# Acid Mine Drainage Abatement and Treatment Plan for the Monday Creek Watershed

Prepared by

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# Monday Creek Acid Mine Drainage Abatement and Treatment Plan

## Forward

Monday Creek Restoration Project (MCRP) has worked since 1994 to identify water quality problems resulting from abandoned underground and surface mines located within the Monday Creek Watershed. Quarterly monitoring of ten long-term sampling sites located in Monday Creek and the Snow Fork tributary began in 1997 and continued until 2003. From 2004 to 2007, monitoring at the ten long-term sampling sites will be performed on a semi-annual basis. Sub-watershed investigations were undertaken in 1998 and 1999 to identify tributaries contributing acid mine drainage (AMD) contamination. In October 2000, a mass balance was performed in Monday Creek. Sites contributing AMD to Monday Creek and Snow Fork were sampled in an attempt to quantify acid load contribution at base flow conditions. In 2000-2001 an abandoned mine land inventory was undertaken in the watershed by cooperating agencies including: Ohio Department of Natural Resources (ODNR), Monday Creek Restoration Project, U.S. Forest Service and the U.S. Army Corps of Engineers. Mining features having a negative impact on water quality and sites discharging AMD were identified. To complement MCRP and ODNR efforts to identify degraded basins and quantify acid loads, a Total Maximum Daily Load (TMDL) study was completed in the watershed by the Ohio Environmental Protection Agency (OEPA) in 2001.

The resulting data set consisted of all water quality monitoring conducted in the basin (MCRP 1995-2002) and TMDL biological and water quality data collected June thru September of 2001 (OEPA). The data set was provided to West Virginia University (WVU) Water Research Institute, for inclusion into the Total Acid Mine Drainage Loading Model (TAMDL), which simulated effects and improvements of various AMD treatments on the water quality in Monday Creek. The goal of the TAMDL was to restore Monday Creek mainstem to Warmwater Habitat through remediation projects constructed throughout the watershed. This report includes information from the aforementioned sources and treatment recommendations, as well as cost estimates for remediation, developed by WVU-Water Resource Institute and the U.S. Army Corps of Engineers.

## Introduction

The purpose of the Monday Creek AMDAT plan is to provide a comprehensive treatment strategy to restore Monday Creek mainstem to the “aquatic use designation” of Warmwater Habitat (WWH). The key components of the AMDAT are to document sources of acid mine drainage (AMD) and then propose remediation strategies to abate the effects of AMD on Monday Creek and its tributaries. The goal of the Monday Creek Restoration Project is to improve water quality and habitat to the greatest extent possible for the support of aquatic life. Monday Creek mainstem is currently designated as Limited Resource Water (LRW) due to AMD impacts in the watershed, determined by Ohio EPA (1991 and 2001).

## Hydrologic Unit and Watershed Description

**Name:** Monday Creek Watershed, Ohio

**Tributary to:** Hocking River (10% of Hocking watershed)

**Drainage Area:** 116 square miles; 74,240 acres

**Perennial Length:** 27 miles

**Main Tributaries:** Little Monday Creek (14.3 miles), Snow Fork (10.7 miles)

**HUC # Code:** 05030204 – 060

**Location:** Athens, Hocking and Perry Counties

**USGS Quadrangles:** Gore, Junction City, Nelsonville, New Lexington, New Straitsville, Union Furnace

The Monday Creek Watershed drains a 116-square mile forested watershed in Appalachian Ohio, an area with a 125-year history of mining. The Wayne National Forest currently owns and manages approximately 42 percent of the land in the watershed. Sunday Creek Coal Company, the second largest landowner in the watershed, owns approximately 8.5 percent of the land. The northern boundary of the watershed is located in southern Perry County. The western portion of the watershed drains a large part of eastern Hocking County and empties into the Hocking River just south of Nelsonville in northern Athens County (Refer to Map 1).

The two major tributaries in the watershed are Little Monday Creek (14.3 stream miles with an average fall of 17 ft/mile), which flows into Monday Creek at River Mile 14.5, and Snow Fork (10.7 stream miles with an average fall of 17.3 ft/mile) flows into Monday Creek at River Mile 3.45, near its mouth. The topography is rugged. Valleys are typically narrow (less than 0.1 mile wide on the eastern side) and slopes are steep, averaging from 30 degrees to 35 degrees. Elevation ranges from 940 ft at the headwaters to 659 ft at the mouth with an average fall of 10.4 ft/mile. Drainage flows roughly from north to south.

In the Monday Creek Watershed, acid mine drainage (AMD) from abandoned underground (deep) mines, strip mines, gob piles and coal spoil piles has destroyed fish and macro-invertebrate populations in much of the 270 stream miles in this limited resource waterway. In addition to the mine drainage, strip mine erosion and bank erosion from non-vegetated stream banks contributes to sedimentation of streams and impairs aquatic habitat. Streams in this condition represent lost environmental and economic opportunities for local residents and a failure to provide the health and aesthetic qualities that lead to the increased property values and greater recreational enjoyment of this watershed (Borch et al, 1997).

## Land Use

Monday Creek lies in the mixed mesophytic forest region of the Low Hill Belt section of the Allegheny Plateau. The vegetation of Monday Creek Watershed is typical of southeastern Ohio. The watershed's forests are composed of tulip poplar; beech; silver and red maple; white, red and chestnut oak; as well as white, pitch and Virginia pine. Primary land cover categories (1994) consist of forest (87 percent), mining in the form of surface mines (4 percent), cropland (3 percent), pasture (1 percent) wetlands (2 percent), grazing (1 percent) and urban (1 percent).

## Geology

Monday Creek Watershed lies in the Pennsylvanian Allegheny coal basin. The Allegheny and Conemaugh formations constitute the bedrock formation. Monday Creek has its headwaters on the Upper Freeport, Allegheny series, Pennsylvanian system sandstone and shale at 990 ft elevation. This bedrock is composed of silty sand to silty shale. The creek flows south over Pleistocene lake and stream sediments to join the Hocking River on glacial outwash, which was deposited on an erosional surface at the top of the Pottsville series. Little Monday Creek, which drains the northwest part of the watershed, has its headwaters on the Upper Freeport sandstone at elevation 1,000 ft. Snow Fork, which drains the eastern portion of the watershed, originates on the Brush Creek limestone (Flint, 1951) at an elevation of 1,000 ft. The thin Brush Creek limestone of the Conemaugh series is the highest unit in the stratigraphic section of the watershed. The total fall of streams in the watershed is approximately 300 ft. Coal deposits typically dip to the southeast with a fall of 30 ft per mile.

## Mining History

The first reported coal production in the area began in Perry County in 1816, followed by Athens County in 1820 and Hocking County in 1840. However, coal mining in the Monday Creek Watershed did not become a major industry until the mid 1800s, when the railroad reached the Hocking Valley coalfields. The coal seams excavated in the watershed were the Middle Kittanning (#6), Lower Freeport (#6a) and the Upper Freeport (#7). The Middle Kittanning coal seam was the most advantageous to mine, owing to the thickness of the seam (4 ft to 10 ft). The major types of mining that occurred in the watershed were drift, slope and surface mining. A drift opening is a horizontal passageway created to exploit coal seams where they crop out. A slope opening is an inclined passageway and exploits coal that is either below regional drainage or under thick cover (Crowell, 1995). Surface or strip mining is the practice of removing soil and rock overburden to exploit coal seams oriented near the lands surface.

From 1800 to about World War I, most of the watershed's coal was mined by underground (deep) mining methods. The procedure used was room and pillar, where coal is mined in rooms and coal or wood pillars are used to support the roof of the mine. Extensive underground mine complexes were developed in the watershed, both above and below stream level. Due to the economic downturn following World War I, Ohio's coal production declined. As a result, many of the deep mines in the watershed closed during the 1920s. By the 1930s and 1940s, the majority of the underground coal mines in the watershed had been abandoned. After the underground mines were abandoned, many of these mines were then contour-strip mined. (Refer to Map 2) By the late 1960s, nearly all of the mining in the watershed had come to an end. Underground mining operations ceased in 1972 in the Athens and Hocking County portions of the watershed and, in 1991, in the Perry County portion of the watershed (ILGARD 1999). There are approximately 14,797 acres of underground mines and 3,172 acres of surface mines within the Monday Creek Watershed.

Ohio's first law regulating coal mining was enacted in 1947. The Ohio Strip Coal Mining Act required mine operators to hold a license and pay a $100 bond for each acre of land mined. Then in 1949, Ohio law required mine operators to close or fence all openings to underground mines abandoned after June 1941. Over the next thirty years Ohio mining laws were gradually strengthened. Reclamation bonds were increased and revegetation of surface mined areas were required. However, it wasn't until the early 1970's that bona fide progress was made toward responsible mining and reclamation practices. In 1972, Ohio revised the Strip Coal Mining Act, and required that mine spoil be graded and contoured, topsoil replaced, and vegetation planted by the mine operator. In 1977, a federal law was passed called the Surface Mining Control and Reclamation Act (SMCRA) which established national standards to regulate the mining industry. Since the SMCRA laws were enacted, some reclamation has taken place on abandoned surface mines in the watershed. However, reclamation traditionally focused on erosion and safety, and did little to address acid mine drainage problems.

## AMD and Water Quality

The hydrologic regime produced by surface and subsurface mining is ideal for acid production. This has resulted in physical and chemical pollution to streams. Physical pollution includes sediment, silt and mine refuse. Chemical pollution contains acidity and heavy metals from mine drainage. In general, the worst water quality (lowest pH, highest metal concentrations, and large amounts of acid loading) is associated with underground mines. Underground mines with horizontal adits contribute the highest discharges and heaviest acidity loading, which have the greatest impact on the watershed.

In the years since the early room-and-pillar mining in the Monday Creek Watershed, there have been frequent documented subsidences of underground mines. Subsidences close to the surface capture streams and runoff, allowing surface water to enter the mine complex. Fresh water dissolves oxidized pyritic material to form acid mine drainage which discharges from mine portals where it is expressed as seeps, contaminating streams and groundwater.

The most prevalent sources of AMD are abandoned openings to underground mines in the Middle Kittanning coal, exacerbated by sulfur-rich mine wastes in or near the mine opening, with flow increased in many cases by stream capture into subsided areas (Borch et al, 1997). Based on a 2001 Ohio EPA Total Maximum Daily Load (TMDL) study, approximately 82 of the 107 miles (77%) of streams assessed in the Monday Creek Watershed are impaired due to AMD (USACE, 2005).

## Acid Mine Drainage Formation

Acid mine drainage is created by water coming into contact with sulfide minerals in the coal. The most common sulfide mineral associated with coal is pyrite ($FeS_2$). AMD, in which mineral acidity exceeds alkalinity, typically contains elevated concentrations of iron (Fe), manganese (Mn) and aluminum (Al). The major source of acidity is oxidation of pyrite in broken rock exposed by mining. Pyrite oxidation can be rapid upon exposure to humid air or aerated water, particularly above the water table (Rose and Cravotta, 1998). The process by which pyrite is oxidized is as follows (Stumm and Morgan, 1996):

$$FeS_2 + 7/2\ O_2 + H_2O \rightarrow Fe^{2+} + SO_4^{2-} + H^+$$

Together these ($2SO_4^{-2} + 2H^+$) form sulfuric acid, $H_2SO_4$. The ferrous iron is then oxidized producing ferric iron.

$$2\ Fe^{2+} + 1/2O_2 + 2\ H^+ \rightarrow 2\ Fe^{3+} + H_2O$$

Dissolved ferric iron may further oxidize pyrite, which releases hydrogen ions and ferrous iron.

$$FeS_2 + 14\ Fe^{3+} + 8\ H_20 \rightarrow 15\ Fe^{2+} + 2\ SO_4^{2-} + 16\ H^+$$

Next, through hydrolysis, the ferric iron ($Fe^{3+}$) produces an insoluble ferric hydroxide precipitate and releases additional hydrogen ions.

$$Fe^{3+} + 3\ H_2O \rightarrow Fe(OH)_3 + 3H^+$$

The hydrogen ions released by this reaction cause the water to become acidic and decrease pH.

## AMD Impacts on Stream Health

A few fish species that could potentially populate Monday Creek can tolerate pH levels as low as 5 (Katz, 1969). However, for reproductive purposes, a pH of between 6.5 and 9 is desirable. When AMD discharges into streams it lowers the pH of the water, often making it corrosive and unsuitable for aquatic life. Iron, aluminum, and manganese are the most common heavy metals which can compound the adverse effects of mine drainage. Heavy metals are generally less toxic at circumneutral pH (Earle and Callaghan, 1998). Ferric and aluminum hydroxides decrease oxygen availability as they form; the precipitate may coat gills and body surfaces, smother eggs, and cover the stream bottom, filling in crevices in rocks, and making the substrate unstable and unfit for habitation by benthic organisms (Hoehn and Sizemore, 1977). Iron concentrations greater than 1 mg/l and aluminum concentrations exceeding 0.5 mg/L can become toxic to fish.

Table 1: Effects of AMD on Stream Systems

| Major Effects of AMD on Stream Systems (Modified from Gray, 1997) | | | |
|---|---|---|---|
| Chemical | Physical | Biological | Ecological |
| Increased Acidity<br><br>Reduction of pH<br><br>Reduction of buffering capacity<br><br>Increase in metal concentrations | Substrate modification<br><br>Turbidity<br><br>Sedimentation<br><br>Absorption of metal into sediment<br><br>Decrease in light penetration | Behavioral<br><br>Respiratory<br><br>Reproduction<br><br>Acute and chronic toxicity<br><br>Acid-base balance in organisms<br><br>Migration or avoidance | Habitat modification<br><br>Niche loss<br><br>Loss of food source<br><br>Elimination of sensitive species<br><br>Reduction in primary productivity<br><br>Food chain modifications |

## Water Quality Standards

Ohio Water Quality Standards, developed by Ohio EPA, do not specifically address chemical parameters for AMD-impacted waters (i.e. specific conductivity, metals, sulfates, etc). Currently, U.S. EPA Water Quality Standards address only two AMD parameters: pH (6.5 to 9 s.u.) and Total Dissolved Solids (TDS) (1,500 mg/l). However, criteria indicating AMD impacts were published in the Federal Water Pollution Control Act (FWPCA) in 1968.

Table 2: FWPCA - Water Quality criteria limits

| Water Quality criteria limits suggesting AMD impacts (FWPCA, 1968) | |
|---|---|
| Parameter | Criteria Limit |
| pH | < 6 |
| Alkalinity | < 20 mg/l |
| Sulfate | >74 mg/l |
| Conductivity | > 800 uS/cm |
| Iron | > 0.5 mg/l |
| Manganese | > 0.5 mg/l |
| Aluminum | > 0.3 mg/l |
| Zinc | > 5 mg/l |

Besides criteria limits that show the presence of AMD, criteria limits exist for the effects of heavy metals associated with AMD on aquatic life. These criteria limits (see table below) are based on literary research and suggest that once parameters reach the limit, aquatic life will be affected. Aquatic species are affected by contaminates in various ways, so criteria limits do not suggest that all aquatic life will be affected, but that some species will be negatively affected (McCament, 2003).

Table 3: Ohio, USEPA, guidelines for analysis of mine drainage systems (Ohio EPA, 1979)

| Parameter | Limit |
|---|---|
| Iron- total (mg/l) | 1.0 |
| Aluminum (mg/l) | 0.5 |
| Manganese (mg/l) | 0.1 |

In order to ascertain the health of the Monday Creek stream system, Ohio EPA evaluated the diversity of biologic communities, habitat integrity, and water chemistry data by performing a Total Maximum Daily Load (TMDL) study in the Monday Creek Watershed in 2001. The data collected was utilized to determine the appropriate "aquatic life use designation" of Monday Creek and its tributaries. To determine a stream use designation, biologic and water quality sampling is conducted. Stream features are evaluated and metric scores are recorded for four indices. The Qualitative Habitat Evaluation Index (QHEI) evaluates habitat quality, such as stream substrate and riparian cover. The measure of fish species diversity and populations are recorded as Index of Biologic Integrity (IBI) and Modified Index of Well Being (Miwb) indices. The measure of macro-invertebrate populations are recorded as Invertebrate Community Index (ICI). The presence of pollution tolerant species and the absence of sensitive species give indications of stream health.

When these indices are coupled with water quality data, Ohio EPA can identify stressors to the stream system. Index scores will determine a stream's use designation.

Ohio is divided into five eco-regions due to the difference in topography, land use, vegetative cover and soil types, which vary significantly across the state. Monday Creek Watershed is located in the Western Allegheny Plateau (WAP) and is more diverse biologically than most other eco-regions in Ohio. There are four use designations which potentially apply to the Monday Creek Watershed:

- Exceptional Warmwater Habitat (EWH) – "These are waters capable of supporting and maintaining an exceptional or unusual community of warm water aquatic organisms having a species composition, diversity, and functional organization comparable to the seventy-fifth percentile of the identified reference sites on a statewide basis" (Ohio Environmental Protection Agency, 2002a).

- Warmwater Habitat (WWH) – "These are waters capable of supporting and maintaining a balanced, integrated, adaptive community of warm water aquatic organisms having a species composition, diversity, and functional organization comparable to the twenty-fifth percentile of the identified reference sites within each of the ecoregions" (Ohio Environmental Protection Agency, 2002a).

- Modified Warmwater Habitat (MWH) –"These are waters that have been the subject of a use attainability analysis and have been found to be incapable of supporting and maintaining a balanced, integrated, adaptive community of warm water organisms due to irretrievable modifications of the physical habitat. Such modifications are of a long-lasting duration (i.e., twenty years or longer) and may include the following examples: extensive stream channel modification activities, extensive sedimentation resulting from abandoned mine land runoff, and extensive permanent impoundment of free-flowing water bodies" (Ohio Environmental Protection Agency, 2002a).

- Limited Resource Water – Acid Mine Drainage (LRW-AMD) – "These are surface waters with sustained pH values below 4.1 s.u. or with intermittently acidic conditions combined with severe streambed siltation, and have a demonstrated biological performance below that of the modified warm water habitat biological criteria" (Ohio Environmental Protection Agency, 2002a).

Table 4: Biocriteria for streams in the Allegheny Plateau region

| WAP – Use Designation | ICI | IBI | QHEI | $MI_{wb}$ |
|---|---|---|---|---|
| EWH | 46+ | 50+ | 75+ | 9.4 |
| WWH | 36-45 | 44-49 | 60-74 | 8.4 |
| MWH | 31-35 | 25-43 | 45-59 | 6.2/5.5 |
| LRW | <31 | 12-24 | <45 | 4.5 |

## Biologic Health of the Watershed

The current aquatic use designation for Monday Creek is Limited Resource Water due to acid mine drainage (LRW–AMD). The suitability of this designation was verified by the 2001 TMDL study, performed by OEPA. As part of the 2001 TMDL study, chemical, biological, and physical data were collected in 77.6 linear stream miles of the Monday Creek Watershed. The study area included a total of 92 sampling stations overall, with 13 stations located in Monday Creek, four stations in Snow Fork, and six stations in Little Monday Creek. The remaining sites were located in tributaries geographically dispersed throughout the watershed (Refer to Map 3). This data provided valuable information regarding the severity of impact of AMD contamination within the watershed. TMDL data (water chemistry, macro-invertebrate taxa, and fish species) collected within the watershed are included in Appendix D on the CD. The following is a summary of the 2001 TMDL results.

Table 5: TMDL Biologic Index Scores for selected tributaries

| Stream | River Mile Fish / Macro. | IBI | ICI Qualitative | ICI Quantitative | QHEI | Attainment Status | Use Designation | Year |
|---|---|---|---|---|---|---|---|---|
| Monday Creek | 26.5 | 12 | Very Poor | 1 | 64 | Non | LRW | 2001 |
| Monday Creek | 25.3 | 12 | Very Poor | 1 | 52.5 | Non | LRW | 2001 |
| Monday Creek | 24 / 24.2 | 20 | Poor | 12 | 77.5 | Full | LRW | 2001 |
| Monday Creek | 23.1 / 23.4 | 16 | Poor | 12 | 74.5 | Non | LRW | 2001 |
| Monday Creek | 19.8 / 19.7 | 22 | - | 34 | 65 | Full | LRW | 2001 |
| Monday Creek | 18.5 | 18 | - | 26 | 81.5 | Non | LRW | 2001 |
| Monday Creek | 15.8 / 16 | 18 | - | 14 | 61.5 | Non | LRW | 2001 |
| Monday Creek | 14.3 | 23 | Fair | 4 | 54 | Full | LRW | 2001 |
| Monday Creek | 10.5 | 29 | - | 28 | 62 | Full | LRW | 2001 |
| Monday Creek | 9.3 | 22 | - | 18 | 63 | Full | LRW | 2001 |
| Monday Creek | 4.3 | 21 | - | 24 | 66 | Non | LRW | 2001 |
| Monday Creek | 3 | 13 | Poor | 12 | 73.5 | Non | LRW | 2001 |
| Monday Creek | 1.7 | 14 | - | 12 | 54.5 | Non | LRW | 2001 |
| Monday Creek | 0.7 | 12 | - | 16 | 68.5 | Non | LRW | 2001 |
| Snow Fork | 6.2 | 12 | Very Poor | 1 | 43 | Non | LRW | 2001 |
| Snow Fork | 4.5 / 4.3 | 12 | Very Poor | 1 | 64.5 | Non | LRW | 2001 |
| Snow Fork | 2.4 | 12 | Very Poor | 1 | 58.5 | Non | LRW | 2001 |
| Snow Fork | 1 | 12 | - | 6 | 57.5 | Non | LRW | 2001 |
| Little Monday | 13.7 / 13.6 | 42 | Marginally Good | 32 | 73 | Full | WWH | 2001 |
| Little Monday | 11.1 | 42 | Marginally Good | 32 | 79 | Full | WWH | 2001 |
| Little Monday | 9.5 / 9.6 | 44 | Good | 36 | 64.5 | Full | WWH | 2001 |
| Little Monday | 6.9 | 32 | Good | 36 | 69 | Partial | WWH | 2001 |
| Little Monday | 3.3 / 3.8 | 34 | - | 56 | 62.5 | Partial | WWH | 2001 |
| Little Monday | 0.1 | 36 | Marginally Good | 32 | 56.5 | Partial | WWH | 2001 |

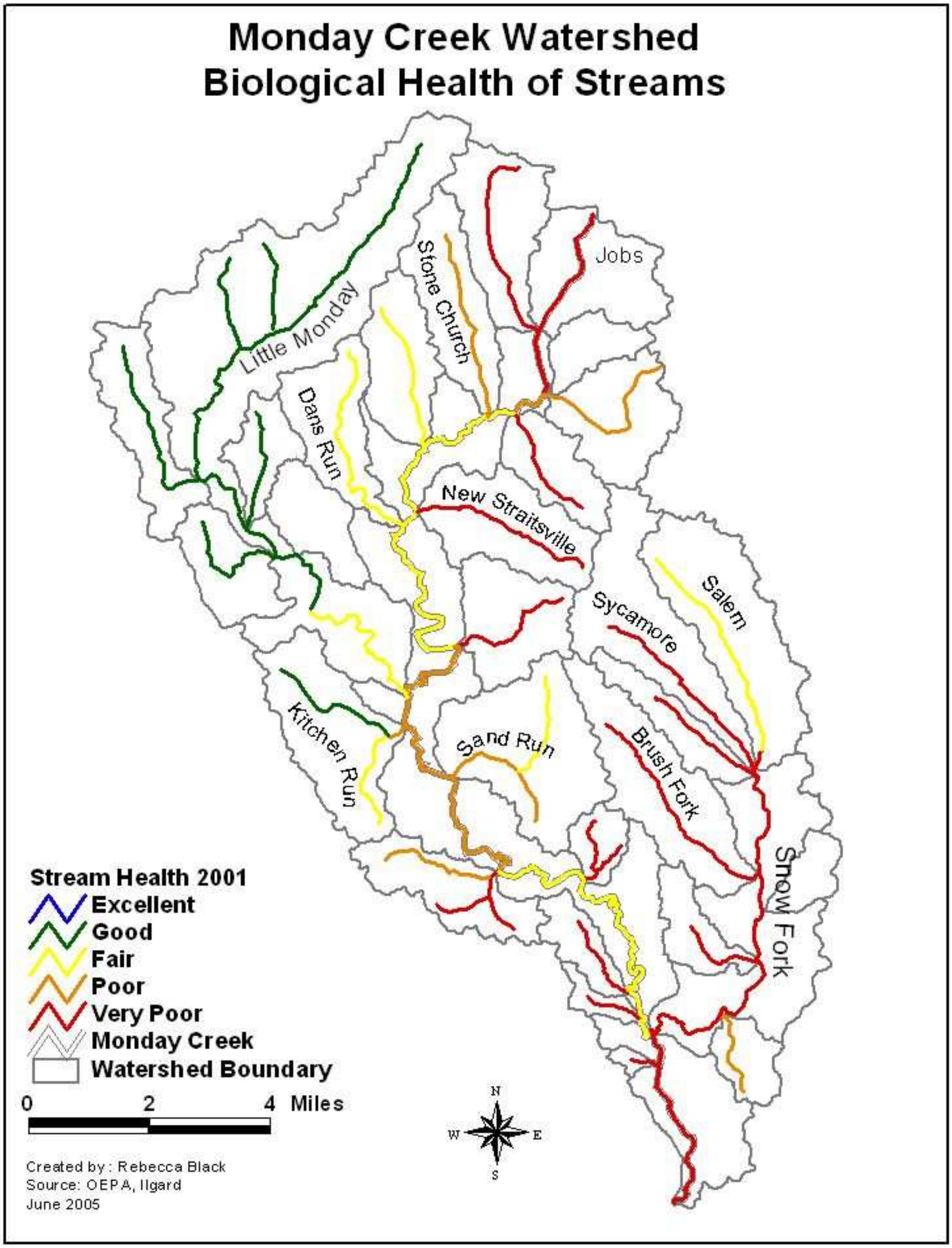


Figure 1: Stream Health - Fall 2001

Three major drainage areas make up the Monday Creek Watershed; Monday Creek, Snow Fork, and Little Monday Creek. The following section briefly describes the chemical and biological health of these areas. The areas are largely characterized by the long-term monitoring (LTM) locations (Refer to Map 1 and 4).

## Monday Creek

(Drainage Area 116 $mi^2$, Length 27 miles) The headwaters of Monday Creek (Jobs Hollow – LTM 148 at RM 26.5) are severely degraded with high acidity, elevated metal concentrations and low pH values. This section of stream received an IBI score of 12 (lowest score possible), and an ICI score of "Very Poor". This trend continues downstream for approximately three river miles to a point where marginally-impacted tributaries begin to join with Monday Creek and dilute acid and metal concentrations. In this stream segment, biological scores and pH values begin to increase. At River Mile 16 (Lost Run – LTM 131), a severely impacted tributary joins with Monday Creek and pH and biological scores again decline. Further downstream, Monday Creek is joined by Little Monday Creek and other tributaries, resulting in biological scores and pH being modestly improved. At River Mile 10.5, scores begin a slow decline until Monday Creek is joined by Snow Fork tributary. At River Mile 3.45, where Snow Fork discharges into Monday Creek, biological scores and pH values decline dramatically, with an IBI score of 13 and ICI score of "Poor". This trend continues to the mouth of Monday Creek where it joins with the Hocking River.

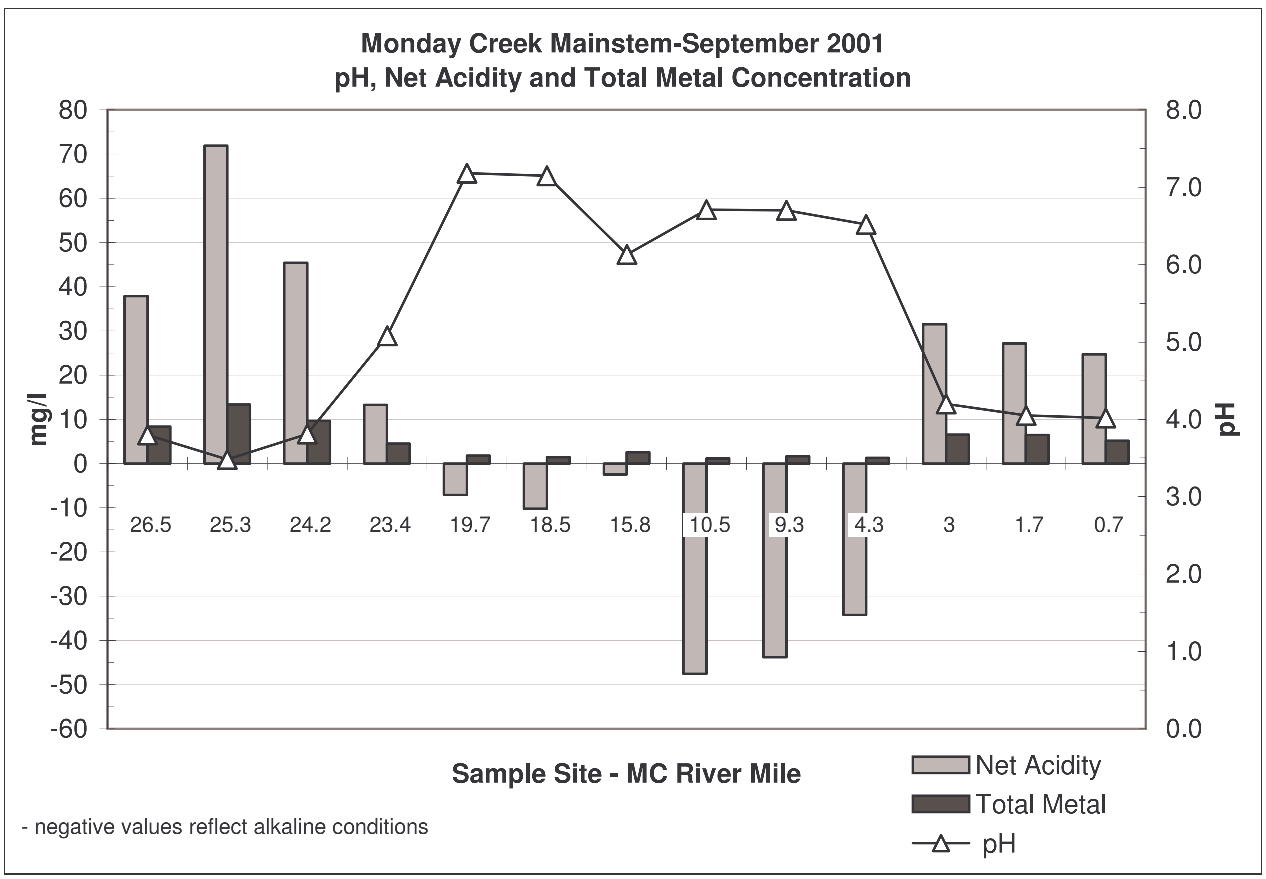


Figure 2: Monday Creek pH, Net Acidity/Alkalinity and Total Metal Concentration- Fall 2001

Biologic scores and water chemistry in the Monday Creek mainstem vary somewhat with geographic location and stream reach. However, QHEI scores remain relatively stable throughout, indicating that suitable physical habitat exists for fish and invertebrate communities, if acid mine drainage impacts could be reduced. The entire length of Monday Creek was found impaired due to acidification, low pH, dissolved solids, and sedimentation associated with mine drainage. Conditions were uniformly degraded, as poor to very poor aquatic communities were commonly observed. The extent and magnitude of the impacts to both chemical water quality and the resident biota were indicative of severe systemic mine drainage problems (Boucher, 2005).

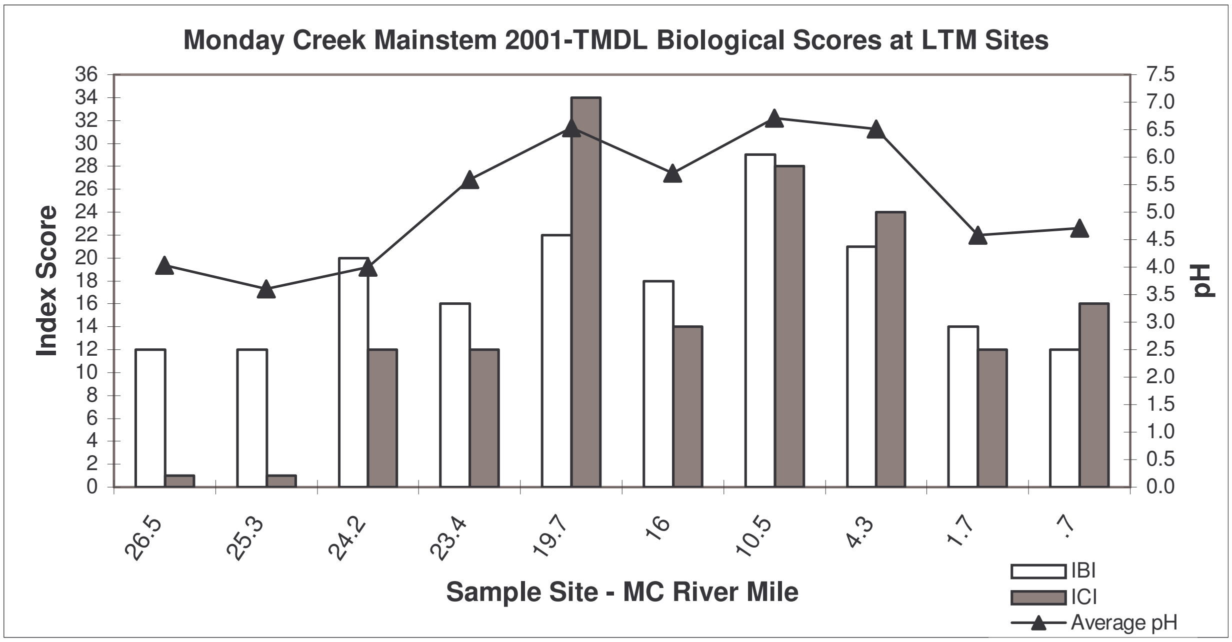


Figure 3: Monday Creek Biological index scores

## Snow Fork

(Drainage Area 27 $mi^2$, 10.7 miles) Snow Fork tributary is located in the eastern portion of the watershed and is currently designated as Limited Resource Water (LRW). Coal mining occurred throughout the Snow Fork basin resulting in approximately 9,000 acres of underground mines beneath the Snow Fork drainage and adjacent sub-watersheds. These sub-watersheds, discharge into Snow Fork mainstem, and include Sycamore Hollow, Spencer Hollow, Salem Hollow, Brush Fork, Goose Run, Long Hollow and Whitmore Hollow. At low flow conditions, Snow Fork discharges 28 percent of the flow and can account for approximately 40 percent of the acid load in Monday Creek. At high flow conditions, Snow Fork discharges 28 percent of the flow and can account for approximately 60 percent of the acid load in Monday Creek (Shimala and Borch, 1999).

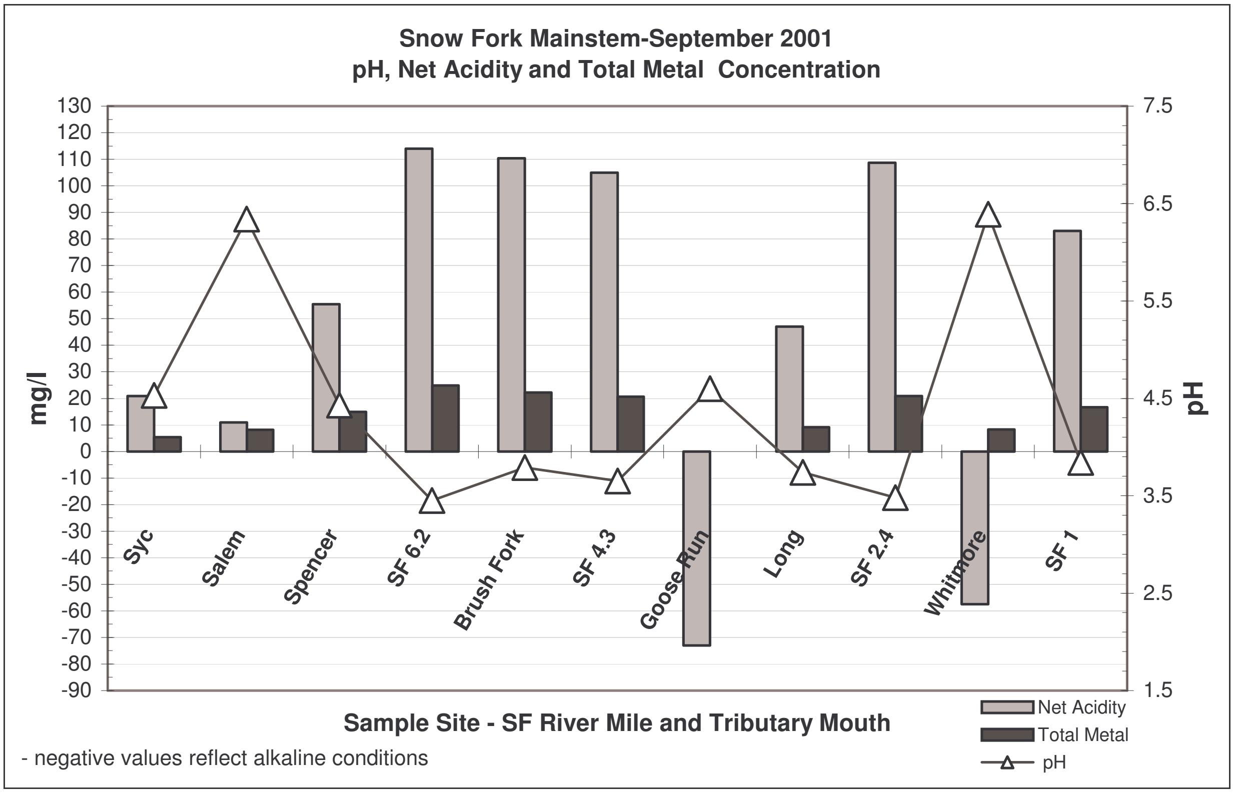


Figure 4: Snow Fork pH, Net Acidity/Alkalinity and Total Metal Concentration- Fall 2001

Sycamore Hollow (Middle Fork) is located in the upper reaches of the Snow Fork tributary. A TMDL sampling station located at the mouth of Sycamore Hollow, RM 0.1, received an IBI score of 12 and an ICI score of “Very Poor”. This is due to a deep mine discharge (Essex Mine), located in an unnamed tributary of Middle Fork. The Essex Mine discharges an average of 1500 gallons per minute (gpm) of contaminated mine water into Middle Fork. Sycamore, Salem (marginally impaired) and Spencer Hollow (severely impaired), come together to form Snow Fork. A TMDL sampling station located downstream of these sub-watersheds, at RM 6.2 in Snow Fork, received an IBI score of 12 and an ICI score of “Very Poor”. Due to the volume of AMD discharging into Snow Fork, these scores remain relatively unchanged to RM 1.0.

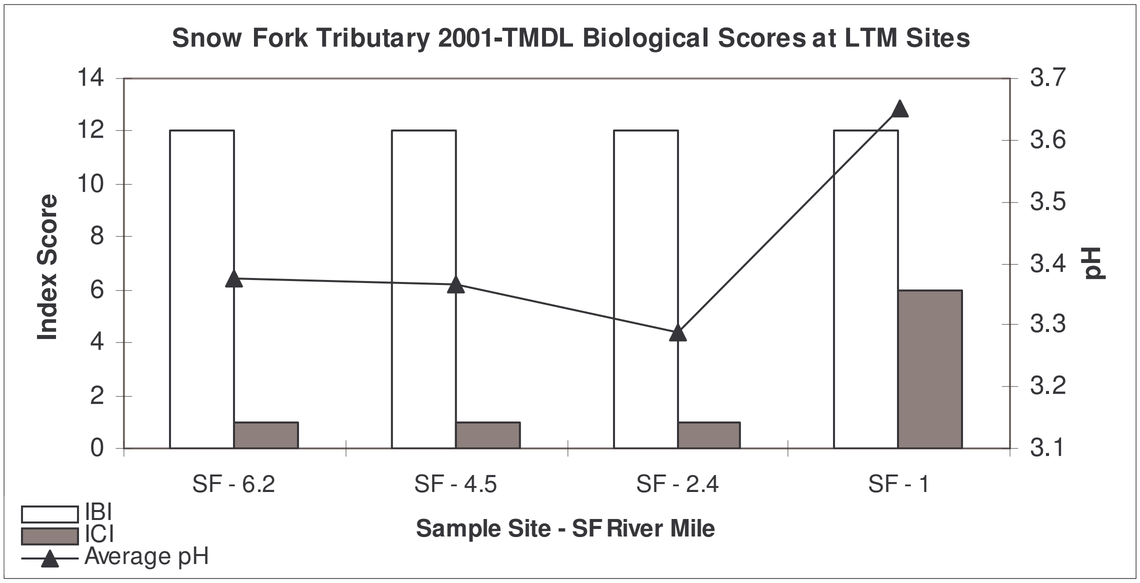


Figure 5: Biological index scores in Snow Fork – Fall 2001

Snow Fork and nearly all its tributaries evaluated in 2001, were profoundly and systematically impaired. Community performance was typically in the poor to very poor range. Acutely toxic conditions, evidenced by the absence of fish, were indicated for Brush Fork, Long Hollow, and selected Snow Fork sampling stations. Water quality throughout these streams was equally degraded. Mine drainage was identified as the source of impairment (Boucher, 2005).

## Little Monday Creek

(Drainage Area 24.5 $mi^2$, Length 14.3 miles) Little Monday Creek is located in the western portion of the watershed. It is the largest of the Monday Creek sub-watersheds and is currently designated as Warmwater Habitat (WWH). Coal mining occurred in the lower section of the drainage, with a total of three documented underground mines, encompassing only 130 acres. The upper reaches of Little Monday Creek are in full attainment of WWH.

Owing to the geology of the sub-basin (limestone and paucity of coal bearing formations), the Little Monday Creek Watershed represents the only true refugium within the greater Monday Creek Basin. Free from significant sources of AMD, nearly half of the Little Monday Creek mainstem and four of the five tributaries fully met WWH biocriteria. Areas of impairment were limited to the lower 6.8 miles of the mainstem and one unnamed tributary. Although impacted, community performance remained largely in the fair range. Departures from the WWH biocriteria were associated with moderate AMD (Boucher, 2005).

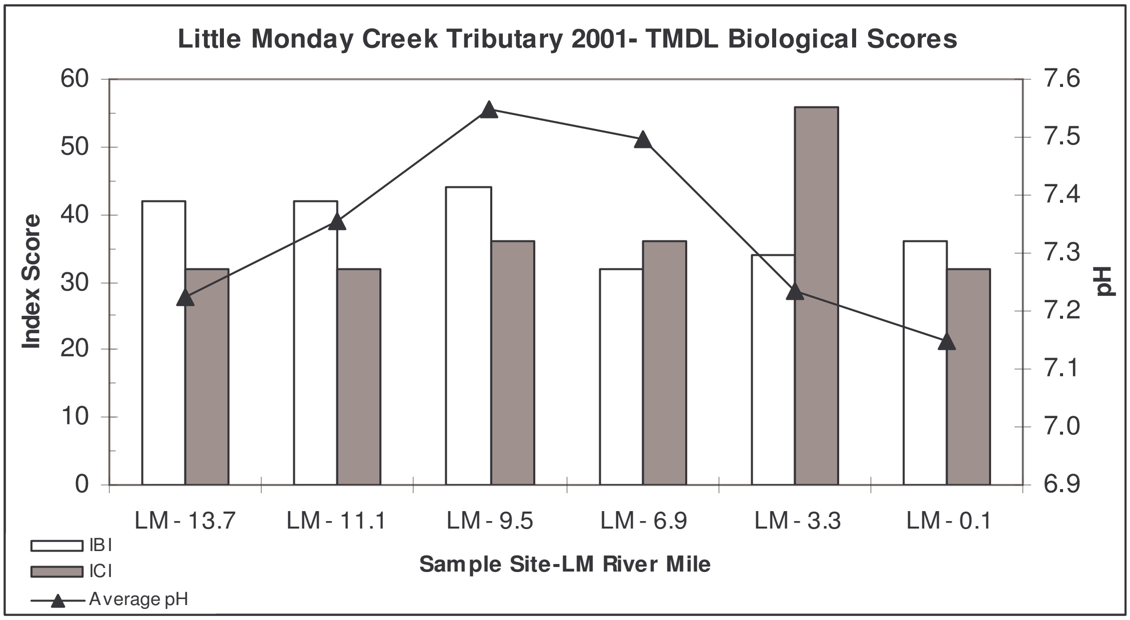


Figure 6: Biological index scores in Little Monday Creek – Fall 2001

## Historical Water Quality

The Monday Creek Restoration Project was formed in 1994. At that time, intensive efforts were made to compile historic data pertaining to water quality. Sources of historic data included the Ohio EPA, U.S. Geologic Survey, U.S. Forest Service, U.S. Bureau of Mines and Ohio University. Other sources of data included the following: a master's thesis by Hartke (1974) in which water quality parameters of Monday Creek and Little Monday Creek were sampled; USGS data (Sedam and Francy, 1993); and EPA data collected in winter 1982 (STORET). Ohio University students have also collected data within the watershed and it includes: Burling, 1996; Updyke, 1996; Worsley, 1996; Bullock, 1996; Pigati, 1997; Oberly, 1997; Stachler, 1997; Raymond, 1998; Carroll, 1999; and Clinton, 2004.

A 1985 USDA study states that the Monday Creek Watershed ranks 11th in severity for environmental damage among the 30 most severely impacted watersheds in southeast Ohio. Monday Creek Watershed also ranks 21st in total erosion, 20th in sediment damage, 9th in loss of useful land, 3rd in impact of mine drainage pollution (44% of total stream miles are polluted by acid, iron, manganese and sulfate), 6th in physical pollution by sediment, 8th in surface mine acreage (3,172 acres) and 3rd in underground mine acreage (14,797 acres).

In 1997, MCRP initiated a long-term monitoring program at ten sites in Monday Creek and the Snow Fork tributary. (Refer to Map 4) Water quality samples and flow data were collected quarterly at the sites for a period of five years, and monitoring continues on a semi-annual basis. From 1997 to the present, MCRP has worked to quantify acid and metal contributions by sub-watershed and to identify individual sites contributing AMD to Monday Creek and its tributaries.

Table 6: Long-term Monitoring Locations in Monday Creek and Snow Fork

| River Mile | Site Name | Map Id | Location |
|---|---|---|---|
| 26.5 | LTM 148 | JH00500 | Monday Creek-Downstream Jobs Hollow/upstream Dixie Hollow |
| 23.1 | LTM 127 | MC00800 | Monday Creek-Downstream Rock Run |
| 19.8 | LTM 103 | MC00580 | Monday Creek-@ Monday Cr. Junction, downstream Dans Run |
| 16 | LTM 131 | MC00500 | Monday Creek- Downstream Lost Run, Adj. SR 595 |
| 10.5 | LTM 153 | MC00300 | Monday Creek- Upstream Monkey Hollow, SR 278 |
| 9.3 | LTM 154 | MC00280 | Monday Creek- Downstream Monkey Hollow, Carbon Hill Buchtel Road (New Site - 2005) |
| 4.3 | LTM 151 | MC00180 | Monday Creek- Woodlane Drive, Buchtel |
| 1.7 | LTM 108 | MC00060 | Monday Creek- Doanville at USGS gage station |
| 6.2 | LTM 106 | SF00940 | Snow Fork- Bridge downstream Murray City Seeps, SR 216 |
| 4.3 | LTM 107 | SF00630 | Snow Fork- Downstream Brush Fork, upstream Goose Run, SR 78 |
| 2.4 | LTM 109 | SF00290 | Snow Fork- Snow Fork at Buchtel gage station, SR 685 |

In October 2000, a mass sampling was performed in the Monday Creek Watershed. Tributary mouths and AMD seeps discharging into Monday Creek and Snow Fork were sampled in an attempt to quantify acid contribution at base flow conditions. Water quality samples, along with flow measures, were collected at each sample site. Based on this sampling event, "priority sub-watersheds" were identified based on percentage of acid contribution. At base flow conditions, discharge quantities are generally less, however pollutants are more heavily concentrated. Loading quantities are determined by multiplying flow times concentration and converting to a weight (pounds, kilograms, etc.). While, loadings will fluctuate with seasonal variation (i.e. dilution, flow rates, etc.) priority ranking of watersheds by percentage is sufficient to identify the major sources of impairment in the watershed and provide guidance for assessing benefit and value of future projects.

The table below identifies each of the 31 sub-watersheds in the Monday Creek drainage basin. Sub-watersheds are grouped by the main tributary into which they discharge. Statistics are listed for each sub-watershed, major tributary and the entire Monday Creek basin.

