ACID MINE DRAINAGE ABATEMENT AND TREATMENT (AMDAT) PLAN FOR THE HEADWATERS OF THE RACCOON CREEK WATERSHED

by

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ABSTRACT

The Raccoon Creek Headwaters study includes all area that drains into the mainstem from river mile 111.9 (the confluence of the East and West Branches of Raccoon Creek) to river mile 80.6 (the bridge over Raccoon Creek on US route 50) covering 200 square miles. The basin extends into Athens, Hocking and Vinton Counties. According to the *Biological and Water Quality Study of the Raccoon Creek Basin (1995),* written by the Ohio Environmental Protection Agency (OEPA), the leading cause of partial or non-attainment of water quality designations is Acid Mine Drainage (AMD). From the confluence of the East and West Branches to the discharge of Sandy Run (Lake Hope) the stream is designated as Limited Resource Water due to AMD and only partially meets this OEPA designated benchmark. The OEPA Raccoon Creek basin study states that the headwaters are substantially affected by the impacts of mining in the East Branch. The remainder of the mainstem is designated as Warmwater Habitat and meets this benchmark.

The Acid Mine Drainage Abatement and Treatment Plan supports this finding along with the identification of prioritized projects in the Brushy Creek, Mainstem to Brushy Creek section, Hewett Fork and West Branch subwatersheds. It is hoped that the completion of reclamation and the application of abatement strategies at the identified locations will lead to significant and immediate response of the biologic resources and overall health of the stream. This plan attempts to reach this goal by applying strategies that provide the appropriate level of technology and are cost effective.

Project costs for the plan total $3,495,816 including design and post construction monitoring. The cost for the individual subwatersheds in order of priority is: East Branch, $1,385, 972, Brushy Creek, $649, 307. Mainstem to Brushy Creek $51, 244, Hewett Fork, $979,881, West Branch, $303,320, and Mainstem to Lake Hope, $126, 092.

METHODS

The study area is broken down into four primary subwatersheds and three mainstem sections (Map 1 – Back Pocket). Sampling sites are named according to their location within a defined subwatershed or mainstem section (Figure 1). The East and West Branch tributaries are given specific designations of East Branch (EB) and West Branch (WB). The section of the mainstem from the confluence of East and West Branches to immediately upstream of the mouth of Brushy Creek is designated as the Mainstem Above Brushy Creek (MSBC). There are no large individual tributaries in this section. Brushy Creek including its major tributaries Siverly Creek and Dunkle Creek are designated as Brushy Creek (BC). The mainstem section below the confluence of Brushy Creek to below the Lake Hope/Sandy Run discharge is designated as Mainstem to Lake Hope (MSLH). Hewett Fork subwatershed is designated as HF. The mainstem section below Hewett Fork to Bolin Mills at the US Route 50 bridge in Vinton County is designated as Mainstem to Bolin Mills (MSBM)[1].

Figure 1

Primary Subwatersheds in the Headwaters of Raccoon Creek

Stream Section	Sample Site Designation	River Reach in River Miles
East Branch	EB	Discharges at RM 111.9
West Branch	WB	Discharges at RM 111.9
Mainstem above Brushy Creek	MSBC	RM 111.9 to RM 103.6
Brushy Creek	BC	Discharges at RM 103.6
Mainstem to Lake Hope	MSLH	RM 103.6 to RM 92.5
Hewett Fork	HF	Discharges at RM 89.6
Mainstem to Bolin Mills	MSBM	RM 89.6 to RM 80.6

A three phased approach was used to prioritize sources based on acidity and metal loads. A Corning Checkmate meter was used to measure pH and specific conductance to determine a stream's likelihood of discharging water with acid mine drainage characteristics. The meter was calibrated each day it was in use.

During phase I six sites were sampled on the Raccoon Creek mainstem and 30 sites were sampled at the mouths of tributaries that showed potential AMD characteristics. Not all tributaries were sampled because of lack of flow, field measurements (i.e. pH above 7, low specific conductance) or inaccessibility. These streams were reviewed for proximity to known mining areas on the Ohio Department of Natural Resources (ODNR) abandoned underground mine maps and the USGS quadrangles for known surface mines.

Phase II involved characterizing the tributaries to the mainstem that exhibit AMD characteristics. A field reconnaissance of all the minor tributaries to the main tributary was

[1] Bolin Mills was a community once located along route 50 near the bridge and while now abandoned the name remains as a good place marker on the USGS 7.5" quadrangle (McArthur Quad.)

conducted in addition to sampling those which exhibit AMD characteristics. Tributaries studied during phase II include East Branch, West Branch, Mitchell Hollow (MSBC90), Brushy Creek, the Lake Hope/Sandy Run tributary (MSLH 120)[2] and Hewett Fork.

The purpose of phase III was to identify and characterize AMD point sources in the tributaries studied during phases I and II. A qualitative description was done for each point source and water samples and discharge measurements were collected where possible. Point source identification was possible in the East Branch and Hewett Fork because of discrete, deep mine discharges. However, point source identification was limited in the headwaters study area because of the diffuse nature of the AMD problem. In cases such as these it was determined that collecting samples at the mouths of the small tributaries receiving the drainage from several potential problem sites was the best method for assessing the diffuse nature of the AMD problem. Brushy Creek, West Branch, Mitchell Hollow, and most of East Branch and Hewett Fork were assessed in this manner.

Samples were collected in a triple-rinsed bucket and split into two triple-rinsed bottles. One bottle was acidified with 20% HCl solution; the other was a cubitainer with the air squeezed out of the headspace. Samples were not filtered. Samples were analyzed at ODNR's Cambridge lab. Parameters measured were ODNR's Group I (pH, total acidity as $CaCO_3$, total alkalinity, specific conductance, total suspended solids, sulfate, total iron, total manganese, aluminum, hardness and total dissolved solids). Group I is sufficient to prioritize sources based on acidity and metal loads.

Discharge was measured for each sample in order to calculate loading (concentration x discharge) using methods appropriate to flow volume. Mainstem discharges during high flows were taken using a bridge crane apparatus specifically built for the purpose of lowering a weighted AA current meter from a bridge. For large discharges a pygmy meter was used. The meter was calibrated daily. For moderate discharges a collapsible cutthroat Baski flume was used. Flume throat size (1", 2", 4" or 8") was selected to keep the stage in the flume between 0.2 and 0.5 feet. For small discharges the flow was dammed and piped into a length of PVC to capture with a bucket using a stopwatch to measure filling time. Samples were packed in ice immediately to limit reactions and shipped to arrive at the lab on a daily basis.

Loading is calculated as the product of discharge with acidity, alkalinity or metal concentration and is expressed in lb/day for treatment considerations. In this report, metal loading is the sum of the individual loads of the three Group I metals, iron, manganese and aluminum.

[2] The Lake Hope/Sandy Run tributary, site MSLH 120, is the only site sampled during this study. All other data included for this section of the mainstem was collected during the 1996 Hughes et al study.

IDENTIFICATION OF THE HYDROLOGIC UNIT

Name:	Raccoon Creek Headwaters Watershed
Tributary To:	Ohio River Basin
Location:	Athens, Hocking, and Vinton Counties
Quadrangles:	South Bloomingville, Allensville, New Plymouth, Union Furnace, Nelsonville, Zaleski, Mineral, The Plains, Vales Mills, McArthur
Drainage:	200 square miles

AMD Effects On Water Quality And Biological Resources

Watershed Description

In the Raccoon Creek watershed acid mine drainage (AMD) from abandoned underground and surface coal mines has severely degraded water quality and reduced the diversity and abundance of fish and macroinvertebrate populations. The entire Raccoon Creek basin drains 683.5 square miles of the Western Allegheny Plateau Ecoregion in southeastern Ohio. The portion of the watershed of interest to this project includes East (20.24 square miles) and West Branch (22.59 square miles), Hewett Fork (40.5 square miles; Wilson 1985), Sandy Run, Brushy Fork (drainage area 34 square miles), to where the mainstem passes under the US Route 50 bridge (Map 1-back pocket). From the confluence of the East and West Branch near the town of New Plymouth, Raccoon Creek flows 108 miles, discharging into the Ohio River. The perennial reach of the Raccoon Creek mainstem from the confluence of the East and West Branch to the bridge at Route 50 is 31.3 miles long and the watershed is 200 square miles.

The average annual temperature in the headwaters area was 53°F for the period between 1931-1980. This area has an annual average precipitation of 40-41 inches per year (Harstine 1991).

The topography of the watershed is typical of the unglaciated Appalachian Plateau physiographic province and consists primarily of bedrock from Pennsylvanian and Mississippian ages (Fenneman 1938). The terrain consists of steep hillsides combined with narrow valleys and highly erodible soils. Rock outcrops and overhangs are common elements of the topography. The elevation ranges from 1,015 feet above sea level at the source of Brushy Fork to 518 feet above sea level at the mouth. The average fall of the river is 3.8 feet per mile (Gazetteer of Ohio Streams ODNR 1960).

Seventy to seventy-five percent of the entire Raccoon Creek watershed is forested. The remaining land is cropland (4 percent), pastureland (15 percent), urban land (4 percent), active or past mined land (10 percent), and other uses (1 percent) (USDA & SCS, 1994). More than half of the cropland is considered "highly erodible," according to the 1985 Farm Bill standards. The headwaters area has seen little agricultural activity because of the steep topography. The major sources of employment in this sparsely populated watershed are manufacturing and professional services. Professional services include health and educational services.

Bedrock Geology

The bedrock of the entire Raccoon Creek watershed includes (from youngest to oldest) the Conemaugh, Allegheny, and Pottsville Formations from the Pennsylvanian Age (Ahmad 1979). The stratigraphy of these formations consists of alternating shale, sandstone, clay, coal and limestone beds. The Allegheny formation is the predominant formation in the headwaters and contains thick and continuous coal beds representing a major source of extractable coal in Ohio.

The Pottsville Formation, the oldest of the four, is concentrated in the northwestern and western areas of the watershed. The Pottsville Formation is the basal formation of the Pennsylvanian System and contains shale and sandstone with a thin strata of limestone. Twelve coal beds have been identified in this formation, some of which are the highest quality heating coals in Ohio. These beds include the Sharon (No. 1) and Quakertown (No. 2). Other mineable beds are the Lower Mercer, Middle Mercer and Bedford beds (Wilson 1988).

The Allegheny Formation can be found in the central portion of the watershed and, like the Pottsville, consists of sandstone and shales. Minor amounts of marine limestone are present; the primary resource in this formation is thick and persistent coal. Thirteen coal beds have been identified, including the Brookville (No. 4), Clarion (No. 4a), Lower Kittanning (No. 5), Middle Kittanning (No. 6), Lower Freeport (No. 6a) and Upper Freeport (No. 7) (Wilson 1988).

The Conemaugh Formation is concentrated in the eastern and southern sections of the watershed. The Conemaugh contains limestone in mineable quantities and consists of 13 identified coal beds. Only a few of these beds are mineable, including the Mahoning, Wilgus, Anderson and Harlem (Wilson 1988).

The Monongahela Formation, the youngest of the four, occurs in the northeast portion of the watershed. It contains a coal bearing strata and has clay, shale, sandstone and limestone. The formation has more freshwater limestone and less sandstone than the other Pennsylvanian formations.

Mining History

Coal mining in Raccoon Creek watershed has taken place since the 1840s and continues today. Much of the mining was concentrated in the Headwaters or upper reaches of the watershed. Four kinds of mining techniques have been used in the watershed. S*trip mining* is used when the coal seam is near to the ground's surface. The soil and rock overburden is removed and the coal is taken out before the overburden is replaced. In *drift mining*, a tunnel is driven into the side of a hill at a coal outcrop. The coal is mined out by following the contour of the bed. Drift mines are commonly found along stream bottoms where erosion has exposed a coal seam. *Slope mining* uses tunnels on a low enough incline to permit mine cars to enter. More than half of all coal mined was taken from drift or slope mines (Ahmad, 1979). A vertical opening is driven into the coal in *shaft mining*. This technique proceeds along the coal seam, but excessive depth increases entry, exit and ventilation hazards.

Shaft and deep mines were originally used until the 1940s when strip mines became more common. From the 1940s to the present, strip mining has replaced underground mining as the dominant method. Surface and underground mining layers were digitized from U.S. Geological Survey 1:24,000, 7.5 minute quadrangles into a GIS and the area was calculated to show that approximately 25,610 acres of underground mines and 21,550 acres of surface mining have taken place in the Raccoon Creek Watershed. Within the headwaters, there are approximately 1,100 acres of abandoned surface mines and 110 acres of abandoned coal refuse piles (Palone 1995).

In addition to coal and limestone, clay, sand and iron ore are found in the basin, though the high-grade iron ore was essentially depleted in the early 1900s.

Hydrogeology And Acid Mine Drainage

The coal in southeastern Ohio is often located in the rock layers close to or directly underneath stream channels. Water captured by underground mine voids can be discharged directly into the stream or in a more diffuse fashion across the watershed. Abandoned surface mines leave highly erodible land exposed to the elements, in addition to mine refuse which is high in pyritic minerals. These abandoned mine lands contribute sediment, metals and acidity to the watershed drainage area. Acid mine drainage (AMD) is formed when pyritic material and other rocks are exposed to oxygen and water. The oxidization of pyritic minerals results in the formation of sulfuric acid. As this acid passes over different rock strata surrounding the pyritic materials, metals, including iron, aluminum, and manganese are dissolved resulting in AMD.

Acid mine drainage has one or more of four major components: high acidity (low pH), high metal concentrations, elevated sulfate levels, and excessive suspended solids and/or siltation. The permeability and porosity of the bedrock itself controls the amount of oxygen allowed to reach the pyrite, and thus, the amount of underground AMD generated. Oil and gas drilling, road salt and mining activity increase concentrations of dissolved solids, primarily sulfates, iron and manganese. The marine shales and sandstones of the Allegheny Formation contain more iron and manganese than the other formations, while sulfate concentrations are higher in the carbonate aquifers of the Monongahela Formation (Razem and Sedam, 1985). Water quality criteria limits that may suggest impact by acid mine drainage are shown below in Figure 2. (FWPCA 1968).

Figure 2
Water Quality Criteria Limits

Water Quality Parameter	**Criteria Limit**
PH	< 6
Alkalinity	< 20 mg/l
Iron	> 0.5 mg/l
Manganese	> 0.5 mg/l
Sulfate	> 74 mg/l
Aluminum	> 0.3 mg/l
Conductivity	> 800 mhos/cm
Zinc	> 5 mg/l

The mineral composition of the rock underlying the Raccoon Creek Watershed is the primary factor affecting the alkalinity, or acid-buffering ability of the surface water. Carbonates, primarily calcium carbonate found in limestone, act as a pH buffer. Carbonate content increases as the formations become younger, so the Monongahela Formation contains the most buffering ability (Razem and Sedam, 1985.)

Physical problems related to mining, specifically strip mining and gob piles, include erosion and sedimentation. According to the ODNR Division of Mineral Resources Management, the Raccoon Creek Headwaters has some of the worst mine-related erosion/siltation problems in the state (USDA 1985). These high erosion rates, in turn, lead to high sediment deposition in stream channels that can bury or cement substrates destroying aquatic habitat.

According to a 1985 study, the Headwaters of Raccoon Creek are moderately impacted (51% of total stream length) by chemical mine drainage (USDA 1985). This AMD directly and indirectly affects the physical, chemical, and biological integrity of streams. The numbers and diversity of aquatic macroinvertebrates and fish are often greatly reduced. Acid mine drainage also increases the corrosiveness of the water, limits domestic uses, and reduces the aesthetic quality of the water.

Historical Water Quality

Tributaries

Many studies of water quality have been conducted over the past 20 years in the Raccoon Creek watershed. Hughes et al. (1996) prepared a review of some of these studies. A study submitted to ODNR (Gwin et al. 1982) ranked the subwatersheds with respect to the severity of AMD impact. The rankings were as follows (starting with the most AMD impacted stream): Hewett Fork, East Branch, Little Raccoon Creek (not in the current study area), Brushy Creek, Two-Mile Run, and Rockcamp Creek.

Wilson (1985) provided historical water quality information for the period 1975-1983. This report also detailed USGS sampling conducted in 1983 throughout the watershed. Results from the study and historical data concluded that the primary sources of AMD affecting Raccoon Creek are: Hewett Fork, East Branch, Brushy Creek, and Little Raccoon Creek.

A follow-up study was conducted by USGS (Wilson 1988), which noted that AMD has degraded water quality in the headwaters. No improvements in water quality were evident in Hewett Fork, East Branch, Brushy Creek or Little Raccoon Creek. High levels of iron, aluminum and manganese, and low pH were found in both Brushy Creek and Hewett Fork.

The U.S. Forest Service produced a report (Palone 1995) that documents the resources of the Raccoon Creek watershed and problems threatening these resources. Some of the problems identified as threats to the watershed were: 1) erosion of abandoned mine land and unreclaimed coal refuse piles, 2) chemical and physical water quality impairment, 3) improper solid waste disposal, and 4) unstable stream banks.

Hughes et al. (1996) completed a Raccoon Creek Watershed Monitoring Project to expand the historical water quality database. Basin analysis indicated that Hewett Fork contributed high acid loadings to the mainstem of Raccoon Creek. Brushy Creek exhibited a moderate influence on the mainstem water quality with regards to acidity. Sandy Run was determined to be contributing very little acidity to the mainstem of Raccoon Creek. According to this study, Two-Mile Run appeared to have recovered from AMD-related problems that were documented by Gwin et al. (1982). While Hughes et al.(1996) noted site-specific improvements in water quality, they ranked Hewett Fork and East Branch as having the poorest water quality.

Most recently, the Ohio EPA (1997) found that the East Branch of Raccoon Creek is severely impacted with elevated levels of aluminum, manganese, sulfate and zinc, and low levels of alkalinity and pH. The West Branch of Raccoon Creek contains high levels of manganese and zinc and low dissolved oxygen levels. In Onion Creek chemical parameters were not high and the stream is not affected by mining. Brushy Fork, Sandy Run, and Hewett Fork were not examined in the 1997 Ohio EPA study.

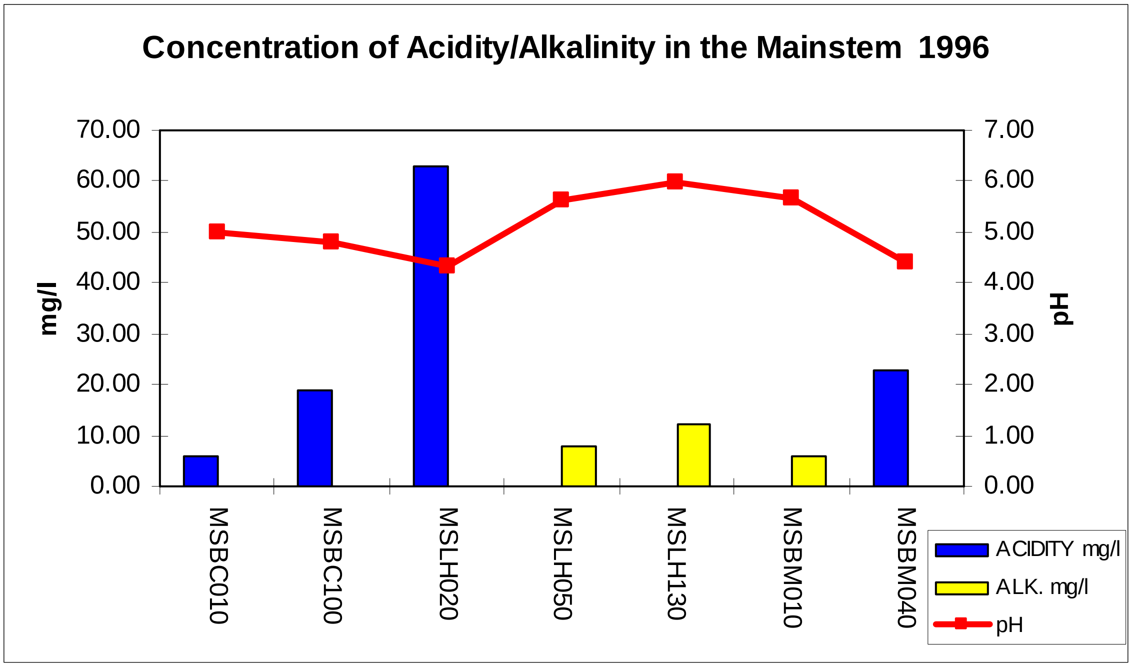
Mainstem

East Branch continues to be a major source of AMD loading although its severity may have declined compared to mid 1980's samples. Most of the sources of AMD are surface mine sources and it is possible that there is some attenuation in the source material (Map 2–Back Pocket). West Branch is a stream that can switch from alkaline to acid production depending on flow regimes (Map 3-Back Pocket). Recent data shows it as a consistent contributor of AMD. Raccoon Creek, from the confluence of the East and West Branches to the sample site below Brushy Creek (MSLH 020), is suffering from AMD degradation year round (Maps 4, 5, 6-Back Pocket). The mainstem sampling suggests that Brushy Creek is a bigger mainstem problem than originally considered as downstream samples show increases in acidity during low flow periods, while high flow periods have only abated the load slightly (Map 5-Back Pocket).

The other AMD sources of significance in the study area are Mitchell Hollow and two unnamed tributaries (MSBC 110 & MSBC 120) (Map 4-Back Pocket). All three of these tributaries drain the same surface mine complex, known as Pumpkin Ridge, where the Vinton County Airport is located. Hewett Fork remains a problem, but apparently only during the lower flow periods (Map 7 – Back Pocket). During the spring 2001 sampling, a high flow period, increases in alkalinity and pH at the downstream site of Hewett Fork were noted. Even though Hewett Fork does not rank as the most significant AMD contributor, its importance as a resource in the watershed and proximity to public lands keeps it on the priority list for restoration.

Overall, Raccoon Creek seems to have improved in ambient quality since 1996. At a very low flow of 16 cfs, samples taken at the bridge on US 50 (MSBM 040) maintained a net alkaline condition and a pH 6.1, but the net condition is unstable at slightly below 4 mg/l of alkalinity (Map 8-Back Pocket). At high flow, 150 cfs, the alkalinity is just above 5 mg/l. This is a very precarious state for the creek to be in and does not provide adequate chemical quality for a healthy aquatic assemblage. Figure 3 details the concentration of acidity versus alkalinity during the 1996 Headwaters study. These samples were taken in the month of June. During this time the laboratory did not provide data on both acid and alkalinity for each sample. Recent sampling data provides both concentrations when present in the sample.

Figure 3



Data from the Hughes et al. study correlates well with most of the current water quality results. The studies consistently point to East Branch, Brushy Fork and Hewett Fork as problems in the Headwaters study area. Site MSBC (mainstem above Brushy Creek) 010 is the first sample in Raccoon Creek downstream from the confluence of the East and West Branches. The creek receives a heavy load of AMD from East Branch resulting in moderate acid concentration and a pH below 6. At MSBC 100 the acid concentration has increased and the pH dropped below 5**.** This site is immediately downstream of Mitchell Hollow, which was not characterized in the 1996 study; however, recent samples show this tributary and two other tributaries as constant AMD contributors draining the same surface mine complex.

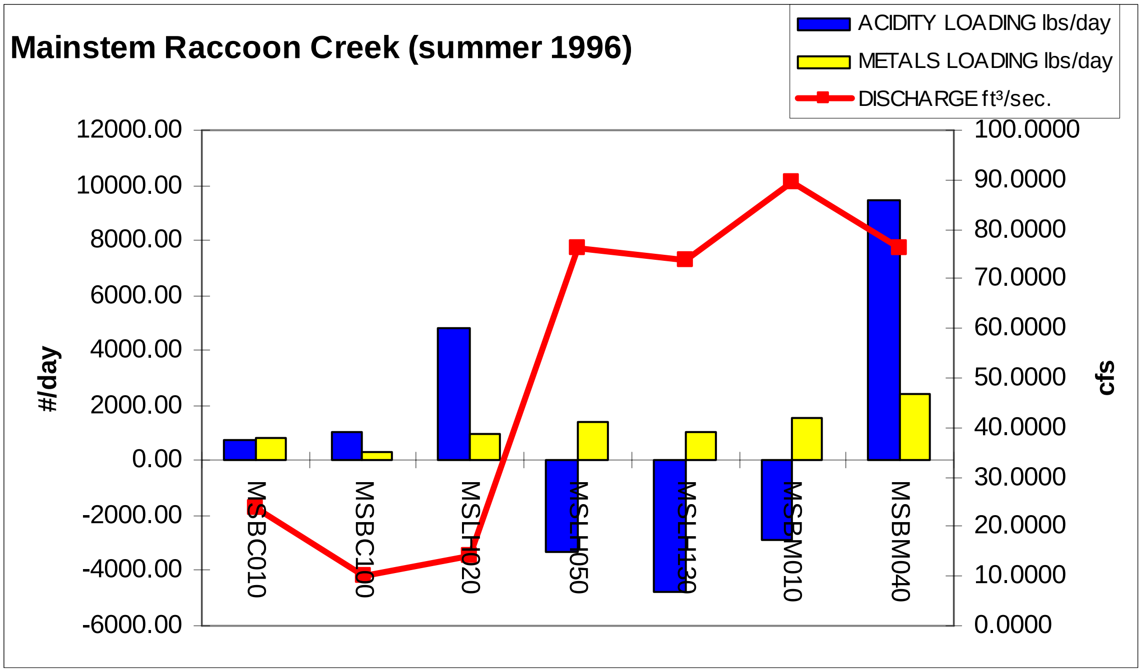
A decline in water quality and a decrease of both alkalinity and pH is evident at the next site MSBM (Mainstem above Bolin Mills) 010, which is directly downstream of the Hewett Fork discharge**.** Figure 3 shows that site MSBM 040 declined significantly returning to an acidic condition with a pH of 4.39. The data from both of these sites point to AMD contribution from

Hewett Fork. An important observation to note from these results is that the stream did show net alkalinity; however, the alkalinity concentrations were not high enough to produce warmwater habitat conditions for the aquatic organisms.

At site MSLH (Mainstem above Lake Hope) 020 the acid concentration increased significantly and the pH dropped below 4.5. This is the first mainstem sample downstream of the Brushy Creek confluence suggesting significant impact by this subwatershed. There is a small drainage discharging into the mainstem upstream of this site. Two sampling events in the fall 2000 and spring 2001 indicate that this unnamed tributary has a pH of approximately 6 and the waters are net alkaline resulting in no AMD contribution. The next two sites showed improvement in the stream with a net alkaline situation developing. Both alkalinity and pH were higher at sites MSLH 050, downstream of the Wheelabout Creek discharge and at MSLH 130, downstream of the Lake Hope/Sandy Run discharge. The highest alkalinity at site MSLH 130 was 12 mg/l and a pH of 5.97

The 1996 study shows two tributaries contributing significant acid loads but the buffering capacity of the stream is not enough to abate that load. As a result the mainstem was in poor condition when passing through the final sampling point at the US Route 50 bridge (MSBM 040) carrying an acid load of 9446 pounds on 7/2/96 with a pH of only 4.39 (Figure 4).

Figure 4



Current Water Quality

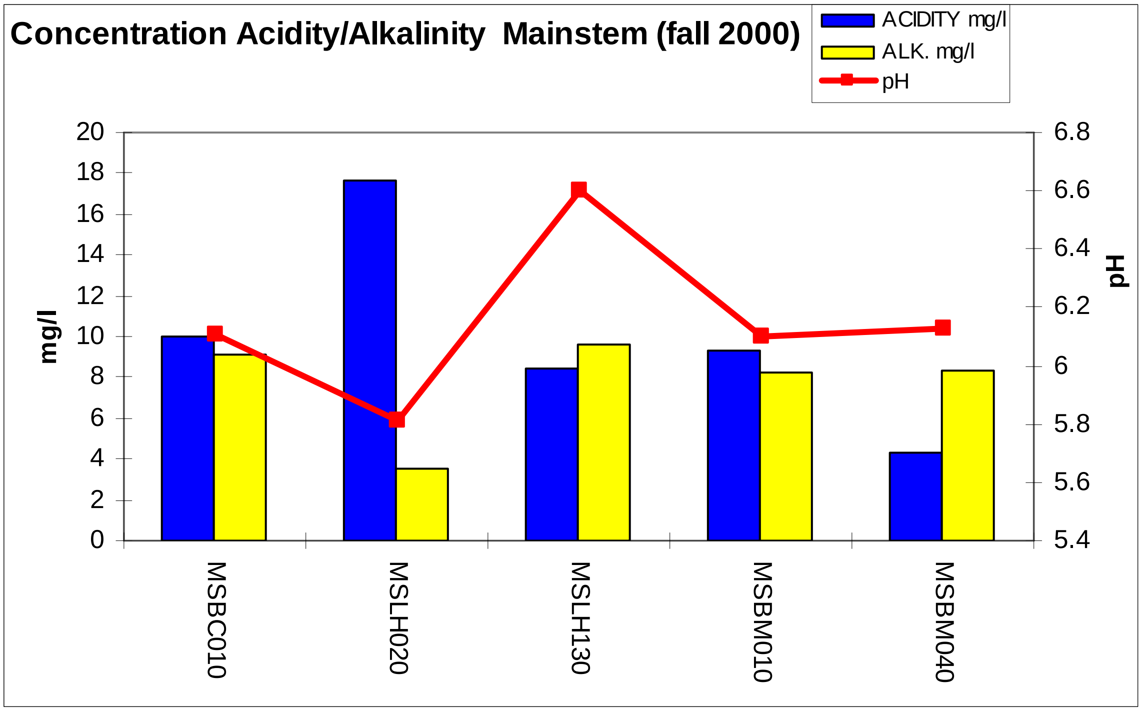
Mainstem

The following section describes current water quality in the mainstem looking specifically at acid versus alkaline concentrations in milligrams per liter and pH from the 2000 and 2001 sampling events. Concentrations are used in the discussion of mainstem quality rather than loadings because flow measurements were not calculated at sites MSLH 130 and MSBM 010 during the fall of 2000. The mainstem water quality discussion is followed by a discussion of the major subwatersheds and their AMD contribution to the mainstem. The subwatershed discussion will detail acid and metal loads in pounds per day for each major tributary.

The sampling event on the mainstem in the fall of 2000 took place during lower flow conditions than the 1996 study. Figure 5 reveals that the results of this sampling period are similar to those of 1996 with the exception of improvement at site MSBM 040[3]. The stream at MSBC 010 is slightly acidic (almost neutral) with a pH just above 6. Sample site MSLH 020, which is below Brushy Creek, shows significant degradation, as was the case in 1996.

