oak and similar tree types. The eastern half of the watershed has a greater amount of forest cover than other parts of the watershed, mainly due to a lack of population centers and farming in this part of the watershed. Forested areas are much thinner near the towns of Coalton and Mabie. The Flatbush Run subbasin in the western part of the Roaring Creek drainage has a large amount of forested area interspersed with farmland and some mined land/barren areas (Figure 5).

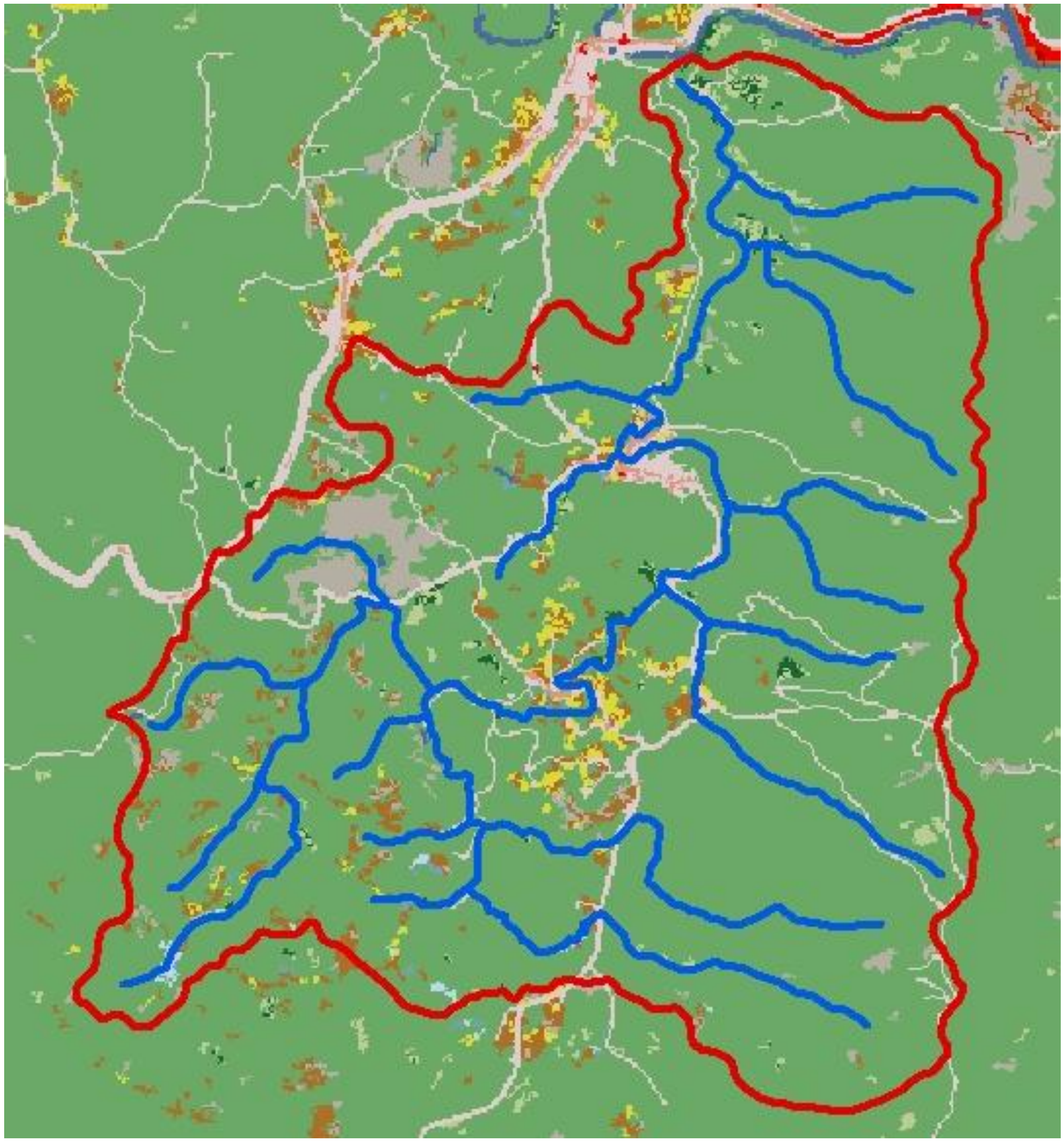

Figure 5. Land uses within the Roaring Creek watershed. The majority of the watershed is forested (green). However, some farming and pasture exist near Mabie and Coalton (brown and yellow areas, respectively). Grey areas signify barren/mined land.

3.2.4 Agricultural Lands

There are 484 farms in Randolph County at an average size of 216 acres (USDA, 2007). Most farms within the county are either cattle or hog farms. The average value of a farm in Randolph County is ~$475,000. It is unknown exactly how many of these farms are within the Roaring Creek drainage. However, 6.71% of the land within the watershed is either cultivated crops or pasture land (Table 2). The majority of these farms are near the population centers of Coalton and Mabie.

3.2.5 Mining

The Lower Kittanning coal seam was mined extensively in Roaring Creek. Underground mining was exclusively performed from the town of Mabie to the mouth of Roaring Creek (Figure 6). Very little surface mining was carried out in this watershed. The heaviest concentration of mining occurred near Coalton (central part of the watershed). The subtributary of Kittle Hollow, which enters Roaring Creek near the high school in Coalton, was mined along its entire length. Because of this, the majority of AMD found in Roaring Creek is found in Kittle Hollow.

Two small mines near Rich Mountain (in the southeastern part of the watershed) removed coal from the Sewell coal seam (Figure 6). However, this seam was too thin to be economically mined in other areas of Roaring Creek.

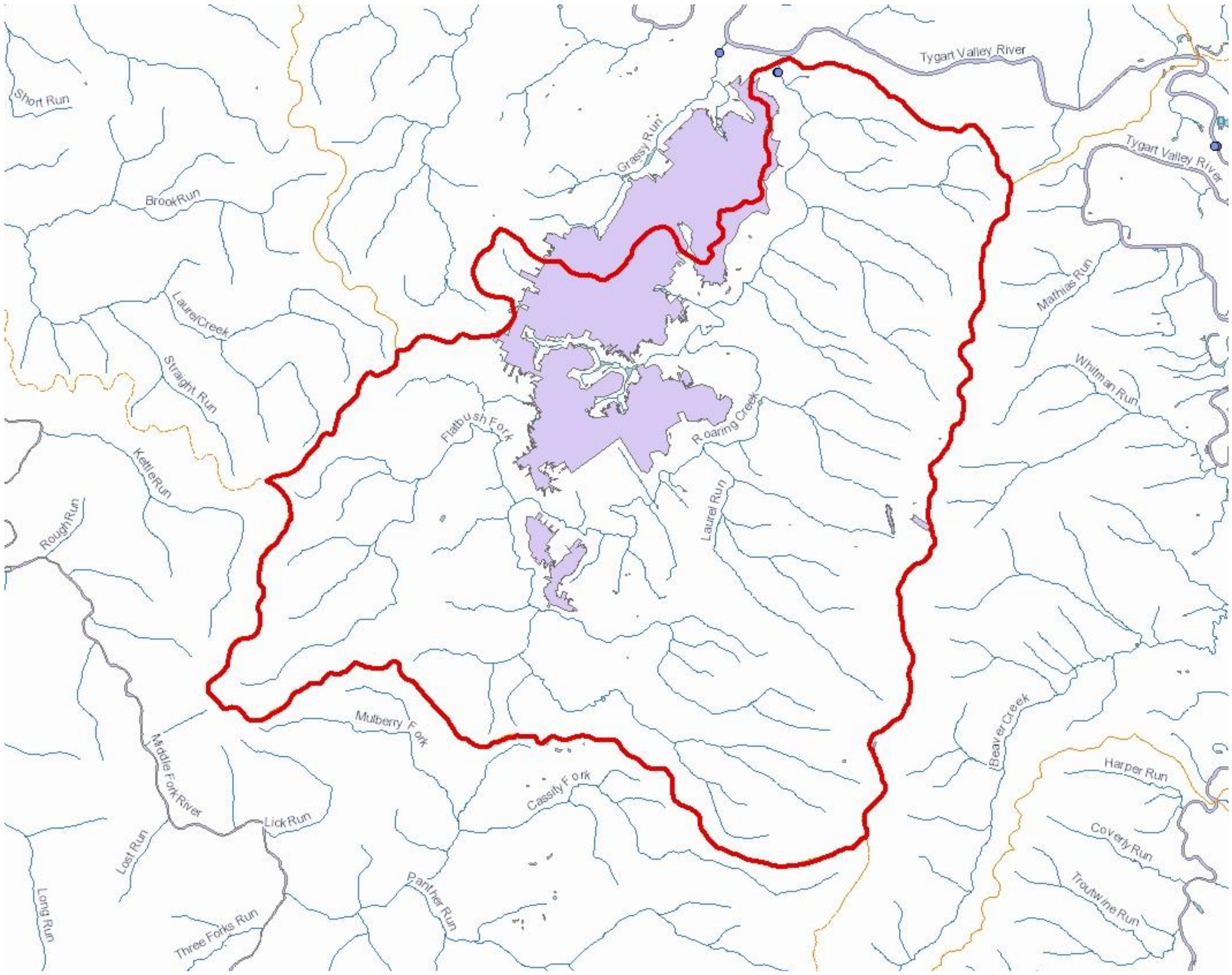

Figure 6. Underground mining within the Roaring Creek watershed. The watershed is delineated by the red line and the extent of underground mining is in purple.

3.2.6 Fisheries

There are no commercial fisheries within the Roaring Creek watershed. However, some areas of the watershed, especially near the headwaters, have native brook trout.

3.2.7 Recreation

Roaring Creek is a fairly small watershed. As such, recreational uses of the stream are limited. The major recreational uses are fishing and contact recreation, such as wading and swimming. Restoration of mining impacts within Roaring Creek may present further opportunities for recreation to the citizens of the watershed.

3.2.8 Developed Areas

Roaring Creek is mostly undeveloped at this time. Figure 7 shows the amount of impervious surfaces within the watershed, with white areas illustrating a larger amount of impervious surfaces and black areas having a lesser amount. The greatest concentration of impervious surfaces, and thus development, is near the towns of Coalton and Mabie, where there are some light and medium intensity urban areas. Some development has also occurred along the main road corridors in the watershed.

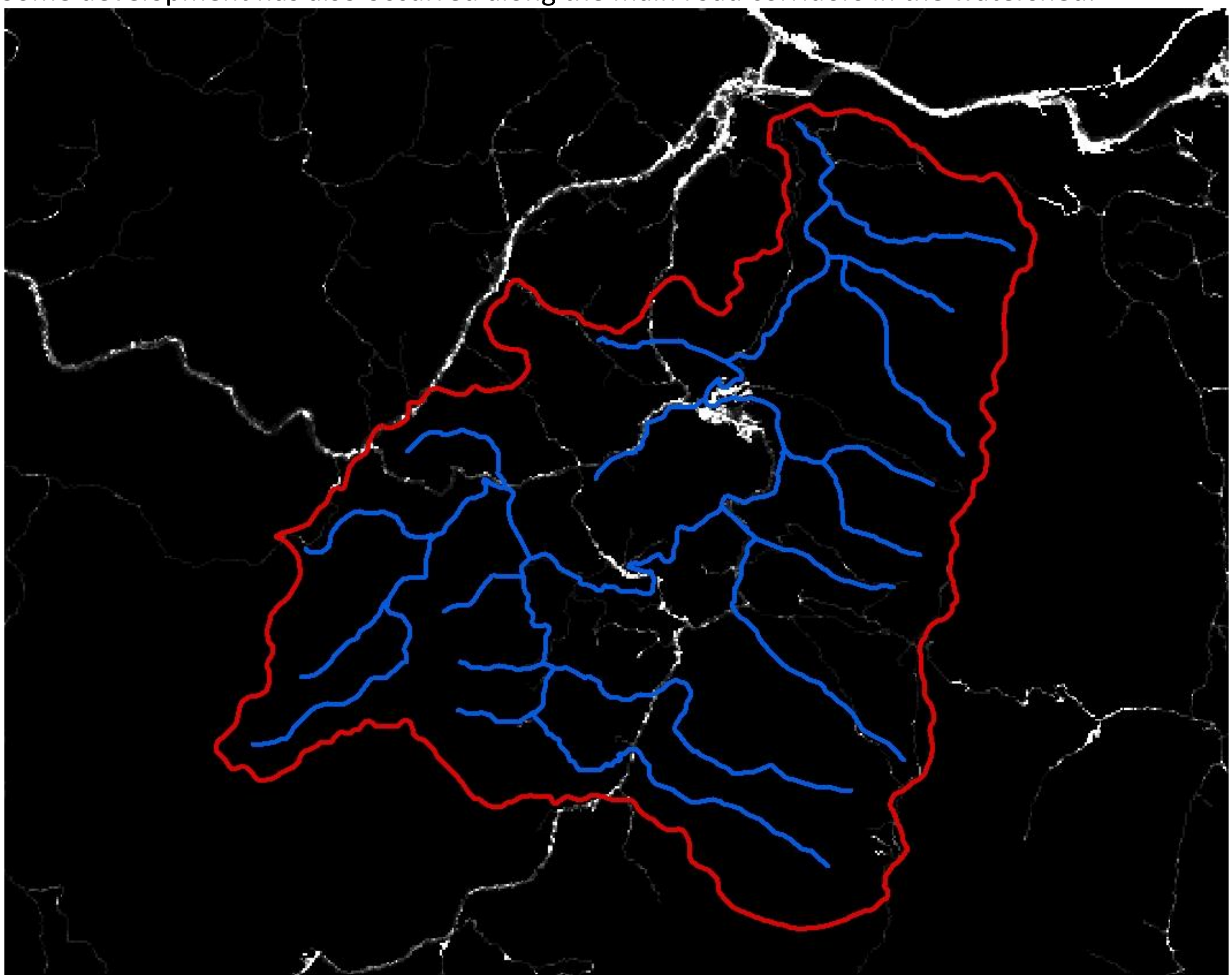

Figure 7. Map of impervious surfaces within the Roaring Creek watershed.

3.2.9 Transportation

There are no major transportation corridors within the watershed. The roads that carry the most traffic are two-lane roads with one lane going each direction. These roads connect the towns of Mabie and Coalton with one another, as well as intersecting Route 33. Route 33 is a four lane divided highway that is just north of the watershed. The largest impact from transportation within the watershed is likely salt used for road de-icing in the winter. The headwaters of Roaring Creek are likely not impacted by salt because population is sparse in this area. The middle of the watershed is more likely to show impacts from road salt due to a greater population density.

3.2.10 Political Boundaries

The majority of the land area within the Roaring Creek watershed is privately owned. There are no Federal or State owned lands within the watershed. In the undeveloped parts of the watershed, most land is owned by land holding companies, who then lease the land to groups of citizens for recreational purposes. Land around the towns of Mabie and Coalton are mainly used for residential dwellings and is owned by private individuals.

3.2.10.1 Federal Lands

Only one parcel of land within the Roaring Creek watershed has a Federal designation. Rich Mountain Battlefield (eastern part of the watershed) is on the National Register of Historic Places. However, the land itself is not federally owned.

3.2.10.2 State Lands

There are no state-owned lands within the Roaring Creek watershed.

3.2.10.3 Tribal Lands

There are no tribal lands within the Roaring Creek watershed.

3.2.10.4 Local Lands

There are no lands owned by local jurisdictions within the Roaring Creek watershed.

3.2.11 Relevant Authorities

This section is not applicable, as there are no federal, state, tribal, or local lands within the watershed.

3.2.12 Future Land Use Considerations

No future land use plan has been conducted for the Roaring Creek watershed. However, one future land use is known. A coal loadout facility will be constructed in 2011 near the confluence of Roaring Creek and the Tygart Valley River. Although it is not known what specific effects this facility will have on water quality, it is likely that it will impact water quality within the Roaring Creek watershed.

3.3 Demographic Characteristics

The US Census Bureau collects demographics data based on political boundaries, such as city limits and county lines. Roaring Creek is completely within Randolph County. As such, the demographic data presented will be for Randolph County. All Census data were obtained from the US Census Bureau's website (US Census Bureau, 2010).

3.3.1 Population

In 1900, Randolph County had a population of 17,670. By 1910, the population had increased almost 68%. Between 1910 and 2000, the population of Randolph County has increased by only 9% to 28,262 people. The US Census Bureau estimated that by 2009, the population had increased to 28,390 with 97.5% of the population being white, 1.3% being black, 0.2% being Native American, and 0.5% being Asian (US Census Bureau, 2010).

3.3.2 Economics

The 2000 Census determined that there were 11,072 households in Randolph County, with 2.41 persons residing in each household. In 2009, the median household income in Randolph County was $34,872, which was slightly lower than the household median income for the state of West Virginia ($37, 528). The per capita income in Randolph County was also lower than the average for the state of West Virginia ($14,918 vs. $16,477). Lastly, the percent of persons living below the poverty level was slightly higher in Randolph County than the rest of West Virginia (17.7% vs. 17.4%) (US Census Bureau, 2010).

3.3.3 Languages

The large majority of citizens within Randolph County speak English as their primary language. However, 2.2% of the county's residents speak a language other than English at home. It is likely that of this 2.2%, the majority of this group of people speak English as well. Since this is the case, outreach materials generated from this watershed-based plan will only need to be printed in English.

4 Watershed Conditions

4.1 Water Quality Standards

All streams within West Virginia are regulated by the WV Department of Environmental Protection. Regulations concerning West Virginia water bodies are promulgated under Title 47, Series 2 of the West Virginia Department of Environmental Protection Water Resources code, entitled "Requirements Governing Water Quality Standards."