Table 7: Sub-watershed Drainage Area, Calculated Mean Annual Flow and Ownership

| Sub-watershed | Drains (acres) | Mean Annual Flow (cfs) | Mean Annual Flow (gpm) | USFS Ownership 2002 (acres) | % Owned by USFS |
|---|---|---|---|---|---|
| LITTLE MONDAY CREEK SUB-1 | 10,637 | 16.8 | 7,534 | 1522 | 14 |
| FELLOWSHIP / UNNAMED 3 | 1,414 | 2.2 | 1,001 | 0 | 0 |
| GORE/ UNNAMED 5 | 1,227 | 1.9 | 869 | 366 | 30 |
| TEMPERANCE HOLLOW | 1,886 | 3.0 | 1,336 | 40 | 2 |
| T-403/ UNNAMED 4 | 955 | 1.5 | 676 | 150 | 16 |
| **Little Monday Creek Total** | **16,118** | **25.4** | **11,417** | **2,078** | **18** |
| SNOW FORK SUB-1 | 4,407 | 7.0 | 3,121 | 1,952 | 44 |
| BRUSH FORK | 3,022 | 4.8 | 2,140 | 300 | 10 |
| GOOSE RUN | 628 | 1.0 | 445 | 47 | 7 |
| LONG HOLLOW | 929 | 1.5 | 658 | 661 | 71 |
| SALEM HOLLOW | 3,481 | 5.5 | 2,466 | 843 | 24 |
| SPENCER HOLLOW | 1,063 | 1.7 | 753 | 15 | 1 |
| SYCAMORE HOLLOW | 3,154 | 5.0 | 2,234 | 1,800 | 57 |
| WHITMORE / UNNAMED 1 | 775 | 1.2 | 549 | 450 | 58 |
| **Snow Fork Total** | **17,458** | **27.6** | **12,366** | **6,067** | **49** |
| MONDAY CREEK SUB-1 | 11,976 | 18.9 | 8,483 | 7,058 | 59 |
| BESSEMER HOLLOW | 330 | 0.5 | 234 | 226 | 69 |
| BIG 4 HOLLOW | 605 | 1.0 | 429 | 509 | 84 |
| COE HOLLOW | 131 | 0.2 | 93 | 124 | 94 |
| DANS RUN | 1,930 | 3.0 | 1,367 | 532 | 28 |
| DIXIE HOLLOW | 2,199 | 3.5 | 1,558 | 646 | 29 |
| IRONPOINT / UNNAMED 6 | 817 | 1.3 | 579 | 530 | 65 |
| JOBS HOLLOW | 2,267 | 3.6 | 1,606 | 822 | 36 |
| KITCHEN RUN | 2,867 | 4.5 | 2,030 | 175 | 6 |
| LOST RUN | 1,919 | 3.0 | 1,359 | 1,112 | 58 |
| MONKEY HOLLOW | 1,790 | 2.8 | 1,268 | 1,540 | 86 |
| NEW STRAITSVILLE / UNNAMED 2 | 2,397 | 3.8 | 1,698 | 1,507 | 63 |
| ROCK RUN | 1,283 | 2.0 | 909 | 1,122 | 87 |
| SALT RUN | 1,729 | 2.7 | 1,225 | 1,333 | 77 |
| SAND RUN | 3,555 | 5.6 | 2,518 | 1,992 | 56 |
| SHAWNEE CREEK | 2,036 | 3.2 | 1,442 | 1,131 | 56 |
| SNAKE HOLLOW | 781 | 1.2 | 553 | 781 | 100 |
| STONE CHURCH | 2,094 | 3.3 | 1,483 | 1,099 | 52 |
| **Monday Creek Total** | **74,285** | **117.2** | **52,617** | **22,239** | **42** |

*Mean Annual Flow calculated as 1.01 cfs per sq mile*

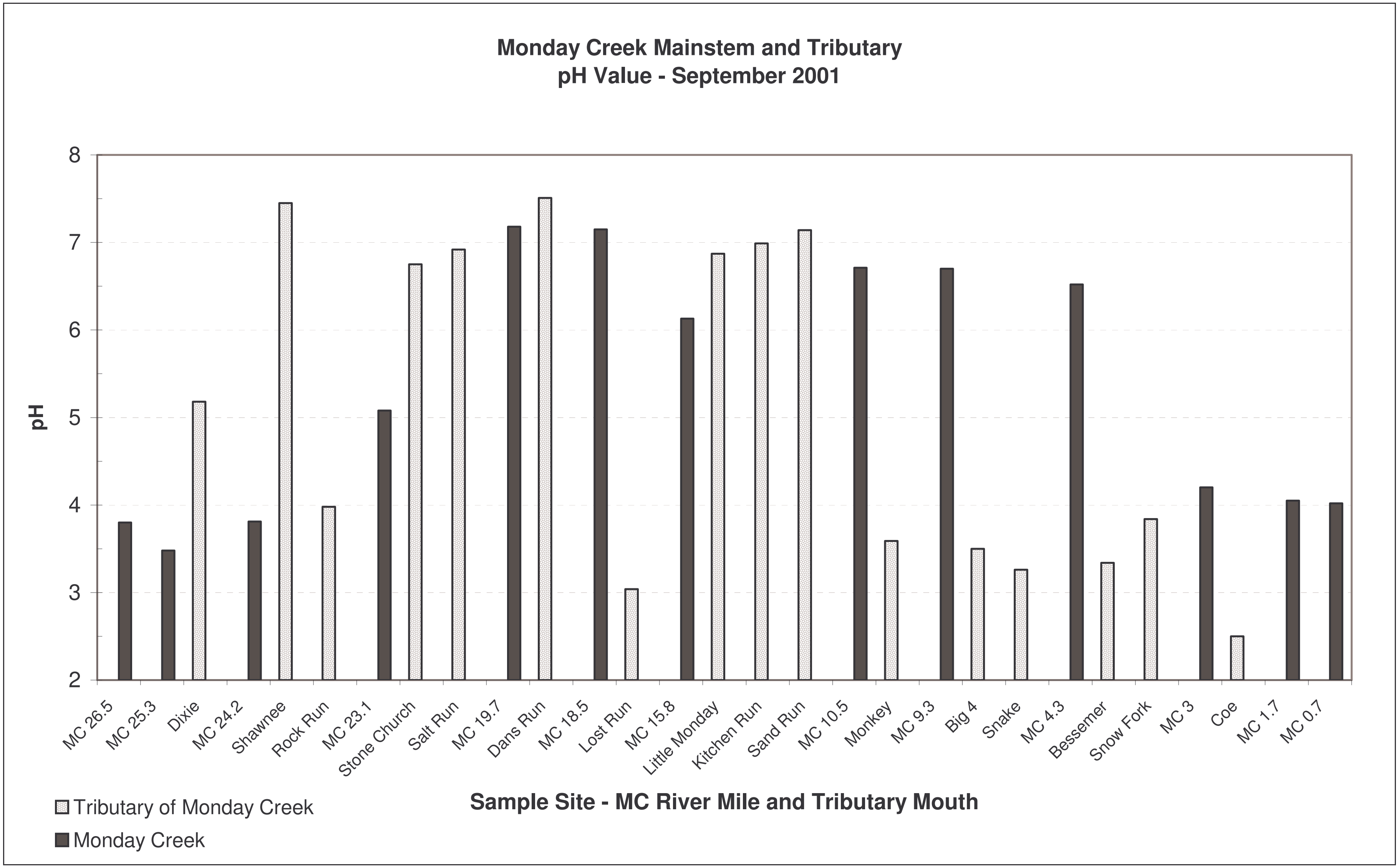


Figure 7: Monday Creek Mainstem and Tributary pH value - Fall 2001

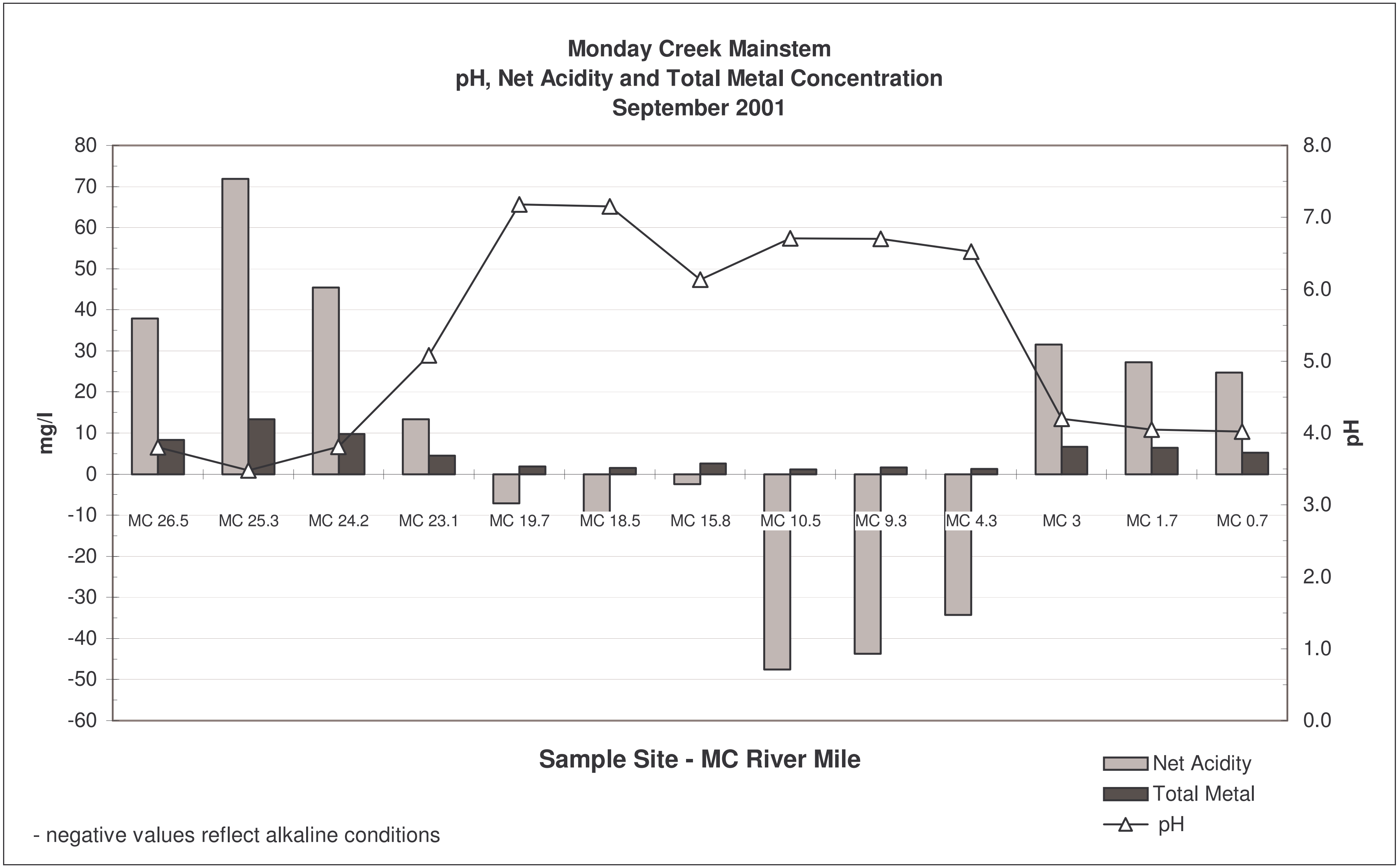


Figure 8: Monday Creek Net Acidity, Total Metal and pH

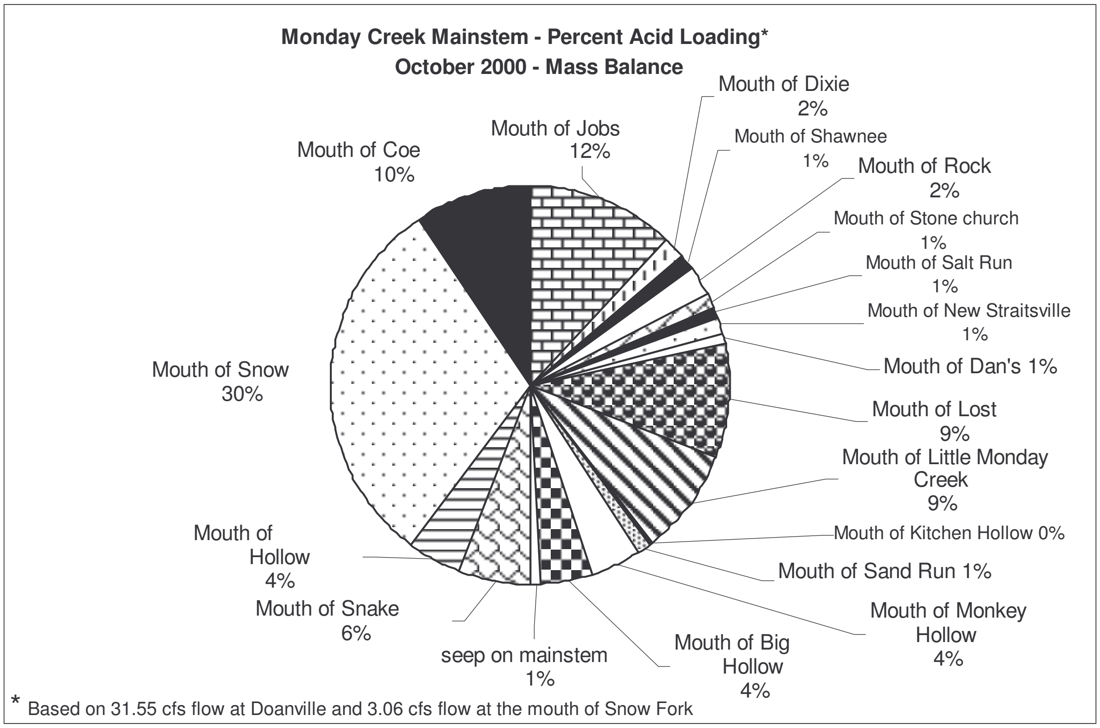


Figure 9: Acid contribution for Monday Creek – October 2000

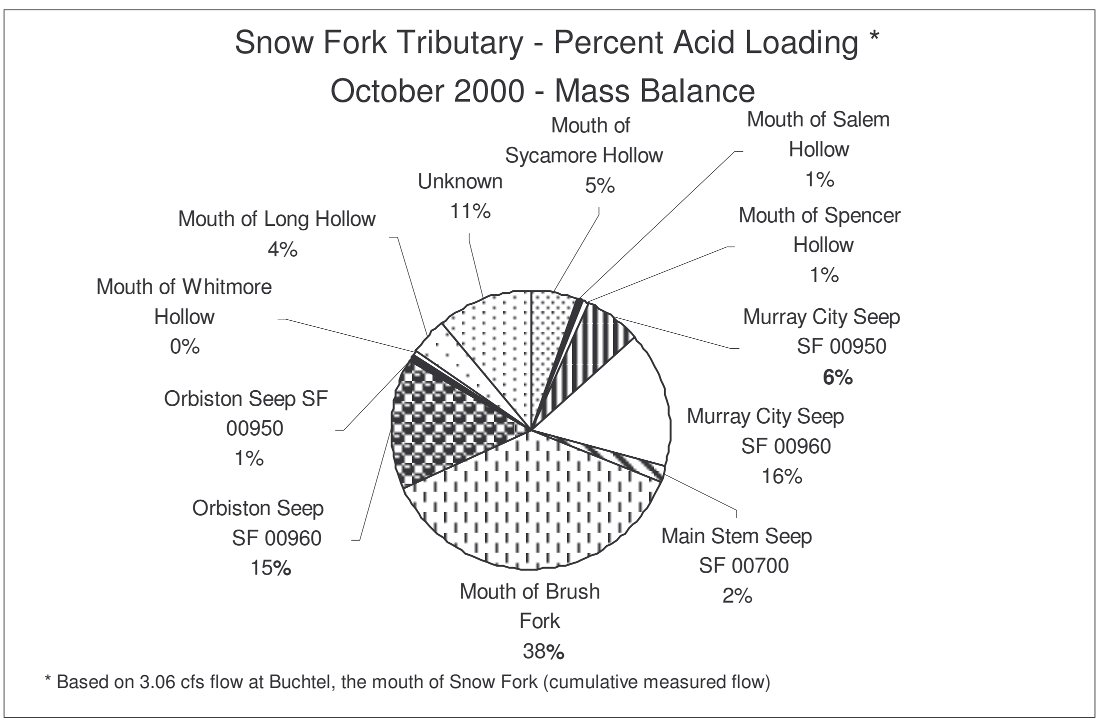


Figure 10: Acid contribution for Snow Fork – October 2000

## Critical Conditions

A study conducted by Cooper and Wagner (1973), recorded the distribution of fish in Pennsylvania streams impacted by AMD. Findings indicated that a pH value less than 4.5 and an acidity level greater than 15 mg/l accounted for a complete absence of fish in 90% of streams studied. Results of this study indicated that fish species were severely impacted at pH 4.5 to 5.5; ten species showed some tolerance to pH 5.5 or less; 38 species were found at pH 5.6 to 6.4; and 68 species were found only at pH greater than 6.4 (Earle and Callaghan, 1998).

### Monday Creek -Acidity and pH

At higher flow regimes, the acid concentrations in Monday Creek mainstem, RM 23.1 to 1.7 , generally exceed acid concentrations measured at low or base flows. This data suggests that at higher flows, deep mine discharges have a more severe impact on water quality than at low flows. Higher acidity concentrations and low pH values, resulting from deep mine flushing, impair the upper four miles (headwaters) and lower three miles of Monday Creek causing water quality conditions toxic to aquatic biology.

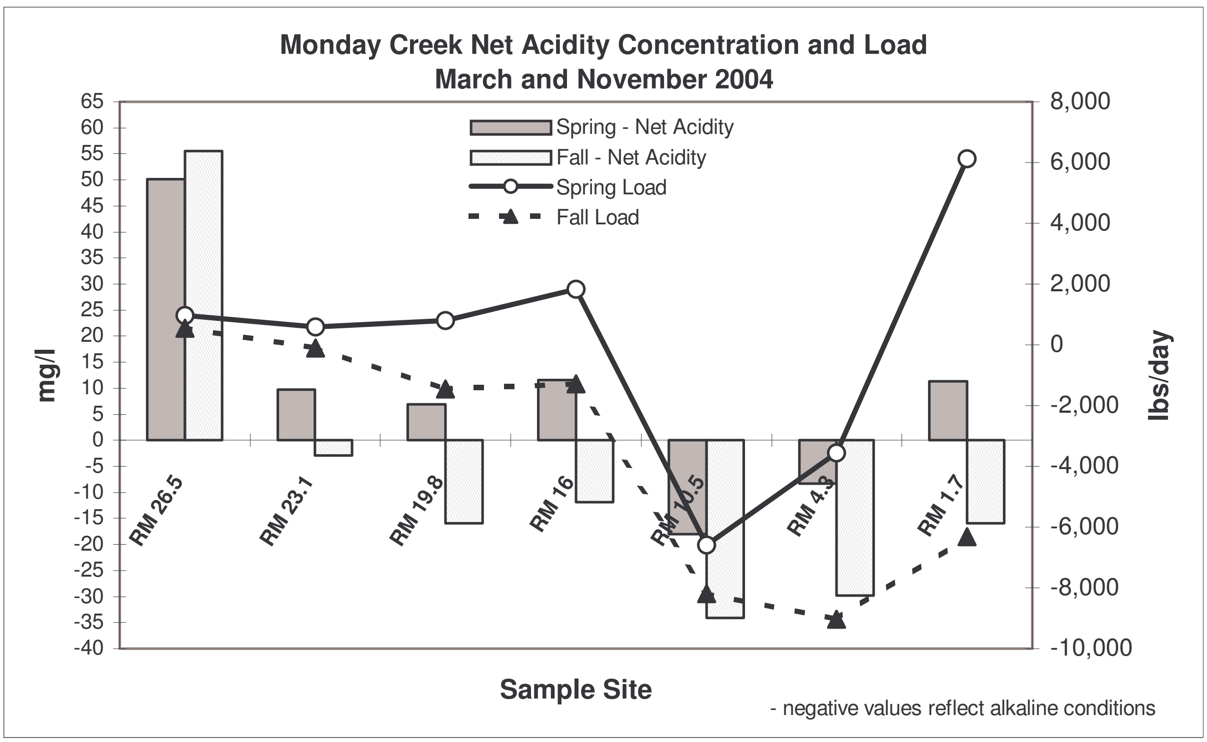


Figure 11: Net Acidity Concentration and Load in Monday Creek - 2004

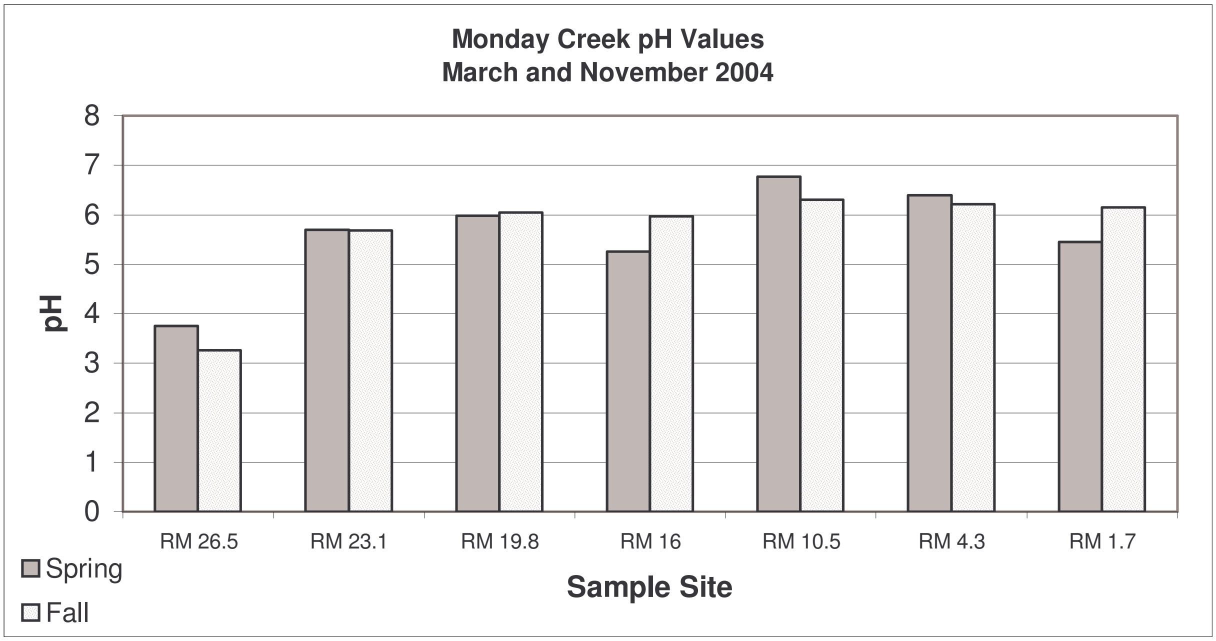


Figure 12: pH in Monday Creek – 2004

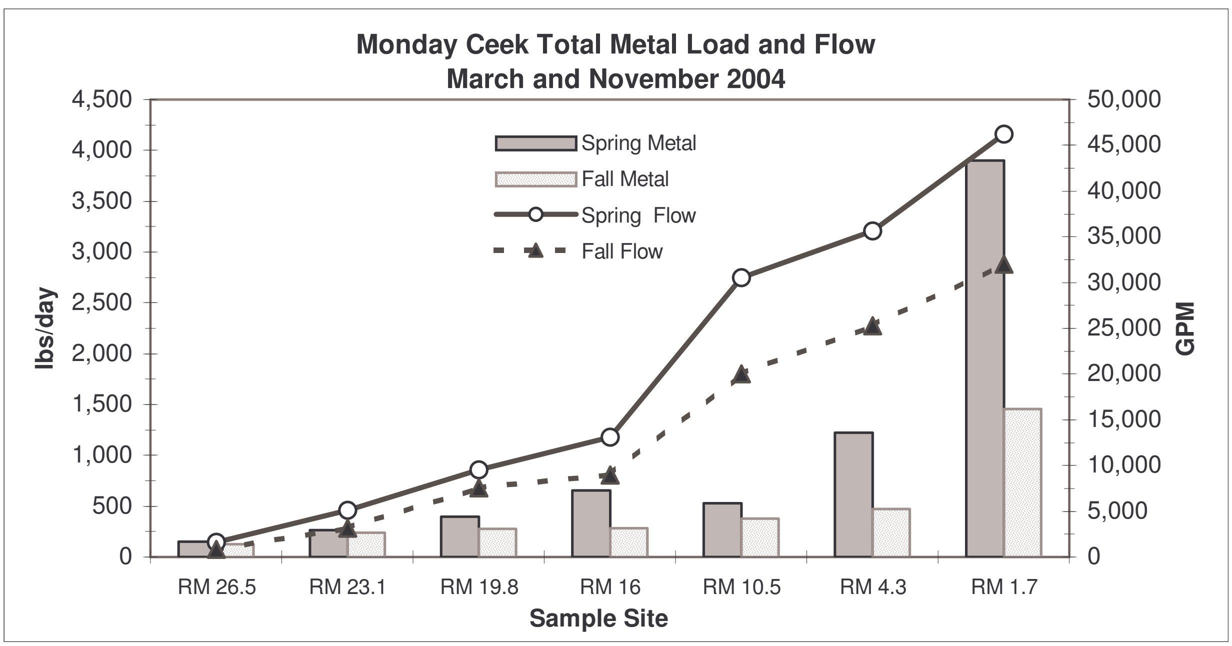


Figure 13: Total Metal and Flow in Monday Creek - 2004

**Snow Fork -Acidity and pH**

At higher flow regimes, the acid concentrations in Snow Fork tributary, RM 6.2 to 2.4 , exceed acid concentrations measured at low or base flows. However, from RM 4.3 to the mouth of Snow Fork, the variation in acidity concentrations fluctuate less than 10 mg/l. This data suggests that at both higher and lower flows, deep mine discharges have a devastating impact on water quality in the lower 4.2 miles of Snow Fork. High acidity concentrations and low pH values create water quality conditions acutely toxic to aquatic biology.

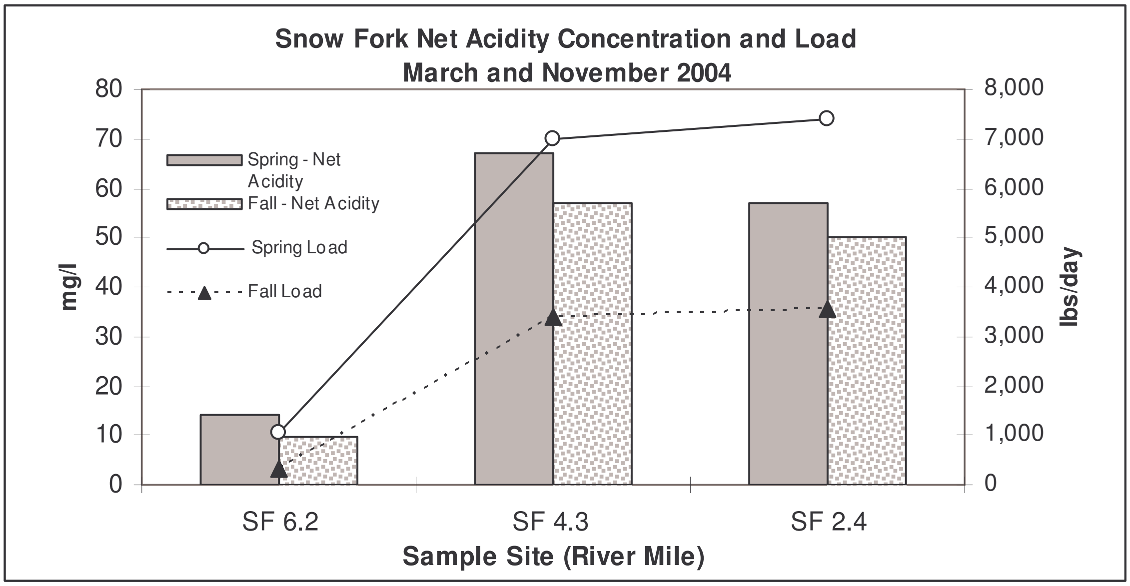


Figure 14: Net Acidity Concentration and Load in Snow Fork - 2004

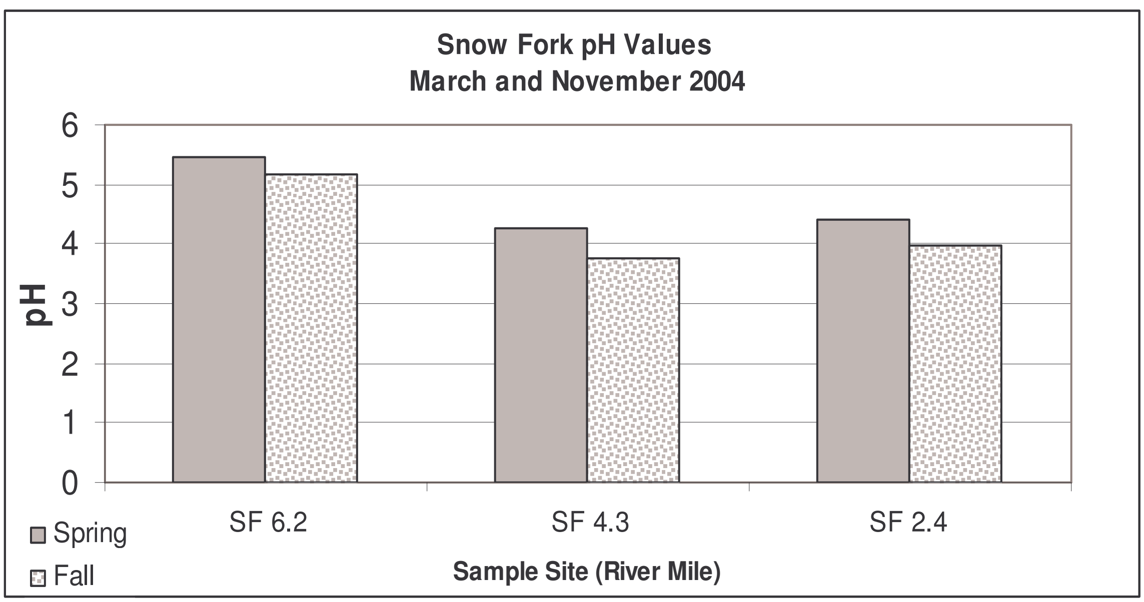


Figure 15: pH in Snow Fork - 2004

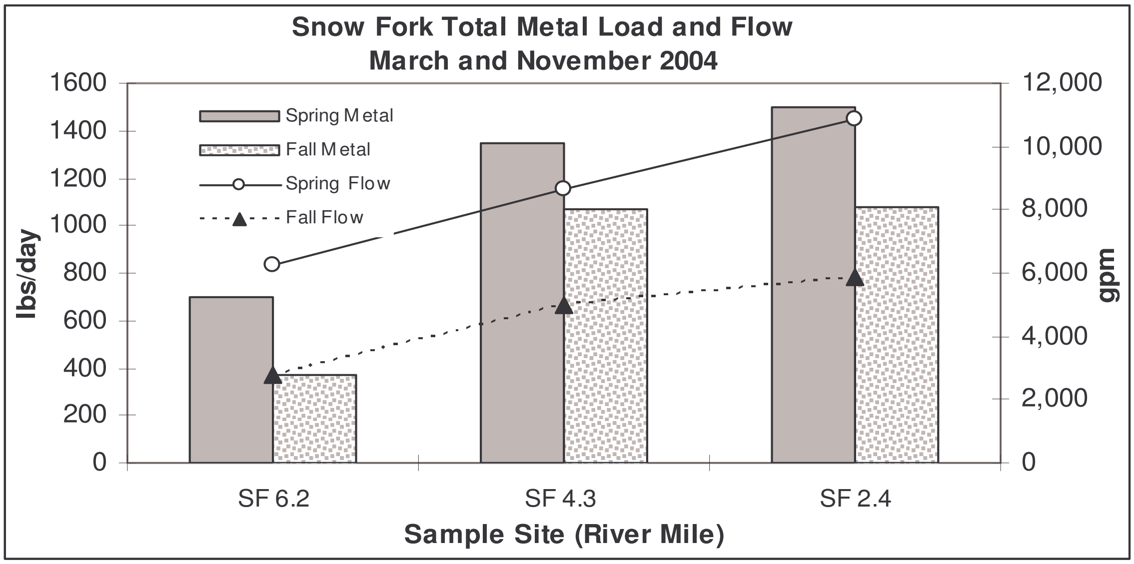


Figure 16: Total Metal and Flow in Snow Fork - 2004

## Water Quality Restoration Targets

The goal of the Monday Creek Restoration Project is to restore Monday Creek mainstem to Warmwater Habitat (WWH) use designation by constructing AMD remediation projects within the most severely impacted drainage basins in the watershed. To accomplish this goal, the Water Research Institute at West Virginia University (WVU) used the Total Acid Mine Drainage Loading Model (TAMDL) hydrological model to calculate the degree of remediation necessary and to design passive and active treatment structures for AMD-affected sub-watersheds. The computer program TAMDL was designed to simulate the evolution of stream water quality in watersheds affected by AMD and its treatment. The feasibility of the designed structures was tested by incorporating them into a Monday Creek model and comparing the simulated stream pH, aluminum, and iron remediation endpoints (Stiles and Ziemkiewicz, 2003).

Water quality data collected by MCRP, OEPA, and the USGS were provided to WVU - Water Research Institute and incorporated into the Total Acid Mine Drainage Loading Model (TAMDL) for use as baseline information or “observed data” which was utilized for calibration. For the model, Monday Creek mainstem was divided into seventeen sections and Snow Fork tributary was divided into three sections. Drainage areas were calculated and “finite nodes” were created for each stream section.

Monday Creek Watershed

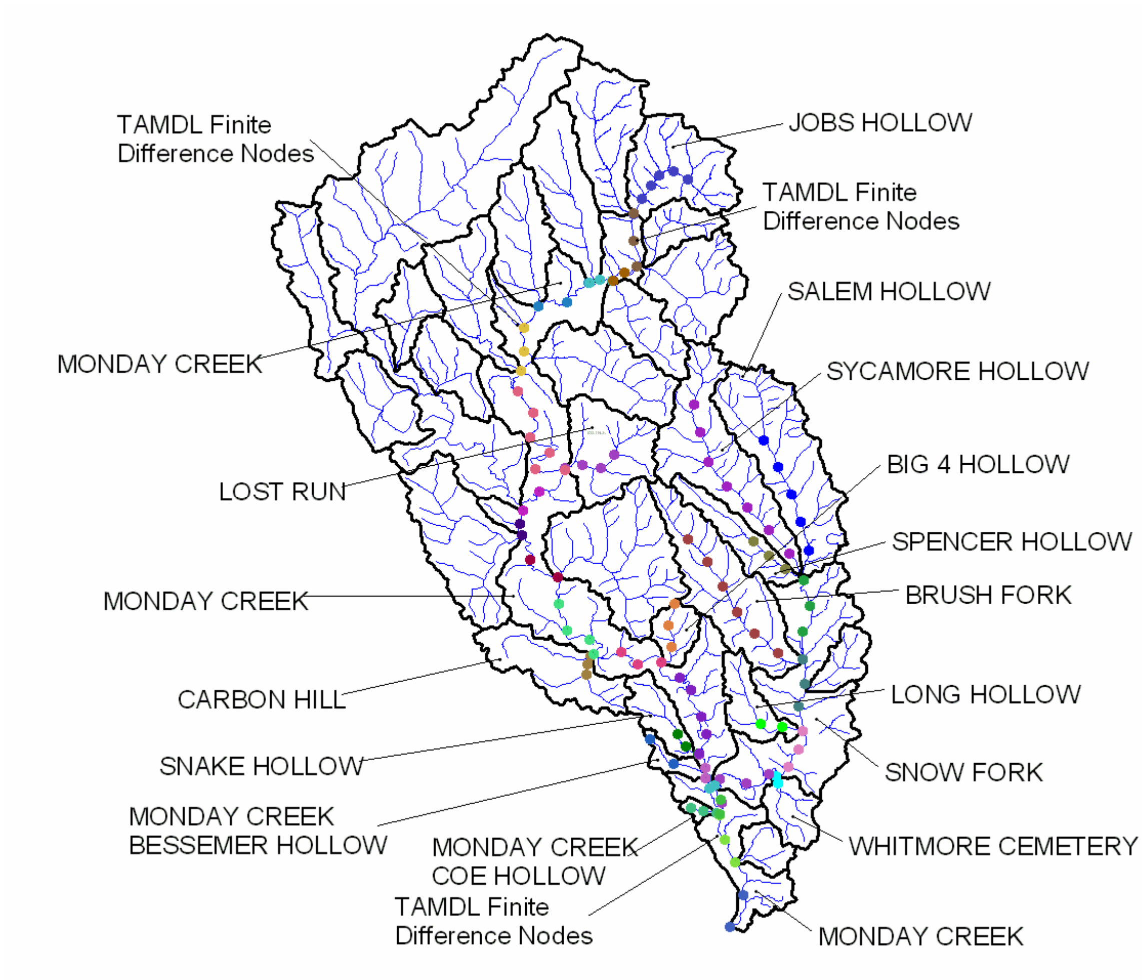


Figure 17: Computational Domain of the Monday Creek TAMDL model (Stiles and Ziemkiewicz, 2003)

The TAMDL model simulated the transport and reaction of aluminum, iron, and the resulting changes of pH. Due to the likelihood of error associated with modeling, margins of safety were specified for the calculated remediation endpoints. Remediation endpoints were determined by comparing associated ambient chemistry at sample locations that met the Warmwater Habitat use designations within the Monday Creek and Sunday Creek watersheds. The Ohio EPA provided a range of remediation endpoint targets.

Table 8: Monday Creek Chemistry Targets for meeting the WAP-WWH Biocriteria, OEPA 2001

| Descriptive Statistics | TDS | AL | Fe | pH | Acidity | Alk | Net Acidity | Drainage | IBI | QHEI | ICI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/l) | (mg/l) | (mg/l) | (field) | (mg/l) | (mg/l) | (mg/l) | (miles2) | Score | Score | Score |
| **95th (5th pH)** | 609 | 1.12 | 1.49 | 6.82 | 10.5 | 201.0 | -30.0 | 9.16 | 48 | 79 | 47 |
| **90th (10th pH)** | 568 | 0.65 | 1.30 | 7.03 | 7.7 | 169.5 | -36.4 | 6.30 | 48 | 75 | 47 |
| **75th (25th pH)** | 443 | 0.22 | 0.56 | 7.27 | 6.1 | 142.0 | -46.6 | 4.50 | 46 | 71 | 36 |
| **50th** | 288 | 0.20 | 0.35 | 7.58 | 2.9 | 94.9 | -90.0 | 2.00 | 44 | 64 | 32 |
| **25th (75th pH)** | 194 | 0.20 | 0.25 | 7.78 | 2.0 | 50.9 | -140.0 | 1.70 | 42 | 57 | 32 |
| | | | | | | | | | | | |
| **Mean** | 332 | 0.32 | 0.54 | 7.58 | 4.2 | 99.6 | -95.4 | 3.18 | 44 | 64 | 35 |
| **Min.** | 112 | 0.02 | 0.05 | 6.41 | 1.3 | 31.0 | -252.6 | 1.00 | 42 | 45 | 32 |
| **Max.** | 1,240 | 1.47 | 2.07 | 8.29 | 16.0 | 255.0 | -15.0 | 11.00 | 50 | 82 | 48 |
| **Number of Samples** | 51 | 51 | 51 | 51 | 51 | 52 | 51 | 17 | 17 | 17 | 16 |

**Associated ambient chemistry for sites meeting the WAP WWH Biocriteria within Monday and Sunday Creek basins. 2001 (Chuck Boucher)**

The endpoints listed below express the minimum allowable 5$^{th}$ percentile for stream pH and the maximum allowable 95$^{th}$ percentile for aluminum and iron concentrations for the entire length of the Monday Creek mainstem. The margins of safety were designed to force the model to overestimate the amount of AMD treatment required to meet remediation endpoints (Stiles and Ziemkiewicz, 2003). However, the alkalinity target was set at the minimum value of 30 mg/l for Monday Creek mainstem, to avoid undue expense caused by over-designing AMD treatment systems.

Table 9: Remediation Endpoints and Margins of Safety for the TAMDL Model

| | Remediation Endpoint | Margin of Safety | Remediation Endpoint plus Margin of Safety |
|---|---|---|---|
| pH | 6.82 standard units | +0.25 standard units | 7.07 standard units |
| Aluminum | 1.12 mg/l | -0.4 mg/l | 0.72 mg/l |
| Iron | 1.49 mg/l | -0.4 mg/l | 1.09 mg/l |
| Alkalinity | 30 mg/l | NA | NA |

The TAMDL model calculated load reductions necessary for Monday Creek mainstem to meet the restoration target and provide water chemistry suitable to support or sustain fish and macro-invertebrate communities. To meet the restoration target, a total load reduction of 2,740 tons per year of acidity is required.

## Remediation Efforts

Remediation efforts in the watershed are ongoing. In 2003, a reclamation project was completed at Jobs Hollow (Grimmett Property). In 2004, other reclamation projects were completed in Jobs Hollow, Big Four Hollow and Snake Hollow. Due to these recent remediation efforts, water chemistry in Monday Creek has improved. However, at this time, there is not enough water quality data available to re-assess these particular sub-watersheds' current acid contribution to Monday Creek. MCRP can provide this data in the near future. Post-construction water quality sampling efforts are ongoing in Jobs Hollow, Snake Hollow and Big Four Hollow. Additional projects in these sub-watersheds may be necessary in the future.

Table 10: Projects Completed in the Monday Creek Watershed

| Sub-basin | Site | Reclamation Project | Agencies / Funding |
|---|---|---|---|
| Jobs Hollow | Jobs 13 Tributary | Installed Boxholm style lime doser unit. Regraded and vegetated a 2 acre gob pile (2004) | MCRP, ODNR, OSM, USFS |
| Jobs Hollow | Grimmett Tributary | Installed OLC's, J-trenches with LKD, moved gob pile out of stream channel, re-graded and vegetated pile (2003) | MCRP, 319-EPA, ODNR |
| Rock Run | Gob Pile & Seep | Regraded, capped and vegetated a 17 acre gob pile, constructed a Successive Alkalinity Production System (SAPS) and OLC's (1999) | MCRP, 319-EPA, ODNR, USFS |
| Rock Run | RR-24 Seep | OLC- open limestone channel (2001) | MCRP, ODNR, OSM, USFS |
| Big Four Hollow | Seeps & Tributary | LLB's (limestone leach bed), OLC's, and rock dams (2004) | MCRP, ODNR, USFS |
| Snake Hollow | Seeps & Tributary | SLB's (slag beds), OLC's, enhanced wetland with rock dams, subsidence filling and established positive drainage (2004) | ODNR, USFS |
| Happy Hollow | Seep & Pond | Diverted AMD discharge away from pond | ODNR, USFS |
| Monday Creek | Majestic Mine (Subsidence) | Subsidence closure (1999) | ODNR |
| Sycamore | Subsidence | Subsidence closure x 3 (2003) | USFS |
| Salem Hollow | Subsidence | Subsidence closure & OLC (2000) | ODNR |
| Murray City | Subsidence | Subsidence closure x 3 (2004) | ODNR |
| Goose Run | Subsidence | Subsidence closure - captured 506 acres (1995) | ODNR |
| Orbiston | Subsidence | Subsidence closure & OLC (2003) | USFS |
| Long Hollow | Subsidence | Subsidence closure x 4 (2003) | USFS |
| Snow Fork | Subsidence | Subsidence closure - captured 140 acres (1999) | ODNR |

## Acid Mine Drainage Treatment Types

### Active

Active treatment involves collecting the AMD and treating with alkaline reagents to neutralize acidity, precipitate metals and raise pH. An active treatment system (i.e. lime doser) is one that requires regular operation and maintenance, uninterrupted chemical addition, as well as long-term costs.

### Passive

Passive treatment involves the collection of AMD and subsequent diversion into controlled environments (i.e. ponds and wetlands) to allow chemical and biological reactions to neutralize acidity, precipitate metals and raise pH. A passive system requires retention time and suitable areas to construct systems. Passive treatment systems have limited life spans and will eventually require reconstruction or replenishment of material. Generally systems require occasional inspection, little maintenance and therefore have little recurring costs.

## Acid Mine Drainage Treatment Systems *(USACE, 2005)*

### Active Treatment Systems

**Limestone Dosing**: A process where limestone product is introduced into a stream in regular increments. The limestone particles may be in a large hopper or from a plant-type operation. Dosers are generally water powered.

### Passive Treatment Systems

**Anoxic Limestone Drain (ALD)**: An ALD is a buried channel containing limestone that is designed to limit oxygen contact with the mine discharge. An ALD requires relatively low metal concentration (dissolved Al <1 mg/L and >75% ferric iron) and low dissolved oxygen (<1 mg/L). Typically, an ALD is used in conjunction with aeration and a wetland system of settling ponds to allow for metal precipitation reactions. Oxygen concentrations are often a design limitation for ALDs. They are generally ineffective where Dissolved Oxygen (DO) concentrations are greater than 1 or 2 mg/l.

**Compost or Anaerobic Wetland:** The wetlands consist of wetland vegetation, permeable organic mixtures of compost, straw/manure etc., and underlain or mixed with limestone. A compost wetland generates alkalinity through a combination of bacterial activity and limestone dissolution. In some cases, an aerobic settling pond may be needed for metal precipitation reactions before the compost wetland.

**Aerobic Wetland**: The wetlands consist of wetland vegetation planted in shallow, relatively impermeable sediments comprised of soil, clay or mine spoil. It typically requires another restoration alternative such as an ALD to raise the pH above 4. Aerobic wetlands are typically designed to promote precipitation of iron hydroxide and thus often require periodic dredging.

**Open Limestone Channels (OLC)**: An open channel is an adequately sized channel containing large limestone that carries and treats the mine discharge. The OLC must be on a fairly steep slope (greater than 10 percent) to ensure sufficient amount of oxygen necessary to precipitate metals and to transport the metal precipitates down the channel otherwise the metals will precipitate onto the limestone affecting the efficiency of the system. An OLC is suited for AMD with high dissolved oxygen and metal concentrations and low pH.

**Successive Alkalinity Producing Systems (SAPS)**: SAPS combine the use of an ALD and an anaerobic wetland. In SAPS, a drainage system is installed in the bottom of the pond. The drainage pipes are overlain by limestone, which is then overlain by organic material. Open water is ponded on top of the organic layer. The principle is to introduce the semi-aerated water into the pond and cause the water to move down through the organic matter to filter out ferric iron or reduce it by microbial iron reduction to ferrous iron. The reduced water then continues downward into the limestone, picking up additional alkalinity by limestone dissolution. The water then discharges through the drainage system in the bottom of the pond, having a pH of 6.0 and a much higher level of alkalinity in the water. The treated water is then aerated and the metals precipitate in a sedimentation pond, aerobic wetland, or anaerobic wetland. A SAPS is suited for AMD where the DO concentrations are above 2 mg/l.

**Limestone Leach Bed (LLB)**: LLBs are buried cells or trenches of limestone which the water flows through. The limestone dissolves in the water and adds alkalinity. The purpose of these leach beds is to provide alkalinity to AMD-impacted streams.

**Slag Leach Beds (SLB)**: Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. Steel slag can be used as an alkaline amendment, as well as a medium for alkaline generating leach beds. Slags are produced by a number of processes, so care is needed to ensure that candidate slags are not prone to leaching metal ions such as chromium (Cr), manganese (Mn), nickel (Ni), or lead (Pb).

## Drainage Problems

**Subsidence closures:** Subsidence closures restore drainage to the stream and reduce AMD generation by preventing contact between stream water and pyritic minerals located within the underground mine workings. Restoring positive drainage to the affected streams would improve the long-term performance of other AMD restoration systems and reduce human and animal hazards. The method of closure would depend on the location, size and extent of the subsidence. Generally, the subsidence may be filled with graded limestone or recycled concrete in conjunction with a geotextile and spoiled soil. Once the subsidence is filled and sealed the previously captured stream would be re-routed, when possible, to avoid the filled subsidence. The stream would be lined with a geosythetic clay liner (GCL) to inhibit downcutting action of the stream and another encounter with the subsidence. The stream would be re-routed to existing channel at the nearest downstream location.

**Spoil blocks:** Spoil blocks are locations where spoil from previous mining operations is blocking the natural stream course and would be either completely removed or partially removed by breaching. The method and extent of removal would depend upon the size of the spoil block. When feasible, the block would be entirely removed to provide positive drainage to a stream. In other cases, when the size of the spoil block does not make removal feasible, the block would be breached to allow stream flow to resume. In most cases, the stream would need to be rerouted to reconnect to the existing channel downstream. Stream reconstruction would entail lining the channel with a geosynthetic clay liner and limestone.

**Dissipating streams:** Dissipating streams are captured by jointed rock, scarps or fractures associated with mining subsidences but visible surface cracking and opening are not present. The proposed fix for dissipating streams is to re-route the channel upstream to avoid the capturing feature and line it using a geosynthetic clay liner (GCL) to prevent contact with the underground mine workings. In other cases, the capturing feature may need to be filled with a high fly ash content grout mixture. In other cases the capturing feature may be filled with spoil material and covered with a GCL.

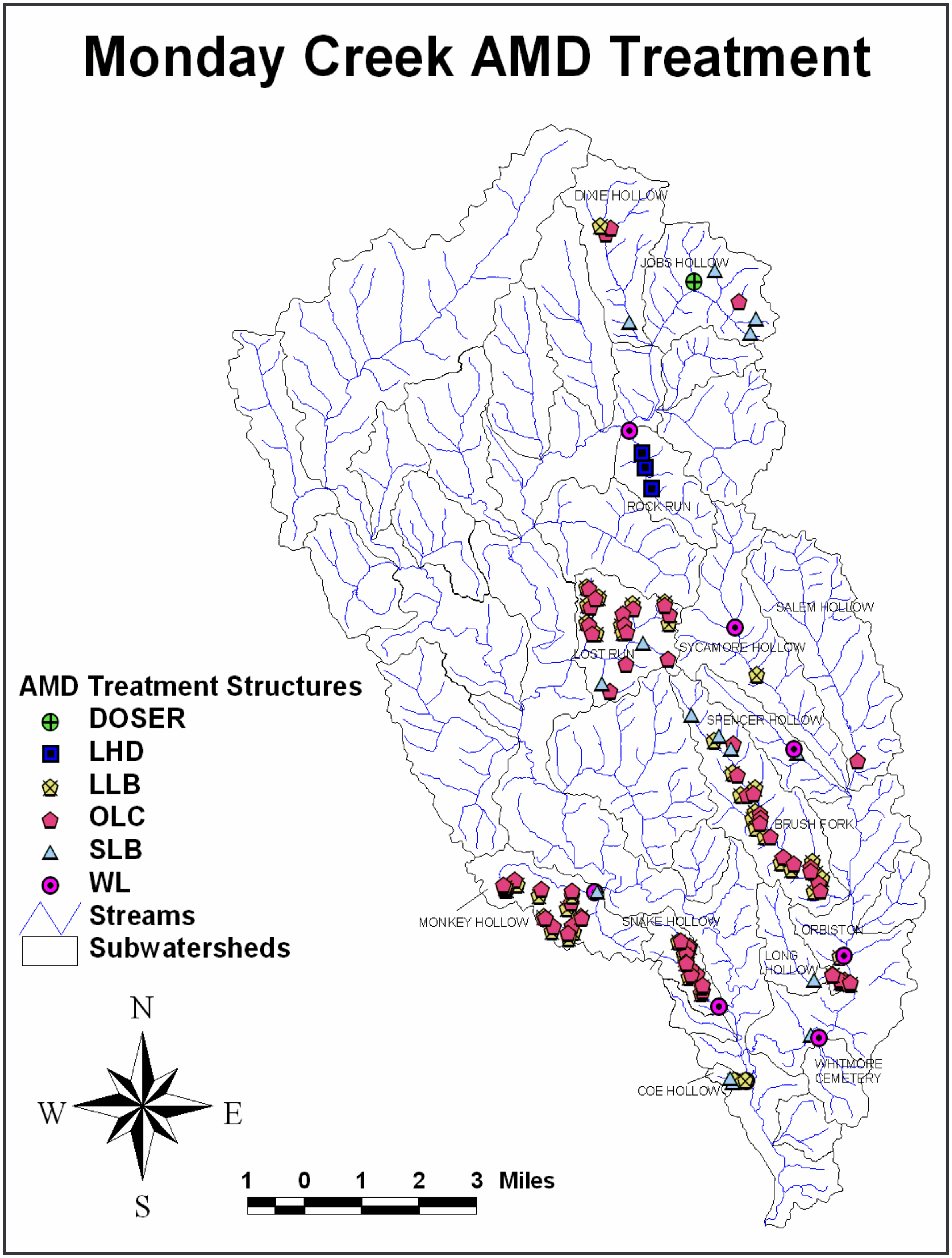


Figure 18: TAMDL Treatment Recommendations for Monday Creek Watershed (Stiles and Ziemkiewicz, 2003)

## Cost of Treatment

Cost estimates for TAMDL treatment recommendations within AMD impaired sub-watersheds are included in Appendix C. Costs were adapted from the U.S. Army Corps of Engineers "Monday Creek Subbasin Ecosystem Restoration Project - Final Feasibility Report and Environmental Assessment 2005". Treatment recommendations are based on water quality samples collected from 1995 to 2003. As more detailed water quality investigations are completed by the Monday Creek Restoration Project, alternative treatment strategies may be explored. AMDAT cost estimates (Appendix C) do not include real estate costs, utility relocation, geo-technical investigations and maintenance of systems.

## Restoration Strategy

Future reclamation projects should be completed in a manner that initially focus on water quality improvement to Monday Creek mainstem. The preferred strategy is to apply a "top-down" approach and implement projects from headwaters to mouth in order to maximize the number of stream miles improved. Secondly, sub-watersheds discharging AMD into the Snow Fork tributary should be addressed according to acid and metal load contribution. When considering viability or success of a reclamation project, numerous criteria need to be taken into consideration (cost effectiveness, accessibility, ownership, construction and design, as well as the goal or end result of the project). These criterion should be discussed prior to reclamation.

The construction of future reclamation projects in the Monday Creek Watershed will be determined based upon Congressional appropriations of the Water Resources Development Act of 2006, as well as the availability of federal funds and associated state and local match.

## Sub-watershed Descriptions and Treatment Recommendations

Monday Creek Watershed contains a total of 31 sub-watersheds. Coal mining occurred in all but two of the sub-watersheds (Temperance Hollow and unnamed #3), located in the northwest section of the watershed. Drainages located in this area of the watershed are generally unimpacted or marginally impacted by acid mine drainage problems. However, the remaining northern, eastern and southern sections of the watershed are moderately to severely impacted by AMD. The next section will provide detailed descriptions of the problems and provide treatment recommendations (where possible) aimed at reducing the devastating effects of AMD to receiving streams.

A three-phased approach is used to assess water quality conditions within sub-watersheds. Phase I involves collecting field measures for pH, acidity, alkalinity, conductivity and temperature of surface water. Locations of sites discharging AMD, subsidence holes and drainages blocked by spoil material are documented with a GPS unit or topographic map. Phase II involves the collection of water quality samples and flow measures in order to characterize acid loading potential of AMD impacted sites. Phase III involves collecting water quality samples and flow measures at AMD impacted sites for a period of six to twelve months in order to document chemical and flow variations. Phase III data collection is needed in order to determine the degree of remediation that is necessary, as well as the appropriate treatment technology required.

Table 11: List of AMD impacted priority sub-watersheds and level of analysis completed.

| Receiving Stream | Sub-watershed | Phase I Initial Investigation | Phase II Sub-watershed Evaluation | Phase III Design Level Sampling |
|---|---|---|---|---|
| Monday Creek | Jobs Hollow | * | * | |
| Monday Creek | Rock Run | * | * | |
| Monday Creek | Lost Run | * | * | * |
| Monday Creek | Monkey Hollow | * | * | |
| Monday Creek | Big Four Hollow | * | * | * |
| Monday Creek | Snake Hollow | * | * | * |
| Monday Creek | Bessemer Hollow | * | * | * |
| Monday Creek | Coe Hollow | * | * | |
| Snow Fork | Sycamore Hollow | * | * | |
| Snow Fork | Spencer Hollow | * | | |
| Snow Fork | Brush Fork | * | * | |
| Snow Fork | Long Hollow | * | * | * |
| Snow Fork | Mainstem-Seeps | * | | |

## Lost Run

Location: Section 31, 32 Coal Twp, Perry County. Section 24, 30, 36 Ward Twp, Hocking County.
Drainage area: 3.14 square miles; 1,919 acres
Stream Length: 1.3 miles
USGS Quadrangles: Gore and New Straitsville
River Mile: 16.1
Percent Acid Load into Monday Creek: 9%
Ownership: Private and public (USFS)
Land owned by USFS: 65%, 1,112 acres

### Basin Assessment

The Lost Run sub-watershed is located in the middle of the Monday Creek Watershed, near the village of New Straitsville. A long-term monitoring site is located immediately downstream of the Lost Run tributary at RM 16 (LTM 131). Approximately 60% of the Lost Run sub-watershed contains underground and/or surface mined areas. There has been some reclamation work performed under present mining law, however much of the area contains exposed gob piles, strip pits, highwalls, subsidence features, blocked drainages and open mine portals. Extensive field reconnaissance performed in 2001 resulted in the identification of 46 seeps with poor water quality. Mining in the sub-watershed occurred in the # 6 Middle Kittanning coal seam, with the average elevation of the coal seam at 855 ft. The topography of Lost Run is steep with the highest point in the sub-watershed located at an elevation of 1,060 ft. The mouth of the tributary discharges into Monday Creek at an elevation of 705 ft.

### Historical Water Quality

In the spring of 1998, water quality samples were collected at the mouth of Lost Run. Results from the sampling show a pH of 3.3, a net acidity value of 131 mg/l and a calculated acid load of 2,904 lbs/day. In 2000-2001, four quarterly water quality samples were collected at the mouth of Lost Run tributary, as well as two mass balances performed in the sub-watershed by MCRP. In 2001, OEPA collected water quality samples at the mouth and performed biological sampling in the mainstem of Lost Run at RM 0.1 and RM 1.3. The highest pH value recorded at the mouth of Lost Run to date is 3.6. The Lost Run sub-watershed is classified as a priority sub-watershed.

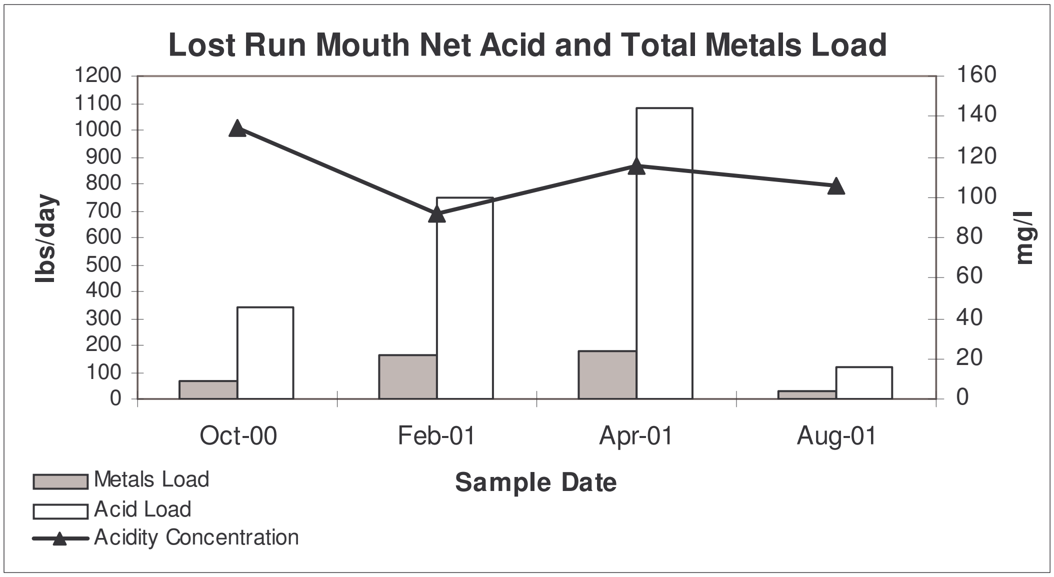


Figure 19: Lost Run Net Acid & Total Metals

**Water Quality Impacts on Monday Creek**

Based on the October 2000 mass balance in Monday Creek, it is estimated that Lost Run contributes 9% (346 lbs/day) of the acid load to Monday Creek at base flow. Data collected at LTM 131 monitoring site on Monday Creek (downstream of Lost Run tributary) records an average pH value of 5.5 and average alkalinity value of 5.8 mg/l. LTM 131 has been monitored quarterly since 1997. Records indicate a pH range of 4.2 to 6.2, and an acidity range of 4-37 mg/l. Lost Run is causing substantial impairment to the mainstem of Monday Creek.