[3] Sample MSLH 050 was not selected as a sample site for the AMDAT report because of its close proximity to MSLH 130. Sample MSBC 100 was missed by the field investigator during the sample event

Figure 5

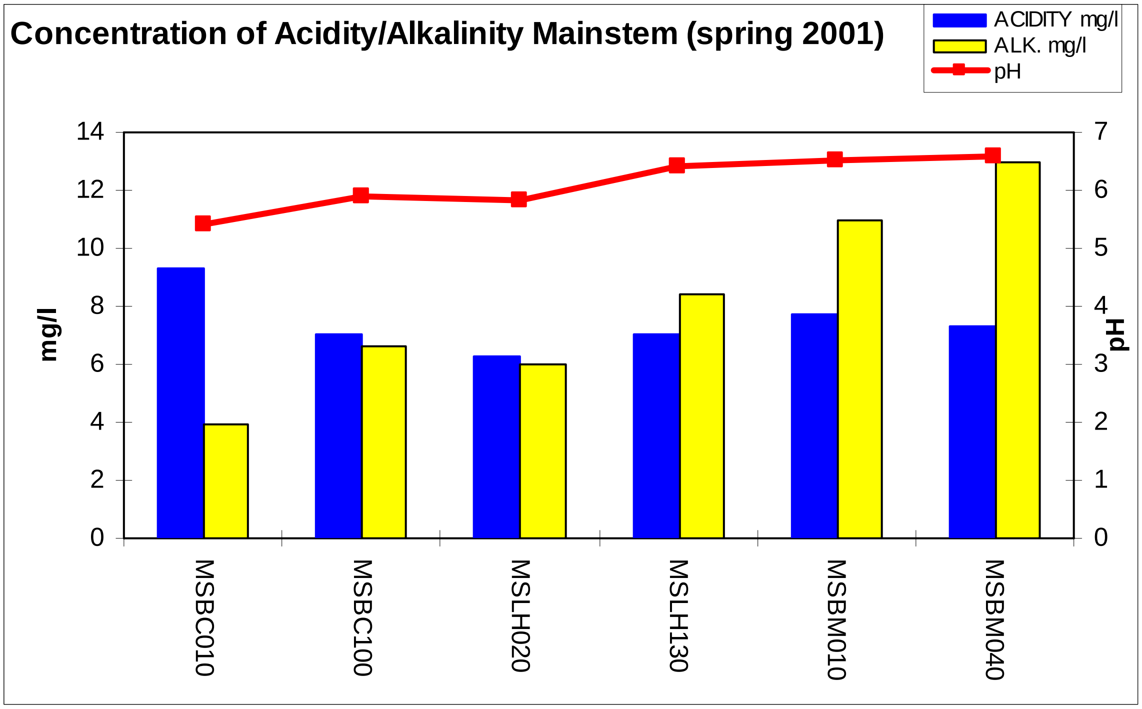


After the discharge of Lake Hope, site MSLH 130 reflects improvement in the water quality with the pH achieving 6.6, but the alkalinity is only slightly greater than the acidity. Similar to the situation in 1996, the result of Hewett Fork discharging into Raccoon Creek degrades the stream with net acidity, but the pH remained above 6 (MSBM010). Hewett Fork consistently presents a problem to Raccoon Creek at low flow.

A change from the 1996 acid/alkalinity trend takes place at the downstream section of the study area with improvement of the water chemistry. Site MSBM 040 shows an increase in the pH and a net alkalinity of 4mg/l (figure 5). Overall, when comparing the 1996 sampling to the fall 2000 data, the latter reflects higher pH and lower acidity concentration.

A final mainstem sampling event occurred in the spring of 2001 during a high flow period (Figure 6). The high flow seems to have lessened the effect of Brushy Creek on the mainstem, but it has not completely abated the acid load. The high flow did not significantly change the conditions at site MSBC 010 compared to the fall 2000 sample. The concentration of acidity remained similar at just under 10 mg/l, but the net condition was slightly higher (<1mg/l acidity fall 2000, 5.38 mg/l acidity spring 2001) and the pH dropped from 6.1 in the fall to 5.4 in the spring. During this sampling period the creek improved at MSLH 020, in contrast to the significant drop in water quality recorded in the fall 2000 sampling events.

Figure 6



A high flow trend of improvement begins at site MSLH 130 (Lake Hope discharge) and continues beyond Hewett Fork (MSBM010) to the bridge at US Route 50 (MSBM040). At the bridge downstream of Hewett (MSBM010) the stream has increased its total and net alkalinity and pH to 6.52. When the stream passes under the bridge at US 50 (MSBM 040) the net and total alkalinity continues to increase and the pH has leveled off at 6.5. This suggests that during high flow events the acid load from Hewett Fork to the mainstem is being abated. During the three mainstem sampling events a wide range of flows have been recorded ranging from 16 cfs to 150 cfs[4]. The recommendations for restoration are strengthened with the collection of a wide range of supporting flow data.

Tributary Water Quality

A review of the historical and current tributary water quality data reveals priorities for restoration (Appendix A). In 1996 sampling data suggested that the East Branch and Hewett Fork

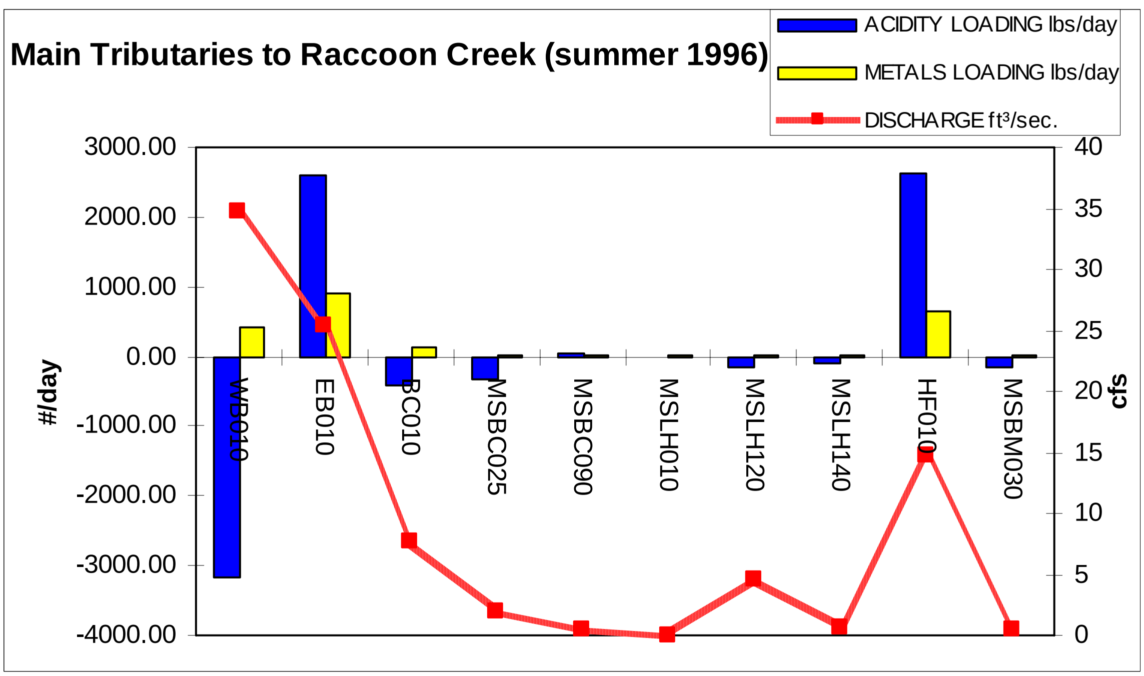
[4] These flow measures were taken at MSBM 040.

were the two main AMD contributors. In the spring 2000 East Branch, Brushy Creek, and the Lake Hope/Sandy Run discharge (MSLH 120) were significant AMD contributors in this order. West Branch contributed, while subsequent sampling in June showed the MSBC tributaries of 090, 110, and 120 also contributing. In the fall 2000 sampling East Branch was not a significant contributor, whereas high acid loads were discharging from West Branch, Brushy Creek and MSBC 120. Hewett Fork remains a contributor, but not a very significant one.

1996 Tributary Sampling

East Branch and Hewett Fork were the main AMD contributors during the 1996 study. Hewett Fork (HF 010) was discharging 2,629 pounds per day of acid, while East Branch (EB 010) was discharging 2,595 pounds per day. Figure 7 below details samples taken between 6/21/96 through 7/17/96[5].

Figure 7



Historic data taken prior to the 1996 study pointed to Two-Mile Run as an AMD contributor (Gwin et al, 1982.). In 1996 Two Mile Run sample site MSBC 025 showed an alkaline load of 317 pounds/day. Recent data also suggests it has recovered chemically and

[5] Negative acid load values reflect a net alkaline load

produces net alkaline water to the mainstem. Other notable discharges were Brushy Creek (BC 010) producing 418 pounds of alkalinity per day and Lake Hope/ Sandy Run (MSLH 120) producing 146 pounds of alkalinity per day. The only other AMD producer in the mainstem during the 1996 study was Mitchell Hollow (MSBC 090), producing 39 pounds per day. While this load is relatively low it is still a concern because of its location. Mitchell Hollow, discharges into the mainstem at River Mile 104.83 (Figure 8–back pocket). This is a section of stream where acidity concentration and loading increases regardless of the flow regime

Spring 2000 Tributary Sampling

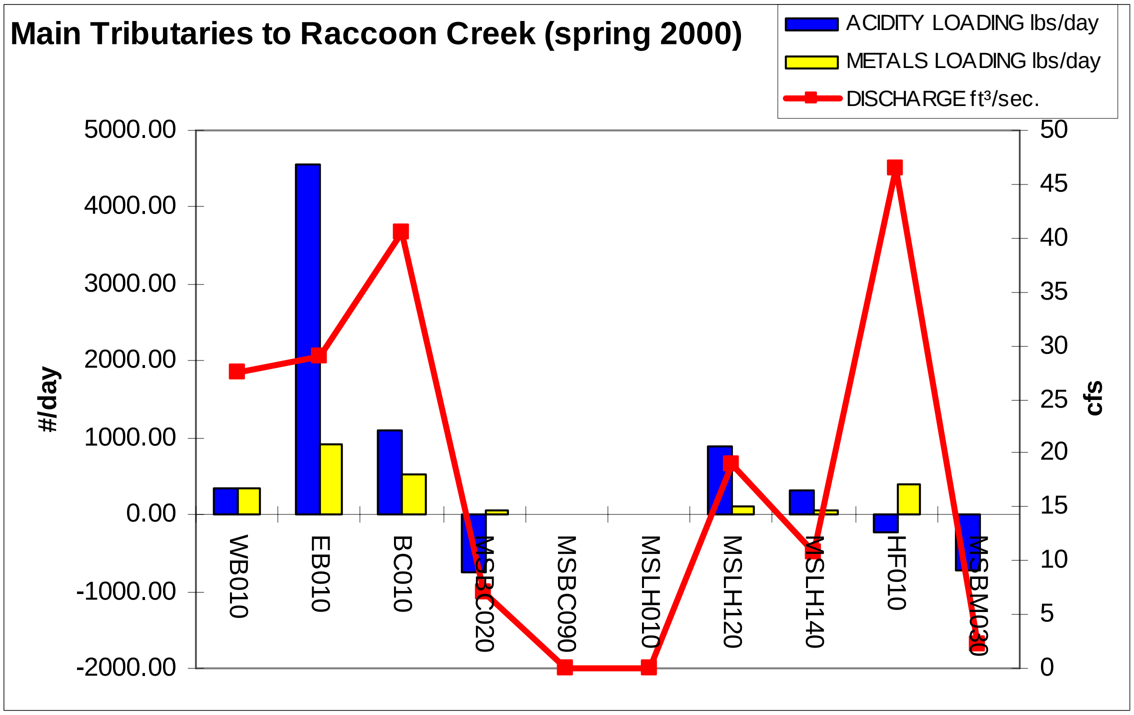
The spring 2000 sampling was taken over a three-day period in March of 2000[6]. All sample sites are located in close proximity to the mouth of the tributaries. Only a few sites maintained the characteristics of the 1996 sample event. In part this is because of a higher flow regime in the spring of 2000. It is also important to note that a large number of the AMD problems found in the study area are the result of either unreclaimed strip mines, or mines reclaimed under the guidance of Ohio's first conventional reclamation law passed in 1972. This law was enforced until the passing of the Surface Mine Reclamation Control Act in 1977. For example, in West Branch and Brushy Creek subwatersheds the prevalence of abandoned surface mines, which were reclaimed under 1972 era law, are responding to higher flow with increased acid loading to the stream. Whereas Hewett Fork subwatershed contains deep and auger mines, which respond differently to high and low flow regimes.

Figure 9 shows East Branch (EB 010) carrying a high acid load of 4,560 pounds per day. It is almost 2,000 pounds higher than the 1996 sample (2,594 pounds per day) at a flow that is 3.6 cubic feet per second (cfs) higher. Two-Mile Run (MSBC 020) maintained a net alkaline discharge producing 760 pounds of alkalinity a day. For this event the sample site at Two-Mile Run was moved downstream of the 1996 sampling location to sample the stream much closer to the mouth (Map 4-Back Pocket)[7]. Onion Creek (MSBM 030) also maintained the same characteristics of the 1996 study producing 722 pounds of alkalinity. Although the Onion Creek data was taken a month after most sites, it is included to document the relatively healthy conditions in the Creek and its contribution as a constant buffering source, over a range of flows, to the mainstem.

[6] All samples were taken on 3/26/00 or 3/28/00, except MSBM 030 (4/30/00) and MSBC 090, 110 120 and MSLH 010 (6/28/00).

[7] Note the difference in site numbers MSBC 025 in the 1996 graph and MSBC 020 in the 2000 sample event

Figure 9



The rest of the sites sampled in March showed different characteristics than the 1996 samples. West Branch (WB010) produced an acid load of 337 pounds per day while producing a large alkaline load in 1996. Brushy Creek (BC010) produced an acid load of 1,103 pounds per day in the spring versus an alkaline load of 418 pounds per day in the summer of 1996. The flow at Brushy Creek in the spring 2000 was 40 cfs versus 7.8 in 1996. The increase in flow is resulting in increased acid load to the stream.

The Lake Hope Discharge (MSLH120) produced an acid load of 887 pounds per day during this sampling event, a significant change from 1996 when the alkaline load was 146 pounds per day. Hewett Fork reversed loadings in a positive direction, producing 224 pounds of alkalinity per day after exhibiting highly acidic conditions in 1996 when it discharged 2,600 pounds of acid per day. This, again, strengthens our assumption that at higher flows Hewett Fork is providing some buffering capacity allowing the stream to improve in ambient quality as it reaches the end of the study area[8].

[8] The discharge at Hewett Fork was approximately 31 cfs greater than during the study in 1996.

Wheelabout Creek (MSLH 140) reversed its loading characteristics with an acid load of 320 pounds per day versus an alkaline load of 88 pounds in 1996. During the 1996 event the flow was less than one cfs, while this sample was taken at nearly 10 times that amount. Wheelabout Creek has some old surface mined areas that have been successfully reclaimed to trees (some naturally), but little recontouring and replacement of topsoil occurred. Exposed toxic material is still present in the tributary. Often during the drier periods of the year these areas are not draining water and lose their capacity to contribute acid to the stream. As a result, during low flow situations there is a net alkaline discharge to Raccoon Creek.

When considering the concentration of acidity to alkalinity in Wheelabout Creek, the spring 2000 sample was only net acidic by 5mg/l at a relatively high flow. At the low flow stage in 1996 it was net alkaline by 23 mg/l (no acidity showing). Wheelabout Creek is not a major contributor of AMD because the data has consistently shown the mainstem improving where this stream discharges (Figure 8). The assumption is that Wheelabout Creek only discharges net acid loads at high flow, in which case the mainstem flow is also high and able to accept the discharge and abate its flow through dilution.

Three sites were sampled outside of the spring fieldwork in the month of June. The flows during this period were very low in comparison to the spring event, but remain important in the overall discussion to AMD contribution to Raccoon Creek. The unnamed tributaries designated MSBC 110, MSBC 120, and Mitchell Hollow (MSBC090) carried net acid loads of 22, 159, and 4.5 pounds per day. These sites produce some of the highest acidity concentrations of all the mainstem tributaries. All three receive the surface water from the southeast drainage of the same surface mine complex where the Vinton County Airport is located. They, like Brushy Fork, were reclaimed under Ohio's Reclamation Law of 1972, leaving highly toxic overburden vulnerable to surface flow.

It is our assumption that because of the extent and nature of the mining in Mitchell Hollow and the other two tributaries, the acid concentrations and loadings will rise as flow increases. These areas need to be considered when prioritizing important sites for reclamation. The sample of site MSLH 010 (unnamed tributary) is included just to assure that it has maintained a net alkaline load to the mainstem of Raccoon Creek.

Fall 2000 Tributary Sampling

The fall of 2000 tributary sampling was narrowed down to those tributaries that have proven to degrade the mainstem of Raccoon Creek [9]. These include the East and West Branches, Brushy Creek, MSBC 090, MSBC 110, MSBC 120 and Hewett Fork (Figure 10). The East Branch sample (EB 010) resulted in a very surprising alkaline load of 213 pounds per day. This situation had never occurred during past sampling events, however, all other samples have been taken at flows of at least 25 cfs and this sample was taken during a flow of 3.7 cfs[10].

The mainstem loading graph for the fall 2000 (Figure 11) shows the result of a sample (MSBC 010) taken just downstream of the East and West Branch confluence. The sample shows a very minor acid load of 35 pounds per day, an almost neutral condition. This result could be expected after sufficient mixing of the West Branch 248 pounds of acid and the East Branch 213 pounds of alkalinity on that day(Figure 10). Brushy Creek (BC 013) continued discharging an acid load (203 pounds per day) as well as Mitchell Hollow (MSBC 090) at 75 pounds per day, MSBC 110 at 45 pounds per day and MSBC 120 at 171 pounds per day. Mitchell Hollow and its associated 110 and 120 tributaries continued to show increased acid concentration and load during increased flows. Figure 11 reflects the downstream accumulation of all these sites at MSLH 020 with an acid load of 981 pounds per day.

[9] Fall 2000 event occurred between 11/15/00 and 11/25/00 except MSBC 090, 110, 120 (10/25/00), and HF 010 taken on 8/21/00

[10] This sample point remains a part of the data, but its validity is questionable.

Figure 10

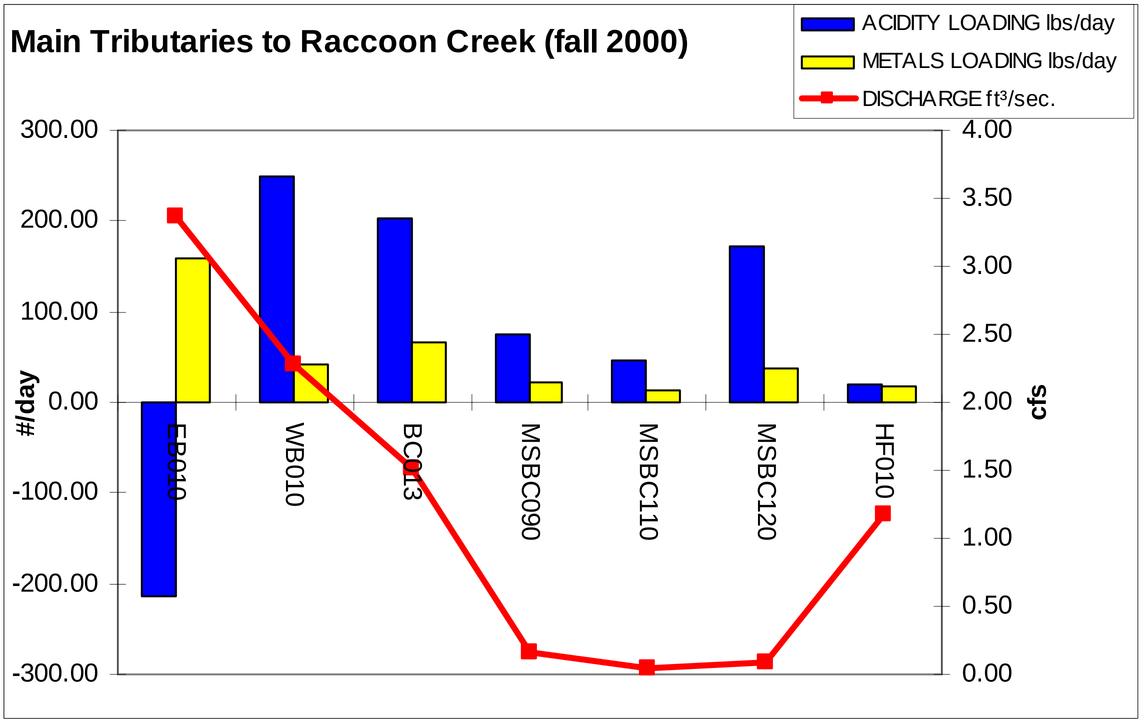
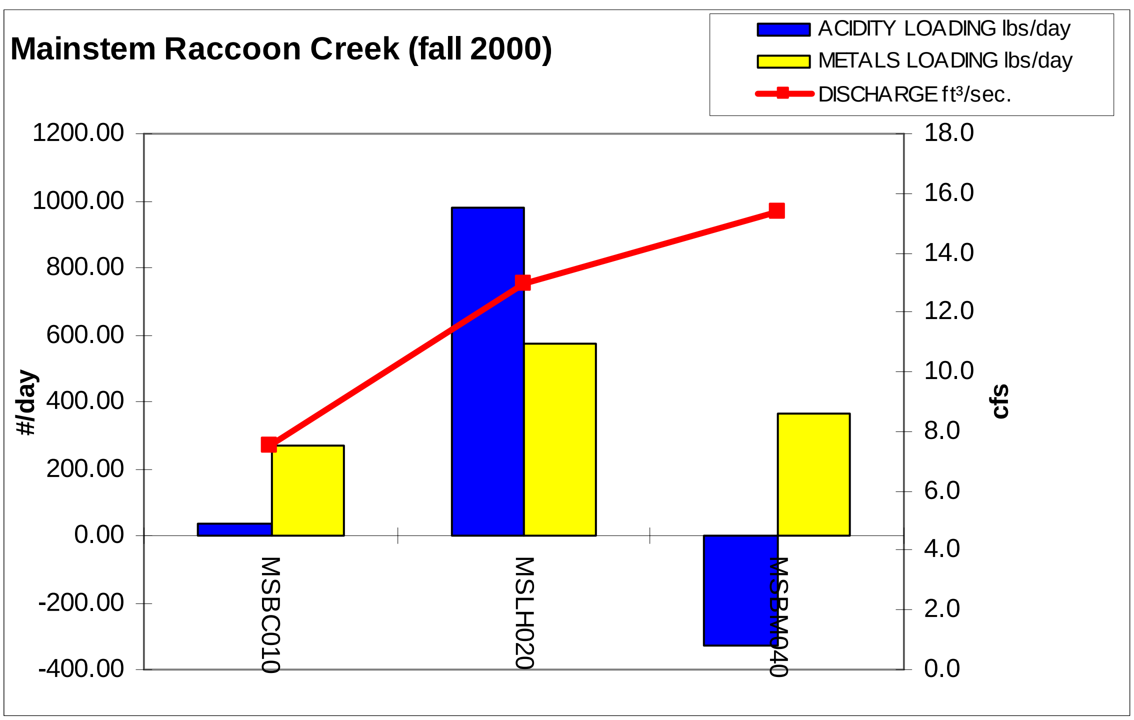


Figure 11



Hewett Fork was sampled outside of the time frame of the other mainstem tributary samples (Figure 10). The August sample was taken during a flow of 1.18 cfs and resulted in a load of only 19.6 pounds per day. The mainstem sample during the fall sampling event at the study endpoint (MSBM 040) shows a net alkaline load of 326 pounds per day in November.

Biological Health

Biological data is used to examine the impact that acid mine drainage has on the aquatic community of the Raccoon Creek Headwaters. Macroinvertebrates are the group most frequently used in the biological monitoring of water quality. Their relative advantages as indicators of a stream's health over other groups of aquatic organisms are well documented (Rosendberg and Resh 1993). Macroinvertebrate and fish assessments of polluted streams provide comprehensive data on the health of a watershed and offer water quality information not readily detected by chemical means. Using stream biological assessments, in conjunction with chemical and physical parameters, to examine water quality before and after AMD remediation, reclamation, or treatments, can be of great value. It is the biology of the stream that ultimately reveals its true health both before and after AMD recovery efforts.

Acid mine drainage has both direct and indirect impacts on the chemical, physical, biological, and ecological integrity of the stream environment (Figure 12). Specific responses of macroinvertebrates in acid mine drainage streams include a decrease in tolerant organisms and reduction in ecosystem productivity.

Figure 12

The major effects of acid mine drainage on lotic systems (modified from Gray 1997).

Chemical	**Physical**	**Biological**	**Ecological**
Increased acidity	Substrate modification	Behavioral	Habitat modification
Reduction in pH	Turbidity	Respiratory	Niche loss
Destruction of buffering system	Sedimentation	Reproduction	Bioaccumulation within food chain
	Absorption of metals into sediment	Acute and chronic toxicity	Loss of food source
Increase in metal concentrations	Decrease in light penetration	Acid-base balance failure in organisms	Elimination of sensitive species
		Migration or avoidance	Reduction in primary productivity
			Food chain modifications

Ohio Water Quality Standards: Designated Aquatic Life Uses on Raccoon Creek Headwaters

The following use designation recommendations were based on a combination of biological, chemical, and physical attributes that were examined during a 1995 study conducted by the Ohio EPA (OEPA 1997).

- Exceptional Warmwater Habitat (EWH) is the most biologically productive environment. These waters support "unusual and exceptional" assemblages of aquatic organisms, which are characterized by a high diversity of species, particularly those that are highly intolerant and/or rare, threatened, endangered, or special status. This use represents a protection goal for water resource management efforts dealing with Ohio's best water resources. None of the waters of the Raccoon Creek Headwaters currently have this designation.
- Warmwater Habitat (WWH) defines the "typical" warm water assemblage of aquatic organisms for Ohio streams. It is the principal restoration target for the majority of water resource management efforts in Ohio. Within the Headwaters study area, the mainstem section from below Sandy Run (RM 92.52) to the limit of the Headwaters retains the WWH aquatic life use. Raccoon Creek Headwater streams with the WWH use designation include West Branch, Two-Mile Run, Grass Run, Pine Run, Rockcamp Creek, Coal Run, Laurel Run, Onion Creek, Tedroe Run, Merrit Run, Russell Run, Flat Run, and one unnamed tributary at RM 98.96. Other Raccoon Creek Headwater areas could achieve this designation, if restored.
- Modified Warmwater Habitat (MWH) applies to streams with extensive and irretrievable physical habitat modifications, for which the biological criteria for warm water habitat are not attainable. The activities contributing to the modified warm water habitat designation have been sanctioned and permitted by state or federal law. The representative aquatic assemblages are generally composed of species that are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor habitat quality. The category applies to dammed or channelized rivers, and also can be applied to streams affected by AMD, although the designation was not used in the Raccoon Creek Headwaters.
- Limited Resource Water – Acid Mine Drainage (LRW-AMD) applies to streams and rivers which have been subjected to severe acid mine drainage pollution from abandoned mine lands or gob piles, and where there is no near term prospect for reclamation. The representative aquatic assemblages are generally composed of species which are tolerant to low pH, silt, metals, and overall pool habitat quality. OEPA stated that the

performance of the biological community and prevalence of AMD chemical parameters in Raccoon Creek Headwaters extending from the confluence of the East and West Branches (RM 111.96) to Sandy Run (RM 92.52), warrants the LRW-AMD use designation. Mining impacts have caused severe degradation in the East Branch of Raccoon Creek, which was also given the LRW-AMD use designation. Based on the use designations, the criteria for Ohio EPA assessments are outlined in Figure 13.

Figure 13
Ecoregion Biocriteria: Western Allegheny Plateau (WAP) (OEPA 1997).[11]

	EWH	WWH	MWH	LRW-AMD
QHEI	75	60	45	?
ICI	46	36	30	8
IBI- wading & headwater	50	44	24	18

Mainstem Biological Health

Mainstem Macroinvertebrate Assessment

An evaluation of biological health, specifically macroinvertebrate communities is important to further assess the impact of acid mine drainage on the stream.[12] Figure 14 provides a summary of aquatic life and use attainment status for the mainstem section of the study area. Detailed sections on the biological health of the Raccoon Creek mainstem and headwaters tributaries follow this section.

[11] QHEI-Qualitative Habitat Evaluation Index; ICI-Invertebrate Community Index; and IBI – Index of Biotic Integrity (fish).

[12] Macroinvertebrate data are not available for all mainstem sites in the study area. The description that follows details OEPA mainstem sites analyzed in the 1995 Basin Study and three sites sampled in the fall 2000 and spring 2001 by Ohio University MSES graduate student Jennifer Last.

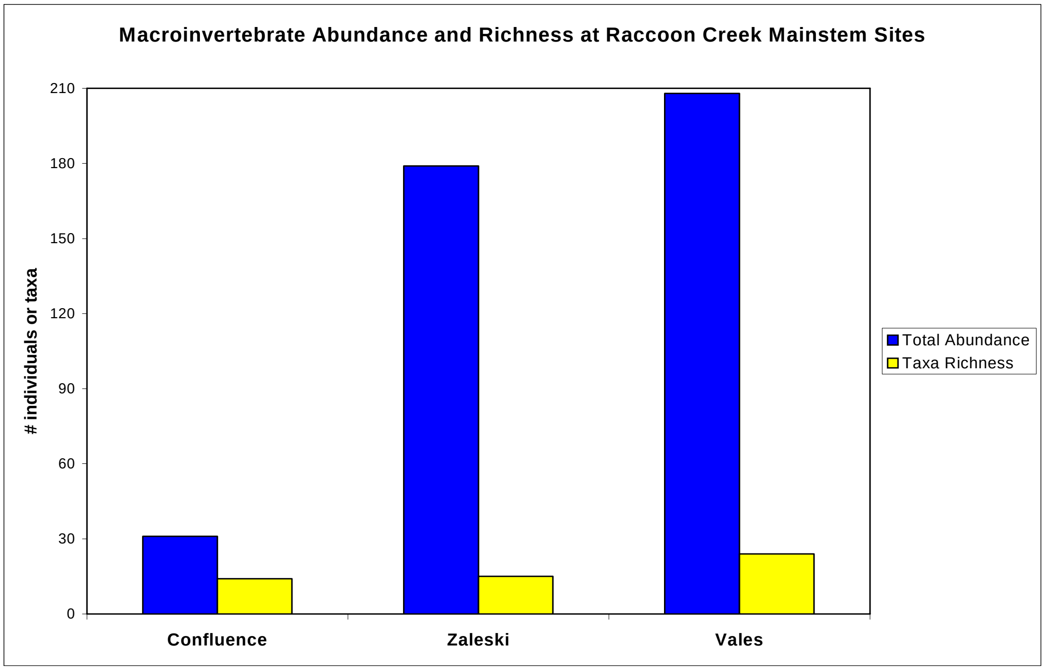
Figure 14
Summary of Aquatic Life Use Attainment status for sections of the Raccoon Creek Mainstem sampled in 1995 (OEPA 1997)[13]

Figure	Reach River Miles (RM)	Use Designation	Attainment Status	Location	Biological Community Performance
Headwaters					
East Branch	Entire length	LRW AMD	Partial	Athens and Hocking County	Poor
West Branch	Entire Length	WWH (recommended)	Non-attainment	Hocking and Vinton County	Poor
Mainstem					
Raccoon Creek	112 (confluence) to 109	LRW – AMD	Partial	Downstream of East and West Branch confluence	Poor
	109 to 98	LRW – AMD	Full	Upstream of Lake Hope (sandy Run)	Poor
	98 to 84	WWH	Partial	Lake Hope to Upstream of Onion Creek	RM 98.3-92.3: poor 92.3-84.1 fair
	84 to 63	WWH	Full	Onion Creek to Upstream of Pierce Run	RM 84.1-~80: fair ~80-72.2: good
	63 to 40	WWH	Partial	Pierce Run to the Village of Vinton	63.8-~60: good ~60-40: fair

The confluence of East and West Branches (MSBC010), sampled fall 2000, contained low abundance, low diversity and an abundance of tolerant species (Figure 15). The community structure is similar to that seen at AMD impacted sites, despite almost neutral acidity. The fall 2000 sample roughly correlates with OEPA findings of 1995, which found macroinvertebrate communities to be characterized by low numbers of taxa. As noted in the mainstem water quality section, the pH showed seasonal fluctuation. This seasonal fluctuation in AMD input from East and West Branches is most likely the limiting factor for biology at this site.