4.1.1 Designated and Desired Uses

According to the West Virginia Legislative Rules for the Department of Environmental Protection, Office of Surface Water Quality, the Water Quality Standards Rule 47 CSR2 requires, at a minimum, all waters of the State of West Virginia be designated for the propagation and maintenance of fish and other aquatic life (Category B) and for water contact recreation (Category C). Category B waters include warm water fishery streams, trout waters, and wetlands. Category C includes swimming, fishing, water skiing, and certain types of pleasure boating such as sailing in very small craft and outboard motor boats. Roaring Creek is not considered a category B2 trout water by the state of West Virginia.

4.1.2 Numeric and Narrative Criteria

In the case of Roaring Creek, numeric criteria have been used to establish whether or not the stream is meeting water quality standards. Numeric criteria are preferred in this case because the source of pollution is known and it is possible that some pollutants found within Roaring Creek could negatively affect human health. Table 3 illustrates numeric criteria for metal concentrations within West Virginia streams.

Table 3. Numeric criteria for acute and chronic exposure to three different metals.

Parameter	Use Designation				
	Aquatic Life				Human Health
	B1, B4		B2		
	Acute	Chronic	Acute	Chronic	Acute
Aluminum (ug/L)	750	750	750	87	
Iron (mg/L)		1.5		0.5	1.5
Manganese (mg/L)					1.0

The allowable amount of fecal coliform bacteria within a water body is also regulated. The maximum allowable level of fecal coliform content for Primary Water Contact Recreation shall not exceed 200 colonies/100 ml as a monthly geometric mean based on not less than 5 samples per month; nor can it exceed 400 colony forming units/100 ml in more than ten percent of all samples taken during the month.

4.1.3 Antidegradation policies

The State of West Virginia's antidegredation policies can be found in the legislative rule for the Department of Environmental Protection Secretary's office (WVDEP, 2001). This rule divides the state waters into Tier 1 and Tier 2 waters. Roaring Creek is a Tier 1 watershed. All waters of the state receive Tier 1 protection. Tier 1 protection states "existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected" (WVDEP, 2001). Tier 1 watershed are waters of the state where the "water quality is not sufficient to support recreation and wildlife and the propagation and maintenance of fish and other aquatic life or where the water quality meets but does not exceed levels necessary to support recreation" (WVDEP, 2001).

4.2 Available Monitoring/Resource Data

All available water quality data pertaining to Roaring Creek was collected for the making of this plan. Water quality data included both chemical and biological data and was collected from a variety of sources. Further descriptions of the data, including who collected it, monitoring station locations, and monitoring duration, will be described in greater detail in the following sections.

4.2.1 Water Quality Data

Acid Mine Drainage

The lower half (from Coalton to the mouth) of the Roaring Creek drainage is heavily impacted by AMD. The main stem of Roaring Creek, as well as the subtributary of Kittle Hollow, are on the 1998 303(d) list of Impaired Streams for pH and metals. TMDLs for iron, aluminum, and manganese have been established for Roaring Creek as part of the Tygart Valley River TMDL that was completed in 2001. The Tygart Valley River is scheduled for TMDL redevelopment in 2012.

Water chemistry data has been collected by several different organizations and groups:

- WVDEP: The Watershed Assessment Protocol (WAP) group collected water chemistry data at seven different points on Roaring Creek from 1997 - 2008. These data were collected on the mainstem of Roaring Creek as well as on Flatbush Fork, a tributary of Roaring Creek. These data can be found in Appendix A.

- US EPA: Sample data was collected as part of the construction of the 2001 Tygart Valley River TMDL (Appendix A). These data show that Roaring Creek is impacted by high metal concentrations from its headwaters to its confluence with the Tygart Valley River.
- USGS: Data was collected during the late 1960's and early 1970's by the USGS. Samples were collected at the USGS gauging station at the mouth of Roaring Creek. Appendix A gives the collected data.
- WVU Division of Forestry: Data was collected in 2004-2005 as part of the EPA Science To Achieve Results (STAR) program. Two sites (one in the upper watershed and one in the lower watershed) within the Roaring Creek watershed were monitored. Data from these sampling times are given in Appendix A.
- WV Water Research Institute: Data was collected in 2009 and 2010 by the WV Water Research Institute. Samples were taken quarterly for a year. Sampling results and sample locations are given in Appendix A.

Bacteria

Fecal coliform data were taken by the WVDEP WAP Group at the same time as their other water chemistry sampling. This data can be found in Appendix A.

4.2.1.2 Impaired Uses and/or Water Quality Threats

The entire length of the mainstem of Roaring Creek is on the Clean Water Act 303(d) list for low pH and high metal concentrations. The main source of these impairments is acidic drainage from abandoned coal mines. The increased metal concentrations from these abandoned mines currently impair the designated use of Roaring Creek. As a Tier 1 stream, Roaring Creek's designated use is contact recreation.

4.2.2. Flow Data

There is a greater amount of existing water chemistry data for Roaring Creek than flow data. However, three organizations have collected flow data. These are:

- USGS: The USGS had a gauging station located at the mouth of Roaring Creek from 1965-1969. Flow data was taken daily during this time period. Appendix A gives daily discharge values for this time period.
- WVU Division of Forestry: Data was collected in 2004-2005 as part of the EPA Science To Achieve Results (STAR) program. Flow data was collected at the same time as the water chemistry samples. Discharge data from these sampling times are given in Appendix A.

- WV Water Research Institute: Flow measurements were taken by the WVWRI during 2009-2010 at the same time as their water chemistry samples. These data are given in Appendix A.

4.2.3 Biological Data

Very little historical biological sampling was found for Roaring Creek. Benthic macroinvertebrate data was collected by West Virginia University during two different times. No formal fish surveys or vegetation data has been collected for this watershed.

4.2.3.1 Benthic Macroinvertebrates

- WVDEP: Benthic macroinvertebrate data was collected by the WAP group at the same time as their water chemistry samples. Benthic organisms were identified in both the mainstem of Roaring Creek and Flatbush Fork. These data are given in Appendix A.
- WVU Division of Forestry: Data was collected in 2004-2005 as part of the EPA Science To Achieve Results (STAR) program. Benthic macroinvertebrates were collected from two different sites within the Roaring Creek watershed (one in the upper watershed and one in the lower watershed). Data from these macroinvertebrate sampling times are given in Appendix A.
- WV Water Research Institute: Benthic macroinvertebrate samples were collected in 2009 and 2010 by the WV Water Research Institute. Samples were taken two times in a year (April and October) because this was deemed the best time of year to capture a representative stream macroinvertebrate population. Sampling results and sample locations are given in Appendix A.

4.2.3.2 Fish

No formal fish surveys have been completed on Roaring Creek. However, informal surveys by Trout Unlimited members have found trout and other species of fish in the headwaters of the watershed. Trout were also found in Laurel Run, a tributary of Roaring Creek.

4.2.3.3 Aquatic Nuisance Species

No data was found regarding Aquatic Nuisance Species (ANSs) within the Roaring Creek watershed. Some ANSs may exist within the watershed, but none have been formally documented.

4.2.3.4 Migratory Patterns

No migratory pattern data specific to the Roaring Creek watershed was found. However, some data do exist for the state of West Virginia. In West Virginia, 88 of 171 bird species migrate to the tropics (WV DNR, 2004). Initiatives such as the Partners in Flight (PIF) program and the Important Birds Area (IBA) program track bird populations and migratory paths. Eight IBAs can be found in West Virginia, including two that are rated as globally important (Audubon Society, 2011). None of these IBAs are within the Roaring Creek watershed or even within Randolph County. The New River Gorge and Coopers Rock IBAs are closest to the Roaring Creek watershed.

4.2.4 Stream Survey Data

Stream survey data for the Roaring Creek watershed was collected by the WV DEP WAP group at the same time as their water chemistry samples were taken. The WAP group computed Rapid Bioassessment Protocol (RBP) scores for five different sites within the watershed. These scores were calculated using multiple physical parameters of the stream. The complete description of this method can be found in the document "Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition" (Barbour et al., 1999). The WAP group data can be found in Appendix A.

5 Pollutant Source Assessment

5.1 Nonpoint Sources

There are multiple potential sources of pollution in the Roaring Creek watershed. These could include sediment, nutrients, bacteria, and mining, among others. It is unlikely that either sediment or nutrients are significant sources of pollution because the watershed is mostly forested (thus soil loss is less of a problem) and there is very little agriculture within the watershed. It is unknown if fecal coliform bacteria are currently a problem in Roaring Creek because no fecal coliform sampling has been performed since 2008. Of all sources of pollution, mining is the most significant impact to Roaring Creek's water quality. The impacts of historic mining within the watershed are very easily seen.

5.1.1 Mining

As previously noted, all of the mining in the Roaring Creek watershed is in the Lower Kittaning and Sewell coal seams, and most was mined between 1930 and 1950. All of the underground mining in the watershed was completed before the 1977 Surface Mine

Control and Reclamation Act (SMCRA). The WVDEPAML program determined that there are 21 AML Problem Area Descriptions (PADs) within Roaring Creek (Figure 8). MCTU and WVWRI completed a sweep of the watershed and found four more abandoned mine sites within the Kittle Hollow subwatershed that were not listed in the AML inventory (Figure 9). The full data set collected at each of these sites sampled by MCTU/WVWRI is located in Appendix A. Table 4 contains the average data for each of the sites.

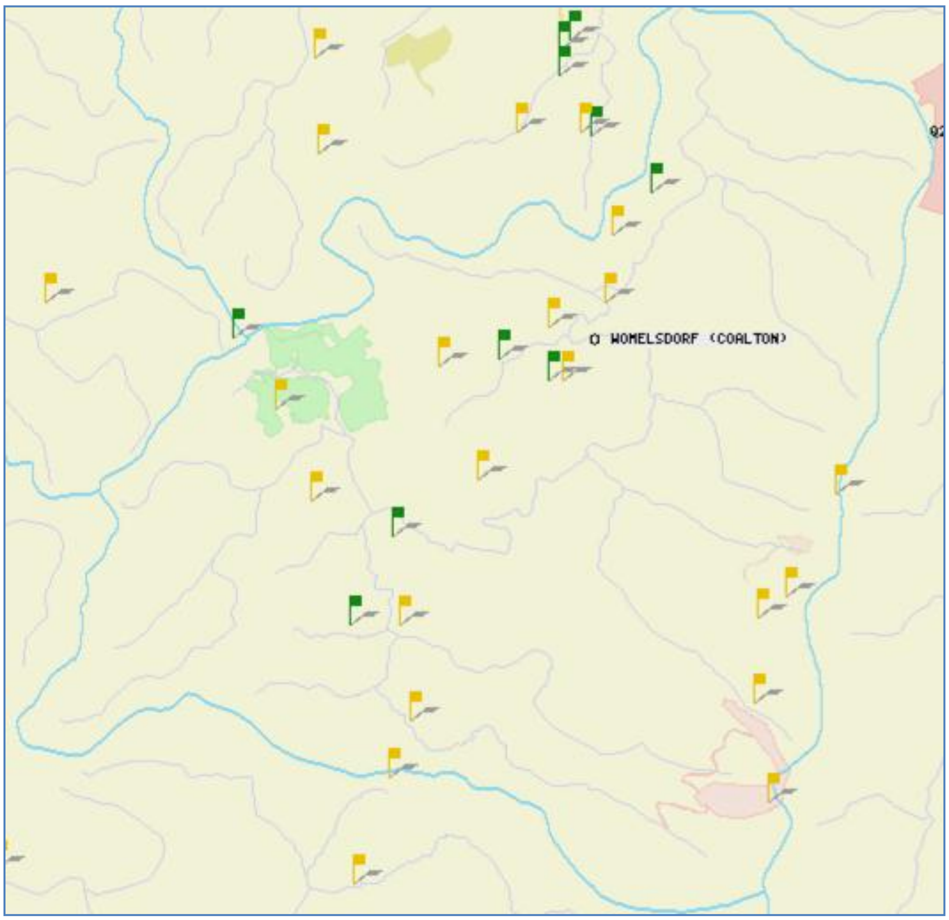

Figure 8. Map of Problem Area Descriptions (PAD) in Roaring Creek inventoried by the West Virginia Abandoned Mine Lands (AML) program. Green flags are completed projects and yellow flags are incomplete projects.

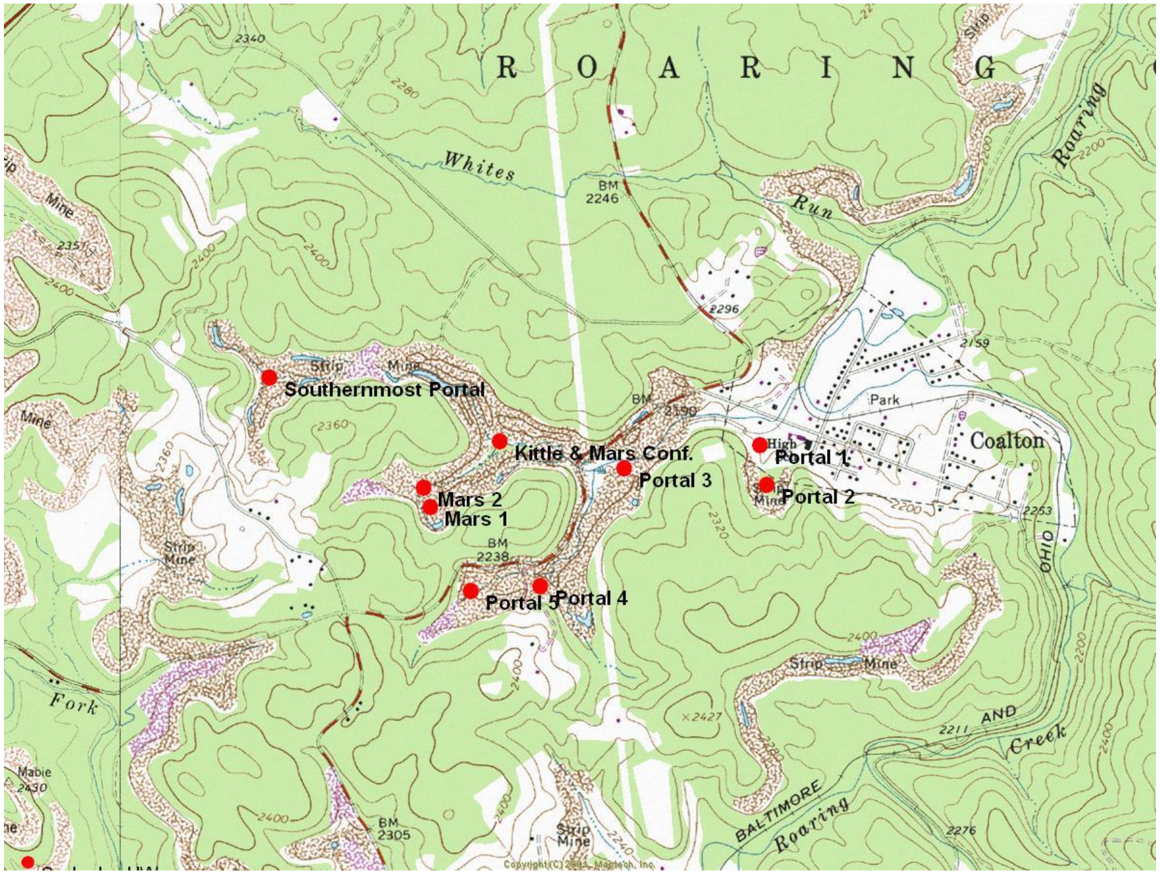

Figure 9. Map of Problem Area Descriptions (PAD) in Kittle Hollow inventoried by the West Virginia Abandoned Mine Lands (AML) program, WVWRI, and MCTU.

Table 4. Average water quality data for sample sites in Kittle Hollow.

Sample site	Flow	EC	pH	Acidity	Alkalinity	SO4	Fe	Al	Mn
	GPM	us/cm3		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Southernmost Portal	133.35	1351.67	2.89	179.29	0.33	682.67	16.02	10.73	1.74

Mars Portal 1	197.57	1287.75	2.89	264.96	0.38	515.75	31.63	17.13	0.91
Mars Portal 2	100.35	1649.50	3.13	108.22	0.50	766.00	12.01	9.76	1.86
Coalton School Portal/Portal 1	50.20	580.75	3.56	72.02	0.38	329.50	1.49	11.15	1.04
Coalton Mine Drainage/Portal 2	53.46	381.25	4.30	13.78	0.50	177.00	0.26	1.77	0.47
Portal 3	264.10	495.00	3.71	33.37	0.50	206.25	0.85	3.61	0.32
Portal 4	8.29	1369.75	3.04	495.13	0.50	692.50	84.58	37.36	1.69
Portal 5	11.20	1275.50	3.00	341.00	0.50	482.25	55.15	24.60	0.83

Mining has affected the lower six miles of Roaring Creek's mainstem and impaired roughly eight miles of Roaring Creek's tributaries. Table 5 details impaired stream miles, pollutant type, and pollutant sources for two of Roaring Creek's tributaries, as well as for the mainstem itself.

Table 5. Description of mining impacted tributaries of Roaring Creek.

Sample point	Impacted stream miles	Pollutant type	Pollutant source
Mainstem Roaring Creek	6.6	Fe, Al, pH	Abandoned mines throughout watershed
Whites Run	3.2	Fe, Al, pH	2 abandoned mines
Kittle Hollow	4.9	Fe, Al, pH	7 abandoned mines

Southernmost Portal

The Southernmost Portal is the farthest upstream mine drainage source in Kittle Hollow. It is not listed in the WVDEP AML database. Although the site has been reclaimed, acidic mine drainage still emanates from a portal that had wet seals installed in it. Presently, the water flows from the wet seals into a small depression before it mixes with a small stream to form the headwaters of Kittle Hollow. Average water quality values for this site can be seen in Table 4. Figure 10 is a picture of the wet seals.