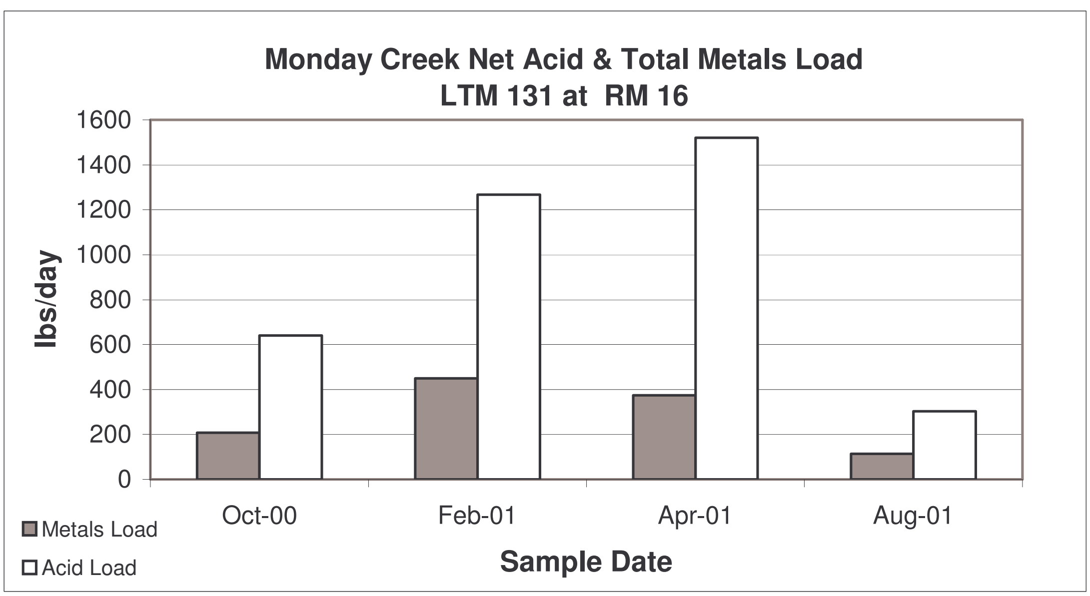


Figure 20: Monday Creek at Lost Run Net Acid & Total Metals

In the summer of 2001, OEPA performed sampling for a TMDL study in the Monday Creek Watershed. Two locations were selected for analysis in the Lost Run sub-watershed, as well as locations upstream and immediately downstream of Lost Runs' confluence with Monday Creek. 2002 results confirm that the Lost Run sub-watershed is severely impaired and meets the requirements for classification as Limited Resource Water (LRW).

Results from TMDL sampling location at River Mile 19.7 in Monday Creek, located 3.7 miles upstream of Lost Run, recorded adequate QHEI (65) and ICI (34ns) scores to meet WWH, with a less than adequate IBI (22) score. At River Mile 16, located immediately downstream of Lost Run confluence with Monday Creek, scores recorded by OEPA document significant decline in all measured indices.

Qualitative Habitat Evaluation (QHEI) scores recorded at RM 18.5 and RM 16 document a decline in habitat quality in a 2.5-mile section of Monday Creek (Dans Run to Lost Run), but still lie within acceptable range to provide suitable habitat for aquatic species. However, ICI and IBI scores at RM 18.5 and RM 16 are negligible and lie within the bounds of LRW classification. This suggests that while suitable habitat exists, water quality impairment present in the stream (specifically AMD contamination) has affected its ability to support fish and insect communities.

Table 12: OEPA TMDL (2001) Monday Creek & Lost Run Sampling Sites

| Location | River Mile | IBI | ICI | QHEI |
|---|---|---|---|---|
| Monday Creek (upstream) | 18.5 | 18.0 | 26 | 81.5 |
| Monday Creek (downstream) | 15.8 / 16 | 18.0 | 14 | 61.5 |
| Lost Run | 1.3 | 12.0 | Very Poor | 65.0 |
| Lost Run | 0.1 | 12.0 | Very Poor | 61.0 |

**Lost Run Water Quality Investigation**

The Lost Run sub-watershed contains seven tributaries, all of which are impacted by AMD and vary depending on location. Mass balances were performed in the Lost Run sub-watershed at high and low flow. While the figures below reflect the average loads, specific tributaries acid concentration and loads demonstrate significant variation at base flow and high flow conditions.

The upstream (eastern) portion of Lost Run lacks positive drainage due to subsidence features (stream captures) as well as spoil blocks in side drainages with intermittent streams. AMD-contaminated water is discharging at the bottom of several drainages, as well as slumped drift mine entries and fractured highwalls. MCRP field investigations documented 20 seeps, 12 subsidence features and 18 spoil blocks in the upper reaches of

Lost Run, resulting in approximately 400 acres providing recharge to underground mine complexes.

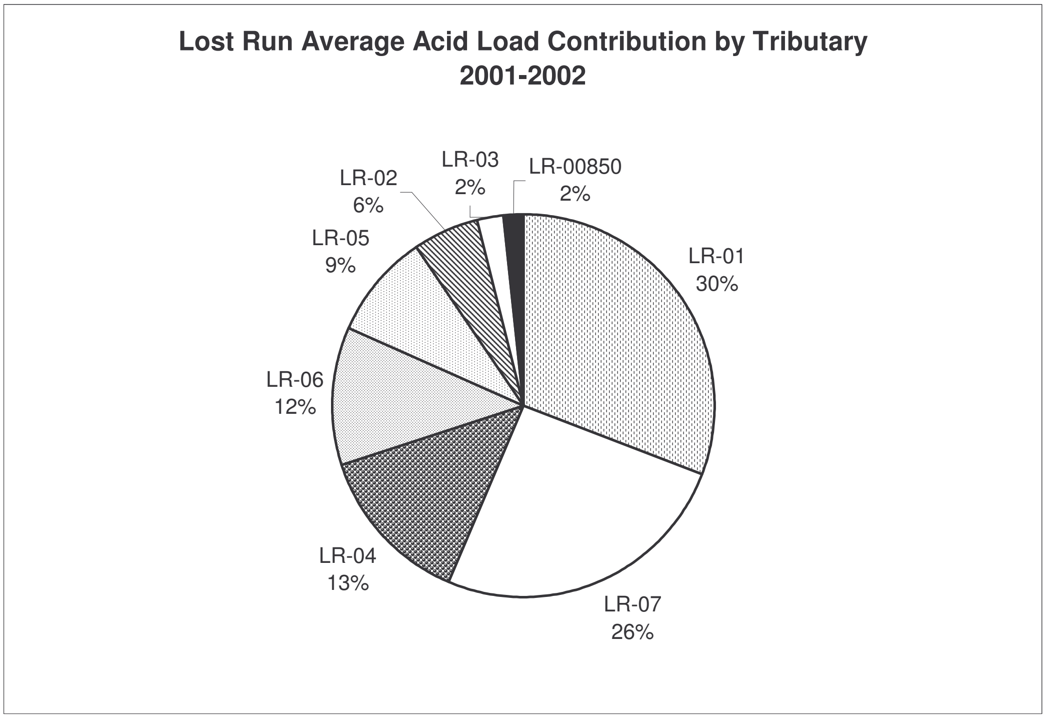


Figure 21: Lost Run Acid Load by Tributary

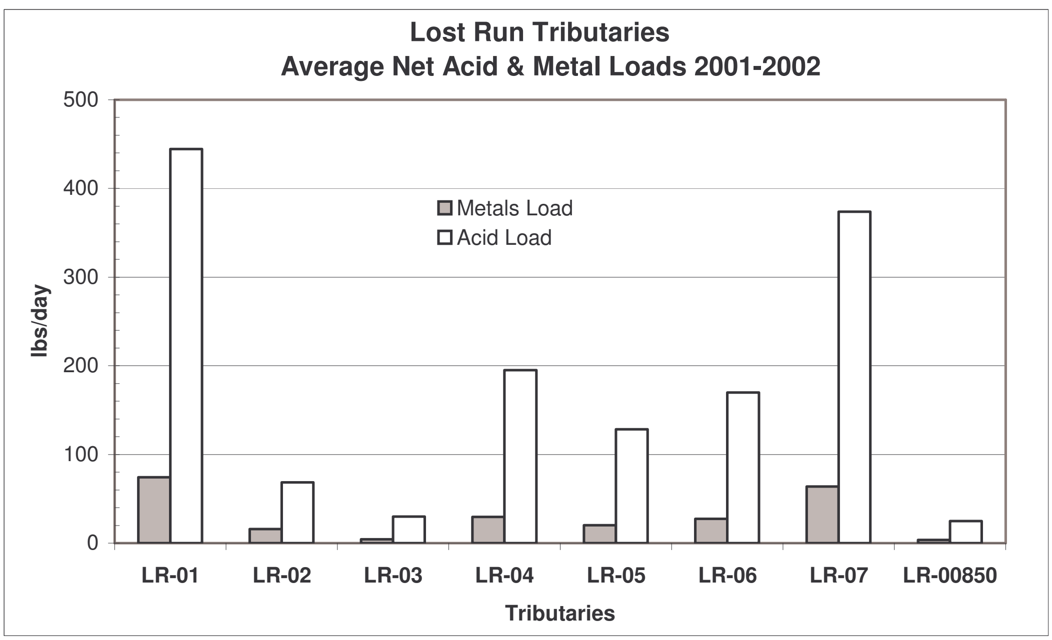


Figure 22: Lost Run Average Net Acid & Total Metal Load by Tributary

The lower (western) portion of the watershed includes areas that have been predominately surface mined, with various degrees of reclamation completed in accordance with mining regulation at the time of operation (1972 to present day). The majority of AMD discharging in the lower portion of Lost Run occurs beneath highwalls or near the perimeter of surface mine reclamation, at the coal crop line. MCRP field investigations documented 26 seeps of poor water quality and observed numerous side drainages where overburden was deposited due to surface mine operations.

**Site Descriptions and Treatment Recommendations**

I. LR 00850 – Tributary (upper mainstem, upstream 4W)

Location
Located on USFS property. Access is limited to foot travel.

Site Description
LR 00850 is the headwaters of Lost Run and encompasses 96 acres of drainage area, with intermittent stream flow. A strip bench/ access road/ and impoundment created during surface mining operations are located at the mouth of the drainage. All water flowing in the stream channels is lost into seven subsidence features located upstream of the strip bench/ access road/ and impoundment, resulting in the tributary's complete capture into underground mines. Due to the dip of the coal seam, water captured in the headwaters region of Lost Run may be transported via inter basin transfer to Esco #1 (Essex) Mine located in Sycamore Hollow.

Two seeps are located above and below the constructed impoundment. Both seeps have an average pH of 3 and discharge 3 to 20 gpm. Samples were collected at seep LR 00840 located below impoundment in 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LR00840 | Seep | 5/10/2001 | 3.1 | 1360 | 6 | 327 | 22 |
| LR00840 | Seep | 3/27/2002 | 3.0 | 1180 | 13 | 236 | 38 |
| LR00840 | Seep | 11/13/2002 | 3.0 | 1750 | 3 | 376 | 12 |

Recommendation
Suggested remediation for LR 00850 is to create positive drainage, close subsidence features that capture surface water and construct OLC and LLB to treat AMD discharging at seep LR 00840.

II. LR 07 – Tributary (4W)

Location
Located on USFS property. Access is limited to foot travel.

Site Description
LR 07 is located in the upstream (eastern) portion of Lost Run. The uppermost section of the drainage is blocked by a spoil pile located in the stream channel that has resulted in erosional subsidence features, capturing approximately 50 acres of surface runoff. The coal seam is oriented both above and below drainage in this tributary.

An unreclaimed highwall is located in the mid- and lower sections of the drainage, where ponding water is also lost into underground mines. There a two seeps located directly downstream of the highwall, where discharging water is routed under a USFS ATV trail via a culvert. Downstream of the culvert, there are approximately four diffuse seeps, which increase in volume as they flow to lower elevations. Due to the dispersed nature of these seeps, samples were collected at the culvert and the mouth of the tributary.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LR07120 | Tributary | 5/9/2001 | 2.8 | 1670 | 146 | 440 | 770 |
| LR07120 | Tributary | 3/27/2002 | 3.1 | 1580 | 60 | 403 | 291 |
| LR07120 | Tributary | 11/13/2002 | 3.0 | 1620 | 13 | 373 | 60 |
| LR07200 | Seep | 3/27/2002 | 2.9 | 1750 | 4 | 684 | 29 |
| LR07300 | Seep | 5/9/2001 | 2.8 | 1640 | 65 | 410 | 321 |
| LR07300 | Seep | 3/27/2002 | 3.1 | 1330 | 20 | 377 | 91 |

Recommendation
Suggested remediation for LR 07 is to create positive drainage, close subsidence features that capture surface water and construct OLC and LLB to treat AMD discharging at seeps near the mouth of the stream.

III. LR 06 – Tributary (3W)

Location
Located on USFS and private property. Access is limited to foot travel.

Site Description
LR 06 is located in the upstream (eastern) portion of Lost Run. An unreclaimed highwall runs the entire length of the drainage basin, with a spoil pile blocking a small side drainage with intermittent flow in the back of the basin. A large strip pond (350 ft x 60 ft) and two adjacent seeps on the east side of the valley discharge AMD directly into the stream channel. The rock face above the strip pond is slipping, opening new portals and discharge points. Samples were collected at the strip pond discharge and the mouth of the stream in 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LR06100 | Tributary | 5/9/2001 | 3.0 | 1310 | 54 | 301 | 195 |
| LR06100 | Tributary | 3/27/2002 | 3.1 | 999 | 99 | 228 | 270 |
| LR06100 | Tributary | 11/13/2002 | 3.1 | 1360 | 12 | 301 | 44 |
| LR06620 | Seep | 3/27/2002 | 3.1 | 1500 | 10 | 367 | 45 |
| LR06620 | Seep | 11/13/2002 | 3.0 | 1630 | 1 | 386 | 6 |

Recommendation
Create positive drainage and construct OLC and LLB to treat AMD discharging at seeps and strip pond. Location of treatment features to be determined.

IV. LR 05 – Tributary (2W)

Location
Located on USFS and private property. Access is limited to foot travel.

Site Description
LR 05 is located in the upstream (eastern) portion of Lost Run. An unreclaimed highwall runs the entire length of the drainage basin. Numerous diffuse seeps with modest flow are located beneath the highwall, which discharge into the stream channel and a series of beaver ponds. On the east side, near the front of the valley, are two large seeps located approximately 500 ft apart. Seep LR 05400 discharges into tributary LR 06 and Seep LR 00540 which correlates to a drift mine entry at Hg-18 and discharges into the mainstem of Lost Run. Discharge at these sites are significant, resulting in ponding water at low and high flow. Samples were collected at seeps LR 05400, LR 00540 and the mouth of LR 05 in 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LR05100 | Tributary | 5/9/2001 | 2.9 | 1260 | 36 | 268 | 115 |
| LR05100 | Tributary | 3/27/2002 | 2.7 | 1060 | 92 | 212 | 233 |
| LR05100 | Tributary | 11/13/2002 | 3.1 | 1140 | 15 | 202 | 37 |
| LR00540 | Seep | 3/27/2002 | 2.7 | 1470 | 20 | 314 | 75 |
| LR00540 | Seep | 11/13/2002 | 3.0 | 1630 | 9 | 315 | 32 |
| LR05400 | Seep | 3/27/2002 | 2.5 | 2280 | 14 | 555 | 90 |
| LR05400 | Seep | 11/13/2002 | 3.0 | 1350 | 2 | 378 | 10 |

Recommendation
Construct OLC and LLB to treat AMD discharging at seeps and ponds. Location of treatment features to be determined.

V. LR 04 – Tributary (3E)

Location
Located on USFS and private property. Sites are adjacent Twp Road T392 (Lost Run Road). Access is limited to foot travel.

Site Description
LR 04 is located in the upstream (eastern) portion of Lost Run. The drainage is unaffected by mining in the upper-most reach of the basin, however stream flow begins to dissipate into sandy stream bottom at an approximate elevation of 900 ft. The valley bottom is extremely disturbed due to underground and surface mining operations resulting in eight small side drainages blocked by spoil. Erosional subsidence features are located upstream of spoil blocks in three of the eight drainages. LR 04 contains three diffuse seeps located on the bottom of the valley, which increase in volume as they flow to lower elevations. A downstream gob pile adjacent to seeps further degrades the water quality. Samples were collected at seeps LR 0450, LR 0460 and at the mouth of tributary in 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LR04150 | Tributary | 5/9/2001 | 3.0 | 992 | 78 | 158 | 148 |
| LR04150 | Tributary | 3/27/2002 | 2.8 | 887 | 229 | 147 | 404 |
| LR04150 | Tributary | 11/13/2002 | 3.1 | 1090 | 15 | 180 | 33 |
| LR04600 | Seep | 6/26/2002 | 3.1 | 1070 | 37 | 240 | 106 |
| LR04500 | Seep | 11/13/2002 | 3.1 | 986 | 4 | 163 | 7 |

Recommendation
Create positive drainage, close subsidence features that capture surface water, reclaim gob pile and construct a SLB upstream of AMD contamination to boost alkaline production. Install LLB and OLC to treat AMD discharging at seeps.

VI. LR 03 – Tributary (2E)

Location
Located on USFS and private property. Tributary is located south of a private residence located on Lost Run Road. Follow old Twp Road T22 (Burton Road). Access is limited to foot travel.

Site Description
LR 03 is located in the upstream (eastern) portion of Lost Run. The drainage contains two drift mine entries, located in a side drainage, which pose a safety risk to the public. Pillars and standing water are visible at the entries, as well as modest discharge at base flow. Coal spoil from these mines block a stream channel, with intermittent flow. Upstream of the spoil block, numerous slumps were observed near the channel, however no subsidence hole was discovered. While the smaller side drainage appears to be the main

contributor of AMD, the drainage basin also contains a highwall, mine spoil and a downstream wetland, which may contribute to the poor water quality of the tributary. Samples were collected at the mouth of the tributary in 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LR03230 | Tributary | 5/9/2001 | 3.8 | 554 | 64 | 41 | 32 |
| LR03230 | Tributary | 3/27/2002 | 3.8 | 442 | 171 | 27 | 54 |

Recommendation
Due to LR 03 tributaries low contribution of acidity and metal load to Lost Runs' mainstem, a minimum amount of remediation is recommended. Suggested remediation for LR 04 is to create an OLC to treat AMD discharging from drift mine entries.

VII. LR 02 – Tributary (1E)

Location
Located on USFS and private property. Sites are adjacent Twp Road T318 (James Road). Access is gained via James Road.

Site Description
LR 02 is located in the downstream (western) portion of Lost Run. LR 02 is a large drainage receiving flow from approximately ten intermittent streams, which flow into a series of beaver ponds located near the mouth of the tributary. LR 02 drainage is predominately affected by surface mining activity of various eras. The drainage contains highwalls, strip ponds, spoil piles and numerous seeps. The discharge at the mouth of the tributary is net alkaline at low and moderate flows. LR 02 was sampled in March and November of 2002, resulting in flow measurements of 50 to 600 gpm. Due to the substantial flow contribution to the mainstem of Lost Run and the tributaries net alkaline status, LR 02 tributary provides the opportunity for increased alkaline production. Samples were collected at the mouth of the tributary in 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day | Alkalinity mg/l |
|---|---|---|---|---|---|---|---|---|
| LR02100 | Tributary | 5/9/2001 | 6.7 | 1170 | 51 | 5 | 3 | 17.0 |
| LR02100 | Tributary | 3/27/2002 | 5.2 | 918 | 610 | 32.5 | 238 | 3.2 |
| LR02100 | Tributary | 11/13/2002 | 6.6 | 1290 | 49 | 6.48 | 4 | 19.8 |

Recommendation
Create an OLC upstream and downstream of existing beaver ponds. A large beaver pond and an existing rock damn located near the mouth of LR 02 provide the means to create a SLB to boost alkaline production and act as treatment to Lost Run's mainstem.

VIII. LR 01 – Tributary (1W)

Location
Located on USFS and private property. Sites are adjacent Twp Road T392 (Lost Run Road) and State Route 595, access is gained via USFS ATV trail, limited to foot travel.

Site Description
LR 01 is located in the downstream (western) portion of Lost Run. LR 01 encompasses approximately 500 acres of drainage area, receiving intermittent flow from eleven smaller side drainages, which flow into a series of beaver ponds located in the upper and midsection of the basin. LR 01 drainage is predominately affected by surface mining activity and contains an unreclaimed highwall, which runs the entire length of the drainage basin. LR 01 contains strip ponds, slumped drift mine entries and numerous seeps of poor water quality. All water flowing in the stream channels originate at seeps below highwalls with an average pH value of 3. Many of the seeps correlate to drift mine entries at underground mines Py-129 and Py-100. In November 2002, samples were collected at all seeps discharging in LR 01 and at the mouth. Field observations completed in spring and fall indicate dramatic variation in flow at the majority of sites. However, samples collected at the mouth on three occasions indicate that LR 01 accounts for 30% of the acid load in the Lost Run sub-watershed.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LR01020 | Tributary | 5/9/2001 | 3.3 | 797 | 198 | 115 | 273 |
| LR01020 | Tributary | 3/27/2002 | 3.3 | 459 | 1221 | 66 | 961 |
| LR01020 | Tributary | 11/12/2002 | 3.6 | 866 | 85 | 97 | 99 |

Recommendation
Construct OLC and LLB to treat AMD discharging at six seeps in the basin. Steep channel slopes and discreet bench seeps lend themselves well to the above technologies.

IX. LR 00020 - Tributary Mouth

Location
Located on USFS property. Site is adjacent to State Route 595.

Site Description
LR 00020 (Lost Run) tributary flows under State Route 595 and discharges into Monday Creek. LR 00020 is a perennial stream contaminated by AMD. This tributary contains unreclaimed surface mines, subsidence features, coal waste piles and deep mine seeps. Uncontaminated water is being lost to the underground mines. A total of seven samples were collected at the tributary mouth from 1998-2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LR00020 | Trib Mouth | 3/26/1998 | 3.3 | 989 | 1849 | 131 | 2907 |
| LR00020 | Trib Mouth | 10/18/2000 | 3.4 | 1070 | 213 | 134 | 343 |
| LR00020 | Trib Mouth | 2/7/2001 | 3.5 | 936 | 678 | 92 | 747 |
| LR00020 | Trib Mouth | 4/4/2001 | 3.6 | 883 | 779 | 116 | 1084 |
| LR00020 | Trib Mouth | 5/9/2001 | 3.3 | 1090 | 785 | 165 | 1554 |
| LR00020 | Trib Mouth | 3/27/2002 | 3.5 | 668 | 3627 | 68 | 2959 |
| LR00020 | Trib Mouth | 11/13/2002 | 3.6 | 1040 | 503 | 108 | 651 |

Recommendation
Currently, there is no suitable remediation recommended for this site. See above recommendations for SLB, LLBs and OLCs.

## Monkey Hollow

Location: Section 26, 31, and 32, Ward Twp, Hocking County.
Drainage area: 3 square miles; 1,790 acres
Stream Length: 2 miles (intermittent)
USGS Quadrangles: Gore, Nelsonville and Union Furnace
River Mile: 9.88
Percent Acid Load into Monday Creek: 4%
Ownership: Private and public (USFS)
Land owned by USFS: 86%, 1,539 acres

### Basin Assessment

Monkey Hollow is located in the southwest section of the Monday Creek Watershed between the city of Nelsonville and the village of Carbon Hill. A long-term monitoring site is located immediately upstream of the Monkey Hollow tributary at RM 10.5 (LTM 153). Approximately 42% of the Monkey Hollow sub-watershed contains underground and/or surface mined areas. The sub-watershed contains exposed gob piles, strip pits, highwalls, subsidence features, blocked drainages, open mine portals and toxic seeps. Extensive field reconnaissance performed in 2001 resulted in the identification of 17 seeps with poor water quality. Mining in the sub-watershed occurred in the # 6 Middle Kittanning coal seam, with the average elevation of the coal seam at 800 ft. The topography of Monkey Hollow is steep with the highest point in the sub-watershed located at an elevation of 1,060 ft. The mouth of the tributary discharges into Monday Creek at an elevation of 700 ft. The basin contains numerous private residences, roads and segments of the USFS Dorr Run Loop ATV trail.

### Historical Water Quality

In May 1998, MCRP performed field reconnaissance in the mainstem of Monkey Hollow. Field parameters were collected and seeps discharging AMD into the tributary were observed. Consequently, the mouth of Monkey Hollow was monitored quarterly for one year. Water quality analysis confirmed that Monkey Hollow is a significant source of AMD contribution to Monday Creek. In 2001, field reconnaissance was performed within the entire sub-watershed. In March 2002, a mass balance was performed by collecting water quality samples at tributary mouths, resulting in characterization of acid load contribution. Due to the numerous discharge points and rugged terrain of Monkey Hollow, attempts to account for total acid generation by sampling individual seep sites was not successful. In 2001, OEPA collected water quality samples near the mouth and performed biological sampling in the sub-watershed. The highest pH value recorded at the mouth of Monkey Hollow to date is 3.8. The Monkey Hollow sub-watershed is classified as a priority sub-watershed.

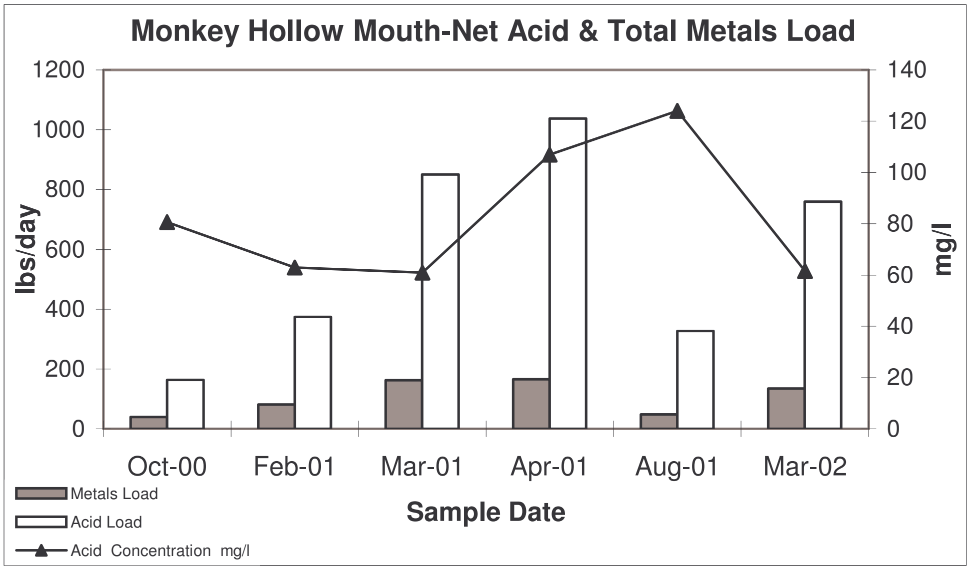


Figure 23: Monkey Hollow Net Acid & Total Metals

**Water Quality Impacts on Monday Creek**

Based on the October 2000 mass balance in Monday Creek, it is estimated that Monkey Hollow contributes 4% (165 lbs/day) of the acid load to Monday Creek at base flow. MCRP data collected at LTM 153 monitoring site in Monday Creek (RM 10.5 located 0.5 miles upstream of Monkey Hollow tributary) records an average pH value of 6.62 and average alkalinity value of 20.6 mg/l, documenting Monday Creek's net alkaline status upstream of the confluence with Monkey Hollow.

In the summer of 2001, OEPA performed biological and water quality sampling for a TMDL study in the Monday Creek Watershed. Three locations were selected for analysis within the Monkey Hollow sub-watershed. Sampling sites were located at RM 0.2 of the mainstem (downstream of confluence with south branch), RM 0.4 of south branch, and at RM 0.1 of the north branch. 2002 results, confirm that the Monkey Hollow sub-watershed is severely impacted by AMD and meets requirements for classification as Limited Resource Water (LRW).

Results from the TMDL sampling in Monday Creek at RM 10.5 (upstream of Monkey Hollow) recorded adequate IBI, ICI and QHEI scores to designate this site as reaching full attainment of Limited Resource Water (LRW). While the LRW classification may sound discouraging, this section of Monday Creek boasts the highest IBI (fish index) score in the entire mainstem of Monday Creek. A sampling station in Monday Creek at RM 9.3, (immediately downstream of Monkey Hollow) documented a 24 % decline in the IBI index score and a 35 % decline in the ICI index score. RM 9.3 also reached full attainment of the LRW classification. However, due to the significant decline in indices values, it is clear that Monkey Hollows' AMD contribution is degrading the biological health of Monday Creek, as well as contributing to the cumulative acid load.

In 2004, MCRP added a monitoring site downstream of Monkey Hollow confluence, near RM 9.3. Water quality samples will be collected on a semi-annual basis.

Table 13: OEPA TMDL (2001) Monday Creek and Monkey Hollow Sampling Sites

| Location | River Mile | IBI | ICI | QHEI |
|---|---|---|---|---|
| Monday Creek (upstream) | 10.5 | 29 | 28 | 62 |
| Monday Creek (downstream) | 9.3 | 22 | 18 | 63 |
| Monkey Hollow | 0.4 | 12 | Very Poor | 60 |
| Monkey Hollow | 0.2 | 12 | Very Poor | 68.5 |
| Monkey Hollow | 0.1 | 12 | Very Poor | 42.5 |

**Monkey Hollow Water Quality Investigation**

The Monkey Hollow sub-watershed contains three main tributaries. The tributaries in Monkey Hollow are the north branch (MH 01), mainstem (MH 02) and the south branch (MH 00400). The mouths of the tributaries were sampled in spring of 2001 and 2002, as well as the summer of 2001. Sample results from both high and base flow conditions indicate that the mainstem (MH 02) and south branch (MH 00400) together account for approximately 80% of the acid load generated in the sub-watershed.

The north branch (MH 01) is the least impacted of the three tributaries and contributes approximately 20 % of acid load. MH 01 contains highwalls, drift entries, strip pits, 3 seeps, 1 small gob pile and 1 stream capture, resulting in approximately 38 acres providing recharge to underground mine complexes. Surface mining occurred in the drainage resulting in creation of highwalls and a lack of positive drainage in the upper reaches, as well as several side drainages. The majority of AMD discharging into the north branch occurs where surface mining operations breeched barriers into underground mine complexes, as well as one drift mine entry which discharges AMD in the lower section of the drainage.

The mainstem (MH 02) is the severely degraded by AMD. MH 02 contains highwalls running the entire length of the drainage, numerous drift entries, 6 seeps, 1 small gob pile, numerous subsidence holes, 2 stream captures and 6 blocked drainages, resulting in approximately 43 acres providing recharge to underground mine complexes. The majority of AMD discharges at or near drift entries to underground mines. A successful accounting of the acid generated in this tributary has not been attained, suggesting the stream channel may be receiving base flow (upwelling) from the mine pool into the stream channel or a discreet discharge source has yet to be identified.

The south branch (MH 00400) is also degraded by AMD. MH 00400 contains highwalls, drift entries, strip pits, 5 seeps, 3 stream captures and 2 spoil blocks resulting in approximately 30 acres providing recharge to underground mine complexes. AMD discharges east and west of State Route 278 where surface mining operations breeched barriers into underground mine complexes. Additionally there are two drift mine entries that discharge AMD in the downstream section of the drainage near private residences.

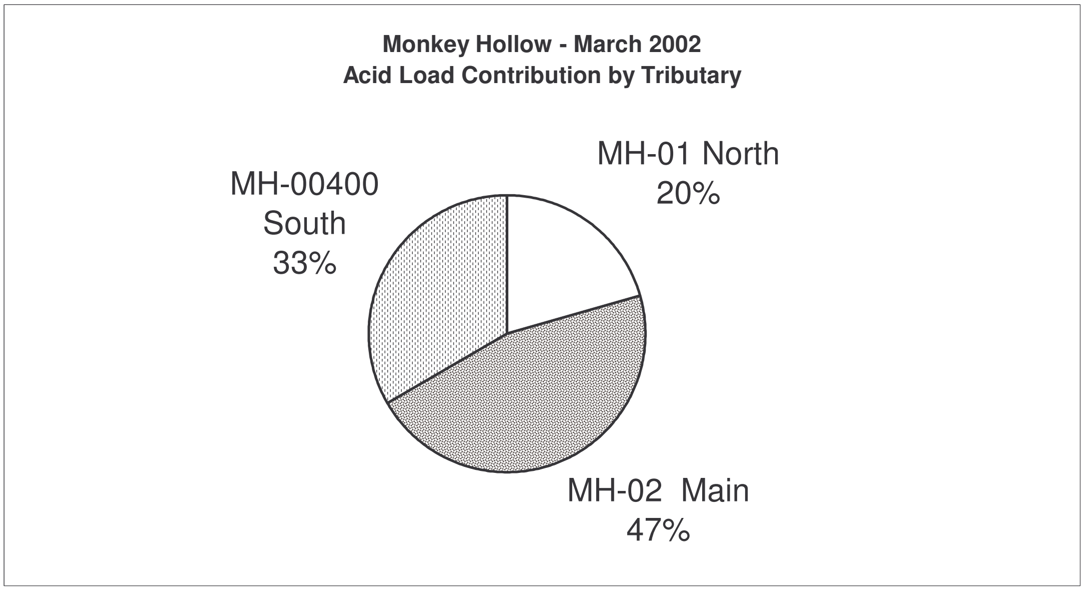


Figure 24: Monkey Hollow Acid Loading

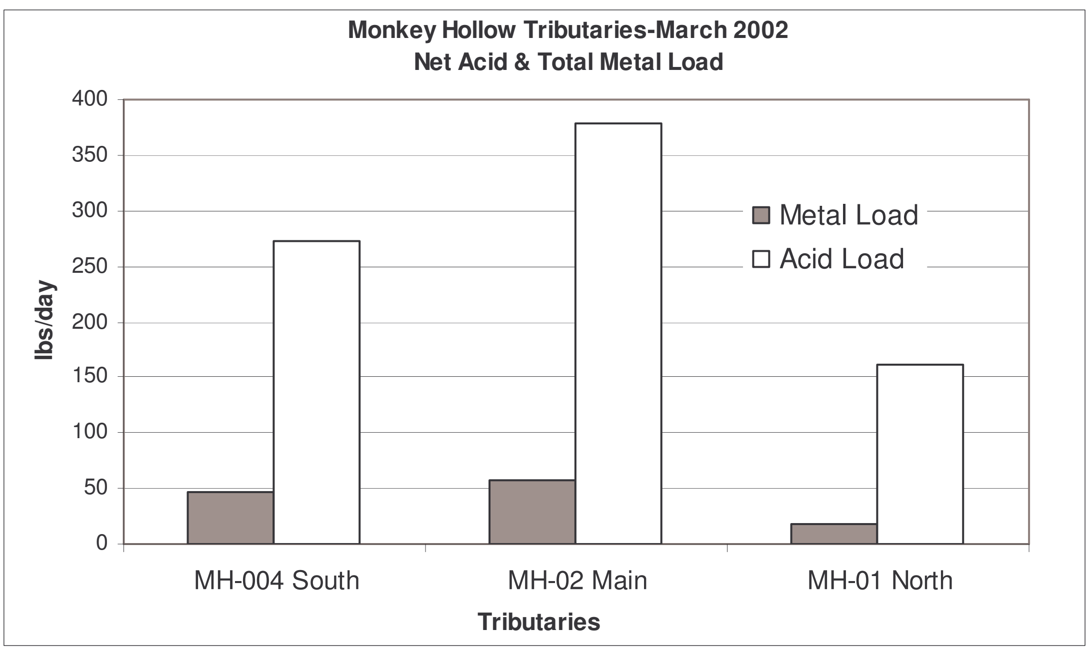


Figure 25: Monkey Hollow Tributaries Net Acid & Total Metals

**Site Descriptions and Treatment Recommendations**

I. MH 00400 – Tributary (south branch)

Location
This site is adjacent to State Route 278, south of Carbon Hill. Located on private property, approximately 30 ft from the road.

Site Description
MH 00400 is a tributary that flows adjacent to State Route 278 and receives flow from MH 04, MH 05 and MH 06, which are all intermittent streams contaminated by AMD. MH 00400 is the mouth sample of the south branch. Samples were collected in March 2001 and 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| MH00400 | Trib Mouth | 3/19/2001 | 4.29 | 710 | 282 | 92.1 | 312 |
| MH00400 | Trib Mouth | 3/25/2002 | 3.98 | 692 | 242 | 93.8 | 273 |

Recommendation
Currently, there is no remediation recommended for this site. More water quality monitoring is needed.

II. MH 06 – Tributary

Location
This site is adjacent to State Route 278, south of Carbon Hill. Located on USFS property. Access is limited to foot travel via ATV trail.

Site Description
MH 06 is located east of State Route 278 in the headwaters area of the south branch encompassing approximately 130 acres. Stream captures were documented in the up-stream section of the drainage resulting in approximately 25 acres providing recharge to underground mines. The downstream portion of the valley is disturbed due to surface mining operations, spoil piles and diffuse seeps were observed, however, flow was minimal and could not be measured. The stream itself flows through coal spoil and a beaver pond before discharging into Monkey Hollow south branch via a culvert under State Route 278. The drainage is oriented directly above (up-dip side) a 390 acre underground mine complex Hg-036. Flow measures taken in March 2002, recorded only 32 gallons per minute at the mouth of the tributary. The drainage lies up-dip of the Snake Hollow sub-watershed. Due to the documented subsidence features, lack of discreet measurable AMD discharges and up-dip orientation, it is possible inter-basin transfer is occurring in the drainage. More reconnaissance is needed specifically at high flow and during rain events, if possible. Samples were collected in March 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| MH00900 | Tributary | 3/25/2002 | 3.4 | 1030 | 32 | 200 | 75 |

Recommendation
Currently, there is no remediation recommended for this site. More water quality monitoring is needed.

III. MH 05 – AMD Discharge

Location
This site is adjacent to State Route 278, south of Carbon Hill. Located on USFS property. Access is limited to foot travel.

Site Description
MH 05 is located in the headwaters area of the south branch. The drainage is relatively small (25 acres), however the sides of the valley have been surface mined and spoil deposited in the valley bottom, blocking the stream channel. A subsidence hole capturing surface run-off (approximately 3 acres) is located behind the spoil block. A seep discharges at the front of the valley and flows into beaver ponds adjacent to State Route 278. Samples were collected in March 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| MH05100 | Tributary | 3/25/2002 | 3.35 | 359 | 31 | 134 | 51 |

Recommendation
Fill subsidence and create positive drainage. Currently, there is no remediation recommended for acid water discharging at this site. More water quality monitoring is needed.

IV. MH 04 – Tributary

Location
This site is adjacent to State Route 278, south of Carbon Hill. Located on USFS and private property. Access is limited to foot travel.

Site Description
MH 04 located east of State Route 278 in the south branch, encompassing approximately 100 acres. One seep was documented in the stream channel, located in upstream section of the tributary. This may indicate upwelling from the mine pool. The drainage is oriented directly above (up-dip side) a 367 acre underground mine complex Hg-159. One subsidence hole was documented below a highwall, which correlates to a drift mine entry. Samples were collected in March 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| MH04100 | Tributary | 3/25/2002 | 3.4 | 567 | 40 | 84.8 | 41 |

Recommendation
Currently, there is no remediation recommended for this site. More water quality monitoring is needed.

V. Unidentified – AMD Discharge

Location
This site is adjacent to State Route 278, south of Carbon Hill. A road ditch runs along east side of road, below private residences. Located on private property.

Site Description
Two small drainages near private residences have been identified as discharging AMD into a road ditch adjacent State Route 278. The drainages are steep and narrow posing access problems. Landowner permission has not been obtained to gain access to the sites. However, one site has been identified as a drift entry located on the hillside. Digital map files indicate surface mining and a drift entry in the second drainage.

Recommendation
Phase I field reconnaissance and collection of water samples.

VI. MH 02 – Tributary (mainstem)

Location
This site is adjacent to Twp Road T268 (Monkey Hollow Road), south of Carbon Hill. Located on USFS property, approximately 10 ft from the road.

Site Description
Unreclaimed highwalls are located in the mid- and upstream sections of the drainage, resulting in 4 spoil blocks and 2 erosional subsidence features in the headwaters of the drainage. Approximately 43 acres of the headwaters provide recharge to underground mines. There are a total of 6 seeps in the drainage. Seeps MH 02700, 02690 and 02450 are located beneath highwalls with average flows of 5 gpm and an average acidity value of 600 mg/l. These seeps were monitored monthly for one year (1999). In the mid-section of the valley, 2 spoil blocks and numerous drift mine entries were documented. Three of the drift mine entries discharge AMD and were identified in 2001. The entries (MH 02480 and MH 02270) are located in the back of steep, narrow valleys and have moderate flows, which increase in volume as they flow to lower elevations. Samples were collected at these sites in March 2002. Attempts to account for acid loading in this tributary has not been successful to date. This suggests the presence of an unidentified discreet source or upwelling of the mine pool into the stream channel. More water quality monitoring is needed.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| MH02700 | Seep | 3/25/2002 | 2.95 | 1080 | 5 | 380 | 23 |
| MH02700 | Seep | 3/25/2002 | 2.75 | 1660 | 1 | 686 | 7 |
| MH02480 | Seep | 3/25/2002 | 2.69 | 2060 | 9 | 589 | 60 |
| MH02450 | Seep | 3/25/2002 | 2.77 | 1860 | 1 | 543 | 9 |
| MH02270 | Seep | 3/25/2002 | 2.78 | 1530 | 17 | 248 | 49 |
| MH02250 | Trib Mouth | 8/18/1999 | 2.88 | 1650 | 12 | 298 | 42 |
| MH02250 | Trib Mouth | 10/27/1999 | 2.83 | 1430 | 15 | 256 | 47 |
| MH02250 | Trib Mouth | 3/19/2001 | 3.05 | 1030 | 274 | 193 | 635 |
| MH02250 | Trib Mouth | 3/25/2002 | 2.96 | 1140 | 166 | 190 | 379 |

Recommendation

Create positive drainage by opening spoil blocks, fill subsidence holes, and construct OLCs and LLBs to treat AMD discharge. More water quality monitoring is needed.

VII. MH 01 – Tributary (north branch)

Location

The downstream sites can be accessed at Twp Road T345 (Coe Hollow Fruitdale Road), south of Carbon Hill. The upstream sites can be accessed from the USFS Dorr Run Trailhead west of Nelsonville. Located on USFS and private property. Most access limited to foot travel. A recently constructed USFS road provides access to the extreme western reaches of the headwaters.

Site Description

The north branch (MH 01) is the least impacted of the three tributaries. Surface mining occurred in the headwaters of this drainage resulting in creation of highwalls and a lack of positive drainage in the extreme upper reaches of the drainage. The headwaters of stream MH 01, flows into a large wetland (sample site MH 01500), west of a USFS access road. Water quality samples collected in June 2002 at the wetland suggest the headwaters of the north branch are minimally impacted with a pH above 6 and a net alkaline status (41.6 mg/l). Immediately downstream of the wetland and access road, the stream receives a substantial amount of AMD-impacted water flowing from a side drainage containing both surface and underground mines (sample site MH 01950). The stream then flows through a smaller wetland, leaves USFS property and flows past several residences. Another significant AMD discharge (sample site MH 01200) occurs downstream near a private residence. The AMD discharge originates in a side drainage containing 1 stream capture (approximately 38 acres providing recharge to underground mine complexes), a gob pile and several drift mine entries, one of which discharges AMD. The stream continues on past private residences, flows under State Route 278 into an open field, where it joins the mainstem and south branch. Samples were collected at the upstream wetland, tributary MH 01200 and the mouth of the north branch tributary in March 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| MH01500 | Wetland | 6/26/2002 | 6.77 | 321 | NM | 7.01 | Net Alkaline |
| MH01950 | Tributary | 3/19/2001 | 3.77 | 635 | 36 | 78.5 | 34 |
| MH01200 | Tributary | 3/19/2001 | 3.03 | 925 | 29 | 183 | 64 |
| MH01200 | Tributary | 3/25/2002 | 3 | 961 | 32 | 164 | 63 |
| MH01020 | Trib Mouth | 3/19/2001 | 4.7 | 325 | 346 | 39.4 | 163 |
| MH01020 | Trib Mouth | 3/25/2002 | 4.54 | 362 | 534 | 26.2 | 168 |

Recommendation
Install 2 SLBs for alkaline addition, upstream of MH 01200 and in wetland upstream USFS access road. Fill subsidence hole, construct OLCs and LLBs at MH 01950 to treat AMD discharge. More water quality monitoring is needed.

VIII. MH 00100 – Tributary (mouth)

Location
This site is located adjacent to and east to State Route 278, south of Carbon Hill. Located on private property.

Site Description
Tributaries south/ main and north branch join near State Route 278, flow through an open field and discharge into Monday Creek. MH 00100 (Monkey Hollow) tributary is an intermittent stream contaminated by AMD. Monkey Hollow contains unreclaimed highwalls, strip pits, subsidence features and deep mine seeps. Uncontaminated surface water is being lost to the underground mine complex. A total of five water quality samples have been collected at the tributary mouth from 2000-2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| MH00100 | Mouth | 10/19/2000 | 3.71 | 745 | 169 | 80.7 | 163 |
| MH00100 | Mouth | 2/7/2001 | 3.82 | 658 | 495 | 62.9 | 374 |
| MH00100 | Mouth | 4/4/2001 | 3.54 | 649 | 808 | 107 | 1038 |
| MH00100 | Mouth | 8/6/2001 | 3.39 | 918 | 220 | 124 | 327 |
| MH00100 | Mouth | 3/25/2002 | 3.84 | 575 | 1028 | 61.6 | 760 |

Recommendation
Construct wetland to treat AMD and precipitate metals if landowners are amenable or if the land can be acquired for long-term operation and maintenance.

## Bessemer Hollow

Location: Section 13, Ward Twp, Hocking County. Section 12 and 18 York Twp, Athens County.
Drainage area: 0.51 square miles; 330 acres
Stream Length: 0.90 miles (Intermittent)
USGS Quadrangles: Nelsonville
River Mile: 3.86
Percent Acid Load into Monday Creek: 4%
Ownership: Private and public (USFS)
Land owned by USFS: 69%, 226 acres

### Basin Assessment

Bessemer Hollow is located in the southwest section of the Monday Creek Watershed between the city of Nelsonville and the village of Buchtel. A long-term monitoring site is located in Monday Creek, upstream of the Bessemer Hollow tributary at RM 4.3 (LTM 151). Approximately 70% of the Bessemer Hollow sub-watershed contains underground and/or surface mined areas. The sub-watershed contains exposed gob piles, strip pits, highwalls, subsidence features, blocked drainages, losing streams and toxic seeps. Field reconnaissance performed in 1998 and 2001 resulted in the identification of 7 seeps with poor water quality. Mining in the sub-watershed occurred in the # 6 Middle Kittanning coal seam, with the average elevation of the coal seam at 760 ft. The topography of Bessemer Hollow is steep with the highest point in the sub-watershed located at an elevation of 1,020 ft. The mouth of the tributary discharges into Monday Creek at an elevation of 680 ft. The basin contains numerous private residences and only one road, Woodlane Drive ("Old Dump Road"), which lies within Nelsonville corporation limits.

### Historical Water Quality

In February 1998, MCRP performed field reconnaissance within the sub-watershed and water quality samples were collected at the mouth of Bessemer Hollow tributary. Results from the sampling show a pH of 3.3, a net acidity value of 125 mg/l and a calculated acid load of 1,095 lbs/day. Seven toxic seeps discharging AMD into the tributary were identified and water quality samples were collected in March, 1998. Based on these sampling results, three seeps, as well as upstream and downstream sites, were monitored for six consecutive months in 1999. Additional sampling was performed quarterly at the mouth of Bessemer Hollow in 2000-2001. In 2001, OEPA collected water quality samples near the mouth of the tributary. The highest pH value recorded at the mouth of Bessemer Hollow to date is 3.5. The Bessemer Hollow sub-watershed is classified as a priority sub-watershed.

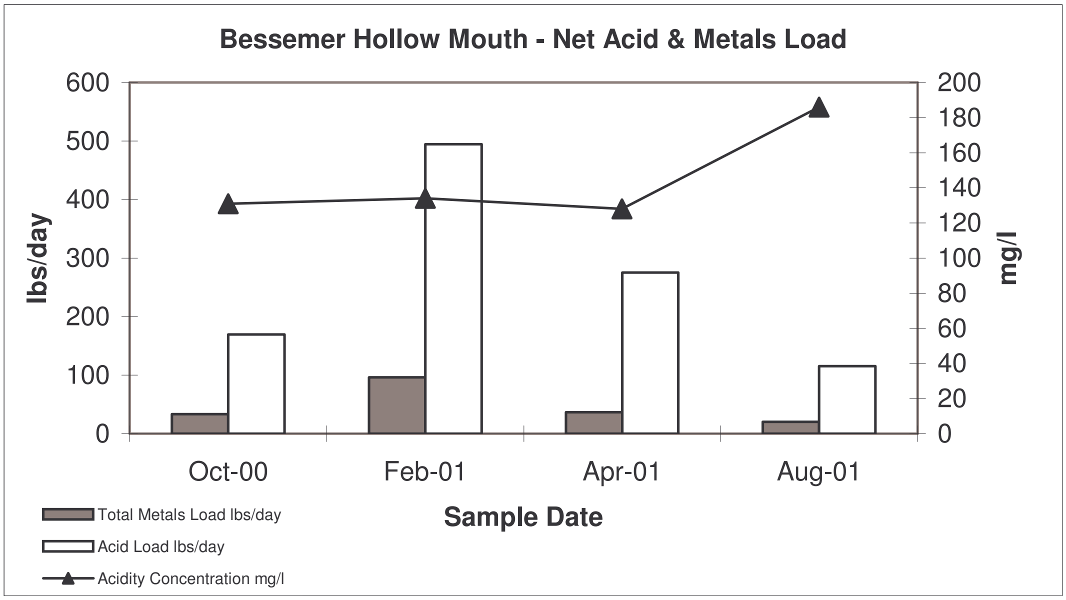


Figure 26: Bessemer Hollow Net Acid & Metals Load

**Water Quality Impacts on Monday Creek**

Based on the October 2000 mass balance in Monday Creek, it is estimated that Bessemer Hollow contributes 4% (169 lbs/day) of the acid load to Monday Creek at base flow. The long-term monitoring site, LTM 151 (RM 4.3) in Monday Creek, upstream of Bessemer Hollow tributary, records an average pH value of 6.4 and average alkalinity value of 6 mg/l. Downstream of Bessemer Hollow at LTM 108 (RM 1.7), Monday Creek records an average pH value of 5.2 and average alkalinity value of 5 mg/l. LTM 108 has been monitored since 1997, records indicate a pH range of 3.6 to 6.3 and an acidity range of 5-76 mg/l. It is difficult to quantify the negative impact Bessemer Hollow has on Monday Creek's riparian habitat and biological performance due to the cumulative effect of the downstream Coe Hollow discharge and the close proximity of Snow Fork mouth. Over a water year, this tributary contributes between 30 to 1,095 lbs/day of acid to Monday Creek mainstem.

In the summer of 2001, OEPA performed water quality sampling for a TMDL study in the Monday Creek Watershed. One location was selected for water quality analysis within the Bessemer Hollow sub-watershed. 2002 results confirm that this sub-watershed is severely impacted by AMD and meets requirements for classification as Limited Resource Water (LRW).

Table 14: OEPA TMDL (2001) Monday Creek Sampling Sites

| Location | River Mile | IBI | ICI | QHEI |
|---|---|---|---|---|
| Monday Creek (upstream) | 4.3 | 21 | 24 | 66 |
| Monday Creek (downstream) | 3 | 13 | Poor | 73.5 |
| Monday Creek (downstream) | 1.7 | 14 | 12 | 54.5 |

**Bessemer Hollow Water Quality Investigation**

The Bessemer Hollow sub-watershed contains a mainstem and two small side drainages, all of which are intermittent due to the size of the drainage area. Underground mines are located throughout the watershed. Surface mining occurred in the mid to lower reaches of the basin. A small drainage located on the west side of the main stem is blocked by spoil with a subsidence hole located immediately behind it. The subsidence captures approximately 28 acres of surface run-off. The upstream / headwaters area of the mainstem lacks positive drainage due to a spoil block and stream capture resulting in approximately 60 acres providing recharge to underground mine complexes. In general, AMD discharging in the upper reaches of the basin correlate with locations of drift mine entries from As-03, a 390-acre mine complex that underlies Monkey, Snake and Bessemer Hollows.

In the mid to lower reach of the basin, surface mine operations created highwalls, strip benches, and piles of coal waste which are located in or near the stream channel. The majority of AMD discharging in this section of Bessemer Hollow occurs beneath highwalls or near the perimeter of surface mined areas, and also correlates with deep mine entries. Discharge sites oriented on the north side of the mainstem are located down dip of an 82-acre mine complex that underlies both Snake and Bessemer Hollows.

The mainstem flows adjacent to the road and most sites can be accessed easily by foot. All sites discharging that have been identified (to date) are located on USFS property. While the figures below reflect the average loads, several sites have only been sampled once. Due to the limited sampling performed within the basin, a characterization by acid load contribution has not been successful to date. Future sampling should include seeps BS 00450, BS 00657, any sources yet to be identified as well as a high and low flow sampling event.