[13] WWH : Warmwater habitat; EWH: Exceptional warmwater habitat; MWH: Modified warmwater habitat; LRW-AMD: Limited resource water – acid mine drainage. The biological community performance is an overall rating of fish and macroinvertebrates developed by Ohio EPA.

Figure 15



MSLH020 was evaluated downstream at RM 101.2 in 1995 by Ohio EPA (Figure 16). While the site received a rating of fair for macroinvertebrates, the site showed a slight improvement from the previous site in both number of taxa and ICI. This does not correlate with water quality findings, which show the severity of the degradation to be high in 1996 and in 2000, even though water quality improvements were noted. An explanation for this is that the 1995 sampling site was further downstream from Brushy Fork; therefore, the AMD impact was diluted, in turn stabilizing the biology.

Figure 16

Mainstem Sites -Macroinvertebrate and Fish Assessments for 1995 and 2000[14]

Mainstem Site **(RM Fish/Macro)**	**Fall 2000 (J. Last)**			**Summer 1995 (OEPA)**			
	Abund	Richness	***EPT***	Richness	***EPT***	***ICI***	***Evaluation Fish/macro***
MSBC010 (RM 109.1/108.9)	31	14	1	25	1	14	V.Poor-Poor/Fair
MSLH020 (RM 99.7/101.2)	NA	NA	NA	36	4	18	Poor/Fair
RM 98.3 (near Zaleski)	179	15	3	36	5	18	Poor/Fair
MSLH130 (RM 92.3)	NA	NA	NA	41	10	36	Fair/Good
MSBM010	NA	NA	NA	NA	NA	NA	NA
MSBM040 (RM 84.1/84.3)	NA	NA	NA	47	12	38	Fair-Mgood/Good
Vales Mill (----/72.20)	208	24	36	NA	NA	NA	----/Fair - Mgood

River mile 98.3, upstream of Lake Hope, was sampled in 1995 and 2000, but water chemistry was not evaluated at this site. Macroinvertebrates made a slight improvement from the previous sites, however chironomid midges dominated the sample at 73 percent. The family Chironomidae contains many pollution tolerant species. The dominance of this family in the sample further indicates poor water quality. OEPA noted that in general, sites upstream from Lake Hope (MSBC010 and MSLH020 in this report) showed macroinvertebrate communities characterized by low abundance, low number of taxa, and the absence of mayflies. The Fall 2000 samples agree with their assessment.

MSLH130 was also evaluated in 1995 and findings indicate an overall improvement from the upstream sites. The number of mayfly taxa and other indicators of good water quality increased at this site. These findings reflect the general improvements noted in water quality at this site from all sampling periods (1996, 2000, 2001).

MSBM040 was not evaluated at the exact location in 1995, but between river mile 84.3 and 72.3 the ICI was good to exceptional. This correlates well with the improvements seen in the water chemistry for all sampling periods.

[14] Due to dissimilarities in collection and identification methods between the two years, comparison should be done with caution.

The last macroinvertebrate mainstem site was Vales Mills. From SR 32 take County Rd 32C and make a right on Twp Rd 30, the sampling point was located at the bridge at this inersection. It is a good distance south of the designated Headwaters area.

The Vales Mill sample was higher in diversity and abundance than the other sampled mainstem sites (Figure 16). There were several Mayfly and Trichoptera species along with one Plecopteran species. Unlike the other mainstem sites, the community composition did not reflect impact by AMD. The relatively high number of Chironomidae in the sample was most likely due to the site location, which had a very fine substrate. This increased siltation might be typical of the mainstem in the area or it may be a product of erosion due to the presence of the bridge and road. During sample sorting it was noted that the Chironomidae were highly diverse, rather than only one or two genera as is commonly seen in AMD waters. The presence of bivalves in the sample also suggests that AMD is not a problem at this site (bivalves typically need a pH greater than 5.5). This site could be classified as fair to moderately good.

Tributary Biological Health

The following section contains macroinvertebrate and fish community evaluations prepared by OEPA as part of the ongoing TMDL process for the Upper Raccoon Creek Basin. The data was collected between 1996-2000[15]. Following OEPA's analysis is a discussion of macroinvertebrate health in Headwater tributaries conducted by Ohio University graduate student Jennifer Last.

OEPA Macroinvertebrate Analysis

Carbondale Creek, Pierce Run, and Hewitt Fork RM♣s 8.1 and 13.1, had very poor macroinvertebrate communities (Figure 17). Total macroinvertebrate taxa collected from the natural substrates yielded only 5 to 11 taxa, with only one EPT taxa collected at two of these sites. The natural substrates had very low densities of all organisms, the most numerous taxa at all four sites was the AMD tolerant megalopteran genus, *Sialus*.

[15] Some analysis outside of the headwaters study area is include with the OEPA evaluation because the Upper Raccoon Creek Basin TMDL includes the middle basin as well as the headwaters study area discussed in this report.

Figure 17

Summary of ICI and IBI values for Raccoon Creek Headwaters Tributaries Sampled by OEPA 1995 and 1999-2000

Site	Year	River Mile Fish/invertebrate	ICI	IBI	Evaluation (ICI)
Honey Fork	1999-2000	0.5/1.5	F	30	Fair
East Branch	1995	6.6/6.6	8	12	Poor
	1995	2.1/0.1	10	12	Poor
West Branch	1995	5.7/5.7	F	22	Fair
	1995	0.2/0.1	38	27	Good
Two-Mile Run	1995	0.1/0.1	G	28	
Brushy Fork	1999-2000				
Dunkle Creek	1999-2000				
Siverly Creek	1999-2000	--/0.3	G	--	Good
Wheelabout Crk	1999-2000	0.6	G	28	Good
Hewitt Fork	1999-2000	13.4/13.1	VP	22	Very Poor
	1999-2000	8.1	VP	12	Very Poor
Carbondale Crk	1999-2000	0.5/0.3	VP	12	Very Poor
Pine Run	1995	--/0.1	P	--	Poor
Grass Run	1995	0.1/0.1	G	30	Good
Coal Run	1995	0.1/0.1	F	30	Fair
Rockcamp Cr	1995	1.5/1.6	F	44	Fair
Onion Creek	1995	1.4/1.4	VG	30	Very good

Wolf Run, Honey Fork, and Brushy Fork RM's 6.7 and 2.9 were evaluated as poor to fair. A total of 18 to 24 total macroinvertebrate taxa were collected from the natural substrates with only one to four EPT taxa collected per site. Mayflies and caddisflies were neither predominant nor common at the poor evaluated sites, Wolf Run and Brushy Fork RM 2.9. Caddisflies and/or mayflies were more numerous at the other two sites evaluated as fair macroinvertebrate communities.

Dunkle Run, Wheelabout Creek, Siverly Creek, and the Tributary to Carbondale Creek had marginally good to good macroinvertebrate communities with 4 to 10 EPT taxa, and both mayflies and caddisflies predominant or common on the natural substrates. Although the Tributary to Carbondale Creek was a small watershed (0.2 square miles), 10 of the 18 taxa collected were mayflies (3), stoneflies (2), and caddisflies (5).

OEPA Fish Community Assessment

Ohio EPA evaluated fish communities in numerous small streams within the Raccoon Creek watershed from 1996 through 2000 (Figure 17). Streams were selected based on the probability of a fish assemblage existing and whether there was any previous fish data available.

At each site a measurement of functional fish habitat and riparian quality, Qualitative Habitat Evaluation Index(QHEI) was obtained. A long line electro-shocking procedure was employed and approximately 120-180 meters of stream was sampled for fish.   Other than voucher specimens, all fish were released back to the stream unharmed.

Brushy Fork, a tributary to upper Raccoon Creek, was sampled at two locations. The site near the mouth, at RM 0.4, was sampled in August 2000 and had a drainage area of 33.4 square miles. Only one individual, a longear sunfish, was collected. A large beaver dam just upstream of SR 328 limited the length of the fish shocking zone to 120 meters. This site was severely impacted by acid mine drainage and the stream substrate was highly embedded with the light flocculate caused by precipitation of heavy metals seeping from abandoned mines. Sinuosity, riparian corridor, slope, pool/riffle development and in-stream habitat were also of poor quality. The presence of even one fish was surprising to the biologists. An IBI of 12, the lowest possible score attainable, and a QHEI of 47 both indicate a stream incapable of meeting warm water habitat (WWH) and one not likely to in the near future. The existing use designation of EWH and SRW is in error. The SRW designation should be retained but the EWH needs to be changed to WWH non-attainment as soon as possible.

Brushy Fork at RM 6.9, upstream of SR 93, was sampled in June of 2000 and based on appearances, seemed to be in much better biological health. The stream substrate was unsilted and composed of sand, gravel, a little cobble and much bedrock. Very little iron staining was visible on the banks and rocks in the stream. Alder and mature trees composed the moderately wide to very wide riparian corridor and provided a great deal of shade to the stream. Similar to the previous site, sandstone was the predominate substrate origin. Although the stream at this site had very little flow, some discharge was obvious and riffles were functional. Although diverse in-stream habitat existed, only creek chubs were collected in this segment. With a drainage area of 8.1 square miles, it would seem unlikely for this stream to become intermittent but that would be the most likely explanation for the loss of many other fish species. Creek chubs are very tolerant to drought conditions as long as there are some small pools where they can subsist until wet weather returns. An IBI of 20 and a QHEI of 63.5 were obtained. Due to the lack of possible fish recruitment from other tributaries or the lower mainstem, this segment is isolated and will not be able to support a diverse fish community even in wet years. The existing use designation of EWH is very much in error and needs to be changed to WWH-Non-attainment. As with the previous site, the State Resource Water designation should be retained.

Wheelabout Creek was sampled at RM 0.60 adjacent to SR 278.   This site had a drainage area of 11.9 square miles. The IBI was 28 and the QHEI was 67.0. Although water quality was good, there was excessive loose sand in the stream at this site which offered poor habitat. Least brook lampreys, creek chubs, white suckers and grass pike were the dominant fish found at this site. Twelve longear sunfish were also collected and represented the only moderately pollution sensitive species collected. This stream is presently designated as EWH and SRW. The SWR should be retained, but a classification change to WWH–Non/Partial attainment is recommended. Justification for the original EWH use designation is unknown and in error.

Dunkle Creek was sampled in 1996 at RM 0.9 and received an IBI score of 34 and 15 species of fish were collected. Creek chubs, bluntnose minnows and johnny darters comprised 78% of the specimens. The QHEI was 64 and contained mostly WWH attributes which should indicate the segment would meet WWH, based on in-stream habitat, however the water quality was moderately poor although there is very little evidence of past coal mining in this small basin. This stream is presently undesignated and is recommended to have its attainment status changed to WWH-partial attainment

Siverly Creek was sampled in 1997 at RM 0.9 and 16 species of mostly pollution tolerant fish were collected. Creek chubs, fantail darters and bluntnose minnows dominated the assemblage. One longear sunfish was also collected and was the only moderately pollution sensitive species found here. The IBI was 40 and the QHEI was 67. Although presently undesignated, this site is attaining WWH status by allowing 4 IBI points (as non-significant departure) to the IBI of 40, thereby bringing it up to 44, the minimum score needed for a small headwater stream in the Western Allegheny Plateau. Any future degradation from habitat modification or AMD/nutrient/siltation increases would easily class this stream as non-attainment. Future water quality monitoring is strongly recommended here. A classification of WWH is recommended.

Honey Fork of West Branch of Raccoon Creek was shocked a t RM 0.5 in 2000 and an IBI of 30 and a QHEI of 76 was obtained. There was very little evidence of past mining at this site, but only ten fish species were collected, dominated by creek chubs. Hog suckers and longear sunfish, both pollution sensitive species, were found here, but only three of each. Although the habitat score was very good, the stream substrate was very sandy and offered little diversity of habitat, which may explain the limited number of specimens and species collected here. The riparian corridor was heavily forested and offered excellent canopy cover and stable banks with deep pools and swift riffles. If the bed load of sand could be reduced over time by reclamation in the upper watershed, this stream would probably easily attain the designation WWH. Presently the use attainment status should be WWH-non-attainment.

Hewett Fork was sampled at two locations in 2000. The upstream site at RM 13.4 was above the artificial wetland near Carbondale close to an old abandoned coal weigh station. Although having the appearance of being heavily affected by AMD, this segment contained seven seven fish species, all tolerant to pollution. Creek chubs, white suckers and bluegills made up 79 % of the specimens collected. The IBI was 22 and the QHEI was 77. There was some AMD flocc observed here which caused excessive embeddedness, and the poor water quality limited, to some extent, the amount of in-stream cover that was functional. The riparian corridor was composed of mature hardwood forest and greatly helped in providing metric points to the excellent QHEI score. Due to the significant level of restoration work planned for this watershed, the current status of LRW-AMD should be changed to WWH-non-attainment.

Hewett Fork was also sampled in 2000 at RM 8.3, opposite the Waterloo Wildlife Station offices. This site was biologically dead from the impacts of acid mine drainage from various tributaries upstream. The IBI was 12, no fish were found, and the QHEI was 70.5. The excellent QHEI reflects the intact riparian corridor of mature hardwood forest , the natural sinuosity, abundant in-stream cover and a low embeddedness due to the fact that the metals in this highly acidic segment are still in a dissolved form and have not precipitated out as flocculate to the stream bottom. This segment of Hewett Fork is very degraded but with extensive reclamation in several other dead tributaries (i.e. Carbondale Creek, Trace Run), all of Hewett Fork could meet WWH criteria. It is recommended, as with the previous site, that the attainment status be changed here to WWH-non-attainment.

Carbondale Creek was sampled in 2000 at RM 0.5 upstream of the community of Carbondale. This stream was also biologically dead, with no fish found, an IBI of 12 and a QHEI of 51.5 measured. The acid mine drainage at this site had extensively armored the substrate, eliminating any functionality to the cobble or gravel to act as habitat for fish or aquatic macroinvertebrates. There was little sinuosity here also, mostly due to the natural course of the stream along the bottom of a hillside. Riparian quality was completely forested on one side and much less wide on the other, but it is the very poor water quality that limits this stream from meeting its potential as a warmwater stream. It is recommended that Carbondale Creek remain classified as LRW-AMD.

Excellent Creek, a small 119-acre tributary to Carbondale Creek, enters it at RM 0.68. It was named this for convenience by OEPA staff, due to its pristine esthetic and water quality. The fish sampling, done at RM 0.1, failed to document this condition because the drainage was too small to support any fish species except creek chubs, thereby producing an IBI with a very low score of 14. The aquatic macroinvertebrate and salamander populations are very abundant and diverse. A headwater habitat evaluation (HHEI) would undoubtedly score very high and place this stream in the most protective classification, Class III. A HHEI needs to be conducted at this site to accurately document the aquatic communities found here. This stream has largely escaped the ravages of past coal mining activities and gives us a look at what most of these small headwater streams once were like, thereby acting as a wonderful control stream after which to model reclamation of other streams. No designation or attainment status is possible at this time.

Tributary Macroinvertebrate Analysis – by Jennifer Last

Macroinvertebrate Sampling Methods

Macroinvertebrates were sampled three times in 2000 (March, June, and September) at seven Raccoon Creek Headwater stream sites. These sites are as follows: Honey Fork, East Branch, West Branch, Hewett Fork, Sandy Run, Brushy Fork, and Onion Creek. These sites were chosen because OEPA (1997) did not fully assess macroinvertebrates at these sites in 1995. At each site macroinvertebrates were sampled via three methods, both quantitative and qualitative based upon Ohio EPA sampling procedures (OEPA 1989). A Surber sampler was used in riffles, modified Hester-Dendy samplers were placed in runs, and a d-ring net was used to sample pools, runs, and other habitat. Replicate samples taken with each method were combined to form one composite sample per season. Because of the low number of macroinvertebrates found in AMD streams, this sampling regime was designed to maximize the amount and diversity of habitat sampled. The US EPA strongly supports this multihabitat sampling where time and resources permit (USEPA 1988).

All samples were sieved through a US #30 sieve and preserved in 70% ethanol in the field and taken to the lab to be sorted in a pan of water. All visible organisms were picked out of the sample, identified to order, and placed in 70% ethanol. Once samples were sorted, organisms were identified to genus according to Merritt and Cummins (1996) and Peckarsky et al. (1990). Some organisms in early instars were not identifiable to genus, and were extrapolated when possible.

Macroinvertebrate Sampling Results

In spring (March), summer (June) and fall (October) of 2000, aquatic macroinvertebrates were sampled at seven tributary sites in the Raccoon Creek Headwaters (Figure 18). Coordinating spring and summer water quality samples were also taken at the seven sites (Figure 19). Collectively, summer yielded the highest amount of macroinvertebrates – two to three times

Figure 18

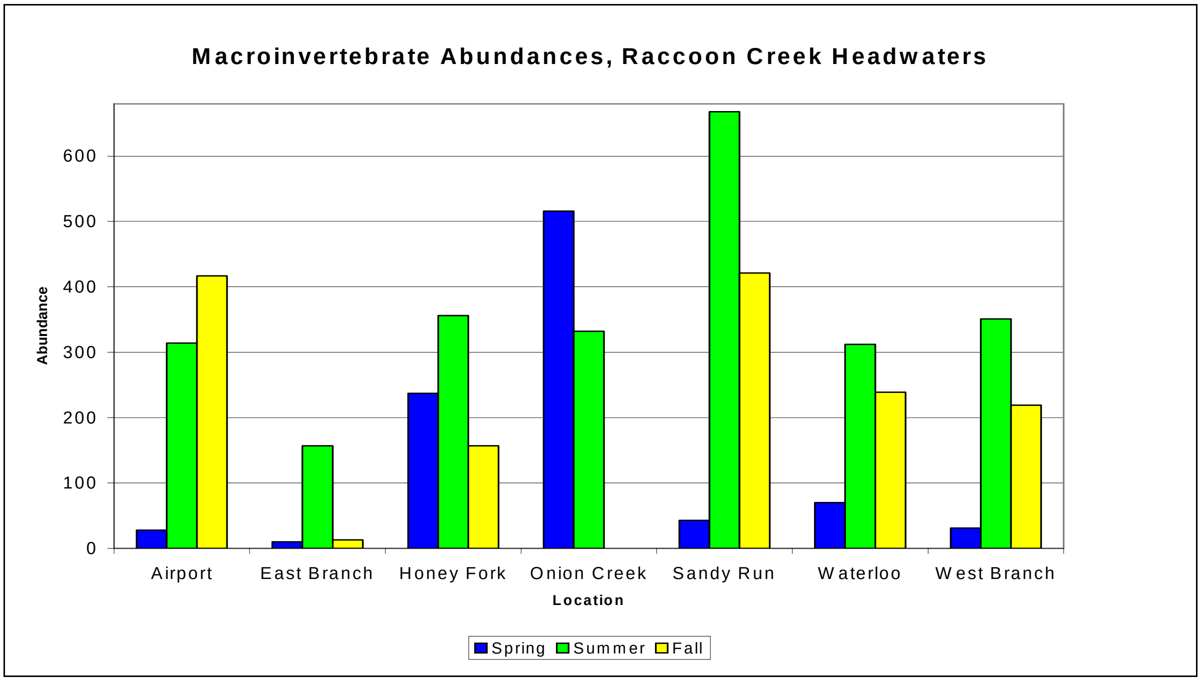
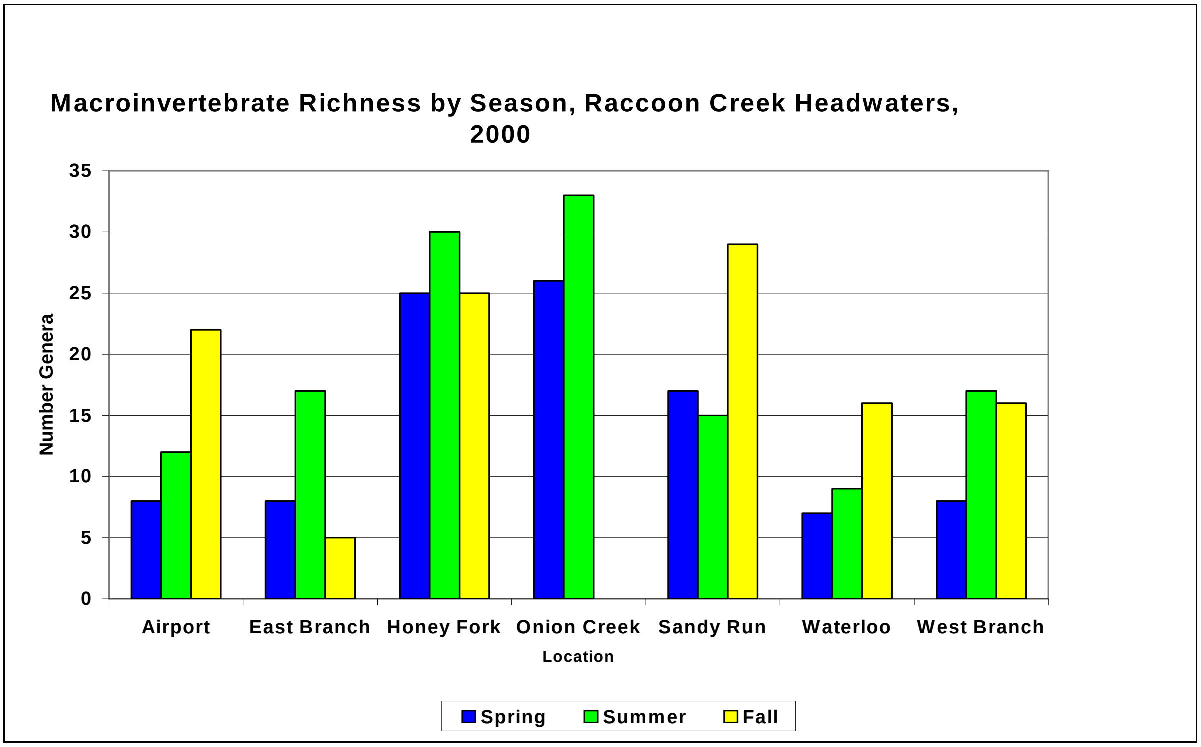


Figure 19



as many were collected during the summer as were collected in the spring and fall. Abundances at most sites showed significant increases between spring and summer sampling, and decreases for the fall sample. Onion Creek was dry during the fall sampling period and no sample was collected. For all sites except Onion Creek and Honey Fork, abundances increased between 5 and 15-fold (Figure 18) from spring to summer. The "Airport" site was the only site where abundances increased in the fall.

Richness, a diversity measure calculated using genus level identification, increased slightly for four of the sites between the spring and summer sampling (Figure 19). For two sites, East and West Branch, richness values doubled from spring to summer, but decreased (East Branch) or stayed the same (West Branch) for fall. For Sandy Run, richness values decreased in summer, whereas abundances increased by 15-fold. The fall sample for Sandy Run yielded almost a two-fold increase in richness. The richness and abundance trend for Honey Fork was similar to that of Sandy Run (i.e. lower abundances in fall with high richness). Trends in abundance and richness are not necessarily correlated linearly. An increase of a few tolerant species can cause significant increases in total abundance while diversity declines.

The macroinvertebrate data revealed trends that correspond directly with water quality. Macroinvertebrate richness and mean pH values at all sites showed a positive (80%) correlation (Figures 20, 21). Sites with low pH values, high conductivity and high metals – Waterloo, Airport (Brushy Fork), and East Branch - generally had low abundances and richness values. In addition, these sites had higher numbers of Dipterans and lower numbers of Ephemeroptera, Plecoptera, and Trichoptera.(EPT) (Figure 22). Organisms in EPT taxa are often associated with streams of good water quality. Dipterans and other groups such as megalopterans are more tolerant to AMD and often dominate in polluted waters.

Figure 20

Water Quality for Raccoon Creek Headwaters Macroinvertebrate Sites

	Date	Acidity, mg/L	Alkalinity, mg/L	pH	Total Al, mg/L	Total Fe	Total Mn	Total Zn	Sulfate, mg/L	Conductivity, uS/cm	TDS
Airport	4/26/00	24	1.3	5.24	2.32	2.24	2.88	0.081	105	315	191
Airport	7/11/00	106	0	3.41	11	5.12	12.1	0.224	427	996	662
Airport	10/23/00	117	0	2.73	8.79	4.83	12		422	998	657
East Branch	4/26/00	38	0.59	4.93	4.11	0.373	4.44	0.121	322	724	514
East Branch	7/11/00	19.5	2.49	5.36	2.31	0.355	5.47	0.126	414	826	674
East Branch	10/23/00	61.1	0	3.94	3.94	0.236	7.92		522	998	842
Honey Fork	4/26/00	0	24.1	6.55	0.402	0.185	0.744	<0.05	48.6	234	127
Honey Fork	7/11/00	6.24	38.6	6.54	1.69	0.558	0.18	<0.05	61.7	272	170
Honey Fork	10/23/00	9.82	54.7	6.18	0.107	0.155	0.09		60.1	298	188
Onion Creek	4/26/00	0	56.7	7.11	0.439	0.215	0.852	<0.05	33.8	250	133
Onion Creek	7/11/00	8.3	54.1	6.57	0.532	0.334	0.291	<0.05	30.5	208	130
Onion Creek	10/23/00	13.4	59.6	6.03	0.106	0.516	1.45		58.4	263	164
Sandy Run	4/26/00	13.3	1.65	5.6	0.743	0.279	1.03	<0.05	51	211	122
Sandy Run	7/11/00	10.5	5.12	5.72	0.874	0.419	0.688	0.064	147	435	296
Sandy Run	10/23/00	12.1	7.69	5.22	0.109	0.681	1.67		151	459	305
Waterloo	4/26/00	27.1	0.28	4.98	1.96	3.83	1.82	0.154	146	410	249
Waterloo	7/11/00	43.5	0	3.62	2.89	1.48	1.41	0.064	260	661	404
Waterloo	10/23/00	67.3	0	2.81	6.95	2.84	3.12		391	922	616
West Branch	4/26/00	7.74	8.15	6.43	0.665	0.427	2.2	0.051	101	318	179
West Branch	7/11/00	8.45	19	6.3	1.82	0.782	2.33	<0.05	120	355	237
West Branch	10/23/00	15.1	30.4	5.7	0.144	0.49	2.99		148	464	304