Figure 10. Water emanating from wet seals at the Southernmost Portal site.

Mars Portal 1 and 2

Although these sites are two separate portals, they will likely be addressed at the same time. They are separated from one another by roughly 0.25 miles. The majority of the discharge from these two portals comes from Mars 1. Mars 2 was dry during the last two sampling times. Both portals are currently open and neither of them are in the WVDEPAML's database. Average water chemistry can be found in Table 4. Figure 11 is a picture of the discharge downstream of the confluence of the two portals, but before their confluence with Kittle Hollow.

Figure 11. Combined discharge from Mars Portals 1 and 2.

Portal 5

Portal 5 is on a separate fork of Kittle Hollow than the previously described sites. It is located at the headwaters of the southern fork of Kittle Hollow. It is collapsed portal that continues to discharge acidic mine water. It was not found in the WVDEPAML database. Average water chemistry can be found in Table 4. Figure 12 is a picture of the portal and its discharge.

Figure 12. Portal 5 and its discharge.

Portal 4

Portal 4 is slightly downstream of Portal 5. It was not found in the WVDEPAML database. It is an open portal that has been fenced off for the safety of the public. Acidic water discharges into a flat area and then into the southern tributary of Kittle Hollow. Average water chemistry can be found in Table 4. Figure 13 is a picture of Portal 4 and its discharge.

Figure 13. Portal 4 and its discharge.

Portal 3

Portal 3 is just downstream of the confluence of the northern and southern forks of Kittle Hollow. It was not found in the WVDEPAML database. It is a partially collapsed portal, although the mine entry can still be seen. As with all the other portals in Kittle Hollow, the discharge is acidic. The water quality of this discharge is not as severe as other mine sites within the watershed. Average water chemistry can be found in Table 4. Figure 14 is a picture of Portal 3 and its discharge.

Figure 14. Portal 3 and its discharge.

Portal 2/Coalton Mine Drainage

Portal 2 is in the town of Coalton near the elementary school. It is listed in the WVDEPAML database as WV5800 – Coalton Mine Drainage. The AML program has not yet done any reclamation at this site. It is an open portal that discharges acidic water down a steep slope into Kittle Hollow near its confluence with Roaring Creek. Water quality at this site is slightly better than mine sites in the headwaters of Kittle Hollow. This mine does not discharge as much water and metal concentrations are lower than some other mines in the area. Average water chemistry can be found in Table 4.

Portal 1/Coalton School Portal

Portal 1 is directly behind Coalton school. It is listed in the WVDEPAML database as WV4966 – Coalton School Portal. This site has been reclaimed by WVDEP AML program. A wet seal was installed to channel the water into a grouted limestone channel. Minimal water treatment occurs before the water discharges into Kittle Hollow. Discharge at this site is similar to Portal 2. However, the pH is much lower and metal concentrations are much higher than Portal 2. For the discharge to be fully treated at this site, further treatment is needed. Average water chemistry can be found in Table 4.

5.1.2 Agriculture

Potential pollutants from agriculture could include nutrients, sediment, animal wastes, and pesticides. Although there is a potential for these pollutants to impact the water quality of Roaring Creek, it is unlikely because the amount of agriculture within the watershed is small (6.5%). In 2007, there were 484 farms totaling 104,441 acres in all of Randolph County (USDA, 2007). Only a small percentage of these are likely within Roaring Creek due to the forested nature of the watershed. Because of this, pollution from agricultural sources would not have as large of an effect on overall water quality as historic coal mining or other nonpoint pollution sources.

5.1.2.1 Livestock

Watershed livestock statistics could not be found for Roaring Creek. However, data are available for Randolph County. In order to estimate the amount of livestock in Roaring Creek, the total land area of the watershed (29 mi^2) was divided by the total land area of Randolph County (1,040 mi^2). By this estimation, the Roaring Creek watershed is approximately 2.8% of Randolph County. This percentage will be used to estimate all agricultural and livestock populations within the watershed. However, it is likely that agricultural activity within the watershed will be overestimated by using this percentage due to the large amount of forested land within Roaring Creek.

Randolph County has a relatively large amount of agricultural activity compared to other counties in West Virginia (USDA, 2007). Table 6 details the estimated amount of livestock within Roaring Creek by animal species.

Table 6. Estimated amount of livestock within the Roaring Creek watershed. Values less than 1 were rounded up to 1. "No Estimate" values were not calculated in the 2007 Census of Agriculture.

Animal type	Number of farms	Number of animals
Beef Cows	5	No estimate
Dairy Cows	1	No estimate
Hogs and Pigs	1	3
Sheep and Lambs	2	84
Chickens (Layers)	2	36
Chickens (Broilers)	1	No Estimate

The amount of farms and number of animals estimated within Roaring Creek imply that livestock are not likely to be a significant source of nonpoint pollution in the watershed.

5.1.2.2 Cropland

Possible water quality impacts from cropland could include nutrients, sediment, pesticides, and other chemicals. Similar to the amount of livestock in the watershed, the amount of cropland is unlikely to cause a significant degree of water quality impairment due to the small number of farms within the watershed. Table 7 gives data for various crops in Roaring Creek.

Table 7. Estimated amount of crops grown within the Roaring Creek watershed. Values less than 1 were rounded up to 1. "No Estimate" values were not calculated in the 2007 Census of Agriculture.

Crop	Number of farms	Number of acres

Corn	1	39
Wheat	No Estimate	No Estimate
Oats	1	3
Barley	1	No Estimate
Forage	10	479
Potatoes	1	No Estimate

5.1.2.3 Wildlife

No detailed statistics on wildlife within the Roaring Creek watershed were found. However, much of the wildlife found in other heavily forested parts of this area of West Virginia are likely found in the watershed. Mammals found in this area could include white-tailed deer, black bear, foxes, coyotes, skunks, moles, bats, and several types of rodents. Various bird species may also be found here, including cardinals, robins, hummingbirds, and many others. Reptiles and amphibians are also represented in the watershed, with several species of snakes, frogs, toads, etc. found within Roaring Creek. Lastly, fish are found in many of the streams in the watershed. Trout are the most sought after species for their recreational value. Trout are currently found in the headwaters of Roaring Creek.

Although Roaring Creek is heavily forested and the wildlife population is high, it is unlikely that wildlife is a significant pollutant to the watershed. Any bacterial or nutrient pollutants within the watershed are currently overwhelmed by the mine drainage that enters the watershed at Kittle Hollow. If bacterial contamination were found, it would more likely be due to human activities such as broken or nonexistent septic systems.

5.1.3 Septic Systems

There is no city sewer system that serves Roaring Creek. Towns in the watershed use private sewage treatment systems or septic systems. No reports on the exact number of septic systems within Roaring Creek could be found. However, Roaring Creek is a very rural watershed and it is likely that decentralized systems make up the majority of sewage treatment within the watershed. Statistics for the state of WV show that there is as high as a 60% failure rate for septic systems within the state. By extrapolating this failure rate to an area the size of Roaring Creek, there is a 0.2% failure rate for septic systems within the watershed. These failed systems could be a source of bacteria in Roaring Creek.

Fecal coliform samples were taken by the WVDEP at six locations between 1997 and 2008. Table 8 shows the average value of the samples taken as well as their locations. The complete data can be found in Appendix A.

Table 8. Locations and concentrations of WVDEP fecal coliform samples.

Site description	Latitude	Longitude	Fecal coliform concentration (cfu/100 mL)
Roaring Creek mainstem mile 6.3	38 53 5.48	79 57 59.67	2
Roaring Creek mainstem mile 7.7	38 52 29.23	79 58 37.69	6
Roaring Creek mainstem mile 9.3	38 52 29.23	79 58 37.69	10
Flatbush Fork mile 0	38 55 10.29	79 55 44.67	1
Flatbush Fork/UNT mile 0.9	38 52 41.29	79 59 51.78	0
UNT/Roaring Creek mile 0.6	38 53 3.28	80 1 36.37	2

None of the samples taken had concentrations above water quality standards. However, the rural nature of the watershed means that there are likely numerous potential sources of bacterial impairment due to untreated sewage from residences. The effects of raw sewage pollution may also be masked by mining impacts within the watershed.

5.1.4 Silviculture

The Roaring Creek watershed is ~82% forested (Table 2). Because of this, there is potential for water quality impacts from silvicultural activities. Much of the watershed's forested areas are owned by one land holding company. However, very little evidence of active timbering was seen during any of the sampling times. Evidence of sedimentation or erosion was rarely found. Although turbidity was not one of the parameters measured, the stream appeared clear during all sampling times. It is unlikely that silviculture currently contributes much pollution to the Roaring Creek watershed.

5.1.5 Urban/Suburban Runoff

1.1% of the watershed is medium or light intensity urban area (Table 2). There are also multiple paved roads in the watershed. These are the largest sources of runoff within Roaring Creek. These areas are concentrated around the population centers of Coalton and Mabie. However, even areas within these two towns are mostly grass or dirt instead of paved. There are no large parking lots or interstates to encourage large amounts of runoff. The greatest impact from runoff would come from road salt used for deicing in the winter. Although no sampling focusing on road salt was conducted, it is unlikely that deicing activities are a large contributor to nonpoint source pollution within the Roaring Creek watershed due to the relatively small amount of paved area.

5.1.6 Streambank Erosion

Streambank erosion is not a large contributor to nonpoint pollution within the watershed. Nearly every sample site was heavily forested with a large riparian buffer along the edges of the stream. Those sites that were less forested still had very little streambank erosion. There may be localized areas of erosion on farmland, particularly if the stream has not been fenced off from livestock. However, none of these areas were observed during the data gathering for this plan.

5.1.7 Atmospheric Deposition

Potential sources of atmospheric deposition can include vehicle traffic, industrial facilities, and power plants, among others. The main source of atmospheric deposition within the Roaring Creek watershed is due to vehicle traffic, although secondary deposition may occur due to pollutants moving from other areas into Roaring Creek. There are no large industrial facilities or power plants within the watershed.

5.2 Point Sources

5.2.1 NPDES Permits

The following table lists NPDES permits in the Roaring Creek watershed (Table 9).

Table 9. NPDES permits within the Roaring Creek watershed.

Permit #	Site name	Latitude	Longitude	Permit type	Permitted discharge amount	Permit expiration date
WV1003500	Carter Roag Coal Company	38 53 21	80 0 16	Remining	N/A	5/14/12
WV1023381	Douglas Coal	38 56 14	79 57 27	Road/Loadout	N/A	8/4/12
WVG551289	Coalton School	38 53 50	79 58 5	Sewage	0.008 MGD	07/13/11
WVG411452	Merle Williams	38 53 53	79 58 0	Individual	0.0005 MGD	12/30/09
WVG980005	WVDOH	38 54 27	79 58 37	Nonclassifiable	0.0056 MGD	07/31/11

WVG990137	WVDOH Car Wash	38° 54'25	79 58 38	Industrial	0.0003 MGD	06/30/09
WVR103305	Coalton Mine Drainage	38 53 40	79 58 1	Construction	N/A	12/4/12
WVR104030	Whites Run Highwall & Portal	38 54 33	79 57 35	Construction	N/A	12/4/12
WVR104884	Roaring Ck. Stream Restoration	38 54 13	79 57 39	Construction	N/A	12/4/12

Of the nine permits listed in Table 9, two are expired and four are projects under construction. The Coalton School and WVDOH permits have remained in compliance since sampling began. The Carter Roag Coal Company is a recently reclaimed coal mine that is currently in Phase 1 bond release. One violation for exceedence of manganese standards occurred in 2008. However, chemical treatment was instituted after this violation and no violations have occurred since this time. No other information could be found on either new facilities coming online or expansion of existing facilities. All known NPDES permits in the Roaring Creek watershed are shown in Table 9.

5.2.1.1 Phase I and II Stormwater Permits

No information could be found on Phase I and II stormwater permits for Roaring Creek. It is likely that no plan for stormwater exists for the watershed due to a lack of urban area and a small population. The watershed also has relatively few impervious surfaces. All of these factors infer that stormwater is not a large contributor of pollutants to Roaring Creek.

5.2.1.2 CAFO Permits

No CAFO permits were found within Roaring Creek.

5.3 Hazardous Waste

5.3.1 CERCLA Sites

No CERCLA sites exist within the Roaring Creek watershed.

5.3.2 RCRA

No RCRA sites exist within the Roaring Creek watershed.

5.3.3 Brownfields

Information on specific brownfield sites within Roaring Creek was not found. West Virginia is currently compiling an inventory of brownfields sites. At this time, the inventory is not yet complete.

5.3.4 Underground Storage Tanks

The exact number of underground storage tanks (USTs) within the watershed is unknown. There are several gas stations which have USTs. It is likely that the majority of USTs within the watershed are found at these gas stations.

5.4 Other Potential Pollutant Sources

There are no other major sources of pollutants in the Roaring Creek watershed.

6 Linkage of Pollutant Loads to Water Quality

6.1 Estimation of Pollutant Loads

6.1.1 Existing Conditions and Pollutant Load Estimates

As discussed previously, eight AMD sources have been located in Roaring Creek. The annual pollutant loadings for these sites are shown in Table 10.

Table 10. Pollutant loadings for eight abandoned mine sites in Roaring Creek.

Sample site	Acid load	Alkalinity load	SO4 load	Fe load	Al load	Mn load
	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr
Southernmost Portal	52.60	0.10	200.28	4.70	3.15	0.51
Mars Portal 1	115.17	0.16	224.17	13.75	7.45	0.39
Mars Portal 2	23.89	0.11	169.11	2.65	2.15	0.41
Coalton School Portal/Portal 1	7.95	0.04	36.39	0.16	1.23	0.12
Coalton Mine Drainage/Portal 2	1.62	0.06	20.82	0.03	0.21	0.06
Portal 3	19.39	0.29	119.83	0.49	2.10	0.18
Portal 4	9.02	0.01	12.62	1.54	0.68	0.03
Portal 5	8.40	0.01	11.88	1.36	0.61	0.02

Bacteria

Currently, Roaring Creek is not on the 303(d) list for bacterial contamination. Bacteria sampling was last performed in Roaring Creek in 2008. Bacteria concentrations from this sampling can be found in Table 8. However, no bacteria sampling occurred as part of the sampling sweep by WVWRI/MCTU. Therefore, load reductions cannot currently be calculated for the watershed. The need for bacteria load reduction will need to be re-evaluated after the AMD sources in the watershed are remediated, as it is likely that the AMD is masking potential bacterial contamination.

6.1.2 Future Conditions and Pollutant Load Estimates

WVWRI and MCTU will construct passive treatment systems on Kittle Hollow at each site listed in Table 10. Typical acidity and metal load reductions for passive treatment projects are 80%. This is the expectation for the projects within Roaring Creek as well. The construction of the first project (Southernmost Portal and the two Mars Portals) is expected to take place in 2013.

6.2 Identification of Critical Areas

Figure 9 illustrates the critical areas within the watershed that require the most immediate intervention. These areas were identified as the most critical during the WVWRI and MCTU's sampling that occurred in 2009-2010. Greater than 90% of the mine drainage impacts in Roaring Creek come from Kittle Hollow. WVWRI and MCTU will begin remediating mine drainage at the farthest upstream mine site in Kittle Hollow and work their way downstream to the confluence of Kittle Hollow and Roaring Creek.

Remediation measures that may be used within Roaring Creek could include: limestone leach beds, limestone channels, wetlands, steel slag beds, and ponds, among others. The priority for Kittle Hollow and Roaring Creek is reduction of acid and metal loads in order to remove Roaring Creek from the 303(d) list and to achieve compliance with the Tygart Valley River TMDL. When properly designed and implemented, passive treatment has been found to be an excellent solution to mine drainage pollution.

7 Watershed Goals and Objectives

7.1 Management Objectives

The main goal of this WBP is to restore and extend the range of the fishery in the Roaring Creek watershed. This will be accomplished by meeting the following objectives:

- AMD remediation;
- Increase available habitat for aquatic life;
- Employ strategies to nsure sedimentation/erosion does not occur;
- Further testing to see if additional control measures need to be put in place to reduce fecal coliform levels in Roaring Creek and its tributaries.

7.2 Load Reduction Targets

7.2.1 AMD

- Metals: Achieve load reduction in iron and aluminum in accordance with the Tygart Valley River TMDL in order to achieve 100% compliance with the West Virginia state water quality standards. The allocated loads, current loads, and target load reductions for iron and aluminum are shown in table 11. Roaring Creek also has a TMDL load reduction required for manganese. However, in 2005, the manganese criterion was revised to only apply within 5 miles of a public water intake. There are no public water intakes in the Roaring Creek watershed.

- pH: Reduce loads and/or mitigate to 100% compliance with state criterion (pH 6-9) in Roaring Creek and its tributaries.

7.2.2 Fecal Coliform Bacteria

Roaring Creek does not have a TMDL, and is not on the 303(d) list for, fecal coliform bacteria. Available data that was taken within the last 15 years shows minimum bacteriological impairment (Table 8). This must be re-evaluated after metals and pH load reduction targets have been met, due to the tendency of AMD pollutants to mask fecal coliform contamination. If fecal coliform bacteria do not meet state criterion, target reduction of 100% compliance will be used as the load reduction target.

7.2.3 Sediment

There is no state criterion for sediment, and currently there is little to no water quality data existing for sediment. No major sediment sources were identified during the most recent sampling. If sediment pollution is detected at a later date, our load reduction target is that no sediment source shall increase the background sediment load by more than 10%.

Table 11. Baseline loads, allocated loads, and targeted load reductions from the Tygart Valley River TMDL.