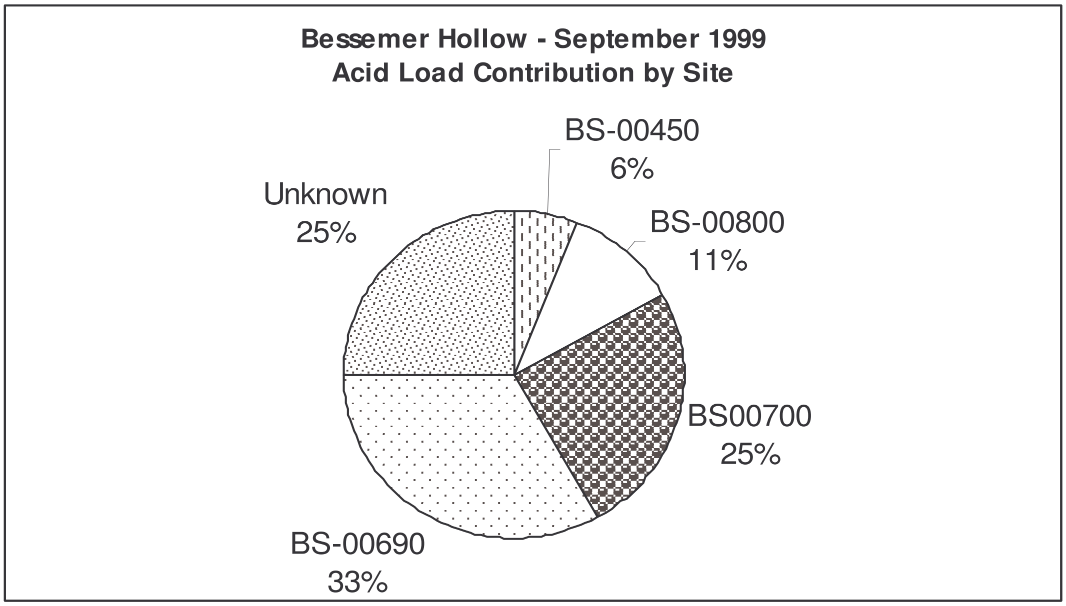


Figure 27: Bessemer Hollow Acid Loading

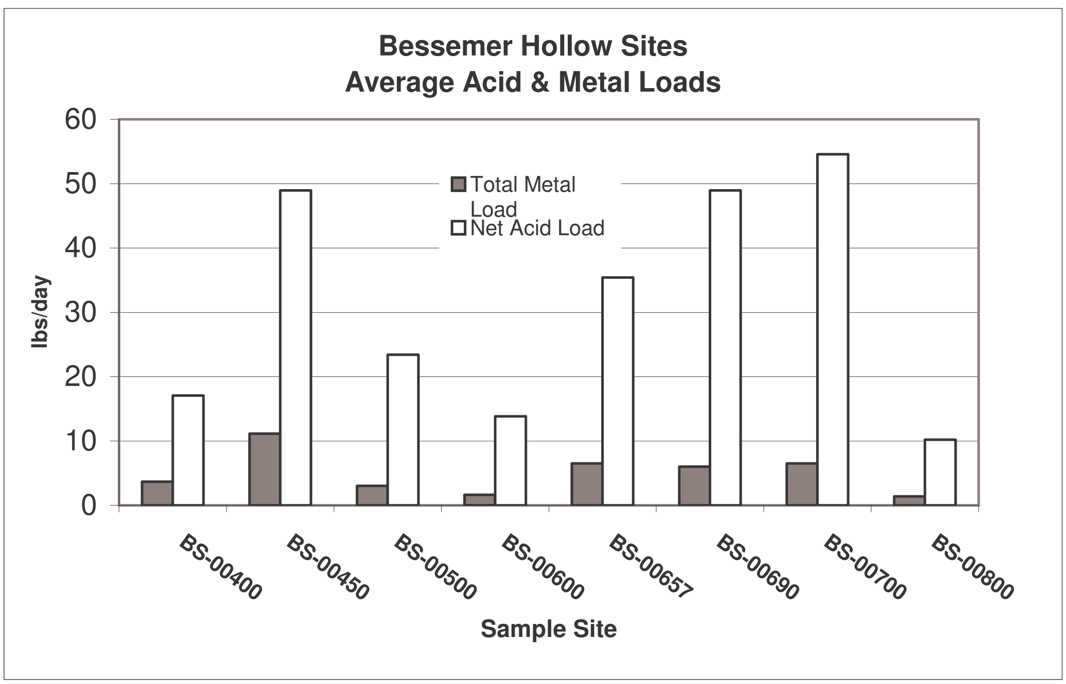


Figure 28: Bessemer Hollow Average Acid & Metal Loads

**Site Descriptions and Treatment Recommendations**

I. BS 00800 – Tributary (Bes-79 upstream)

Location
This site is adjacent to Woodlane Drive. Located on USFS property, immediately off roadside at culvert.

Site Description
BS 00800 is the upstream section of the tributary. BS 00800 is an intermittent stream which is completely captured into a deep mine portal, adjacent to the stream. Approximately 60 acres in the headwaters provide recharge to underground mines. Downstream of the portal, the valley bottom is blocked by spoil. AMD contaminated water discharges or upwells into the existing stream channel (near a drift mine opening) and meanders through the marshy valley floor until it reaches the road. The stream is routed under the roadway via a culvert.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BS00800 | Tributary | 4/30/1999 | 3.4 | 827 | 15 | 120 | 21 |
| BS00800 | Tributary | 5/26/1999 | 3.5 | 862 | 11 | 120 | 15 |
| BS00800 | Tributary | 6/28/1999 | 2.9 | 1002 | 4 | 150 | 7 |
| BS00800 | Tributary | 7/18/1999 | 3.1 | 955 | 2 | 120 | 3 |
| BS00800 | Tributary | 8/8/1999 | 3.2 | 1016 | 6 | 130 | 9 |
| BS00800 | Tributary | 9/19/1999 | 3.2 | 1134 | 2 | 160 | 3 |
| BS00800 | Tributary | 10/1/2002 | 3.3 | 1080 | 4 | 144 | 7 |

Recommendation
Suggested remediation for BS 00800 is to create positive drainage, and close the subsidence feature which captures surface water. Install SLB upstream in headwater area.

II. BS 00700/00690 - AMD Discharge (Bes-78 and 77)

Location
This site is located on the south side of the road. Access is limited to foot travel. Located on USFS property, approximately 150 ft from the road.

Site Description
BS 00700, 00690 and 00680 are deep mine seeps, which discharge below an old access road, close to the stream channel. The topography consists of slumps, slides, and piles of coal waste. While there are three points of discharge at various elevations, water quality is similar at all three sites. Seeps BS 00700 and 00690 were sampled for six months in 1999. Flows range from 2 to 43 gpm. However, the seep oriented at the lowest elevation has not been monitored. These seeps are located in a poor site for reclamation due to the limited space and close proximity to stream channel.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BS00690 | Seep | 3/8/1998 | 3.0 | 1414 | 44 | 286 | 149 |
| BS00690 | Seep | 4/30/1999 | 2.6 | 1627 | 20 | 370 | 87 |
| BS00690 | Seep | 5/26/1999 | 3.0 | 1637 | 14 | 380 | 65 |
| BS00690 | Seep | 6/28/1999 | 2.4 | 1779 | 6 | 420 | 30 |
| BS00690 | Seep | 7/18/1999 | 2.8 | 1715 | 4 | 400 | 17 |
| BS00690 | Seep | 8/8/1999 | 3.0 | 1793 | 3 | 380 | 15 |
| BS00690 | Seep | 9/19/1999 | 3.1 | 1796 | 2 | 380 | 10 |
| BS00690 | Seep | 10/1/2002 | 2.8 | 1800 | 4 | 399 | 17 |
| BS00700 | Seep | 3/6/1999 | 3.0 | 1478 | 30 | 290 | 105 |
| BS00700 | Seep | 4/30/1999 | 2.6 | 1504 | 43 | 330 | 170 |
| BS00700 | Seep | 5/26/1999 | 2.8 | 1582 | 12 | 380 | 54 |
| BS00700 | Seep | 6/28/1999 | 2.6 | 1746 | 4 | 420 | 21 |
| BS00700 | Seep | 7/18/1999 | 2.8 | 1725 | 3 | 390 | 13 |
| BS00700 | Seep | 8/8/1999 | 2.9 | 1797 | 2 | 400 | 12 |
| BS00700 | Seep | 9/19/1999 | 3.0 | 1749 | 2 | 400 | 8 |

Recommendation
Currently, there is no remediation recommended for this site. More water quality monitoring is needed at high flow. Possible LLBs.

III. BS 00657 - AMD Discharge (Bes-76BP)

Location
This site is located on the south side of the road. Access is limited to foot travel. Located on USFS property.

Site Description
BS 00657 is a deep mine seep and discharging pit located under a highwall near the front of a small drainage. This drainage is blocked by spoil and a subsidence hole is located behind it, which captures approximately 28 acres of surface run-off. One sample was collected in 2002. This site appears to be a significant source of contamination. The discharge site is oriented in a manner that is conducive to treatment.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BS00657 | Seep | 10/1/2002 | 3.2 | 982 | NM | 220 | NM |

Recommendation
Currently, there is no remediation recommended for this site. More water quality monitoring is needed. Possible LLB and OLC.

IV. BS 00600 - AMD Discharge (Bes-75)

Location
This site is located on the north side of the road. Access is limited to foot travel. Located on USFS property.

Site Description
BS 00600 is a deep mine seep oriented on the hillside north of Woodlane Drive. This site was sampled once in 1998 and again in 2002. Flow at this seep varies seasonally. This seep is located in a poor site for reclamation due to the limited space available.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BS00600 | Seep | 3/6/1998 | 3.3 | 777 | 13 | 153 | 23 |
| BS00600 | Seep | 10/1/2002 | 3.1 | 1030 | 2 | 172 | 5 |

Recommendation
Currently, there is no remediation recommended for this site.

V. BS 00480 - AMD Discharge (strip pit)

Location
This site is located on the south side of the road. Access is limited to foot travel. Located on USFS property.

Site Description
BS 00480 is a discharging strip pit located beneath a highwall. This seep flows over the hillside directly into the stream channel. This site has not been sampled. This seep is located on the bench with a distance of 100 ft or less to the stream channel. The discharge site is oriented in a manner that is conducive to treatment.

Recommendation
Currently, there is no remediation recommended for this site. More water quality monitoring is needed.

VI. BS 00450 - AMD Discharge (Bes-72)

Location
This site is located on the north side of the road. Access is limited to foot travel. Located on USFS property.

Site Description
BS 00450 is a deep mine seep located below a highwall. This seep discharges from a slumped mine entry and flows down the hillside into a road ditch, where it is routed via a culvert under Woodlane Drive to the main stream channel. This site was sampled for six months in 1999. The discharge site is oriented in a manner that is conducive to treatment.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BS00450 | Seep | 2/26/1998 | 3.7 | 363 | 266 | 45 | 144 |
| BS00450 | Seep | 4/30/1999 | 3.1 | 828 | 106 | 120 | 153 |
| BS00450 | Seep | 5/26/1999 | 3.4 | 822 | 23 | 130 | 36 |
| BS00450 | Seep | 6/28/1999 | 3.0 | 899 | 3 | 140 | 5 |
| BS00450 | Seep | 7/18/1999 | 3.2 | 811 | 1 | 140 | 2 |
| BS00450 | Seep | 8/8/1999 | 3.4 | 995 | 0 | 150 | 1 |
| BS00450 | Seep | 9/19/1999 | 4.0 | 937 | 1 | 160 | 2 |
| BS00450 | Seep | 10/1/2002 | 3.3 | 912 | 1 | 146 | 2 |

Recommendation

Currently, there is no remediation recommended for this site. Possible LLB and OLC.

VII. BS 00400 - AMD Discharge (Bes-71)

Location

This site is located on the south side of the road. Access is limited to foot travel. Located on USFS property.

Site Description

BS 00400 is a deep mine seep that meanders behind a half-acre gob pile before discharging into the stream channel. This site was sampled once in 1998. This seep is located in a poor site for reclamation due to the limited space available.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BS00400 | Seep | 2/25/1998 | 3.3 | 933 | 9 | 151 | 17 |

Recommendation

Currently, there is no remediation recommended for this site. Possible reclamation of gob pile and OLC at seep location.

VIII. BS 00100– Tributary (Bes-74 mouth)

Location

This site is adjacent to Woodlane Drive. Located on private property adjacent to Monday Creek, approximately 1,000 ft from the road.

Site Description

BS 00100 (Bessemer Hollow) tributary flows behind several private residences and into an open field were it then discharges into Monday Creek near State Route 78. BS 01000 is an intermittent stream contaminated by AMD. This tributary contains highwalls, spoil blocks, subsidence features and deep mine seeps. Uncontaminated surface water is being lost to the underground mine complex. There are nine seeps located in the drainage. A total of nine water quality samples have been collected at the tributary mouth from 1998-2002. Load is very flow dependent and shows exceptional variation.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BS00100 | Trib Mouth | 2/26/1998 | 3.3 | 851 | 730 | 125 | 1095 |
| BS00100 | Trib Mouth | 4/30/1999 | 2.9 | 969 | 312 | 160 | 599 |
| BS00100 | Trib Mouth | 5/26/1999 | 3.0 | 1010 | 107 | 190 | 244 |
| BS00100 | Trib Mouth | 6/28/1999 | 2.7 | 1121 | 42 | 270 | 136 |
| BS00100 | Trib Mouth | 7/18/1999 | 3.0 | 1172 | 11 | 230 | 30 |
| BS00100 | Trib Mouth | 8/8/1999 | 3.1 | 1185 | 69 | 220 | 181 |
| BS00100 | Trib Mouth | 9/19/1999 | 3.2 | 1188 | 11 | 240 | 31 |
| BS00100 | Trib Mouth | 10/19/2000 | 3.3 | 887 | 108 | 131 | 171 |
| BS00100 | Trib Mouth | 10/1/2002 | 3.1 | 1180 | 19 | 227 | 51 |

Recommendation

Currently, there is no remediation recommended for this site. See above recommendations for SLB, LLBs and OLCs.

## Coe Hollow

Location: Section 11, York Twp, Athens County.
Drainage area: 0.21 square miles; 131 acres
Stream Length: 0.64 miles
USGS Quadrangles: Nelsonville
River Mile: 2.7
Percent Acid Load into Monday Creek: 10%
Ownership: Private and public (USFS)
Land owned by USFS: 97%, 124 acres

### Basin Assessment

Coe Hollow is located in the southern part of the Monday Creek Watershed between the city of Nelsonville and the village of Buchtel. While the sub-basin is small, approximately 58% of Coe Hollow contains underground-mined areas. Field reconnaissance performed in 2001 documented numerous slumps on hillsides, dissipating or losing streams, one subsidence hole in the main-stem and north tributary, slumped mine entries, a small gob pile located in and adjacent to the stream channel, as well as several seeps discharging AMD at stream level. The topography of Coe Hollow is steep with the highest point in the sub-watershed located at an elevation of 944 ft. The mouth of the tributary discharges into Monday Creek at an elevation of 680 ft. Mining in the sub-watershed occurred in the #6 Middle Kittanning coal seam, with the average elevation of the coal seam at 710 ft.

Coe Hollow is oriented to the southeast of a 200-acre underground mine complex (As-77) which extends to the city of Nelsonville, Ohio. While only 62 acres of the mine complex lie in Coe Hollow, this portion of the mine lies at the lower elevation of the complex (down dip). The result is a substantial quantity of contaminated mine water discharging in the valley bottom, suggesting that inter-basin transfer is occurring and discharging into the sub-watershed. A smaller underground mine, As-33 (13 acres), located on the north side of Coe Hollow. There is no record of surface mining in the drainage. Due to the significant amount of surface disturbance and observation of numerous slumped mine entries not recorded, it is clear that historical underground mine maps are not complete.

ODNR-Division of Mineral Resources Management performed limited reclamation in Coe Hollow during the 1980s. ODNR-DMRM closed a stream capture in the mainstem and installed a mine drain at location CH 00500. However, the subsidence has since re-opened and the mine drain is no longer visible due to sedimentation and pooling water. Digital map files indicate Coe Hollow lies within the corporation limits of the city of Nelsonville.

**Historical Water Quality**

In the October 2000, MCRP performed a mass balance in Monday Creek. At that time, Coe Hollow was identified as an AMD-affected tributary. A water quality sample and flow measure was collected at the mouth of the tributary. Based on the October 2000 sampling event, it is estimated that Coe Hollow contributes 10% (359 lbs/day) of the acid load to Monday Creek at base flow. Results from the sampling show a pH of 2.7 and a net acidity value of 399 mg/l. MCRP records indicate the net acidity value of 399 mg/l is a particularly high value for a tributary in the watershed and is more commonly seen at seep locations. The laboratory analysis resulted in Coe Hollow sub-watershed being classified as a priority sub-watershed, warranting further investigation and chemical analysis. From 2000 to 2001, MCRP performed quarterly monitoring at the mouth of Coe Hollow tributary. In the spring of 2002, a mass balance was performed in the sub-watershed. The highest pH value recorded at the mouth of Coe Hollow to date is 3.0. Coe Hollow tributary is severely impacted by AMD and meets requirements for classification as Limited Resource Water (LRW).

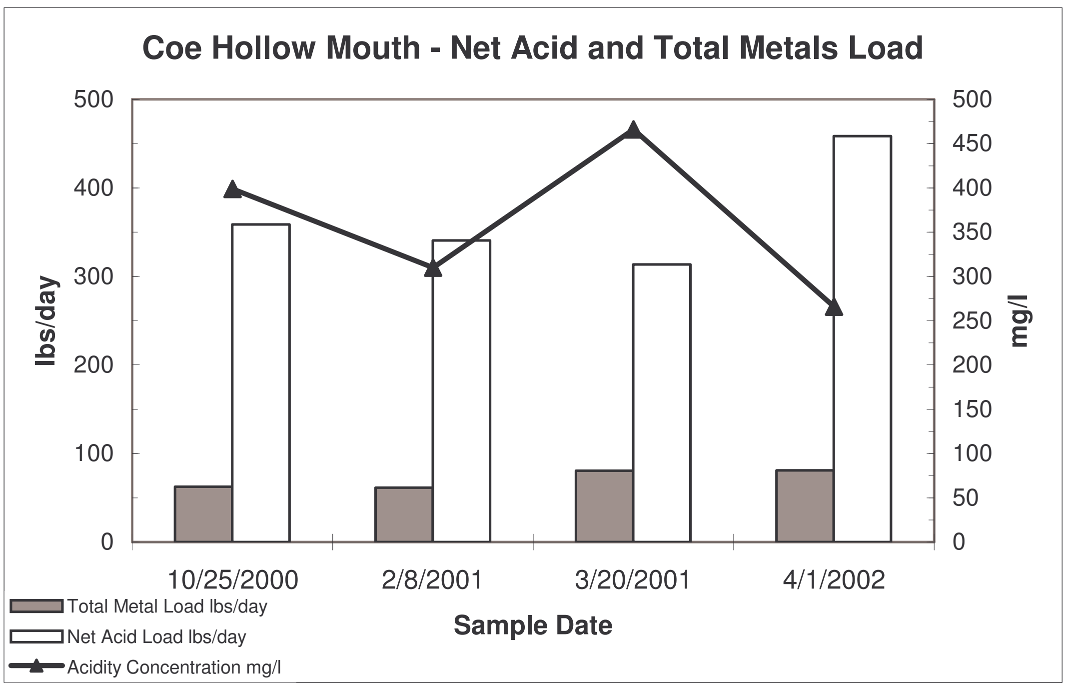


Figure 29: Coe Hollow Net Acid & Metal Loads

Long-term monitoring site LTM 108 in Monday Creek (one mile downstream of Coe Hollow tributary) has an average net acidity load of 2,082 lbs/day and an average total metal load of 350 lbs/day at base flow. Coe Hollow contributes an average of 359 lbs/day of net acidity and an average total metal load of 60 lbs/day at base flow. Data collected at LTM 108 in Monday Creek records an average pH value of 5.2 and average alkalinity value of 5 mg/l. LTM 108 was monitored quarterly between 1997 and 2003 and monitoring continues on a semi-annual basis. Records indicate a pH range of 3.6 to 6.3

and an acidity range of 5-76 mg/l. Acid flows from Coe Hollow cause substantial impairment to the last 2.7 miles of Monday Creek.

It is difficult to accurately quantify the negative impact Coe Hollow has on Monday Creek's riparian habitat and biological performance due to the cumulative effect of the numerous upstream (AMD) discharges and the close proximity of Snow Fork mouth. OEPA TMDL data collected in the mainstem confirm very poor aquatic health in the last three miles of Monday Creek, with all biological scores lying within LRW classification.

Table 15: OEPA TMDL (2001) Monday Creek Sampling Sites

| Location | River Mile | IBI | ICI | QHEI |
|---|---|---|---|---|
| Monday Creek (upstream) | 4.3 | 21 | 24 | 66 |
| Monday Creek (upstream) | 3 | 13 | Poor | 73.5 |
| Monday Creek (downstream) | 1.7 | 14 | 12 | 54.5 |
| Monday Creek (downstream) | 0.7 | 12 | 16 | 68.5 |

**Coe Hollow Water Quality Investigation**

The Coe Hollow sub-watershed contains a main-stem and two small tributaries, all of which are intermittent due to the size of the drainage area. Preliminary observations confirmed that the streams were intact in the upper reaches of the hollow, however, water in the tributaries did not reach the mainstem located in valley bottom. The valley bottom is disturbed with numerous slumped areas (probably from the collapse of overburden) impairing any natural drainage pattern of surface water, which is then lost into underground mines. A small stream capture was documented in the mainstem, resulting in complete capture of the mainstem headwaters and tributary CH 02 at low flow. A mine drain is located approximately 300 ft downstream, adjacent to the stream channel. The stream channel then becomes wider, deeper and receives discharge from two discreet seeps, as well as diffuse flow from stream banks. Due to the depth of the channel, it is likely that the channel is receiving base flow (or upwelling) from the mine pool. Further downstream, a coal refuse pile is located in and adjacent to the stream channel. The stream meanders past the pile and through a wetland, crosses under County Road 1A and discharges into Monday Creek.

Due to the stream capture and pervasive disturbance, a comprehensive mass balance could not be performed in the sub-watershed, however, samples were collected at seeps and downstream of the gob pile.

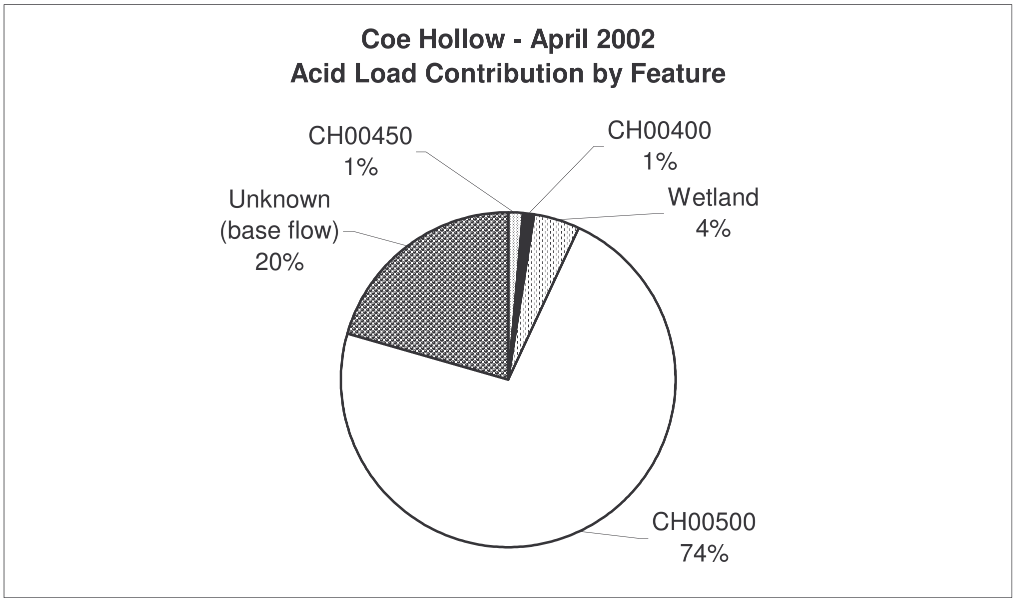

Figure 30: Coe Hollow Acid Load Contributions

**Site Descriptions and Treatment Recommendations**

I. CH 01 – Tributary (south tributary)

Location
Located on USFS property. Access is limited to foot travel.

Site Description
CH 01 is a small tributary located toward the south side of the sub-watershed. Field observations confirm this is a losing stream and lacks a discreet stream channel as it nears confluence with the mainstem.

Recommendation
Regrade stream channel to establish positive drainage, install impervious stream liner, install a slag leach bed (SLB), and utilize water as a source for alkaline addition to the acid waters of Coe Hollow mainstem.

II. CH 02 – Tributary (north tributary)

Location
Located on USFS property. Access is limited to foot travel.

Site Description
CH 02 is a small tributary located on the north side of the sub-watershed. Field observations confirm this is a losing stream and lacks a discreet stream channel as it nears confluence with Coe Hollow's mainstem. A subsidence hole was identified in the channel in December 2003, resulting in partial capture of runoff during high flow conditions.

Recommendation
Regrade stream channel to establish positive drainage, fill and seal subsidence, install impervious stream liner, and utilize fresh water for alkaline addition.

III. Stream Capture (mainstem)

Location
Located on USFS property. Access is limited to foot travel.

Site Description
A stream capture located in the main stream channel, downstream of CH 02 trib, results in the capture of run-off from approximately 75 acres of the drainage.

Recommendation
Regrade stream channel to establish positive drainage, fill and seal subsidence, install impervious stream liner, install SLB, and utilize water for alkaline addition to main stream channel.

IV. CH 00500 – AMD discharge (mine drain)

Location
Located on USFS property. Access is limited to foot travel.

Site Description
CH 00500 is a seep (specifically a wet mine seal installed by ODNR-DMRM) located on the north side of the sub-watershed, and adjacent to a drift entry of mine As-33. Contaminated mine water is upwelling into a pool approximately 10 ft x 30 ft and immediately discharges into the main stream channel. CH 00500 accounts for approximately 74% of AMD in Coe Hollow at high flow.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| CH00500 | Seep | 3/20/2001 | 3.1 | 755 | 130 | 182 | 285 |
| CH00500 | Seep | 4/1/2002 | 2.7 | 1040 | 153 | 251 | 338 |
| CH00500 | Seep | 9/30/2002 | 3.1 | 1190 | 19 | 224 | 41 |

Recommendation
Install a limestone leach bed (LLB) and open limestone channel (OLC) to treat AMD.

V. CH 00450 - AMD discharge (Coe A, diffuse seeps on stream bank)

Location
Located on USFS property. Access is limited to foot travel.

Site Description
CH 00450 is a seep located on the south bank of the main stream channel. The seep is diffuse in nature, and is located approximately 40 ft to the northwest of seep CH 00400, and is situated at a lower elevation. At low flow, discharge was observed at approximately five different points along the stream bank. However, cumulative flow was less than 5gpm and difficult to measure. Discharge at the adjacent seep, CH 00400, has only been observed during high flow conditions. Due to the close proximity and similar water quality of the two discharges, it is likely both seeps are driven by the same source.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| CH00450 | Seep | 3/20/2001 | 3.1 | 1050 | 4.3 | 209 | 11 |
| CH00450 | Seep | 4/1/2002 | 2.6 | 1690 | 1.3 | 388 | 6 |
| CH00450 | Seep | 9/30/2002 | 3.0 | 2030 | 0.4 | 391 | 2 |

Recommendation
Install LLB and OLC to treat AMD.

VI. CH 00400 - AMD discharge (Coe C, portal on hillside)

Location
Located on USFS property. Access is limited to foot travel.

Site Description
CH 00400 is a seep located on a hillside situated to the south of the main stream channel. To date, MCRP has not been able to collect adequate data at this location, due to its unpredictable flow patterns. However, moderate flow has been observed at this location on three occasions. AMD discharges from two small portals and flows into CH 01 tributary, near its confluence with the main channel.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| CH00400 | Seep | 9/30/2002 | 3.1 | 1720 | 1 | 300 | 3 |

Recommendation
Install LLB and OLC to treat AMD.

VII. CH 00200 - Tributary (downstream)

Location
Located on USFS and private property. Access is limited to foot travel.

Site Description
CH 00200 is the downstream section of the Coe Hollow tributary, located downstream of all discreet AMD discharges identified. Flow measurements obtained at this site indicate that it is likely AMD-contaminated water is upwelling from the mine pool into the stream channel due to elevation of the coal seam.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| CH00200 | Tributary | 4/1/2002 | 2.7 | 1260 | 121 | 302 | 439 |
| CH00200 | Tributary | 9/30/2002 | 3 | 1910 | 100 | 382 | 459 |

Recommendation
Install aerobic wetland and rock dams for aeration to precipitate metals. Upstream SLBs will provide alkalinity upstream.

VIII. CH 00100 - Tributary (mouth)

Location
Located on private property, adjacent to Twp Road 1A. Access is limited to foot travel.

Site Description
CH 00100 (Coe Hollow) tributary flows under Twp Road 1A and discharges into Monday Creek. CH 00100 is an intermittent stream contaminated by AMD. This tributary contains subsidence features and deep mine seeps. Uncontaminated surface water is being lost to the underground mine complex. A total of five water quality samples have been collected at the tributary mouth from 2000-2002.

| Site ID | Site Type | Sample Date | pH | Conductivit y uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| CH00100 | Trib Mouth | 10/25/2000 | 2.7 | 1790 | 75 | 399 | 359 |
| CH00100 | Trib Mouth | 2/8/2001 | 3 | 1350 | 92 | 310 | 342 |
| CH00100 | Trib Mouth | 3/20/2001 | 2.8 | 1760 | 56 | 466 | 313 |
| CH00100 | Trib Mouth | 7/10/2001 | 2.5 | 1357 | 85 | 368 | 375 |
| CH00100 | Trib Mouth | 4/1/2002 | 2.8 | 1240 | 144 | 266 | 460 |

Recommendation
Currently, there is no suitable remediation recommended for this site. See above recommendations for SLB, LLBs and OLCs.

## Rock Run

Location: Section 17, 21 and 20, 28, 29, Salt Lick and Coal Twp. Perry County.
Drainage area: 2 square miles; 1,283 acres
Stream Length: 2 miles (Intermittent)
USGS Quadrangles: New Straitsville
River Mile: 23.4
Percent Acid Load into Monday Creek: 2%
Ownership: Private and public (USFS)
Land owned by USFS: 87%, 1,122 acres

### Basin Assessment

Rock Run is located in the northeast section of the watershed between the villages of Shawnee and New Straitsville. A long-term monitoring site is located immediately downstream of the Rock Run tributary at RM 23.1 (LTM 127). Approximately 53% of the Rock Run sub-watershed contains underground and/or surface mined areas. Mining in the sub-watershed occurred in the # 6 Middle Kittanning coal seam, with the average elevation of the coal seam at 880 ft. The sub-watershed contains exposed gob piles, strip pits, highwalls, losing streams and toxic seeps. To date, only four significant sources of AMD have been identified in the sub-watershed. The topography of Rock Run is steep with the highest point in the sub-watershed located at an elevation of 1,020 ft. The mouth of the tributary discharges into Monday Creek at an elevation of 760 ft.

The headwaters of Rock Run drainage (east of State Route 93) lacks positive drainage due to spoil blocks and losing streams. Approximately 300 acres of the Rock Run headwaters is lost to underground mines. West of State Route 93, at deep mine seep RR 00820 (Rock Run-24), a 900 ft OLC was constructed to remediate AMD discharging from a small side drainage. Rock Run tributary then flows through several beaver ponds and wetland areas until it reaches a reclaimed gob pile. Rock Run gob pile (13 acres) was reclaimed in 1999 by MCRP and ODNR-DMRM. Deep mine seeps located in the drainage behind the gob pile are being treated by a SAPS system. The treated alkaline discharge is routed away from the gob pile in an OLC and flows into the tributary immediately upstream of the pile. Downstream of the gob pile, Rock Run tributary receives discharge from a side drainage containing several strip pits with poor water quality. The tributary then flows through a large wetland area inundated with coal refuse and discharges into Monday Creek.

### Historical Water Quality

Based on the October 2000 mass balance in Monday Creek, it is estimated that Rock Run contributes 2% (87 lbs/day) of the acid load to Monday Creek at base flow. In 2001, MCRP monitored the mouth of Rock Run tributary quarterly for one year. Based on that data, the average pH at the mouth is 4.9 and the average acid load is 200 lbs/day.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| RR00020 | Trib Mouth | 7/27/2000 | 3.2 | 1380 | 96 | 85 | 98 |
| RR00020 | Trib Mouth | 10/18/2000 | 5.1 | 1080 | 145 | 50 | 87 |
| RR00020 | Trib Mouth | 2/7/2001 | 5.3 | 925 | 291 | 48 | 167 |
| RR00020 | Trib Mouth | 4/2/2001 | 4.7 | 860 | 384 | 72 | 334 |
| RR00020 | Trib Mouth | 8/7/2001 | 4 | 1490 | 162 | 103 | 200 |
| RR00020 | Trib Mouth | 12/10/2001 | 5.7 | 1150 | 162 | 52 | 101 |

**Recommendation**

Establishing positive drainage in the headwaters of the sub-watershed could further enhance water quality at Rock Run. Coal waste deposited in the downstream wetland should be moved away from the stream channel. Construction of rock dams, incorporated with alkaline material, could treat remaining acidity. Water quality sampling should be conducted at this site to determine if additional treatment is warranted.

## Snow Fork

Location: Section 1, 2, 3, 4 Ward Twp, Hocking County. Section 12, York Twp, Section 31, 32, 33 Trimble Twp, Athens County.
Drainage area: 6.89 square miles; 4,407 acres
Stream Length: 10.7 miles
USGS Quadrangles: Nelsonville and New Straitsville
River Mile: 3.45
% Acid Load into Monday Creek: 30%
Ownership: Private and public (USFS)
Land owned by USFS: 44%, 1,952 acres

### Basin Assessment

Snow Fork is located in the southeast section of the Monday Creek Watershed between the villages of New Straitsville and Buchtel. Snow Fork tributary discharges into Monday Creek near RM 3.45. Approximately 67% of the Snow Fork sub-watershed contains underground and/or surface mined areas. The sub-watershed contains exposed gob piles, strip pits, highwalls, subsidence features, open mine portals and toxic seeps. Mining in the sub-watershed occurred in the # 6 Middle Kittanning coal seam, with the average elevation of the coal seam at 700 ft. The topography of Snow Fork is fairly steep with the highest point in the sub-watershed located at an elevation of 1,000 ft. The mouth of the tributary discharges into Monday Creek at an elevation of 660 ft.

### Historical Water Quality

Snow Fork is the second largest tributary to Monday Creek. Snow Fork was identified as an AMD impacted tributary in 1997. Consequently, MCRP established three long-term monitoring sites in the tributary. The long-term monitoring sites are located at RM 6.2 (LTM 106), RM 4.3 (LTM 107) and RM 2.4 (LTM 109). The sites were monitored quarterly between 1997 and 2003 and monitoring continues on a semi-annual basis.
In October 2000, a mass balance was performed in the Monday Creek Watershed, resulting in characterization of acid load contribution in the Snow Fork basin as well as Monday Creek. Water quality samples were collected at seeps and streams flowing into Snow Fork at base flow conditions. From this sampling event, MCRP was able to calculate the amount of acid contributed from each site and estimate that particular site's contribution to the total acid load of Snow Fork. See figure below.

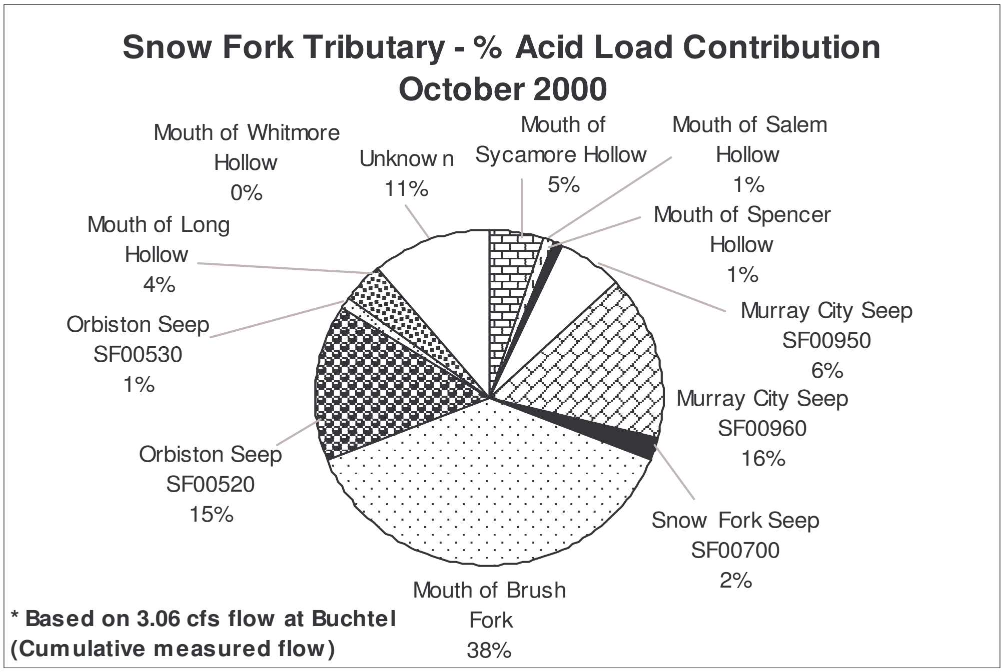


Figure 31: Snow Fork Acid Loading

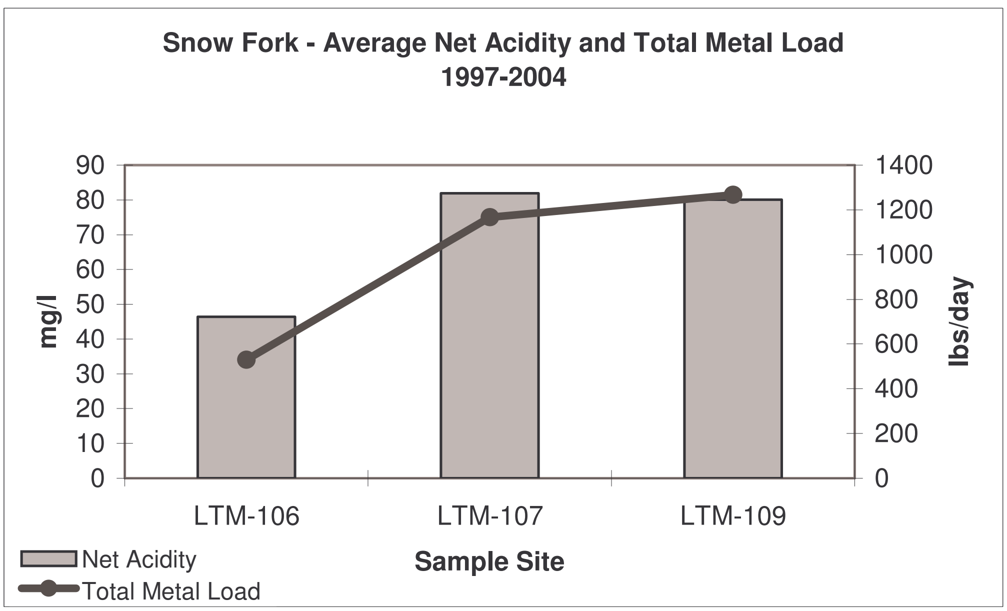


Figure 32: Snow Fork Net Acidity and Metal Load

In 2001, OEPA collected water quality samples and biological data at the LTM monitoring sites, as well as the mouth of Snow Fork. In the downstream section of Snow Fork tributary (last 6 miles), the average measured pH is 3.7. The Snow Fork sub-watershed is classified as a priority sub-watershed.

**Water Quality Impacts on Monday Creek**

Based on the October 2000 mass balance in Monday Creek, it is estimated that Snow Fork contributes 30% (1,930 lbs/day) of the acid load to Monday Creek at base flow. MCRP data collected at LTM 151 (RM 4.3) monitoring site in Monday Creek (located 0.9 miles upstream of Snow Fork tributary) records an average pH value of 6.2 and average alkalinity value of 16.1 mg/l. Downstream of the Monday Creek / Snow Fork confluence, at LTM 108, the average pH value declines to 5.3 with an average alkalinity value of 5.9 mg/l. Acid and metal concentrations in Monday Creek double after receiving flow from Snow Fork. Upstream of the confluence, the average net acid concentration is 6.7 mg/l and the average total metal concentration is 3.7 mg/l. Downstream at LTM 108, the net acid concentration is 17 mg/l and the average total metal concentration increases to 6.2 mg/l.

In the summer of 2001, OEPA performed biological and water quality sampling for a TMDL study in the Monday Creek Watershed. Three locations were selected for analysis within the Snow Fork sub-watershed. Sampling sites correlated with LTM sites. 2002 results confirm that Snow Fork is severely impacted by AMD and meets requirements for classification as Limited Resource Water (LRW).

Table 16: OEPA TMDL (2001) Monday Creek and Snow Fork Sampling Sites

| Location | River Mile | IBI | ICI | QHEI |
|---|---|---|---|---|
| Monday Creek (upstream) | 4.3 | 21 | 24 | 66 |
| Monday Creek (downstream) | 3.0 | 13 | 12 | 73.5 |
| Snow Fork | 6.2 | 12 | 1 | 43 |
| Snow Fork | 4.5 | 12 | 1 | 64.5 |
| Snow Fork | 2.4 | 12 | 1 | 58.5 |
| Snow Fork | 1.0 | 12 | 6 | 57.5 |

The biologic sampling site in Monday Creek at RM 3.0 (downstream of Snow Fork) documented a 38 % decline in the IBI index score and a 50 % decline in the ICI index score after joining with Snow Fork. In Monday Creek, sample sites both up and downstream of Snow Fork are not attaining the LRW classification. Due to the significant decline in index values, it is clear that Snow Fork's AMD contribution is degrading the biological health of Monday Creek, as well as contributing to the cumulative acid load in the last three miles of stream.

**Snow Fork Water Quality Investigation**

Sycamore Hollow, Salem Hollow and Spencer Hollow are the headwaters of the Snow Fork tributary. These streams converge above Murray City and form Snow Fork mainstem. All of these sub-watersheds are impacted by AMD.

Salem Hollow Run is a net alkaline stream. Two AMD sources in Salem Hollow have been documented near the mouth of tributary. However, neither source is causing significant water quality impairment. The tributary has an average pH value of 6.5 and contributes approximately 315 lbs/day of alkalinity to Snow Fork. Both underground and surface mining occurred in the sub-watershed.

Spencer Hollow tributary is a net acidic stream. Three AMD sources have been identified in this sub-watershed. The tributary has an average pH value of 3.8 and contributes approximately 119 lbs/day of acid to Snow Fork. Both underground and surface mining occurred in the sub-watershed. A surface mine in the basin was reclaimed in 2000.

Sycamore Hollow tributary (also known as Middle Fork) is a net acidic stream. The most significant source of AMD is located in an unnamed tributary located in the headwaters. The Essex Mine discharge has an average pH value of 4.8 and contributes approximately 800 lbs/day of acid to Sycamore Hollow tributary. AMD from this discharge flows 3.5 miles before reaching the confluence with Spencer and Salem Hollow. Both underground and surface mining occurred in the sub-watershed.

Once these three headwater streams join, Snow Fork flows south through Murray City. Seeps SF 00960 / 00970 (ball field) discharge into Snow Fork upstream of LTM 106. Downstream (approximately 1,000 ft) seep SF 00880 (Simon) discharges into Snow Fork. Below Murray City, Snow Fork receives AMD from seep SF 00700 (78 & New Pitts), Brush Fork tributary and seep SF 00600 (trailhead). LTM 107 is oriented downstream of these discharges. Downstream of LTM 107, the stream receives more AMD from SF 00520/00530 (Orbiston) and Long Hollow tributary. Snow Fork flows through the village of Buchtel and discharges into Monday Creek at RM 3.45. Seeps oriented along the mainstem of Snow Fork are located within 500 ft of the stream. These discharges are consistently oriented at low elevations, near the roadside, leaving little room for reclamation and treatment.

MCRP data collected in Snow Fork, at RM 6.2 (LTM 106) downstream of athletic fields in Murray City, exhibit an average pH value of 4.6 and average acidity value of 46 mg/l. Data collected downstream at RM 4.3 (LTM 107) and RM 2.4 (LTM 109) record an average pH value of 3.7 and average acidity value between 85-87 mg/l. Water quality data collected since 1997 document Snow Forks extremely degraded status from RM 6.2 to the confluence with Monday Creek (near Buchtel). Brush Fork tributary is the largest AMD source, contributing to the decline in water quality. Over a water year, Brush Fork contributes between 595 to 5,000 lbs of acid per day to Snow Fork mainstem.

**Site Descriptions and Treatment Recommendations**

I. SF 00950 /00960 – AMD Discharge (ball field seeps)

Location
Located in the village of Murray City. Access can be gained from Hack Street.

Site Description
SF 00950 and SF 00960 are located at mine entries located in the hillside at the Murray City athletic field. The two seeps discharge into a road ditch and are routed under the road via a culvert and discharge into Snow Fork. MCRP has performed short term and design level monitoring at these seeps from 1999-2002. ATC Associates performed an engineering study for the sites in 2004. The site is oriented southeast of underground mine Hg-016 (880 acres). Both seeps together have an average pH of 2.8 and discharge an average 382 lbs/day of acid and 96 lbs/day of total metals into Snow Fork. Combined, these seeps account for 21% of Snow Fork acid load at base flow.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| SF00950 | Seep | 2/16/2000 | 2.6 | 2170 | 156 | 603 | 1127 |
| SF00950 | Seep | 3/21/2000 | 2.4 | 2100 | 370 | 609 | 2703 |
| SF00950 | Seep | 11/18/2002 | 3.0 | 2150 | 23 | 611 | 168 |
| SF00950 | Seep | 12/10/2002 | 2.9 | 2190 | 15 | 610 | 112 |
| SF00960 | Seep | 2/16/2000 | 2.6 | 2090 | 43 | 595 | 306 |
| SF00960 | Seep | 3/21/2000 | 2.3 | 2120 | 48 | 613 | 357 |
| SF00960 | Seep | 11/18/2002 | 3.0 | 2220 | 29 | 611 | 211 |
| SF00960 | Seep | 12/10/2002 | 2.9 | 2290 | 27 | 606 | 199 |

Recommendation
Possible remediation for SF 00950/ 00960 could include a SAPS system to treat the discharge. However, in the recent past, the village of Murray City was not open to construction on the site. The discharges are oriented at low elevations, near the roadside, leaving little room for reclamation and treatment.

II. SF 00880 – AMD Discharge (Simon)

Location
Located in the village of Murray City. Access can be gained from Hack Street.

Site Description
SF 00880 is a mine entry located in the hillside, behind the Simon home on Hack Street in Murray City. The seep discharges behind the Simon home and is piped into Snow Fork. In 2004, ODNR-DMRM laid a 6-inch diameter pipe and rerouted the discharge around the home. Flow at this site increased from 50 gpm to 360 gpm, at the time of

construction. The site is oriented southeast of underground mine Hg-016 (880 acres) and Hg-130 (200 acres), underlying Brush Fork sub-watershed and Murray City.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| SF00880 | Seep | 4/2/2001 | 3.5 | 1440 | 58 | 208 | 146 |
| SF00880 | Seep | 7/15/2002 | 3.1 | 1630 | 54 | 347 | 224 |
| SF00880 | Seep | 10/18/2004 | 3.2 | 1620 | 363 | 413 | 1802 |

Recommendation
Currently, there is no suitable remediation recommended for this site. The discharge is oriented at a low elevation, in the village of Murray City, leaving little room for reclamation and treatment. Additional water quality monitoring is needed.

III. SF 00700 – AMD Discharge (78 and Jobs New Pittsburg)

Location
Located south of Murray City and north of CR-22 (Jobs New Pittsburg Road). Access can be gained from State Route 78.

Site Description
SF 00700 is a mine entry located on the hillside, beside State Route 78, south of Murray City. The seep discharges from a brick structure on the east side of the road and flows 100 ft, where it discharges into Snow Fork. The site is oriented southeast of underground mine Hg-016 (880 acres), underlying Brush Fork sub-watershed and Murray City.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| SF00700 | Seep | 10/23/2000 | 2.9 | 1090 | 15 | 159 | 29 |
| SF00700 | Seep | 5/6/2003 | 3.1 | 1040 | 198 | 132 | 314 |

Recommendation
Currently, there is no suitable remediation recommended for this site. The discharge is oriented at a low elevation, near State Route 78 and Snow Fork, leaving little room for reclamation and treatment. Additional water quality monitoring is needed.

IV. SF00600 – AMD discharge (USFS trailhead)

Location
Located south of Murray City across from Twp Road 558A (Goose Run Road). Access can be gained from State Route 78.

Site Description
SF 00600 is AMD discharging into road ditches on the west side of State Route 78, south of Murray City. The seep discharges from a brick structure and also directly into the ditch where the coal seam crops. The discharge is routed under State Route 78 via a culvert and

discharge into Snow Fork. The site is oriented southeast of underground mine Hg-048 (2,334 acres), underlying Brush Fork and Long Hollow sub-watersheds.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| SF00600 | Seep | 11/18/2002 | 2.6 | 2520 | 5 | 714 | 42 |

Recommendation
Currently, there is no suitable remediation recommended for this site. The discharge is oriented at a low elevation, near State Route 78 and Snow Fork, leaving little room for reclamation and treatment.

V. SF00520 / SF 00530 – AMD discharge (Orbiston)

Location
Located south of Murray City and upstream of Long Hollow. Access can be gained from State Route 78.

Site Description
SF 00520 and SF 00530 are mine entries located immediately off the roadside of State Route 78. AMD discharges into road ditches on the west side of State Route 78. The seeps are culverted under State Route 78, and flow into Snow Fork. MCRP has performed short term monitoring at these seeps from 1999-2000. The site is oriented southeast of underground mine Hg-048 (2,334 acres), underlying Brush Fork and Long Hollow sub-watersheds. Both seeps together have an average pH of 2.6 and discharge an average 145 lbs/day of acid and 32 lbs/day of total metals into Snow Fork. Combined, these seeps account for 16% of Snow Fork acid load at base flow.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| SF00520 | Seep | 8/15/2000 | 3.0 | 1760 | 23 | 406 | 111 |
| SF00520 | Seep | 10/16/2000 | 2.6 | 1880 | 53 | 395 | 249 |
| SF00520 | Seep | 2/8/2001 | 3.0 | 1780 | 226 | 355 | 962 |
| SF00520 | Seep | 4/4/2001 | 2.9 | 1560 | 62 | 323 | 242 |
| SF00530 | Seep | 7/26/2000 | 2.6 | 2200 | 16 | 606 | 114 |
| SF00530 | Seep | 8/15/2000 | 2.7 | 2080 | 4 | 602 | 31 |
| SF00530 | Seep | 3/28/2002 | 2.9 | 1390 | 37 | 374 | 167 |
| SF00530 | Seep | 10/16/2000 | 2.4 | 2170 | 2 | 623 | 12 |

Recommendation
Suggested remediation for SF 00520 / 00530 is to install a wetland, east of State Route 78, to precipitate metals and treat AMD.

## Brush Fork

Location: T13N, R15W, Section 2, 3, 9, 10, 16, 17 Ward Twp, Hocking County.
Drainage area: 4.72 square miles; 3,021 acres
Stream Length: 5.2 miles
USGS Quadrangles: Nelsonville and New Straitsville
Ownership: Private and public (USFS)
River Mile: 4.90 - Snow Fork Tributary
% Acid Load into Snow Fork: 38%
Land owned by USFS: 10%, 299 acres

### Basin Assessment

Brush Fork is located in the southwest section of the Monday Creek Watershed between the villages of Murray City and Buchtel. Brush Fork tributary discharges into Snow Fork near RM 4.9. A long-term monitoring site is located downstream of the Brush Fork tributary confluence with Snow Fork at RM 4.3 (LTM 107). Approximately 86% of the Brush Fork sub-watershed contains underground and/or surface mined areas. The sub-watershed contains exposed gob piles, strip pits, highwalls, subsidence features, blocked drainages, losing streams, open mine portals and toxic seeps. Field reconnaissance performed in 2001 resulted in the identification of 24 seeps with poor water quality. Mining in the sub-watershed occurred in the # 6 Middle Kittanning coal seam, with the elevation of the coal seam between 720 ft and 800 ft. The topography of Brush Fork is steep with the highest point in the sub-watershed located at an elevation of 1,080 ft. The mouth of the tributary discharges into Snow Fork at an elevation of 700 ft. The basin contains seven private residences and only one road (Jobs New Pittsburg Road / County Road 22), which lies south of Murray City.

### Historical Water Quality

The Brush Fork sub-basin was identified as an AMD-impacted tributary in 1997. In 1998, Ohio University received an EPA 319 Water Quality Grant, to perform a lime sand dosing study in the mainstem of Brush Fork. The mouth of the stream was subsequently monitored (20 samples 1997-2000) to document the effectiveness of the project. In 2001, MCRP performed field reconnaissance in the basin to identify sources of AMD discharge and mine features affecting water quality. MCRP collected water quality samples at discharge points in April and October of 2002. In 2001, OEPA collected water quality samples near the mouth and performed biological sampling in the sub-watershed. The highest pH value recorded at the mouth of Brush Fork to date is 3.8. The Brush Fork sub-watershed is classified as a priority sub-watershed.

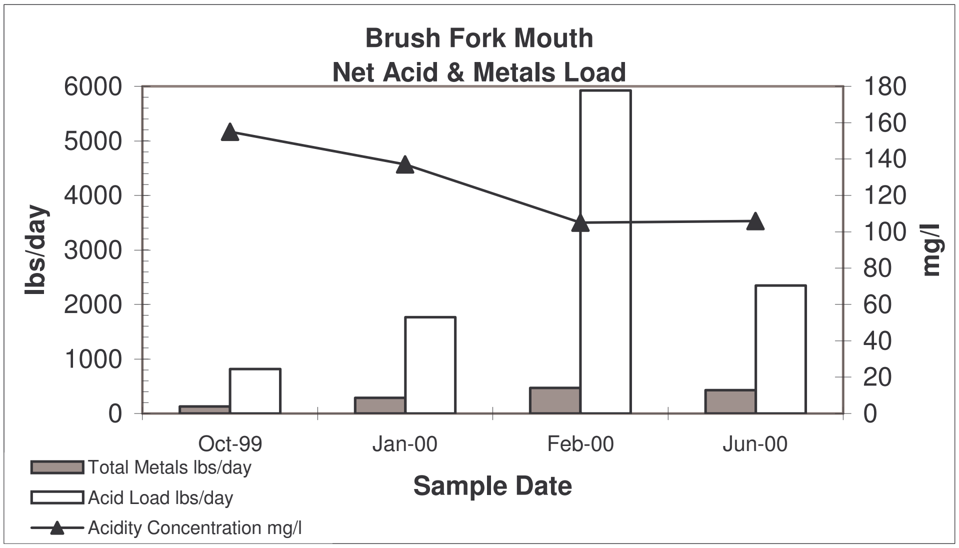


Figure 33: Brush Fork Net Acid & Metals Load

**Water Quality Impacts on Monday Creek**

Based on the October 2000 mass balance in Monday Creek, it is estimated that Brush Fork contributes 38% (594 lbs/day) of the acid load to Snow Fork at base flow, while Snow Fork contributes approximately 30% of the acid load to Monday Creek. MCRP data collected in Snow Fork, at RM 6.2 (LTM 106) approximately 1 mile upstream of the Brush Fork tributary, exhibit an average pH value of 4.6 and average acidity value of 46 mg/l. Data collected at RM 4.3 (LTM 107), which is oriented 0.5 mile downstream of Brush Fork / Snow Fork confluence, exhibit an average pH value of 3.8 and average acidity value of 80 mg/l. This illustrates a significant decline in water quality, with an average pH reduction of 0.8 standard units and a doubling of acidity concentration. Two mainstem seeps have been identified in this section of Snow Fork, however, Brush Fork tributary is largest AMD source contributing to the decline. Over a water year, this tributary contributes between 595 to 5,000 lbs/day of acid to Snow Fork mainstem. In 2001, OEPA performed water quality sampling for a TMDL study in the Monday Creek Watershed. Three locations were selected for analysis within the Brush Fork sub-watershed. 2002 results confirm that this sub-watershed is severely impacted by AMD and meets requirements for classification as Limited Resource Water (LRW).