Figure 21

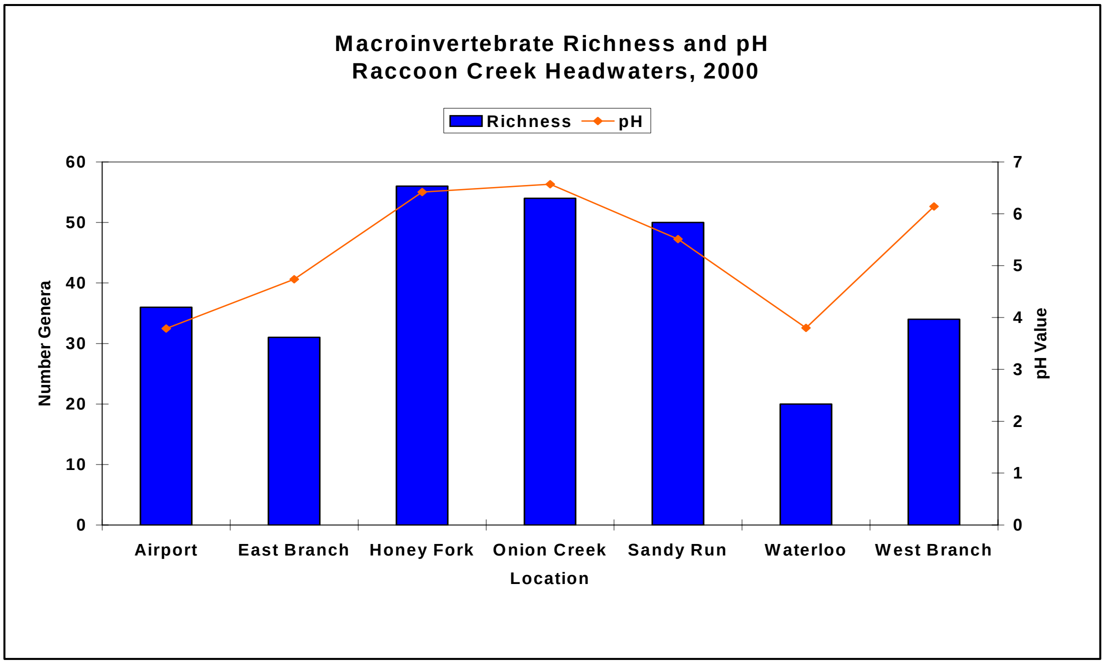
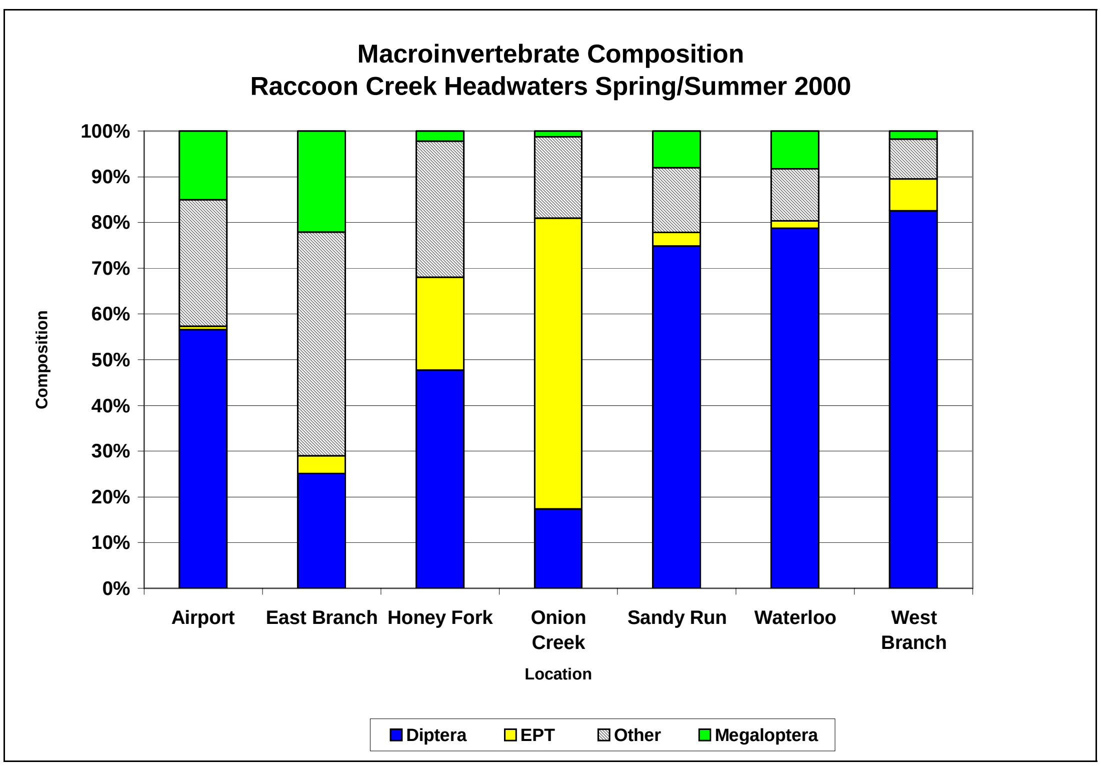
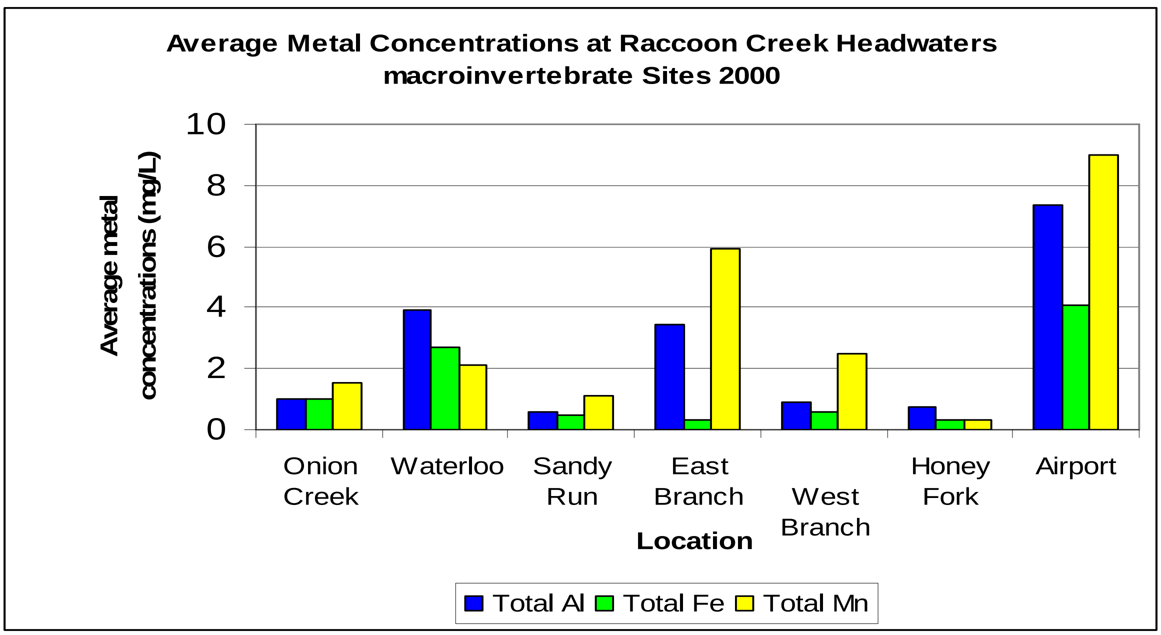


Figure 22



As pH values decreased at AMD impacted sites, richness also decreased (Figure 21). While the chemistry data for East Branch shows AMD impact, the macroinvertebrate population differs from the other AMD-impacted sites in richness and abundance. East Branch exhibited higher richness values, but lower abundances than either Waterloo or Airport. This dissimilarity may be due to the fact that differing metal concentrations and forms can have different effects on the macroinvertebrate community. Water quality data shows that aluminum and manganese had the highest concentrations at the East Branch site (Figure 23), while iron values were similar to those found at Onion Creek (relatively low). The Airport site showed the highest overall metal concentrations, but neither richness nor abundance was very different from Waterloo. The overall macroinvertebrate composition at Airport was also similar to Waterloo. The similarity in macroinvertebrate composition, pH and metals concentration at Airport and Waterloo sites suggests similar levels and types of AMD impact.

Figure 23



Both Onion Creek and Honey Fork represent streams that generally have higher numbers of EPT taxa and lower numbers of dipterans (Figure 22). Honey Fork had a large number of dipterans in the summer, which directly affected the overall composition. Water quality parameters indicate that both Honey Fork and Onion Creek represent sites that are unimpacted by AMD. However, the relatively high number of dipterans and field observations at Honey Fork indicate sedimentation and/or nutrient input may be a problem, especially in the summer months when water levels are lower. For purposes of comparison to other headwaters macroinvertebrate sites, Onion Creek was designated as the "control" site.

Sites that appear moderately impacted by AMD include both Sandy Run and West Branch. Sandy Run has a lower mean pH than West Branch. Metal concentrations are relatively low for Sandy Run, but West Branch has elevated manganese. The macroinvertebrate composition of Sandy Run and West Branch appears similar to that of Waterloo. Although EPT taxa made up about 10% of the sample in West Branch, dipterans made up 80% or more of the sample, as they did in Waterloo and Sandy Run. Sandy Run and West Branch both show slight to moderate impact by AMD. Because of the community composition differences at high AMD impacted sites, the possibility of other water quality impacts at these sites is high.

The overall trends seen at Raccoon Creek headwaters sites impacted by AMD include high numbers of tolerant taxa such as *Sialis* and *Nigronia* spp. (Megaloptera), and chironomid midges (Diptera) (Figure 24). Other dominant taxa vary by site, but include certain hemipterans and coleopterans. Tolerant caddisflies (Trichoptera) are often present in small numbers and include the following genera: *Ptilostomis* sp. (Phryganeidae), *Polycentropus* sp. (Polycentropodidae), and some Limnephilidae. Other species which may occur in variable numbers include the dragonfly (Odonata) *Aeshna* (Aeshnidae), and other dipterans such as mosquito (Culicidae) or crane fly (Tipulidae) larvae.

Figure 24
Summary of AMD Impact at Headwaters Sites, Based on Macroinvertebrate Sampling, Water Chemistry and Visual Observation

Site	Dominant Organisms	Visible AMD Impact	Overall AMD impact
Airport	*Sialis*, Chironomidae, Hemiptera	Orange flocculate covered substrate	High
East Branch	*Sialis*, *Nigronia*, Hemiptera, Chironomidae	White-gray flocculate covered substrate	High
Honey Fork	Chironomidae, mayflies, snails	None, organic input noted	None, organic enrichment
Onion Creek	Mayflies, stoneflies, snails	None, Control site	None, Control site
Sandy Run	Chironomidae, *Sialis*, Odonata	Some orange flocculate at edges	Low to moderate
Waterloo	Chironomidae, *Nigronia*	Orange flocculate covered substrate	High
West Branch	*Sialis*, Trichoptera, Black Fly, Chironomidae	Very little, some flocculate at edges	Low to Moderate, other impacts as well

Future Recommendations:

Macroinvertebrate sampling should be continued at all of the headwater sites completed for this study. Sampling recommendations are to sample in June or July using both the dip net and Hester-Dendy artificial samplers following the outlined methods. Particular attention should be focused on the most highly impacted sites: Brushy Fork, Waterloo, and East Branch. Other sites to monitor include those identified as priority sites in this document. Biological sampling should be done at these sites to obtain a baseline for monitoring future recovery. Monitoring should continue at these sites following remediation to understand the recolonization and recovery process of macroinvertebrates.

Tributaries

In this section high priority tributaries are discussed individually.

East Branch

Name: East Branch of Raccoon
Location: Discharges into Raccoon Creek at River Mile 111.9
Quadrangle: Union Furnace, New Plymouth
Drainage Area: 20.24 Sq. Miles, 12955.36 Acres

Overview:

East Branch ranks first on the priority list for AMD abatement and restoration. The following tributaries in East Branch are the main acid producers that need to be considered in the abatement of AMD (Map 2 – back pocket). EB 190 and EB160 are two of the larger acid producers. Tributaries EB 200, EB 220, EB 240, and EB 260 are located in close proximity to one another in the same drainage and they all produce water with very high concentrations of acidity. This small drainage area consists of barren striped mine lands, lands reclaimed under the 1972 law and auger mined areas. All of these sites have the capacity to produce high acid loads with increased flows. EB 120 and EB 140 have consistently been the seventh and eighth highest acid load contributors in the tributary. At this time the recommendation is to not address these tributaries. It is felt that abatement of EB 190, EB 160 and all the sources identified in the EB 210 tributary will adequately achieve the goal of returning East Branch to net alkaline and abate its affect on the mainstem of Raccoon Creek.

Summary of Specific Sites:

- EB 190 and all associated tributaries – EB 191 through EB 195,
- EB 160, specifically sites EB 162, EB 169.4 (White House Seeps), and EB 169 (alkaline addition)
- EB 210, specifically sites EB 200, EB 220, EB 240, and EB 260.

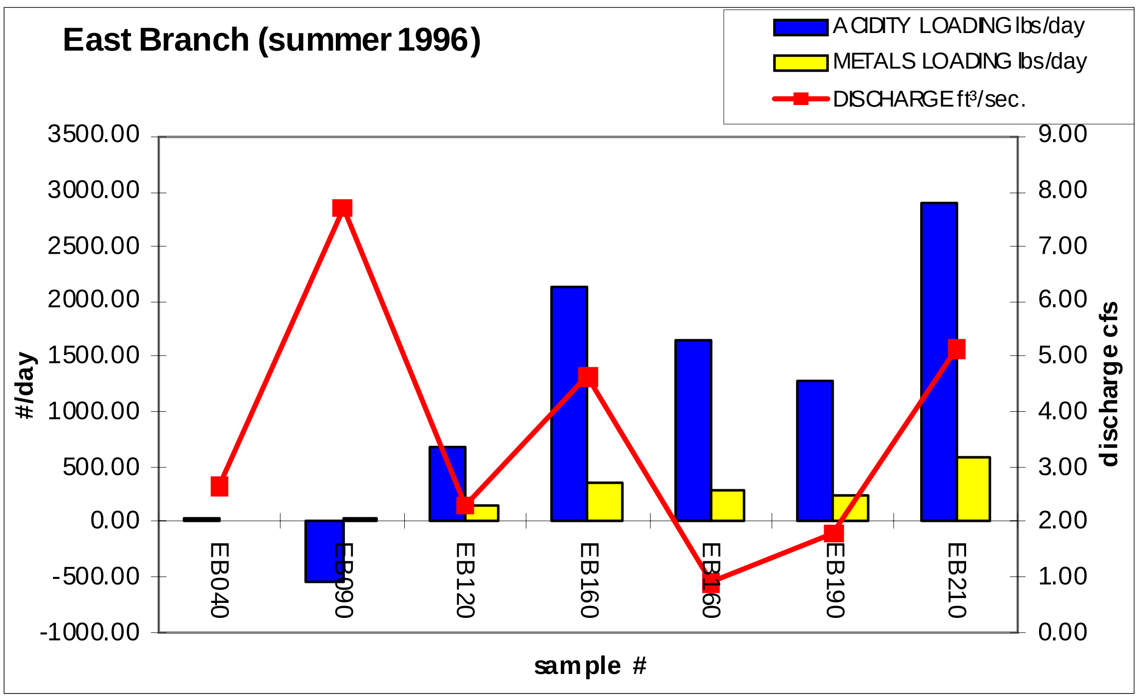
Location/Access to Priority Sites**:** EB 190 can be accessed near the corner of Meada and Sanner Roads in Starr Township, Hocking County. Meada Road continues up through the EB 190 sub watershed where its tributaries can be accessed. The entire EB 160 tributary can be accessed via SR 56 by traveling west on 56 from the intersection of SR 56 and SR278. EB 160 discharges into

East Branch proper at the intersection of Sanner Road. and SR 56 in Hocking County. EB 210 and its tributaries (EB 200 – EB 280) are accessible by traveling along Sanner Road.

Water Quality: See Appendix B, Table 1.

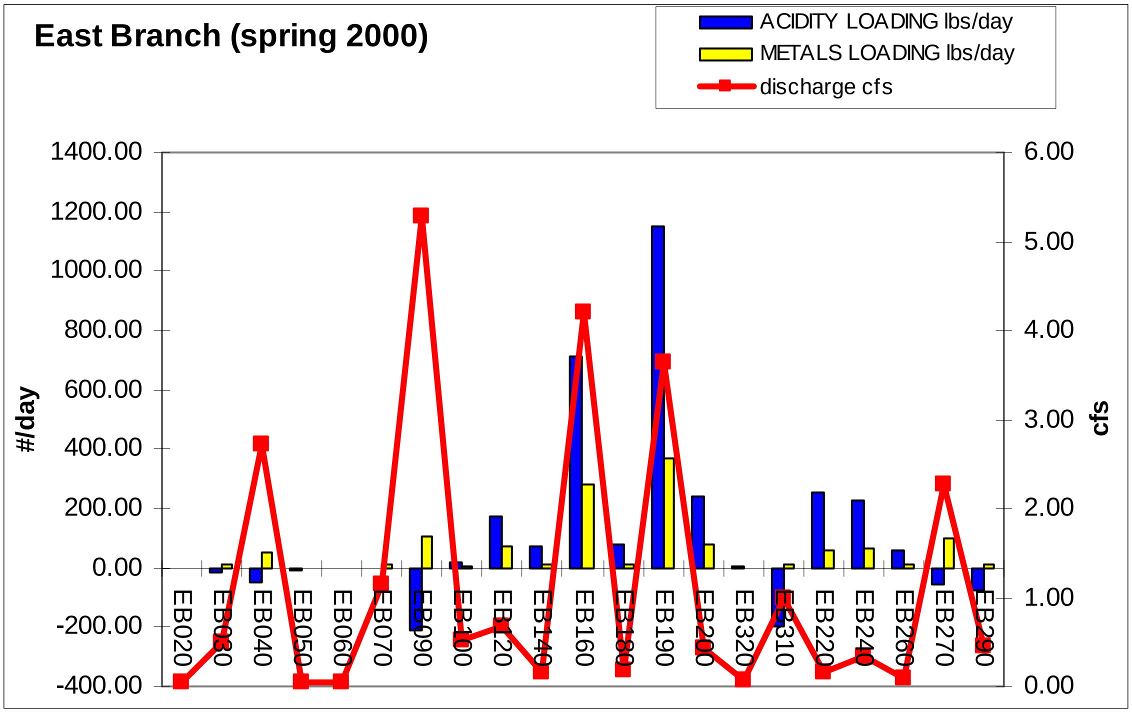
The data from the 1996 Hughes et al. study showed that EB 190, EB 160 (sampled twice) and EB 120 were significant acid contributors (Figure 25). Similar results can be found in the more recent sampling for this study.

Figure 25



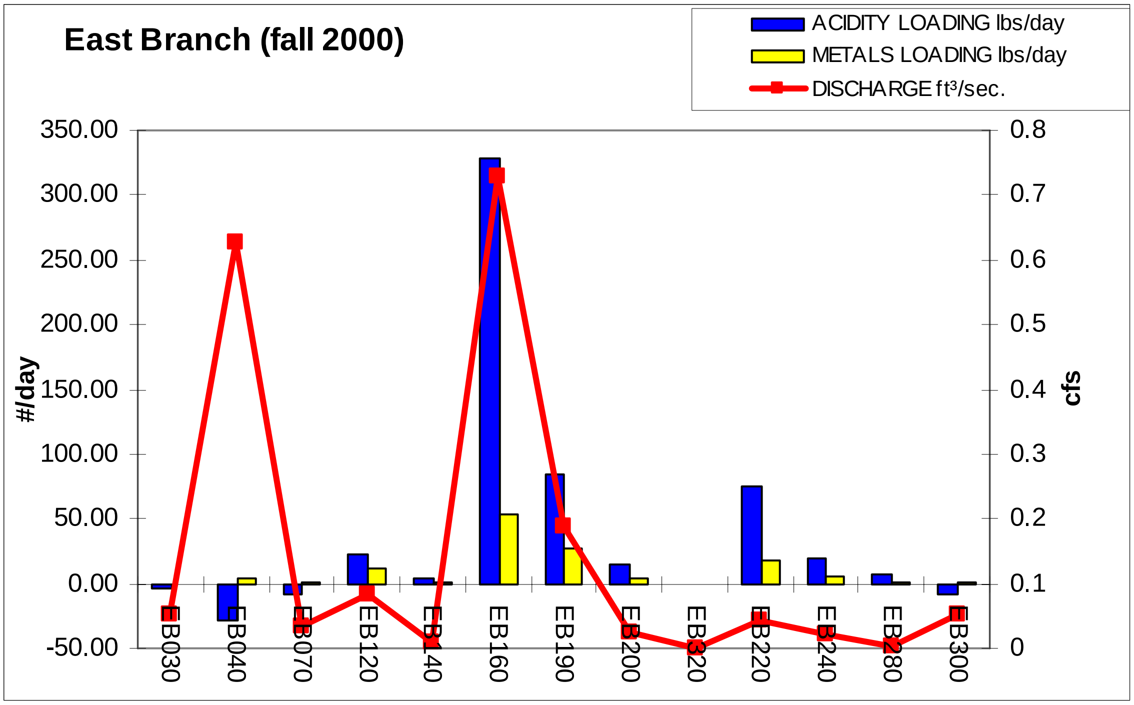
The spring sampling in the East Branch of Raccoon Creek identified ten acid producing tributaries (Figure 26). Two of these tributaries were producing significantly higher acid loads than the others. Specifically, EB 190 produced 1,150 pounds per day and EB 160 produced 714 pounds per day. EB 220 (255 pounds per day), EB 200 (241 pounds per day) EB 240 (230 pounds per day) and EB 120 (173 pounds per day) as a group are significant contributors to the acid load of East Branch with a recorded flow of less than one cfs. The three remaining sites, EB 180, EB 140, and EB 260, were discharging between 50 and 80 pounds per day of acid.

Figure 26



The fall 2000 samples were taken during the period from 8/30/00 to 10/03/00 (Figure 27). The samples were taken over a two-month period, which makes it difficult to compare acid contribution between the sites, but the data does show that the same small tributaries to East Branch are maintaining their contribution as flow decreases or increases. The individual importance may change between the sites as flow regimes change because of different AMD sources.

Figure 27

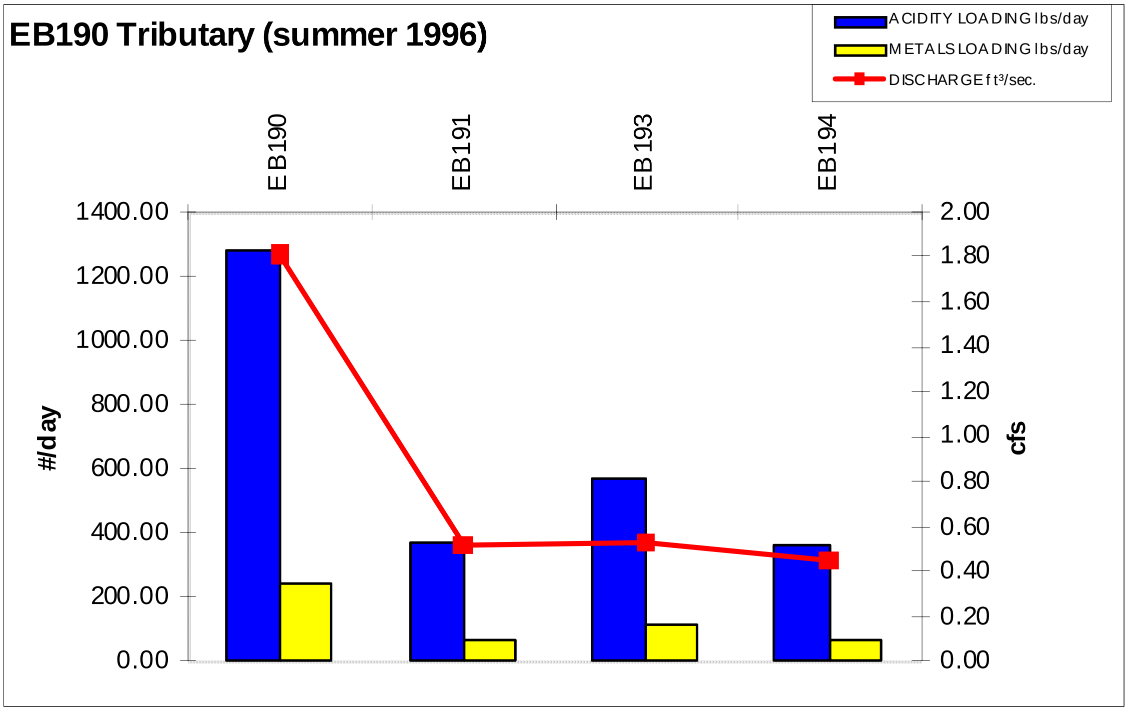


EB 160 discharged a load of 329 pounds per day at a flow of .7 cfs. EB 190 produced 85 pounds per day when sampled in early September. EB 280 and EB 200, also sampled at the beginning of September, were net acidic, but the loads and flows were very small.

Site: East Branch 190

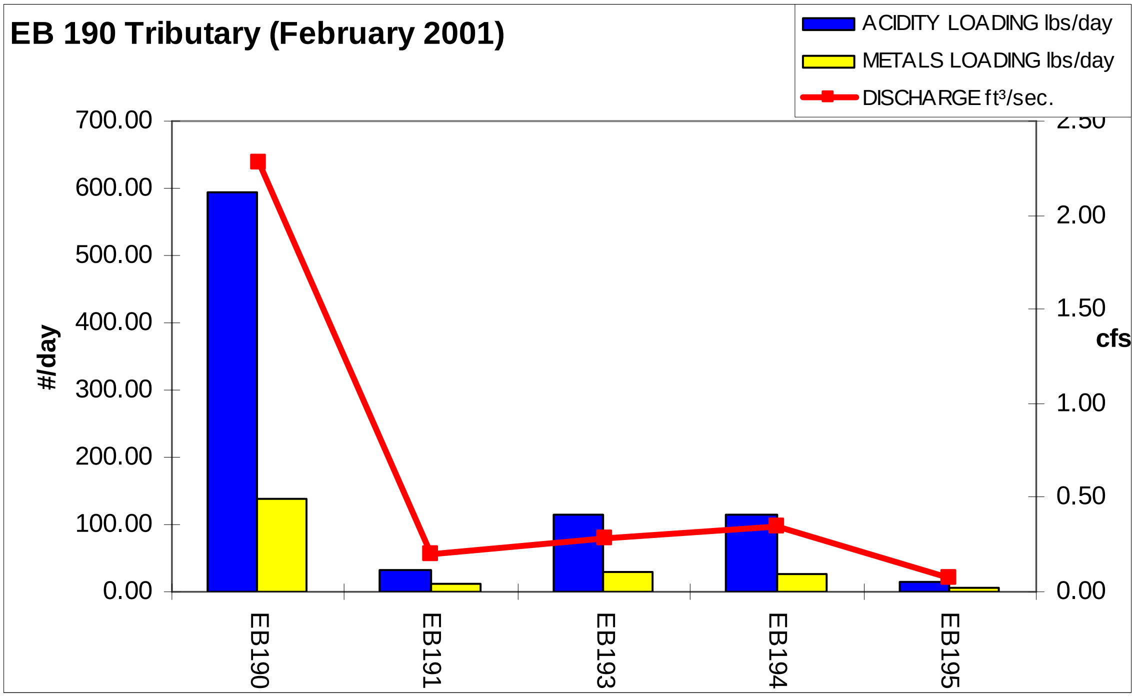
During the 1996 sampling event tributary EB 190 was producing a significant amount of acid (Figure 28). The flows were uniform from each tributary with EB 193 contributing the greatest load of acidity at 567 pounds per day. EB 191 and EB 194 were producing very close to 365 pounds per day each. Even though EB 195 was missed this round of sampling can account for a majority of the acid in the creek.

Figure 28



During the one-day sampling event in February, EB 190 produced very similar results to the 1996 sampling (Figure 29). Although the acid contribution was less severe from the smaller tributaries, the result is a consistent contribution of acid mine drainage to EB 190 and to East Branch. The EB 190 subwatershed has been extensively surface mined. The ridge tops above every stream in this tributary have been affected. A few of the mines have been reclaimed under the 1972 era law and several in the upper reaches remain unreclaimed with steep slopes and exposed gob and toxic refuse. No underground mines are shown on the available maps, nor have there been any discrete seeps or discharges identified. All the previously mined areas, whether reclaimed or not, are producing AMD in a very diffuse manner. Because of this it is not possible to identify point sources during a phase III sampling. As a result abatement of the problem will require a basin wide approach with the possibility of adding to the buffering capacity of the stream where possible. It is not feasible to reclaim all surface areas affected by mining, especially those that have already received some reclamation. EB 190 subwatershed is considered a priority as a single project.

Figure 29

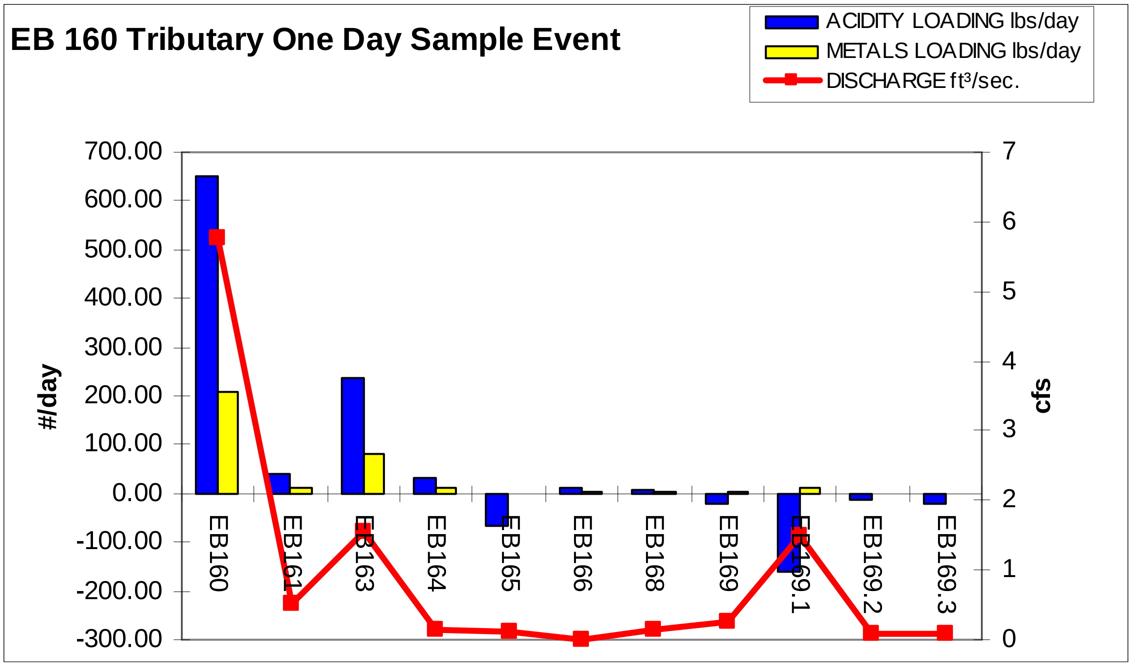


<u>Site: East Branch 160</u>

The EB 160 tributary is the second largest AMD contributor to East Branch (Figure 30). It also underwent a one-day sampling event to determine the sources of degradation. This proceeded by sampling every minor tributary feeding into the EB 160 tributary. EB 160 discharged 650 pounds of acid per day during the event. EB 161 and EB 164 were identified as acid producers, but their numbers were low compared to the total load (40 and 33 pounds per day.) EB 166 and EB 167 were also net acidic, but the loads were each less than 10 pounds per day. Site EB 162, a known mine discharge, was not sampled due to inability to access private property on this day.

The other known AMD problem site in the EB 160 tributary is a series of mine openings that discharge in a diffuse manner and are located behind an old white farm house located right on the edge of the stream. They are referred to as EB 169.4 (the White House Seeps.) These openings were sealed during the 1998 Coonville project with standpipe discharge outlets to relieve the mine of excess water as a safety measure. Samples were not taken at the sources; however, most of the AMD is coming from EB 162 and EB 169.4. This assumption is based on the fact that the sample from the main channel of EB 160 above the problem areas is net alkaline producing 161 pounds of alkalinity. At site EB 163 just downstream of the White House Seeps

Figure 30



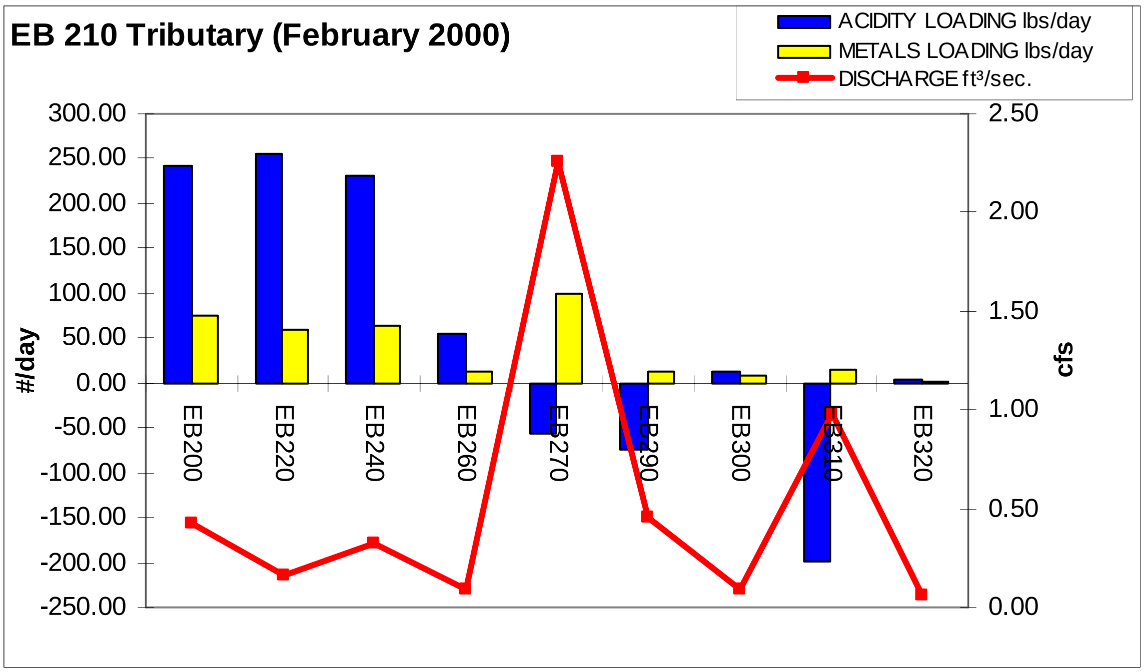
the stream becomes net acidic producing 235 pounds of acid per day. All the other tributaries to EB 160 from here to the mouth were sampled except the EB 162 seep. The combined net acid load (acid minus alkaline loads) of these streams only accounts for 22 pounds of acid per day. In addition, when the loads from all the other acid producers are added together it only totals 89.7 pounds of acid per day. The EB 160 tributary picks up an additional 420 pounds of acid by the time it reaches the mouth. The assumption is that the EB 162 discharge accounts for this contribution.