Aluminum	Baseline load (lbs/yr)	45,553
	Allocated load (lbs/yr)	40,989
	Reduction required (lbs/yr)	4,564
Iron	Baseline load (lbs/yr)	43,045
	Allocated load (lbs/yr)	38,874
	Reduction required (lbs/yr)	4,171
Manganese	Baseline load (lbs/yr)	32,942
	Allocated load (lbs/yr)	27,270
	Reduction required (lbs/yr)	5,672

8 Identification of Management Strategies

8.1 Existing Management Strategies

8.1.1 Structural Controls for Acid Mine Drainage

Two sites have existing management strategies for AMD in Roaring Creek. The first of these is the Southernmost Portal site. This site was reclaimed ~20 years ago. The reclamation consisted of two wet seals that discharge water from a backfilled portal. There are also 3 open limestone channels to convey and treat mine discharge on this site. Neither of these remediation methods is sufficient to treat the water emanating from this site.

The other site that has an existing management strategy is the Coalton School Portal. In this case, the portal was backfilled and had a wet seal installed, which discharges into a grouted rip-rap channel. These remediation measures do not fully treat the acidic mine water discharging from this site.

8.1.2 Nonstructural Controls

There are no known nonstructural controls in the Roaring Creek watershed or its tributaries.

8.2 Additional Strategies Needed to Achieve Goals

8.2.1 Structural Controls for Acid Mine Drainage

The primary method of abatement of mine drainage in Roaring Creek will be passive treatment. Passive treatment in Roaring Creek will utilize combinations of passive treatment modules in succession to neutralize the acid sources in the watershed. Precipitation of metals through the use of passive treatment will neutralize acidity and lower metal loads.

Almost all of the potential project sites in the Roaring Creek watershed are located in areas that are rural in nature. The terrain is agreeable to the use of passive treatment because there is a large amount of space available at each prospective project site to build treatment modules. The topography is also not very steep, which aids in the construction of treatment systems. However, it is possible that other treatment methods, such as active or in-situ treatment, may be employed due to unforeseen circumstances found at the potential project sites.

Some examples of passive treatment technologies include, but are not limited to:

Open Limestone Channels (OLCs) - Open limestone channels are treatment modules that will be installed to convey the effluent through and to the systems. In addition to conveyance, the OLCs will also help to neutralize acidity and precipitate metals. The OLCs are generally constructed with limestone sand and/or steel slag base, with rip- rap sized limestone above.

Limestone Leach Beds (LLB) – Limestone leach beds are another treatment module which utilizes limestone to neutralize acidity and precipitate metals. Leach beds are used in very low pH environments, are generally rectangular in shape, and designed for retention times of approximately 1.5 hours. The effluent enters the bed from the top and exits through a manifold system situated in the bottom of the bed.

Steel Slag Leach Beds (SSLB) – Steel slag leach beds are used in areas where there is a source of water that is relatively free of metals and a near neutral pH (generally surface flow). The slag beds generate excess alkalinity which in turn is used to neutralize the AMD.

Anoxic Limestone Drain (ALD) – ALDs consist of buried trenches of limestone which allow for neutralization of AMD without the presence of oxygen and without iron oxidation/precipitation. ALDs are used in situations where there is little to no dissolved oxygen and very little to no aluminum. Additionally, the iron in the effluent entering the bed should be ferrous (in a reduced state).

Vertical Flow Reactors (VFR) - Vertical flow reactors combine two passive technologies into one module. A VFR is constructed with a layer of organic material on top of a limestone bed. The effluent enters the bed from the top and flows down through the organic material where oxygen is removed and sulfates are reduced. The water then enters the limestone where neutralization occurs. The effluent leaves the reactor, at which point oxidation occurs and the metals precipitate from solution.

Aerobic Wetlands – Aerobic wetlands are utilized in passive treatment as more of a polishing feature where precipitates can be gathered and any metals still in solution can be collected. An aerobic wetland generally has an organic rich substrate that will produce a variety of wetland species. These wetlands can be used for both acidic and alkaline discharges.

8.2.1.1 Treatment Scenarios

All AMD sources are found within the Kittle Hollow tributary. The following conceptual designs are based on preliminary data that we have collected for the following proposed project locations and are subject to change as additional samples are collected. These systems will utilize combinations of passive treatment modules mentioned above in an effort to neutralize the acidity, precipitate metals, and raise the pH. The goal of these projects is to achieve 80% acid load reduction.

The estimated costs for these projects were determined using the following formula: Acid load * cost of neutralization of 1 ton of acid load * expected life of treatment system. The acid load is determined by multiplying flow * acidity * 0.0022. The unit of acid load is tons of acid/year. The cost of neutralization of 1 ton of acid load had an assumed value of $125 and the expected life of the treatment system was 20 years for all sites. The cost of neutralization of 1 ton/year of acid load was determined to be $50 per ton in this case.

Southernmost Portal -

The Southernmost Portal site, which is located at the headwaters of the northernmost fork of Kittle Hollow, is a wet-sealed portal that discharges at ground level from two pipes and flows through a small depression before emptying into the headwaters of Kittle Hollow. This site is the most upstream AMD source on this tributary. Although some reclamation work has been performed here (open limestone channels, wet seals, and backfilling), the discharge is still highly acidic and requires further treatment. However, there is a large amount of space available to passively treat this discharge. A limestone leachbed would be placed in the footprint of the current depression to begin to raise the pH. Water will be discharged from this leachbed into an open limestone channel (OLC) where it will mix with water from another source. The second source will also be run through an OLC. The combined OLC will discharge into a second limestone leach bed. Water from the second leachbed will mix with freshwater that enters Kittle Hollow from an existing OLC. A steel slag bed will be added to the OLC previously constructed by AML in order to increase the alkalinity of the freshwater before it mixes with the treated water from upstream. From the steel slag bed, the freshwater will be conveyed by an OLC into Kittle Hollow, where it will enter a settling pond in order to precipitate out metal flocculants. From the settling pond, the water would discharge to Kittle Hollow. The estimated cost for these modules would be $117,677. Currently, the Southernmost Portal site adds 9,400 lbs/yr of iron and 6,300 lbs/yr of aluminum to Roaring Creek. The remediation project described above will remove an estimated 7,520 lbs/yr of iron and 5,040 lbs/yr of aluminum. The implementation of a remediation project at the Southernmost Portal site will help meet the load reduction goals listed in the Tygart Valley River TMDL.

Mars Portal 1 and 2 –

Both Mars Portal 1 and 2 are located downstream of the Southernmost Portal. These two portals are very close to one another. As such, they will be treated as one project site. These two portals are open and free-draining. Currently, they discharge acidic water approximately 0.25 miles through a low gradient area before discharging into Kittle Hollow. Two wet seals will be installed in the mine openings of Mars Portals 1 and 2 to direct the drainage into an OLC, which will lead into a limestone leachbed. The water discharged from this leachbed will move into another OLC and then into a second leachbed. The discharge from the second leachbed will be conveyed via an OLC into a settling pond where it will be discharged just upstream of the confluence with Kittle Hollow. The estimated cost for these modules would be $129,720. Currently, the Mars Portal 1 and 2 site adds 32,800 lbs/yr of iron and 19,200 lbs/yr of aluminum to Roaring Creek. The remediation project described above will remove an estimated 26,240 lbs/yr of iron and 15,360 lbs/yr of aluminum. The implementation of a remediation project at the Mars Portal 1 and 2 site will help meet the load reduction goals listed in the Tygart Valley River TMDL.

Portal 5 –

The Portal 5 site is located at the headwaters of the southern fork of Kittle Hollow. It is a collapsed portal that continues to discharge acidic mine water. Wet seals would be installed to gather the water in preparation for treatment. From the wet seals, the water would discharge into a limestone leachbed. The water would then be conveyed via an OLC to an aerobic wetland. In addition to reducing the metal concentrations in the water, the wetland will also act as a settling area for metal precipitates. Baffles would be installed in the wetland in order to increase retention time of the water. Water would discharge from the wetland into another OLC before emptying into Kittle Hollow. The estimated cost for these modules would be $68,065. Currently, the Portal 5 site adds 2,720 lbs/yr of iron and 1,220 lbs/yr of aluminum to Roaring Creek. The remediation project described above will remove an estimated 2,176 lbs/yr of iron and 976 lbs/yr of aluminum. The implementation of a remediation project at the Portal 5 site will help meet the load reduction goals listed in the Tygart Valley River TMDL.

Portal 4 -

Portal 4 is slightly downstream of Portal 5. It is an open portal from which acidic water discharges into a flat area and then into the southern tributary of Kittle Hollow. Wet seals would be installed to remove the opening and gather the water in preparation for treatment. From the wet seals, the water would discharge into a limestone leachbed. The water would then be conveyed via an OLC to a settling pond. Baffles would be installed in the pond in order to increase retention time of the water. Another OLC would carry the treated water to Kittle Hollow. The estimated cost for these modules would be $87,126. Currently, the Portal 4 site adds 3,080 lbs/yr of iron and 1,360 lbs/yr of aluminum to Roaring Creek. The remediation project described above will remove an estimated 2,464 lbs/yr of iron and 1,088 lbs/yr of aluminum. The implementation of a remediation project at the Portal 4 site will help meet the load reduction goals listed in the Tygart Valley River TMDL.

Portal 3 -

Portal 3 is just downstream of the confluence of the northern and southern forks of Kittle Hollow. It is a partially collapsed portal, although the mine entry can still be seen. As with all the other portals in Kittle Hollow, the discharge is acidic. Treatment of the discharge at this site will be similar to the treatment plan for Portal 4. Wet seals would be installed to gather the water in preparation for treatment. From the wet seals, the water would discharge into a limestone leachbed. The water would then be conveyed via an OLC to a settling pond. Baffles would be installed in the pond in order to increase retention time of the water. Another OLC would carry the treated water to Kittle Hollow. The estimated cost for these modules would be $73,341. Currently, the Portal 3 site adds 980 lbs/yr of iron and 4,200 lbs/yr of aluminum to Roaring Creek. The remediation project described above will remove an estimated 784 lbs/yr of iron and 3,360 lbs/yr of aluminum. The implementation of a remediation project at the Portal 3 site will help meet the load reduction goals listed in the Tygart Valley River TMDL.

Portal 2/Coalton Mine Drainage –

The Portal 2/Coalton Mine Drainage site, which is located near the Coalton School Portal in the town of Coalton, is an open portal that discharges acidic water down a steep slope into Kittle Hollow near its confluence with Roaring Creek. No reclamation work has been performed here. However, the discharge is only slightly acidic and will not require a large amount of treatment. The current wet seals would be left in place and the water would flow down a 200 ft OLC. At this point, the water would discharge into a wetland. Baffles would be installed in the wetland in order to increase retention time of the water. Water would discharge from the wetland into another OLC before emptying into Kittle Hollow. The estimated cost for these modules would be $44,327. Currently, the Coalton Mine Drainage site adds 60 lbs/yr of iron and 420 lbs/yr of aluminum to Roaring Creek. The remediation project described above will remove an estimated 48 lbs/yr of iron and 336 lbs/yr of aluminum. The implementation of a remediation project at the Coalton Mine Drainage site will help meet the load reduction goals listed in the Tygart Valley River TMDL.

Portal 1/Coalton School Portal –

The Portal 1/Coalton School Portal site, which is located behind the school in Coalton, is a wet-sealed portal that discharges from one pipe and flows through a ~100 ft grouted limestone channel and through a forested area before emptying into Kittle Hollow. Although some reclamation work has been performed here (grouted open limestone channels, wet seals, and backfilling), the discharge is still acidic and requires further treatment. However, the mine water at this site has smaller concentrations of metals and acidity. As such, less treatment will be needed at this site than some others in Kittle Hollow. The current wet seals would be left in place and the water would flow down a 200 ft OLC. At this point, the water would discharge into a wetland. Baffles would be installed in the wetland in order to increase retention time of the water. Water would discharge from the wetland into another OLC before emptying into Kittle Hollow. The estimated cost for these modules would be $62,970. Currently, the Coalton School Portal site adds 320 lbs/yr of iron and 2,460 lbs/yr of aluminum to Roaring Creek. The remediation project described above will remove an estimated 256 lbs/yr of iron and 1,968 lbs/yr of aluminum. The implementation of a remediation project at the Coalton School Portal site will help meet the load reduction goals listed in the Tygart Valley River TMDL.

In conclusion, these module designs and their costs were estimated using AMDTreat software from the Office of Surface Mining. The designs and costs were constructed using the most recent water quality data. However, these designs/costs are merely preliminary attempts to mitigate the AMD in the Roaring Creek watershed. As such, both the costs and the designs could change before the commencement of project construction.

8.2.1.2 Nonstructural Controls

There are no plans for implementation of nonstructural controls in the Roaring Creek watershed or its tributaries. This is because the mine drainage will be treated after it is discharged from the mines. For a control module to be nonstructural, the formation of AMD would have to be slowed down or stopped. The AMD in the Roaring Creek watershed will be treated after formation, which more appropriately fits the definition of a structural control.

9 Implementation Program Design

9.1 Management Strategies

AMD is currently the limiting factor for life in Roaring Creek. Therefore, reclamation will focus on AMD first. Once load reductions have been achieved to allow life, fecal coliform bacteria will be re-assessed. Concurrent with the AMD reclamation, the WVDEP and the MCTU will educate community members about AMD related issues. Table 12 provides an overall view of management strategies for the Roaring Creek watershed. More details regarding the types of passive treatment for each project site are given in section 8.2.1.1 of this document. Project site locations are shown on Figure 9 in section 5.1.1 of this document.

Table 12. Management strategies for the Roaring Creek watershed.

Site name	Responsible Party	Costs	Expected Fe load reductions	Expected Al load reductions	Timeline	Interim Milestones	Progress Criteria	Info/Education	Monitoring
			lbs/yr	lbs/yr					
Southernmost Portal	WVDEP/ NMLRC/ MCTU	$117,677	7,520	5,040	Section 9.2	Section 9.3	Section 9.4	Section 9.6	Section 9.7
Mars Portal 1/2	WVDEP/ NMLRC/ MCTU	$129,720	26,240	15,360	Section 9.2	Section 9.3	Section 9.4	Section 9.6	Section 9.7
Coalton School Portal/Portal 1	WVDEP/ NMLRC/ MCTU	$62,970	256	1,968	Section 9.2	Section 9.3	Section 9.4	Section 9.6	Section 9.7
Coalton Mine Drainage/Portal 2	WVDEP/ NMLRC/ MCTU	$44,327	48	336	Section 9.2	Section 9.3	Section 9.4	Section 9.6	Section 9.7
Portal 3	WVDEP/ NMLRC/ MCTU	$73,341	784	3,360	Section 9.2	Section 9.3	Section 9.4	Section 9.6	Section 9.7
Portal 4	WVDEP/ NMLRC/ MCTU	$87,126	2,464	1,088	Section 9.2	Section 9.3	Section 9.4	Section 9.6	Section 9.7
Portal 5	WVDEP/ NMLRC/ MCTU	$68,065	2,176	976	Section 9.2	Section 9.3	Section 9.4	Section 9.6	Section 9.7
TOTAL REDUCTION			**39,488**	**28,128**					

9.2 Schedule of Activities

As described in the management strategy, the first reclamation activities that will take place will be AMD remediation, as it is currently the limiting factor in Roaring Creek. As remediation progresses, this should be re-evaluated in 2017. Once all AMD remediation is complete in 2018, Roaring Creek should be re-evaluated for impairment from other sources of pollution. Table 13 gives a timeline for completion of AMD remediation projects within the Roaring Creek watershed.

Table 13. Timeline for AMD remediation within the Roaring Creek watershed.

<table>
<tr><th>Project</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th></tr>
<tr><td>Southern Portal</td><td colspan="2">Pre-const. sampling</td><td>Apply for 2012 grant</td><td colspan="2">Construction</td><td colspan="7">Post-construction sampling</td></tr>
<tr><td>Mars 1 & 2</td><td colspan="2">Pre-const. sampling</td><td>Apply for 2012 grant</td><td colspan="2">Construction</td><td colspan="7">Post-construction sampling</td></tr>
<tr><td>Portal 1</td><td colspan="3">Pre-const. sampling</td><td>Apply for 2013 grant</td><td colspan="2">Construction</td><td colspan="6">Post-construction sampling</td></tr>
<tr><td>Portal 2</td><td colspan="4">Pre-const. sampling</td><td>Apply for 2014 grant</td><td colspan="2">Construction</td><td colspan="5">Post-construction sampling</td></tr>
<tr><td>Portal 3</td><td colspan="5">Pre-const. sampling</td><td>Apply for 2015 grant</td><td colspan="2">Construction</td><td colspan="4">Post-construction sampling</td></tr>
<tr><td>Portal 4</td><td colspan="6">Pre-const. sampling</td><td>Apply for 2016 grant</td><td colspan="2">Construction</td><td colspan="3">Post-construction sampling</td></tr>
<tr><td>Portal 5</td><td colspan="7">Pre-const. sampling</td><td>Apply for 2017 grant</td><td colspan="2">Construction</td><td colspan="2">Post-construction sampling</td></tr>
<tr><td>Education/Outreach</td><td colspan="12">Education and Outreach about AMD related issues</td></tr>
</table>

9.3 Interim Milestones

Interim milestones will be met for the Kittle Hollow tributary of Roaring Creek. These milestones include metal load reductions of 50-80% of the original load of the tributary. These load reductions are anticipated to occur within one year after project construction. As each project within Kittle Hollow is completed, loading at the mouth of Kittle Hollow will be determined and compared to the initial loading. This will detail the removal of AMD pollution in Kittle Hollow, as well as the mainstem of Roaring Creek, in a scientifically rigorous manner. Table 14 shows the initial loadings from all AMD sources for Kittle Hollow, as well as the anticipated load reductions for iron and aluminum.