Table 17: OEPA TMDL (2001) Snow Fork and Brush Fork Sampling Sites

| Location | River Mile | IBI | ICI | QHEI |
|---|---|---|---|---|
| Snow Fork | 6.2 | 12 | Very Poor | 43 |
| Snow Fork | 4.3 | 12 | Very Poor | 64.5 |
| Brush Fork | 3.4 | 12 | Very Poor | 59 |
| Brush Fork | 2.3 | 12 | Very Poor | 55 |
| Brush Fork | 0.1 | 12 | Very Poor | 73 |

**Brush Fork Water Quality Investigation**

The Brush Fork sub-watershed contains a mainstem and 14 intermittent tributaries. The Brush Fork sub-watershed contains abandoned underground mines and surface mines. The area of underground mines is far reaching and continues into adjacent drainage basins, including Sand Run, Spencer Hollow and the Snow Fork sub-watershed.

Surface water in the headwaters of the Brush Fork drainage is unimpacted by past mining activity. Water quality samples collected in the upstream segment (RM 4.5) of Brush Fork record a pH value of 7 and a net alkalinity value of 113 mg/l. However, downstream near RM 4 (at seep BH 00690), AMD sources begin to degrade Brush Fork's mainstem. Surface mining occurred along the west side of the mainstem, beginning at RM 4 and continuing to the mouth, resulting in direct input of AMD into Brush Fork. The majority of AMD discharges are located on the southwest side of the stream and oriented within 50 ft to 100 ft of the mainstem. Most inputs correlate with deep mine entries, coffer dams or portals created by surface mining. AMD discharges oriented on the northeast side of Brush Fork are generally located near the mouth of drainages which are captured due to subsidence or lack positive drainage. These discharges are consistently oriented at low elevations, near the roadside, leaving little room for reclamation and treatment.

Underground and surface mining also affect the side drainages. Overburden and coal waste piles fill the valleys, which results in a total lack of positive drainage in 7 intermittent tributaries, with virtually no stream channel remaining. Erosional subsidence features are frequently found upstream of waste piles (spoil blocks), resulting in direct recharge to underground mine complexes. Dissipating or losing streams are also pervasive in the sub-watershed. Due to fracturing immediately below the stream channel, 6 intermittent streams never reach Brush Fork mainstem. Surface water flowing in the stream channels flow toward the main stem, reach an elevation of approximately 800 ft and are then lost through subsurface fissures to underground mines.

In the mid to lower reach of the basin, surface mine operations created highwalls, strip pits and piles of coal waste which are located in or near the stream channels. Several of these pits serve as catchments for AMD discharging from mine entries or portals adjacent to the pits. Brush Fork mainstem then flows southeast through several large wetlands near New Pittsburgh. The downstream section of Brush Fork receives additional AMD discharge near the small community of Jobs. It then flows under State Route 78, where it discharges into Snow Fork.

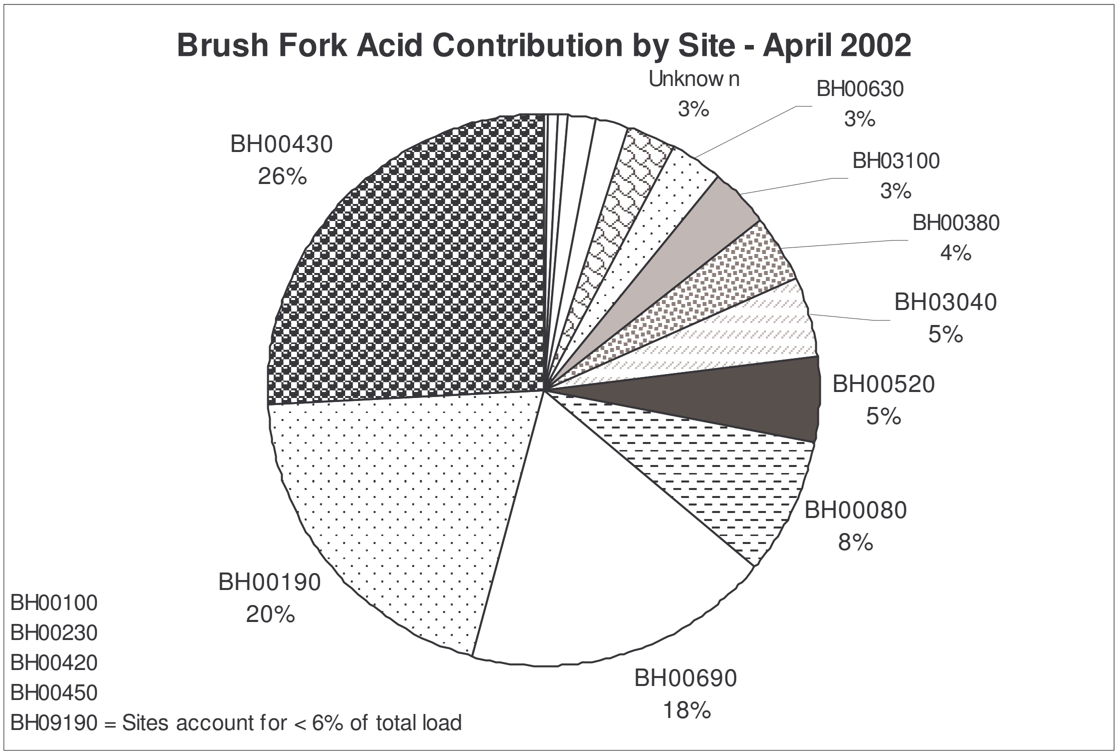


Figure 34: Brush Fork Acid Contribution

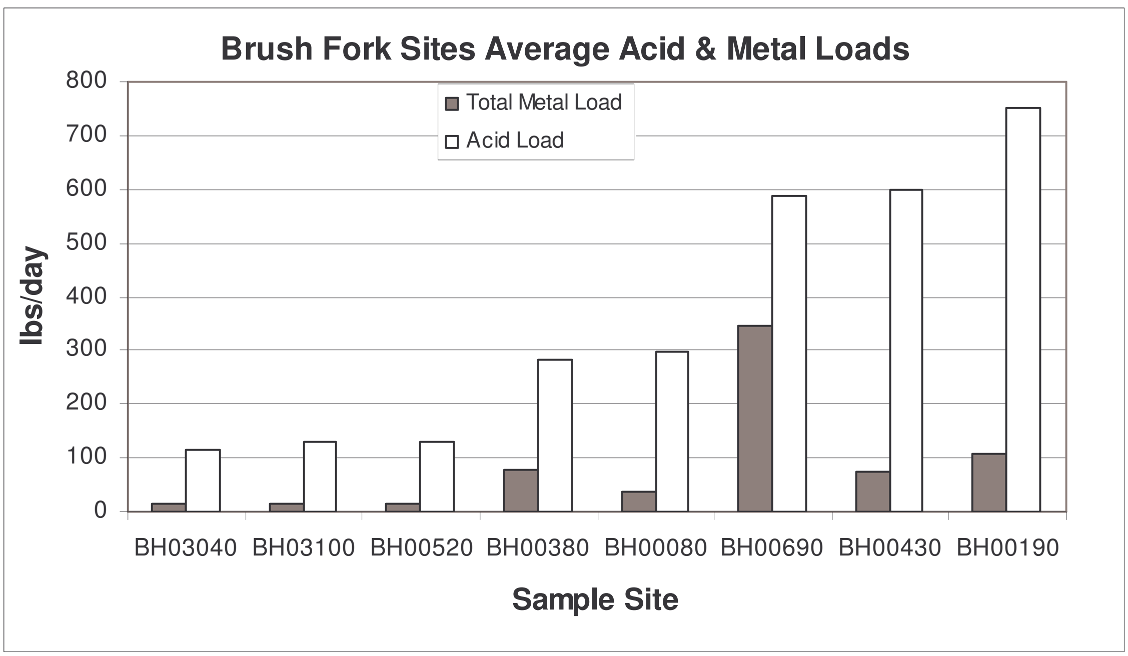


Figure 35: Brush Fork Average Acid & Metal Loads

**Site Descriptions and Treatment Recommendations**

I. BH 00690 – AMD discharge (MSBS)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, across from surface mine reclamation site, downstream of road fork.

Site Description
BH 00690 is located in the upstream section of the mainstem. The seep upwells on the west side of the roadside and flows approximately 50 ft, where it discharges into Brush Fork. BH 00690 is oriented southeast of deep mine Hg-155 (274 acres). Surface mining also occurred east of the seep and this area has been reclaimed. The reclamation is planted in grass with two OLCs and a small pond with neutral pH water. To the west of BH 00690, drainages are blocked by spoil and streams provide recharge to a 12-acre underground mine. Spoil piles are located along the stream channel, as well as to the south of the seep. BH 00690 is highly acidic and accounts for 18 % of Brush Fork's total acid load at high flow. BH 00690 seep has a high total iron concentration of 203 to 262 mg/l, most of which is ferrous iron.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00690 | Seep | 5/13/2001 | 3.5 | 1690 | 169 | 468 | 948 |
| BH00690 | Seep | 4/10/2002 | 3.5 | 1840 | 130 | 440 | 687 |
| BH00690 | Seep | 10/7/2002 | 3.0 | 2070 | 20 | 553 | 134 |

Recommendation
Suggested remediation for BH 00690 is to install an SLB at the reclamation site north of the seep. The SLB would utilize water from a pond to treat AMD in Brush Fork. A LLB could be installed at the seep location, however, this recommendation should be investigated further.

II. BH 13100 – AMD discharge (7 east)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, across from gated gas lines.

Site Description
BH 13100 is located near the mouth of tributary BH 13, in the upstream section the sub-watershed. BH 13 has been surface mined and deep mined (Hg-155) and lacks positive drainage due to spoil blocks. Approximately 66 acres in this drainage are lost to underground mines. The stream valley is difficult to navigate due to overburden deposited on the valley floor and logging that occurred in this tributary. No subsidence has been documented. The source of the seep BH 13100 is a strip pit located beneath a highwall. Three deep mine entries are located near the pit. The embankment of the pit

appears to be spoil material. Seep BH 13100 discharges below the pit, east of an access road, then flows into tributary BH 13, as well as a road ditch.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH13100 | Seep | 5/13/2001 | 4.1 | 969 | 9 | 82 | 8 |

Recommendation
Suggested remediation for BH 13100 is to establish positive drainage in the stream channel of BH 13. If a suitable water source can be located, a SLB could be installed to treat BH 13100 and add alkalinity to Brush Fork mainstem. An OLC could be installed at the seep site, however, the area is relatively flat and this option should be investigated further. Due to the small amount of flow at this site, it may not be economically feasible to construct treatment.

III. BH 00630 – AMD discharge (7 east roadside)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, south of BH 13 tributary, on northeast side of road.

Site Description
BH 00630 is located near a deep mine entry, east of tributary BH 13. BH 00630 is oriented southeast of deep mine Hg-155 (274 acres). The seep upwells on the road bank, flows 10 ft down to a ditch where it is culverted under the road and flows approximately 50 ft, where it discharges into Brush Fork.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00630 | Seep | 4/10/2002 | 4.1 | 1110 | 92 | 108 | 119 |

Recommendation
Currently, there is no remediation recommended for this site.

IV. BH 00520 – AMD discharge (waterfall – mssp2)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, south of BH 13 tributary and the Withem home, on southwest side of road.

Site Description
BH 00520 is located at a deep mine entry, west of the mainstem. The seep is oriented southeast of deep mine Hg-055 (510 acres) and Hg-023 (2.2 acres). BH 00520 seep discharges from a portal located on the strip bench and flows approximately 30 ft and discharges into the mainstem.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00520 | Seep | 5/13/2001 | 2.7 | 910 | 118 | 142 | 202 |
| BH00520 | Seep | 4/10/2002 | 3.1 | 1030 | 123 | 127 | 187 |
| BH00520 | Seep | 10/7/2002 | 3.0 | 1220 | 3 | 169 | 6 |

Recommendation
Suggested remediation for BH 00520 is to install a LLB and OLC to treat AMD.

V. BH 00450 and BH 11 – AMD discharge and Tributary (5 east)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, downstream of BH 00520 near the mouth of tributary BH 11, on southwest side of road, east side of stream.

Site Description
BH 00450 seep is located near the mouth of a losing stream. This tributary is a captured and blocked tributary. The drainage was both underground mined and surface mined. The seep is oriented west of deep mine Hg-058 (17 acres). BH 00450 seep discharges from a spoil area and then flows approximately 50 ft where it discharges into Brush Fork. It is unclear whether the seep is a deep mine discharge or water contaminated by large amount of spoil at this site. One sample was collected in 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00450 | Seep | 4/10/2002 | 3.4 | 1300 | 7 | 141 | 12 |

Recommendation
Suggested remediation for BH 11 is to establish positive drainage and restore the stream channel. A LLB and OLC could be installed at the seep site, however, the area is relatively flat and this option should be investigated further. Due to the small amount of flow at this site, it may not be economically feasible to construct treatment.

VI. BH 00430 – AMD discharge (New Pitts highwall)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, north of BH 09 tributary, on southwest side of road.

Site Description
BH 00430 seep is located below a fractured highwall located on the west side of the mainstem. The seep is oriented southeast of deep mine Hg-055 (510 acres). BH 00430 seep discharges from a strip pit and then flows approximately 50 ft where it discharges into Brush Fork. Discharge occurs at several points within the pit. A logging road runs

adjacent to the site. BH 00430 accounts for 26 % of Brush Forks total acid load at high flow.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00430 | Seep | 5/13/2001 | 2.5 | 1160 | 126 | 201 | 304 |
| BH00430 | Seep | 4/10/2002 | 2.9 | 1380 | 384 | 211 | 972 |
| BH00430 | Seep | 10/7/2002 | 3.0 | 1360 | 232 | 187 | 521 |

Recommendation
Suggested remediation for BH 00430 is to install a LLB and OLC to treat AMD.

VII. BH 09, BH 09190 and BH 00420 – Tributary and AMD discharge (New Pitts log road)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, south of BH 00450 seep, on southwest side of road.

Site Description
BH 09 is a tributary located near the middle of Brush Fork. The drainage is completely captured by subsidence. Intermittent tributaries are blocked by spoil piles created during surface mine operations. Additionally, logging access roads exacerbate post-mining conditions by further impairing drainage patterns. Approximately 368 acres of this drainage are lost to underground mines. A total of 5 subsidence holes have been documented. Downstream of subsidence / spoil blocks are two discharging pits, located on the north side of the drainage. Deep mine entries discharge AMD into the pits, which is then culverted under an access road (site BH 09190) and back into the stream channel near the front of the valley.

Seep BH 00420 is located at the front of the valley (adjacent to the main stem) below a fractured highwall and south of seep BH 00430. It located below an access road and is oriented at a slightly lower elevation than BH 00430. AMD at this site flows over a flat marshy area and discharges into Brush Fork. The seeps are oriented southeast of deep mine Hg-055 (510 acres).

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00420 | Seep | 4/10/2002 | 3.1 | 1160 | 40 | 148 | 71 |
| BH00420 | Seep | 10/7/2002 | 3.0 | 1280 | 11 | 162 | 22 |
| BH09190 | Seep | 4/10/2002 | 3.1 | 1080 | 36 | 132 | 57 |
| BH09190 | Seep | 10/7/2002 | 3.2 | 1200 | 27 | 146 | 48 |

Recommendation
Suggested remediation for BH 09 is to establish positive drainage in the stream channel by filling subsidence holes and establishing a viable stream channel. LLBs and OLCs could be installed at seep discharge sites. However, the area is relatively flat and this option should be investigated further.

VII. BH 00380 – AMD discharge (h2g)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, downstream of BH 09 tributary and wetlands, on west side of the mainstem.

Site Description
BH 00380 seep is located below a highwall on the west side of the mainstem. The seep is oriented southeast of deep mine Hg-006 (180 acres). BH 00380 seep discharges, from a strip pit and then flows approximately 150 ft where it discharges into Brush Fork. Discharge from the pit occurs at several points. The majority of the discharge is seeping from the bottom of the impoundment. A wetland area is located adjacent (upstream/downstream) to the site. BH 00380 accounts for 4 % of Brush Fork's total acid load at high flow.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00380 | Seep | 5/13/2001 | 3.0 | 1010 | 159 | 209 | 400 |
| BH00380 | Seep | 4/10/2002 | 3.4 | 1310 | 70 | 179 | 151 |
| BH00380 | Seep | 10/7/2002 | 3.6 | 1250 | 110 | 227 | 301 |

Recommendation
Suggested remediation for BH 00380 is to install a LLB and OLC to treat AMD.

VIII. BH 00230 – AMD discharge (4w)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property downstream of wetlands and adjacent to the reservoir, on west side of the mainstem. Site can be accessed by an oil and gas road.

Site Description
BH 00230 is located near a deep mine entry, on the west side of the mainstem. The seep is oriented northeast of deep mine Hg-048 (665 acres). AMD flows from the mouth of a small drainage (4 acres) and discharges directly into Brush Fork mainstem.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00230 | Seep | 4/10/2002 | 2.9 | 1410 | 10 | 228 | 27 |

Recommendation
Suggested remediation for BH 00230 is to install a LLB and OLC to treat AMD. Due to the small amount of flow at this site, it may not be economically feasible to construct treatment.

IX. BH 00190 – AMD discharge (32 a-c)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, on west side of the mainstem. Site can be accessed by crossing Brush Fork mainstem, immediately downstream of reservoir.

Site Description
BH 00190 seep is a deep mine entry located below a highwall on the west side of the mainstem. The seep is oriented northeast of deep mine Hg-048 (665 acres). BH 00190 seep discharges from a strip pit and then flows approximately 20 ft down the stream bank, where it discharges into Brush Fork. Discharge from the pit occurs at several points. BH 00190 accounts for 20 % of Brush Fork's total acid load at high flow.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00190 | Seep | 10/7/2002 | 2.9 | 1590 | 90 | 278 | 299 |
| BH00190 | Seep | 4/10/2002 | 2.7 | 1930 | 163 | 384 | 751 |

Recommendation
Suggested remediation for BH 00190 is to install a LLB and OLC to treat AMD.

X. BH 03 and 03040 and 03100 – Tributary and AMD discharge (Bateman)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, on BH 03 tributary, across from Jobs Church.

Site Description
BH 03 tributary is located in the downstream section the sub-watershed. The upper reaches of this tributary are intact with neutral pH water. BH 03 has been surface mined, as well as deep mined (Hg-016 approximately 880 acres) and lacks positive drainage due to a blocked and dissipating stream. Approximately 213 acres in this drainage are lost to underground mines. No subsidence has been documented, however, a shaft entry is located near the point where the stream dissipates. At the front of the valley, a deep mine entry is located on the west side of the drainage. The entry is oriented southeast of the underground mine complex. A coffer dam (BH 03100) is located approximately 50 ft from the opening. The structure discharges AMD and is culverted under CR-22 to the mainstem of Brush Fork. A second discharge originates from the same source and is a buried clay pipe which is routed into BH 03 stream channel (BH 03040). The stream flows under a road bridge near Jobs Church and flows into Brush Fork mainstem.

Discharges BH 03040 (5%) and BH 03100 (3%) account for 8% of Brush Fork's total acid load at high flow.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH03040 | Seep | 5/13/2001 | 2.9 | 825 | 81 | 102 | 99 |
| BH03040 | Seep | 4/10/2002 | 3.4 | 994 | 184 | 82 | 181 |
| BH03040 | Seep | 10/7/2002 | 3.4 | 1050 | 55 | 94 | 62 |
| BH03100 | Seep | 4/10/2002 | 3.4 | 1030 | 120 | 90 | 130 |

Recommendation
Suggested remediation for BH 03 is to establish positive drainage in the stream channel. Possible installation of a SLB to treat AMD discharge and add alkalinity to Brush Fork mainstem. Suggested remediation for BH 03040 and BH 03100 is to install LLBs and OLCs to treat AMD.

XI. BH 00080 – AMD discharge (2 west #20)

Location
This site is adjacent to CR-22 / Jobs New Pittsburg Road. Located on private property, northwest of BH 02 tributary and south of BH 03 tributary.

Site Description
BH 00080 is a deep mine entry located below a highwall on the west side of the mainstem. The seep is oriented southeast of deep mine Hg-048 (665 acres). BH 00080 seep discharges from a deep mine entry and flows across the bench approximately 20 ft and discharges into Brush Fork mainstem.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00080 | Seep | 4/10/2002 | 2.9 | 1460 | 99 | 251 | 297 |
| BH00080 | Seep | 10/7/2002 | 3.0 | 1430 | 23 | 234 | 64 |

Recommendation
Suggested remediation for BH 00080 is to install a LLB and OLC to treat AMD.

XII. Losing Streams and Subsidences

Location
These sites are located throughout the sub-watershed and are accessed by hiking into side drainages.

Site Description
Blocked drainages are the result of spoil piles being deposited in the valley bottoms and obstructing stream channels. Surface water will flow as far as the spoil block, then percolate underground. In this sub-watershed, blocked drainages are generally coupled

with subsidence holes and dissipating streams. Therefore, reconstructing stream channels could be a costly endeavor in Brush Fork. The drainage area (acres) recovered by establishing viable stream channels should be a determining factor.

Recommendation

Suggested remediation for surface drainage impairments are twofold. Spoil blocks should be opened. Subsidence holes should be filled and stream channels reestablished.

XIII. BH 00010 – Tributary Mouth

Location

This site is adjacent to State Route 78. Located on USFS property.

Site Description

BH 00010 (Brush Fork) tributary, flows under State Route 78 and discharges into Snow Fork. BH 00010 is a perennial stream contaminated by AMD. This tributary contains unreclaimed surface mines, subsidence features, coal waste piles and deep mine seeps. Uncontaminated water is being lost to the underground mines. A total of eight water quality samples were collected at the tributary mouth from 2000-2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| BH00010 | Trib Mouth | 1/12/2000 | 3.0 | 1060 | 1072 | 137 | 1763 |
| BH00010 | Trib Mouth | 5/17/2000 | 3.3 | 1090 | 2213 | 121 | 3213 |
| BH00010 | Trib Mouth | 6/7/2000 | 3.6 | 1000 | 1845 | 106 | 2346 |
| BH00010 | Trib Mouth | 7/26/2000 | 3.7 | 1000 | 829 | 110 | 1094 |
| BH00010 | Trib Mouth | 8/15/2000 | 3.8 | 1020 | 669 | 100 | 803 |
| BH00010 | Trib Mouth | 10/16/2000 | 3.4 | 1060 | 468 | 106 | 595 |
| BH00010 | Trib Mouth | 5/13/2001 | 2.9 | 884 | 1593 | 132 | 2523 |
| BH00010 | Trib Mouth | 4/10/2002 | 3.3 | 1150 | 2491 | 126 | 3766 |

Recommendation

Currently, there is no suitable remediation recommended for this site. See above recommendations for SLB, LLBs and OLCs.

## Long Hollow

Location: Section 1, 7 and 8, Ward Twp, Hocking County.
Drainage area: 1.45 square miles; 929 acres
Stream Length: 2 miles (Intermittent)
USGS Quadrangles: Nelsonville
River Mile: 3.40 - Snow Fork Tributary
Percent Acid Load into Snow Fork: 4%
Ownership: Private and public (USFS)
Land owned by USFS: 71%, 660 acres

### Basin Assessment

Long Hollow is located in the southeast section of the watershed between the villages of Murray City and Buchtel. Long-term monitoring sites are located both upstream and downstream of the Long Hollow tributary at RM 4.3 (LTM 107) and RM 2.4 (LTM 109) in Snow Fork. Approximately 97% of the Long Hollow sub-watershed contains underground and/or surface-mined areas. The sub-watershed contains exposed gob, strip pits, highwalls, subsidence features, losing streams and toxic seeps. Field reconnaissance performed in 1998 and 2001 resulted in the identification of 3 seeps and a large wetland with poor water quality, which may also be a source of AMD discharge. Mining in the sub-watershed occurred in the # 6 Middle Kittanning coal seam, with the average elevation of the coal seam at 720 ft. The topography of Long Hollow is steep with the highest point in the sub-watershed located at an elevation of 1,000 ft. The mouth of the tributary discharges into Snow Fork at an elevation of 680 ft.

### Historical Water Quality

In June 1998, MCRP performed field reconnaissance in the Long Hollow tributary. Field parameters were collected and toxic seeps discharging AMD into the tributary were observed. Consequently, the mouth of Long Hollow was monitored quarterly for one year and water quality analysis confirmed that this tributary is a significant source of AMD contribution to Snow Fork. In June 1998, a mass balance was performed by collecting water quality samples at seep sites that resulted in characterization of acid load contribution. In 2001, OEPA collected water quality samples near the mouth and performed biological sampling at one site in the sub-watershed. The highest pH value recorded at the mouth of Long Hollow to date is 5.1. Long Hollow is classified as a priority sub-watershed.

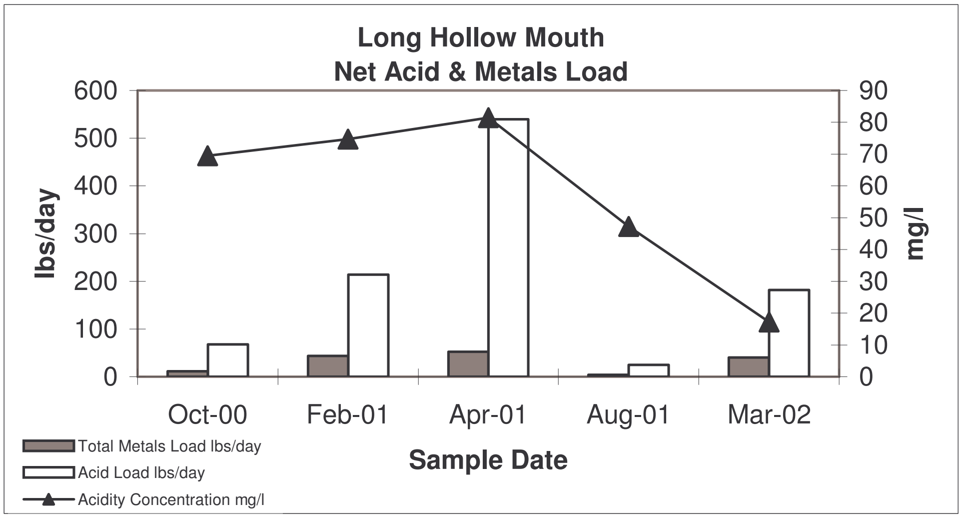


Figure 36: Long Hollow Net Acid & Metals Load

**Water Quality Impacts on Monday Creek**

Based on the October 2000 mass balance in Monday Creek, it is estimated that Long Hollow contributes 4% (165 lbs/day) of the acid load to Snow Fork at base flow, while Snow Fork contributes approximately 30% of the acid load to Monday Creek. MCRP data collected in Snow Fork at RM 4.3 (LTM 107) and RM 2.4 (LTM 109) indicate that both sites have an average pH value of 3.7, average alkalinity value of 0 mg/l, and average acidity value between 85-87 mg/l, illustrating Snow Fork's extremely degraded status both upstream and downstream of the confluence with Long Hollow. Due to the distance between monitoring sites, the numerous identified seeps along State Route 78, the elevation of the coal seam and the seasonal variation of flow at many of the discharge sites, it is difficult to quantify the negative impact Long Hollow has on Snow Fork tributary. In the summer of 2001, OEPA performed biological and water quality sampling for a TMDL study in the Monday Creek Watershed. One location was selected for analysis within the Long Hollow sub-watershed. 2002 results confirm that this sub-watershed is severely impacted by AMD and meets requirements for classification as Limited Resource Water (LRW).

Table 18: OEPA TMDL (2001) Snow Fork and Long Hollow Sampling Sites

| Location | River Mile | IBI | ICI | QHEI |
|---|---|---|---|---|
| Snow Fork (upstream) | 4.3 | 12 | Very Poor | 64.5 |
| Snow Fork (downstream) | 2.4 | 12 | Very Poor | 58.5 |
| Long Hollow | 1.3 | 12 | Very Poor | 72 |

## Long Hollow Water Quality Investigation

The Long Hollow sub-watershed contains an underground mine which runs the entire length of the drainage. Mine Hg-48 encompasses approximately 2,330 acres, (according to digital map files) and underlies Long Hollow, as well as parts of the Orbiston drainage, Brush Fork and the Monday Creek sub-watersheds.

The upper reaches of Long Hollow drainage are unaffected by mining, showing no signs of poor water quality and no obvious signs of mining activity. However, downstream of tributary LH 03, the valley floor is riddled with subsidence features due to surface mining or “shovel mine” operations and overburden collapse. Due to collapse of the mine ceilings, many sections of stream flow into slumped areas and become captured until the water levels rise high enough for the stream to exit these depressions.

Surface water is certainly being lost into the underground mine complex in these areas. One example of this is a large subsidence feature in the mainstem (near the USFS property line) approximately twenty feet deep, where a small portal could only be observed during low flow conditions. Strip pits oriented below highwalls, slumps, coal waste and overburden deposited on the valley floor in the mid- and lower reaches of the basin contribute to a lack of positive drainage.

The downstream section of the mainstem flows through a wetland area near the front of the valley and receives AMD discharge from three discreet seeps adjacent to the stream channel. The stream crosses under State Route 78, where it discharges into Snow Fork. AMD discharge has only been documented near the mouth of the sub-basin, which is oriented at the south and east perimeter (down dip) of the Hg-048 mine complex. Discharge sites correlate with drift mine entries or air/pumping shafts.

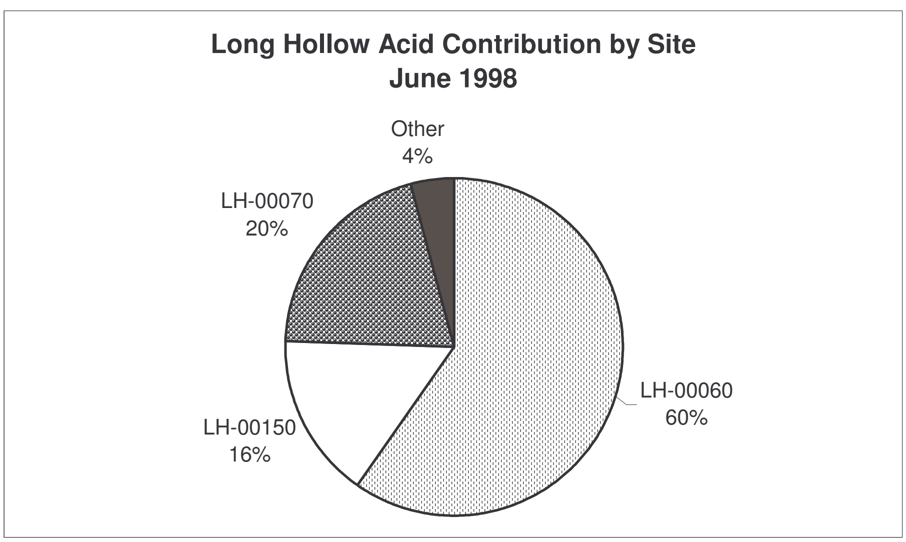


Figure 37: Long Hollow Acid Contribution

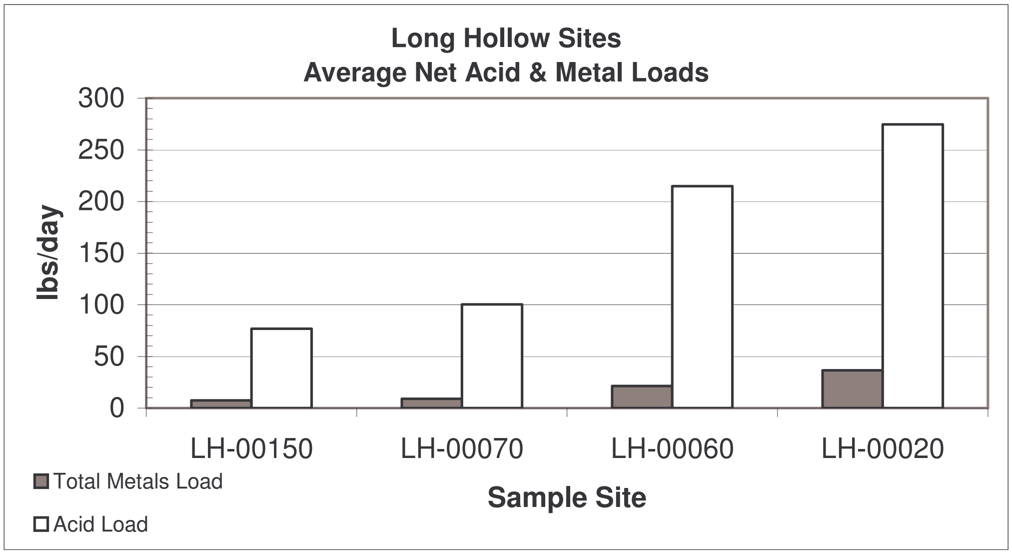

Figure 38: Long Hollow Net Acid & Metal Loads

**Site Descriptions and Treatment Recommendations**

I. LH 00 – Tributary (mainstem)

Location
This site can be accessed by parking on State Route 78 and following ATV trail / access road. Located on USFS and private property. Access is limited to foot travel.

Site Description
LH 00 is an intermittent stream. The headwaters is unaffected by mining, however, near its confluence with LH 03, the stream becomes a losing stream at low flow conditions.

Recommendation
Suggested remediation for LH 00 is to install a SLB to boost alkalinity production and treat AMD discharge downstream. Possible installation of stream channel lining where water loss occurs.

II. LH 01 – Tributary (first trib-north)

Location
This site can be accessed by parking on State Route 78 and following ATV trail / access road. Located on USFS property. Access is limited to foot travel.

Site Description
LH 01 is an intermittent stream. The headwaters is unaffected by mining, however, near its confluence with the mainstem, the stream lacks a discreet stream channel. Due to subsidence filling performed by the USFS, this area was graded and seeded. No stream channel was constructed.

Recommendation
Suggested remediation for LH 01 is to create positive drainage by constructing stream channel to accommodate seasonal flows. Present status unknown.

III. LH 00150 – AMD Discharge (LON 95 pit)

Location
This site can be accessed by parking on State Route 78 and following ATV trail / access road. Located on USFS property.

Site Description
LH 00150 is a deep mine entry / discharging strip pit oriented on the north side of the access road, below a highwall. LH 00150 flows across the access road and into the wetland before discharging into the mainstem. This seep contributes approximately 152 lbs/day of acid to Long Hollow tributary at high flow. Samples were collected June 1998 and November 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LH00150 | Strip Pit | 6/4/1998 | 3.6 | 803 | 242 | 52 | 151 |
| LH00150 | Strip Pit | 11/18/2002 | 3.7 | 774 | 5 | 42 | 2 |

Recommendation
Suggested remediation for LH 00150 is to construct a LLB to treat AMD discharge.

IV. LH 00070– AMD Discharge (small seep)
Location
This site can be accessed by parking on State Route 78 and walking upstream (approximately 100 feet) past coffer dam (LH 00060), on the south side of stream channel. Located on USFS property. Access is limited to foot travel.

Site Description

LH 00070 is a deep mine seep oriented against the hillside and adjacent to the stream bank. This seep flows directly into the mainstem, near the mouth. This seep contributes approximately 196 lbs/day of acid to Long Hollow tributary at high flow. Samples were collected June 1998 and November 2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LH00070 | Seep | 6/4/1998 | 3.1 | 1116 | 115 | 142 | 196 |
| LH00070 | Seep | 11/18/2002 | 3.1 | 1030 | 3 | 125 | 5 |

Recommendation
Suggested remediation for LH 00070 is to construct a LLB and OLC to treat AMD discharge. Additional flow monitoring needed. This seep is located in a poor site for reclamation due to the limited space available.

V. LH 00060 – AMD Discharge (coffer dam)

Location
This site can be accessed by parking on State Route 78 and walking upstream to a coffer damn (brick structure) on the south side of channel. Located on USFS property. Access is limited to foot travel.

Site Description
LH 00060 is a deep mine seep oriented against the hillside and adjacent to the stream bank. This seep flows directly into the mainstem, near the mouth. This seep contributes approximately 572 lbs/day of acid to Long Hollow tributary at high flow. A total of three samples have been collected at the site from 1998-2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LH00060 | Seep | 6/4/1998 | 3.1 | 1268 | 268 | 178 | 572 |
| LH00060 | Seep | 10/16/2000 | 2.9 | 1020 | 41 | 100 | 49 |
| LH00060 | Seep | 11/18/2002 | 3.1 | 975 | 19 | 103 | 23 |

Recommendation
Suggested remediation for LH 00060 is to construct a LLB and OLC to treat AMD discharge. Possible separation of seep and stream flow, install a LLB and downstream wetland. This seep is located in a poor site for reclamation due to the limited space available.

VI. LH 00020 – Tributary Mouth

Location
This site is located adjacent to State Route 78.

Site Description
LH 00020 (Long Hollow) tributary, flows under State Route 78 and discharges into Snow Fork. LH 00020 is an intermittent stream contaminated by AMD. This tributary contains unreclaimed highwalls, strip pits, subsidence features, and deep mine seeps. Uncontaminated surface water is being lost to the underground mine complex. Three significant seeps have been identified in the drainage. A total of seven water quality samples have been collected at the tributary mouth from 1998-2002.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| LH00020 | Trib Mouth | 6/4/1998 | 3.2 | 1068 | 655 | 122 | 959 |
| LH00020 | Trib Mouth | 10/16/2000 | 3.2 | 971 | 81 | 70 | 67 |
| LH00020 | Trib Mouth | 2/8/2001 | 3.2 | 935 | 239 | 75 | 214 |
| LH00020 | Trib Mouth | 4/4/2001 | 3.2 | 866 | 552 | 82 | 540 |
| LH00020 | Trib Mouth | 8/7/2001 | 3.5 | 943 | 44 | 47 | 25 |
| LH00020 | Trib Mouth | 3/28/2002 | 5.1 | 466 | 880 | 17 | 182 |
| LH00020 | Trib Mouth | 11/18/2002 | 3.5 | 979 | 37 | 65 | 29 |

Recommendation
Currently, there is no suitable remediation recommended for this site. Close subsidence features. See above recommendations for SLB, LLBs and OLCs.

## Spencer Hollow

Location: Section 4, 11, 18, Ward Twp, Hocking County.
Drainage area: 1.66 square miles; 1,063 acres
Stream Length: 1.7 miles (Intermittent)
USGS Quadrangles: New Straitsville
River Mile: 6.4
Percent Acid Load into Snow Fork: 1%
Ownership: Private and public (USFS)
Land owned by USFS: 1%, 14.7 acres

### Basin Assessment

Spencer Hollow is located in the eastern section of the watershed near the village of Murray City. A long-term monitoring site is located downstream of the Spencer Hollow tributary at RM 6.2 (LTM 106). Approximately 31% of the Spencer Hollow sub-watershed contains underground and/or surface-mined areas. The sub-watershed contains exposed gob, highwalls, toxic seeps and surface mine reclamation (completed 2000, Addington Coal). To date, only three sources of AMD have been identified in the sub-watershed. Mining in the sub-watershed occurred in the # 6 Middle Kittanning coal seam, with the average elevation of the coal seam at 780 ft. The topography of Spencer Hollow is steep with the highest point in the sub-watershed located at an elevation of 1,020 ft. The mouth of the tributary discharges into Snow Fork at an elevation of 720 ft.

The headwaters of the drainage is now a reclaimed surface mine. In 1998, surface water discharging from this upstream section, had a pH value of 6.7. Downstream, at the boundary of the reclamation, the stream flows into a wetland area. A small seep (SP 0040) is oriented on the south side the tributary and discharges AMD immediately downstream of the wetland. Fractured highwalls are located on the north side of the drainage. AMD has been identified at the base of the highwall, however, the observed flow was not measurable. Below the wetlands, pH values in the mainstem decline significantly. Downstream, the tributary receives flow from a deep mine discharge located in a side drainage, flows past several residences and flows into Snow Fork.

### Historical Water Quality

Spencer Hollow contributes 1 % of the acid load to Snow Fork at base flow (Monday Creek Mass Balance, October 2000). Spencer Hollow tributary has an average pH value of 3.8 and contributes approximately 119 lbs/day of acid to Snow Fork.

| Site ID | Site Type | Sample Date | pH | Conductivity uS/cm | Discharge GPM | Acidity mg/l | Acid Load lbs/day |
|---|---|---|---|---|---|---|---|
| SP00100 | Trib Mouth | 6/18/1998 | 3.9 | 547 | 420 | 42 | 212 |
| SP00100 | Trib Mouth | 10/16/2000 | 3.6 | 926 | 16 | 79 | 15 |
| SP00100 | Trib Mouth | 5/11/2005 | 4 | 579 | 224 | 50 | 133 |
| SP00400 | Seep | 6/18/1998 | 3.1 | 2210 | 2 | 196 | 5 |

**Recommendation**

A mass balance should be completed in the sub-watershed. Due to the decline in water quality in the wetland downstream of the reclamation, it is likely that Spencer Hollow tributary is being contaminated by base flow. This occurrence should be documented. Unimpacted water sources need to be identified. If suitable water can be located, a SLB could be constructed to treat AMD.

## Water Quality Sampling Procedures and Methods

### Laboratory and Field Parameters

There are three phases of investigation that require the measurement of field and laboratory parameters. Phase I includes the collection of a limited amount of field parameters. Phase II and III require the measurement of field and laboratory parameters. Parameters measured in the field for all phases include pH, conductivity, and temperature. In addition, phase II and III investigations require a discharge measurement and a field acidity titration. The protocol for accurate collection of field parameters starts with daily calibration of the pH and conductivity sensors. Refer to Table 20 for calibration procedures of equipment used in water quality sampling.

When measuring water quality parameters in-stream below a seep discharge, the sampler should stand at least 50 ft downstream of the confluence or in a mixed zone downstream of any riffles. PH readings should be measured in flowing water to provide accurate representation of all the water. When reading the pH of the stream, allow ample time for the sensor to achieve an accurate reading of the temperature. The conductivity probe must be free of air bubbles. The sampler should place the probe in relatively calm, slow-moving water and swirl the sensor to eliminate any small air bubbles. Acidity must be titrated in the field at the same temperature as the stream. The bottle is rinsed with the stream water three times before the titration. The sampler should fill the bottle with ten milliliters of water, add a packet of phenolphthalein indicator powder and swirl until dissolved. Then the sodium hydroxide standard solution should be added drop by drop until pink color persists for 30 seconds. Each drop of NaOH used to titrate the acidic water to a neutral pH is multiplied by 17.1, in order to obtain the concentration of total acidity in mg/l.

Samples collected in the field for all Phase II and III sites must be held at 4 degrees Celsius until they arrive at the ODNR-DMRM Laboratory. A chain-of-custody form must accompany the samples from the field to the laboratory. A non-filtered, acidified sample and a non-filtered, non-acidified sample are sent for all analyses. A non-filtered, non-acidified sample is collected to analyze pH, acidity/alkalinity, specific conductivity, total suspended solids, total dissolved solids and sulfates. The sample is collected in a collapsible plastic container from which all oxygen is excluded. The non-filtered, acidified sample is analyzed for total metals (iron, aluminum and manganese) present in both dissolved and suspended form. Monitoring sites often require an additional filtered, acidified sample to be sent to the laboratory. The filtered, acidified sample is analyzed for dissolved metals (iron, aluminum and manganese) that are present in acid mine drainage water. These measurements provide a preliminary understanding of the chemical reactions occurring in the water. The laboratory performs Group I analysis on all water samples, which include the following list of parameters:

Table 19: Group1 Analysis and Test Methods

| Parameters | Methods for the Chemical Analysis of Water and Wastes |
|---|---|
| Total Acidity | SM2310B |
| Total Alkalinity | SM2320B |
| Specific Conductivity | SM2510B |
| Total Suspended Solids | SM2540B |
| Total Dissolved Solids | SM2540B |
| Total Manganese | SM3120B |
| Total Aluminum | SM3120B |
| Total Iron | SM3120B |
| Hardness | SM2340B |
| Sulfate (SO4) | SM4500-SO4 D |

EPA 600/4-79-020.1983

**Discharge Measurements**

Discharge is the most complex of all the field measurements. There are several factors to consider before actually performing a discharge measurement. First, a section of the stream is chosen where the flow lines are straight, flow is laminar, and the stream bottom is uniform. No circular moving water, eddies, or back flow can exist. Second, select a location free of woody debris and other objects that would cause irregular flow patterns. Finally, check the depth of the water. If the depth is greater than 2.5 ft, the measurement requires the type AA current meter. This type of meter can be suspended from a bridge with a crane. For depths less than 2.5 ft, the pygmy meter is used. The actual procedure for collecting an accurate flow measurement is complex and the reader should refer to: Techniques of Water-Resources Investigations of the United States Geological Survey - "Discharge Measurements at Gaging Stations" Book 3, Chapter AS. Small flows discharging from deep mine seeps or other sources are measured using a Baski cutthroat flume or a bucket, small pipe, and stop watch.

**Quality Assurance / Quality Control**

To provide assurance that the laboratory is accurately reporting the samples collected and to prevent contamination of samples through mishandling in the field, MCRP follows a QA/QC program. Quality Assurance guides the field sampling with a consistent protocol. Every tenth sample is split into two sample bottles that are labeled and analyzed to determine if the laboratory results are similar.

## Equipment

Equipment for this project was purchased with U.S. EPA 319 funds or borrowed from the Ohio Department of Natural Resources - Division of Mineral Resources Management (ODNR-DMRM). The equipment, manufacturer, and calibration procedure are listed below.

Table 20: Equipment Specifications

| Equipment | Manufacturer | Calibration |
|---|---|---|
| PH probe | Corning Checkmate | Calibration: Use buffer solution pH 4 -90 and pH 7 Cat. No.478540, 478570 Maintenance: Replace sensor as needed. |
| Dissolved Oxygen YSI DO200 probe | YSI Inc. | Calibration: Built in calibration chamber Maintenance: Replace sensor as needed. |
| Conductivity probe | Corning Checkmate | Use standard solution 1413 ~S Cat. No.473623 |
| Acidity Kit<br>* Phenolphthalein<br>* Sodium Hydroxide | HACH Model MD-2 | No Calibration.<br>Maintenance: Clean glass jar and refill standard solution of NaOH frequently.<br>Procedure: Rinse bottle three times and fill with 10 ml of water. Add indicator standard solution and gently swirl until dissolved. Add drop by drop the standard solution until pink color persists for 30 seconds. |
| Alkalinity kit<br>* Bromcresol Green-Methyl red indicator Powder pillows<br>* Sulfuric Acid | HACH Model MD-2 | No Calibration.<br>Maintenance: Clean glass jar and refill standard solution of NaOH frequently.<br>Procedure: Rinse bottle three times and fill with 10 ml of water. Add indicator standard solution and gently swirl until dissolved. Add drop by drop the standard solution until pink color persists for 30 seconds |
| Water filtering system | QED Environmental Systems, Inc. FF-8500 | Clean sample vessel with (0.1N) HCl or nitric acid, then rinse with tap water, and then type II reagent grade water.<br>Size: Filter pore size is 0.45 micron.<br>Procedure: Allow 100 ml to pass before collecting sample |
| Pygmy current meter | USGS Hydrologic Instrumentation Facility | Calibration: Spin test for 30- 60 seconds<br>Instrumentation Maintenance: Rinse cups with distilled water after every use, oil when needed, adjust pin accordingly |
| Cut-throat Flume | Baski Inc. | Throat size changes to accommodate flow, level in all directions |

## Funding Opportunities

There are various existing funding sources, which are dedicated to AMD remediation and others that can be adapted to assist in restoration of the watershed (ILGARD, 2001).

Ohio Department of Natural Resources, Division of Mineral Resources Management

1) Federally Funded Abandoned Mine Land Program: Federal excise taxes on coal are returned to the State of Ohio for reclamation of abandoned mine land sites that adversely affect the public's health and safety.
2) Acid Mine Drainage Set-Aside Program: Up to ten percent of Ohio's federal excise tax monies are set aside for acid mine drainage abatement. Priority is given to leveraging these funds with watershed restoration groups and other governmental agencies.
3) State Abandoned Mine Land Program: State excise taxes on coal and industrial minerals are dedicated to reclamation projects that improve water quality in impacted streams. Priority is given to leveraging these funds with partners.

Office of Surface Mining (OSM), Reclamation and Enforcement

1) Appalachian Clean Streams Initiative: The mission of ACSI is to facilitate and coordinate citizens groups, university researchers, the coal industry, corporations, the environmental community, and local, state, and federal government agencies that are involved in cleaning up streams polluted by acid mine drainage. OSM provides funds for ACSI projects on an annual basis.
2) Direct grants to Watershed Groups: A grant process for directly funding citizen watershed group efforts to restore acid mine drainage-impacted streams on a project basis.

Environmental Protection Agency

1) EPA Section 319 Non-point Source Grant Program: Funding is available for planning, education and remediation of watershed pollution problems including acid mine drainage.
2) Office of Water – Watershed Protection and Flood Prevention/PL566 Program: This program provides technical and financial assistance to address resources and related economic problems on a watershed basis that address watershed protection, flood prevention, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, and public recreation. Technical assistance and cost sharing with varied amounts are available for implementation of NRCS-authorized watershed plans.

United States Army Corps of Engineers

1) Section 905b – Water Resource Development Act (86): Recent additions to the Army Corps' conventional mission include a habitat restoration grant program for the completion of feasibility studies and project construction where a Federal interest can be verified. A principle non-federal sponsor must be identified for this cost-share program.

2) Flood Hazard Mitigation and Ecosystem Restoration Program/Challenge 21: This watershed-based program assists groups involved in mitigating flood hazards and restoration of riparian ecosystems. Assistance is provided for nonstructural solutions in flood-prone areas, while retaining traditional measures where appropriate. Cost sharing is between federal and local governments (Federal share is 50 percent for studies and 65 percent for project implementation, up to a maximum federal allocation of $30 million).
3) Section 206 Aquatic Ecosystems Restoration Project under the Water Resources Development Act of 1996. Annual appropriation of $25 million. The maximum Federal cost-share is $5 million. 100% federal for study costs, 35% of the study costs are recovered from the non-federal sponsor during the first year. Both programs have a 65/35 cost-share ratio during construction.

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# Appendix A - Future Monitoring

Recommendations for Long-Term Monitoring
Monday Creek Watershed
In conjunction with the Army Corps of Engineers feasibility study
January 16, 2004
Author – Mary Ann Borch, ODNR-DMRM

Committee members and logistics

The following names were provided for inclusion in this committee.

| | | |
|---|---|---|
| Mary Ann Borch | ODNR | Lead |
| Vince Marchese | ACOE | Water quality |
| Chuck Boucher | OEPA | Biologist |
| Keith Orr | OEPA | Water quality |
| Kelly Capuzzi | OEPA | Biologist (fish) |
| Jen Bowman | Sunday Creek WS | Sunday Creek Coordinator |
| Rebecca Black | Monday Creek WS | Monday Creek water quality |
| Ted King | USFS | Statistician |
| Kelly Johnson | OU | Biologist (bugs) |

Issue Statement

Acid mine drainage restoration projects are being planned by the Army Corps of Engineers for the sub-basins within the Monday Creek watershed. Funding authorities for much of the restoration work requires that the environmental impact of restoration projects be monitored in order to determine the effectiveness of the restoration measures. The water quality information will serve to educate the technical team as well as to educate and inform the residents of the watershed and funders. Water quality characterization will take place before and after restoration is complete by collecting water chemistry and biologic samples. The cumulative impact of all restoration projects on water quality within the Monday Creek Watershed will be documented and understood.

Monitoring plan

The goal of reclamation efforts proposed by the Army Corps of Engineers is to rehabilitate the mainstem to restore aquatic habitat and life in Monday Creek. Reclamation efforts are targeted in sub-watersheds whose toxic loadings negatively affect the mainstem of Monday Creek. Therefore, long-term monitoring is proposed for the mainstem to do the following:

- Assess the impact of reclamation in the tributaries on Monday Creek
- Provide an assessment of water chemistry and biologic trends over time

The long-term monitoring plan will consist of water chemical and biologic monitoring. Long-term monitoring will take place in the mainstem of Monday Creek and Snow Fork in long established monitoring sites. The baseline dataset is robust with historic data dating back to 1997. In addition, the EPA's Total Maximum Daily Load (TMDL) monitoring sites are tied to these locations. The EPA data includes chemistry, sediment, biology (fish and macros) and flow.

Monitoring of water chemistry will also be conducted in tributaries proposed for reclamation projects. This effort will be confined temporally to pre and post-construction projects.

Water chemistry

**Parameters**

The following water quality parameters will be collected;

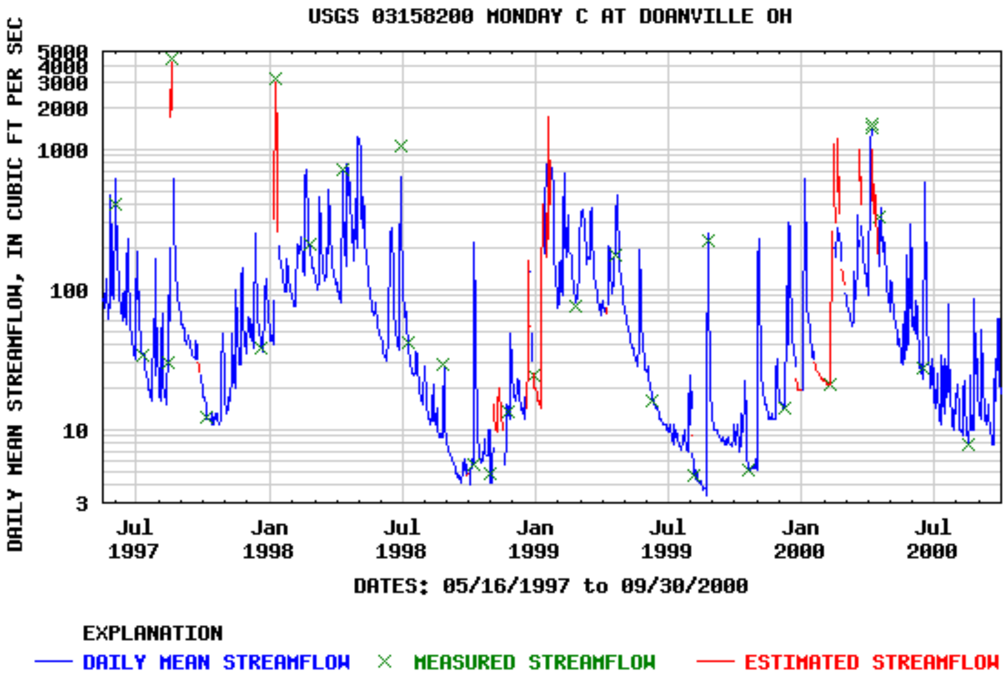
| | | |
|---|---|---|
| Specific conductance | Field and lab | Us/cm |
| pH and Temp | Field and lab | SU and C |
| Total Dissolved Solids | Laboratory | mg/L |
| Acidity (total hot) | Laboratory | mg/L |
| Alkalinity (total) | Laboratory | mg/L |
| Sulfate (total) | Laboratory | mg/L |
| Aluminum (total and dissolved) | Laboratory | mg/L |
| Manganese (total and dissolved) | Laboratory | mg/L |
| Iron (total and dissolved) | Laboratory | mg/L |

Calculate total net acidity.