Because of the nature of the problem in this subwatershed and the geographic setting, developing a treatment at the site of discharge may not be possible. A basin approach with alkaline amendment in select locations and a new technique of alkaline injection into the mine voids is recommended. Tributary EB 160 has to be considered a priority tributary with EB 162 and the White House Seeps as the main problems in the small subwatershed.

<u>Site: East Branch 210 Tributary</u>

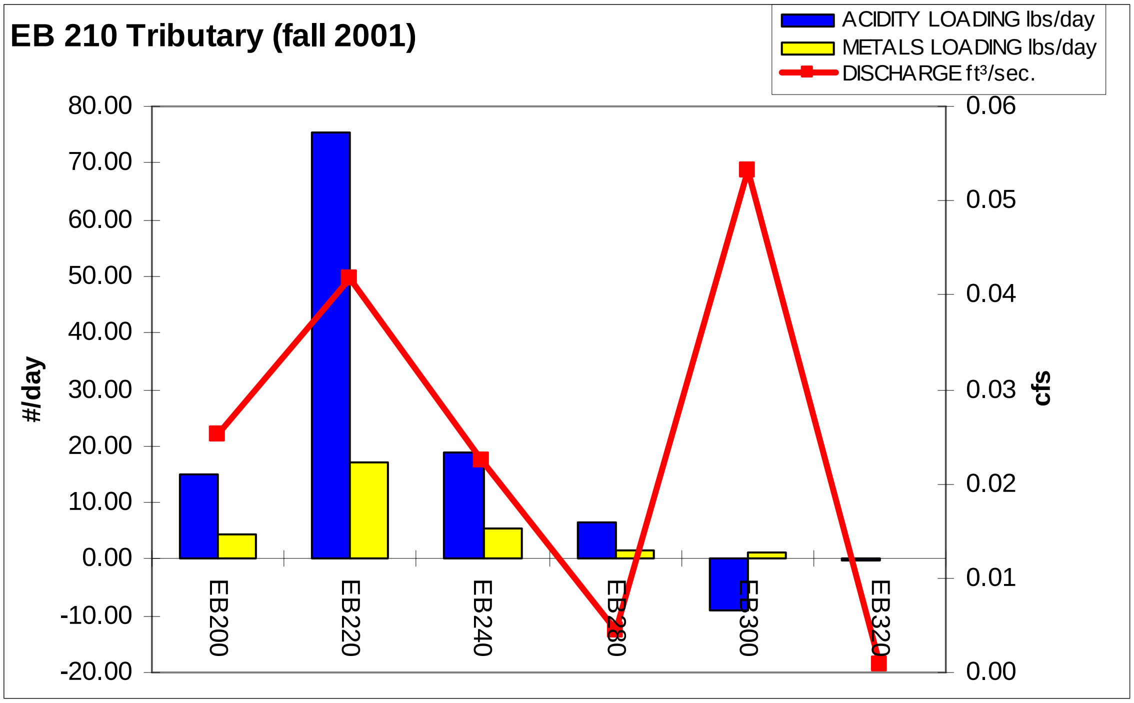
The upper reach of East Branch's EB 210 tributary is similar to the EB 190 tributary. The ridge tops on either side of the stream have been heavily affected by mining with much of the reclamation occurring under the 1972 requirements of the State of Ohio. As a result many of the streams are producing water with high acid concentrations and loads. In the spring of 2000 EB 200, EB 220, and EB 240 were contributing relatively equal acid loads (Figure 31). EB 260 was also producing acid along with an insignificant acid load from EB 300.

Figure 31



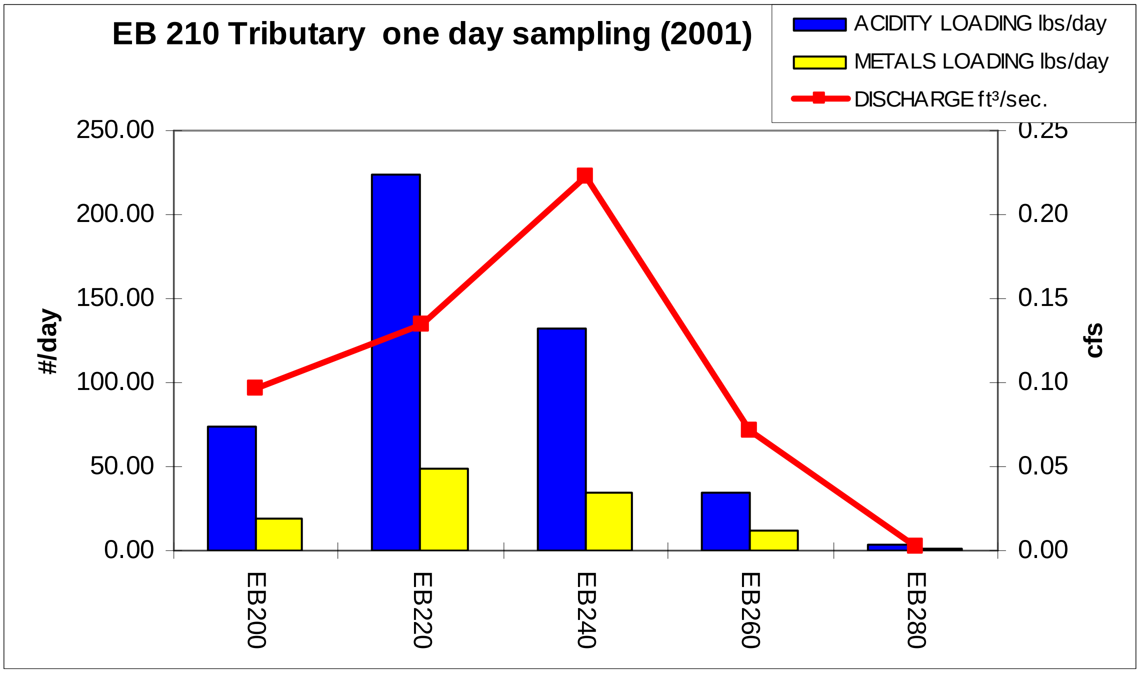
EB 210 received another sampling event in the fall of 2000 and results were similar to the spring of 2000. Once again, EB 200, EB 220, and EB 240 were the main acid contributors (Figure 32). EB 260 was not flowing during this sampling event. An additional discharge of surface water was found draining site EB 240 (known as the Yost Tract, owned by the US Forest Service). EB 300 was net alkaline this time around.

Figure 32



EB 210 was revisited one more time in spring of 2001. The results remain the same with EB 200, EB 220, and EB 240 as the main contributors of acidity to EB 210 (Figure 33). The data on tributary EB 210 shows that the primary focus must be given to EB 200, EB 220, and EB 240. Like EB 190 the nature of the problem is such that conventional reclamation to abate all spots may be very difficult. The extent of the area affected by surface mining is large and the production of AMD is diffuse. Some alkaline amendment will be needed where possible. Addressing the Yost Tract (EB 240) in partnership with the US Forest Service would directly affect one of the major acid contributors in the EB 210 basin.

Figure 33



Recommendation:

Identified as the main acid contributors that need to be addressed in the East Branch are EB 160, EB 190, and EB 210. EB 190 will require a basin wide approach with alkaline additions. Almost all the tributaries are consistent AMD contributors produced from surface mining, some of which have received reclamation in the past. It is not feasible to reclaim all the area affected by mining but one area suggested for possible reclamation would include the upper reaches of EB 193 and 194. It is recommended that further reconnaissance be done in EB 191, EB 195, and in the headwaters of EB 193 and 194. The purpose of the reconnaissance is to identify any pits or lakes that may be contributing to the acidic conditions and could possibly be removed. Initial reconnaissance of the tributaries was done, but further investigation before entering into project design and construction is warranted.

EB 160 has two discrete sites discharging AMD; EB 162 and EB169.4 (White House Seeps.) Site location does not allow for many options for AMD abatement directly at the discharges. Alkaline additions will be required in this tributary. In addition, this option may be optimal for site EB 169 and other minor tributaries in the headwaters of EB 160. The recommended treatment for the discharging deep mines involves the injection of alkaline material into the mine void. EB 210 and all its associated AMD producing drainages will also need a basin approach of adding alkaline material. This includes tributaries EB 200, EB 220, EB 240 (EB 280 is a part of this complex), and EB 260.

Summary of Potential Treatment Sites:

Tributary #	Recommendation	Site Identification
EB 190	Basin Wide approach with alkaline addition through limestone or steel slag lined channels.	Tributary 190 discharges into East Branch at the intersection of Sanner Rd and SR 56.
EB 191, 193, 194, 195	Repeat reconnaissance for the identification of pits that may be associated with AMD production. All receive alkaline channels.	
EB 160	Two approaches – alkaline addition in clean water tributaries, experimental approach in deep mine complex.	EB 160 enters East Branch at the junction of SR 56 and Laural Run Rd.
EB 162 and EB169.4 (White House Seeps)	Test drilling for exploration of deep mine void. Injection of alkaline material into mine void	
EB 169	Clean water sources for alkaline addition	
EB 210	Basin wide approach with alkaline addition in AMD producing tributaries	EB 210 tributary accessed via Sanner Rd.
EB 200 EB 220	Alkaline amendment with limestone or steel slag lined channels.	
EB 240 and EB 280	Explore possible hydraulic seal on auger mine complex, alkaline channel with limestone or steel slag lining.	
EB 260	Reconnaissance of tributary to determine if is contributing flow to AMD production, alkaline channel with limestone or steel slag lining	

West Branch

Name: West Branch of Raccoon Creek **Location:** Discharges into Raccoon creek at river mile 111.9 **Quadrangle:** New Plymouth **Drainage Area:** 22.59 square miles, 14,459.87 acres

Overview

West Branch subwatershed ranks fifth on the priority list for AMD abatement and restoration. Abatement strategies need to be identified for WB 050, WB 060, WB 070, and WB 100 (Map 3 – back pocket). The nature of the problem in West Branch is very similar to East Branch. The surface mines are either completely abandoned with some modest tree growth, or there are reclaimed areas (under the 1972 law) producing acid mine drainage. Future monitoring may be needed to be certain of the relative importance in each tributary to West Branch, but the major contributors have been identified. Additional monitoring may be useful to determine if WB 170 or WB 130 contribute more than what has been determined in the past, but at present data suggest they are not priority contributors.

Specific sites:

- WB 060 – Unreclaimed but forested surface mine, southeast of Orland.
- WB 070 – Reclaimed surface mine at Mt. Pleasant.
- WB 100 – Unreclaimed surface mine along Harble-Griffith Road and extending westward.
- WB 050 – Orland Gob Pile

Location/Access**:**

WB 060 can be accessed by traveling south on CR 32 from Orland. The area affected extends into sections 1, 2, 11, and 12 of Swan Township, Vinton County. The reclaimed area of WB 070 can be accessed along SR 93 at Mt. Pleasant. The tributary draining WB 070 into West Branch can be accessed by traveling east across the reclaimed site or by traveling east on Fairview Rd. from Mt. Pleasant. Site WB100 is an extensive surface mines complex that can be accessed by traveling west on Fairview Road from Mt. Pleasant and turning right on Harble-Griffith Road. The mined area extends into sections 33, 28 and 29 of Washington Township in Hocking County. WB 050 can be easily accessed along SR 56 just west of Orland. It is visible from the highway and is located in section 2 of Swan Township, Vinton County.

Water Quality: See Appendix B, Table 2.

Sites: West Branch 060, 070, 100, 050

The 1996 data showed the West Branch as net alkaline and providing buffering capacity to the mainstem. It was assumed that this study would produce similar results. That has not been the case; in fact sample results have shown the discharge of West Branch to be net acidic in both the spring and fall mainstem sampling (Figures 9 and 10). The spring sample, taken in March, produced 338 pounds per day of acid and the fall sample (11/15/00) produced 249 per day (Figures 34 and 35). The individual tributaries were sampled in the West Branch between the dates 5/16/00 and 6/5/00 and again in October of 2000. The May sampling identified two main acid contributors at WB 060 discharging 85.9 pounds per day and WB 100 38 pounds per day. Also net acidic, but only producing minimal AMD discharges were WB 110 (10.8 pounds per day,) WB 070, WB 080, and WB 130 all at less than five pounds per day of acid.

Figure 34

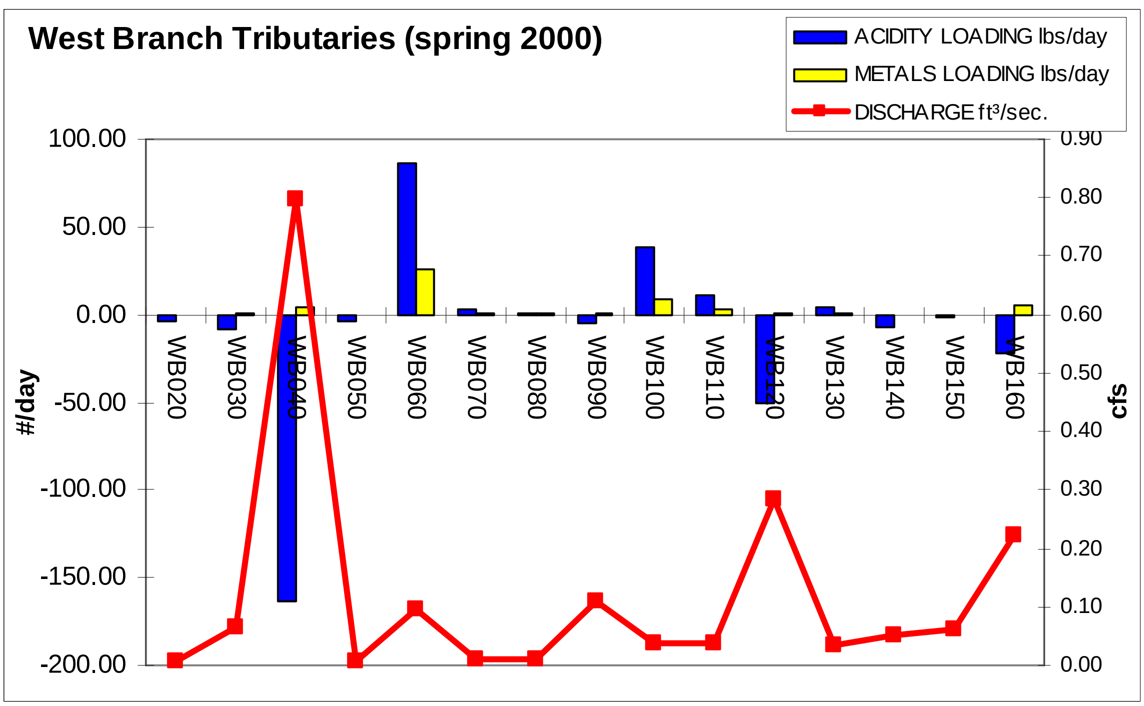
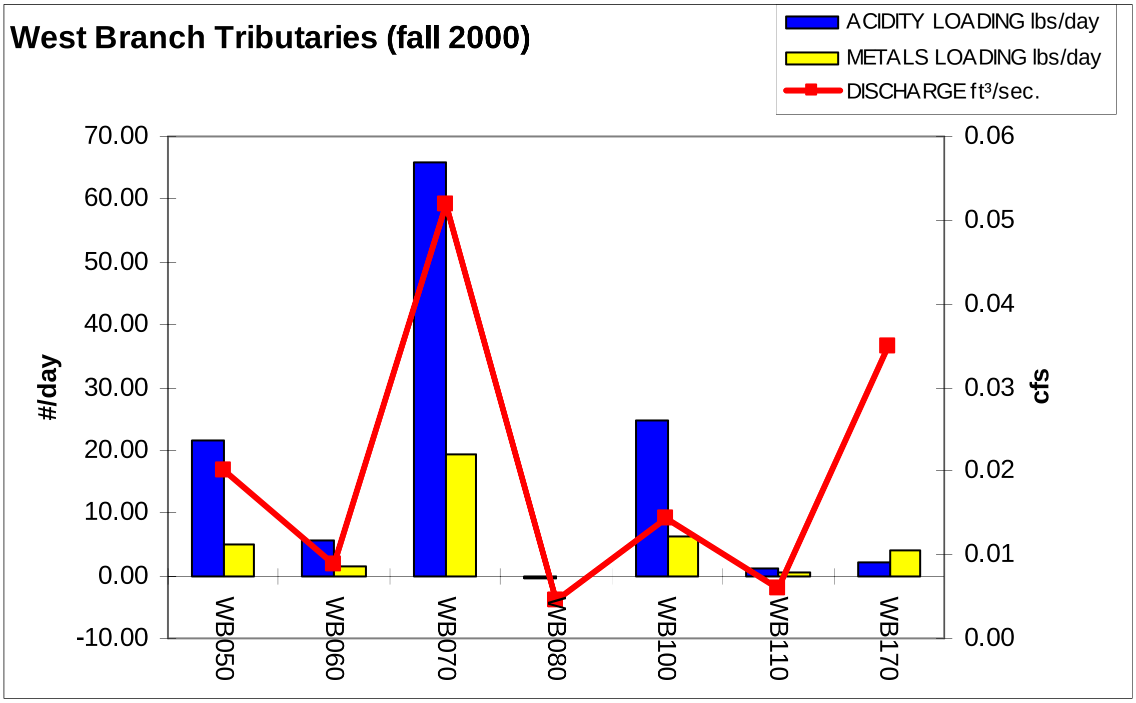


Figure 35



During the fall sampling event only the acid producing tributaries or those that were on the bubble were collected. WB 060 was still net acidic, but not the most significant contributor. WB 070 at 66 pounds per day was the highest acid contributor followed by WB 100 and WB 050 at just above 20 pounds per day. WB 110 and WB 170 remained net acidic, but at less than five pounds per day.

<u>Recommendations:</u>

Even though West Branch is not the top priority in terms of acid loading to the mainstem it is recommended for abatement actions for a few reasons. One, the sites identified can be abated at relatively low cost. Two, the creek has the capacity to produce net alkaline discharge to the mainstem. Abatement of the acid loads at the identified sites will increase the amount of alkalinity loading into the mainstem and make it more of a constant source of alkalinity. A third reason is because of its location as one of the primary headwater's streams to the mainstem of Raccoon Creek. Abating the acid load at this point (RM 111.9) could affect the net alkaline/acid concentrations through the reach of the mainstem identified as most severely impacted by AMD (RM 111.9 through RM 92.5) (Figure 8).

WB 070 is draining an area know as Mt. Pleasant which was reclaimed and bond released in the late 1970's. This site is not suitable for conventional reclamation to abate the acid producing activities directly, but will have to involve alkaline amendment for treatment. WB 060 drains an area that was strip mined and left mostly abandoned, but the site has developed a relatively healthy cover of trees and other woody vegetation. For this reason it is not recommended to disturb the natural vegetation, but to treat this site with alkaline amendment. It is recommended to do a full reconnaissance of the site to identify if there are some pits flooded with water that contribute to the AMD production which could be removed.

WB 050 and WB 100 drain unreclaimed sites that can be addressed through more direct methods of conventional reclamation. It is possible that ponds may be eliminated (WB 100) and toxic material be centrally located out of the water table and capped. This will prevent infiltration and cease the production of AMD at both sites.

Summary of Potential Treatment Sites:

Tributary #	Recommendation	Site Identification
WB 060	Alkaline Amendment with limestone or steel or steel slag lined channels	WB 060 can be accessed by traveling south on CR 32 from Orland.
WB 070	Alkaline Amendment with limestone or steel or steel slag lined channels	WB 070 into West branch can be accessed by traveling east (from SR 93) across the reclaimed site or by traveling east on Fairview Rd. from Mt. Pleasant.
WB 100	Reconnaissance of the area for identification of pits for removal and the possibility of surface reclamation. Alkaline Amendment with limestone or steel or steel slag lined channels	Accessed by traveling west on Fairview Rd from Mt. Pleasant and turning right on Harble-Griffith Road.
WB 050 – Orland Gob Pile	Regrade, cap toxic material to prevent infiltration, establish vegetative cover	WB 050 can be easily accessed along SR 56 just west of Orland.

Mainstem Above Brushy Creek

Name: MSBC
Location: RM 111.9 to RM 103.6
Quadrangle: Zaleski, Mineral, Union Furnace
Drainage Area: 16.21 square miles, 10,374.44 acres

Overview:

The mainstem above Brushy Creek section ranks third on the priority list for AMD abatement and restoration. MSBC 090, MSBC 110, and MSBC 120 are the only priority streams in this section of the mainstem (Map 4 – back-pocket). They should be folded into the project that will be developed to abate the loads of BC 06, BC 070, BC 090 draining Pumpkin Ridge on the other side of the hill.

Specific sites:

- MSBC 090 – Mitchell Hollow/Pumpkin Ridge
- MSBC 110 - Pumpkin Ridge/Vinton County Airport
- MSBC 120 – Pumpkin Ridge/Vinton County Airport

Location/Access:

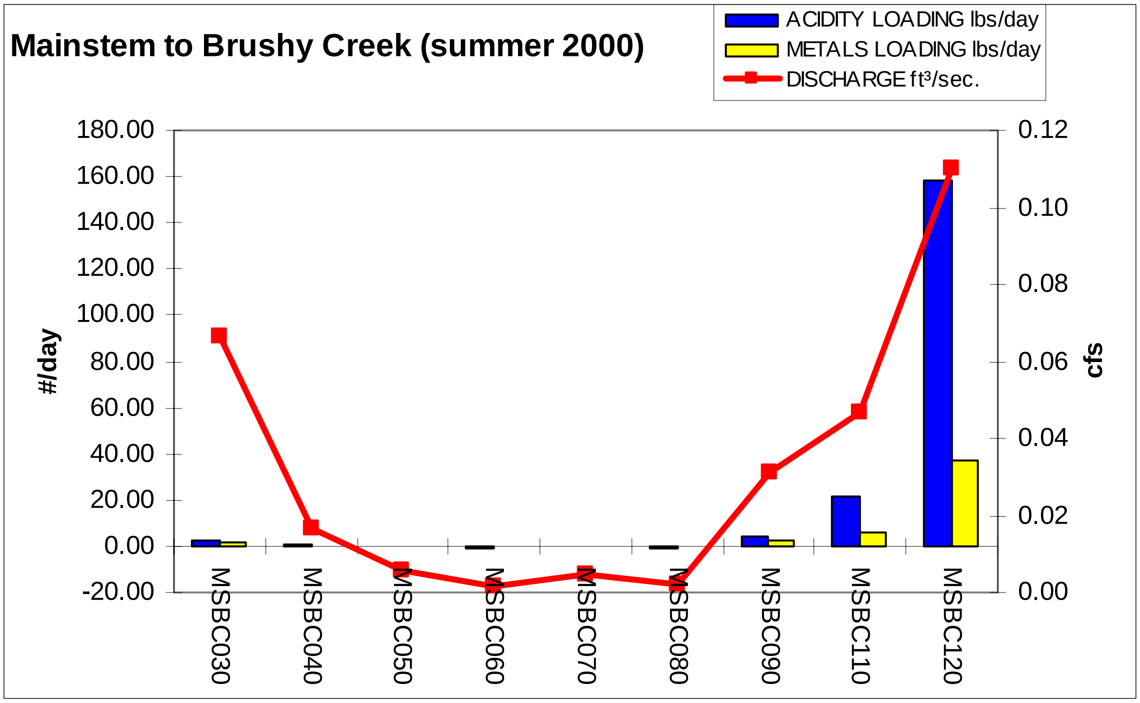
The entire site can be accessed in a couple of ways. The actual reclaimed area on the top of Pumpkin Ridge where the airport is located can be accessed by traveling east/ northeast from SR 93 on County Road 32 or south/southwest on the same road from SR 56. The mouths of the tributaries can be accessed via SR 328 traveling between New Plymouth and the intersection of SR 328 and SR 93. The total area affected by mining extends into sections35, 26, 27, 23, and 24 of Swan Township, Vinton County.

Water Quality: See Appendix B, Table 3

Sites: Mainstem to Brushy Creek 120, 110, 090

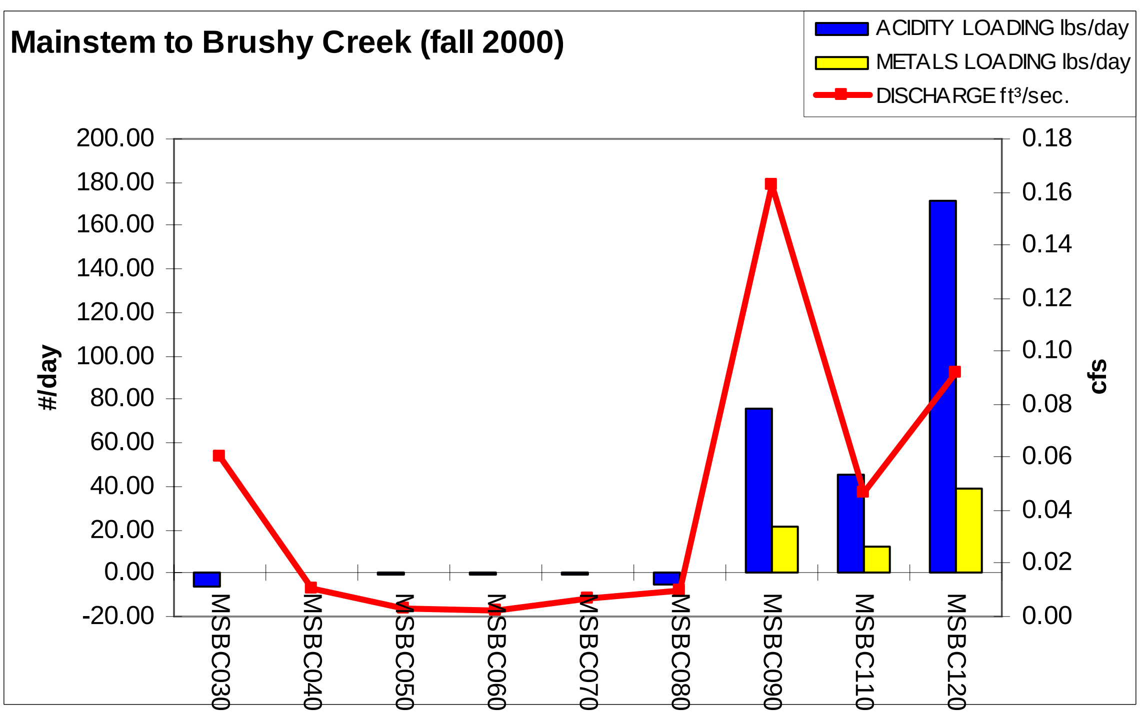
MSBC 120, MSBC 110, and MSBC 090 (Mitchell Hollow) all collect the surface water drainage from the southeast side of the Pumpkin Ridge area (Figure 36). During the June 2000 sampling event MSBC 120 caught most of the flow and as a result has the highest acid load at 158 pounds per day. These tributaries showed the same characteristics as other Brushy Creek tributaries with high acid concentrations including MSBC 120 at 268 mg/L during this event.

Figure 36



The fall 2000 sampling event confirmed the results with the same three tributaries contributing AMD with increased acid loads and concentrations (Figure 37).

Figure 37



Recommendation:

Sites MSBC 090, MSBC 110, and MSBC 120 are the priority streams in this section of the mainstem. Projects should be developed based on abatement strategies for BC 06, BC 070, BC 090 which are draining Pumpkin Ridge on the other side of the hill. These sites will have to be addressed with alkaline amendments in the form of open alkaline channels and alkaline recharge leach beds.

Summary of Potential Treatment Sites:

Tributary #	**Recommendation**	**Site Identification**
MSBC 090 – Mitchell Hollow/Pumpkin Ridge	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	The reclaimed area on the top of Pumpkin Ridge where the airport is located can be accessed by traveling east/ northeast from SR 93.
MSBC 110 - Pumpkin Ridge/ Vinton County Airport	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	
MSBC 120 – Pumpkin Ridge/ Vinton County Airport	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	

Brushy Creek

Name: Brushy Creek
Location: Discharges into the mainstem of Raccoon Creek at River Mile 103.6
Quadrangle: Zaleski, New Plymouth, Allensville
Drainage Area: 33.85 Sq. Miles 21,663.85 acres

Overview:

Brushy Creek subwatershed ranks second on the priority list for AMD abatement and restoration. Because Brushy Creek is suffering from very diffuse production of AMD and most sites will not allow for direct source control, the abatement strategy will be a basin wide treatment approach (Map 5- back – pocket)[16]. No discrete sources have been identified to date, but further investigation should be done. Two perennial net alkaline streams, Siverly and Dunkle, produce consistent and significant buffering capacity to Brushy Creek. Highest priority should be given to the tributaries draining the Pumpkin Ridge area. Most notably would be BC 060, the most significant contributor in every sampling event. BC 070 and BC 090 also produce consistently high acid loads. If the acid loads from BC 060, BC 070, BC 090, BC 110 and BC 150 can be reduced there is enough buffering capacity present to abate the acid load from Brushy Creek making it a more consistent net alkaline discharge to Raccoon Creek.

Specific sites:

- BC 060 Pumpkin Ridge/Vinton County Airport
- BC 070 Pumpkin Ridge/Vinton County Airport
- BC 090 Pumpkin Ridge/Vinton County Airport
- BC 110 Specifically sites BC 111, BC 113, 114 which are the individual tributaries to BC110
- BC 150 Mt. Pleasant

Location/Access:

BC 060 can be accessed from County Rd. 32 and BC 090 can be reached from County Road 12. They are both just west of SR 93. BC 070 must be accessed by parking on either one of these roads and hiking the abandoned rail to the tributary. Note: this is private property. All three of these sites are in Section 22 of Swan Township, Vinton County. The Pumpkin Ridge Airport area can be accessed via County Road 32, which travels through a large portion of the reclaimed hilltop of Pumpkin Ridge. The area affected by mining on Pumpkin Ridge extends into

[16] Reclamation is difficult because of the Vinton County Airport on Pumpkin Ridge and other areas that have been previously reclaimed.