Table 14. Initial metal loads and anticipated load reductions for the Kittle Hollow subwatershed of Roaring Creek.

Subwatershed	Initial Fe load	Expected Fe Reduction	Initial Al load	Expected Al Reduction
	lbs/yr	lbs/yr	lbs/yr	lbs/yr
Kittle Hollow	27,109	13,555-21,687	23,815	11,908-19,052

9.4 Indicators to Measure Progress

Multiple indicators will be used to track progress. These will include:

1. Water Quality - The most important water quality goal is to reduce metal and acidity loadings from AMD by 50-80%. Attainment of these load reductions will be assessed by periodic pre and post-construction sampling at each project site, as well as at the confluence of Kittle Hollow and Roaring Creek. The sample taken at the confluence will help determine the effect on water quality of the AMD remediation projects. Sampling will be conducted during various times of the year in order to determine how pollutant loads change with large or small flow values.

2. Fish Habitat - The biological integrity of Roaring Creek is an important indicator of potential fish habitat. Monitoring of benthic organisms within the stream will establish the potential for fish to repopulate the entire watershed. Benthic monitoring will occur once per year at the mouths of the major tributaries of Roaring Creek. Physical attributes of the stream will also be assessed during sampling times. Lastly, anecdotal evidence from watershed residents will help to further target sampling sites.

3. Public Support - Public support is important to the remediation of the Roaring Creek watershed. During the gathering of data for this plan, many citizens of the watershed observed the water sampling activities and by doing so, became more engaged in the welfare of the watershed. MCTU hopes to capitalize on this interest by taking a leadership role in the garnering of public support for Roaring Creek.

9.5 Estimation of Costs and Technical Assistance Needed

9.5.1 Estimation of Costs

Costs of the AMD remediation projects are given in Table 12. These costs include all construction, engineering, and any other capital costs for each project. Each passive treatment system is designed to last 20 years without requiring maintenance. Because of this, maintenance costs are assumed to be $0. However, project performance will be closely monitored during post-construction sampling and beyond. If a maintenance issue does arise, it will be taken care of as soon as possible.

9.5.1.1 Funding Sources

Section 319 funds

Clean Water Act Section 319 funds may be provided by USEPA to WVDEP to be used for reclamation of nonpoint-source AMD sources. This Watershed-Based Plan is being developed so that these funds in fiscal year 2012 and beyond can be allocated to the Roaring Creek watershed. WVDEP’s Division of Water Resources sets priorities and administers the state Section 319 program.

Watershed Cooperative Agreement Program

Grants specifically for AMD remediation projects on Abandoned Mine Lands (AMLs) are available through OSM's Watershed Cooperative Agreement Program (WCAP). The WCAP is part of the Appalachian Clean Streams Initiative. Grants of up to $100,000 are awarded to not-for-profit organizations that have developed cooperative agreements with other entities to reclaim AML sites.

Stream Restoration Fund (SRF)

In the 2010, the WV Code was updated to include the Stream Restoration Fund (SRF). This money is to be used for the restoration and remediation of streams in the state of WV which have been affected by coal mining or acid mine drainage. The funds in this account are replenished through mitigation monies and private sources. SRF funds can be used as matching funds for Clean Water Act 319 funds.

9.5.2 Technical Assistance

West Virginia Department of Environmental Protection

The Division of Water and Waste Management will provide technical assistance in the implementation of the WBP through the Nonpoint Source Program (NPS). The NPS Program is funded primarily by the Clean Water Act Section 319 Grants in order to:

- Educate the public and land users on non-point source issues,
- Support citizen-based watershed organizations,
- Support enforcement of non-point source water quality laws, and
- Restore impaired watersheds

Another technical assistance program within the WVDEP is the WV Save Our Streams program. This is a volunteer monitoring program that trains West Virginia citizens of all ages how to monitor, as well as to become watchdogs over their local wadeable streams and rivers. This program has proven to be an invaluable asset in educating members of watershed groups as well as the general public.

West Virginia University

The primary organization housed within West Virginia University that provides technical assistance for watershed groups is the National Mine Land Reclamation Center (NMLRC). This organization can provide conceptual site designs for reclamation of AMD, as well as oversee the installation of the reclamation project, and monitor the pre- and post - construction water quality. The NMLRC also provides support to DEP in developing watershed plans and training for watershed organizations. NMLRC can draw upon the expertise of the numerous university colleges at WVU to address other types of nonpoint source pollutants as well.

Trout Unlimited

Trout Unlimited (TU) will provide technical assistance by aiding in pre- and post-construction water quality monitoring. TU will also offer support for education and outreach efforts, especially in watersheds where there is a current or potential fish population.

9.6 Information/Education Component

A prominent part of the partnership between NMLRC, WVDEP, and MCTU is to publicize the status of reclamation within Roaring Creek, and encourage education of environmental issues within Roaring Creek to a wide audience. The target audience of these education efforts will be any stakeholder within the watershed, including, but not limited to, sportsmen, private citizens, and industry. The three partners involved in the reclamation of Roaring Creek will educate stakeholders and members of the community about AMD through:

- the websites of the respective partners;
- public meetings;
- and educational displays at regional and local festivals, conferences, and other public events.

In the future, the three partners may:

- organize volunteer citizen monitoring within the watershed;
- publicize results to the general public of reclamation projects as they are gathered;
- and work with local schools and community members to educate citizens of the watershed and surrounding area in water quality related issues.

The efficacy of this information sharing will be evaluated by a survey given after the educational activity. Results of the survey will be used to improve educational materials and presentations to better share information with interested watershed stakeholders.

9.7 Monitoring Component

Monitoring is an essential component of a watershed-based plan because it allows stakeholders to see what progress is being made and when goals are achieved. Monitoring will be a key component of each of the projects described in section 8.2.1.1 above. In general, at least one year of chemical monitoring (sampled once a month) will be conducted before and after the construction of the reclamation project at various points within the project site. Monitoring will also take place at the mouth of the completed project's tributary in order to quantify the effect of AMD treatment at each project site. AMD monitoring will include pre and post-construction sampling for 8 project sites, as well as the mouth of each project tributary and the mouth of Kittle Hollow, for a total of 11 sample points. This number and frequency of samples was deemed appropriate for a watershed this size because all AMD sources would be sampled several times and both initial metal loads and metal load reductions could be accurately calculated with this number of samples. A sampling regime of this size and frequency has also been previously used on other AMD remediation projects and has been found to effectively represent water quality conditions. All samples will be collected and analyzed using standard EPA protocols. Data collected from these samples will be stored at the NMLRC. Figure 15 shows the location of the 11 AMD project sampling points and the sampling point at the mouth of Kittle Hollow.

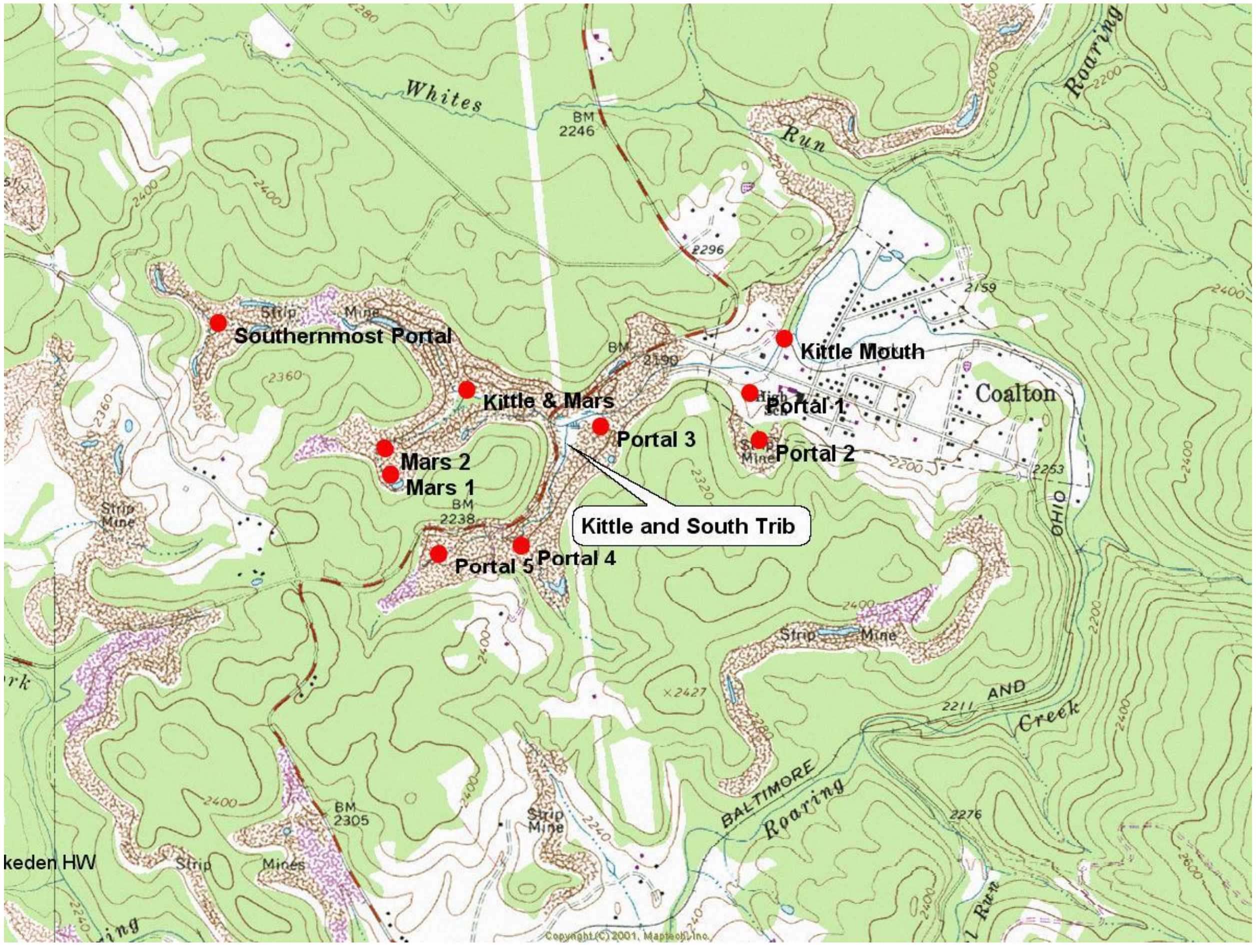

Figure 15. AMD sampling points in Kittle Hollow.

Chemical sampling will be the responsibility of the organization that is conducting the reclamation. In addition to localized, project-related monitoring, NMLRC will apply for further funding to complete monitoring surveys of other Roaring Creek subwatersheds.

These monitoring surveys will be targeted to areas where impacts on water quality have been noted during past sampling events. If more project sites are discovered due to increased sampling, NMLRC and/or MCTU will apply for more project funds.

The above monitoring plan will effectively address the evaluation criteria in Section 8.2.1.1 of this plan by comparing existing monitoring data with data collected in the future. These data will be linked through the parameter of metal loads. Iron and aluminum loads will be calculated for future samples and compared to previous samples to determine load reductions. Metal load reductions will also be used to establish the extent to which the Tygart Valley River TMDL is being implemented. The data comparison will allow the WVDEP to determine the amount of progress made toward the ultimate goal of removing Roaring Creek from the WV 303(d) list of impacted streams. The progress toward these goals will be continually reassessed by the WVDEP as reclamation is completed.

9.8 Evaluation Framework

Three parts of this WBP will be assessed by the evaluation framework. These include: inputs, outputs, and outcomes. Various strategies will be used to evaluate these sections of the plan.

9.8.1 Evaluation of Inputs

There are two main inputs to this program. These are reclamation project funds and time spent on planning and implementation of projects. Project funds will be tracked by both the NMLRC and the WVDEP. Funds will be disbursed according to a pre-determined budget. The indicator used to measure the input of project funds will be a spreadsheet used to track project costs. This spreadsheet will be compared against the pre-determined budget to make sure that project funds are spent correctly and efficiently.

The time spent by various individuals and groups on reclamation projects will also be tracked. The hours that each individual/group will spend on a given project will be delineated during the budget process. Similar to the tracking of funds, a spreadsheet tracking these hours will be maintained for comparison against the budgeted amount of hours.

9.8.2 Evaluation of Outputs

The major outputs of this plan will be water quality data and completed reclamation projects. Water quality data will be collected before and after construction at each project site, as well as at the mouth of each project tributary (see Section 9.7 of this document). The indicator that will be used to measure water quality is the amount of samples collected. Samples will be tracked by date and site name to ensure accuracy of sampling. All this information, as well as water quality results, will be recorded on a spreadsheet and used to aid in future project design and implementation.

The second output will be completed reclamation projects. The indicator to evaluate these projects will be post-construction water sampling. When construction is complete, post-construction water sampling can commence. Post-construction water sampling will continue for at least a year after construction. Samples will be tracked to ensure the reclamation project is performing adequately.

9.8.3 Evaluation of Outcomes

The outcomes related to this project will be a reduction in metal and acidity loads and an increased aquatic life population. Load reductions will be determined using post-construction data and comparing it to pre-construction data. The indicator of success in reducing metal and acidity loads will be a 50-80% reduction at the mouth of Kittle Hollow.

Increased aquatic life population is another outcome of this program. Indicators of success will be both scientific and antecdotal. Benthic macroinvertebrate populations will be monitored and quantified (particularly downstream of completed projects). These organisms will be the best indicator of possible fish population expansion. MCTU members will also patrol the watershed looking for fish in various parts of the watershed. MCTU will record any fish that are found and approximately where the fish were seen. Evidence of both metal/acidity load reduction and increased aquatic life will be documented in semi-annual project reports submitted to WVDEP.

References

1. Audubon Society. 2011. West Virginia's Important Bird Areas program. http://iba.audubon.org/iba/viewState.do?state=US-WV. Updated 2011.

2. Barbour, M., Gerritsen, J., Snyder, B., and Stribling, J. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

3. National Oceanic and Atmospheric Administration. 2010. NOAA online weather data for Elkins, WV. http://nowdata.rcc-acis.org/RLX/pubACIS_results. Accessed June 2011.

4. Reger, D. 1931. West Virginia Geological Survey: Randolph County. West Virginia University, Morgantown, WV. 989 p.

5. US Census Bureau. 2010. Randolph County, West Virginia. http://quickfacts.census.gov/qfd/states/54/54083.html. Updated November 2010.

6. USDA. 2007. 2007 Census of Agriculture. West Virginia State and County Data. http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/West_Virginia/wvv1.pdf. Updated 2007.

7. WVDEP. 2001. Antidegradation Implementation Procedures. WV Department of Environmental Protection, Secretary's Office. 12 pg.

8. WVDNR. 2003a. West Virginia Animals. http://www.wvdnr.gov/Wildlife/Animals.shtm. Updated 2003.

9. WVDNR, 2003b. Rare, Threatened, and Endangered Species. http://www.wvdnr.gov/Wildlife/Endangered.shtm. Updated 2003.

10. WVDNR. 2004. Neotropical Birds of West Virginia. Wildlife Resources Section, Wildlife Diversity Program. 9 p.

11. West Virginia GIS Technical Center, 2005. West Virginia Statewide Digital Elevation Models. Available from: <http://seamless.usgs.gov> Accessed April 2011.

12. West Virginia GIS Technical Center, 2008. Statewide 100-year Floodplain Polygons for West Virginia. Available from: <http://wvgis.wvu.edu/data/dataset.php?action=search&ID=128> Accessed June 2011.