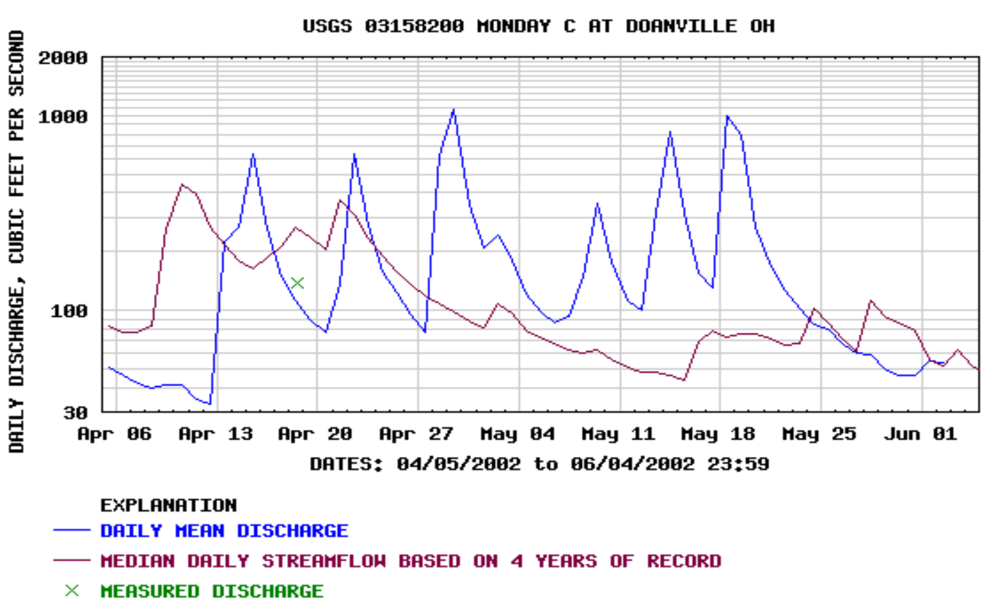
Sample for totals except under turbid conditions, where filtering is then preferred. Sometimes, iron especially and other metals are still somewhat present in higher concentrations for totals. However, as this method has been utilized from the inception, members thought it appropriate to continue. This method has been used for the WVU model and all baseline data to date.

**Flow Data**

Flow data will be compared against the USGS gage Doanville station flow measurements so that relative conditions can be established for flow during sampling events and in order to calculate loading rates. The graph below shows flow conditions for three years. This type of information provides a benchmark for yearly fluctuations.




The next USGS graph from the Doanville gage station shows daily mean discharge and median daily stream flow for four years of record for flow conditions several weeks prior to sampling. When collecting flow in the field, do not measure the extreme high flows that occur after a precipitation event, but monitor during the baseline (as represented on the hydrograph, not baseflow) conditions. These are more manageable to measure and easier to plan a sampling event when organizing equipment and field crew.



| Daily mean flow statistics for 6/4 based on 5 years of record in $ft^3/sec$ | | | | | | |
|---|---|---|---|---|---|---|
| **Current Flow** | **Minimum** | **Mean** | **Maximum** | **80 percent exceedence** | **50 percent exceedence** | **20 percent exceedence** |
| | 26 | 105 | 232 | 28.0 | 52.0 | 221 |
| Percent exceedance means that 80, 50, or 20 percent of all daily mean flows for 6/4 have been greater than the value shown. | | | | | | |

**Sampling locations**
The following sites are located in Monday Creek mainstem from downstream to upstream. All the historic monitoring sites are located just downstream of the proposed reclamation projects with the exception of Oreville (103) and Carbon Hill (153). Oreville should still be included as it provides a transition point between Lost Run and Rock Run, a distance of seven miles. Carbon Hill (153) should be relocated below the input from the Monkey Hollow tributary. The new station would be renamed Carbon Hill B (154), approximately 1.1 miles downstream at RM 10.4. Unfortunately, there would not be historic baseline data for this site. (see map)

| | | |
|---|---|---|
| 1 | Doanville at USGS gage station | 108 TR 1042 dst Coe Hollow (RM 1.7) |
| 2 | Below Snake Hollow | 151 Loop Rd dst McKnight Seep (RM 4.3) |
| 3* | Below Carbon Hill Run | 153 SR 278 (RM 10.4) |
| 3 | Carbon Hill Below Monkey | 154 dst of Monkey Hollow (RM 9.29-Establish) |
| 4 | Below Lost Run | 131 Adj. SR 595 (RM 16.0) |
| 5 | Above Oreville | 103 @ Monday Cr. Junction (RM 19.7) |
| 6 | Below Rock Run | 127 (RM 23.4) |
| 7 | Below Jobs Hollow/Above Dixie Hollow | 148 Portie Flamingo Rd (RM 26.5) |

Snow Fork enters Monday Creek at RM 3.5.
Sites along Snow Fork mainstem from downstream to upstream:

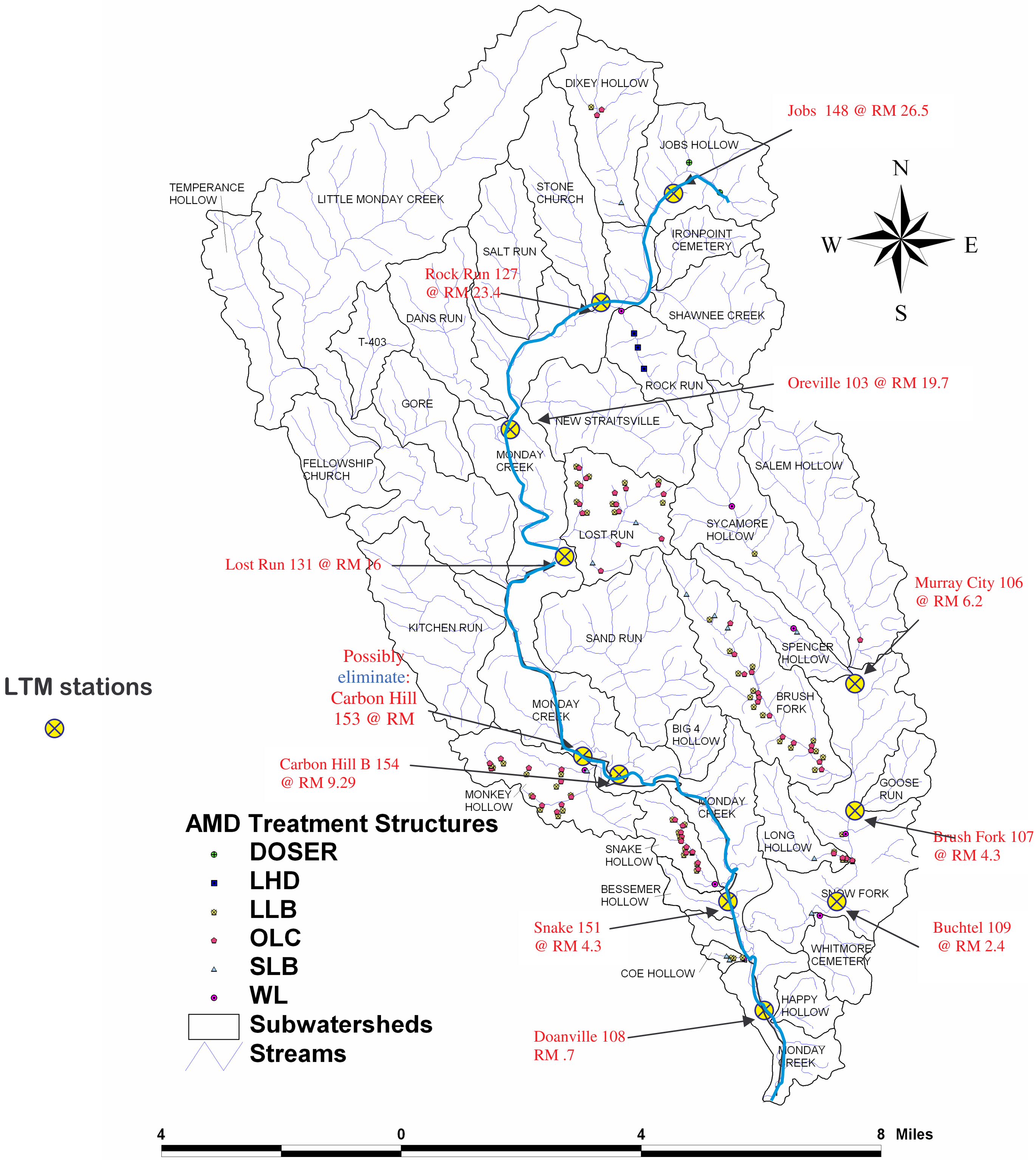
| | | |
|---|---|---|
| 8 | Snow Fork at Buchtel gage station | 109 SR 685 dst Orbisten Seep (RM 2.4) |
| 9 | Snow Fork above Goose Run | 107 Dst Snow Fk Mainstem Seep (RM 4.3) |
| 10 | Murray City Bridge | 106 Dst Murray City Seeps 1&2 (RM 6.2) |

**Add a new site downstream of Little Monday Creek. This location has the best water chemistry and may offer information on biologic refugia that could repopulate Monday Creek.**

**Frequency of collection**
For the long-term monitoring, the chemistry and hydrologic data will be collected two times a year at low flow and high flow prior to initiation of restoration work, during construction, and for at least five years after restoration work is complete. The timeline for completion of reclamation work is an unknown and is dependent on funding. Attempt to correlate the low and high flows with fall and spring.

**Tributary monitoring for pre- and post-construction**
Both Ohio EPA (in 2001 TMDL survey) and Monday Creek group conducted sampling in the tributaries to Monday Creek and Snow Fork. Therefore, tributary level monitoring for reclamation projects should be located at the site of previous monitoring where some historic data exists. Construction monitoring will begin one year prior to reclamation construction and for one year after completion. Monitoring frequency will be every other month so that six sampling events are conducted for each year.

# Monday Creek
# AMD Treatment Structures



**Reporting**
**A standard report format will be developed and will include (but not be limited to) the following:**

- A brief summary of historic water quality (a one-time effort already discussed in WV modeling report)
- The results will be reported for the same parameters and in units consistent with those already established on baseline long-term monitoring.
- Water chemistry reports will include calculated net-acidity and total metal concentrations and loading rates. Iron, manganese, and aluminum concentrations can be combined together as total metal concentrations and loads. In addition, remediation systems and targets are designed to accommodate each of these metals separately. Task: develop a table template for in-putting water chemistry with embedded formulas for calculating loadings and net acidity.
- Proposed methods of data interpretation:
  - ✓ Trend analysis will show 1) water quality changes through time at each station during a high and low flow and 2) changes along the mainstem at individual sampling sites. This will be done for the high and low flow showing the changes in water quality from the headwaters to the mouth. (This may be a reason to add a station at the mouth of Little Monday, to know how much alkalinity is contributed).
  - ✓ Graphics showing concentration and loading rate for metals and acidity
  - ✓ A brief summary accompanying graphics to interpret changes and progress for each year
  - ✓ Include a list or graphic of the treatment projects that have been completed, the date of completion and their location since they won't all be completed at the same time (or possibly a ghant chart)
  - ✓ (Mary Stoertz' performance measures analysis also using targets for comparison)> Method presented at end of document.
- Reporting shall be on an annual basis
- Proposed timeframe of long-term monitoring (i.e. life of project for funding purposes)
- Report any maintenance or repairs that are needed or conducted on any projects. Also include any issues or problems encountered
- Recipients of the Water Quality Monitoring Report
  - ✓ Watershed members,
  - ✓ funders (ODNR, EPA, OSM, ARMY CORPS, etc…),
  - ✓ technical advisory committee.

**Sediment Monitoring**
Sediment sampling was conducted by Dr. Dina Lopez and graduate students of Ohio University that accompanies Ohio EPA's TMDL in 2001. However, a comparison of the methods used by Lopez to those used at EPA, determined that the two methods produced differences in results by an order of magnitude. Therefore, a new baseline will be

established by Ohio EPA. These sediment-sampling sites will be located at the established (and new) long-term monitoring locations. Sampling will occur with the 10-year return of the TMDL update.

**Biological Monitoring**

Fish and macroinvertebrate baseline data were collected by Ohio EPA in the 2001 TMDL survey. To document improvements to the watershed, fish and/or macroinvertebrate data will be collected following the same methodologies used by Ohio EPA. The Macroinvertebrate Aggragate Index for Streams (MAIS) method will also be used for a rapid assessment of macroinvertebrates. Baseline data should be collected using this methodology so that trends can be documented. Below is a link to the web page for Ohio EPA's Biocriteria users manual:
http://www.epa.state.oh.us/dsw/bioassess/BioCriteriaProtAqLife.html
Explanation for the MAIS is included at the end of this document.

**Sampling locations**

The biological sampling locations should be conducted at chemical sampling locations (Monday Creek's long-term monitoring stations). As restoration projects are completed in the sub-watersheds and the tributaries, biological monitoring stations may be added downstream from those projects to document improvements if a long-term monitoring station does not exist at that location. Biologic monitoring for these sites would include MAIS and fish assemblege methods.

**Frequency of biologic monitoring**

- ✓ EPA full biological assessment: Every 10 years to be sampled next in year 2011.
- ✓ MAIS family-level aggregate multimetric index annually.
- ✓ Fish assemblage to be sampled by EPA SEDO, every five years to be sampled next 2006 and also on an as-needed basis.

**All methodologies need sufficient baseline monitoring prior to reclamation. As individual restoration projects are completed in the tributaries, monitoring should be conducted downstream from the project or at the mouth of the tributary.**

Reporting

Agencies or contractors conducting the biologic monitoring will be responsible for annual reporting, providing the data and interpretations as needed.

Describe how work load will be allocated in terms of persons and funding. (this may have to weight till later or be answered by the funders)

Summary of the MAIS Method proposed by Kelly Johnson's (Dec. 19, 2003)

Our methodology has undergone several modifications over the last few years as we explored different options that provide a good basis for between-year and between-site comparisons. The core elements of the field methodology include both single habitat (1 meter kick net in riffles) and multiple habitat (20 D-frame dip net sweeps) sampling following the US EPA Rapid Bioassessment Protocols. Taxa are picked from the nets in the field and/or are transported to the laboratory and sorted under the stereoscope (see details below). For added continuity and our own research interests, we have also used Hester-Dendy multiplate samplers and collect Surber samples from riffles at sites we have identified as long-term sites, but these are not necessary for calculating the family level MAIS index. We've continued to collect them primarily to provide a basis for future calculations and comparisons with other metrics (e.g. OEPA's ICI).

Macroinvertebrates are identified to family by trained students/ volunteers or myself, and all are archived in the event that further taxonomic resolution or verification proves feasible at a later date. We have been using a family-level aggregate multimetric index (MAIS) to assign a numerical score to each site. The MAIS was developed using an ecoregion, reference site approach from data from six ecoregions in West Virginia, Virginia, Maryland, Pennsylvania, including the WAP, although proportionally fewer WAP sites were represented in the dataset. Thus, the current cut-off values for the four classification levels ("very good", "good", "fair" or "poor") may differ slightly for our ecoregion (but a study by the West Virginia DEP with a very similar index found no differences between biota in the WAP and neighboring Central Highlands ecoregion. However, the numerical values of the index (which range from 0 to 20) should provide a reasonable basis for year-to-year monitoring and local comparisons with unimpacted control sites. I have not been able to locate any studies that have investigated year-to-year variation in the index, but intend to do it with our own sites in the near future.

Its worth noting that the MAIS is the primary benthic index used by the Virginia Department of Environmental Quality in their TMDL reports, and also by the Forest Service as the rapid bioassessment tool of choice for pre and post monitoring of projects in national forest areas in Virginia and Kentucky, so it isn't regarded as a "volunteer" index by those agencies. They use a modified version for volunteers with some training (days, not weeks) because non-biologists tend to have more difficulty with identifications, even at the family level. I agree, but in my experience, dedicated volunteers who are willing to invest several weeks in training with appropriate supervision, can become skilled at family level identification. The West Virginia Department of Environmental Protection developed and tested a family level index (SCI) in 2000, based on US Rapid Bioassessment kick and dip protocols that contains metrics very similar those in the MAIS, and their "advanced" volunteer program calls for family level identification. As a caveat, however, it should be noted that state programs can vary in the precision and accuracy of their bioassessments, so just because another state uses it doesn't necessarily mean it is the best or only good protocol.

1. Field Sampling (for a 100 meter reach)

a) **three 1 meter kick net** samples from riffles (USEPA Single habitat Rapid Bioassessment Protocol, section 7.1 2 in EPA 841-B-99-002 (Barbour et al. 1999).

b) **twenty D-ring dip net jabs/passes** (approximately 30 minutes) taken in multiple habitats in proportional representation (USEPA Multiple habitat Rapid Bioassessment Protocol, section 7.1 2 in EPA 841-B-99-002 (Barbour et al. 1999).

Additionally, depending on resources:
c) **one set of Hester-dendy** multiplate samplers attached to a brick and placed for 5-7 weeks in a high flow area of the stream *

d) **three 60 second Surber samples** in riffles (If flow is insufficient, the top 2 cm of substrate delineated by the Surber are collected and picked for macroinvertebrates at the laboratory)*
** During years with low rainfall, flow at some sites drops too low for kick nets or Hester-dendy. In these years, the Surber+ dip samples provide some basis for comparison to previous years, although a MAIS score based on Surber+dip might would not be comparable to one calculated from kick+ dip.*

These field methods follow the latest US Rapid Bioassessment protocols for kick net and multihabitat dip net (Barbour et al. 1999 from www.epa.gov/owow/monitoring/rbp , Sept 2003) and overlap reasonably well with Ohio EPA's macroinvertebrate protocol (Ohio EPA 1989). For example, the season (between June 15 and Sept 30), and the placement and collection of Hester-dendys and qualitative dip net method are similar, although for the former, we use four samplers per site. The most significant departures from OEPA protocol are the taxonomic resolution with which organisms are identified (many only to family, not genus), and the indices that are subsequently calculated (e.g. the MAIS, not ICI). All organisms are archived and stored, however, so follow-up identification and calculation of the Ohio ICI or some modification of the qualitative score (QCTV?) is possible if time and resources allow.

2. Sorting, subsampling and laboratory processing
a) Kick and dip net samples are hand picked in the field. We have not found it necessary to subsample, since macroinvertebrate abundances at even lightly impacted sites in this area tend to be relatively low. (This was the main reason we began collecting kick net samples instead/in addition to Surber samples in riffle areas after 2001). At many impacted sites we don't come close to even a 200 organism minimum count.

b) Hester-Dendy and Surber samples (the latter sometimes contain a lot of organic debris) are placed in containers (zip-loc freezer bags or large glass jars, respectively) with no preservative and kept in a cooler until transport to the lab. When Hester-Dendy's are retrieved, place a large diameter metal sieve downstream and underneath as we lift them out of the water to capture any potential escapees. At the laboratory *the same day*, multiplate samplers and organic debris are washed over a 600 μm (No. 30) screen and sorted under the stereoscope. We have found that the time required to pick a sample is significantly reduced (from 6 hours to 0.5 –1 hour) if the animals are alive and still moving; also fewer of the small organisms (eg. Chironomid larvae) are missed. Subsampling of Surber samples is occasionally necessary; to accomplish this, the entire mixture of substrate and organic matter is poured into a pan and one fourth to one half of the pan is delineated for picking. Following the procedure described above, we can typically complete the field work and laboratory sorting for 4-5 sites a day. A field notebook is maintained for recording the sample date and notable habitat characteristics (eg.narrative description of flow) at each site.

3. Taxonomic identification

Although we routinely perform generic level identification of many of the taxa collected, the time and expertise needed for some groups exceeds our resources, and slows the processing time considerably. In contrast, family-level identifications can be performed by graduate students or dedicated volunteers after a course in entomology or a few weeks of training and appropriate supervision. We use Merritt and Cummins (1996) primarily, but have an array of other literature for non-insect taxa and cross-referencing. We are developing a reference collection and protocol for systematic verifications by outside experts, but it is not yet complete. As taxa are identified and enumerated, they are entered into a log book, which also contains the name of the person who conducted the identification, specific notes made during identification, the sampling method, and the location of the site (name, watershed basin, county).

4. Metric calculation and comparisons to reference or control sites

Any number of the common biological metrics (total taxonomic richness, % EPT taxa, family level Hilsonhoff Biotic Index, Simpson or Shannon-Weiner Diversity indices) can be calculated and compared to previous years and/or control sites within the same or nearby watersheds. We have also explored the use of a family-level aggregate multimetric index developed in 1997 for use in the central Appalachians (list the states). The MAIS (Macroinvertebrate Aggregate Index for Streams) was developed for wadeable streams in the mid-Atlantic highlands and is used for samples collected with open-net, natural substrate devices (kickseine, D-ring dip net, Surber sampler). It was developed from a database of 455 sites from six ecoregions in the mid-Atlantic highlands (including 90 sites from the Western Allegheny Plateau). Sixty nine possible metrics were statistically evaluated for redundancy and the ability to detect impairment (list types). Nine metrics (% 5 dominant taxa, modified Hilsenhoff biotic index, % haptobenthos, EPT index, # Ephemeroptera taxa, Simpson diversity index, # intolerant taxa and % scrapers) were selected. The final index provides a single numerical score between 0 and 20 that can be compared to nearby control sites, the same site in previous years, or to the regional reference sites from which the index was developed. The MAIS is used by the Virginia Department of Environmental Quality in their TMDL reports, and by the Forest Service as a rapid bioassessment method for all projects (including post project monitoring) in the George Washington and Jefferson National Forests (see web sources listed in references below). Interestingly, Virginia also just modified their volunteer SOS protocol to more closely match the "professional" MAIS based on a study by Engel and Voshell (2002) that showed conclusions about ecological conditions (attainment vs non-attainment) reached by volunteer and professional protocols agreed closely (96% of the time). However, the actual scores of the volunteer index were less well-correlated ($r = 0.60$), probably because the volunteer index required less taxonomic resolution than the family level MAIS. It should be noted that the volunteers in this study were citizens and only briefly trained and certified (e.g. for days, not weeks), whereas most in our group (to date) have degrees in biology, a course in entomology, or at least several weeks of training to do family level identifications.

It should be noted that because the index was developed primarily from data (and reference sites) in the mid-Atlantic highlands, the reference site expectations may be a bit different than if reference sites were specific to the WAP; however, the group who developed the index believes they are not that different (R. Voshell, personal communication, Sept 2003). A validation study with WAP reference sites would be valuable. Our preliminary analyses from 26 sites show that the MAIS is sensitive to AMD impact and correlates reasonably well with pH and conductivity ($p < 0.05$, $r^2$ of 0.41 and 0.37, respectively) (Johnson et al. 2002). In addition, some of the long-term sites we have monitored have been assessed by the OEPA (Sunday and Monday Creek watersheds) in recent years, direct comparison of MAIS versus IBI and ICI scores can be made to evaluate the calibration of the metric.

References

"A stream condition index for West Virginia wadeable streams" (2000). Prepared for US EPA Region 3 Environmental Services division and US EPA Office of Science and Technology, Office of Water by Tetra Tech, Inc., Owings Mills, MD. www.dep.state.wv.us/docs/536_WV-Index

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Merritt, R. W. and K. W. Cummins (eds) 1996. An introduction to the Aquatic Insects of North America. 3rd ed.Kendall/Hunt Publishing, Dubuque, Iowa.

Ohio Environmental Protection Agency (1989). Biological criteria for the protection of aquatic life: Vol. III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities.

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Virginia Department of Environmental Quality (2003). Benthic TMDL for Quails Run, Rockingham County, Virginia. www.deq.state.va.us/tmdl/apptmdls/shenrvr/quailbc

George Washington and Jefferson National Forest system (2003) www.southernregion.fs.fed.us/gwj/resource info.htm#Aquatic%20Ecology

**Evaluation of Performance Measures.**
This method will be useful for comparing changes in acidity loads against historic and baseline conditions.  A baseline curve is established as shown below, and new loading rates can be compared to the baseline to provide a quantitative measure for change.  As this has been demonstrated as effective on subwatershed, we need to yet determine its effectiveness on the long term monitoring stations.

**Estimating Mean Annual Acidity Load** **by Mary Stoertz** **1/28/2004**

I believe we should be treating for the mean annual acidity load.
This spreadsheet will show you how to estimate it from limited data.

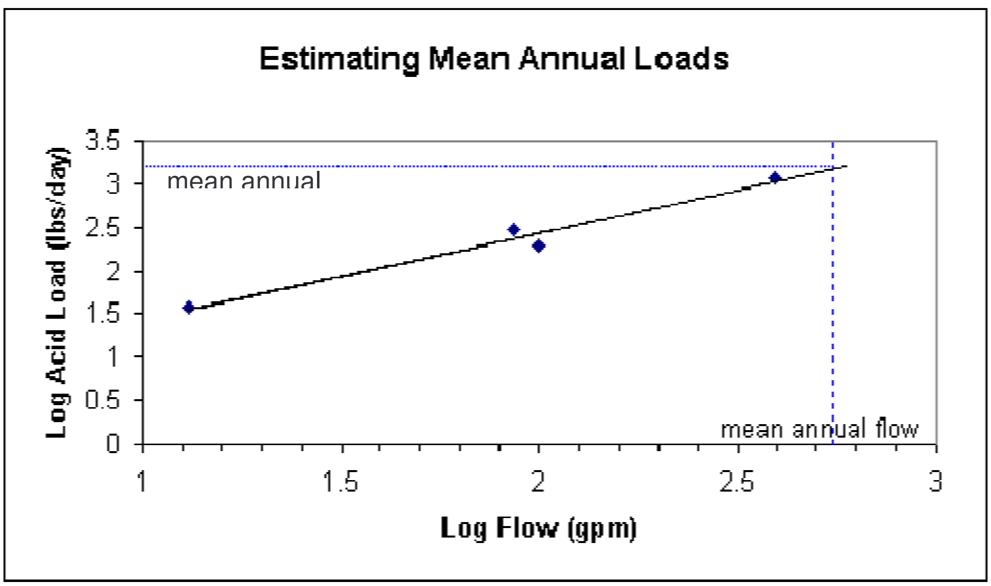
Example:

Data from Snake Hollow

| Sample # | Flow (gpm) | Acid Load (lbs/day) | Log(Flow) | Log (Load) |
|---|---|---|---|---|
| 1 | 392 | 1158 | 2.593286 | 3.063709 |
| 2 | 86 | 290 | 1.934498 | 2.462398 |
| 3 | 13 | 38 | 1.113943 | 1.579784 |
| 4 | 100 | 191 | 2 | 2.281033 |

| Mean Q line | |
|---|---|
| 2.74 | 0 |
| 2.74 | 3.5 |

Graph of above data




The mean annual acidity load corresponds to the load during the mean annual flow.

The mean annual flow in SE Ohio is roughly 1 cfs/sq. mi., using USGS data.
You need to determine the drainage area (sq. mi.) for the sampling station.
Snake Hollow sampling station has a drainage area of 781 acres or 1.22 sq. mi.
(640 acres per square mile)
Thus, Snake Hollow has a mean annual flow of 1.22 cfs or 548 gpm.
(449 gpm per cfs.)
The log of that is 2.74.
Extend an arrow from mean annual flow to the trendline of the available data.
Extend an arrow from where it meets the trendline to the y-axis to get mean annual load.
Log mean annual load is 3.2, so mean annual load is 10^3.2, or about 1585 lbs/day.
Note that this is much greater than one might expect based on low flow and high flow data.
Why is it greater? Because the big events are so big they skew the average.
I found that the Brush Fork dosing resulted in less pH increase than expected
because we seriously underestimated the mean annual load.