Sections 35, 27, 26, 23, 24 and 14 of Swan Township. The BC 110 sample site is located along the abandoned railroad south of County Road 21 in section 15 of Swan Township. BC 111 is accessible via Township Road 16 in section 14 of Swan Township, BC 113 is accessible from County Road 21, and BC 114 is accessible from County Road 32 south of Orland in section 11 Swan Township. BC150 can be accessed via SR 93 in Section 3 and 4 of Swan Township, Vinton County.

<u>Water Quality:</u> See Appendix B, Table 4

<u>Sites: Brushy Creek (BC) 060, 070, 090, 150</u>

Like West Branch, the Brushy Creek sampling in June of 1996 reflected favorable conditions in the stream producing 418 pounds per day of alkalinity. More recent sampling in the study area showed the opposite results in Brushy Creek. In the spring of 2000 Brushy Creek was producing 1,103 pounds of acid per day at a flow of 40 cfs (Figure 9). In the fall of 2000 the flow had dropped considerably, but was still net acidic at 200 pounds per day (Figure 10). Brushy Creek was sampled again in February 2001 and the acid load increased to 379 pounds per day at 18 cfs. The loading changes are reflective of what is happening across the Headwaters study area. Water quality in Brushy Creek is affected by either unreclaimed strip mines or areas reclaimed under the guidance of Ohio's first conventional reclamation law passed in 1972. Brushy Creek drains many of the same complexes as both West Branch and the MSBC section of the mainstem.

In June 2000 tributaries to the mainstem of Brushy Creek that exhibited AMD characteristics were examined (Figure 38). Four main acid contributors were identified during this event including Brushy Creek (BC) 060, 070, 090 and 150. BC 060 and BC 090 were the largest acid producers with loads of 200 and 172 pounds per day. BC 070 produced 77 pounds per day. All three of these sites drain Pumpkin Ridge in Vinton County. BC 150, located upstream of the Pumpkin Ridge area, produced 46.42 pounds per day. It also is draining a partially reclaimed strip mine area.

In October the Brushy Creek tributary was assessed again and BC 060 was the main acid contributor at 345 pounds per day (Figure 39). BC 070 and BC 090 each produced approximately 90 pounds per day and BC 150 was at 57 pounds per day. This event identified two more acid producers at sites BC 110 at 53 pounds per day and BC 170 at 86 pounds per day.

Figure 38

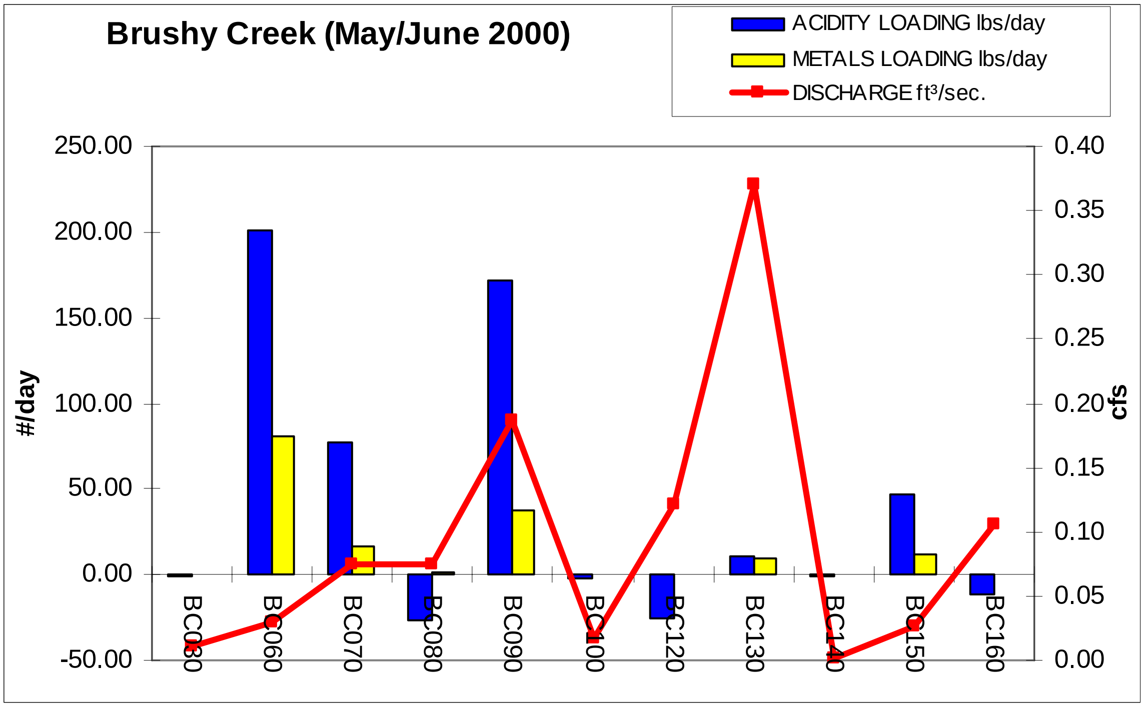
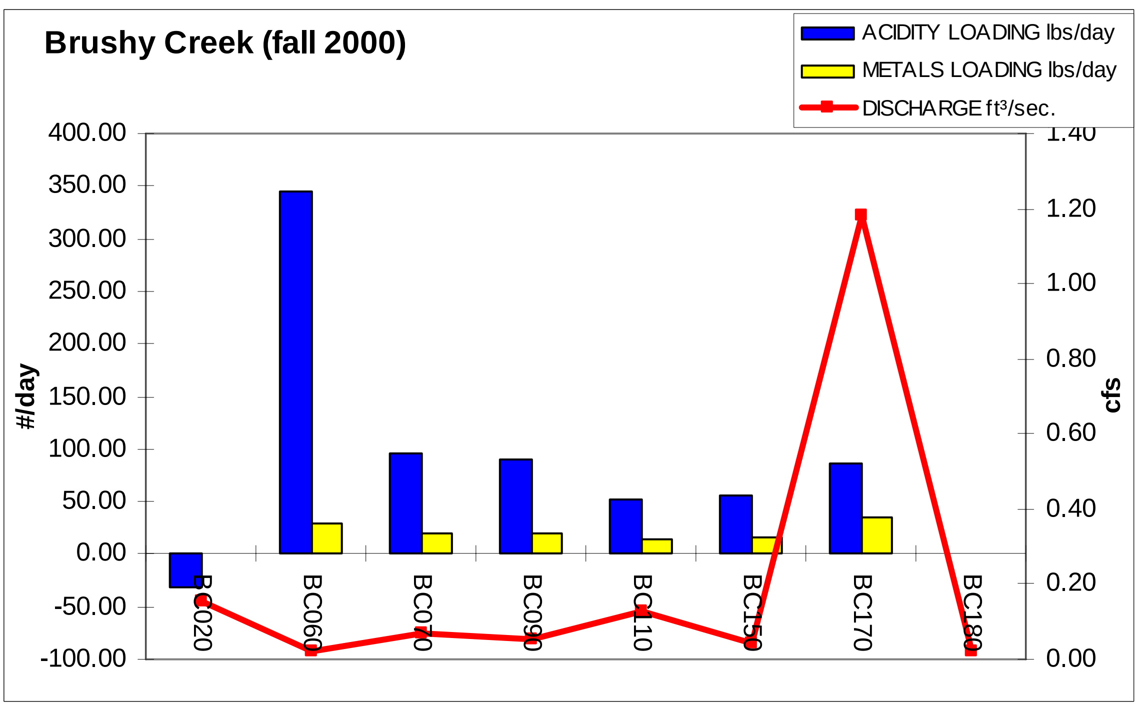
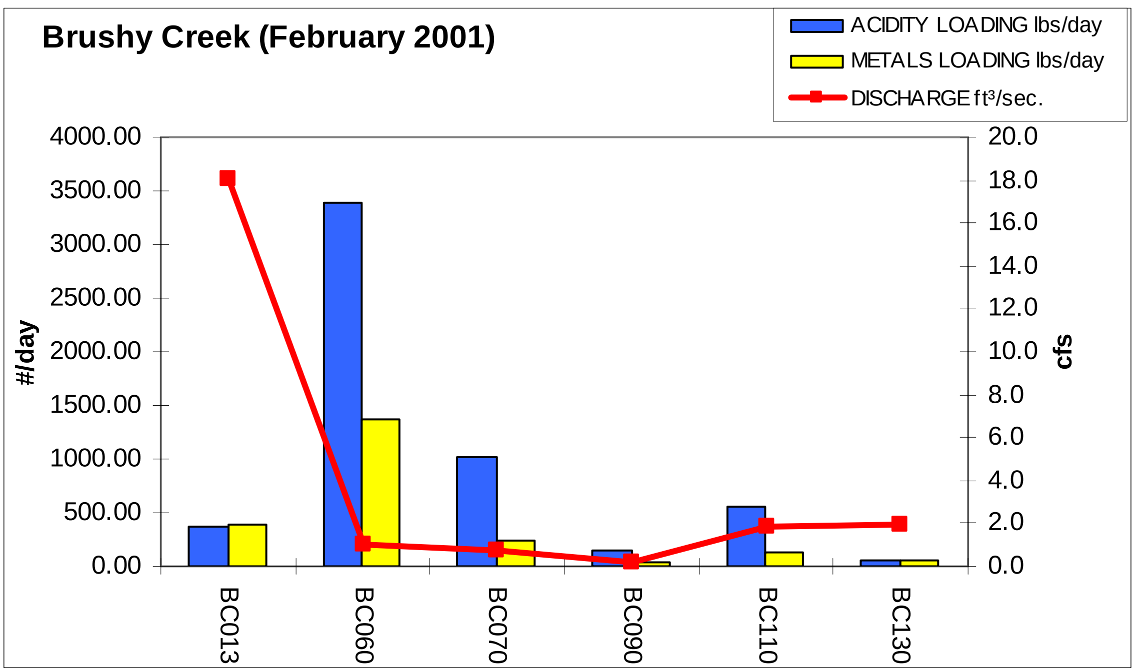


Figure 39



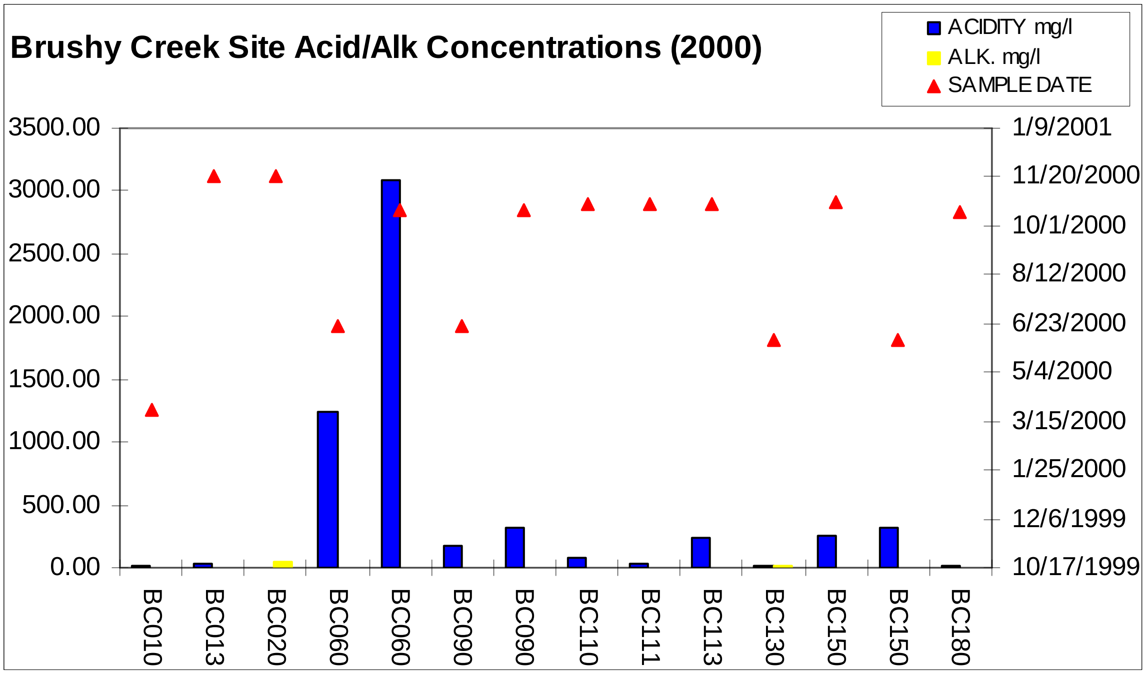
In February 2001 a third round of sampling focused on the consistent AMD contributors to get a better understanding of their relative importance (Figure 40). BC 013 has a similar acid load to the sample point at the mouth of Brushy Creek (BC 010) producing 379 pounds per day at 18 cfs. The flows were considerably higher this period than in the fall and an increase in acid loading was evident. BC 060 produced a staggering load of 3387 pounds while BC 070 produced 1016 pounds per day. BC 110 was also contributing a substantial load at 562 pounds per day. Samples at site BC 013 suggest that the stream is receiving significant buffering from Siverly and Dunkle tributaries, which are consistently net alkaline and do not carry much evidence of AMD.

Figure 40



The acid alkaline concentration graph (Figure 41) supports ranking Brushy Creek as a high priority sub watershed. Sampling in the watershed identifies several sites with the capacity to produce water with acid concentrations over 200 mg/L. These sites seem to show an increase in concentration with an increase in flow. BC 060, in particular, has produced water with over 3000 mg/L of acid and a pH of 1.8.

Figure 41



Recommendations:

BC 060, BC 070, BC 090 will have to be addressed by using alkaline amendment in the form of long open alkaline channels with the possibility of leach beds in a few areas. BC 150 is associated with the same reclaimed mined area at Mt. Pleasant that also drains into West Branch. It is located at the top of a long steep hill along SR 93 and can be addressed through a long open channel with alkaline amendment. BC 110 has three tributaries that are each producing a portion of its acid load including BC 111 which drains the most northern portion of the Pumpkin Ridge area. BC 113 drains the southeast corner of the same complex associate with BC 150 and Mt. Pleasant, and BC 114 drains the southern portion of the unreclaimed area associated with WB 060. It has a few pits and areas that can be reclaimed conventionally and additional alkalinity added through open alkaline channels

Summary of Potential Treatment Sites:

Tributary #	Recommendation	Site Identification
BC 060	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	Pumpkin Ridge/Vinton Co. Airport. BC 060 can be accessed from County Road 32.
BC 070	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	BC 070 must be accessed by parking on either one of these roads and hiking the abandon rail to the tributary. Note: this is private property.
BC 090	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	BC 090 can be reached from County Road 12.
BC 111	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	BC 111is accessible via Township Rd 16 in section 14 of Swan Township.
BC 113	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	BC 113 is accessible from County Road 21.
BC 114	Additional reconnaissance to identify pits associated with AMD production	BC 114 is accessible from CR 32 south of Orland in section 11.
BC 150	Alkaline Amendment with limestone or steel or steel slag lined channels and leach beds	BC150 can be accessed via SR 93 in Section 3 and 4 of Swan Township, Vinton County.

Mainstem to Lake Hope

Name: Mainstem to Lake Hope **Location**: Mainstem of Raccoon Creek to just downstream of Lake Hope Quadrangle**:** Zaleski, Mineral, Union Furnace **Drainage area**: 41.08 square miles, 26,295 acres	

Overview:

The data on the mainstem have shown that this reach of stream, from the mouth of Brushy Creek (RM 103.6) to just downstream of Lake Hope (MSLH 130, approximately RM 93), is net acidic at the top of this reach, but improves to net alkaline by the time it reaches the mainstem sample site MSLH 130 located at the bridge over Raccoon Creek leading to the Hope School House (Map 6 – back pocket). Each mainstem sampling event (1996, 2000, and 2001) produced this result along with a rise in pH. There are acid producing tributaries in this section; however, the trend of improvement in water quality makes this section a lower priority for AMD abatement. However, it is recommended that a project be developed to abate the acid contribution from Sandy Run (MSLH 121) before discharging into Lake Hope because the lake is a valuable resource in the watershed

Specific sites:

- MSLH 121– open alkaline channel with \metals retention basin
- MSLH 020 – monitoring
- MSLH 130 - monitoring

Location/Access: MSLH 020 can be accessed on Creek Road between SR 328 and SR 677 in section 2 of Elk Township, Vinton County. MSLH 130 can be accessed at the bridge over Raccoon Creek on County Road 3 - Pinney Hollow Rd**.** very near the Hope School House in Brown Township, Vinton County. MSLH 121 can be accessed at the north end of Lake Hope at the Hope Furnace/Zaleski Forest Backcountry parking lot along SR 278 in Vinton County.

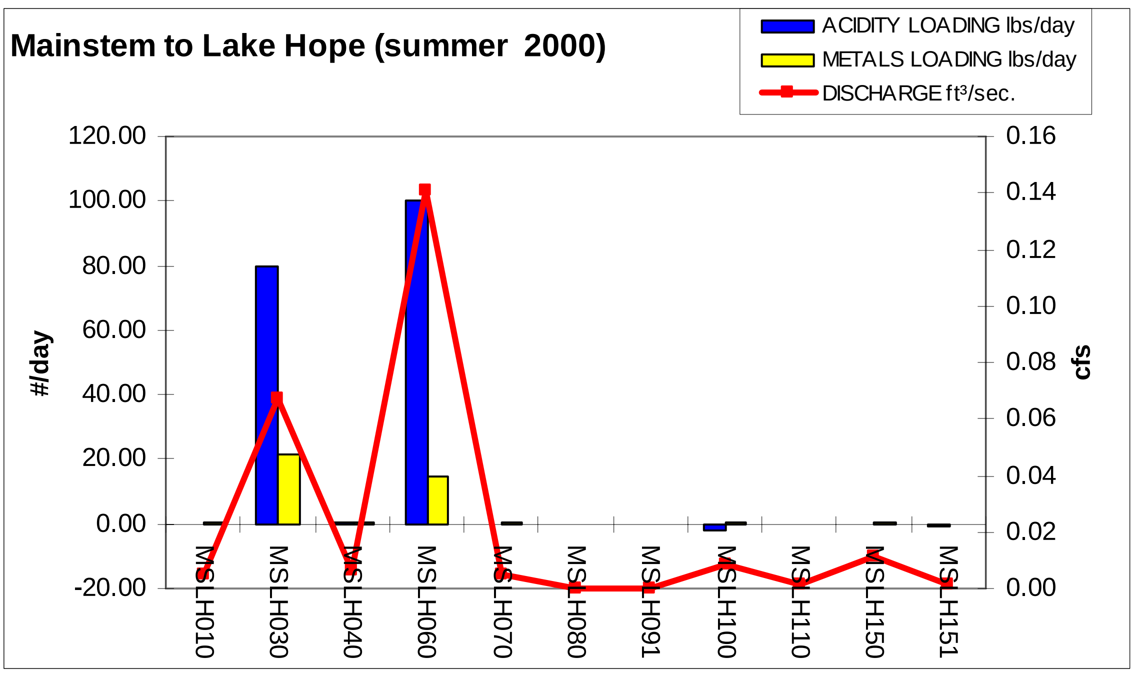
Water Quality: See Appendix B, Table 5

Sites: Mainstem to Lake Hope (MSLH) 060 and 030:

The summer sampling of this section of the mainstem revealed two AMD contributors, MSLH 060 and MSLH 030. MSH 060 is located in the vicinity of Webb-Mine Hollow and discharges into a wetland along SR 278 just north of the town of Zaleski (Figure 42). The wetland is created by the existence of an abandoned railroad running parallel to Raccoon Creek. There is a breech in the railroad bed where the wetland could discharge but at present it is dammed by beavers. The wetland was not observed discharging at any point during the reconnaissance of this mainstem section. The pH of the water in the wetland was 6.4. The major tributaries to the mainstem, in particular, MSLH 120 sample point (Figure 9) revealed that the Lake Hope discharge is a heavy acid loader at 887 pounds per day. Additional monitoring will be done at this site in the future. This is discussed in more detail in the Monitoring Plan section of this document.

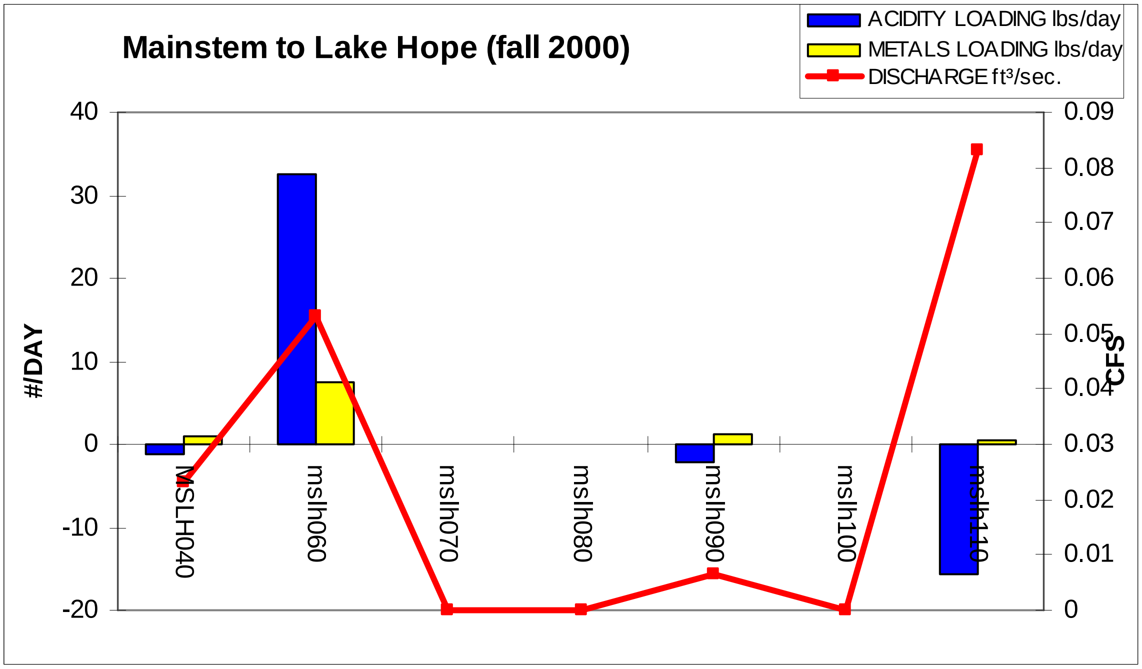
The second tributary producing an acid load was MSLH 030, producing 79.5 pounds of acid per day. MSLH 030 drains an old strip mined area that has been reclaimed by tree planting and has recovered naturally to some extent.

Figure 42



The fall sampling of these same tributaries produced similar results with MSLH 060 being the only acid producer (Figure 43). MSLH 030 had no flow during this event. The mainstem sampling during the fall of 2000 (Figure 5) is taken within a few days of these samples and shows no impact from these tributaries.

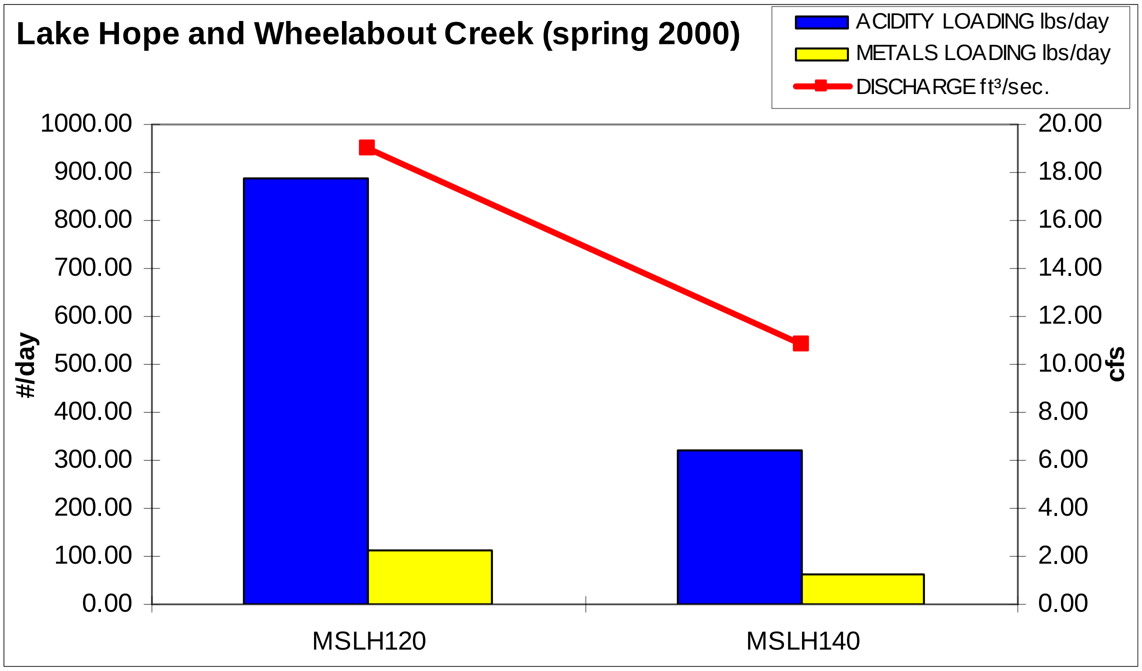
Figure 43



<u>Sites: Lake Hope/Sandy Run MSLH 120 and Wheelabout Creek (MSLH 140):</u>

The two tributaries missing from this analysis are Lake Hope/Sandy Run (MSLH 120) and Wheelabout Creek (MSLH 140). They were sampled approximately three months prior to the rest of the MSLH section (Figure 44). Both tributaries show net acidic loads. No associated downstream sample is available to gain an understanding of the effect of these discharges and their relative importance during this flow regime. However, it is important to note that a net alkaline situation develops downstream at site MSLH 130.

Figure 44



<u>Recommendations:</u>

The tributaries of Raccoon Creek in this reach of the mainstem do not appear to have a significant impact on the water quality and biologic resources of the stream. Recommendations for this segment include 1) continued monitoring at sites MSLH 020 and MSLH 130 and 2) an open alkaline channel for AMD abatement of site MSLH 121 if the trend of improvement does not continue after monitoring of MSLH and Wheelabout Creek.

<u>Summary of Potential Treatment Sites:</u>

Tributary	**Recommendation**	**Site Identification**
M SLH 121	Open alkaline channel with metals retention basin	MSLH 121 can be accessed at the north end of Lake Hope at the Hope Furnace/Zaleski Forest Backcountry parking lot along SR 278 in Vinton County.

Hewett Fork

Name: Hewett Fork
Location: Discharges into Raccoon Creek at river mile 89.6
Quadrangle: Union Furnace, The Plains, Nelsonville, Union Furnace, Mineral
Drainage Area: 40.51 sq. mile, 25,925.23 acres

Overview:

Hewett Fork subwatershed ranks fourth on the priority list for AMD abatement and restoration. All of the acid producing tributaries affecting the main stem of Hewett Fork are located upstream of the bridge crossing the creek at the Waterloo Wildlife Station corresponding to sample site HF 090 in Waterloo Township, Athens County. Sites HF 110, HF 120, HF 131, HF 140, and HF 180 have proven to be the consistent acid contributors in the upper reach of the Hewett Fork Basin (Map 7-back pocket). All Hewett Fork tributaries downstream of this site either contribute insignificant amounts of AMD or produce net alkaline water.

Specific sites:

- HF 110 – Trace Run
- HF 120 – Carbondale Creek
- HF 131 – Carbondale Wetland
- HF 140 – Dr. Dew
- HF 180 – Connett Rd.

Location/Access**:**

Trace Run (HF 110) can be accessed by traveling east on SR 56 from its intersection with SR 278 in Hocking County. Descend the ridge to the stream valley and the Kennard seep is located on the left side of the road, at the foot of the hill, at the turnout on the road. Park in the turnout and proceed up the stream approximately 75 yards. The stream passes under SR 56 and travels adjacent to the road until it discharges into Hewett Fork downstream of the small community of Carbondale.

Carbondale Creek (HF 120) flows through the center of the community of Carbondale. The reclamation project and proposed treatment area can be accessed by traveling north out of Carbondale village on Mine Rd. The old haul road is gated and travel on foot is required, up the haul road, to visit the site. The Carbondale (HF 131) wetland is located just east of the village of Carbondale along Carbondale Road in Waterloo Township along with Trace Run. Carbondale

Creek discharges into Hewett Fork in Waterloo Township, but the Project site is located in Section 31 of York Township, Athens County.

HF 180 can be accessed traveling east from Carbondale on Carbondale Road and turning left (northwest) onto Connett Rd. HF 180 can be found by traveling on Connett Road just west of Willotte Rd. HF 180 complex is a large strip mined area that starts in sections 26 and 32 of York Township, Athens County, and stretches into sections 2 and 3 of Starr Township, Hocking County.

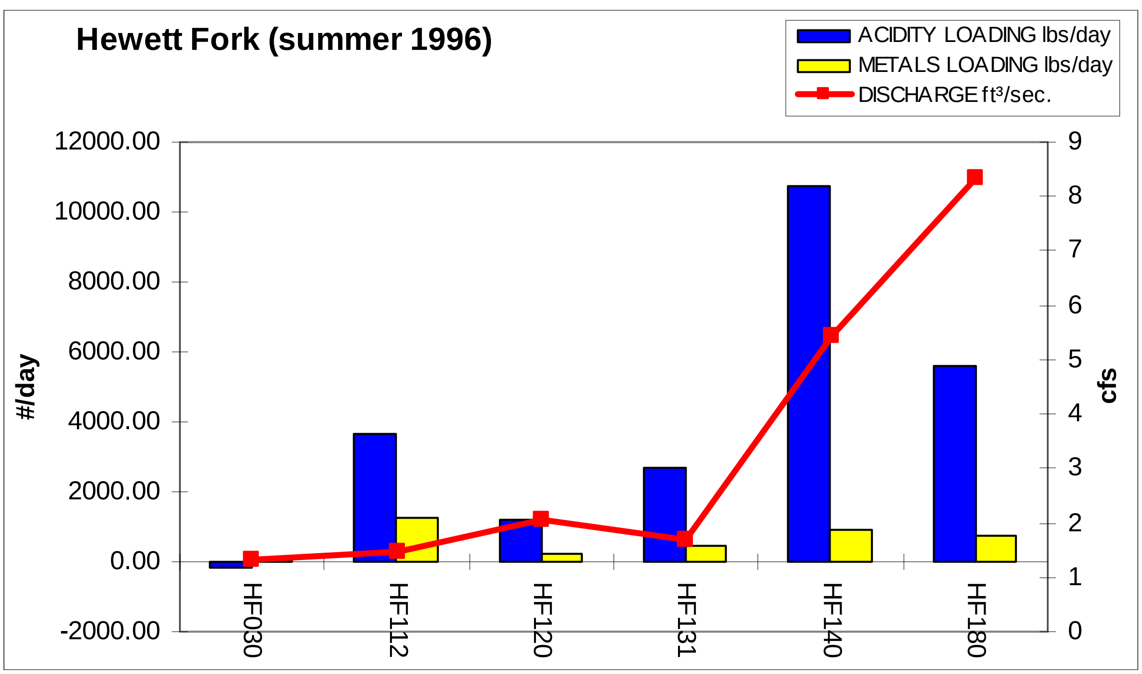
HF 140, Dr. Dew, is accessible via the same directions as accessing HF 180 except turning left onto Dr. Dew Rd. in section 26 of York Township. The HF 140 complex is located in section 26 of York Township, Athens County.