Appendix A Data Inventory

WVDEP WAP water quality data

STREAM_NAME	MILE_POINT	DATE	Al Dissolved	Al Total	Alk.	Ammonia-N	Ca Dissolved	Ca Total	Cl Total	Cr Total	Cu Dissolved	Cu Total	DO	Fe Dissolved	Fe Total	Hardness	Hot Acidity
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Roaring Creek	6.3	03-Oct-02	0.3	0.34	5			16.5					7.49	0.25	0.35		5
Roaring Creek	7.7	16-Sep-97	1.87	1.8	3	0.5	25.76	27	2	0.001		0.01	7.8	0.39	0.48	120.95	12
Roaring Creek	9.3	03-Oct-02	0.38	0.42	5								8.07	0.24	0.28		5
UNT/Roaring Creek RM 1.14	1.2	21-May-03	0.04	0.07	2.3			0.75	2		0.005	0.005	10.56		0.061	2.29	1
Flatbush Fork	0	03-Oct-02	0.88	0.88	5								7.37	0.81	0.9		12.2
UNT/Flatbush Fork RM 1.80	0.9	25-Aug-97	19.6	0.42	1	0.5	18.58	160	3	0.003		0.012	7.5	1.93	0.24	510.71	170
UNT/Roaring Creek RM 11.0	0.6	11-Jun-02	0.19	0.23	5			1.09	1		0.001	0.001	8.69	0.06	0.11	4.78	5
UNT/Roaring Creek RM 11.0	0.6	29-May-08	0.21	0.24	5			1	1		0.003		9.95	0.02	0.05	4.56	5

NAME	MILE	DATE	Lab Specific Conductance	Mg Total	Mn Total	N Total	Ni Total	NO2-NO3-N	P Total	Pb Dissolved	PH	Se Total	Specific Conductance	Sulfate	Temperature	TKN	TSS	Zn Dissolved	Zn Total
			um/cm^3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		mg/L	um/cm^3	mg/L	degrees C		mg/L	mg/L	mg/L
Roaring Creek	6.3	03-Oct-02			7.67						5.55	0.005	190	23.1	15.71		3		
Roaring Creek	7.7	16-Sep-97		13	2.5		0.044	0.49	0.02	0.002	4.5		304	210	13.3		3		0.14
Roaring Creek	9.3	03-Oct-02			1.02						4.89	0.005	161	90	16.41		3		
UNT/Roaring Creek RM 1.14	1.2	21-May-03		0.1	0.0129	0.61		0.41	0.05		5.69		27	5.3	10.88	0.2	2	0.01	0.01
Flatbush Fork	0	03-Oct-02			1.58						4.33	0.005	236	125	15.98		3		
UNT/Flatbush Fork RM 1.80	0.9	25-Aug-97		27	0.31		0.307	0.22	0.02	0.002	3.3		810	350	15.4		5		0.084
UNT/Roaring Creek RM 11.0	0.6	11-Jun-02		0.5	0.21	1.1		0.1	0.02		4.68	0.005	25	5.98	15.72	1	3	0.001	0.001

UNT/Roaring Creek RM 11.0	0.6	29-May-08	25	0.5	0.105	0.69		0.09	0.01		4.73	0.001	21	6	11.21	0.6	2	0.009	

WVDEP WAP Fecal Coliform data

STREAM_NAME	ANCODE	MILE_POINT	SAMPLE_DATE	Fecal Coliform
Roaring Creek	WVMT-42	6.3	03-Oct-02	2
Roaring Creek	WVMT-42	7.7	16-Sep-97	6
Roaring Creek	WVMT-42	9.3	03-Oct-02	10
UNT/Roaring Creek RM 1.14	WVMT-42-0.4A	1.2	21-May-03	
Flatbush Fork	WVMT-42-B	0	03-Oct-02	1
UNT/Flatbush Fork RM 1.80	WVMT-42-B-1	0.9	25-Aug-97	0
UNT/Roaring Creek RM 11.0	WVMT-42-E	0.6	11-Jun-02	1
UNT/Roaring Creek RM 11.0	WVMT-42-E	0.6	29-May-08	2

WVDEP WAP Benthic data

NAME	CODE	MILE	DATE	Benthic IBI Comparable?	BENTHIC REASON NOT IBI COMPAR	PCT 2 DOMINANT TAXA FAMILY	% CHIRONOMIDAE	% EPT FAMILY	HBI FAMILY	NUM EPT TAXA FAMILY	NUM TOTAL TAXA FAMILY	WVSCI
Roaring Creek	WVMT-42	7.7	16-Sep-97	No	MACS	62.07	37.93	20.69	5.28	2	8	43.75

Roaring Creek	WVMT-42	7.7	16-Sep-97	No	MACS	58.54	31.71	32.93	4.89	3	8	50.18
UNT/Roaring Creek RM 1.14	WVMT-42-0.4A	1.2	21-May-03	WVSCI/GLIMPSS	No indication by field crew that it was not comparable.	45.59	3.43	85.78	3.33	13	17	91.44
UNT/Flatbush Fork RM 1.80	WVMT-42-B-1	0.9	25-Aug-97	WVSCI	CAUTION: Less than 100 individuals collected in benthic sample (However, in 1996-1997 a 100-Count Subsample was part of the protocol).	77.08	59.38	17.71	5.45	3	6	34.94
UNT/Roaring Creek RM 11.0	WVMT-42-E	0.6	11-Jun-02	WVSCI/GLIMPSS	No indication by field crew that it was not comparable.	85.85	1.42	93.87	3.01	6	13	70.4
UNT/Roaring Creek RM 11.0	WVMT-42-E	0.6	29-May-08	WVSCI/GLIMPSS		68.52	5.56	87.96	3.02	9	15	79.44

WVDEP WAP Stream Survey data

Name	Code	Mile	Date	Form Used	Epifaunal Substrate/ Available Fish Cover	Instream Fish Cover (Pre-98)	Epifaunal Substrate (Pre-98)	Embeddedness/ Pool Substrate	Velocity Depth/ Pool Variability	Channel Alteration	Sediment Deposition	Riffle Frequency /Channel Sinuosity	Channel Flow Status
Roaring Creek	WVMT-42	6.3	10/3/2002	Riffle/Run									

Roaring Creek	WVMT-42	7.7	9/16/1997	Glide/Pool	12	13	11	8	14	19	13	9	18
Roaring Creek	WVMT-42	7.7	9/16/1997	Glide/Pool	12	11	13	12	9	17	7	6	16
UNT/Roaring Creek RM 1.14	WVMT-42-0.4A	1.2	5/21/2003	Riffle/Run	18			15	13	18	12	19	17
UNT/Flatbush Fork RM 1.80	WVMT-42-B-1	0.9	8/25/1997	Riffle/Run	9	6	12	4	7	15	8	11	17
UNT/Roaring Creek RM 11.0	WVMT-42-E	0.6	6/11/2002	Riffle/Run	14			13	12	12	10	16	14

Code	Mile	Date	Form Used	Left Bank Vegetative Protection	Right Bank Vegetative Protection	Total Bank Vegetative Protection	Bank Vegetative Protection (Pre-98)	Grazing/Vegetative Disruption (Pre-98)	Left Bank Undisturbed Vegetative Zone	Right Bank Undisturbed Vegetative Zone	Total Width Undisturbed Vegetative Zone	Total RBP Score	RBP Narrative Score	Total RBP Score (Pre-98)	Benthic Macro Substrate Rating
WVMT-42	6.3	10/3/2002	Riffle/Run												
WVMT-42	7.7	9/16/1997	Glide/Pool				7	7						119	

WVMT-42	7.7	9/16/1997	Glide/Pool				8	8						108	
WVMT-42-0.4A	1.2	5/21/2003	Riffle/Run	9	9	18			9	9	18	166	Optimal		16
WVMT-42-B-1	0.9	8/25/1997	Riffle/Run				16	15						142	
WVMT-42-E	0.6	6/11/2002	Riffle/Run	8	8	16			8	8	16	141	Sub-Optimal		

USEPA Water Chemistry data

Parameter	Start Date	End Date	SWS	WQ station	Avg (ug/L)	Min (ug/L)	Max (ug/L)
Fe	16-Sep-97	16-Sep-97	635	MT-42-{07.7}	1800	1800	1800
Al	27-Mar-80	22-Jul-81	556	385605079570039	1430	590	2300
	1-Jun-84	8-Apr-85	614	385341079575401	13333	12000	15000
	16-Sep-97	16-Sep-97	635	MT-42-{07.7}	480	480	480

Mn	27-Mar-80	22-Jul-81	556	385605079570039	747	530	1100
	1-Jun-84	8-Apr-85	614	385341079575401	343	330	360
	16-Sep-97	16-Sep-97	635	MT-42-{07.7}	2500	2500	2500

USGS Water Chemistry data

Date/time	**Temp**	**Specific conductance**	**H^+**	**DO**	**pH**	**CO_2**	**Alk.**	**Acidity**	**Hardness**	**Ca**	Mg
	deg C	**uS/cm**	**mg/L**	**mg/L**	**su**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	mg/L
9/21/1964 12:10	18.5										
11/23/1964 10:25	33										
12/16/1964 12:35	2										
1/6/1965 9:15	3.5										
3/23/1965 9:35	3.5										
3/25/1965 10:30	5.5										
5/6/1965 15:15	16.5										
6/1/1965 13:40	18.5										
6/21/1965 12:30	16.5										

7/6/1965 13:25	21										
8/19/1965 8:30	20.5										
9/8/1965 13:15	24.5										
10/21/1965 14:15	13										
11/8/1965 13:50	10										
11/30/1965 14:25	0.5										
1/6/1966 12:45											
2/3/1966 10:40	0.5										
3/7/1966 11:25	0.5										
3/23/1966 10:35	9										
6/10/1966 9:40	13.5										
6/30/1966 14:30	25.5										
8/22/1966 13:20	22										
10/1/1966 16:00	11										
10/21/1966 13:00	7.5										
1/13/1967 10:10	0										

3/24/1967 11:10	4										
4/28/1967 15:30	11										
5/7/1967 13:40	11										
6/7/1967 14:45	16.5										
6/30/1967 9:20											
6/30/1967 10:20	18										
8/20/1967 12:00											
8/20/1967 12:20	18										
8/27/1967 14:10	17										
9/1/1967 8:40	12.5										
10/17/1967 15:15	14.5										
10/18/1967 12:20	12										
11/27/1967 16:10	5										
2/27/1968 11:15	0										
3/22/1968 13:50	9										
5/3/1968 14:50	11										

6/7/1968 16:00	9										
7/12/1968 15:40	16.5										
8/21/1968 13:25	21										
9/27/1968 14:50	13.5										
11/26/1968 14:30	5										
1/24/1969 14:15	6										
2/18/1969 14:30	2										
3/28/1969 15:30	5.5										
5/5/1969 15:00	15.5										
6/11/1969 14:55	18.5										
7/14/1969 14:55	18.5										
8/25/1969 10:40	16										
10/1/1969 14:30	14										
2/23/1978 14:00	1	280	0.40127	12	3.4			57	70	16	7.3
4/20/1979 9:50	7	190	0.20111		3.7	780	2	40	46	11	4.5

Date/time	**Na**	**K**	**Cl^-**	**SO_4**	**F**	**Silica**	**Cd**	**Cr**	**Cu**	**Fe**	**Pb**	**Mn**

	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
9/21/1964 12:10												
11/23/1964 10:25												
12/16/1964 12:35												
1/6/1965 9:15												
3/23/1965 9:35												
3/25/1965 10:30												
5/6/1965 15:15												
6/1/1965 13:40												
6/21/1965 12:30												
7/6/1965 13:25												
8/19/1965 8:30												
9/8/1965 13:15												
10/21/1965 14:15												
11/8/1965 13:50												
11/30/1965 14:25												

1/6/1966 12:45												
2/3/1966 10:40												
3/7/1966 11:25												
3/23/1966 10:35												
6/10/1966 9:40												
6/30/1966 14:30												
8/22/1966 13:20												
10/1/1966 16:00												
10/21/1966 13:00												
1/13/1967 10:10												
3/24/1967 11:10												
4/28/1967 15:30												
5/7/1967 13:40												
6/7/1967 14:45												
6/30/1967 9:20												
6/30/1967 10:20												
8/20/1967 12:00												

8/20/1967 12:20												
8/27/1967 14:10												
9/1/1967 8:40												
10/17/1967 15:15												
10/18/1967 12:20												
11/27/1967 16:10												
2/27/1968 11:15												
3/22/1968 13:50												
5/3/1968 14:50												
6/7/1968 16:00												
7/12/1968 15:40												
8/21/1968 13:25												
9/27/1968 14:50												
11/26/1968 14:30												
1/24/1969 14:15												
2/18/1969 14:30												

3/28/1969 15:30												
5/5/1969 15:00												
6/11/1969 14:55												
7/14/1969 14:55												
8/25/1969 10:40												
10/1/1969 14:30												
2/23/1978 14:00	2.2	0.9		110		11			20	3300		1500
4/20/1979 9:50	1.5	0.8	2.1	69	0.1	5.6	20	<20		1700	200	810

Date/time	**Zn**	**Al**	**TDS**	**Acidity**	**Hg**	**TSS**
	ug/L	**ug/L**	**mg/L**	**mg/L as H+**	**ug/L**	**mg/L**
9/21/1964 12:10						
11/23/1964 10:25						
12/16/1964 12:35						
1/6/1965 9:15						
3/23/1965 9:35						

3/25/1965 10:30						
5/6/1965 15:15						
6/1/1965 13:40						
6/21/1965 12:30						
7/6/1965 13:25						
8/19/1965 8:30						
9/8/1965 13:15						
10/21/1965 14:15						
11/8/1965 13:50						
11/30/1965 14:25						
1/6/1966 12:45						
2/3/1966 10:40						
3/7/1966 11:25						
3/23/1966 10:35						
6/10/1966 9:40						
6/30/1966 14:30						

8/22/1966 13:20						
10/1/1966 16:00						565
10/21/1966 13:00						
1/13/1967 10:10						
3/24/1967 11:10						
4/28/1967 15:30						340
5/7/1967 13:40						1240
6/7/1967 14:45						
6/30/1967 9:20						643
6/30/1967 10:20						599
8/20/1967 12:00						673
8/20/1967 12:20						674
8/27/1967 14:10						209
9/1/1967 8:40						
10/17/1967 15:15						
10/18/1967 12:20						

11/27/1967 16:10						
2/27/1968 11:15						
3/22/1968 13:50						
5/3/1968 14:50						
6/7/1968 16:00						
7/12/1968 15:40						
8/21/1968 13:25						
9/27/1968 14:50						
11/26/1968 14:30						
1/24/1969 14:15						
2/18/1969 14:30						
3/28/1969 15:30						
5/5/1969 15:00						
6/11/1969 14:55						
7/14/1969 14:55						
8/25/1969 10:40						

10/1/1969 14:30						
2/23/1978 14:00	210	3800				
4/20/1979 9:50	110	1900	101	0.8	<0.5	

USGS Flow data (cubic feet per second)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1964										4.18	11.7	71.1
1965	143.1	79	135.6	170.2	23.7	3.1	3.66	0.429	0.943	2.06	3.36	5.82
1966	29.8	110.8	65.5	104.9	70.4	11.4	2.89	9.2	12.5	26.8	28.2	69.4
1967	35	59	230.8	64.9	146.1	20.3	28.3	23.7	15.5	49.4	48.2	81.5
1968	53.1	42.8	110.9	61.2	109.6	37.5	7.78	9.88	4.06	6.65	70.6	83.8
1969	92	73.1	83.5	97.2	45.1	12	35.5	42.8	32			
Mean	71	73	125	100	79	17	16	17	13	18	32	62

WVU Division of Forestry Water Quality data

Stream	Date	pH	Temp.	Sp. Cond.	DO	TDS	Alk	Acid	SO_4^{-2}	Al	Cd	Cr	Fe
			°C	µS/cm	mg/L	g/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Tygart Valley River above Roaring	4/12/2005	7.35	13.80	135	11.76	0.102	22.02	6.56	18.00	0.029	0.0000	0.0000	0.014
Tygart Valley River above Roaring	8/15/2005	7.62	27.20	127		0.083	40.80	25.70	8.86	0.000	0.0038	0.0000	0.200
Lower Roaring Creek	3/19/2004	5.25	5.42	110		0.071	2.06	0.91	22.50	0.240	0.0000	0.0025	0.150

Lower Roaring Creek	6/3/2004	4.79	14.50	133		0.086	1.43	8.03	56.94	0.670	0.0000	0.0000	0.220
Lower Roaring Creek	8/17/2004	4.08	16.85	221		0.144	2.23	0.00	50.90	1.060	0.0000	0.0012	0.120
Roaring Creek Upper	3/19/2004	5.92	5.21	103		0.067	2.25	1.61	24.20	0.260	0.0000	0.0026	0.230
Roaring Creek Upper	6/3/2004	5.24	14.14	114		0.074	2.79	6.87	44.32	0.095	0.0000	0.0000	0.220
Roaring Creek Upper	8/16/2004	6.56	16.26	158		0.103	5.13	0.00	39.40	0.017	0.0000	0.0014	0.230

Stream	**Date**	**Mn**	**Ni**	**Ca**	**Mg**	**Hardness**	**TSS**	**Ba**	**Co**	**Cu**	**Zn**	**Na**	**Cl**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Tygart Valley River above Roaring	4/12/2005	0.066	0.000	8.39	2.09		4	0.026	0.0030	0.0000	0.004	3.17	4.95
Tygart Valley River above Roaring	8/15/2005	0.037	0.000	14.79	2.39		0	0.029	0.0000	0.0036	0.008	6.05	5.42
Lower Roaring Creek	3/19/2004	0.420	0.011	7.94	3.44	34.18	4.0	0.038	0.0044	0.0000	0.024	3.21	4.80
Lower Roaring Creek	6/3/2004	0.430	0.015	12.14	4.38	48.60	18.0	0.036	0.0063	0.0028	0.027	1.65	0.00
Lower Roaring Creek	8/17/2004	0.510	0.017	18.31	6.85	74.32	2.0	0.040	0.0085	0.0047	0.036	2.01	2.88
Roaring Creek Upper	3/19/2004	0.650	0.009	6.80	3.57	31.88	4.0	0.039	0.0058	0.0000	0.030	2.56	3.78
Roaring Creek Upper	6/3/2004	0.670	0.014	8.14	4.03	37.14	0.0	0.039	0.0089	0.0000	0.026	1.43	1.99
Roaring Creek Upper	8/16/2004	0.750	0.014	11.50	5.54	51.83	0.0	0.048	0.0100	0.0000	0.032	1.56	2.58

WVU Division of Forestry Flow data

Stream	**Date**	**Q (m^3/s)**
Tygart Valley River above Roaring	4/12/2005	
Tygart Valley River above Roaring	8/15/2005	
Lower Roaring Creek	3/19/2004	6.473

Lower Roaring Creek	6/3/2004	0.710
Lower Roaring Creek	8/17/2004	0.228
Roaring Creek Upper	3/19/2004	2.044
Roaring Creek Upper	6/3/2004	0.741
Roaring Creek Upper	8/16/2004	0.098