# Appendix B - Water Quality Data

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH00010 | Brush Fork | 3/30/1998 | 3254 | 150 | 5857 | NM | 520 | NM | NM | NM | 2.8 | 3.4 | 15.0 | 21.2 | 828 |
| BH00010 | Brush Fork | 4/22/1998 | 8896 | 140 | 14945 | NM | 250 | NM | NM | NM | 4.2 | 2.7 | 13.0 | 19.9 | 2124 |
| BH00010 | Brush Fork | 7/23/1998 | 1935 | 210 | 4877 | NM | 440 | NM | NM | NM | 2.6 | 4.0 | 18.0 | 24.6 | 571 |
| BH00010 | Brush Fork | 12/18/1998 | 673 | NM | NM | NM | 600 | NM | NM | NM | 4.0 | 5.0 | 20.0 | 29.0 | 234 |
| BH00010 | Brush Fork | 7/28/1999 | 452 | 193 | 1046 | 0 | 614 | 780 | 3.0 | 1340 | 1.4 | 4.4 | 6.7 | 12.5 | 68 |
| BH00010 | Brush Fork | 8/23/1999 | 438 | 184 | 966 | 0 | 600 | 868 | 2.8 | 1490 | 2.3 | 4.6 | 16.5 | 23.3 | 122 |
| BH00010 | Brush Fork | 9/21/1999 | 492 | 152 | 897 | 0 | 619 | 857 | 2.8 | 1250 | 3.2 | 5.2 | 23.6 | 32.0 | 189 |
| BH00010 | Brush Fork | 10/19/1999 | 439 | 155 | 816 | 0 | 592 | 920 | 3.2 | 1220 | 4.2 | 4.2 | 16.1 | 24.5 | 129 |
| BH00010 | Brush Fork | 11/16/1999 | 579 | 144 | 1000 | 0 | 575 | 861 | 3.3 | 1160 | 3.4 | 4.7 | 15.6 | 23.6 | 164 |
| BH00010 | Brush Fork | 12/20/1999 | 1170 | 121 | 1698 | 0 | 468 | 686 | 3.0 | 1080 | 2.8 | 4.0 | 15.5 | 22.3 | 314 |
| BH00010 | Brush Fork | 1/12/2000 | 1072 | 137 | 1763 | 0 | 488 | 682 | 3.0 | 1060 | 3.3 | 3.5 | 15.3 | 22.1 | 285 |
| BH00010 | Brush Fork | 2/16/2000 | 4701 | 105 | 5923 | 0 | 326 | 510 | 3.3 | 765 | 2.7 | 2.7 | 3.0 | 8.4 | 472 |
| BH00010 | Brush Fork | 3/21/2000 | 11140 | 84 | 11189 | 0 | 262 | 440 | 3.1 | 670 | 2.1 | 1.7 | 2.1 | 5.9 | 783 |
| BH00010 | Brush Fork | 5/17/2000 | 2213 | 121 | 3213 | 0 | 483 | 754 | 3.3 | 1090 | 2.3 | 3.3 | 15.5 | 21.1 | 561 |
| BH00010 | Brush Fork | 6/7/2000 | 1845 | 106 | 2346 | 0 | 496 | 760 | 3.6 | 1000 | 1.7 | 3.4 | 14.1 | 19.2 | 425 |
| BH00010 | Brush Fork | 7/26/2000 | 829 | 110 | 1094 | 0 | 522 | 825 | 3.7 | 1000 | 1.1 | 4.1 | 18.0 | 23.2 | 231 |
| BH00010 | Brush Fork | 8/15/2000 | 669 | 100 | 803 | 0 | 542 | 856 | 3.8 | 1020 | 0.1 | 4.5 | 16.6 | 21.2 | NM |
| BH00010 | Brush Fork | 10/16/2000 | 468 | 106 | 595 | 0 | 565 | 879 | 3.4 | 1060 | 0.8 | 4.4 | 21.0 | 26.2 | 147 |
| BH00010 | Brush Fork | 5/13/2001 | 1593 | 132 | 2523 | 0 | 491 | 749 | 2.9 | 884 | 2.4 | 3.4 | 13.4 | 19.2 | 367 |
| BH00010 | Brush Fork | 4/10/2002 | 2491 | 126 | 3766 | 0 | 485 | 724 | 3.3 | 1150 | 3.8 | 3.5 | 13.4 | 20.7 | 618 |
| BH00080 | Brush Fork | 4/10/2002 | 99 | 251 | 297 | 0 | 634 | 883 | 2.9 | 1460 | 4.6 | 2.7 | 23.9 | 31.1 | 37 |
| BH00080 | Brush Fork | 10/7/2002 | 23 | 234 | 64 | 0 | 636 | 909 | 3.0 | 1430 | 2.8 | 2.7 | 23.6 | 29.2 | 8 |
| BH00100 | Brush Fork | 4/10/2002 | 9 | 164 | 17 | 0 | 365 | 548 | 3.1 | 931 | 1.9 | 3.0 | 16.7 | 21.6 | 2 |
| BH00190 | Brush Fork | 4/10/2002 | 163 | 384 | 751 | 0 | 831 | 1120 | 2.7 | 1930 | 22.5 | 3.7 | 29.7 | 55.9 | 109 |
| BH00190 | Brush Fork | 10/7/2002 | 90 | 278 | 299 | 0 | 719 | 1050 | 2.9 | 1590 | 6.4 | 4.2 | 27.4 | 38.0 | 41 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH00230 | Brush Fork | 4/10/2002 | 10 | 228 | 27 | 0 | 543 | 774 | 2.9 | 1410 | 4.0 | 4.1 | 23.5 | 31.6 | 4 |
| BH00380 | Brush Fork | 5/13/2001 | 159 | 209 | 400 | 0 | 652 | 978 | 3.0 | 1010 | 34.2 | 4.4 | 21.6 | 60.2 | 115 |
| BH00380 | Brush Fork | 4/10/2002 | 70 | 179 | 151 | 0 | 545 | 894 | 3.4 | 1310 | 20.8 | 3.8 | 19.6 | 44.2 | 37 |
| BH00380 | Brush Fork | 10/7/2002 | 110 | 227 | 301 | 0 | 706 | 1060 | 3.6 | 1250 | 31.7 | 4.1 | 23.6 | 59.4 | 79 |
| BH00430 | Brush Fork | 5/13/2001 | 126 | 201 | 304 | 0 | 519 | 792 | 2.5 | 1160 | 3.9 | 3.7 | 16.7 | 24.3 | 37 |
| BH00430 | Brush Fork | 4/10/2002 | 384 | 211 | 972 | 0 | 578 | 837 | 2.9 | 1380 | 5.3 | 3.7 | 17.4 | 26.3 | 121 |
| BH00430 | Brush Fork | 10/7/2002 | 232 | 187 | 521 | 0 | 599 | 897 | 3.0 | 1360 | 3.0 | 4.0 | 16.3 | 23.2 | 65 |
| BH00450 | Brush Fork | 4/10/2002 | 7 | 141 | 12 | 0 | 610 | 929 | 3.4 | 1300 | 0.4 | 7.0 | 18.0 | 25.4 | 2 |
| BH00520 | Brush Fork | 5/13/2001 | 118 | 142 | 202 | 0 | 396 | 600 | 2.7 | 910 | 1.8 | 2.6 | 13.0 | 17.3 | 25 |
| BH00520 | Brush Fork | 4/10/2002 | 123 | 127 | 187 | 0 | 365 | 532 | 3.1 | 1030 | 2.2 | 2.3 | 9.9 | 14.3 | 21 |
| BH00520 | Brush Fork | 10/7/2002 | 3 | 169 | 6 | 0 | 515 | 777 | 3.0 | 1220 | 3.3 | 3.2 | 14.5 | 21.1 | 1 |
| BH00610 | Brush Fork | 5/13/2001 | 62 | 85 | 64 | 0 | 487 | 759 | 3.2 | 922 | 5.4 | 5.3 | 8.9 | 19.6 | 15 |
| BH00630 | Brush Fork | 4/10/2002 | 92 | 108 | 119 | 0 | 546 | 812 | 4.1 | 1110 | 0.5 | 4.7 | 12.5 | 17.7 | 19 |
| BH00690 | Brush Fork | 5/13/2001 | 169 | 468 | 948 | 0 | 1045 | 1570 | 3.5 | 1690 | 292.0 | 4.6 | 15.8 | 312.4 | 633 |
| BH00690 | Brush Fork | 4/10/2002 | 130 | 440 | 687 | 0 | 1029 | 1500 | 3.5 | 1840 | 210.0 | 4.8 | 12.3 | 227.1 | 355 |
| BH00690 | Brush Fork | 10/7/2002 | 20 | 553 | 134 | 0 | 1194 | 1820 | 3.0 | 2070 | 203.0 | 4.8 | 14.2 | 222.0 | 54 |
| BH00720 | Brush Fork | 6/26/2002 | NM | 4 | NM | 106 | 289 | 514 | 7.8 | 742 | 0.1 | 0.1 | 0.3 | 0.4 | NM |
| BH00850 | Brush Fork | 5/13/2001 | 47 | 9 | 5 | 122 | 185 | 423 | 7.1 | 530 | 0.1 | 0.1 | 0.1 | 0.4 | 0 |
| BH03040 | Brush Fork | 5/13/2001 | 81 | 102 | 99 | 0 | 440 | 674 | 2.9 | 825 | 1.2 | 2.5 | 9.7 | 13.3 | 13 |
| BH03040 | Brush Fork | 4/10/2002 | 184 | 82 | 181 | 0 | 449 | 641 | 3.4 | 994 | 0.3 | 2.4 | 8.1 | 10.8 | 24 |
| BH03040 | Brush Fork | 10/7/2002 | 55 | 94 | 62 | 0 | 474 | 706 | 3.4 | 1050 | 0.4 | 2.5 | 9.6 | 12.5 | 8 |
| BH03100 | Brush Fork | 4/10/2002 | 120 | 90 | 130 | 0 | 43.6 | 646 | 3.4 | 1030 | 0.3 | 2.1 | 8.8 | 11.2 | 16 |
| BH09100 | Brush Fork | 4/10/2002 | 40 | 148 | 71 | 0 | 505 | 707 | 3.1 | 1160 | 2.9 | 3.5 | 11.9 | 18.2 | 9 |
| BH09100 | Brush Fork | 10/7/2002 | 11 | 162 | 22 | 0 | 576 | 814 | 3.0 | 1280 | 2.3 | 3.8 | 14.5 | 20.6 | 3 |
| BH09190 | Brush Fork | 4/10/2002 | 36 | 132 | 57 | 0 | 468 | 681 | 3.1 | 1080 | 5.8 | 3.3 | 9.9 | 19.1 | 8 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH09190 | Brush Fork | 10/7/2002 | 27 | 146 | 48 | 0 | 540 | 808 | 3.2 | 1200 | 7.5 | 4.3 | 13.0 | 24.8 | 8 |
| BH13100 | Brush Fork | 5/13/2001 | 9 | 82 | 8 | 0 | 596 | 910 | 4.1 | 969 | 0.4 | 8.0 | 11.7 | 20.1 | 2 |
| BS00100 | Bessemer | 2/26/1998 | 730 | 125 | 1095 | 0 | 386 | 612 | 3.3 | 851 | 2.0 | 1.0 | 13.0 | 16.0 | 140 |
| BS00100 | Bessemer | 4/30/1999 | 312 | 160 | 599 | NM | 340 | NM | NM | NM | 2.6 | 1.4 | 16.0 | 20.0 | 75 |
| BS00100 | Bessemer | 5/26/1999 | 107 | 190 | 244 | NM | 490 | NM | NM | NM | 5.3 | 1.9 | 20.0 | 27.2 | 35 |
| BS00100 | Bessemer | 6/28/1999 | 42 | 270 | 136 | NM | 630 | NM | NM | NM | 9.4 | 2.3 | 23.0 | 34.7 | 17 |
| BS00100 | Bessemer | 7/18/1999 | 11 | 230 | 30 | NM | 810 | NM | NM | NM | 8.4 | 2.8 | 25.0 | 36.2 | 5 |
| BS00100 | Bessemer | 8/8/1999 | 69 | 220 | 181 | NM | 650 | NM | NM | NM | 9.4 | 2.7 | 25.0 | 37.1 | 31 |
| BS00100 | Bessemer | 9/19/1999 | 11 | 240 | 31 | NM | 680 | NM | NM | NM | 8.1 | 2.4 | 24.0 | 34.5 | 4 |
| BS00100 | Bessemer | 10/19/2000 | 108 | 131 | 169 | 0 | 370 | 567 | 3.3 | 887 | 3.7 | 2.6 | 19.4 | 25.7 | 33 |
| BS00100 | Bessemer | 10/19/2000 | 108 | 131 | 171 | 0 | 370 | 567 | 3.3 | 887 | 3.7 | 2.6 | 19.4 | 25.7 | 33 |
| BS00100 | Bessemer | 2/8/2001 | 307 | 134 | 494 | 0 | 364 | 565 | 3.4 | 868 | 3.8 | 1.8 | 20.4 | 26.1 | 96 |
| BS00100 | Bessemer | 4/3/2001 | 179 | 128 | 276 | 0 | 338 | 546 | 3.2 | 822 | 1.9 | 1.3 | 14.0 | 17.1 | 37 |
| BS00100 | Bessemer | 8/7/2001 | 52 | 186 | 115 | 0 | 428 | 716 | NM | 1200 | 6.2 | 2.4 | 24.4 | 33.0 | 20 |
| BS00100 | Bessemer | 10/1/2002 | 19 | 227 | 51 | 0 | 526 | 798 | 3.1 | 1180 | 9.8 | 2.5 | 24.6 | 36.8 | 8 |
| BS00400 | Bessemer | 2/25/1998 | 9 | 151 | 17 | 0 | 464 | 716 | 3.3 | 933 | 1.3 | 3.3 | 28.0 | 32.6 | 4 |
| BS00450 | Bessemer | 2/26/1998 | 266 | 45 | 144 | 0 | 137 | 280 | 3.7 | 363 | 0.6 | 0.8 | 16.0 | 17.4 | 56 |
| BS00450 | Bessemer | 4/30/1999 | 106 | 120 | 153 | NM | 280 | NM | NM | NM | 0.5 | 1.0 | 12.0 | 13.5 | 17 |
| BS00450 | Bessemer | 5/26/1999 | 23 | 130 | 36 | NM | 430 | NM | NM | NM | 0.8 | 1.0 | 13.0 | 14.8 | 4 |
| BS00450 | Bessemer | 6/28/1999 | 3 | 140 | 5 | NM | 500 | NM | NM | NM | 1.3 | 1.2 | 14.0 | 16.5 | 1 |
| BS00450 | Bessemer | 7/18/1999 | 1 | 140 | 2 | NM | 620 | NM | NM | NM | 2.4 | 1.3 | 16.0 | 19.7 | 0 |
| BS00450 | Bessemer | 8/8/1999 | 0 | 150 | 1 | NM | 560 | NM | NM | NM | 1.7 | 1.8 | 16.0 | 19.5 | 0 |
| BS00450 | Bessemer | 9/19/1999 | 1 | 160 | 2 | NM | 550 | NM | NM | NM | 1.0 | 1.5 | 17.0 | 19.5 | 0 |
| BS00450 | Bessemer | 10/1/2002 | 1 | 146 | 2 | 0 | 439 | 662 | 3.4 | 912 | 3.6 | 1.5 | 17.2 | 22.3 | 0 |
| BS00500 | Bessemer | 2/25/1998 | 15 | 128 | 23 | 0 | 350 | 532 | 3.2 | 845 | 1.5 | 1.2 | 14.0 | 16.7 | 3 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BS00550 | Bessemer | 3/7/1998 | 16 | 188 | 35 | 0 | 405 | 548 | 3.3 | 821 | 7.6 | 2.1 | 25.0 | 34.7 | 7 |
| BS00570 | Bessemer | 10/1/2002 | NM | 220 | NM | 0 | 451 | 684 | 3.2 | 982 | 12.5 | 2.2 | 23.3 | 38.0 | NM |
| BS00600 | Bessemer | 3/6/1998 | 13 | 153 | 23 | 0 | 289 | 500 | 3.3 | 777 | 1.4 | 0.9 | 15.0 | 17.2 | 3 |
| BS00600 | Bessemer | 10/1/2002 | 2 | 172 | 5 | 0 | 429 | 661 | 3.2 | 1030 | 2.9 | 1.4 | 19.5 | 23.9 | 1 |
| BS00650 | Bessemer | 3/8/1998 | 44 | 286 | 149 | 0 | 587 | 880 | 3.0 | 1414 | 3.6 | 2.3 | 30.0 | 35.9 | 19 |
| BS00650 | Bessemer | 3/6/1999 | 30 | 290 | 105 | 0 | 626 | 956 | 3.0 | 1478 | 3.7 | 1.8 | 28.0 | 33.5 | 12 |
| BS00650 | Bessemer | 4/30/1999 | 20 | 370 | 87 | NM | 690 | NM | NM | NM | 5.9 | 2.2 | 33.0 | 41.1 | 10 |
| BS00650 | Bessemer | 5/26/1999 | 14 | 380 | 65 | NM | 780 | NM | NM | NM | 5.6 | 2.4 | 38.0 | 46.0 | 8 |
| BS00650 | Bessemer | 6/28/1999 | 6 | 420 | 30 | NM | 500 | NM | NM | NM | 5.9 | 2.7 | 43.0 | 51.6 | 4 |
| BS00650 | Bessemer | 7/18/1999 | 4 | 400 | 17 | NM | 1200 | NM | NM | NM | 6.0 | 2.9 | 44.0 | 52.9 | 2 |
| BS00650 | Bessemer | 8/8/1999 | 3 | 380 | 15 | NM | 980 | NM | NM | NM | 7.0 | 3.4 | 47.0 | 57.4 | 2 |
| BS00650 | Bessemer | 9/19/1999 | 2 | 380 | 10 | NM | 630 | NM | NM | NM | 5.7 | 2.8 | 39.0 | 47.5 | 1 |
| BS00650 | Bessemer | 10/1/2002 | 4 | 399 | 17 | 0 | 799 | 1280 | 2.8 | 1800 | 6.0 | 2.8 | 45.9 | 54.7 | 2 |
| BS00670 | Bessemer | 10/1/2002 | 4 | 165 | 7 | 0 | 391 | 615 | 3.1 | 986 | 3.9 | 1.1 | 16.8 | 21.8 | 1 |
| BS00700 | Bessemer | 4/4/1998 | 13 | 79 | 12 | 0 | 294 | 464 | 3.6 | 651 | 5.0 | 1.6 | 10.0 | 16.6 | 3 |
| BS00700 | Bessemer | 4/30/1999 | 43 | 330 | 170 | NM | 600 | NM | NM | NM | 4.8 | 2.1 | 33.0 | 39.9 | 21 |
| BS00700 | Bessemer | 5/26/1999 | 12 | 380 | 54 | NM | 830 | NM | NM | NM | 5.1 | 2.3 | 36.0 | 43.4 | 6 |
| BS00700 | Bessemer | 6/28/1999 | 4 | 420 | 21 | NM | 950 | NM | NM | NM | 5.6 | 2.6 | 42.0 | 50.2 | 3 |
| BS00700 | Bessemer | 7/18/1999 | 3 | 390 | 13 | NM | 1200 | NM | NM | NM | 5.5 | 2.9 | 44.0 | 52.4 | 2 |
| BS00700 | Bessemer | 8/8/1999 | 2 | 400 | 12 | NM | 1000 | NM | NM | NM | 6.4 | 3.3 | 46.0 | 55.7 | 2 |
| BS00700 | Bessemer | 9/19/1999 | 2 | 400 | 8 | NM | 940 | NM | NM | NM | 5.5 | 2.9 | 39.0 | 47.4 | 1 |
| BS00700 | Bessemer | 10/1/2002 | 2 | 393 | 8 | 0 | 784 | 1140 | 2.8 | 1770 | 6.0 | 2.8 | 43.8 | 52.6 | 1 |
| BS00800 | Bessemer | 4/30/1999 | 15 | 120 | 21 | NM | 260 | NM | NM | NM | 1.5 | 1.0 | 10.0 | 12.5 | 2 |
| BS00800 | Bessemer | 5/26/1999 | 11 | 120 | 15 | NM | 400 | NM | NM | NM | 2.5 | 1.2 | 12.0 | 15.7 | 2 |
| BS00800 | Bessemer | 6/28/1999 | 4 | 150 | 7 | NM | 430 | NM | NM | NM | 2.3 | 1.5 | 12.0 | 15.8 | 1 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BS00800 | Bessemer | 7/18/1999 | 2 | 120 | 3 | NM | 650 | NM | NM | NM | 2.5 | 1.7 | 13.0 | 17.2 | 0 |
| BS00800 | Bessemer | 8/8/1999 | 6 | 130 | 9 | NM | 510 | NM | NM | NM | 3.9 | 2.0 | 13.0 | 18.9 | 1 |
| BS00800 | Bessemer | 9/19/1999 | 2 | 160 | 3 | NM | 600 | NM | NM | NM | 4.0 | 2.1 | 17.0 | 23.1 | 0 |
| BS00800 | Bessemer | 10/1/2002 | 4 | 144 | 7 | 0 | 428 | 659 | 3.3 | 1080 | 5.8 | 1.8 | 15.6 | 23.3 | 1 |
| BS00850 | Bessemer | 10/1/2002 | 2 | 260 | 5 | 0 | 583 | 877 | 3.0 | 1460 | 5.8 | 1.6 | 27.4 | 34.7 | 1 |
| CH00100 | Coe | 10/25/2000 | 75 | 399 | 362 | 0 | 963 | 1400 | 2.7 | 1790 | 20.5 | 6.2 | 42.9 | 69.6 | 63 |
| CH00100 | Coe | 10/25/2000 | 75 | 399 | 359 | 0 | 963 | 1400 | 2.7 | 1790 | 20.5 | 6.2 | 42.9 | 69.6 | 63 |
| CH00100 | Coe | 2/8/2001 | 92 | 310 | 341 | 0 | 723 | 1060 | 3.0 | 1350 | 23.3 | 4.5 | 28.2 | 56.0 | 61 |
| CH00100 | Coe | 3/20/2001 | 56 | 466 | 314 | 0 | 1021 | 1470 | 2.8 | 1760 | 56.7 | 4.9 | 58.2 | 119.8 | 81 |
| CH00100 | Coe | 3/20/2001 | 56 | 466 | 314 | 0 | 1021 | 1470 | 2.8 | 1760 | 56.7 | 4.9 | 58.2 | 119.8 | 81 |
| CH00100 | Coe | 4/4/2001 | 56 | 466 | 314 | 0 | 1021 | 1470 | 2.8 | 1760 | 56.7 | 4.9 | 58.2 | 119.8 | 81 |
| CH00100 | Coe | 8/7/2001 | 0 | 282 | 0 | 0 | 698 | 1290 | NM | 1750 | 20.5 | 4.8 | 37.1 | 62.4 | 0 |
| CH00100 | Coe | 4/1/2002 | 144 | 266 | 458 | 0 | 593 | 859 | 2.8 | 1240 | 20.2 | 3.1 | 23.6 | 46.9 | 81 |
| CH00200 | Coe | 4/1/2002 | 121 | 302 | 439 | 0 | 624 | 919 | 2.7 | 1260 | 30.2 | 3.1 | 26.0 | 59.3 | 86 |
| CH00200 | Coe | 9/30/2002 | 100 | 382 | 459 | 0 | 988 | 1440 | 3.0 | 1910 | 44.0 | 5.6 | 40.5 | 90.1 | 108 |
| CH00400 | Coe | 9/30/2002 | 1 | 300 | 3 | 0 | 856 | 1290 | 3.1 | 1720 | 51.6 | 4.2 | 28.0 | 83.8 | 1 |
| CH00450 | Coe | 3/20/2001 | 4 | 209 | 11 | 0 | 531 | 737 | 3.1 | 1050 | 17.1 | 2.6 | 28.0 | 47.7 | 2 |
| CH00450 | Coe | 4/1/2002 | 1 | 388 | 6 | 0 | 881 | 1290 | 2.6 | 1690 | 77.0 | 4.3 | 26.2 | 107.5 | 2 |
| CH00450 | Coe | 9/30/2002 | 0 | 391 | 2 | 0 | 1021 | 1500 | 3.0 | 2030 | 85.0 | 5.0 | 34.8 | 124.8 | 1 |
| CH00500 | Coe | 3/20/2001 | 131 | 182 | 285 | 0 | 375 | 524 | 3.1 | 755 | 16.9 | 1.6 | 18.2 | 36.7 | 58 |
| CH00500 | Coe | 4/1/2002 | 112 | 251 | 338 | 0 | 482 | 755 | 2.7 | 1040 | 19.6 | 2.3 | 23.0 | 44.9 | 60 |
| CH00500 | Coe | 9/30/2002 | 15 | 224 | 41 | 0 | 525 | 763 | 3.1 | 1190 | 11.0 | 2.4 | 26.2 | 39.6 | 7 |
| LH00020 | Long | 6/4/1998 | 655 | 122 | 959 | 0 | 333 | 700 | 3.2 | 1068 | 4.1 | 1.1 | 7.1 | 12.3 | 97 |
| LH00020 | Long | 10/16/2000 | 81 | 70 | 67 | 0 | 335 | 599 | 3.2 | 971 | 2.2 | 1.7 | 7.8 | 11.7 | 11 |
| LH00020 | Long | 2/8/2001 | 239 | 75 | 214 | 0 | 310 | 529 | 3.2 | 935 | 3.4 | 1.7 | 10.2 | 15.3 | 44 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LH00020 | Long | 4/4/2001 | 552 | 82 | 540 | 0 | 344 | 530 | 3.2 | 866 | 1.4 | 0.6 | 5.9 | 7.9 | 52 |
| LH00020 | Long | 8/7/2001 | 44 | 47 | 25 | 0 | 275 | 456 | NM | 943 | 2.1 | 1.0 | 4.6 | 7.7 | 4 |
| LH00020 | Long | 3/28/2002 | 880 | 17 | 182 | | 167 | 267 | 5.1 | 466 | 1.4 | 0.6 | 1.7 | 3.8 | 40 |
| LH00020 | Long | 3/28/2002 | 880 | 17 | 182 | 2.1 | 167 | 267 | 5.1 | 466 | 1.4 | 0.6 | 1.7 | 3.8 | 40 |
| LH00020 | Long | 11/18/2002 | 37 | 65 | 29 | 0 | 328 | 562 | 3.5 | 979 | 2.9 | 2.5 | 3.7 | 9.1 | 4 |
| LH00060 | Long | 6/4/1998 | 268 | 178 | 572 | 0 | 413 | 844 | 3.1 | 1268 | 4.6 | 0.9 | 12.0 | 17.5 | 56 |
| LH00060 | Long | 10/16/2000 | 41 | 100 | 49 | 0 | 366 | 561 | 2.9 | 1020 | 1.9 | 0.7 | 9.3 | 12.0 | 6 |
| LH00060 | Long | 11/18/2002 | 19 | 103 | 23 | 0 | 373 | 509 | 3.1 | 975 | 1.9 | 0.7 | 6.2 | 8.8 | 2 |
| LH00070 | Long | 6/4/1998 | 115 | 142 | 196 | 0 | 295 | 832 | 3.1 | 1116 | 3.7 | 0.8 | 8.0 | 12.6 | 17 |
| LH00070 | Long | 11/18/2002 | 3 | 125 | 5 | 0 | 390 | 542 | 3.1 | 1030 | 3.0 | 0.8 | 8.3 | 12.1 | 0 |
| LH00150 | Long | 6/4/1998 | 242 | 52 | 151 | 0 | 293 | 608 | 3.6 | 803 | 1.6 | 0.6 | 2.8 | 5.0 | 14 |
| LH00150 | Long | 11/18/2002 | 5 | 42 | 2 | 0 | 342 | 491 | 3.7 | 774 | 1.7 | 0.4 | 2.1 | 4.2 | 0 |
| LR00020 | Lost Run | 3/26/1998 | 1849 | 131 | 2907 | 0 | 737 | 860 | 3.3 | 989 | 5.0 | 4.5 | 16.0 | 25.5 | 565 |
| LR00020 | Lost Run | 10/18/2000 | 213 | 134 | 346 | 0 | 503 | 763 | 3.4 | 1070 | 4.4 | 8.0 | 15.1 | 27.5 | 70 |
| LR00020 | Lost Run | 5/9/2001 | 785 | 165 | 1554 | 0 | 515 | 781 | 3.3 | 1090 | 4.6 | 5.1 | 18.5 | 28.2 | 265 |
| LR00020 | Lost Run | 3/27/2002 | 3627 | 68 | 2959 | 0 | 301 | 463 | 3.5 | 668 | 1.9 | 3.0 | 6.8 | 11.7 | 507 |
| LR00020 | Lost Run | 11/13/2002 | 503 | 108 | 651 | 0 | 509 | 780 | 3.6 | 1040 | 3.1 | 5.7 | 11.3 | 20.2 | 122 |
| LR00540 | Lost Run | 3/27/2002 | 20 | 314 | 75 | 0 | 682 | 985 | 2.7 | 1470 | 20.8 | 5.6 | 27.0 | 53.4 | 13 |
| LR00540 | Lost Run | 11/18/2002 | 9 | 315 | 32 | 0 | 814 | 1130 | 3.0 | 1630 | 28.6 | 7.0 | 26.3 | 61.9 | 6 |
| LR00840 | Lost Run | 3/27/2002 | 13 | 236 | 38 | 0 | 462 | 651 | 3.1 | 1180 | 9.2 | 3.4 | 19.4 | 32.0 | 5 |
| LR00840 | Lost Run | 11/13/2002 | 3 | 376 | 12 | 0 | 922 | 1280 | 3.0 | 1750 | 10.8 | 8.8 | 41.1 | 60.7 | 2 |
| LR00850 | Lost Run | 5/10/2001 | 6 | 327 | 22 | 0 | 466 | 701 | 2.7 | 1360 | 18.5 | 3.1 | 24.4 | 46.0 | 3 |
| LR01020 | Lost Run | 5/9/2001 | 198 | 115 | 273 | 0 | 356 | 562 | 3.3 | 797 | 3.0 | 5.3 | 13.6 | 21.9 | 52 |
| LR01020 | Lost Run | 3/27/2002 | 1221 | 66 | 961 | 0 | 205 | 311 | 3.3 | 459 | 1.0 | 2.6 | 6.6 | 10.2 | 150 |
| LR01020 | Lost Run | 11/12/2002 | 85 | 97 | 99 | 0 | 426 | 625 | 3.6 | 866 | 3.3 | 7.7 | 9.9 | 20.9 | 21 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LR01100 | Lost Run | 11/12/2002 | 4 | 180 | 9 | 0 | 440 | 662 | 3.6 | 958 | 0.6 | 5.0 | 25.0 | 30.6 | 1 |
| LR01200 | Lost Run | 11/12/2002 | 20 | 52 | 13 | 0 | 611 | 896 | 3.7 | 1140 | 0.7 | 9.4 | 2.5 | 12.6 | 3 |
| LR01500 | Lost Run | 11/12/2002 | 8 | 240 | 22 | 0 | 753 | 1090 | 3.0 | 1350 | 21.6 | 7.0 | 17.7 | 46.3 | 4 |
| LR01700 | Lost Run | 11/12/2002 | 3 | 69 | 3 | 0 | 364 | 552 | 3.7 | 769 | 1.9 | 5.5 | 6.3 | 13.7 | 1 |
| LR01800 | Lost Run | 11/12/2002 | 1 | 601 | 6 | 0 | 1095 | 1530 | 2.8 | 1810 | 12.8 | 11.2 | 70.7 | 94.7 | 1 |
| LR01900 | Lost Run | 11/12/2002 | 2 | 333 | 9 | 0 | 988 | 1440 | 3.4 | 1630 | 11.2 | 14.0 | 42.7 | 67.9 | 2 |
| LR02000 | Lost Run | 11/12/2002 | 4 | 132 | 6 | 0 | 519 | 782 | 3.3 | 1190 | 9.9 | 7.3 | 10.0 | 27.2 | 1 |
| LR02100 | Lost Run | 5/9/2001 | 51 | 5 | 3 | 17 | 651 | 1030 | 6.7 | 1170 | 0.4 | 3.7 | 0.2 | 4.4 | 3 |
| LR02100 | Lost Run | 3/27/2002 | 610 | 33 | 238 | 3.2 | 448 | 691 | 5.2 | 918 | 0.4 | 3.9 | 1.6 | 5.9 | 43 |
| LR02100 | Lost Run | 11/13/2002 | 48 | 6 | 4 | 19.8 | 689 | 1040 | 6.6 | 1290 | 0.4 | 3.3 | 0.3 | 3.9 | NM |
| LR02150 | Lost Run | 6/26/2002 | 0 | 5 | 0 | 50.8 | 591 | 951 | 6.8 | 1180 | 1.9 | 6.5 | 0.4 | 8.8 | 0 |
| LR03230 | Lost Run | 5/9/2001 | 64 | 41 | 32 | 0 | 247 | 404 | 3.7 | 554 | 0.1 | 1.8 | 4.9 | 6.8 | 5 |
| LR03230 | Lost Run | 3/27/2002 | 171 | 27 | 54 | 0 | 167 | 263 | 3.8 | 442 | 0.7 | 0.5 | 2.1 | 3.2 | 7 |
| LR03230 | Lost Run | 11/13/2002 | 4 | 70 | 4 | 0 | 357 | 515 | 3.8 | 729 | 0.3 | 3.7 | 8.2 | 12.1 | 1 |
| LR04150 | Lost Run | 5/9/2001 | 78 | 158 | 148 | 0 | 439 | 685 | 3.0 | 992 | 3.0 | 4.8 | 16.2 | 24.0 | 22 |
| LR04150 | Lost Run | 3/27/2002 | 229 | 147 | 404 | 0 | 370 | 562 | 2.8 | 887 | 4.9 | 4.2 | 13.0 | 22.1 | 61 |
| LR04150 | Lost Run | 11/13/2002 | 15 | 180 | 33 | 0 | 500 | 716 | 3.1 | 1090 | 5.7 | 5.1 | 16.6 | 27.3 | 5 |
| LR04500 | Lost Run | 11/18/2002 | 4 | 163 | 7 | 0 | 440 | 65 | 3.1 | 986 | 1.1 | 1.7 | 16.7 | 19.5 | 1 |
| LR04550 | Lost Run | 11/18/2002 | NM | 92 | NM | 0 | 424 | 653 | 3.9 | 821 | 23.0 | 1.9 | 4.6 | 29.4 | NM |
| LR04600 | Lost Run | 5/9/2001 | 56 | 182 | 121 | 0 | 412 | 600 | 3.0 | 1080 | 18.5 | 4.1 | 11.0 | 33.6 | 22 |
| LR04600 | Lost Run | 6/26/2002 | 37 | 240 | 106 | 0 | 477 | 747 | 3.1 | 1070 | 8.2 | 4.5 | 24.3 | 37.1 | 16 |
| LR04600 | Lost Run | 6/26/2002 | 37 | 240 | 106 | 0 | 477 | 747 | 3.1 | 1070 | 8.2 | 4.5 | 24.3 | 37.1 | 16 |
| LR04700 | Lost Run | 6/26/2002 | 0 | 2 | 0 | 64.1 | 25.5 | 122 | 7.3 | 176 | 0.7 | 1.2 | 0.3 | 2.1 | NM |
| LR05100 | Lost Run | 5/9/2001 | 36 | 268 | 115 | 0 | 564 | 832 | 2.9 | 1260 | 10.0 | 5.1 | 26.5 | 41.6 | 18 |
| LR05100 | Lost Run | 3/27/2002 | 92 | 212 | 233 | 0 | 426 | 649 | 2.7 | 1060 | 8.7 | 4.3 | 20.6 | 33.7 | 37 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LR05100 | Lost Run | 11/13/2002 | 15 | 202 | 37 | 0 | 506 | 740 | 3.1 | 1140 | 5.3 | 6.7 | 20.4 | 32.4 | 6 |
| LR05400 | Lost Run | 3/27/2002 | 14 | 555 | 90 | 0 | 1054 | 1470 | 2.5 | 2280 | 40.0 | 6.0 | 49.8 | 95.8 | 16 |
| LR05400 | Lost Run | 11/18/2002 | 2 | 378 | 10 | 0 | 704 | 995 | 3.0 | 1350 | 54.5 | 5.4 | 25.3 | 85.2 | 2 |
| LR06100 | Lost Run | 5/9/2001 | 54 | 301 | 195 | 0 | 636 | 931 | 3.0 | 1310 | 7.4 | 7.9 | 34.3 | 49.6 | 32 |
| LR06100 | Lost Run | 3/27/2002 | 99 | 228 | 270 | 0 | 466 | 683 | 3.1 | 999 | 4.1 | 6.6 | 25.3 | 36.0 | 43 |
| LR06100 | Lost Run | 11/13/2002 | 12 | 301 | 44 | 0 | 687 | 979 | 3.1 | 1360 | 4.5 | 10.5 | 36.8 | 51.8 | 8 |
| LR06620 | Lost Run | 3/27/2002 | 10 | 367 | 45 | 0 | 772 | 1150 | 3.1 | 1500 | 16.7 | 6.4 | 37.3 | 60.4 | 7 |
| LR06620 | Lost Run | 11/18/2002 | 1 | 386 | 6 | 0 | 873 | 1270 | 3.0 | 1630 | 25.6 | 8.1 | 36.4 | 70.1 | 1 |
| LR07120 | Lost Run | 5/9/2001 | 146 | 440 | 770 | 0 | 840 | 1220 | 2.8 | 1670 | 18.5 | 6.4 | 46.0 | 70.9 | 124 |
| LR07120 | Lost Run | 3/27/2002 | 60 | 403 | 291 | 0 | 831 | 1220 | 3.1 | 1580 | 29.0 | 6.7 | 38.0 | 73.7 | 53 |
| LR07120 | Lost Run | 11/13/2002 | 13 | 373 | 60 | 0 | 881 | 1260 | 3.0 | 1620 | 44.8 | 8.2 | 33.5 | 86.5 | 14 |
| LR07200 | Lost Run | 3/27/2002 | 4 | 684 | 29 | 0 | 1054 | 1550 | 2.9 | 1750 | 44.5 | 7.2 | 72.1 | 123.8 | 5 |
| LR07300 | Lost Run | 5/9/2001 | 65 | 410 | 321 | 0 | 796 | 1170 | 2.8 | 1640 | 11.5 | 6.1 | 45.3 | 62.9 | 49 |
| LR07300 | Lost Run | 3/27/2002 | 20 | 377 | 91 | 0 | 714 | 1040 | 3.1 | 1330 | 8.2 | 5.7 | 39.9 | 53.8 | 13 |
| MH00250 | Monkey | 4/27/1999 | 412 | 202 | 998 | 0 | 493 | 703 | 2.8 | 1550 | 13.8 | 3.6 | 25.3 | 42.7 | 211 |
| MH00250 | Monkey | 5/24/1999 | 255 | 224 | 686 | 0 | 478 | 677 | 2.5 | 1550 | 8.6 | 4.6 | 20.7 | 33.8 | 104 |
| MH00250 | Monkey | 6/23/1999 | 94 | 303 | 341 | 0 | 666 | 884 | 2.7 | 1500 | 7.9 | 6.1 | 28.2 | 42.2 | 48 |
| MH00250 | Monkey | 7/21/1999 | 12 | 293 | 42 | 0 | 714 | 940 | 2.9 | 1860 | 8.8 | 6.1 | 29.9 | 44.8 | 6 |
| MH00250 | Monkey | 8/18/1999 | 12 | 298 | 42 | 0 | 723 | 1100 | 2.9 | 1650 | 8.6 | 6.8 | 24.4 | 39.8 | 6 |
| MH00250 | Monkey | 9/27/1999 | 12 | 281 | 40 | 0 | 701 | 1070 | 2.6 | NM | 7.4 | 7.2 | 30.3 | 44.9 | 6 |
| MH00250 | Monkey | 10/27/1999 | 15 | 256 | 47 | 0 | 688 | NM | 2.8 | 1430 | 6.9 | 7.5 | 26.9 | 41.2 | 8 |
| MH00250 | Monkey | 11/29/1999 | 57 | 280 | 190 | 0 | 659 | NM | 2.8 | 1470 | 7.3 | 6.8 | 29.9 | 44.0 | 30 |
| MH00250 | Monkey | 2/15/2000 | 370 | 175 | 776 | 0 | 366 | 539 | 2.9 | 977 | 5.3 | 4.4 | 11.7 | 21.4 | 95 |
| MH00250 | Monkey | 3/27/2000 | 1057 | 230 | 2918 | 0 | 426 | 654 | 3.1 | 1230 | 13.3 | 3.5 | 17.5 | 34.3 | 435 |
| MH00250 | Monkey | 4/27/2000 | 326 | 293 | 1146 | 0 | 559 | 834 | 2.8 | 1490 | 14.4 | 4.3 | 33.4 | 52.1 | 204 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MH00250 | Monkey | 3/19/2001 | 274 | 193 | 635 | 0 | 423 | 661 | 3.1 | 1030 | 5.7 | 5.2 | 18.6 | 29.5 | 97 |
| MH00250 | Monkey | 3/25/2002 | 166 | 190 | 379 | 0 | 431 | 651 | 3.0 | 1140 | 6.3 | 5.2 | 17.7 | 29.2 | 58 |
| MH00400 | Monkey | 3/19/2001 | 282 | 92 | 312 | 0 | 327 | 487 | 4.3 | 710 | 1.1 | 2.7 | 13.7 | 17.5 | 59 |
| MH00400 | Monkey | 3/25/2002 | 242 | 94 | 273 | 0 | 331 | 507 | 4.0 | 692 | 1.1 | 2.9 | 12.3 | 16.3 | 47 |
| MH00900 | Monkey | 3/25/2002 | 31 | 134 | 51 | 0 | 359 | 547 | 3.3 | 359 | 1.0 | 1.3 | 16.1 | 18.4 | 7 |
| MH01190 | Monkey | 3/20/2001 | 8 | 200 | 18 | 0 | 353 | 525 | 2.9 | 898 | 3.0 | 3.3 | 18.5 | 24.8 | 2 |
| MH01200 | Monkey | 3/19/2001 | 29 | 183 | 64 | 0 | 370 | 602 | 3.0 | 925 | 2.9 | 3.8 | 18.4 | 25.1 | 9 |
| MH01200 | Monkey | 3/25/2002 | 32 | 164 | 63 | 0 | 377 | 557 | 3.0 | 961 | 3.0 | 4.0 | 16.9 | 23.9 | 9 |
| MH01480 | Monkey | 3/19/2001 | 1 | 455 | 7 | 0 | 665 | 880 | 2.6 | 1580 | 28.4 | 3.6 | 35.7 | 67.7 | 1 |
| MH01700 | Monkey | 3/19/2001 | 1 | 340 | 4 | 0 | 445 | 681 | 3.1 | 986 | 66.9 | 1.4 | 25.5 | 93.8 | 1 |
| MH01950 | Monkey | 3/19/2001 | 36 | 79 | 34 | 0 | 288 | 439 | 3.8 | 635 | 1.4 | 2.8 | 10.1 | 14.3 | 6 |
| MH01990 | Monkey | 3/19/2001 | 2 | 274 | 7 | 0 | 481 | 746 | 3.3 | 1060 | 4.7 | 3.5 | 39.0 | 47.3 | 1 |
| MH02050 | Monkey | 10/19/2000 | 169 | 81 | 165 | 0 | 342 | 523 | 3.7 | 745 | 0.9 | 4.7 | 14.2 | 19.7 | 40 |
| MH02050 | Monkey | 10/19/2000 | 169 | 81 | 163 | 0 | 342 | 523 | 3.7 | 745 | 0.9 | 4.7 | 14.2 | 19.7 | 40 |
| MH02050 | Monkey | 2/7/2001 | 495 | 63 | 374 | 0 | 256 | 410 | 3.8 | 658 | 1.2 | 3.1 | 9.3 | 13.6 | 81 |
| MH02050 | Monkey | 3/19/2001 | 1162 | 61 | 851 | 0 | 238 | 354 | 3.9 | 510 | 1.3 | 2.4 | 8.0 | 11.6 | 162 |
| MH02050 | Monkey | 4/4/2001 | 808 | 107 | 1038 | 0 | 324 | 521 | 3.5 | 649 | 3.4 | 2.9 | 10.9 | 17.1 | 166 |
| MH02050 | Monkey | 8/6/2001 | 220 | 124 | 327 | 0 | 379 | 593 | 3.4 | 918 | 1.8 | 4.1 | 12.3 | 18.2 | 48 |
| MH02050 | Monkey | 3/25/2002 | 1028 | 62 | 760 | 0 | 244 | 375 | 3.8 | 575 | 1.4 | 2.6 | 6.9 | 10.9 | 134 |
| MH02100 | Monkey | 6/26/2002 | 0 | 7 | 0 | 48.6 | 103 | 191 | 6.8 | 321 | 3.2 | 5.0 | 0.3 | 8.5 | NM |
| MH02270 | Monkey | 3/19/2001 | 22 | 257 | 66 | 0 | 602 | 873 | 2.8 | 1520 | 10.7 | 5.8 | 19.4 | 35.9 | 9 |
| MH02270 | Monkey | 3/25/2002 | 17 | 248 | 49 | 0 | 580 | 841 | 2.8 | 1530 | 11.2 | 5.3 | 16.1 | 32.6 | 7 |
| MH02370 | Monkey | 3/25/2002 | 58 | 247 | 173 | 0 | 584 | 822 | 2.9 | 1280 | 12.8 | 6.9 | 22.3 | 42.0 | 29 |
| MH02400 | Monkey | 5/27/1998 | 90 | 419 | 451 | 0 | 734 | 1160 | 2.7 | 1752 | 16.3 | 5.1 | 64.0 | 85.4 | 92 |
| MH02420 | Monkey | 3/25/2002 | 90 | 162 | 175 | 0 | 356 | 546 | 3.1 | 841 | 3.8 | 4.4 | 16.1 | 24.3 | 26 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MH02450 | Monkey | 5/24/1999 | 2 | 411 | 9 | 0 | 793 | 950 | 2.4 | 1650 | 45.1 | 4.1 | 29.4 | 78.6 | 2 |
| MH02450 | Monkey | 6/23/1999 | 1 | 483 | 6 | 0 | 643 | 1050 | 2.6 | 1710 | 61.5 | 4.7 | 25.8 | 92.0 | 1 |
| MH02450 | Monkey | 7/21/1999 | 1 | 589 | 6 | 0 | 996 | 1360 | 2.9 | 1760 | 108.0 | 6.3 | 33.5 | 147.8 | 1 |
| MH02450 | Monkey | 8/18/1999 | 1 | 602 | 4 | 0 | 1103 | 1620 | 2.8 | 1970 | 125.0 | 8.1 | 30.2 | 163.3 | 1 |
| MH02450 | Monkey | 9/27/1999 | 1 | 638 | 5 | 0 | 1062 | 1680 | 2.6 | 1990 | 149.0 | 8.7 | 35.0 | 192.7 | 2 |
| MH02450 | Monkey | 10/27/1999 | 1 | 598 | 4 | 0 | 1161 | 1790 | 2.8 | 1860 | 175.0 | 9.1 | 27.9 | 212.0 | 1 |
| MH02450 | Monkey | 11/29/1999 | 1 | 627 | 5 | 0 | 1152 | 1760 | 2.7 | 1870 | 152.0 | 8.1 | 29.7 | 189.8 | 2 |
| MH02450 | Monkey | 2/15/2000 | 1 | 574 | 7 | 0 | 1070 | 1600 | 2.7 | 1860 | 131.0 | 8.9 | 20.4 | 160.3 | 2 |
| MH02450 | Monkey | 3/22/2000 | 34 | 405 | 165 | 0 | 593 | 848 | 2.6 | 1618 | 42.8 | 2.6 | 26.7 | 72.1 | 29 |
| MH02450 | Monkey | 4/27/2000 | 6 | 456 | 35 | 0 | 709 | 1070 | 2.9 | 1800 | 27.6 | 3.2 | 48.7 | 79.5 | 6 |
| MH02450 | Monkey | 3/20/2001 | 3 | 562 | 20 | 0 | 1045 | 1500 | 2.8 | 1860 | 110.0 | 7.7 | 50.4 | 168.1 | 6 |
| MH02450 | Monkey | 3/25/2002 | 1 | 543 | 9 | 0 | 1021 | 1480 | 2.8 | 1860 | 124.0 | 7.9 | 28.6 | 160.5 | 3 |
| MH02480 | Monkey | 3/20/2001 | 20 | 486 | 118 | 0 | 840 | 1190 | 2.6 | 1780 | 31.2 | 5.7 | 54.6 | 91.5 | 22 |
| MH02480 | Monkey | 3/25/2002 | 9 | 589 | 60 | 0 | 1078 | 1510 | 2.7 | 2060 | 61.6 | 9.0 | 40.5 | 111.1 | 11 |
| MH02600 | Monkey | 5/27/1998 | 22 | 235 | 63 | 0 | 431 | 812 | 2.9 | 1257 | 5.5 | 5.4 | 33.0 | 43.9 | 12 |
| MH02700 | Monkey | 5/24/1999 | 4 | 524 | 26 | 0 | 780 | 1010 | 2.4 | 1530 | 100.0 | 2.8 | 32.5 | 135.3 | 7 |
| MH02700 | Monkey | 5/24/1999 | 2 | 554 | 15 | 0 | 840 | 1120 | 2.4 | 1840 | 69.2 | 3.6 | 45.3 | 118.1 | 3 |
| MH02700 | Monkey | 6/23/1999 | 4 | 568 | 28 | 0 | 751 | 1010 | 2.6 | 1450 | 97.6 | 3.2 | 35.6 | 136.4 | 7 |
| MH02700 | Monkey | 6/23/1999 | 1 | 707 | 9 | 0 | 1013 | 1330 | 2.5 | 1910 | 82.7 | 4.5 | 51.6 | 138.8 | 2 |
| MH02700 | Monkey | 7/21/1999 | 4 | 580 | 26 | 0 | 804 | 1060 | 2.8 | 1580 | 95.6 | 3.1 | 39.0 | 137.7 | 6 |
| MH02700 | Monkey | 7/21/1999 | 1 | 725 | 9 | 0 | 1078 | 1420 | 2.8 | 2180 | 92.4 | 4.8 | 53.2 | 150.4 | 2 |
| MH02700 | Monkey | 8/18/1999 | 3 | 619 | 24 | 0 | 856 | 1240 | 2.8 | 1550 | 121.0 | 3.9 | 33.1 | 158.0 | 6 |
| MH02700 | Monkey | 8/18/1999 | 1 | 738 | 7 | 0 | 1078 | 1540 | 2.7 | 2000 | 93.4 | 5.3 | 53.7 | 152.4 | 1 |
| MH02700 | Monkey | 9/27/1999 | 4 | 704 | 32 | 0 | 864 | 1370 | 2.5 | 1650 | 146.0 | 4.4 | 42.1 | 192.5 | 9 |
| MH02700 | Monkey | 9/27/1999 | 1 | 774 | 7 | 0 | 1070 | 1580 | 2.5 | 1970 | 104.0 | 5.3 | 62.4 | 171.7 | 2 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MH02700 | Monkey | 10/27/1999 | 4 | 705 | 30 | 0 | 996 | 1520 | 2.7 | 1620 | 172.0 | 4.8 | 38.0 | 214.8 | 9 |
| MH02700 | Monkey | 10/27/1999 | 1 | 739 | 6 | 0 | 1120 | 1780 | 2.6 | 1810 | 114.0 | 5.4 | 56.8 | 176.2 | 2 |
| MH02700 | Monkey | 11/29/1999 | 3 | 768 | 25 | 0 | 1136 | 1710 | 2.8 | 1940 | 114.0 | 4.8 | 61.6 | 180.4 | 6 |
| MH02700 | Monkey | 11/29/1999 | 1 | 769 | 8 | 0 | 1070 | 1670 | 2.6 | 1550 | 187.0 | 4.4 | 42.1 | 233.5 | 2 |
| MH02700 | Monkey | 2/15/2000 | 8 | 418 | 38 | 0 | 612 | 827 | 2.7 | 1310 | 98.0 | 3.3 | 18.0 | 119.3 | 11 |
| MH02700 | Monkey | 2/15/2000 | 1 | 622 | 9 | 0 | 873 | 1370 | 2.7 | 1600 | 90.3 | 4.8 | 44.4 | 139.5 | 2 |
| MH02700 | Monkey | 3/22/2000 | 12 | 273 | 40 | 0 | 392 | 568 | 2.7 | 1130 | 60.9 | 2.0 | 14.2 | 77.1 | 11 |
| MH02700 | Monkey | 3/22/2000 | 3 | 510 | 16 | 0 | 705 | 1030 | 2.7 | 1640 | 60.1 | 3.3 | 37.8 | 101.2 | 3 |
| MH02700 | Monkey | 4/7/2000 | 1 | 551 | 5 | 0 | 813 | 1240 | 2.7 | 1810 | 67.0 | 3.7 | 51.2 | 121.9 | 1 |
| MH02700 | Monkey | 4/27/2000 | 4 | 476 | 21 | 0 | 688 | 1030 | 2.8 | 1580 | 100.0 | 3.1 | 35.2 | 138.3 | 6 |
| MH02700 | Monkey | 3/20/2001 | 8 | 493 | 45 | 0 | 677 | 1030 | 3.0 | 1550 | 132.0 | 4.0 | 29.5 | 165.5 | 15 |
| MH02700 | Monkey | 3/20/2001 | 4 | 676 | 29 | 0 | 988 | 1460 | 2.8 | 1680 | 90.0 | 4.7 | 78.7 | 173.4 | 7 |
| MH02700 | Monkey | 3/25/2002 | 5 | 380 | 23 | 0 | 566 | 854 | 3.0 | 1080 | 101.0 | 3.5 | 17.8 | 122.3 | 7 |
| MH02700 | Monkey | 3/25/2002 | 1 | 686 | 7 | 0 | 980 | 1420 | 2.8 | 1660 | 118.0 | 4.6 | 22.6 | 145.2 | 2 |
| MH03100 | Monkey | 3/25/2002 | 40 | 85 | 41 | 0 | 252 | 409 | 4.0 | 567 | 2.3 | 2.0 | 11.0 | 15.3 | 7 |
| MH04100 | Monkey | 3/25/2002 | 31 | 200 | 75 | 0 | 559 | 834 | 3.4 | 1030 | 3.5 | 5.7 | 26.1 | 35.3 | 13 |
| MH10020 | Monkey | 3/19/2001 | 346 | 39 | 163 | 0.5 | 154 | 220 | 4.7 | 325 | 0.3 | 1.7 | 3.7 | 5.7 | 24 |
| MH10020 | Monkey | 3/25/2002 | 534 | 26 | 168 | 0.9 | 146 | 227 | 4.5 | 362 | 0.5 | 1.8 | 0.5 | 2.7 | 17 |
| RR00020 | Rock Run | 7/27/2000 | 96 | 85 | 98 | 0 | 654 | 951 | 3.2 | 1380 | 3.3 | 3.6 | 4.9 | 11.7 | 14 |
| RR00020 | Rock Run | 10/18/2000 | 145 | 50 | 87 | 0 | 531 | 845 | 5.1 | 1080 | 12.6 | 4.0 | 2.8 | 19.3 | 34 |
| RR00020 | Rock Run | 2/7/2001 | 291 | 48 | 167 | 1.3 | 379 | 650 | 5.3 | 925 | 9.7 | 2.8 | 4.3 | 16.7 | 58 |
| RR00020 | Rock Run | 4/2/2001 | 384 | 72 | 334 | 0.9 | 459 | 786 | 4.7 | 860 | 12.6 | 2.9 | 5.7 | 21.2 | 98 |
| RR00020 | Rock Run | 8/7/2001 | 162 | 103 | 200 | 0 | 656 | 1080 | NM | 1490 | 18.8 | 4.0 | 7.3 | 30.1 | 58 |
| RR00020 | Rock Run | 12/10/2001 | 162 | 52 | 101 | 6.4 | 496 | 936 | 5.7 | 1150 | 22.8 | 3.1 | 4.1 | 29.9 | 58 |
| RR00200 | Rock Run | 7/26/2000 | 184 | 69 | 151 | 0 | 631 | 1040 | 4.7 | 1170 | 22.1 | 3.7 | 5.5 | 31.3 | 69 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RR00200 | Rock Run | 12/10/2001 | 197 | 59 | 141 | 6.5 | 534 | 906 | 5.4 | 1160 | 22.7 | 3.0 | 3.5 | 29.2 | 69 |
| RR00600 | Rock Run | 7/24/2000 | 123 | 32 | 47 | 0 | 380 | 683 | 4.3 | 915 | 0.4 | 4.9 | 1.7 | 7.0 | 10 |
| RR00600 | Rock Run | 12/10/2001 | NM | 9 | NM | 13.7 | 374 | 713 | 6.1 | 1060 | 0.7 | 3.3 | 0.3 | 4.3 | NM |
| RR00820 | Rock Run | 1/21/1998 | 105 | 150 | 188 | NM | 570 | NM | NM | NM | 0.7 | 7.0 | 25.0 | 32.7 | 41 |
| RR00820 | Rock Run | 2/4/1998 | 150 | 180 | 324 | NM | 180 | NM | 3.3 | NM | 0.7 | 5.1 | 20.0 | 25.8 | 46 |
| RR00820 | Rock Run | 4/22/1998 | 256 | 180 | 553 | NM | 380 | NM | NM | NM | 0.7 | 5.1 | 19.0 | 24.8 | 76 |
| RR00820 | Rock Run | 7/5/1998 | 119 | 185 | 263 | NM | 390 | NM | NM | NM | 0.6 | 4.0 | 16.0 | 20.6 | 29 |
| RR00820 | Rock Run | 8/2/1998 | 83 | 140 | 139 | NM | 860 | NM | NM | NM | 0.4 | 4.0 | 15.0 | 19.4 | 19 |
| RR00820 | Rock Run | 9/6/1998 | 46 | 140 | 78 | NM | 720 | NM | NM | NM | 0.3 | 3.6 | 13.0 | 16.9 | 9 |
| RR00820 | Rock Run | 10/17/1998 | 32 | 130 | 50 | NM | 770 | NM | NM | NM | 0.3 | 3.7 | 11.0 | 15.0 | 6 |
| RR00820 | Rock Run | 11/29/1998 | 20 | 150 | 35 | NM | 750 | NM | NM | NM | 0.3 | 3.6 | 11.0 | 14.9 | 4 |
| RR00820 | Rock Run | 12/19/1998 | 17 | 120 | 25 | 3.6 | NA | NM | NM | NM | 0.3 | 4.5 | 14.0 | 18.8 | 4 |
| RR00820 | Rock Run | 7/27/2000 | 71 | 113 | 97 | 0 | 614 | 948 | 3.4 | 1250 | 0.5 | 3.7 | 15.4 | 19.6 | 17 |
| RR00820 | Rock Run | 10/1/2001 | 76 | 17.6 | 16 | 110 | 655 | 1130 | 6.9 | 1370 | 0.454 | 2.17 | 0.1 | 2.7 | NM |
| RR00820 | Rock Run | 12/10/2001 | 76 | 6 | 6 | 36.1 | 484 | 842 | 6.8 | 1110 | 0.9 | 1.8 | 0.6 | 3.3 | 3 |
| RR00820 | Rock Run | 4/11/2002 | 60 | 120 | 86 | 0 | 761 | 1140 | 4.3 | 1390 | 0.3 | 6.1 | 18.7 | 25.1 | 18 |
| RR00820 | Rock Run | 11/18/2002 | 54 | 42 | 27 | 1.6 | 685 | 1050 | 4.8 | 1270 | 0.2 | 3.2 | 4.1 | 7.5 | 5 |
| RR00820 | Rock Run | 3/17/2003 | 189 | 176 | 398 | 0 | 747 | 1140 | 4.2 | 1320 | 0.4 | 6.8 | 25.1 | 32.3 | 73 |
| RR00820 | Rock Run | 6/23/2003 | 251 | 120 | 362 | 0 | 526 | 923 | 4.2 | 1130 | 0.1 | 4.3 | 15.9 | 20.3 | 61 |
| RR00820 | Rock Run | 9/29/2003 | 144 | 124 | 214 | 0 | 614 | 936 | 4.2 | 1190 | 0.5 | 7.0 | 15.9 | 23.3 | 40 |
| RR00820 | Rock Run | 2/23/2004 | 81 | 148 | 143 | 0 | 666 | 978 | 3.8 | 1190 | 0.6 | 4.9 | 19.8 | 25.3 | 25 |
| RR00820 | Rock Run | 5/17/2004 | 202 | 102 | 247 | 0 | 626 | 890 | 3.9 | 1120 | 0.4 | 3.8 | 13.3 | 17.5 | 43 |
| RR00850 | Rock Run | 7/25/2000 | 7 | 8 | 1 | 52.7 | 328 | 685 | 6.5 | 936 | 0.7 | 1.4 | 0.5 | 2.6 | 0 |
| RR00850 | Rock Run | 12/10/2001 | 26 | 7 | 2 | 58.7 | 282 | 647 | 7.0 | 1000 | 0.6 | 1.5 | 1.2 | 3.3 | 1 |
| RR02100 | Rock Run | 7/25/2000 | 55 | 5 | 3 | 94.2 | 963 | 1560 | 8.1 | 1610 | 0.1 | 0.1 | 0.3 | 0.5 | 0 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RR02100 | Rock Run | 12/10/2001 | 40 | 5 | 2 | 103 | 810 | 1300 | 7.6 | 1370 | 0.1 | 0.1 | 0.1 | 0.2 | NM |
| RR02100 | Rock Run | 4/11/2002 | 332 | 69 | 275 | 0 | 519 | 861 | 4.5 | 1150 | 23.4 | 3.3 | 5.3 | 32.0 | 128 |
| RR04200 | Rock Run | 7/25/2000 | 0 | 72 | 0 | 0 | 394 | 641 | 4.4 | 789 | 25.4 | 8.6 | 0.3 | 34.3 | 0 |
| SA00100 | Salem | 4/24/1998 | 4161 | 22 | 1098 | 25 | 193 | 492 | 6.7 | 477 | 1.5 | 0.9 | 1.3 | 3.8 | 187 |
| SA00100 | Salem | 10/16/2000 | 94 | 12 | 14 | 27.6 | 305 | 529 | 5.8 | 714 | 1.1 | 1.1 | 0.6 | 2.7 | 3 |
| SA00100 | Salem | 5/11/2005 | 1216 | 9 | 136 | 38.3 | 213 | 362 | 6.7 | 508 | 0.9 | 0.7 | 1.0 | 2.5 | 37 |
| SF000700 | Snow Fork | 10/23/2000 | 15 | 159 | 29 | 0 | 477 | 728 | 2.9 | 1090 | 4.3 | 2.7 | 15.6 | 22.6 | 4 |
| SF000700 | Snow Fork | 5/6/2003 | 198 | 132 | 314 | 0 | 392 | 584 | 3.1 | 1040 | 1.5 | 1.7 | 13.2 | 16.4 | 39 |
| SF00290 | Snow Fork | 10/16/2000 | 2334 | 98 | 2764 | 0 | 494 | 814 | 3.5 | 1030 | 3.1 | 3.8 | 14.2 | 21.1 | 590 |
| SF00290 | Snow Fork | 5/16/2005 | 9237 | 110 | 12193 | 0 | 412 | 596 | 3.6 | 854 | 5.4 | 2.5 | 12.5 | 20.3 | 2253 |
| SF00500 | Snow Fork | 8/23/1999 | NM | 429 | NM | 0 | 980 | 1410 | 2.5 | 2210 | 52.9 | 4.0 | 34.1 | 91.0 | NM |
| SF00520 | Snow Fork | 9/23/1999 | 19 | 385 | 86 | 0 | 971 | 1440 | 2.6 | 1850 | 53.7 | 4.3 | 38.9 | 96.9 | 22 |
| SF00520 | Snow Fork | 10/19/1999 | 8 | 424 | 40 | 0 | 980 | 1530 | 3.1 | 1850 | 68.7 | 3.4 | 31.9 | 104.0 | 10 |
| SF00520 | Snow Fork | 11/16/1999 | 9 | 402 | 42 | 0 | 996 | 1500 | 3.0 | 1800 | 67.0 | 4.2 | 31.1 | 102.3 | 11 |
| SF00520 | Snow Fork | 12/20/1999 | 4 | 602 | 27 | 0 | 971 | 1310 | 2.5 | 2200 | 68.9 | 4.3 | 43.6 | 116.8 | 5 |
| SF00520 | Snow Fork | 1/12/2000 | 11 | 375 | 47 | 0 | 938 | 1360 | 2.8 | 1940 | 50.7 | 3.6 | 29.7 | 84.0 | 11 |
| SF00520 | Snow Fork | 2/16/2000 | 60 | 374 | 269 | 0 | 906 | 1330 | 2.7 | 1800 | 44.5 | 3.9 | 20.7 | 69.1 | 50 |
| SF00520 | Snow Fork | 4/1/2000 | 66 | 404 | 321 | 0 | 897 | 1310 | 2.4 | 1870 | 35.1 | 3.4 | 32.6 | 71.1 | 56 |
| SF00520 | Snow Fork | 5/17/2000 | 42 | 363 | 183 | 0 | 930 | 1310 | 2.8 | 1950 | 33.6 | 3.3 | 28.5 | 65.4 | 33 |
| SF00520 | Snow Fork | 6/7/2000 | 20 | 353 | 85 | 0 | 938 | 1390 | 2.9 | 1850 | 37.3 | 3.4 | 30.7 | 71.4 | 17 |
| SF00520 | Snow Fork | 7/26/2000 | 42 | 402 | 201 | 0 | 988 | 1460 | 2.9 | 1910 | 48.9 | 3.9 | 38.7 | 91.5 | 46 |
| SF00520 | Snow Fork | 8/15/2000 | 23 | 406 | 111 | 0 | 1004 | 1520 | 3.0 | 1760 | 56.7 | 4.5 | 41.7 | 102.9 | 28 |
| SF00520 | Snow Fork | 10/16/2000 | 53 | 395 | 249 | 0 | 955 | 1470 | 2.6 | 1880 | 82.7 | 3.7 | 41.4 | 127.8 | 81 |
| SF00520 | Snow Fork | 10/16/2000 | 53 | 395 | 249 | 0 | 955 | 1470 | 2.6 | 1880 | 82.7 | 3.7 | 41.4 | 127.8 | 81 |
| SF00520 | Snow Fork | 2/8/2001 | 226 | 355 | 962 | 0 | 914 | 1330 | 3.0 | 1780 | 55.5 | 3.8 | 32.8 | 92.1 | 249 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SF00520 | Snow Fork | 2/8/2001 | 226 | 355 | 962 | 0 | 914 | 1330 | 3.0 | 1780 | 55.5 | 3.8 | 32.8 | 92.1 | 249 |
| SF00520 | Snow Fork | 4/4/2001 | 62 | 323 | 242 | 0 | 864 | 1240 | 2.9 | 1560 | 34.6 | 3.1 | 26.5 | 64.2 | 48 |
| SF00520 | Snow Fork | 4/4/2001 | 62 | 323 | 242 | 0 | 864 | 1240 | 2.9 | 1560 | 34.6 | 3.1 | 26.5 | 64.2 | 48 |
| SF00520 | Snow Fork | 8/6/2001 | 22 | 399 | 105 | 0 | 947 | 1370 | NM | 1890 | 45 | 3.84 | 35.3 | 84.1 | 22 |
| SF00520 | Snow Fork | 3/28/2002 | 30 | 349 | 126 | 0 | 840 | 1220 | 3.2 | 1520 | 40.5 | 3.2 | 26.1 | 69.8 | 25 |
| SF00520 | Snow Fork | 11/18/2002 | 35 | 390 | 166 | 0 | 930 | 1370 | 3.1 | 1610 | 63.5 | 3.8 | 31.0 | 98.3 | 42 |
| SF00530 | Snow Fork | 8/23/1999 | 2 | 651 | 15 | 0 | 1120 | 1450 | 2.4 | 2490 | 82.4 | 4.4 | 47.5 | 134.3 | 3 |
| SF00530 | Snow Fork | 9/23/1999 | 1 | 639 | 10 | 0 | 1120 | 1520 | 2.4 | 2170 | 87.7 | 4.9 | 55.6 | 148.2 | 2 |
| SF00530 | Snow Fork | 10/19/1999 | 1 | 651 | 7 | 0 | 1087 | 1630 | 2.9 | 2100 | 97.1 | 3.6 | 44.6 | 145.3 | 2 |
| SF00530 | Snow Fork | 11/16/1999 | 1 | 612 | 5 | 0 | 1095 | 1590 | 2.9 | 1850 | 96.3 | 4.4 | 47.1 | 147.8 | 1 |
| SF00530 | Snow Fork | 12/20/1999 | 13 | 398 | 60 | 0 | 947 | 1420 | 2.7 | 1890 | 58.9 | 4.2 | 29.4 | 92.5 | 14 |
| SF00530 | Snow Fork | 1/12/2000 | 4 | 481 | 22 | 0 | 747 | 973 | 2.5 | 1890 | 44.4 | 3.1 | 32.7 | 80.2 | 4 |
| SF00530 | Snow Fork | 2/16/2000 | 30 | 400 | 144 | 0 | 553 | 736 | 2.4 | 1580 | 35.3 | 2.5 | 14.5 | 52.3 | 19 |
| SF00530 | Snow Fork | 3/21/2000 | 67 | 574 | 459 | 0 | 752 | 991 | 2.3 | 1920 | 57.7 | 2.5 | 41.0 | 101.2 | 81 |
| SF00530 | Snow Fork | 5/17/2000 | 17 | 571 | 117 | 0 | 988 | 1320 | 2.5 | 2210 | 58.2 | 3.6 | 44.0 | 105.8 | 22 |
| SF00530 | Snow Fork | 6/7/2000 | 11 | 558 | 71 | 0 | 971 | 1330 | 2.6 | 2130 | 58.9 | 3.6 | 43.8 | 106.3 | 14 |
| SF00530 | Snow Fork | 7/26/2000 | 16 | 606 | 114 | 0 | 1021 | 1440 | 2.6 | 2200 | 63.1 | 4.3 | 52.5 | 119.9 | 23 |
| SF00530 | Snow Fork | 8/15/2000 | 4 | 602 | 31 | 0 | 1054 | 1480 | 2.7 | 2080 | 62.5 | 4.4 | 52.0 | 118.9 | 6 |
| SF00530 | Snow Fork | 10/16/2000 | 2 | 623 | 12 | 0 | 1045 | 1560 | 2.4 | 2170 | 101.0 | 3.9 | 57.8 | 162.7 | 3 |
| SF00530 | Snow Fork | 3/28/2002 | 37 | 374 | 167 | 0 | 520 | 711 | 2.9 | 1390 | 29.6 | 2.1 | 24.0 | 55.7 | 25 |
| SF00630 | Snow Fork | 11/18/2002 | 5 | 714 | 42 | 0 | 1185 | 1640 | 2.6 | 2520 | 51.1 | 4.0 | 58.9 | 114.0 | 7 |
| SF00730 | Snow Fork | 11/18/2002 | 5 | 291 | 17 | 0 | 672 | 952 | 3.0 | 1390 | 14.6 | 2.5 | 27.6 | 44.7 | 3 |
| SF00880 | Snow Fork | 4/2/2001 | 58 | 208 | 146 | 0 | 682 | 1080 | 3.5 | 1440 | 72.6 | 3.6 | 23.0 | 99.2 | 69 |
| SF00880 | Snow Fork | 7/15/2002 | 54 | 347 | 224 | 0 | 914 | 1300 | 3.1 | 1630 | 59.7 | 5.0 | 31.9 | 96.6 | 62 |
| SF00880 | Snow Fork | 10/18/2004 | 364 | 413 | 1802 | 0 | 1017 | 1470 | 3.3 | 1620 | 74.6 | 6.5 | 44.7 | 125.8 | 549 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SF00950 | Snow Fork | 8/25/1999 | 22 | 685 | 181 | 0 | 1350 | 1870 | 2.6 | 2640 | 107.0 | 6.7 | 46.8 | 160.5 | 42 |
| SF00950 | Snow Fork | 9/23/1999 | 11 | 650 | 86 | 0 | 1358 | 1940 | 2.9 | 2200 | 113.0 | 7.8 | 55.5 | 176.3 | 23 |
| SF00950 | Snow Fork | 10/19/1999 | 6 | 642 | 43 | 0 | 1301 | 2020 | 2.9 | 2250 | 119.0 | 6.2 | 47.7 | 172.9 | 11 |
| SF00950 | Snow Fork | 11/16/1999 | 7 | 651 | 57 | 0 | 1350 | 1980 | 2.9 | 2200 | 115.0 | 7.1 | 46.3 | 168.4 | 15 |
| SF00950 | Snow Fork | 12/20/1999 | 32 | 608 | 236 | 0 | 1301 | 1870 | 2.7 | 2270 | 105.0 | 7.4 | 43.6 | 156.0 | 61 |
| SF00950 | Snow Fork | 1/12/2000 | 44 | 602 | 318 | 0 | 1251 | 1810 | 2.7 | 2320 | 103.0 | 6.6 | 44.9 | 154.5 | 82 |
| SF00950 | Snow Fork | 2/16/2000 | 156 | 603 | 1127 | 0 | 1202 | 1790 | 2.7 | 2170 | 96.3 | 6.9 | 34.7 | 137.9 | 258 |
| SF00950 | Snow Fork | 3/21/2000 | 370 | 609 | 2703 | 0 | 1161 | 1730 | 2.5 | 2100 | 84.6 | 5.8 | 41.3 | 131.7 | 585 |
| SF00950 | Snow Fork | 5/17/2000 | 135 | 604 | 978 | 0 | 1259 | 1790 | 2.8 | 2390 | 90.1 | 6.7 | 47.8 | 144.6 | 234 |
| SF00950 | Snow Fork | 6/7/2000 | 76 | 561 | 509 | 0 | 1243 | 1820 | 2.8 | 2240 | 88.6 | 6.6 | 44.7 | 139.9 | 127 |
| SF00950 | Snow Fork | 7/26/2000 | 63 | 599 | 452 | 0 | 1235 | 1850 | 2.8 | 2260 | 95.2 | 7.0 | 49.8 | 152.0 | 115 |
| SF00950 | Snow Fork | 8/15/2000 | 63 | 585 | 441 | 0 | 1276 | 1920 | 3.0 | 2030 | 96.1 | 7.4 | 60.0 | 163.5 | 123 |
| SF00950 | Snow Fork | 10/16/2000 | 14 | 594 | 99 | 0 | 1276 | 1960 | 2.5 | 2250 | 101.0 | 7.2 | 54.8 | 163.0 | 27 |
| SF00950 | Snow Fork | 8/12/2002 | 76 | 618 | 566 | 0 | 1301 | 1880 | 2.9 | 2110 | 102.0 | 7.3 | 45.6 | 154.9 | 142 |
| SF00950 | Snow Fork | 9/9/2002 | 49 | 615 | 364 | 0 | 1309 | 1870 | 2.9 | 2090 | 143.0 | 7.3 | 44.6 | 194.9 | 115 |
| SF00950 | Snow Fork | 9/30/2002 | 55 | 569 | 374 | 0 | 1325 | 1920 | 3.0 | 2230 | 148.0 | 7.5 | 51.1 | 206.6 | 136 |
| SF00950 | Snow Fork | 11/18/2002 | 23 | 611 | 168 | 0 | 1334 | 1870 | 3.0 | 2150 | 120.0 | 7.8 | 48.0 | 175.8 | 48 |
| SF00960 | Snow Fork | 8/25/1999 | 61 | 663 | 485 | 0 | 1358 | 1880 | 2.6 | 2220 | 107.0 | 6.7 | 46.0 | 159.7 | 117 |
| SF00960 | Snow Fork | 9/23/1999 | 43 | 632 | 323 | 0 | 1284 | 1960 | 2.9 | 2300 | 112.0 | 7.8 | 51.7 | 171.5 | 88 |
| SF00960 | Snow Fork | 10/19/1999 | 41 | 632 | 309 | 0 | 1325 | 2000 | 3.0 | 2250 | 119.0 | 6.4 | 46.5 | 171.9 | 84 |
| SF00960 | Snow Fork | 11/16/1999 | 41 | 639 | 318 | 0 | 1317 | 1970 | 2.9 | 2220 | 115.0 | 7.1 | 46.4 | 168.5 | 84 |
| SF00960 | Snow Fork | 12/20/1999 | 44 | 588 | 314 | 0 | 1243 | 1830 | 2.7 | 2210 | 104.0 | 7.2 | 41.6 | 152.8 | 82 |
| SF00960 | Snow Fork | 1/12/2000 | 41 | 605 | 295 | 0 | 1276 | 1820 | 2.7 | 1970 | 108.0 | 6.8 | 43.8 | 158.6 | 77 |
| SF00960 | Snow Fork | 2/16/2000 | 43 | 595 | 306 | 0 | 1169 | 1750 | 2.7 | 2090 | 96.2 | 6.4 | 40.0 | 142.6 | 73 |
| SF00960 | Snow Fork | 3/21/2000 | 48 | 613 | 357 | 0 | 1169 | 1730 | 2.4 | 2120 | 86.3 | 5.8 | 42.2 | 134.3 | 78 |

| Map Identifier | Basin | Sample Date | Discharge (GPM) | Acidity (mg/l) | Acid Load (lbs/day) | Alkalinity (mg/l) | Sulfate (mg/l) | TDS (mg/l) | pH | Conductivity (uS) | TOTAL FE (mg/l) | TOTAL Mn (mg/l) | TOTAL AL (mg/l) | Total Metals (mg/l) | Total Metal Load (lbs/day) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SF00960 | Snow Fork | 5/17/2000 | 42 | 601 | 303 | 0 | 1251 | 1800 | 2.8 | 2180 | 89.9 | 6.6 | 46.8 | 143.3 | 72 |
| SF00960 | Snow Fork | 6/7/2000 | 33 | 553 | 221 | 0 | 1251 | 1850 | 2.8 | 2240 | 88.6 | 6.4 | 42.3 | 137.3 | 55 |
| SF00960 | Snow Fork | 7/26/2000 | 28 | 587 | 198 | 0 | 1243 | 1880 | 2.8 | 2230 | 92.4 | 7.0 | 50.3 | 149.7 | 51 |
| SF00960 | Snow Fork | 8/15/2000 | 35 | 583 | 242 | 0 | 1251 | 1940 | 3.0 | 2040 | 96.6 | 7.5 | 48.7 | 152.8 | 63 |
| SF00960 | Snow Fork | 10/16/2000 | 36 | 591 | 256 | 0 | 1284 | 1960 | 2.5 | 2260 | 102.0 | 7.2 | 54.7 | 163.9 | 71 |
| SF00960 | Snow Fork | 8/12/2002 | 28 | 600 | 200 | 0 | 1292 | 1890 | 2.9 | 2110 | 104.0 | 7.3 | 44.5 | 155.8 | 52 |
| SF00960 | Snow Fork | 9/9/2002 | 27 | 602 | 197 | 0 | 1325 | 1880 | 3.0 | 2080 | 106.0 | 7.5 | 45.3 | 158.8 | 52 |
| SF00960 | Snow Fork | 9/30/2002 | 27 | 577 | 190 | 0 | 1309 | 1930 | 2.9 | 2240 | 131.0 | 7.5 | 48.2 | 186.7 | 61 |
| SF00960 | Snow Fork | 11/18/2002 | 29 | 611 | 211 | 0 | 1325 | 1910 | 3.0 | 2220 | 114.0 | 7.9 | 44.1 | 166.0 | 57 |
| SF00960 | Snow Fork | 12/10/2002 | 27 | 606 | 199 | 0 | 1334 | 1900 | 3.0 | 2290 | 123.0 | 7.7 | 47.6 | 178.3 | 59 |
| SF00980 | Snow Fork | 8/12/2002 | 444 | 35 | 187 | 0.7 | 381 | 597 | 4.6 | 825 | 0.7 | 2.0 | 2.2 | 4.8 | 26 |
| SF00980 | Snow Fork | 9/9/2002 | 251 | 36 | 109 | 0 | 405 | 613 | 4.5 | 826 | 0.5 | 2.3 | 2.1 | 4.9 | 15 |
| SF00980 | Snow Fork | 9/30/2002 | 404 | 37 | 180 | 0.7 | 369 | 586 | 4.7 | 856 | 0.6 | 2.2 | 2.2 | 4.9 | 24 |
| SF00980 | Snow Fork | 11/18/2002 | 1522 | 10 | 174 | 19.4 | 271 | 447 | 6.7 | 659 | 2.3 | 1.4 | 0.9 | 4.6 | 84 |
| SF00980 | Snow Fork | 12/10/2002 | 301 | 19 | 69 | 13.6 | 333 | 542 | 6.3 | 798 | 3.6 | 1.9 | 1.4 | 6.8 | 25 |
| SF00980 | Snow Fork | 5/11/2005 | NM | 15 | NM | 11.1 | 270 | 432 | 6.2 | 586 | 2.9 | 1.2 | 2.7 | 6.9 | NM |
| SP00100 | Spencer | 6/18/1998 | 420 | 42 | 212 | 0 | 240 | 536 | 3.9 | 547 | 3.0 | 3.5 | 3.7 | 10.2 | 51 |
| SP00100 | Spencer | 10/16/2000 | 16 | 79 | 15 | 0 | 485 | 752 | 3.6 | 926 | 0.7 | 7.1 | 15.6 | 23.4 | 5 |
| SP00100 | Spencer | 5/11/2005 | 224 | 50 | 133 | 0 | 285 | 431 | 4.0 | 579 | 1.9 | 2.5 | 4.8 | 9.2 | 25 |
| SP00400 | Spencer | 6/18/1998 | 2 | 196 | 5 | 0 | 118 | 1556 | 3.1 | 2210 | 73.0 | 19.6 | 6.3 | 98.9 | 3 |
| SY00050 | Sycamore | 5/11/2005 | 2635 | 24 | 762 | 3.0 | 295 | 473 | 5.6 | 647 | 4.6 | 1.3 | 3.0 | 8.8 | 278 |
| SY00800 | Sycamore | 5/11/2005 | 355 | 10 | 41 | 67.9 | <50 | 145 | 7.7 | 239 | 0.2 | 0.1 | 0.1 | 0.3 | 1 |
| SY10100 | Sycamore | 5/11/2005 | 1499 | 48 | 865 | 2.4 | 390 | 594 | 5.2 | 753 | 10.9 | 1.8 | 6.8 | 19.5 | 351 |
| SY10500 | Sycamore | 5/11/2005 | 1414 | 47 | 796 | 3.8 | 405 | 617 | 4.9 | 819 | 11.3 | 1.9 | 6.7 | 19.9 | 337 |

Source: U.S. Army Corps of Engineers

# Appendix C - Treatment Costs

| Sub-watershed | Site Name | Map Identifier | Treatment Type | Amdat Cost Estimate |
|---|---|---|---|---|
| Brush Fork | 6WB | BH0910 | LLB / OLC | $6,672 |
| Brush Fork | 5E50 | BH0043 | LLB / OLC | $7,959 |
| Brush Fork | MSBS | BH0069 | LLB | $17,107 |
| Brush Fork | MS7 | BH0304 | LLB / OLC | $20,981 |
| Brush Fork | MS7C | BH0310 | LLB / OLC | $32,681 |
| Brush Fork | MSSP1 | BH0061 | LLB / OLC | $49,244 |
| Brush Fork | 6WC | BH0919 | LLB / OLC | $34,162 |
| Brush Fork | MSSP2 | BH0052 | LLB / OLC | $48,907 |
| Brush Fork | MSSP3 | BH0045 | LLB / OLC | $67,414 |
| Brush Fork | 21 | BH0010 | LLB / OLC | $68,144 |
| Brush Fork | MSSP7E | BH1310 | SLB / OLC | $128,893 |
| Brush Fork | 20 | BH0008 | LLB / OLC | $75,629 |
| Brush Fork | MSSP5 | BH0038 | LLB / OLC | $97,378 |
| Brush Fork | 4W | BH0023 | LLB / OLC | $104,701 |
| Brush Fork | 32A | BH0019 | LLB / OLC | $105,428 |
| Brush Fork | SM-E-MSBS | BH0043 | SLB | $121,684 |
| Brush Fork | TOP | BH0085 | SLB | $168,388 |
| Brush Fork | Spoil Blocks | | Removal | $126,313 |
| Brush Fork | Subsidences | | Fill | $272,173 |
| Brush Fork | Dissipating Streams | | Channel Reconstruction | $77,179 |
| Brush Fork | Brush Fork Treatment Installation Cost | | | $1,631,039 |
| Brush Fork | Design, Env. Protection, Mobilization & Misc Material | | | $316,699 |
| Brush Fork | Brush Fork Sub-watershed Total Cost | | | $1,947,738 |

AMDAT cost estimates do not include real estate costs, utility relocation, geo-technical investigations and maintenance of systems. ODNR-DMRM holds the confidential engineers estimate provided by the U.S. Army Corps of Engineers.