Water Quality: See Appendix B, Table 6

Sites: Hewett Fork (HF) 100, 112, 120, 131, 140, and 180:

The 1996 sampling identified the major acid loaders to Hewett Fork including HF 112 (Trace Run), HF 120 (Carbondale Creek), HF 131 (Carbondale Wetland), HF 140 (Dr. Dew project) and HF 180 (Figure 45). All sites were producing significant acid loads ranging

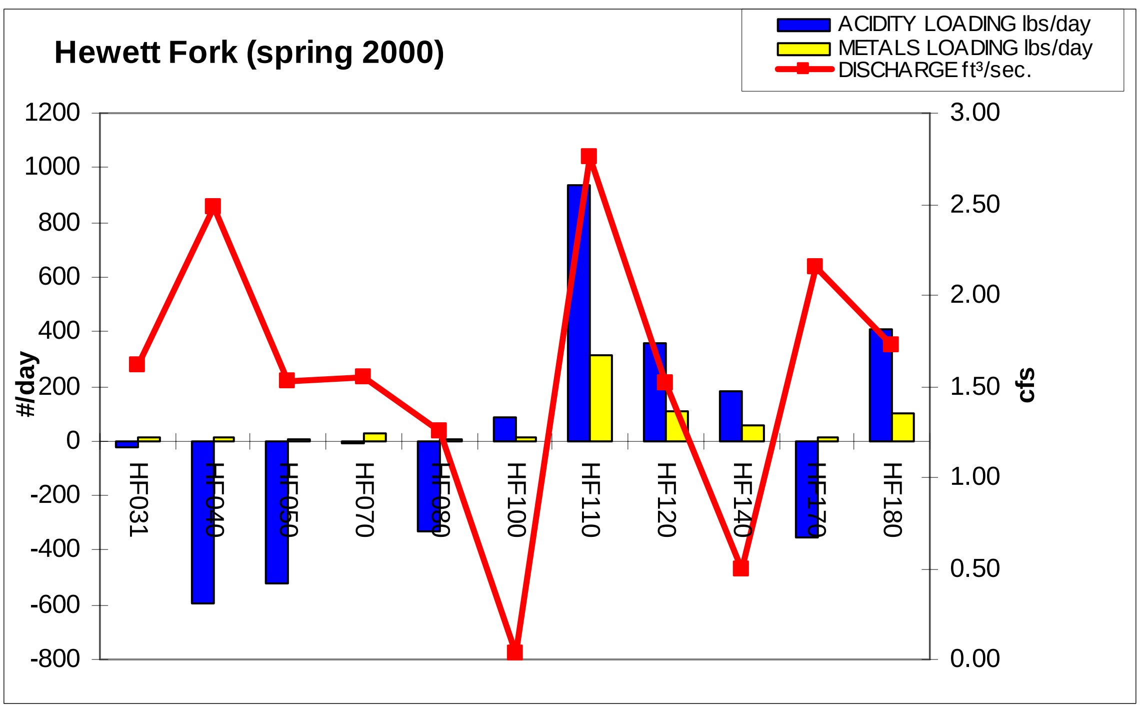
Figure 45



from over 10,000 pounds per day at HF 140 to 1,200 pounds per day at Carbondale Creek. Sample HF 112 was taken upstream of a smaller tributary to Trace Run which produces a significant amount of alkalinity. The result was an overall lower acid load into Hewett Fork on the day of sampling.

In the spring of 2000 sampling was done from April 25 – May 1 in the Hewett Fork basin (Figure 46). Site HF 031 through HF 080 (all downstream of the HF 090 Waterloo Wildlife sampling site) were all producing alkaline loads. Upstream of these sites the same acid producers were identified as those in 1996 (HF 110, HF 120, HF 140, and HF 180). The HF 100 seep was the only new source identified. The seep is located along SR 56 where the highway crosses over Carbondale Creek. This site was not sampled in 1996, but was known at the time. It was the smallest of the AMD contributors during the current sampling event.

Figure 46

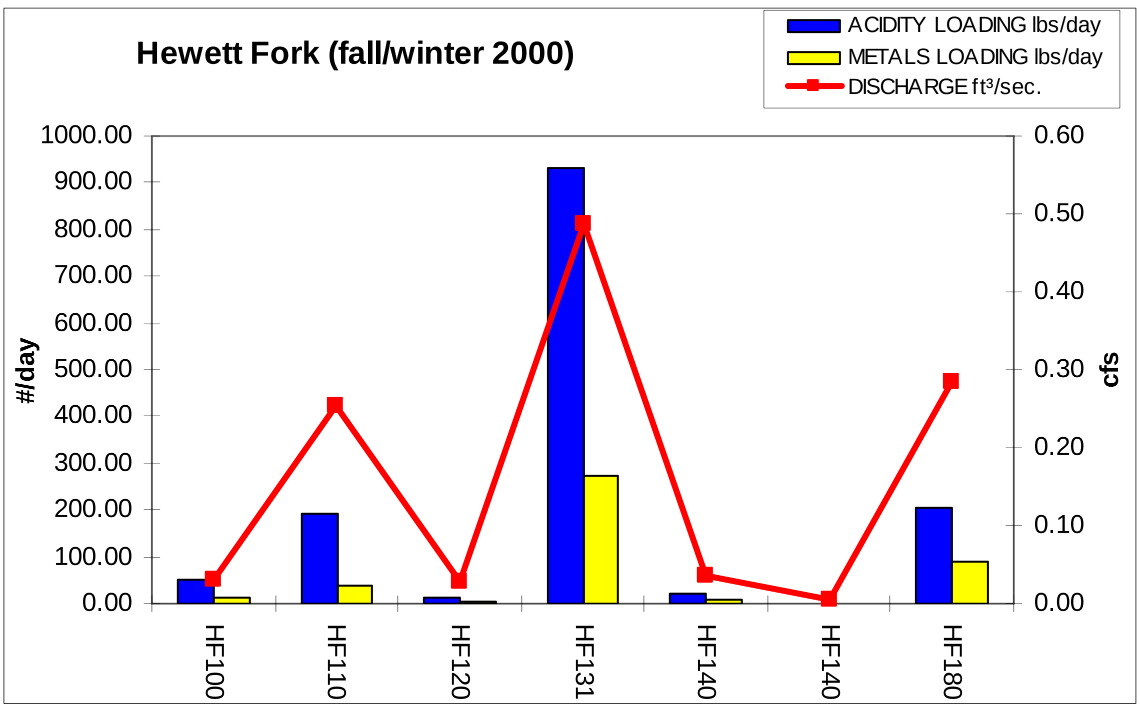


Sites HF 100, HF 110[17], HF 180 and HF 140 were sampled in August 2000. HF 120, HF 131, and HF 140 were sampled in December (Figure 47). The main acid contributor during this time frame was HF 131, the Carbondale Wetland. The wetland receives discharges from two

[17] New sample site for Trace Run closer to mouth of the stream.

mine portals year round that produce a significant acid and metal load. The site was the recipient of a reclamation effort by the Ohio Department of Natural Resources when a passive wetland treatment system was constructed. The system was one of the first attempts in the state to abate acid mine drainage through treatment. The system has been moderately successful in removing iron (approximately 60%) from the discharge of the mines. The project has been less successful in abating the acid load to the stream which continues to be the main acid contributor to Hewett Fork. Trace Run (HF 110) and the Connett Road area (HF 180) remained significant contributors through the fall, however, the contribution of HF 140 decreased because of low flow conditions during the sampling event.

Figure 47



<u>Recommendations:</u>

HF 131, the Carbondale Wetland, is already scheduled for the construction of a treatment project. The project is in the final design phase and construction is due to start in the summer of 2002 using funds from the Ohio EPA and ODNR Mineral Resources Management.

HF 110, Trace Run is the recipient of the discharge from the Kennard Mine portal and two associated seeps on the streambank along SR 56. The site has been reviewed and the suggested treatment option is to abate the acid load with the addition of a highly alkaline material upstream of the Kennard discharge. The alkaline recharge system will be followed by a series of rock channels and limestone check dams. Downstream of this system a Successive Alkaline Producing System (SAPS) will be constructed to treat the remaining acidity from the Kennard site and the associated seeps along SR 56.

HF 120, Carbondale Creek, was the site of a reclamation project in 1998 that reclaimed a large gob pile, closed some subsidence features, and revegetated the site, but it was not a project focused on water quality. Most of the site is under the ownership of the State of Ohio. An alkaline dosing unit to abate the acid load in HF 120 tributary may be a possible solution to increase the alkalinity discharge into Hewett Fork.

HF 140 is the site of the Dr. Dew reclamation project. This project provided some revegetation and recontouring of the land, but the intention was not to produce net alkaline water. The site was abandoned before regulatory programs were in place and reclaimed through Ohio's Abandon Mine Land Program. To abate the acid load will require alkaline additions through the use of open alkaline channels and alkaline recharge systems (leach beds and check dams).

The recommendation for site HF 180 involves further reconnaissance and water sampling. It is a large tributary with exposed gob piles and overburden, in addition to some auger mine seeps and a long network of beaver ponds.

Summary of Potential Treatment Sites:

Tributary #	Recommendation	Site Identification
HF 110 – Trace Run	Alkaline recharge system above Kennard Mine (HF114), followed by a series of rock channels and limestone check dams. Downstream of this a Successive Alkaline Producing System will be constructed to treat the remaining acidity from the Kennard site and the associated seeps (HF115, HF116) along SR 56	Trace run can be accessed by traveling east on SR 56 from its intersection with SR 278 in Hocking County
HF 120 – Carbondale Creek	Construct an alkaline dosing unit to abate the acid load in the HF 120 tributary and produce excess alkalinity to discharge into Hewett Fork	Carbondale Creek flows through the center of the community of Carbondale. The reclamation project and proposed treatment area can be accessed by traveling north out of Carbondale village on Mine Road
HF 131 – Carbondale Wetland	Remediation project currently under design. Construction spring 2002	The Carbondale wetland is located just east of the village of Carbondale along Carbondale Road
HF 140 – Dr. Dew	Alkaline addition through the use of open alkaline channels and alkaline recharge systems (leach beds and check dams	Accessible via the same Carbondale Road, Connett Road path as HF 180 except turning left onto Dr. Dew Road
HF 180 – Connett Road.	Further reconnaissance and water sampling	HF 180 can be accessed traveling east from Carbondale on Carbondale Road and turning left (northwest) onto Connett Road. HF 180 can be found by traveling on Connet just west of Willotte Road.

Mainstem from Lake Hope to Bolin Mills

Name: Mainstem from Lake Hope to Bolin Mills
Location: River Mile 92.5 to River Mile 80.6 (Bridge on US Route 50)
Quadrangle: Mineral, Vales Mill
Drainage Area: 25.57 Sq. Miles, 16368.08 Acres

Overview:

The MSBM section of the mainstem has no priority sites for AMD abatement.

Specific sites: None

Location/Access:

Sample site MSBM 010 is located just downstream of the Hewett Fork discharge in section 7 of Brown Township of Vinton County and can be accessed via Robinett Ridge Road. at the bridge over the mainstem of Raccoon Creek. MSBM 040 is the final downstream study site on the mainstem of Raccoon Creek and can be accessed via US Route 50 at the bridge over the creek in section 32 of Knox Township in Vinton County.

Water Quality: See Appendix A for the complete water quality database.

Proposed Treatment

Treatment Selection and Costs

Site	Cost	Notes
East Branch: **EB 191, 193, 194, 195, 200, 220, 240,260, 280.**	Limestone: $436,950 Revegetation: 22,990 Mobilization: 65,542 Design: 78,822 Monitoring: 15,480 Subtotal: $619,784	All of these East Branch sites will be receiving open alkaline channels. Cost has been developed into one lump sum Average cost of removal for one ton over the life of these projects: **$46.33/ton**
EB 162 **EB 169.4 (White House seep)** **EB 169**	Kiln dust: $300,136 Design: 45,024 Monitoring: 2,640 Kiln dust: 319,337 Design: 47,901 Monitoring: $2,640 Slag ARS: 40,566 Design: 6,084 Monitoring: 1,760 Subtotal: $766,188	Kiln Dust Injection into mine void and Slag ARS used together for basin approach in EB 160 tributary Average cost of removal for one ton of acid over the life of these projects: **$216.87/ton**
East Branch Total	$1,385,972	
West Branch: **WB 060, 070, 100**	Limestone: $149,575 Revegetation: 4,800 Mobilization: 23,156 Design: 38,629 Monitoring: 6160 Subtotal: $223,320	These West Branch sites will all be receiving open alkaline channels. . Cost has been developed into one lump sum Average cost of removal for one ton of acid over the life of these projects: **$39.98/ton**
WB 050 – Orland Gob Pile	$80,000	Cap toxic coal refuse, recontour for positive drainage and revegetate. **3.95/tons per year abated from West Branch**
West Branch Total	$303,320	
Mainstem to Brushy Creek: **MSBC 090, 110, 120**	Limestone: $28,975 Revegetation: 3,000 Mobilization: 4,796 Design: 9,193 Monitoring 5,280	All of these MSBC sites will be receiving open alkaline channels. Cost has been developed into one lump sum. Average cost of removal for one ton of acid over the life of these projects: **$35.15/tons**
MSBC total	$51,244	
Brushy Creek: **BC: 060, 070, 090, 111, 113, 114, 150**	Limestone: $406,965 Revegetation: 10,800 Mobilization: 61,089 Earthwork: 99,472 Design: 61,301 Monitoring: 9,680	All of these BC sites will be receiving open alkaline channels. Cost has been developed into one lump sum. Average cost of removal for one ton of acid over the life of these projects: **$58.10/ton**
Brushy Creek total	$649,307	

Site	Cost	Notes
Mainstem to Lake Hope **MSLH 121**	Limestone: $90,350 Revegetation: 3,000 Design: 16,102 Mobilization: 14,000 Monitoring: 2,640	MSLH site will be receiving open alkaline channels.
		Average cost of removal for one ton of acid over the life of this project: **$39.94/ton**
MSLH total	$126,092	
Hewett Fork:		
HF 114 **HF 115** **HF 116**	Slag ARS: $9840 Design: 2,460 Monitor: 1,760 SAPS: $190,708 Design: 28,606 Monitoring: 3,520 Subtotal: $ 236,624	Slag ARS above Kennard Seep, SAPS downstream to abate load from seeps at HF 115 and 116 SAPS
		Average cost of removal for one ton of acid over the life of these projects: **$55.29/ton**
HF 120	Kiln dust: $163,942 Design: 24,951 Monitoring: 3,520 Subtotal: $192,413	Alkaline Dosing Unit.
		Average cost of removal for one ton of acid over the life of this project: **$224.24/ton**
HF131	Carbondale wetland: $436,427	Currently in design; construction 2002. This includes both capital and 15 year maintenance and operation cost.
		Average cost of removal for one ton of acid over the life of this project: **$176.25/ton**
HF 140	Slag ARS: $96,432 Design: 14,465 Monitoring: 3,520 Subtotal: $114,417	Dr. Dew site
		Average cost of removal for one ton of acid over the life of this project: **$246.00/ton**
Hewett Fork Total:	$979,881	
Project Total:	$3,495,816	

Benefits and Cost Effectiveness

The benefits of eliminating acid mine drainage problems are difficult to quantify, although attempts have been made. Qualitatively, the benefits are ecological, aesthetic and economic. The economic impacts may be direct or indirect. Indirect benefits include diversity and abundance of fish and game for anglers and hunters, reduced erosion and siltation and consequent reduction of flood risks and downstream sedimentation. Direct economic benefits arise from restoration activities including increased tourism, recreation opportunities and increased property values.

In the thesis "Determining the Value of Improved Water Quality in the Hocking River Valley to Boaters and Fishers" by Ohio State University graduate student Allan Sommers, an attempt was made to place a value on water quality and the subsequent improvement of water quality to people who utilize the resource. Though the study did not occur in the Raccoon Creek Watershed it did occur in the Southeast Ohio region in a watershed directly north and adjacent to the Raccoon Creek Watershed.

The result of surveying fisherman showed that they do place value on the quality of water and it is reflected in the number of fishing trips that are taken. Sommers' thesis states that the current environmental quality provides an adjusted annual benefit of $1.45 million to fishers traveling to the Hocking River Valley. This is based on a benefit of $12.45 per trip. If an improvement in environmental quality were to occur the survey response indicated that the value of the average annual benefit would increase by $1.3 million (p. 100). The benefit can be translated into a willingness to pay for the improvements. And depending on what can be done to improve the water quality it could be viewed as a willingness to pay for reclamation or AMD abatement.

The Raccoon Creek Watershed does provide a viable fishery to the fishers of southeast Ohio. While stretches of the mainstem currently do not meet warmwater habitat designation much of it does and all sections have good fish habitat with fish populations migrating through. There is also the opportunity for both incremental and large improvements in the quality of the stream. The prioritized projects in this document cover those areas where the largest improvements could be seen with reclamation efforts.

From the confluence of the East and West Branches through river mile 98 the Ohio EPA lists the mainstem of Raccoon Creek as Limited Resource Water due to AMD (Figure 8 – back pocket). Projects in the East and West Branches, at MSBC 090,110, 120, and Brushy Creek will directly affect this 24 mile reach of the stream. Lake Hope State Park is one of the most popular fishing and recreation locations in Raccoon Creek. The project at MSLH 121 will directly affect the lake. The reach from the discharge of Lake Hope (river mile 98) to just upstream of Hewett Fork (river mile 84.1) is only partially meeting its warmwater habitat designation. The biologic communities go from poor to fair. The projects mentioned above will affect the upper stretch of this reach while the Hewett Fork projects should improve the lower section rated as fair. The remainder of the mainstream in the study area meets the warmwater habitat designation.

The cost effectiveness of reclamation can be measured by calculating pounds of acid removed per dollar spent. The overall abatement strategy in the Headwaters study area focuses on a sub-basin approach. For example, restoration efforts in the East Branch will have to implement all of the alkaline amendment channels in the EB 190 and the EB 200 tributary. Simply constructing an open limestone channel in EB 191 will not accomplish the expected out come. For that reason the cost for removing a pound of acid is based on subwatershed figures.

The alkaline amendment channels provide some of the most cost effective abatement measures for AMD treatment. As stated, the study proposes the application of this abatement strategy in several of the sub-basins in the Headwaters. Estimating the total tons of acid removed over the life of each project and dividing that total into the total construction cost of the project provides a dollar figure for the cost of one ton of acid removed over the life of the project. The MSBC projects scheduled for MSBC 090, 110, and 120 are the most cost effective at $35.15 per ton of acid removed, with a total removal of 1,046 tons. MSLH 121, with just one channel proposed, is next at $39.94 per ton, while removing 2,688 tons in total. The three channels proposed for the West Branch at WB 060, 070, 100 are third at $46.33 per ton, while removing 4,440 tons in total. The East Branch is fourth with nine proposed channels costing $46.33 per ton, however it is important to note that overall this project removes the largest acid load of 11,343 tons followed by the seven channels in Brushy Creek at $58.10 per ton that remove 9,954 tons.

The remaining treatment strategies are slightly different because of the level of maintenance required. For example, the alkaline dosing units and SAPS systems carry higher costs because of the associated maintenance costs that are built in over the life of the project. Hewett Fork has four unique projects scheduled. The most cost effective plan is the HF 114, 115, 116 combined alkaline recharge system/ SAPS project. The projected cost for one ton of acid removal for this treatment is $55.29 (3,267 tons removed.) The remaining projects scheduled for Hewett Fork are alkaline dosing units which require much more frequent attention. These projects are scheduled for HF 120, 131, and 140. The most cost effective is the Carbondale wetland, HF 131, $176.25 per ton (2,476 tons removed) followed by HF 120, $224.24 per ton (731 tons removed) and HF 140 at $246.00 per ton (392 tons removed.)

The only remaining project is in the East Branch where a more experimental technique of injection of alkaline material into a mine void is being proposed. The project should abate the acid load with the inclusion of an alkaline recharge system that will abate the acid loads from EB 162 and 169.4 at a cost of $216.87 (3,043 tons removed.) This project requires more exploration and design work before it could begin. This additional research could change our prediction of the cost effectiveness.

Funding Opportunities

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

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 government 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 other partners.

Office of Surface Mining (OSM), Reclamation and Enforcement

1) Appalachian Clean Streams Initiative: The mission of the 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 groups efforts to restore acid mine drainage impacted streams on a project basis.

Natural Resource Conservation Services

1) Conservation Reserve Program (CRP). CRP is a voluntary land retirement program designed to reduce erosion and protect environmentally sensitive lands with grass, trees, and other long term cover. Landowners bid for annual rental payments during a sign-up period. If selected, landowners contract their land for a ten year period. Cost-sharing of 50 percent is available.

2) Conservation Reserve Enhancement Program is a voluntary program that encourages farmers to enroll in CRP in contracts of 10 to 15 years. The State provides approximately 20 percent of the total program costs and the Federal Government provides 80 percent.
3) Environmental Quality Incentive Program assists in the conservation of structural, vegetative, and land management practices on eligible land. Five to ten-year contracts are made with eligible producers. Cost-share payments may be made to implement one or more eligible structural or vegetative practices, filter strips, tree planting, and permanent wildlife habitat. Incentive payments can be made to implement one or more land management practices.
4) Forestry Incentives Program (FIP) aides in tree planting, timber stand improvement, site preparation for natural regeneration, and other related activities.
5) Wetland Reserve Program This program is a voluntary program to restore wetlands. Participating landowners can establish conservation easements of either permanent or 30-year duration, or can enter into restoration cost-share agreements where no easement is involved. In exchange for establishing a permanent easement, the landowner receives payment up to the agricultural value of the land and 100 percent of the restoration costs for restoring the wetlands. The 30-year easement payment is 75 percent of what would be provided for a permanent easement on the same site and 75 percent of the restoration cost. The voluntary agreements are for a minimum ten year duration and provide for 75 percent of the cost of restoring the involved wetlands.
6) Rural Abandoned Mine Program (RAMP): This program provides technical and financial assistance to land users who voluntarily enter into five to ten year contracts for reclamation of up to 320 acres of eligible abandoned coal-mined lands and waters.

<u>Environmental Protection Agency</u>

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 resource 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 amount 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 principal 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 in groups involved in mitigating flood hazards and restoration of riparian ecosystems. Assistance is provided to assist in identifying sustainable solutions to flooding problems by examining nonstructural solutions in flood-prone areas, while retaining traditional measures where appropriate. Cost-share 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.

United States Fish and Wildlife Service

1) Partners for Fish and Wildlife Program: This program assists private landowners by providing technical and financial assistance to establish self-sustaining native habitats.
2) Clean Water Action Plan Fund: The purpose of this fund is to restore streams, riparian areas and wetlands resulting in direct and measurable water quality improvements.
3) Five Star Challenge Restoration Grants: The purpose of this program is to provide modest financial assistance to support community-based wetland and riparian restoration projects that build diverse partnerships and foster local natural source stewardship

Ohio Division of Wildlife

1) Wildlife Diversity Fund: This fund financially assists with research, surveys (biological or sociological), management, preservation, law enforcement, education, and land acquisition.

Lindbergh Foundation

1) Lindbergh Grants: This program financially assists organizations that are making significant contributions toward the balance between technology and nature through the conservation of natural resources. The Lindbergh Grants provides a maximum grant of

$10,580. The program is considered a provider of seed money and credibility for pilot projects that subsequently receive larger sums from other sources.

Turner Foundation

1) Water/Toxins Program: The program wants to protect rivers, lakes, wetlands, aquifers, oceans and other water systems from contamination, degradation, and other abuses; to stop the further degradation of water-dependent habitats from new dams, diversions and other large infrastructure projects; to reduce wasteful water use via conservation; to support efforts to improve public policies affecting water protection, including initiatives to secure pollution prevention and habitat protection.

The Acorn Foundation

1) The Acorn Foundation supports projects dedicated to building a sustainable future for the planet and to restoring a healthy global environment. The Acorn Foundation funds community-based projects which: preserve and restore habitats supporting biological diversity and wildlife; advocate for environmental justice, particularly in low-income and indigenous communities; and prevent or remedy toxic pollution.

Future Monitoring

Pre-construction monitoring

All proposed treatment options require intense, short-term, pre-design water quality sampling. Each site selected for treatment should receive monthly sampling for six months capturing high and low flows before entering into a design phase.

Post-construction monitoring

Performance of the AMD projects must be monitored for six months post construction for ODNR group I parameters. The monitoring needs to be done at the discharge of the treatment site. The upper portion of Hewett Fork is going to require quite a bit more reconnaissance work along with water quality monitoring to completely understand the complex problem created by the deep mining that has occurred in the watershed.

Long-term watershed monitoring

Long term monitoring for both biological and chemical parameters is required to develop a base of information to understand the effectiveness of the proposed AMD treatment and abatement strategies. Macroinvertebrate and fish assessment should be duplicated at headwaters sites every three to five years while restoration activities are occurring. A shorter frequency on the tributary sites (three years) and a longer (five year) frequency on the mainstem sites would be sufficient to develop the needed information. Water quality samples analyzed for ODNR group II parameters should be collected during these assessments.

Water samples and discharge measurements for water chemistry should be collected quarterly across the basin during restoration activities. Samples analyzed for group I parameters will be collected at: EB 010, WB 010 MSBC 010, MSBC 100, BC 010, MSLH 020, MSLH 130, HF 010, MSBM 010, MSBM 040.

Low priority sites

Some sites exhibit mild characteristics of AMD, or may have sample results that fluctuate between net acidic and net alkaline conditions. Other sites have net acidic discharges that are not high priority because they do not have a noticeable effect on the mainstem of Raccoon Creek. It is also possible that conditions were not conducive to allow a site to produce high acidic loads during this study. These types of sites should be considered for sampling on occasion to see if anything has changed. Also, if changes occur during long-term monitoring with no clear reason, sampling at the low priority sites may provide some clarity. A list of the low priority sites by sub watershed includes:

- East Branch: EB120, EB140, and EB180
- West Branch: WB080, WB110, WB120, WB130
- Mainstem to Brushy Creek: MSBC030, MSBC040
- Brushy Creek: BC130, BC 170
- Mainstem to Lake Hope: The wetlands that catch Bolster (MSLH091, Webb-Mine (MSLH060), and Coalmont Hollows (MSLH080), MSLH120 (Lake Hope), MSLH140 (Wheelabout Creek)
- Mainstem to Bolin Mills: Tedroe Run, Merrit Run

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APPENDIX A – COMPLETE WATER QUALITY DATABASE FOR THE STUDY AREA

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day negative value reflects alkaline load	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
EB010	3/27/2000	4.98	588.00	28.9700	30.80	1.56	4559.42	249.00	0.94	2.14	2.83	923.57
EB010	6/24/1996	4.49	507.00	25.3700	19.00	0.00	2594.52	271.00	0.70	2.59	3.28	899.12
EB010	11/15/2000	6.34	480.00	3.3640	7.33	19.10	-213.12	167.00	0.53	2.04	6.18	158.69
EB020	5/30/2000	5.37	106.00	0.0422	6.43	3.80	0.60	31.30	0.05	0.25	0.05	0.08
EB030	4/12/2000	6.55	179.00	0.5002	5.69	10.60	-13.22	51.00	1.88	1.51	0.37	10.15
EB030	9/25/2000	6.06	236.00	0.0532	2.87	14.90	-3.44	74.10	0.06	0.29	0.05	0.11
EB040	4/12/2000	6.32	197.00	2.7174	3.60	7.11	-51.34	57.60	1.86	1.38	0.36	52.83
EB040	9/25/2000	5.83	313.00	0.6255	5.12	13.50	-28.21	114.00	0.48	0.39	0.33	4.07
EB040	6/21/1996	6.59	156.00	2.6700	2.67	0.00	38.37	59.00	0.16	0.10	0.11	5.33
EB050	4/20/2000	6.79	194.00	0.0511	0.00	39.20	-10.78	28.30	0.85	0.66	0.05	0.43
EB060	4/20/2000	6.07	121.00	0.0526	5.87	5.74	0.04	27.20	0.72	0.47	0.05	0.35
EB060	10/3/2000			0.0000			0.00					0.00
EB070	4/20/2000	6.30	128.00	1.1420	8.72	9.03	-1.91	33.80	0.74	0.53	0.05	8.08
EB070	10/3/2000	6.38	238.00	0.0343	3.28	47.30	-8.12	51.90	0.42	0.35	0.36	0.21
EB080	6/20/1996	4.33	654.00	30.7600	64.00	0.00	10596.20	400.00	0.76	5.18	4.59	1747.22
EB090	4/12/2000	6.42	231.00	5.2777	4.12	11.50	-209.65	79.00	1.84	1.07	0.69	102.35
EB090	6/20/1996	6.49	202.00	7.7100	0.00	13.00	-539.49	84.00	0.38	0.37	0.46	50.32
EB091	6/20/1996	6.51	102.00	5.0900	0.00	8.00	-219.18	37.00	0.96	0.31	0.43	46.68
EB092	6/19/1996	6.99	364.00	7.3000	0.00	25.00	-982.31	150.00	0.25	0.90	0.89	80.33
EB100	4/20/2000	5.49	341.00	0.5202	8.77	2.14	18.56	130.00	0.57	0.29	0.35	3.40
EB100	10/3/2000			0.0000								0.00
EB110	4/21/2000	4.73	879.00	11.2514	60.70	0.65	3636.66	427.00	2.20	9.17	4.87	985.66
EB110	6/20/1996	3.85	849.00	18.7500	83.00	0.00	8376.51	470.00	1.57	7.43	6.70	1587.94
EB120	6/19/2026	4.86	721.00	2.3000	54.00	0.00	668.51	355.00	2.33	5.40	5.10	159.18
EB120	4/11/2000	4.70	981.00	0.6721	47.90	0.00	173.28	759.00	5.33	7.23	7.61	73.13
EB120	10/2/2000	4.34	1540.00	0.0832	49.30	0.00	22.08	955.00	1.78	7.94	15.30	11.23
EB121	10/2/2000	6.11	2000.00	0.0352	15.00	38.80	-4.51	1358.00	8.44	1.40	20.40	5.74
EB122	10/2/2000	3.18	1400.00	0.0476	130.00	0.00	33.29	743.00	1.04	19.70	13.30	8.73
EB130	6/20/1996	3.84	842.00	0.0000	82.00	0.00	0.00	500.00	1.57	7.92	6.40	0.00
EB140	4/21/2000	4.16	945.00	0.1520	88.70	0.00	72.57	499.00	1.03	10.10	4.84	13.09
EB140	10/3/2000	3.86	1200.00	0.0084	74.30	0.00	3.37	694.00	0.65	12.60	11.50	1.13
EB150	4/20/2000	4.72	880.00	9.6489	51.90	0.60	2664.27	435.00	2.50	8.14	4.50	788.02
EB160	6/19/1996	3.95	865.00	4.6600	85.00	0.00	2132.01	385.00	6.10	5.40	2.76	358.46