WVWRI Water Chemistry data, Round 1

Site	Date	Temp	DO	Sp Cond	Field pH	Lab pH	Lab Cond	Alk.	SO4	Acidity	Mg	Ca	Fe	Al	Mn	Calc acidity	Net acidity	acid load
		degrees C	mg/L	us/cm			us/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	tons/yr
US Tygart	4/18/2009	9.87	6.75	94	7.24													
DS Tygart	4/18/2009	7.95	7.39	115	6.14													
Site 1	4/18/2009	8.17	6.71	116	5.36	4.74	110	1.25	32.3	25.46	2.43	6.11	0.05	0.44	0.22	3.20	1.95	271.00
Site 2 mouth	4/18/2009	8.96	6.98	40	6.14	6.76	43.2	10.32	10.5	0	0.55	4.89	0.05	0.05	0.05	0.54	-9.78	0.58
Site 2 US	4/18/2009	9	5.98	118	5.3	4.64	112.9	0	32.5	13.83	2.44	6	0.1	0.46	0.22	3.48	3.48	
Site 2 DS	4/18/2009	9.05	7.36	117	4.81	4.75	111.4	1.06	33.4	13.08	2.45	6.07	0.2	0.5	0.22	4.49	3.43	
Site 3 mouth	4/18/2009	9.06	8.86	23	5.5	5.31	22.6	1.26	8.95	11.89	0.58	0.93	0.05	0.05	0.05	0.66	-0.60	2.36
Site 3 US	4/18/2009	10.41	7.22	126	4.5	3.72	165.1	0	33.9	19.71	2.64	6.55	0.17	0.48	0.24	5.14	5.14	
Site 3 DS	4/18/2009	10.19	6.99	100	4.6	4.54	98	0	28	13.71	2.04	4.81	0.05	0.35	0.16	3.63	3.63	
Site 4 combined mouth	4/18/2009	9.49	4.36	22	4.61	5.09	22	1.31	8.64	9.45	0.49	0.8	0.05	0.05	0.05	1.73	0.42	8.36
Site 4 US combined	4/18/2009	11.4	3.17	137	4.55	4.28	137.2	0	38.9	18.09	2.79	6.91	0.26	0.52	0.25	5.45	5.45	
Site 4 DS combined	4/18/2009	9.68	3.38	36	4.94	4.93	35.3	1.24	11.7	10.76	0.76	1.32	0.05	0.15	0.05	1.63	0.39	
Site 4 mouth Spring	4/18/2009	9.46	3.01	23	4.51	5.02	22.3	1.39	9.59	8.81	0.46	0.71	0.05	0.05	0.05	2.05	0.66	8.74
Site 4 mouth Broad	4/18/2009	9.92	2.55	21	4.85	5.52	21	1.78	8.49	9.3	0.61	0.82	0.05	0.05	0.05	1.21	-0.57	2.60
Site 5	4/18/2009	7.61	8.19	70	6.69	6.66	69.4	7.96	11.2	1.88	0.67	3.12	0.05	0.05	0.05	0.51	-7.45	0.98
Site 6 mouth	4/18/2009	12.01	7.92	202	4.11	4.11	212	0	52.5	23.61	2.91	10.02	0.95	1.66	0.25	16.12	16.12	54.48
Site 6 US	4/18/2009	10.25	8.02	132	4.15	4.78	134	2.32	41.4	13.54	3.35	7.77	0.67	0.78	0.3	10.22	7.90	871.08

Site 6 DS	4/18/2009	10.84	8.29	141	4.34	4.71	142.5	1.58	41.4	13.06	3.24	7.95	1.1	1.16	0.29	12.22	10.64	1082.39
Site 7 mouth	4/18/2009	11.41	7.95	706	3.01	3.32	751	0	268	77.82	12.9	34.5	5.28	4.43	0.76	89.05	89.05	501.80
Site 7 US	4/18/2009	8.86	8.36	79	5.42	6.5	82.5	4.02	28	5.34	2.17	4.55	0.13	0.15	0.31	1.94	-2.08	127.81
Site 7 DS	4/18/2009	9.03	8.4	82	5.46	6.52	83.1	4.18	26.8	5.38	2.39	5.15	0.27	0.53	0.27	4.34	0.16	310.51
Site 8 mouth	4/18/2009	9.22	8.43	20	3.76													
Site 8 US	4/18/2009																	
Site 8 DS	4/18/2009	9.71	8.42	85	5.46													
Site 9 mouth	4/18/2009	13.07	7.62	67	6.46	7.21	68	14.33	15.5	0	2.27	4.71	0.27	0.05	0.05	1.11	-13.22	16.50
Site 9 US	4/18/2009	9.53	8.11	98	5.15	5.55	100.1	2.97	30.4	7.34	2.64	5.49	0.71	1.03	0.37	8.66	5.69	443.91
Site 9 DS	4/18/2009	9.6	8.18	96	4.92	5.56	98.9	2.91	30.3	7.68	2.71	5.66	0.15	0.64	0.39	5.27	2.36	348.47
Site 10 mouth	4/18/2009	10.03	9.4	328	5.93	6.22	329	3.06	124	7.82	8.49	21.55	0.21	0.15	1.86	4.84	1.78	10.52
Site 10 US	4/18/2009	6.96	10.7	68	5.05	4.99	70.8	2.56	20.1	12.09	1.16	2.44	0.05	0.67	0.21	4.69	2.13	66.44
Site 10 DS	4/18/2009	7.49	9.6	107	5.13	5.06	111.2	2.56	33.9	11.19	2.22	5.19	0.13	0.6	0.45	4.87	2.31	69.92
Site 10 A	4/18/2009	9.54	9.97	33	4.44											1.82	1.82	0.00
Site 11 mouth	4/18/2009	10.72	9.69	121	4.85	4.97	125.4	2.02	37.1	12.2	2.53	5.79	0.14	0.75	0.57	6.29	4.27	116.88
Site 11 US	4/18/2009	11.07	9.75	70	5.34	6.18	72.1	3.16	23.1	6.81	2.19	3.92	0.05	0.1	0.26	1.39	-1.77	24.42
Site 11 DS	4/18/2009	10.9	9.77	92	5.17	5.24	95.3	2.45	29.3	9.4	2.42	4.76	0.05	0.39	0.4	3.37	0.92	123.67
Site 12	4/18/2009	11.3	9.7	100	5.22	5.38	103.2	2.68	31.8	7.19	2.56	5.48	0.46	0.39	0.39	4.41	1.73	175.14
Site 13	4/30/2009	11.72	9.44	32	6.62	7.35	83	10.86	14	1.97	1.72	2.53	0.19	0.85	0.15	5.52	-5.34	22.77
Site 14 north trib	4/30/2009	11.92	9.29	69	7.03	7.29	74	18.39	23	0	2.4	6.02	0.05	0.05	0.05	0.51	-17.88	1.90
Site 14 south trib	4/30/2009	11.74	9.31	122	7.54	7.45	127	36.56	18	0	6.45	10	0.72	0.39	0.1	4.29	-32.27	14.60
Site 15	4/18/2009	10.84	9.68	22	4.68	5.18	23.2	3.06	8.96	8.2	0.41	0.81	0.05	0.24	0.05	2.60	-0.46	10.13
Site 16	4/18/2009	11.49	9.42	52	6.35	7.08	45.7	10.85	11.6	0	1.95	2.78	0.13	1.03	0.05	6.19	-4.66	44.15

WVWRI Water Chemistry data, Round 2

Sample Site	Date	Temp	DO	Sp Cond	Field pH	Lab pH	Lab Cond	Alk	SO4	Acidity	Mg	Ca	Fe	Al	Mn	Calc acidity	Net acidity	acid load
		degrees C	mg/L	us/cm			us/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	tons/yr
US Tygart	7/25/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			

DS Tygart	7/25/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Site 1	7/25/2009	18.77	9.1	222	5.36	4.9	215	2.1	77.4	14.33	6.27	20.22	0.22	0.58	0.49	4.93	2.83	31.78
Site 2 mouth	7/25/2009	16.82	6	132	6.8	8.21	216	99.1	10.2	0	2.18	38.85	0.05	0.05	0.05	0.51	-98.59	
Site 2 US	7/25/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Site 2 DS	7/25/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Site 3 mouth	7/25/2009	16.09	8.2	22	5.88	5.7	20	2.11	8.07	10.29	0.68	1.21	0.43	0.46	0.05	3.87	1.76	0.07
Site 3 US	7/25/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Site 3 DS	7/25/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Site 4 combined mouth	7/25/2009	15.16	8.7	19	6.9	5.57	17	1.37	7.76	8.39	0.65	1.3	0.05	0.05	0.05	0.51	-0.86	0.13
Site 4 US combined	7/25/2009	17.34	9.2	239	5.2	4.79	231	1.43	85.8	15.79	7.84	22.54	0.19	0.7	0.48	5.59	4.16	31.42
Site 4 DS combined	7/25/2009	17.3	9.3	232	5	4.83	223	1.81	81.3	15.68	6.67	20.82	0.14	0.62	0.45	5.14	3.33	30.21
Site 4 mouth Spring	7/25/2009	15.56	8.61	18	4.9	5.15	18	1.51	7.66	9.92	0.64	0.95	0.13	0.11	0.05	1.68	0.17	0.41
Site 4 mouth Broad	7/25/2009	15.28	9.14	19	5.26	5.66	18	2.13	7.79	10	0.66	1.05	0.05	0.05	0.05	0.78	-1.35	0.01
Site 5	7/25/2009	18.52	5.6	169	7.44	8.76	159.3	54.95	10.8	0	1.68	20.95	0.05	0.05	0.05	0.51	-54.44	
Site 6 mouth	7/25/2009	NS	NS	470	4.46	4.46	470	0	202	26.96	10.59	48.26	1.22	1.83	1.5	17.91	17.91	0.72
Site 6 US	7/25/2009	NS	NS	241	4.63	4.63	241	0	91.3	18.96	7.26	22.33	0.51	1.21	0.44	10.07	10.07	72.52
Site 6 DS	7/25/2009	NS	NS	262	4.5	4.5	262	0	100	30.7	7.57	24.63	0.51	1.2	0.52	10.57	10.57	76.54
Site 7 mouth	7/25/2009	14.95	7.77	936	3.74	2.99	960	0	418	17.19	21.14	66.56	8.92	8.04	1.06	79.68	79.68	96.05
Site 7 US	7/25/2009	19.71	6.63	147	6.56	7.16	135.8	12.28	41.7	13.69	5.24	15.17	0.2	0.05	0.29	1.36	-10.92	6.29
Site 7 DS	7/25/2009	19.15	7.15	279	4.58	4.48	247	0	92.5	125.49	7.64	23.32	0.56	1.27	0.41	10.63	10.63	62.05
Site 8 mouth	7/25/2009	16.49	6.53	19	5.85	5.86	18	1.61	802	14.87	0.75	1.22	0.05	0.05	0.05	0.57	-1.04	
Site 8 US	7/25/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Site 8 DS	7/25/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Site 9 mouth	7/25/2009	17.7	4.1	140	6.56	7.67	131	39.6	31.4	0	4.07	15.5	0.05	0.48	0.05	2.91	-36.69	2.95
Site 9 US	7/25/2009	17.58	3.65	179	6.5	6.44	163	5.36	54.2	6.84	5.8	14.42	0.77	0.18	1.04	4.98	-0.38	16.63
Site 9 DS	7/25/2009	17.69	3.76	163	6.36	7.06	149	17.63	40.1	0	5.32	15.21	0.13	1.67	0.64	10.82	-6.81	47.14
Site 10 mouth	7/25/2009	17.27	5.88	671	3.8	3.63	633	0	329	64.85	22.61	55.82	1.58	2.17	11.3	44.80	44.80	5.21
Site 10 US	7/25/2009	15.45	6.09	136	4.63	3.99	137	0	40.9	23.88	2.95	8.53	1.69	1.13	0.88	13.60	13.60	2.09

Site 10 DS	7/25/2009	16.78	6.15	337	3.88	4.01	316	0	127	31.54	10.34	25.99	1.14	1.52	4.46	26.22	26.22	8.19
Site 10 A	7/25/2009	19.09	9.03	26	5.16	4.84	31.6	3.26	7.3	19.89	0.43	2.89	0.25	0.43	0.18	3.74	0.48	0.85
Site 11 mouth	7/25/2009	18.48	3.3	282	4.8	4.18	279	0	104	27.56	7.76	19.34	1.57	1.64	3.36	20.24	20.24	10.57
Site 11 US	7/25/2009	15.85	4.36	163	7.15	6.72	151	4.94	50.9	5.92	5.58	12.09	0.33	0.05	0.46	2.01	-2.93	2.67
Site 11 DS	7/25/2009	16.07	5.07	173	5.29	4.4	209	0	77.2	21.7	6.47	14.24	0.64	0.34	1.33	6.29	6.29	11.64
Site 12	7/25/2009	18.33	3.62	187	5.28	6.26	172	3.86	59.1	9.05	6.06	14.78	0.48	0.05	1.13	3.89	0.03	8.82
Site 13	7/25/2009	18.09	9.01	45	7.25	7.07	44	9.27	11.6	2.16	2.17	3.85	0.05	0.05	0.05	0.51	-8.76	0.18
Site 14 north trib	7/25/2009	17.62	3.84	157	6.28	7.71	147	34.14	30.3	0	4.09	18.12	0.1	0.05	0.05	0.66	-33.48	0.11
Site 14 south trib	7/25/2009	17.11	9.05	220	7.94	8.23	217	57.43	38.6	0	11.27	20.53	0.1	0.05	0.05	0.64	-56.79	0.18
Site 15	7/25/2009	17.57	3.83	27	5.67	6.38	25	3.56	9.49	9.99	1.92	3.13	0.16	0.05	0.05	0.91	-2.65	0.27
Site 16	7/25/2009	17.83	3.7	62	5.82	6.94	59	14.45	11.5	0	2.61	4.73	0.25	0.34	0.05	2.73	-11.72	4.35

WVWRI Water Chemistry data, Round 3

Sample Site	Date	Temp	DO	Sp Cond	Field pH	Lab pH	Lab Cond	Alk	SO4	Acidity	Mg	Ca	Fe	Al	Mn	Calc acidity	Net acidity	acid load
		degrees C	mg/L	us/cm			us/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	tons/yr
US Tygart	10/10/2009	15.52	6.78	210	6.95	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
DS Tygart	10/10/2009	13.97	8.21	102	7.26	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Site 1	10/10/2009	14.03	7.87	110	6.99	6.04	94.8	4.86	25.2	10.26	2.68	8.54	0.17	0.05	0.32	1.32	-3.54	NS
Site 2 mouth	10/10/2009	12.7	8.46	126	6.06	6.72	122.8	39.91	15.9	0	1.55	20.83	0.43	0.32	0.18	3.31	-36.60	1.48
Site 2 US	10/10/2009	13.26	8.28	120	6.23	5.99	106.1	3.4	27.8	12.21	3.24	9.62	0.12	0.05	0.48	1.50	-1.90	NS
Site 2 DS	10/10/2009	13.56	8.45	120	6.1	6.12	107.5	7.37	27.5	9.66	3.25	10.5	0.14	0.05	0.46	1.53	-5.84	NS
Site 3 mouth	10/10/2009	12.71	8.69	20	6.69	5.59	17.7	1.9	14	10.13	0.59	1.14	0.11	0.05	0.05	0.67	-1.23	0.60
Site 3 US	10/10/2009	13.82	8.1	97	6.61	6	98.4	3.56	26.5	12.4	2.86	8.63	0.12	0.05	0.39	1.32	-2.24	182.15
Site 3 DS	10/10/2009	13.36	8.61	113	6.68	5.98	92.9	3.71	25.3	11.46	2.58	7.7	0.24	0.05	0.34	1.55	-2.16	215.15
Site 4 combined mouth	10/10/2009	12.62	8.43	25	5.53	5.72	16.58	1.45	13.8	10.31	0.59	1.03	0.18	0.12	0.05	1.39	-0.06	4.09
Site 4 US combined	10/10/2009	13.64	8.44	120	5.46	5.91	71.8	2.51	22	21.32	3.32	9.87	0.25	0.11	0.54	2.44	-0.07	NS
Site 4 DS combined	10/10/2009	13.03	8.42	68	5.28	5.67	33.6	1.97	15.7	14.6	1.33	3.39	0.05	0.05	0.18	1.00	-0.97	NS