Source: U.S. Army Corps of Engineers

| Sub-watershed | Site Name | Map Identifier | Treatment Type | Amdat Cost Estimate |
|---|---|---|---|---|
| Bessemer Hollow | JS-79 | BS0080 | SLB / OLC | NA |
| Bessemer Hollow | JS-78 & JS-79 | BS0069/0070 | LLB / OLC | NA |
| Bessemer Hollow | Blocked Drainages | | Removal | NA |
| Bessemer Hollow | Subsidences | | Fill | NA |
| Bessemer Hollow | Bessemer Hollow Treatment Installation Cost | | | $287,812 |
| Bessemer Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $147,481 |
| Bessemer Hollow | Bessemer Hollow Sub-watershed Total Cost | | | $435,293 |
| Coe Hollow | A Seep | CH00450 | LLB | $128,026 |
| Coe Hollow | B Seep | CH00500 | LLB | $20,826 |
| Coe Hollow | D TRIB | CH00200 | LLB | $2,741 |
| Coe Hollow | UP-MAIN | NA | SLB | $71,977 |
| Coe Hollow | South-TRIB | NA | SLB | $103,304 |
| Coe Hollow | MAINSTEM | CH00100 | Wetland | $20,142 |
| Coe Hollow | Subsidences | | Fill | $6,889 |
| Coe Hollow | Dissipating Streams | | Channel Reconstruction | $19,949 |
| Coe Hollow | Coe Hollow Treatment Installation Cost | | | $373,854 |
| Coe Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $102,665 |
| Coe Hollow | Coe Hollow Sub-watershed Total Cost | | | $476,519 |
| Long Hollow | LON-93 | LH00060 | LLB / OLC | $75,992 |
| Long Hollow | LON-94 | LH00070 | LLB / OLC | $16,269 |
| Long Hollow | LON-95 | LH00150 | LLB / OLC | $193,617 |
| Long Hollow | LON-4 | LH00300 | SLB | $362,913 |
| Long Hollow | Subsidences | | Fill | $35,247 |
| Long Hollow | Dissipating Streams | | Channel Reconstruction | $42,422 |
| Long Hollow | Long Hollow Treatment Installation Cost | | | $726,461 |
| Long Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $157,297 |
| Long Hollow | Long Hollow Sub-watershed Total Cost | | | $883,758 |

AMDAT cost estimates do not include real estate costs, utility relocation, geo-technical investigations and maintenance of systems. ODNR-DMRM holds the confidential engineers estimate provided by the U.S. Army Corps of Engineers.

Source: U.S. Army Corps of Engineers

| Sub-watershed | Site Name | Map Identifier | Treatment Type | Amdat Cost Estimate |
|---|---|---|---|---|
| Monkey Hollow | FRT-1 | MH0195 | LLB / OLC | $55,143 |
| Monkey Hollow | FRT-2 | MH0199 | LLB / OLC | $151,711 |
| Monkey Hollow | FRT-3 | MH0170 | LLB / OLC | $112,348 |
| Monkey Hollow | FRT-4 | MH0148 | LLB / OLC | $116,722 |
| Monkey Hollow | FRT-5 | MH0120 | LLB / OLC | $35,726 |
| Monkey Hollow | FRT-5A | MH0119 | LLB / OLC | $17,772 |
| Monkey Hollow | FRT-6 | MH1002 | SLB / Wetland | $625,502 |
| Monkey Hollow | MNK-1 | MH0275 | LLB / OLC | $49,172 |
| Monkey Hollow | MNK-11 | MH0248 | LLB / OLC | $117,710 |
| Monkey Hollow | MNK-13 | MH0227 | LLB / OLC | $30,794 |
| Monkey Hollow | MNK-7A | MH0270 | LLB / OLC | $76,896 |
| Monkey Hollow | MNK-8 | MH0245 | LLB / OLC | $4,751 |
| Monkey Hollow | Spoil Blocks | | Removal | $204,645 |
| Monkey Hollow | Subsidences | | Fill | $121,977 |
| Monkey Hollow | Monkey Hollow Treatment Installation Cost | | | $1,720,868 |
| Monkey Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $352,196 |
| Monkey Hollow | Monkey Hollow Sub-watershed Total Cost | | | $2,073,065 |
| Orbiston | 302+304 | SF0052/0053 | LLB / Wetland | $515,690 |
| Orbiston | Orbiston Treatment Installation Cost | | | $515,690 |
| Orbiston | Design,Env. Protection, Mobilization & Misc Material | | | $107,648 |
| Orbiston | Orbiston Sub-watershed Total Cost | | | $623,339 |
| Salem Hollow | 87+89 | SA0025/0035 | OLC | $89,232 |
| Salem Hollow | Salem Hollow Treatment Installation Cost | | | $89,232 |
| Salem Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $29,492 |
| Salem Hollow | Salem Sub-watershed Total Cost | | | $118,724 |

AMDAT cost estimates do not include real estate costs, utility relocation, geo-technical investigations and maintenance of systems. ODNR-DMRM holds the confidential engineers estimate provided by the U.S. Army Corps of Engineers.

Source: U.S. Army Corps of Engineers

| Sub-watershed | Site Name | Map Identifier | Treatment Type | Amdat Cost Estimate |
|---|---|---|---|---|
| Spencer Hollow | SPN | SP0010 | SLB / Wetland | $158,081 |
| Spencer Hollow | Spencer Hollow Treatment Installation Cost | | | $158,081 |
| Spencer Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $56,660 |
| Spencer Hollow | Spencer Hollow Sub-watershed Total Cost | | | $214,741 |
| Sycamore Hollow | RM-2.5 | NA | LLB | $113,236 |
| Sycamore Hollow | RM-3.4 | NA | Wetland | $698,607 |
| Sycamore Hollow | Sycamore Hollow Treatment Installation Cost | | | $811,843 |
| Sycamore Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $208,629 |
| Sycamore Hollow | Sycamore Hollow Sub-watershed Total Cost | | | $1,020,472 |
| Lost Run | LR-1E | LR0210 | SLB / OLC | $302,621 |
| Lost Run | LR-1W | LR0102 | LLB / OLC | $627,280 |
| Lost Run | LR-2E | LR0323 | OLC | $182,043 |
| Lost Run | LR-2W | NA | LLB / OLC | $321,234 |
| Lost Run | LR-3E | LR0415 | SLB / OLC | $449,239 |
| Lost Run | LR-3W | LR0610 | LLB / OLC | $209,719 |
| Lost Run | LR-4W | LR0712 | LLB / OLC | $153,296 |
| Lost Run | LR-MS | LR0084 | LLB / OLC | $61,787 |
| Lost Run | Spoil Blocks | | Removal | $344,387 |
| Lost Run | Subsidences | | Fill | $124,994 |
| Lost Run | Limestone Rock Dam for SLB | | | $606,064 |
| Lost Run | Lost Run Treatment Installation Cost | | | $3,382,665 |
| Lost Run | Design,Env. Protection, Mobilization & Misc Material | | | $611,873 |
| Lost Run | Lost Run Sub-watershed Total Cost | | | $3,994,538 |

AMDAT cost estimates do not include real estate costs, utility relocation, geo-technical investigations and maintenance of systems. ODNR-DMRM holds the confidential engineers estimate provided by the U.S. Army Corps of Engineers.

Source: U.S. Army Corps of Engineers

| Sub-watershed | Site Name | Map Identifier | Treatment Type | Amdat Cost Estimate |
|---|---|---|---|---|
| Jobs Hollow | JOB-5 | JH09850 | SLB | $84,654 |
| Jobs Hollow | JOB-7 | JH11100 | OLC | $52,065 |
| Jobs Hollow | JOB-10 | JH12200 | SLB | $227,923 |
| Jobs Hollow | JOB-US | JH00100 | SLB | $84,648 |
| Jobs Hollow | Jobs Hollow Treatment Installation Cost | | | $449,290 |
| Jobs Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $116,282 |
| Jobs Hollow | Jobs Hollow Sub-watershed Total Cost | | | $565,572 |
| Snake Hollow | SNA-60 | SH00950 | LLB / OLC | $49,646 |
| Snake Hollow | SNA-61 | SH02100 | LLB / OLC | $27,060 |
| Snake Hollow | SNA-62 | SH00450 | LLB / OLC | $14,313 |
| Snake Hollow | SNA-63 | SH00470 | LLB / OLC | $27,757 |
| Snake Hollow | SNA-64 | SH00200 | LLB / OLC | $6,744 |
| Snake Hollow | US SNA-65 | SH00100 | Wetland | $212,077 |
| Snake Hollow | Snake Hollow Treatment Installation Cost | | | $337,596 |
| Snake Hollow | Design, Env. Protection, Mobilization & Misc Material | | | $14,631 |
| Snake Hollow | Snake Hollow Sub-watershed Total Cost | | | $352,227 |
| Rock Run | MOUTH | | Wetland | $355,839 |
| Rock Run | RR-1 | RR0020 | Low Head Dam | $2,304 |
| Rock Run | RR-2 | RR0020 | Low Head Dam | $2,304 |
| Rock Run | RR-3 | RR0020 | Low Head Dam | $2,304 |
| Rock Run | Rock Run Treatment Installation Cost | | | $362,752 |
| Rock Run | Design, Env. Protection, Mobilization & Misc Material | | | $74,430 |
| Rock Run | Rock Run Sub-watershed Total Cost | | | $437,182 |

AMDAT cost estimates do not include real estate costs, utility relocation, geo-technical investigations and maintenance of systems. ODNR-DMRM holds the confidential engineers estimate provided by the U.S. Army Corps of Engineers.

# Appendix D - TMDL Biology Data

**Table I: List of TMDL sampling locations [Fish Community-F, Benthic Macro-invertebrates-B, Water column Chemistry (including fecal coliform counts)-C, and Sediment Analysis (organics and metals)-S] in the 2001 Monday Creek study area.**

| *Stream* River Mile | Sample Type | Drain Area ($mi^2$) | Latitude/Longitude | Landmarks | USGS 7.5' Quad. |
|---|---|---|---|---|---|
| ***Monday Creek* (01-300)** | | | | | |
| 26.5 | (F,B,C,S) | 2.9 | 39E38'18"/82E13'29 | Portie Flamingo Rd.(DNR-148) | New Lexington |
| 25.3 | (F,B,C) | 3.7 | 39E37'42"/82E13'58 | At McCuneville, TR 224 | New Lexington |
| 24.2 | (B,C) | 7.3 | 39E36'49"/82E13'53 | Ust. Shawnee Cr., SR 93 | New Straitsville |
| 24.0 | (F) | 7.3 | 39E37'01"/82E13'58 | Ust. Shawnee Cr., SR 93 | New Straitsville |
| 23.4 | (B,C) | 14.5 | 39E36'27"/82E14'34 | Dst. Rock Run | New Straitsville |
| 23.1 | (F,S) | 14.5 | 39E36'28"/82E14'51 | Dst. Rock Run (DNR -127) | New Staitsville |
| 19.8 | (F,S) | 26.0 | 39E34'46"/82E16'32 | Monday Creek Junction (DNR-103) | Gore |
| 19.7 | (B,C) | 26.0 | 39E34'47"/82E16'33 | Monday Creek Junction | Gore |
| 18.5 | (F,B,C) | 32.0 | 39E34'03"/82E16'16 | Private Dr. (sec. 36) | Gore |
| 16.0 | (B,S) | 36.0 | 39E33'00"/82E15'32 | Dst. Lost Run, SR 595 (DNR-131) | Gore |
| 15.8 | (F,C) | 36.0 | 39E32'49"/82E15'37 | Dst. Lost Run, SR 595 | Gore |
| 14.3 | (F,B) | 62.0 | 39E32'09"/82E16'29 | Dowley Rd. | Gore |
| 10.5 | (F,B,C,S) | 77.0 | 39E30'02"/82E14'48 | SR 278 (DNR LT-153) | New Straitsville |
| 9.3 | (F,B,C) | 81.0 | 39E29'51"/82E14'11 | Carbon Hill Rd., dst Monkey Hollow | Nelsonville |
| 4.3 | (F,B,C,S) | 84.0 | 39E27'49"/82E12'13 | Dst. McKnight seep, Loop Rd. (DNR-151) | Nelsonville |
| 3.0 | (F,B,C) | 112.0 | 39E27'02"/82E11'50 | Dst. Bessemer Hollow, Hollow Rd. | Nelsonville |
| 1.7 | (F,B,C,S) | 114.0 | 39E26'07"/82E11'30 | Dst. Coe Hollow, TR1042/569 (DNR-108) | Nelsonville |
| 0.7 | (F,B,C) | 116.0 | 39E25'20"/82E11'15 | Ust. US 33, Elm Rock Rd./TR 36 | Nelsonville |
| ***Dixie Hollow Tributary* (01-308)** | | | | | |
| 2.0 | (F,B,C) | 1.9 | 39E39'07"/82E14'59 | TR 224, at Dixie | New Lexington |
| 0.1 | (F,B,C) | 3.3 | 39E37'40"/82E14'06 | SR 93 | New Lexington |
| ***Shawnee Creek* (01-370)** | | | | | |
| 1.3 | (F,B,C) | 1.7 | 39E36'09"/82E12'45 | At Shawnee, SR 93 | New Straitsville |
| 0.3 | (C) | 2.0 | 39E36'41"/82E13'40 | Adj. SR 93 | New Straitsville |
| 0.1 | (F,B) | 4.4 | 39E36'43"/82E13'53 | Adj. SR 93 | New Straitsville |
| ***Shawnee Creek Tributary @ RM 1.25*** | | | | | |
| 0.1 | (C) | | 39E36'06"/82E12'48 | SR 93 | New Straitsville |
| ***Shawnee Creek Tributary* @ RM 0.59 (01-371)** | | | | | |
| 0.1 | (F,B) | 1.4 | 39E36'45"/82E13'39 | Tecumsey Rd. | New Straitsville |

| *Stream* River Mile | Sample Type | Drain Area ($mi^2$) | Latitude/Longitude | Landmarks | USGS 7.5' Quad. |
|---|---|---|---|---|---|
| ***Monday Creek Tributary I @ RM 23.4, Rock Run* (01-307)** | | | | | |
| (F,B,C,S) | 1.8 | 39E36'24"/82E14'27 | Adj. Rock Run Rd. | | New Straitsville |
| ***Stone Church Run* (01-302)** | | | | | |
| (C) | 1.8 | 39E37'40"/82E15'14 | Adj. Stone Church Hollow Rd. | | Junction City |
| (F,B) | 2.0 | 39E37'41"/82E15'15 | Adj. Stone Church Hollow Rd. | | Junction City |
| (F,B,C) | 3.4 | 39E36'28"/82E14'57 | Old Town Rd. | | New Straitsville |
| ***Salt Run* (01-360)** | | | | | |
| (F,B,C) | 1.3 | 39E36'53"/82E16'21 | TR 190 | | Gore |
| ***Monday Creek Tributary II @ RM 20.3, New Straitsville Trib.* (01-306)** | | | | | |
| 1.5 | (F,B,C) | 2.1 | 39E34'50"/82E14'42 | TR 255 | New Straitsville |
| 0.1 | (F,B,C) | 3.7 | 39E35'03"/82E16'07 | Crossing at Oreville | Gore |
| ***Monday Creek III @ 19.73, Dans Run* (01-301)** | | | | | |
| 0.2 | (F,B,C) | 3.0 | 39E34'51"/82E16'37 | SR 93 | Gore |
| ***Lost Run* (01-350)** | | | | | |
| 1.3 | (F,B,C) | 1.0 | 39E33'16"/82E14'28 | Brandy Rd. | New Straitsville |
| 0.1 | (F,B,C,S) | 3.1 | 39E33'06"/82E15'30 | SR 595 | Gore |
| ***Little Monday Creek* (01-340)** | | | | | |
| 13.7 | (F,C) | 1.8 | 39E39'21'/82E16'48" | Adj. TR 131 | Junction City |
| 13.6 | (B) | 1.8 | 39E39'13"/82E16'54 | Adj. TR 131 | Junction City |
| 11.1 | (F,B,C) | 4.7 | 39E37'43"/82E18'35 | Dutch Ridge Rd. | Junction City |
| 9.6 | (B,C) | 8.7 | 39E37'03"/82E19'57 | At Maxville, Griggs Rd. | Gore |
| 9.5 | (F) | 8.7 | 39E37'02"/82E19'58 | At Maxville, Griggs Rd. | Gore |
| 6.9 | (F,B,C) | 15.4 | 39E35'32"/82E20'06 | Adj. SR 93 | Gore |
| 3.8 | (B) | 22.0 | 39E34'02"/82E18'08 | Price Rd. | Gore |
| 3.3 | (F,C) | 23.0 | 39E33'37"/82E18'17 | Price Rd | Gore |
| 3.2 | (F) | 24.0 | 39E33'34"/82E18'17 | Price Rd. | Gore |
| 0.1 | (F,B,C,S) | 24.5 | 39E32'26"/82E16'34 | SR 595 (DNR-PT Site) | Gore |
| ***Coal Brook* (01-345)** | | | | | |
| 0.1 | (F,B,C) | 1.0 | 39E37'43"/82E18'57 | TR 131 | Junction City |
| ***Little Monday Creek Tributary I @ RM 10.15* (01-344)** | | | | | |
| 0.1 | (F,B,C) | 1.1 | 39E37'28"/82E19'36 | SR 668 | Gore |
| ***Temperance Hollow Tributary* (01-341)** | | | | | |
| 1.3 | (F,B,C) | 2.0 | 39E35'57"/82E21'04 | SR 312 | Gore |
| ***Little Monday Creek Tributary II @ RM 5.69* (01-343)** | | | | | |
| 0.1 | (F,B,C) | 1.7 | 39E34'50"/82E19'24 | SR 93 | Gore |
| ***Little Monday Creek Tributary III @ RM 4.85* (01-342)** | | | | | |
| 0.9 | (F,B,C) | 1.6 | 39E34'08"/82E19'41 | Lane East of CR 17 | Gore |

| *Stream River Mile* | **Sample Type** | **Drain Area (mi²)** | **Latitude/Longitude** | **Landmarks** | **USGS 7.5' Quad.** |
|---|---|---|---|---|---|
| ***Kitchen Run* (01-330)** | | | | | |
| 1.6 | (F,B,C) | 1.9 | 39E32'07"/82E17'57 | Stout Guess Rd. | Gore |
| 0.5 | (B) | 5.3 | 39E31'47"/82E16'52 | Ust. Trib. at RM 0.37, SR 595 | Gore |
| 0.4 | (F,C) | 5.3 | 39E31'45"/82E16'49 | Ust. Trib. at RM 0.37, SR 595 | Gore |
| ***Kitchen Run Tributary @ RM 0.37* (01-331)** | | | | | |
| 0.1 | (F,B,C) | 1.8 | 39E31'45"/82E16'52 | SR 595 | Gore |
| ***Sand Run* (01-320)** | | | | | |
| 1.7 | (F,B,C) | 1.7 | 39E31'06"/82E14'18 | Dawley-New Pittsburg Rd. | New Straitsville |
| 0.2 | (F,B,C) | 5.9 | 39E31'15"/82E15'34 | Dawley Rd. | Gore |
| ***Sand Run Tributary @ RM 1.44* (01-321)** | | | | | |
| 0.4 | (F,B) | 1.5 | 39E31'28"/82E14'06 | Adj. New Straitsville Rd. | New Straitsville |
| 0.2 | (C) | | 39E31'17"/82E14'14 | Adj. New Straitsville Rd. | New Straitsville |
| ***Monday Creek Tributary IV @ RM 9.88, Monkey Hollow* (01-304)** | | | | | |
| 0.2 | (F,B,C) | 1.1 | 39E29'43"/82E14'58 | Ust. Monday Cr. Trib. IV@RM 9.88/0.12 | Nelsonville |
| 0.1 | (F,B,C,S) | 2.8 | 39E29'47"/82E14'51 | At Mouth (DNR-PT Site) | Nelsonville |
| ***Tributary of Monday Creek Trib. IV @ RM 9.88/0.12* (01-305)** | | | | | |
| 0.4 | (F,B,C) | 1.7 | 39E29'26"/82E14'59 | SR 278 | Nelsonville |
| ***Big Four Hollow*** | | | | | |
| 0.47 | (S,C) | - | 39E29'53"/82E13'03 | Carbon Hill-Buchtel Rd. (ODNR-PT Site) | Nelsonville |
| ***Trib to Big Four Hollow*** | | | | | |
| 0.12 | (C) | - | 39E29'51"/82E12'55 | Carbon Hill-Buchtel Rd. | Nelsonville |
| ***Snake Hollow Tributary* (01-309)** | | | | | |
| 0.1 | (B,C,S) | 1.2 | 39E28'02"/82E12'23 | At Mouth (ODNR-PT Site) | Nelsonville |
| ***Bessemer Hollow*** | | | | | |
| 0.1 | (C,S) | - | 39E27'39"/82E12'12 | At Mouth (ODNR-PT Site) | Nelsonville |
| ***Snow Fork* (01-310)** | | | | | |
| 6.2 | (F,B,C,S) | 12.2 | 39E30'51"/82E09'55 | Murray City, dst. Murray City Seeps 1&2 (DNR- | New Straitsville |
| 4.5 | (F) | 18.2 | 39E29'17"/82E09'58 | Goose Run Rd., dst. Mainstem Seep | Nelsonville |
| 4.3 | (B,C,S) | 18.2 | 39E29'18"/82E09'57 | Goose Run Rd., dst. Mainstem seep (DNR-107) | Nelsonville |
| 2.4 | (F,B,C,S) | 24.5 | 39E27'51"/82E10'16 | Dst. Orbiston seep, SR 685 (DNR-109) | Nelsonville |
| 1.0 | (F,B,C,S) | 26.7 | 39E27'25"/82E11'18 | Foot Bridge at Buchtel, dst. Whitmore Hollow | Nelsonville |
| ***Salem Hollow Tributary* (01-313)** | | | | | |
| 3.1 | (F,B,C) | 1.7 | 39E33'36"/82E10'54 | Adj. Black Gold Rd. | New Straitsville |
| 2.2 | (F,B,C) | 3.4 | 39E32'45"/82E10'22 | Salem Hollow Rd. | New Straitsville |
| 0.1 | (F,B,C) | 5.7 | 39E31'18"/82E10'02 | SR 216 | New Straitsville |

| *Stream* River Mile | Sample Type | Drain Area ($mi^2$) | Latitude/Longitude | Landmarks | USGS 7.5' Quad. |
|---|---|---|---|---|---|
| ***Middle Fork, Sycamore Hollow* (01-312)** | | | | | |
| 3.2 | (F) | 2.4 | 39E33'08"/82E12'10 | SR 216 | New Straitsville |
| 3.0 | (B,C) | 2.4 | 39E33'08"/82E12'08 | SR 216 | New Straitsville |
| 0.1 | (F,B,C) | 4.9 | 39E31'16"/82E10'06 | Private Dr. | New Straitsville |
| ***Spencer Hollow* (01-314)** | | | | | |
| 0.3 | (F,B,C) | 1.4 | 39E31'16"/82E10'15 | Spencer Hollow Rd. | New Straistville |
| ***Brush Fork* (01-311)** | | | | | |
| 3.4 | (F,B,C) | 1.1 | 39E32'01"/82E12'56 | Adj. Brush Fork Rd. | New Straitsville |
| 2.3 | (F,B,C) | 2.0 | 39E30'52"/82E11'45 | Dawley-New Pittsburg Rd. | New Straitsville |
| 0.1 | (F,B,C) | 4.5 | 39E29'45"/82E10'01 | SR 78 (DNR-PT Site) | Nelsonville |
| ***Goose Run*** | | | | | |
| 0.1 | (C) | 1.1 | 39E29'19"/82E09'41 | Adj. Goose Run Rd. | Nelsonville |
| ***Long Hollow Run* (01-315)** | | | | | |
| 0.1 | (F,B,C) | 1.3 | 39E28'27"/82E10'01 | SR 78 (DNR-PT Site) | Nelsonville |
| ***Whitmore Hollow Tributary* (01-316)** | | | | | |
| 0.2 | (C) | - | 39E27'37"/82E10'33 | Crossing South East of Buchtel | Nelsonville |
| 0.1 | (B) | - | 39E27'41"/82E10'42 | Crossing South East of Buchtel | Nelsonville |
| ***Coe Hollow*** | | | | | |
| 0.1 | (C) | 0.2 | 39E26'59"/82E11'55 | At Mouth (ODNR-PT Site) | Nelsonville |
| ***Majestic Mine*** | | | | | |
| 0.1 | (S) | - | 39E25'26"/82E11'12 | At Mouth | Nelsonville |

**Table II: Total list of fish species collected in the Monday Creek basin by the Ohio EPA in 2001.**

Total list of fish species collected in the Monday Creek basin by the Ohio EPA in 2001

Grand Total of All Streams
Date Range: 06/28/2001
Thru: 08/14/2001

Dist Fished: 13.01 km    No of Streams: 28    No of Passes: 75

| Species Name / ODNR Status | IBI Group | Feed Guild | Breed Guild | Tol | # of Fish | Relative Number | % by Number | Relative Weight | % by Weight | Ave (gm) Weight |
|---|---|---|---|---|---|---|---|---|---|---|
| Grass Pickerel | | P | M | P | 186 | 4.09 | 0.85 | 0.11 | 3.70 | 27.23 |
| Golden Redhorse | R | I | S | M | 1 | 0.02 | 0.00 | 0.01 | 0.22 | 312.00 |
| Northern Hog Sucker | R | I | S | M | 1 | 0.02 | 0.00 | 0.00 | 0.09 | 126.00 |
| White Sucker | W | O | S | T | 988 | 22.78 | 4.72 | 0.28 | 9.82 | 13.10 |
| Blacknose Dace | N | G | S | T | 1,450 | 37.66 | 7.80 | 0.05 | 1.81 | 1.39 |
| Creek Chub | N | G | N | T | 7,907 | 196.20 | 40.63 | 1.46 | 50.57 | 7.81 |
| South. Redbelly Dace | N | H | S | | 2,599 | 67.47 | 13.97 | 0.08 | 2.93 | 1.26 |
| Redfin Shiner | N | I | N | | 27 | 0.57 | 0.12 | 0.00 | 0.02 | 1.11 |
| Striped Shiner | N | I | S | | 832 | 16.91 | 3.50 | 0.11 | 3.77 | 6.47 |
| Spotfin Shiner | N | I | M | | 3 | 0.06 | 0.01 | 0.00 | 0.01 | 3.33 |
| Silverjaw Minnow | N | I | M | | 78 | 1.60 | 0.33 | 0.00 | 0.12 | 2.21 |
| Fathead Minnow | N | O | C | T | 12 | 0.32 | 0.07 | 0.00 | 0.02 | 1.75 |
| Bluntnose Minnow | N | O | C | T | 1,158 | 25.90 | 5.36 | 0.07 | 2.37 | 2.66 |
| Central Stoneroller | N | H | N | | 1,507 | 36.36 | 7.53 | 0.12 | 4.06 | 3.28 |
| Cr Chub X S. Redbelly D | | | | | 3 | 0.06 | 0.01 | 0.00 | 0.01 | 2.67 |
| Yellow Bullhead | | I | C | T | 211 | 4.89 | 1.01 | 0.25 | 8.57 | 50.72 |
| Brown Bullhead | | I | C | T | 1 | 0.02 | 0.00 | 0.00 | 0.05 | 66.00 |
| Black Bullhead | | I | C | P | 4 | 0.09 | 0.02 | 0.00 | 0.09 | 28.75 |
| Rock Bass | S | C | C | | 1 | 0.02 | 0.00 | 0.00 | 0.09 | 134.00 |
| Largemouth Bass | F | C | C | | 51 | 1.14 | 0.24 | 0.01 | 0.29 | 7.86 |
| Green Sunfish | S | I | C | T | 904 | 21.32 | 4.42 | 0.18 | 6.11 | 8.31 |
| Bluegill Sunfish | S | I | C | P | 836 | 20.44 | 4.23 | 0.10 | 3.46 | 5.13 |
| Redear Sunfish | E | I | C | | 1 | 0.02 | 0.00 | 0.00 | 0.01 | 8.00 |
| Pumpkinseed Sunfish | S | I | C | P | 11 | 0.29 | 0.06 | 0.00 | 0.05 | 5.36 |
| Green Sf X Bluegill Sf | | | | | 12 | 0.25 | 0.05 | 0.01 | 0.27 | 32.17 |
| Green Sf X Hybrid | | | | | 20 | 0.46 | 0.10 | 0.01 | 0.39 | 25.70 |
| Hybrid X Sunfish | | | | | 2 | 0.05 | 0.01 | 0.00 | 0.14 | 84.50 |
| Blackside Darter | D | I | S | | 10 | 0.20 | 0.04 | 0.00 | 0.01 | 1.90 |
| Johnny Darter | D | I | C | | 557 | 12.42 | 2.57 | 0.01 | 0.39 | 0.89 |
| Fantail Darter | D | I | C | | 504 | 11.21 | 2.32 | 0.02 | 0.58 | 1.46 |
| No Fish | | | | | 0 | 0.00 | 0.00 | | | |
| | | Grand Total | | | 19,877 | 482.83 | | 2.90 | | |
| | | Number of Species | | | 26 | | | | | |
| | | Number of Hybrids | | | 4 | | | | | |

Source: Ohio EPA

**Table III: Summary of acid mine drainage (AMD) associated macro-invertebrate taxa found within the Monday Creek basin in 2001.**

Numbers in **bold** meet the criteria for highly degraded AMD streams which generally include number of qualitative sample taxa $\leq$ 11, qualitative EPT $\leq$ 1, and percent of total number of taxa that are AMD indicators $\geq$ 33%.

| **Stream** River Mile | Qual Taxa | Qual EPT[a] | % AMD Taxa | Acid Mine Drainage (AMD) Macroinvertebrate Taxa |
|---|---|---|---|---|
| **Monday Creek** | | | | |
| 26.5 | **8** | **1** | **75%** | *Sigara sp, Sialis sp, Nigronia serricornis, Hydroporus sp, Chironomus (C.) decorus group, Polypedilum (P.) Illinoense* |
| 25.3 | 12 | **1** | **58%** | *Sialis sp, Nigronia sp, Hydroporus sp, Laccophilus sp, Ceratopogonidae, Chironomus (C.) decorus group, Polypedilum (P.) sp 2* |
| 24.2 | **10** | 2 | **40%** | *Sialis sp, Nigronia serricornis, Hydroporus sp, Polypedilum (Pentapedilum) tritum var. I* |
| 23.4 | **8** | 3 | 13% | *Sialis sp* |
| 19.7 | 23 | 9 | 9% | *Sialis sp, Nigronia serricornis, Ceratopogonidae, Polypedilum (P.) Illinoense* |
| 18.5 | 20 | 6 | 15% | *Coenagrionidae, Sialis sp, Nigronia serricornis, Hydroporus sp, Ceratopogonidae, Polypedilum (P.) Illinoense* |
| 16.0 | 13 | 2 | 23% | *Coenagrionidae, Sialis sp, Nigronia serricornis, Ceratopogonidae, Chironomus (C.) decorus group, Polypedilum (Pentapedilum) tritum var. I, Polypedilum (P.) sp 2* |
| 14.3 | 13 | 5 | 10% | *Sialis sp, Nigronia serricornis* |
| 10.5 | 17 | 3 | 8% | *Sialis sp, Nigronia serricornis, Ceratopogonidae* |
| 9.3 | 12 | 2 | 11% | *Sialis sp, Nigronia serricornis, Ceratopogonidae, Chironomus (C.) sp* |
| 4.3 | **11** | 5 | 13% | *Sialis sp, Nigronia serricornis, Ceratopogonidae* |
| 3.0 | **8** | 3 | **38%** | *Sigara sp, Sialis sp, Chironomus (C.) decorus group* |
| 1.7 | **8** | 2 | 18% | *Sialis sp, Nigronia serricornis, Polypedilum* |

| **Stream** River Mile | Qual Taxa | Qual EPT[a] | % AMD Taxa | Acid Mine Drainage (AMD) Macroinvertebrate Taxa |
|---|---|---|---|---|
| | | | | *(Pentapedilum) tritum var. I, Polypedilum (P.) sp 2* |
| 0.7 | **6** | **1** | 30% | *Notonecta sp, Sialis sp, Nigronia serricornis, Chironomus (C.) decorus group, Polypedilum (Pentapedilum) tritum var. I, Polypedilum (P.) Illinoense* |
| **Dixie Hollow Creek** | | | | |
| 2.0 | 9 | 4 | **44%** | *Sigara sp, Sialis sp, Nigronia serricornis, Hydroporus sp* |
| 0.1 | 10 | 5 | **50%** | *Sigara sp, Sialis sp, Laccophilus sp, Hydroporus sp, Chironomus (C.) decorus group* |
| **Shawnee Creek** | | | | |
| 1.3 | 15 | 2 | 7% | *Sialis sp* |
| 0.1 | 15 | 4 | 7% | *Nigronia serricornis* |
| **Trib. to Shawnee Creek (RM 0.14)** | | | | |
| 0.1 | **6** | **0** | 0% | |
| **Rock Run** | | | | |
| 0.1 | **4** | **0** | **50%** | *Sialis sp, Hydroporus sp* |
| **Stone Church Run** | | | | |
| 1.9 | 18 | 9 | 17% | *Sialis sp, Hydroporus sp, Polypedilum (P.) Illinoense* |
| 0.1 | 15 | 2 | 20% | *Sialis sp, Nigronia serricornis, Ceratopogonidae* |
| **Salt Run** | | | | |
| 1.1 | 21 | 5 | 9% | *Ceratopogonidae, Polypedilum (P.) Illinoense* |
| **Trib. to Monday Creek (RM 20.03)** | | | | |
| 1.5 | **9** | **1** | **44%** | *Cambarus thomai, Hydroporus sp, Laccophilus sp, Polypedilum (P.) Illinoense* |
| 0.1 | **1** | **0** | 0% | |
| | | | | |

| **Stream** River Mile | Qual Taxa | Qual EPT[a] | % AMD Taxa | Acid Mine Drainage (AMD) Macroinvertebrate Taxa |
|---|---|---|---|---|
| **Trib. to Monday Creek (RM 19.73)** | | | | |
| 0.2 | 23 | 7 | 9% | *Sialis sp, Nigronia serricornis* |
| **Lost Run** | | | | |
| 1.3 | **3** | **0** | **33%** | *Sialis sp* |
| 0.1 | **9** | **1** | **44%** | *Notonecta sp, Sialis sp, Nigronia serricornis, Hydroporus sp* |
| **Little Monday Creek** | | | | |
| 13.6 | 18 | 6 | 11% | *Coenagrionidae, Sialis sp* |
| 11.1 | 22 | 8 | 9% | *Sialis sp, Ceratopogonidae* |
| 9.6 | 25 | 12 | 4% | *Hydroporus sp* |
| 6.9 | 23 | 9 | 12% | *Sialis sp, Chironomus (C.) decorus group* |
| 3.8 | 29 | 12 | 4% | *Sialis sp, Nigronia serricornis* |
| 0.1 | 19 | 7 | 6% | *Sialis sp, Nigronia serricornis* |
| **Coal Brook** | | | | |
| 0.1 | 20 | 6 | 10% | *Sialis sp, Chironomus (C.) decorus group* |
| **Trib. I to Little Monday Creek (RM 10.15)** | | | | |
| 0.1 | 21 | 6 | 29% | *Coenagrionidae, Sigara sp, Sialis sp, Hydroporus sp, Ceratopogonidae, Chironomus (C.) decorus group* |
| **Temperance Hollow Creek** | | | | |
| 1.3 | 27 | 10 | 7% | *Sialis sp, Hydroporus sp* |
| **Trib. II to Little Monday Creek (RM 5.69)** | | | | |
| 0.1 | 22 | 7 | 9% | *Sialis sp, Hydroporus sp* |
| **Trib. III to Little Monday Creek (RM 4.85)** | | | | |
| 0.9 | 23 | 6 | 4% | *Hydroporus sp* |
| **Kitchen Run** | | | | |
| | | | | |

| **Stream** River Mile | Qual Taxa | Qual EPT[a] | % AMD Taxa | Acid Mine Drainage (AMD) Macroinvertebrate Taxa |
|---|---|---|---|---|
| 1.6 | 29 | 7 | 7% | *Hydroporus sp, Chironomus (C.) decorus group* |
| 0.5 | **7** | **1** | 0% | |
| **Trib. to Kitchen Run (RM 0.37)** | | | | |
| 0.1 | 19 | 3 | 11% | *Coenagrionidae*, *Ceratopogonidae* |
| **Sand Run** | | | | |
| 1.7 | **11** | 2 | **45%** | *Coenagrionidae*, *Sialis sp*, *Ceratopogonidae*, *Chironomus (C.) decorus group, Polypedilum (Pentapedilum) tritum var. I* |
| 0.2 | **8** | **1** | 12% | *Sialis sp* |
| **Trib. to Sand Run (RM 1.44)** | | | | |
| 0.2 | 17 | 4 | 18% | *Nigronia serricornis*, *Ceratopogonidae*, *Chironomus (C.) sp* |
| **Trib. to Monday Creek/ Monkey Hollow (RM 9.88)** | | | | |
| 0.2 | **10** | **1** | **60%** | *Notonecta sp, Sialis sp, Nigronia serricornis, Hydroporus sp, Chironomus (C.) sp*, *Polypedilum (P.) Illinoense* |
| 0.1 | **8** | **0** | **88%** | *Sigara sp, Sialis sp, Nigronia serricornis, Hydroporus sp, Ceratopogonidae*, *Chironomus (C.) sp*, *Polypedilum (P.) Illinoense* |
| **Trib. to Monday Creek (RM 9.88/0.1) / Trib. to Monkey Hollow** | | | | |
| 0.4 | **6** | **0** | **83%** | *Sialis sp, Nigronia serricornis, Hydroporus sp, Chironomus (C.) decorus group*, *Polypedilum (P.) Illinoense* |
| **Snake Hollow** | | | | |
| 0.1 | **3** | **1** | **67%** | *Sialis sp, Nigronia serricornis,* |
| **Snow Fork** | | | | |
| 6.2 | **5** | **0** | **60%** | *Sialis sp*, *Ceratopogonidae, Chironomus (C.) decorus group* |
| 4.3 | **8** | **0** | **75%** | *Nigronia serricornis, Hydroporus sp*, *Laccophilus* |

| **Stream** River Mile | Qual Taxa | Qual EPT[a] | % AMD Taxa | Acid Mine Drainage (AMD) Macroinvertebrate Taxa |
|---|---|---|---|---|
| | | | | *sp*, *Chironomus (C.) decorus group*, *Polypedilum (Pentapedilum) tritum var. I*, *Polypedilum (P.) sp 2* |
| 2.4 | **6** | **0** | **83%** | *Sialis sp*, *Nigronia serricornis, Hydroporus sp*, *Chironomus (C.) decorus group*, *Polypedilum (Pentapedilum) tritum var. I* |
| 1.0 | **5** | **1** | **50%** | *Sialis sp*, *Nigronia serricornis, Chironomus (C.) decorus group*, *Polypedilum (Pentapedilum) tritum var. I*, *Polypedilum (P.) sp 2* |
| **Salem Hollow Creek** | | | | |
| 3.1 | 26 | 7 | 19% | *Sialis sp*, *Nigronia serricornis*, *Hydroporus sp*, *Ceratopogonidae, Chironomus (C.) decorus group* |
| 2.2 | 31 | 9 | 13% | *Sialis* sp, *Hydroporus sp*, *Ceratopogonidae, Chironomus (C.) decorus group* |
| 0.1 | 13 | 3 | 25% | *Sialis* sp, *Ceratopogonidae, Chironomus (C.) decorus group*, *Polypedilum (P.) Illinoense* |
| **Sycamore Hollow Creek** | | | | |
| 3.4 | **2** | **1** | 0% | |
| 0.1 | **5** | **1** | 20% | *Sialis sp* |
| **Spencer Hollow Creek** | | | | |
| 0.3 | 17 | 2 | **59%** | *Coenagrionidae, Sigara sp, Notonecta sp, Sialis sp, Nigronia serricornis*, *Hydroporus sp*, *Laccophilus sp*, *Ceratopogonidae, Chironomus (C.) decorus group*, *Polypedilum (Pentapedilum) tritum var. I* |
| **Brush Fork** | | | | |
| 3.4 | 15 | **1** | **33%** | *Coenagrionidae, Sigara sp, Sialis sp, Hydroporus sp, Chironomus (C.) decorus group* |
| 2.3 | **10** | **1** | **50%** | *Sigara sp, Sialis sp*, *Nigronia serricornis*, *Hydroporus sp*, *Chironomus (C.) decorus group* |
| 0.1 | **6** | **1** | **67%** | *Sialis sp*, *Nigronia serricornis*, *Hydroporus sp*, *Polypedilum (Pentapedilum) tritum var. I* |
| | | | | |

| **Stream** River Mile | Qual Taxa | Qual EPT[a] | % AMD Taxa | Acid Mine Drainage (AMD) Macroinvertebrate Taxa |
|---|---|---|---|---|
| **Long Hollow Creek** | | | | |
| 0.1 | **9** | **0** | 22% | *Hydroporus sp*, *Ceratopogonidae, Chironomus (C.) decorus group* |
| **Whitmore Hollow - Trib to Snow Fork (RM 1.8)** | | | | |
| 0.1 | 13 | 2 | 23% | *Sialis sp*, *Nigronia serricornis*, *Chironomus (C.) decorus group* |
| **Trib. to Monday Creek (RM 2.41)** | | | | |
| 0.4 | **6** | **0** | 0% | |

a EPT = total Ephemeroptera (mayflies), Plecoptera (stoneflies), & Trichoptera (caddisflies) taxa richness.

**Table IV: TMDL sample locations IBI, QHEI, and ICI scores within the Monday Creek basin in 2001. A total of 2 to 6 water quality samples were collected at sites and utilized to determine station mean.**

| Stream (Rivercode) | River Mile (RM) | Mean pH | Mean Acid (mg/l) (Measured and/or Calculated) | Mean Alkalinity (mg/l) (Measured and/or Calculated) | IBI | QHEI | ICI |
|---|---|---|---|---|---|---|---|
| *Monday Creek (01-300)* | 26.5 | 4.0 | 31 | 5 | 12 | 64 | 1 |
| *Monday Creek (01-300)* | 25.3 | 3.6 | 56 | 5 | 12 | 52.5 | 1 |
| *Monday Creek (01-300)* | 24 | 4.1 | 116 | 5 | 20 | 77.5 | 12 |
| *Monday Creek (01-300)* | 23.4 | 5.6 | 13 | 10 | 16 | 74.5 | 12 |
| *Monday Creek (01-300)* | 19.8 | 6.5 | 13 | 12 | 22 | 65 | 34 |
| *Monday Creek (01-300)* | 18.5 | 6.7 | 5 | 13 | 18 | 81.5 | 26 |
| *Monday Creek (01-300)* | 15.8 | 5.7 | 13 | 7 | 18 | 61.5 | 14 |
| *Monday Creek (01-300) (fish/bug only)* | 14.3 | NA | NA | NA | 23 | 54 | 4 |
| *Monday Creek (01-300)* | 10.5 | 6.7 | 4 | 38 | 29 | 62 | 28 |
| *Monday Creek (01-300)* | 9.3 | 6.6 | 6 | 81 | 22 | 63 | 18 |
| *Monday Creek (01-300)* | 4.3 | 6.5 | 6 | 24 | 21 | 66 | 24 |
| *Monday Creek (01-300)* | 3 | 4.6 | 28 | 5 | 13 | 73.5 | 12 |
| *Monday Creek (01-300)* | 1.7 | 4.6 | 27 | 5 | 14 | 54.5 | 12 |
| *Monday Creek (01-300)* | 0.7 | 4.7 | 26 | 5 | 12 | 68.5 | 16 |
| *Dixie Hollow Trib (01-308)* | 2 | 5.4 | 24 | 5 | 12 | 77 | 1 |
| *Dixie Hollow Trib (01-308)* | 0.1 | 5.5 | 9 | 5 | 12 | 59 | 1 |
| *Shawnee Creek (01-370)* | 1.3 | 7.1 | 3 | 123 | 22 | 54.5 | 12 |
| *Shawnee Creek (01-370)* | 0.1 | 7.0 | 3 | 71 | 22 | 44 | 13 |
| *Shawnee Cr. Trib @ RM 1.25* | 0.1 | 7.2 | 7 | 88 | 34 | 45.5 | 1 |
| *Rock Run (01-307)(MC Trib I @ RM 20.3)* | 0.1 | 4.2 | 92 | 5 | 12 | 56 | 1 |
| *Stone Church Run (01-302)* | 1.9 | 6.8 | 6 | 39 | 22 | 62 | 32 |
| *Stone Church Run (01-302)* | 0.1 | 6.6 | 4 | 31 | 20 | 62.5 | 12 |
| *Salt Run (01-360)* | 1.1 | 6.7 | 4 | 46 | 26 | 67 | 32 |
| New Straitsville Trib (01-306)(MC Trib II @ RM 20.3) | 1.5 | 7.4 | 7 | 52 | 16 | 55 | 1 |
| *Dans Run (03-301)(MC Trib III @ RM 19.73)* | 0.2 | 7.3 | 4 | 61 | 34 | 65 | 32 |
| *Lost Run (01-350)* | 1.3 | 2.6 | 262 | 5 | 12 | 65 | 1 |
| *Lost Run (01-350)* | 0.1 | 3.1 | 166 | 5 | 12 | 61 | 1 |

| Stream (Rivercode) | River Mile (RM) | Mean pH | Mean Acid (mg/l) (Measured and/or Calculated) | Mean Alkalinity (mg/l) (Measured and/or Calculated) | IBI | QHEI | ICI |
|---|---|---|---|---|---|---|---|
| *Little Monday Creek (01-340)* | 13.7 | 7.2 | 9 | 44 | 42 | 73 | 32 |
| *Little Monday Creek (01-340)* | 11.1 | 7.4 | 4 | 36 | 42 | 79 | 32 |
| *Little Monday Creek (01-340)* | 9.5 | 7.5 | 3 | 155 | 44 | 64.5 | 36 |
| *Little Monday Creek (01-340)* | 6.9 | 7.5 | 3 | 130 | 32 | 69 | 36 |
| *Little Monday Creek (01-340)* | 3.3 | 7.2 | 3 | 116 | 34 | 68.5 | 56 |
| *Little Monday Creek (01-340)* | 0.1 | 7.1 | 3 | 100 | 36 | 56.5 | 32 |
| *Coal Brook (01-345)* | 0.1 | 7.3 | 2 | 46 | 42 | 63 | 32 |
| *L. Monday Cr. Trib I (01-344)(@ RM 10.15)* | 0.1 | 7.5 | 5 | 428 | 46 | 59.5 | 31 |
| *Temperance Hollow (01-341)* | 1.3 | 7.4 | 2 | 93 | 42 | 67 | 36 |
| *L. Monday Creek Trib II (01-343)(@ RM 5.69)* | 0.1 | 7.5 | 3 | 52 | 42 | 56.5 | 32 |
| *L Monday Cr Trib III (01-342)(@ RM 4.85)* | 0.9 | 7.6 | 2 | 43 | 46 | 64 | 32 |
| *Kitchen Run (01-330)* | 1.6 | 7.0 | 3 | 80 | 34 | 48.5 | 32 |
| *Kitchen Run (01-330)* | 0.4 | 7.0 | 7 | 69 | 34 | 55.5 | 1 |
| *Kitchen Run Trib (01-331)(@ RM 0.37)* | 0.1 | 7.1 | 6 | 53 | 38 | 42 | 13 |
| *Sand Run (01-320)* | 1.7 | 6.2 | 13 | 9 | 30 | 65.5 | 12 |
| *Sand Run (01-320)* | 0.2 | 7.1 | 8 | 70 | 30 | 59.5 | 1 |
| *Sand Run Trib (01-321)(@ RM 1.44)* | 0.4 | 7.4 | 2 | 61 | 40 | 57.5 | 31 |
| *Monkey Hollow Trib (01-304)(Monday Cr Trib IV @ 9.88)* | 0.2 | 4.9 | 26 | 6 | 12 | 68.5 | 1 |
| *Monkey Hollow Trib (01-304)(Monday Cr Trib IV @ 9.88)* | 0.1 | 3.3 | 117 | 5 | 12 | 42.5 | 1 |
| *Trib of Monkey Hollow Trib (01-305)* | 0.4 | 4.6 | 142 | 5 | 12 | 60 | 1 |
| *Snake Hollow (01-309) (no fish)* | 0.1 | 3.0 | 212 | 14 | NA | NA | 1 |
| *Bessemer Hollow (Chem only)* | 0.1 | 3.1 | 189 | 5 | NA | NA | NA |
| *Coe Hollow (Chem Only)* | 0.1 | 2.4 | 311 | 5 | NA | NA | NA |

| Stream (Rivercode) | River Mile (RM) | Mean pH | Mean Acid (mg/l) (Measured and/or Calculated) | Mean Alkalinity (mg/l) (Measured and/or Calculated) | IBI | QHEI | ICI |
|---|---|---|---|---|---|---|---|
| *Snow Fork (01-310)* | 6.2 | 3.4 | 92 | 5 | 12 | 43 | 1 |
| *Snow Fork (01-310)* | 4.5 | 3.4 | 109 | 5 | 12 | 64.5 | 1 |
| *Snow Fork (01-310)* | 2.4 | 3.3 | 109 | 5 | 12 | 58.5 | 1 |
| *Snow Fork (01-310)* | 1 | 3.7 | 77 | 5 | 12 | 57.5 | 6 |
| *Salem Hollow (01-313)* | 3.1 | 6.8 | 9 | 67 | 38 | 78.5 | 32 |
| *Salem Hollow (01-313)* | 2.2 | 7.0 | 6 | 58 | 28 | 56 | 36 |
| *Salem Hollow (01-313)* | 0.1 | 6.6 | 16 | 28 | 26 | 73 | 16 |
| *Sycamore Hollow (01-312)(Middle Fork)* | 3.2 | 4.8 | 52 | 5 | 30 | 67 | 1 |
| *Sycamore Hollow (01-312)(Middle Fork)* | 0.1 | 4.5 | 23 | 5 | 12 | 69.5 | 1 |
| *Spencer Hollow (01-314)* | 0.3 | 4.1 | 57 | 5 | 12 | 76 | 12 |
| *Brush Fork (01-311)* | 3.4 | 6.9 | 20 | 110 | 12 | 59 | 1 |
| *Brush Fork (01-311)* | 2.3 | 3.2 | 117 | 5 | 12 | 55 | 1 |
| *Brush Fork (01-311)* | 0.1 | 3.3 | 106 | 5 | 12 | 73 | 1 |
| *Long Hollow Run (01-315)* | 0.1 | 3.3 | 62 | 5 | 12 | 72 | 1 |
| *Whitmore Hollow (01-316)(no fish)* | 0.1 | 6.5 | 15 | 63 | NA | NA | 12 |