Site 4 mouth Spring	10/10/2009	12.62	8.9	19	4.98	5.01	18.01	1.16	13.6	39.06	0.76	1.13	0.59	0.42	0.28	4.95	3.79	10.49
Site 4 mouth Broad	10/10/2009	12.52	8.7	25	5.01	5.65	16.82	1.47	14	10.71	0.58	0.86	0.05	0.05	0.05	0.99	-0.48	0.82
Site 5	10/10/2009	13.31	7.62	80	6.23	6.53	74	16.4	19.5	0.49	1.15	7.05	0.18	0.1	0.05	1.16	-15.24	4.91
Site 6 mouth	11/6/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Site 6 US	11/6/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Site 6 DS	11/6/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Site 7 mouth	10/10/2009	12.9	8.71	357	4.38	3.9	357	0	121	35.67	8.81	30.71	3.79	2.69	0.71	28.51	28.51	NS
Site 7 US	10/10/2009	13.48	9.27	90	6.75	5.94	86.4	4.32	21.9	10.2	2.74	7.28	0.64	0.36	0.53	4.69	0.37	NS
Site 7 DS	10/10/2009	13.37	9.1	138	5.45	5.37	161.6	1.43	42	15.9	4.71	15.16	1.57	1.03	0.5	11.03	9.60	NS
Site 8 mouth	11/6/2009	7	11.94	20	6.99	5.52	17.69	2.05	11	13.11	1.03	2.75	0.22	0.28	0.14	2.41	0.36	5.54
Site 8 US	11/6/2009	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Site 8 DS	11/6/2009	6.11	9.64	82.00	6.53	6.21	78.6	5.45	21.2	14.58	2.66	6.6	0.27	0.05	0.35	1.66	-3.79	NS
Site 9 mouth	10/10/2009	12.72	9.71	76	7.97	6.61	73.8	19.81	16.3	0	2.29	25.35	0.64	0.2	0.05	2.92	-16.89	29.44
Site 9 US	10/10/2009	13.7	6.85	96	6.43	5.97	91.9	2.5	24.4	13.1	2.72	7.28	0.82	0.44	0.57	5.70	3.20	516.57
Site 9 DS	10/10/2009	13.71	8.55	95	6.42	6	91.6	2.46	25.5	12.99	2.72	7.24	0.85	0.46	0.57	5.90	3.44	593.37
Site 10 mouth	10/10/2009	13.39	9.09	109	5.2	4.83	106.7	1.4	27.5	16.46	3.1	7.5	0.49	0.54	0.82	6.13	4.73	NS
Site 10 US	10/10/2009	13.16	8.99	75	5.6	5.69	71	1.9	21.3	12.18	2.35	5.16	0.2	0.25	0.33	2.65	0.75	NS
Site 10 DS	10/10/2009	13.33	9.07	103	5.25	4.96	98.1	1.64	26.4	17.97	2.92	6.81	0.55	0.46	0.69	5.57	3.93	NS
Site 10 A	10/10/2009	12.99	9.39	33	4.6	4.6	29.7	0	14.4	15.75	0.39	1.23	0.14	0.34	0.12	3.74	3.74	59.80
Site 11 mouth	10/10/2009	14.33	8.96	324	6.26	6.18	313	8.07	113	11.81	10.75	28.38	1.04	0.15	2.3	7.84	-0.23	25.27
Site 11 US	10/10/2009	12.85	9.44	52	4.88	4.65	51	0.85	17.4	16.87	0.97	2.45	0.21	0.57	0.33	4.99	4.14	NS
Site 11 DS	10/10/2009	13	9.42	88	5.34	5.22	86	1.17	23.7	12.93	2.5	6.06	0.55	0.65	0.75	6.68	5.51	NS
Site 12	10/10/2009	13.31	7.89	96	5.67	5.77	92.1	2.76	25.4	13.28	2.61	6.66	0.31	0.23	0.56	3.24	0.48	NS
Site 13	10/10/2009	12.91	9.74	38	7.92	6.19	36.8	7.61	15.4	11.62	1.93	3.2	0.29	0.16	0.05	1.76	-5.85	5.11
Site 14 north trib	10/10/2009	12.41	9.37	111	8.03	6.45	107.8	24.04	20.1	0	3.46	12.84	0.3	0.28	0.05	2.45	-21.59	3.31
Site 14 south trib	10/10/2009	12.4	9.02	172	8.01	6.67	166.9	39.5	27.5	0	8.23	15.3	0.81	0.27	0.05	3.77	-35.73	2.78
Site 15	10/10/2009	12.34	9.67	22	5.41	6.11	20.6	3.21	13.8	8.39	0.41	1.52	0.05	0.14	0.05	1.20	-2.01	2.03
Site 16	10/10/2009	12.23	9.8	59	6.03	6.47	56	13.58	17.2	0	2.78	4.02	0.1	0.05	0.05	0.68	-12.90	3.95

WVWRI Water Chemistry data, Round 4

Sample Site	Date	Temp	DO	Sp Cond	Field pH	Lab pH	Lab Cond	Alk	SO4	Acidity	Mg	Ca	Fe	Al	Mn	Calc acidity	Net acidity	acid load
US Tygart	4/24/2010	14.38	8.42	108	6.94	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
DS Tygart	4/24/2010	12.9	10.07	128	5.99	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Site 1	4/24/2010	11.28	10.5	161	3.7	4.9	157.5	3.91	47.3	74.41	4.76	13.49	0.19	0.93	0.58	16.71	12.80	NS
Site 2 mouth	4/24/2010	11.58	10.36	62	6.97	6.31	60.7	23.75	10.2	93.87	3	13.77	0.35	0.44	1.28	5.72	-18.03	5.83
Site 2 US	4/24/2010	12.46	10.16	162	4.58	4.61	158	1.12	47.6	102.4	4.94	14.6	0.15	0.92	0.66	8.03	6.91	98.15
Site 2 DS	4/24/2010	12.47	10.37	161	4.29	4.62	156.3	1.66	46.3	104.86	4.95	13.31	0.18	1.15	0.56	10.46	8.80	138.46
Site 3 mouth	4/24/2010	10.13	10.6	21	4.32	5.27	20.4	3.34	8.59	115.57	0.74	1.19	0.2	0.05	0.05	3.30	-0.04	62.66
Site 3 US	4/24/2010	11.49	10.22	175	4.28	4.44	169.8	0	49.4	157.96	<0.1	<0.1	0.12	0.05	0.05	3.32	3.32	65.42
Site 3 DS	4/24/2010	11.57	10.53	169	4.25	4.45	169.6	0	50.2	159.45	8.13	18.16	3.16	4.39	3.54	42.15	42.15	831.66
Site 4 combined mouth	4/24/2010	11.11	10.58	19	4.75	5.13	18.61	3.1	8.84	136.33	5.02	13.82	0.22	1.08	0.45	8.30	5.20	12.60
Site 4 US combined	4/24/2010	13.29	9.96	190	4.28	4.35	182.6	0	54.9	171.22	0.78	1.7	0.16	0.05	0.05	3.42	3.42	NS
Site 4 DS combined	4/24/2010	13.13	10.26	168	4.23	4.37	182.1	0	54	146.85	5.78	15.93	0.22	1.27	0.5	11.51	11.51	NS
Site 4 mouth Spring	4/24/2010	11.06	10.51	20	4.23	5.01	19.22	2.22	9.67	148.87	0.64	1.14	0.36	0.05	0.05	5.03	2.81	4.01
Site 4 mouth Broad	4/24/2010	10.81	10.44	19	4.65	5.23	19.01	2.56	8.94	125.57	5.44	14.92	0.16	1.22	0.46	8.42	5.86	1.33
Site 5	4/24/2010	11.99	6.72	66	5.61	5.91	64.6	14.01	9.71	158.42	1.05	5.8	0.18	0.21	0.05	2.83	-11.18	0.20
Site 6 mouth	4/24/2010	13.20	7.33	837.00	3.05	4.25	259.00	0.00	84.20	273.29	6.01	16.47	1.17	2.85	0.58	NS	NS	NS
Site 6 US	4/24/2010	12.95	8.20	104.00	5.19	4.27	194.60	0.00	58.40	162.39	5.82	16.00	0.27	1.22	0.53	NS	NS	NS
Site 6 DS	4/24/2010	13.17	9.00	114.00	5.32	4.30	196.80	0.00	58.40	172.47	5.84	5.80	0.67	1.38	0.44	NS	NS	NS
Site 7 mouth	4/24/2010	12.38	7.92	267	4.29	4.24	844	0	324	242.3	20.77	69.67	1.17	7.81	0.74	50.47	50.47	6.91
Site 7 US	4/24/2010	11.07	9.05	200	3.95	4.85	103.8	3.33	36.9	191.36	3.91	11.34	0.18	0.05	0.55	7.37	4.04	23.11
Site 7 DS	4/24/2010	11.16	9.04	204	3.83	3.94	204	0	59.3	169.41	5.69	16.4	0.2	1.21	0.56	15.68	15.68	51.29
Site 8 mouth	4/24/2010	11.44	8.78	19	4.68	5.19	19.97	2.36	8.76	153.86	0.86	1.04	0.33	0.05	0.05	2.30	-0.06	0.92

Site 8 US	4/24/2010	12.45	6.76	113	5.49	5.4	110.3	5.47	31.2	161.91	3.77	11.4	0.19	0.1	0.57	NS	NS	NS
Site 8 DS	4/24/2010	12.42	8.15	109.00	5.54	5.33	105.9	4.55	32.8	158.75	3.96	9.6	0.23	0.24	0.58	3.15	-1.40	NS
Site 9 mouth	4/24/2010	13.56	7.21	80	5.93	5.74	77.9	20.83	14.7	135.44	3.01	8.78	0.18	0.05	0.05	0.91	-19.92	0.69
Site 9 US	4/24/2010	12.65	7.9	126	5.66	5.06	120.7	2.46	36.5	125.04	4.21	10.55	0.14	0.18	0.75	2.85	0.39	9.62
Site 9 DS	4/24/2010	13.26	7.96	97	5.88	4.89	122.6	2.27	38	166.52	4.17	10.12	0.16	0.25	0.86	3.45	1.18	14.27
Site 10 mouth	4/24/2010	14.07	9.3	415	4.16	3.74	421	0	160	142.97	14.21	0.38	0.38	1.62	4.79	22.20	22.20	20.77
Site 10 US	4/24/2010	10.56	9.3	77	4.46	4.39	76.9	0	21.4	135.98	1.53	3.6	0.2	1.03	0.46	8.83	8.83	27.52
Site 10 DS	4/24/2010	11.57	9.89	135	4.58	4.25	152.8	0	43.6	159.53	4.25	11.09	0.17	1.08	1.42	10.36	10.36	41.97
Site 10 A	4/24/2010																	
Site 11 mouth	4/24/2010	12.03	9.31	153	4.58	5.12	157.4	4.16	45.2	143.51	4.88	11.66	0.17	1.48	1.6	11.60	7.44	57.90
Site 11 US	4/24/2010	11.21	10.5	98	5.2	5.5	100.5	3.02	31.6	138.59	3.96	8.65	0.18	0.32	0.41	3.32	0.30	35.94
Site 11 DS	4/24/2010	11.81	9.88	120	4.98	4.72	123.8	1.59	36.6	199.32	4.15	9.07	0.19	0.59	0.81	5.79	4.20	91.48
Site 12	4/24/2010	12.54	9.79	124	5.29	4.83	126.6	2.35	37.9	153.09	4.26	9.91	0.16	0.41	0.81	4.44	2.09	56.99
Site 13	4/24/2010	14.21	9.46	34	7.07	5.73	34	7.11	10.6	159.8	2.02	7.51	0.18	0.12	0.5	2.06	-5.05	0.93
Site 14 north trib	4/24/2010	14.37	9.48	98	6.98	5.78	99.8	19.69	27.7	144.68	3.62	11.59	0.15	0.21	0.5	2.49	-17.20	1.44
Site 14 south trib	4/24/2010	13.53	9.72	137	7.49	5.89	139.1	36.88	26.7	104.97	7.36	12.51	0.17	0.16	0.5	2.26	-34.62	1.66
Site 15	4/24/2010	13.87	9.87	21	4.45	4.82	21.2	2.11	7.94	136.98	0.32	1.04	0.17	0.5	0.5	5.92	3.81	9.28
Site 16	4/24/2010	14.31	9.06	39	6.42	5.7	40.2	9.96	10.6	146.22	1.81	2.9	0.15	0.5	0.5	4.11	-5.85	8.17

WVWRI Flow data (NS = Not Sampled)

Sample Site	Date	Flow	Date	Flow	Date	Flow	Date	Flow
		Gall/min		Gall/min		Gall/min		Gall/min
US Tygart	4/18/2009	--	7/25/2009	NS	10/10/2009	NS	4/24/2010	NS
DS Tygart	4/18/2009	--	7/25/2009	NS	10/10/2009	NS	4/24/2010	NS
Site 1	4/18/2009	38,505.60	7/25/2009	2,933.06	10/10/2009	NS	4/24/2010	11,674.88
Site 2 mouth	4/18/2009	488.32	7/25/2009	NS	10/10/2009	203.84	4/24/2010	463.55
Site 2 US	4/18/2009	--	7/25/2009	NS	10/10/2009	NS	4/24/2010	5,553.09

Site 2 DS	4/18/2009	--	7/25/2009	NS	10/10/2009	NS	4/24/2010	6,016.64
Site 3 mouth	4/18/2009	1,621.76	7/25/2009	7.84	10/10/2009	406.34	4/24/2010	336
Site 3 US	4/18/2009	--	7/25/2009	NS	10/10/2009	62,608	4/24/2010	8,632.96
Site 3 DS	4/18/2009	--	7/25/2009	NS	10/10/2009	63,014.34	4/24/2010	8,968.96
Site 4 combined mouth	4/18/2009	2,195.20	7/25/2009	116.48	10/10/2009	1,339.07	4/24/2010	689.92
Site 4 US combined	4/18/2009	--	7/25/2009	2,554.05	10/10/2009	NS	4/24/2010	NS
Site 4 DS combined	4/18/2009	--	7/25/2009	2,670.53	10/10/2009	NS	4/24/2010	NS
Site 4 mouth Spring	4/18/2009	1,939.40	7/25/2009	112	10/10/2009	962.3	4/24/2010	362.88
Site 4 mouth Broad	4/18/2009	976.64	7/25/2009	7.17	10/10/2009	376.77	4/24/2010	71.68
Site 5	4/18/2009	866.43	7/25/2009	NS	10/10/2009	1,924.61	4/24/2010	31.81
Site 6 mouth	4/18/2009	1,536.64	7/25/2009	18.37	11/6/2009	NS	4/24/2010	299.26
Site 6 US	4/18/2009	38,735.87	7/25/2009	3,273.54	11/6/2009	NS	4/24/2010	1,909.38
Site 6 DS	4/18/2009	40,272.51	7/25/2009	3,291.91	11/6/2009	NS	4/24/2010	2,055.87
Site 7 mouth	4/18/2009	2,561.22	7/25/2009	547.9	10/10/2009	NS	4/24/2010	62.27
Site 7 US	4/18/2009	29,986.43	7/25/2009	2,106.50	10/10/2009	NS	4/24/2010	1,424.64
Site 7 DS	4/18/2009	32,547.65	7/25/2009	2,654.40	10/10/2009	NS	4/24/2010	1,486.91
Site 8 mouth	4/18/2009	2,784.77	7/25/2009	NS	11/6/2009	1,045.63	4/24/2010	182.33
Site 8 US	4/18/2009		7/25/2009	NS	11/6/2009	NS	4/24/2010	NS
Site 8 DS	4/18/2009		7/25/2009	NS	11/6/2009	NS	4/24/2010	NS
Site 9 mouth	4/18/2009	6,747.33	7/25/2009	461.44	10/10/2009	4,578.50	4/24/2010	345.86
Site 9 US	4/18/2009	23,298.24	7/25/2009	1,518.72	10/10/2009	41,160	4/24/2010	1,534

Site 9 DS	4/18/2009	30,045.57	7/25/2009	1,980.16	10/10/2009	45,738.00	4/24/2010	1,879.36
Site 10 mouth	4/18/2009	987.39	7/25/2009	52.86	10/10/2009	NS	4/24/2010	425.15
Site 10 US	4/18/2009	6,443.28	7/25/2009	69.89	10/10/2009	NS	4/24/2010	1,416.13
Site 10 DS	4/18/2009	6,519.74	7/25/2009	142.02	10/10/2009	NS	4/24/2010	1,841.28
Site 10 A	4/18/2009		7/25/2009	103.94	10/10/2009	7,266.56	4/24/2010	NS
Site 11 mouth	4/18/2009	8,447.49	7/25/2009	237.44	10/10/2009	1,464.96	4/24/2010	2,269.57
Site 11 US	4/18/2009	7,974.40	7/25/2009	604.35	10/10/2009	NS	4/24/2010	4,914.11
Site 11 DS	4/18/2009	16,688	7/25/2009	841.79	10/10/2009	NS	4/24/2010	7,183.68
Site 12	4/18/2009	18,032	7/25/2009	1,031.74	10/10/2009	NS	4/24/2010	5,834.30
Site 13	4/30/2009	1,874.43	7/25/2009	158.59	10/10/2009	1,319.92	4/24/2010	204.74
Site 14 north trib	4/30/2009	1,696.58	7/25/2009	77.95	10/10/2009	613	4/24/2010	263.42
Site 14 south trib	4/30/2009	1,548.74	7/25/2009	127.68	10/10/2009	335	4/24/2010	333.31
Site 15	4/18/2009	1,768.70	7/25/2009	133.95	10/10/2009	770.56	4/24/2010	712.32
Site 16	4/18/2009	3,243.07	7/25/2009	725.31	10/10/2009	2,625.28	4/24/2010	903.62

WVWRI Benthic data

Sample Site	Date	Stream score	Integrity Rating	Date	Stream score	Integrity Rating
Site 1	04/18/2009	14	Marginal	10/10/09	15	Marginal
Site 2 mouth	04/18/2009	16	Marginal	10/10/09	18	Marginal
Site 3 mouth	04/18/2009	18	Marginal	10/10/09	18	Marginal
Site 4 mouth combined	04/18/2009	18	Marginal	10/10/09	18	Marginal

Site 4 mouth Spring	04/18/2009	16	Marginal	10/10/09	16	Marginal
Site 4 mouth Broad	04/18/2009	14	Marginal	10/10/09	20	Suboptimal
Site 5	04/18/2009	20	Suboptimal	10/10/09	NS	NS
Site 6 mouth	04/18/2009	12	Marginal	10/10/09	18	Marginal
Site 7 US	04/18/2009	14	Marginal	10/10/09	NS	NS
Site 8 mouth	04/18/2009	18	Marginal	10/10/09	NS	NS
Site 8 DS	04/18/2009	16	Marginal	10/10/09	17	Marginal
Site 9 mouth	04/18/2009	20	Suboptimal	10/10/09	19	Suboptimal
Site 9 DS	04/18/2009	10	Poor	10/10/09	11	Poor
Site 10 US	04/18/2009	16	Marginal	10/10/09	NS	NS
Site 10 DS	04/18/2009	10	Poor	10/10/09	NS	NS
Site 10 A	04/18/2009	18	Marginal	10/10/09	14	Marginal
Site 11 mouth	04/18/2009	14	Marginal	10/10/09	10	Poor
Site 11 DS	04/18/2009	14	Marginal	10/10/09	NS	NS
Site 13	04/18/2009	20	Suboptimal	10/10/09	NS	NS
Site 14 north trib	04/18/2009	18	Marginal	10/10/09	NS	NS
Site 14 south trib	04/18/2009	20	Suboptimal	10/10/09	19	Suboptimal
Site 15	04/18/2009	18	Marginal	10/10/09	12	Marginal
Site 16	04/18/2009	14	Marginal	10/10/09	NS	NS