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day negative value reflects alkaline load	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
EB160	7/9/1996	2.90	2130.00	0.8900	345.00	0.00	1652.70	1341.00	28.20	25.50	7.40	293.34
EB160	4/11/2000	4.77	756.00	4.1934	32.10	0.46	714.15	353.00	4.33	5.91	2.22	281.85
EB160	9/25/2000	3.22	1210.00	0.7294	83.80	0.00	329.00	649.00	0.23	13.10	0.40	54.03
EB160	2/1/2001	5.21	572.00	5.754254	22.30	1.30	650.42	212.00	2.00	3.10	1.56	206.73
EB161	6/19/1996	4.83	1029.00	0.9050	50.00	0.00	243.56	580.00	0.49	3.40	2.72	32.27
EB161	2/1/2001	4.92	733.00	0.51565	16.80	2.40	39.97	347.00	0.63	1.56	1.76	10.98
EB162	7/3/1996	2.51	3720.00	0.0870	1476.00	0.00	691.18	2923.00	322.00	48.80	9.10	178.29
EB163	6/19/1996	3.97	749.00	1.9900	87.00	0.00	931.87	245.00	8.60	9.10	2.10	212.55
EB163	2/1/2001	4.78	502.00	1.56254	30.00	2.03	235.24	164.00	4.44	4.04	1.02	80.07
EB164	2/1/2001	4.77	1250.00	0.1300	49.40	2.38	32.90	710.00	0.53	7.88	6.17	10.23
EB165	2/1/2001	7.01	1080.00	0.1200	8.27	113.00	-67.65	4878.00	0.08	0.33	0.17	0.38
EB166	2/1/2001	3.48	1000.00	0.0130	137.00	0.00	9.59	421.00	4.42	15.10	5.47	1.75
EB167	2/1/2001	5.84	1280.00	0.0408	53.40	16.70	8.06	719.00	35.90	3.24	13.00	11.48
EB168	2/1/2001	5.15	292.00	0.1450	11.90	1.90	7.80	182.00	0.19	1.26	2.08	2.76
EB169	2/1/2001	6.30	180.00	0.2663	5.55	21.20	-22.44	42.00	0.48	0.69	0.29	2.11
EB169.1	2/1/2001	6.35	338.00	1.49676	6.35	26.40	-161.53	74.90	0.54	0.68	0.16	11.09
EB169.2	2/1/2001	6.33	231.00	0.0917	8.34	33.60	-12.47	231.00	0.30	0.50	0.22	0.50
EB169.3	2/1/2001	6.84	430.00	0.0917	5.30	47.20	-20.68	33.80	0.41	0.73	0.16	0.64
EB170	6/20/1996	4.08	795.00	12.9600	70.00	0.00	4883.00	414.00	0.83	7.42	7.20	1080.11
EB170	7/9/1996	3.99	1300.00	1.3800	123.00	0.00	913.62	808.00	0.44	13.50	14.10	208.73
EB180	4/20/2000	4.52	1080.00	0.1800	84.20	0.00	81.58	587.00	0.52	8.21	5.46	13.78
EB180	10/3/2000			0.0000								0.00
EB190	6/18/1996	4.28	1078.00	1.8140	131.00	0.00	1279.06	590.00	0.28	14.00	10.60	243.46
EB190	4/11/2000	4.67	1010.00	3.6469	58.60	0.00	1150.28	539.00	1.78	9.07	7.94	369.64
EB190	8/30/2000	4.29	1200.00	0.1870	84.00	0.00	84.55	701.00	0.15	12.40	15.10	27.89
EB190	2/19/2001	4.91	905.00	2.2742	50.30	1.83	593.32	533.00	0.51	2.61	8.21	139.03
EB191	6/18/1996	4.31	1233.00	0.5160	132.00	0.00	366.61	655.00	0.10	14.00	7.30	59.57
EB191	10/2/2000	3.98	1360.00	0.0182	56.40	0.00	5.53	802.00	0.15	8.83	6.75	1.55
EB191	2/19/2001	4.63	1010.00	0.1950	34.40	2.33	33.66	609.00	0.25	5.45	4.62	10.86
EB192	6/18/1996	4.06	1192.00	1.4800	158.00	0.00	1258.64	515.00	0.56	18.00	13.20	253.56
EB193	6/18/1996	3.78	1264.00	0.5300	199.00	0.00	567.69	635.00	0.40	21.00	17.70	111.79
EB193	10/2/2000	3.20	1410.00	0.0568	115.00	0.00	35.16	787.00	4.55	11.00	23.00	11.81
EB193	12/13/2000	3.88	1530.00	0.0119	115.00	0.00	7.37	938.00	2.74	14.40	26.50	2.80
EB193	2/19/2001	4.55	1090.00	0.2850	76.30	0.96	115.57	667.00	1.22	5.31	13.50	30.79

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day negative value reflects alkaline load	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
EB194	6/18/1996	4.01	1229.00	0.4440	152.00	0.00	363.25	550.00	0.40	17.00	12.20	70.89
EB194	2/19/2001	4.46	956.00	0.3430	61.80	0.00	114.09	572.00	0.75	3.91	9.86	26.86
EB195	12/15/2000	4.80	1300.00	0.0403	43.80	2.13	9.04	771.00	0.00	4.41	8.00	2.70
EB195	10/2/2000	4.23	1270.00	0.0107	42.20	0.00	2.44	727.00	0.12	5.55	6.46	0.70
EB195	2/19/2001	4.61	738.00	0.0713	43.30	2.03	15.84	410.00	0.34	6.06	5.66	4.64
EB196	12/13/2000	5.40	1590.00	0.0390	62.20	3.14	12.40	1004.00	18.50	4.69	10.60	7.11
EB196	10/2/2000	3.71	1410.00	0.0276	47.90	0.00	7.12	840.00	10.10	4.86	10.10	3.73
EB197	10/2/2000	6.10	1300.00	0.0069	4.59	25.80	-0.78	761.00	0.12	0.66	5.80	0.24
EB200	4/11/2000	4.56	1420.00	0.4226	106.00	0.00	241.13	676.00	6.05	16.40	10.80	75.80
EB200	8/30/2000	4.01	1650.00	0.0252	111.00	0.00	15.06	1004.00	0.14	16.20	15.10	4.27
EB200	2/6/2001	4.14	1330.00	0.0964	143.00	0.00	74.16	766.00	2.78	21.10	12.90	19.12
EB210	6/14/1996	4.19	845.00	5.1500	104.00	0.00	2882.86	280.00	2.20	12.00	6.70	580.61
EB210	4/20/2000	4.76	780.00	3.3321	55.60	0.85	981.94	375.00	2.61	9.01	4.97	298.19
EB220	5/30/2000	3.08	2120.00	0.1643	288.00	0.00	254.69	1317.00	7.08	37.10	22.40	59.01
EB220	8/30/2000	2.99	2380.00	0.0418	336.00	0.00	75.56	1465.00	9.98	41.20	25.30	17.24
EB220	2/6/2001	3.12	2080.00	0.1347	309.00	0.00	224.03	1251.00	6.99	37.30	23.40	49.18
EB230	6/14/1996	3.91	707.00	3.4200	98.00	0.00	1804.00	235.00	5.10	8.90	5.10	352.37
EB230	4/16/2000	3.94	905.00	1.3632	67.50	0.00	495.27	424.00	5.13	11.50	6.24	168.17
EB240	6/14/1996	3.35	1276.00	0.8230	201.00	0.00	890.39	560.00	3.80	19.00	10.90	149.61
EB240	4/16/2000	3.50	1380.00	0.3260	131.00	0.00	229.89	727.00	5.12	19.90	11.40	64.05
EB240	10/2/2000	3.17	1740.00	0.0224	157.00	0.00	18.93	1070.00	6.30	19.30	19.50	5.45
EB240	2/6/2001	3.46	1220.00	0.2230	110.00	0.00	132.03	654.00	2.72	15.30	10.50	34.31
EB250	6/14/1996	3.89	636.00	2.2500	79.00	0.00	956.74	315.00	5.40	7.60	4.51	212.52
EB260	5/30/2000	3.29	1020.00	0.0950	109.00	0.00	55.74	722.00	8.22	8.76	7.80	12.70
EB260	2/6/2001	3.48	905.00	0.0710	91.80	0.00	35.08	400.00	11.10	12.30	7.99	12.02
EB270	4/11/2000	5.88	461.00	2.2602	5.59	10.30	-57.30	157.00	3.73	2.74	1.74	100.10
EB280	4/16/2000	3.10	2070.00	0.0336	328.00	0.00	59.32	1218.00	15.30	41.20	15.50	13.05
EB280	8/31/2000	2.91	2210.00	0.0045	270.00	0.00	6.55	1268.00	8.68	32.30	22.60	1.55
EB280	2/6/2001	3.04	1830.00	0.0025	225.00	0.00	3.01	1045.00	9.75	27.60	14.70	0.70
EB290	4/16/2000	6.69	356.00	0.4604	0.00	29.80	-73.85	81.50	2.21	2.10	0.88	12.89
EB300	4/16/2000	5.56	603.00	0.0950	29.00	2.49	13.56	261.00	8.18	4.09	3.12	7.89
EB300	8/31/2000	6.27	655.00	0.0532	6.52	37.70	-8.93	181.00	1.41	0.53	2.62	1.31
EB310	4/11/2000	6.99	264.00	0.9793	0.00	37.60	-198.18	66.70	1.42	0.95	0.40	14.60
EB320	4/21/2000	5.72	77.00	0.0640	12.80	2.92	3.40	13.20	0.99	0.80	0.10	0.65

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day negative value reflects alkaline load	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
EB320	9/25/2000	6.37	308	0.0008	6.57	57.3	-0.21	33.8	1.34	0.577	1.61	0.01
WB010	6/21/1996	6.51	219.00	34.7700	0.00	17.00	-3181.54	72.00	0.55	0.18	1.50	418.26
WB010	3/27/2000	6.13	277.00	27.5300	10.30	8.02	337.85	84.00	0.79	0.25	1.23	336.81
WB010	11/15/2000	5.31	819.00	2.2790	22.50	2.26	248.28	412.00	0.22	0.17	3.05	42.33
WB020	5/16/2000	7.00	450.00	0.0064	0.00	106.00	-3.67	54.30	0.40	0.34	0.69	0.05
WB030	5/16/2000	6.88	246.00	0.0639	0.00	24.30	-8.36	77.40	0.41	0.30	0.64	0.46
WB040	6/24/1996	6.82	182	14.41	0	27	-2094.17	49	0.33	0.10	0.23	51.30
WB040	5/16/2000	6.88	245.00	0.7964	0.00	38.10	-163.32	52.70	0.35	0.48	0.14	4.17
WB050	5/16/2000	7.00	450.00	0.0064	0.00	106.00	-3.67	54.30	0.40	0.34	0.69	0.05
WB050	10/3/2000	2.63	959.00	0.0200	201.00	0.00	21.64	328.00	24.60	17.50	2.67	4.83
WB060	6/24/1996	4.88	250.00	9.1300	14.00	0.00	687.99	104.00	0.25	0.99	1.43	131.50
WB060	5/17/2000	3.35	1410.00	0.0950	168.00	0.00	85.90	749.00	1.18	14.60	33.70	25.36
WB060	10/3/2000	3.11	696.00	0.0088	116.00	0.00	5.47	329.00	0.19	19.60	8.10	1.32
WB070	6/24/1996	3.22	388.00	0.1560	72.00	0.00	60.46	170.00	0.48	2.96	6.20	8.11
WB070	5/16/2000	3.74	477.00	0.0089	62.90	0.00	3.01	187.00	0.32	9.16	3.60	0.63
WB070	10/16/2000	3.26	1630.00	0.0520	236.00	0.00	66.00	955.00	1.45	23.60	43.40	19.19
WB078	6/25/1996	5.12	266.00	5.9200	0.00	7.00	-223.05	119.00	0.13	1.14	1.72	95.48
WB080	5/16/2000	5.34	560.00	0.0106	19.30	3.40	0.91	180.00	0.35	5.35	4.25	0.57
WB080	10/3/2000	5.50	454.00	0.0046	9.75	26.40	-0.42	98.00	0.07	0.46	0.20	0.02
WB090	5/22/2000	6.19	227.00	0.1080	0.00	8.02	-4.66	76.60	0.05	0.25	0.05	0.20
WB095	6/25/1996	5.40	286.00	3.7500	0.00	8.00	-161.47	121.00	0.09	1.47	1.67	65.34
WB100	7/15/1996	3.59	727.00	0.0830	153.00	0.00	68.35	325.00	0.81	17.60	13.30	14.20
WB100	5/17/2000	3.81	830.00	0.0383	185.00	0.00	38.14	479.00	0.34	26.70	13.70	8.42
WB100	10/3/2000	3.24	1340.00	0.0144	319.00	0.00	24.73	840.00	0.85	51.10	28.90	6.28
WB110	7/15/1996	4.35	431.00	0.1700	50.00	0.00	45.75	184.00	0.07	2.93	4.29	6.69
WB110	5/22/2000	4.54	503.00	0.0371	54.20	0.00	10.83	227.00	0.25	8.24	4.95	2.69
WB110	10/3/2000	4.38	628.00	0.0060	40.70	0.00	1.31	271.00	0.11	8.02	7.74	0.51
WB115	6/25/1996	5.63	275.00	2.3900	0.00	19.00	-244.42	110.00	0.06	0.16	0.70	11.86
WB120	5/22/2000	6.83	420.00	0.2850	0.00	32.80	-50.32	109.00	0.05	0.25	0.05	0.54
WB130	6/5/2000	4.32	262.00	0.0342	23.30	0.00	4.29	102.00	0.05	2.72	1.89	0.86
WB140	5/22/2000	6.86	220.00	0.0511	0.00	25.30	-6.96	72.40	0.05	0.25	0.05	0.10
WB150	5/22/2000	6.56	158.00	0.0608	1.49	7.44	-1.95	44.50	0.05	0.25	0.05	0.11
WB160	6/5/2000	6.34	478.00	0.2230	2.21	20.80	-22.31	163.00	0.14	0.26	3.75	5.00
WB170	10/16/2000	5.54	878.00	0.0350	18.00	7.25	2.02	445.00	2.10	0.59	17.80	3.87

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day negative value reflects alkaline load	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
MSBC010	11/16/2000	6.11	671.00	7.5028	9.99	9.12	35.13	300.00	0.32	1.35	5.00	269.79
MSBC010	3/27/2001	5.43	370.00	15.3782	9.28	3.90	445.32	161.00	0.85	1.54	2.16	377.11
MSBC020	3/28/2000	6.69	317.00	7.1280	0.00	19.80	-759.66	92.20	0.63	0.25	0.29	45.03
MSBC025	6/28/1996	6.25	494.00	2.0300	0.00	29.00	-316.87	186.00	0.73	0.63	1.34	29.57
MSBC030	6/26/2000	6.52	105.00	0.0667	39.60	32.80	2.44	26.30	2.54	0.25	1.15	1.42
MSBC030	10/26/2000	6.36	103.00	0.0601	9.04	27.20	-5.87	17.30	0.54	0.45	0.10	0.35
MSBC040	6/26/2000	5.89	130.00	0.0168	14.80	7.85	0.63	34.60	0.25	0.25	0.52	0.09
MSBC040	10/26/2000	6.01	166.00	0.0109	15.70	12.50	0.19	49.40	0.17	0.37	0.20	0.04
MSBC050	6/26/2000	6.58	300.00	0.0055	6.51	17.60	-0.33	70.80	0.05	0.25	0.05	0.01
MSBC050	10/26/2000	6.42	601.00	0.0030	9.68	40.40	-0.50	160.00	0.07	0.38	0.06	0.01
MSBC060	7/11/2000	6.66	306.00	0.0016	12.00	88.90	-0.64	26.30	2.44	0.25	10.70	0.11
MSBC060	10/26/2000	6.46	287.00	0.0024	19.40	59.00	-0.52	50.20	1.78	0.38	1.57	0.05
MSBC070	7/11/2000	6.61	209.00	0.0046	7.52	18.80	-0.28	48.60	0.91	0.25	1.17	0.06
MSBC070	10/26/2000	6.73	245.00	0.0066	7.82	24.30	-0.58	54.30	2.59	0.49	0.91	0.14
MSBC080	6/26/2000	7.27	1340.00	0.0021	9.28	109.00	-1.14	425.00	0.06	0.25	0.06	0.00
MSBC080	10/26/2000	6.76	1580.00	0.0099	10.90	106.00	-5.04	536.00	0.05	0.38	0.05	0.03
MSBC090	6/28/1996	4.45	574.00	0.4240	17.00	0.00	38.80	239.00	1.03	1.52	6.90	21.61
MSBC090	6/26/2000	5.13	888.00	0.0310	29.60	2.28	4.56	443.00	0.33	1.87	12.70	2.49
MSBC090	10/25/2000	4.28	1070.00	0.1630	86.00	0.00	75.45	597.00	0.43	7.50	16.40	21.39
msbc091	10/25/2000	4.59	1260.00	0.0601	94.70	1.58	30.12	735.00	0.21	8.31	19.10	8.95
msbc092	10/25/2000	3.70	794.00	0.0917	64.20	0.00	31.69	390.00	0.51	6.52	12.70	9.76
MSBC100	7/22/1996	4.80	723.00	10.2200	19.00	0.00	1045.17	356.00	0.37	0.82	4.83	331.88
MSBC100	4/25/2000	6.27	418.00	48.5635	5.57	5.16	107.17	148.00	0.38	0.60	2.35	872.61
MSBC100	3/27/2001	5.89	326.00	27.6102	7.04	6.61	63.90	149.00	0.66	0.46	1.80	434.90
MSBC110	6/28/2000	3.38	1410.00	0.0468	85.70	0.00	21.59	724.00	2.43	6.62	13.80	5.77
MSBC110	10/25/2000	3.10	2440.00	0.0468	180.00	0.00	45.34	1457.00	4.51	20.60	23.30	12.22
MSBC120	6/28/2000	2.87	2160.00	0.1100	268.00	0.00	158.68	1227.00	4.89	26.90	30.90	37.20
MSBC120	10/25/2000	2.75	2450.00	0.09	347.00	0.00	171.27	1498.00	5.03	36.90	35.90	38.50
BC010	7/1/1996	5.51	266.00	7.7600	0.00	10.00	-417.68	98.00	0.65	0.19	2.07	121.81
BC010	3/27/2000	6.03	225.00	40.4311	11.30	6.23	1103.33	57.60	1.17	0.25	1.04	536.52
BC010	11//15/00	4.72	589.00	0.0000	37.00	0.64	0.00	252.00	0.20	3.67	7.86	0.00
BC012	11/20/2000	6.52	468.00	0.0740	8.34	108.00	-39.70	50.20	0.96	0.17	0.73	0.74
BC013	11/20/2000	4.47	470.00	1.5220	27.20	2.40	203.17	183.00	0.91	2.40	4.87	67.18
BC013	2/21/2001	5.83	225.00	18.0399	10.50	6.60	378.69	74.90	1.06	1.55	1.47	397.03

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BC020	11/20/2000	6.98	246.00	0.1520	6.60	44.70	-31.17	37.00	0.45	0.00	0.10	0.45
BC030	6/21/2000	6.43	3445.00	0.0105	6.64	34.00	-1.55	82.30	0.52	0.25	0.84	0.09
BC040	7/16/1996	6.69	147.00	0.5000	0.00	35.00	-94.19	20.00	0.51	0.14	0.05	1.89
BC050	7/1/1996	3.25	498.00	3.2800	50.00	0.00	882.73	227.00	6.90	2.09	4.44	237.62
BC060	6/21/2000	2.74	3410.00	0.0300	1248.00	0.00	201.52	2363.00	403.00	59.40	35.80	80.62
BC060	10/18/2000	1.80	14700.00	0.0208	3088.00	0.00	345.72	2066.00	180.00	45.10	35.40	29.23
BC060	2/21/2001	2.68	2180.00	0.9910	635.00	0.00	3387.12	1391.00	202.00	31.90	22.50	1370.65
BC070	6/21/2000	2.85	1790.00	0.0751	191.00	0.00	77.21	831.00	3.12	18.60	20.50	17.10
BC070	10/18/2000	2.91	2150.00	0.0674	265.00	0.00	96.14	1144.00	7.58	19.40	26.40	19.41
BC070	2/28/2001	3.02	1350.00	0.7800	242.00	0.00	1016.00	823.00	8.11	25.70	22.10	235.24
BC080	6/7/2000	6.80	188.00	0.0751	0.00	66.20	-26.76	20.60	2.16	0.25	2.36	1.93
BC090	7/1/1996	3.19	1159.00	0.1300	119.00	0.00	83.27	650.00	3.43	13.80	18.10	24.78
BC090	6/21/2000	2.95	1480.00	0.1870	171.00	0.00	172.12	687.00	3.16	16.20	17.50	37.18
BC090	10/18/2000	2.97	2220.00	0.0532	317.00	0.00	90.77	1292.00	11.10	27.50	33.40	20.66
BC090	2/21/2001	2.99	893.00	0.1860	139.00	0.00	139.16	480.00	5.12	17.50	11.50	34.23
BC095	10/25/2000	2.89	1720.00	0.0128	219.00	0.00	15.05	763.00	8.62	10.20	41.90	4.18
BC100	6/7/2000	6.19	113.00	0.0168	0.79	25.10	-2.20	19.80	1.09	0.25	0.56	0.17
BC110	7/1/1996	3.29	520.00	1.0300	42.00	0.00	232.85	240.00	2.27	3.33	6.90	69.45
BC110	6/7/2000	3.68	564.00	0.5780	51.40	0.00	159.91	220.00	1.30	5.23	9.03	48.51
BC110	10/24/2000	3.38	681.00	0.1300	75.70	0.00	52.97	293.00	2.05	6.67	12.20	14.67
BC110	2/21/2001	3.79	384.00	1.8260	57.20	0.00	562.19	184.00	0.60	7.72	4.24	123.71
BC111	7/16/1996	4.79	335.00	0.0920	20.00	0.00	9.90	107.00	0.97	1.44	4.29	3.33
BC111	10/24/2000	4.82	363.00	0.0065	31.60	2.80	1.00	146.00	0.31	2.12	3.94	0.22
BC112	7/16/1996	3.39	809.00	0.1530	166.00	0.00	136.70	294.00	2.59	18.20	11.00	26.24
BC113	7/16/1996	3.28	1781.00	0.0600	394.00	0.00	127.24	1260.00	1.91	46.30	19.40	21.88
BC113	10/24/2000	3.04	1060.00	0.0240	238.00	0.00	30.74	497.00	3.31	28.90	14.50	6.05
BC114	10/24/2000	3.34	489.00	0.0169	74.50	0.00	6.77	184.00	2.22	8.57	4.93	1.43
BC120	6/7/2000	5.59	197.00	0.1220	0.00	38.20	-25.08	24.70	0.06	0.25	0.05	0.23
BC130	6/25/1996	5.53	193.00	6.9700	0.00	15.00	-562.74	68.00	0.76	0.51	2.23	131.59
BC130	6/7/2000	5.79	374.00	0.3699	14.30	8.68	11.19	121.00	0.10	0.25	4.38	9.43
BC130	2/28/2001	6.09	228.00	1.9830	8.99	2.95	64.47	92.20	0.44	1.39	2.68	48.20
BC140	6/21/2000	6.75	532.00	0.0078	5.02	63.20	-2.46	59.30	0.07	0.31	0.70	0.05
BC140	10/18/2000	6.99	628.00	0.0021	9.37	72.90	-0.71	628.00	0.40	0.10	1.10	0.02
BC150	7/16/1996	2.81	2500.00	0.0310	1019.00	0.00	170.03	1701.00	61.00	103.00	79.00	40.64

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day negative value reflects alkaline load	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
BC150	10/25/2000	3.00	1860.00	0.0266	324.00	0.00	46.42	980.00	4.74	38.00	43.80	12.43
BC151	6/7/2000	3.01	2010.00	0.0172	620.00	0.00	57.37	1284.00	78.70	74.30	50.20	18.84
BC151	10/25/2000	2.91	2090.00	0.0113	636.00	0.00	38.58	1375.00	5.97	74.40	48.80	7.85
BC160	10/18/2000	7.15	160.00	0.1055	10.30	30.20	-11.30	24.70	0.23	0.11	0.23	0.32
BC170	7/11/2000	5.11	279.00	1.1800	13.60	0.00	86.38	114.00	0.28	0.83	4.27	34.21
BC180	6/25/1996	4.08	226.00	1.0200	33.00	0.00	181.17	96.00	0.45	2.95	3.27	36.70
BC180	10/16/2000	5.49	209.00	0.0233	15.10	7.33	0.97	86.40	0.36	1.34	3.41	0.64
MSLH010	7/1/1996	6.39	621.00	0.0420	0.00	31.00	-7.01	302.00	2.08	0.39	8.60	2.51
MSLH010	6/28/2000	5.98	693.00	0.0048	20.40	23.00	-0.07	333.00	0.78	0.25	11.40	0.32
MSLH020	7/17/1996	4.32	870.00	14.2000	63.00	0.00	4815.18	347.00	0.41	4.75	7.10	939.10
MSLH020	4/24/2000	6.26	382.00	378.3730	5.53	5.14	794.27	143.00	0.18	0.61	2.32	6353.80
MSLH020	11/14/2000	5.81	749.00	12.9690	17.60	3.54	981.47	366.00	0.13	2.02	6.08	576.04
MSLH020	3/27/2001	5.82	268.00	29.3078	6.27	6.03	37.86	135.00	0.77	0.46	1.84	485.03
MSLH030	7/1/1996	2.91	2360.00	0.1900	179.00	0.00	183.06	1447.00	7.80	16.50	35.20	60.98
MSLH030	6/28/2000	3.03	2560.00	0.0674	219.00	0.00	79.45	1572.00	6.64	15.10	37.30	21.47
MSLH040	7/9/2000	6.03	649.00	0.0062	18.30	12.30	0.20	244.00	3.88	0.39	4.51	0.29
MSLH040	10/30/2000	5.48	818.00	0.0230	10.50	19.40	-1.10	344.00	1.16	1.17	5.46	0.97
MSLH050	7/1/1996	5.62	433.00	76.3000	0.00	8.00	-3285.48	207	0.27	0.10	3.08	1419.96
MSLH060	7/1/1996	3.01	782.00	0.2280	110.00	0.00	134.99	405.00	1.96	10.90	2.49	18.88
MSLH060	7/5/2000	3.27	910.00	0.1410	132.00	0.00	100.18	392.00	1.53	15.10	2.51	14.56
MSLH060	10/30/2000	3.08	738.00	0.0532	114.00	0.00	32.64	373.00	0.44	22.30	3.46	7.52
MSLH070	7/5/2000	5.89	172.00	0.0047	11.00	13.70	-0.07	56.00	2.56	2.58	1.97	0.18
MSLH070	10/30/2000	3.04	525.00	0.0000	56.30	0.00	0.00	183.00	4.17	14.40	2.50	0.00
MSLH 080	7/2/1996	3.25	352.00	0.1040	40.00	0.00	22.39	107.00	3.39	1.91	1.51	3.82
MSLH080	7/5/2000	3.66	369.00	0.0000	48.00	0.00	0.00	123.00	10.20	1.50	1.87	0.00
MSLH080	10/30/2000	5.52	352.00	0.0000	33.20	22.80	0.00	118.00	12.70	1.36	3.17	0.00
MSLH090	11/13/2000	6.82	234.00	0.0066	27.10	86.40	-2.09	24.50	27.60	0.81	8.54	1.31
MSLH091	7/2/1996	5.89	207.00	0.1450	10.00	0.00	7.80	95.00	7.00	0.88	2.49	8.11
MSLH091	7/5/2000	3.76	446.00	0.0000	36.30	0.00	0.00	165.00	1.15	0.25	1.83	0.00
MSLH091	10/30/2000	6.75	209.00	0.0000	7.63	31.40	0.00	32.10	0.89	1.03	0.40	0.00
MSLH100	7/12/2000	6.56	343.00	0.0087	13.30	56.80	-2.04	51.00	3.11	0.26	5.98	0.44
MSLH100	10/30/2000	5.81	177.00	0.0000	7.26	12.20	0.00	64.20	0.87	0.99	3.02	0.00
MSLH110	7/9/2000	6.60	278.00	0.0017	13.50	59.80	-0.41	51.90	1.49	0.36	2.09	0.04
MSLH110	11/13/2000	6.66	284.00	0.0832	9.04	44.00	-15.66	73.30	0.43	0.33	0.59	0.60

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day negative value reflects alkaline load	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
MSLH120	3/28/2000	6.33	116.00	18.9730	14.60	5.91	887.44	29.60	0.72	0.25	0.12	111.35
MSLH121	6/27/1996	5.63	205.00	2.0100	28.00	0.00	302.93	74.00	0.59	0.10	0.82	16.37
MSLH122	6/27/1996	4.13	272.00	0.4230	16.00	0.00	36.43	127.00	1.71	0.51	1.52	8.53
MSLH122	7/17/1996	3.60	414.00	0.1650	23.00	0.00	20.43	181.00	0.79	0.81	2.28	3.45
MSLH130	6/27/1996	5.97	308.00	73.6000	0.00	12.00	-4753.82	129.00	0.48	0.11	2.04	1044.16
MSLH130	4/10/2000	6.10	247.00	151.9790	22.70	2.89	16205.10	77.40	1.62	1.17	1.33	3377.65
MSLH130	11/14/00	6.60	715.00	0.00	8.40	9.58	0.00	333.00	0.25	0.72	4.53	0.00
MSLH130	36969.00	6.42	289.00	68.56	7.03	8.43	-516.65	106.00	0.28	0.31	1.41	740.05
MSLH140	7/17/1996	6.70	288.00	0.7100	0.00	23.00	-87.90	83.00	3.84	0.33	0.80	19.03
MSLH140	3/28/2000	6.63	214.00	10.7977	18.90	13.40	319.65	56.00	0.60	0.25	0.22	62.61
MSLH150	6/28/2000	6.10	873.00	0.0113	15.10	18.10	-0.18	455.00	0.77	0.25	6.14	0.44
MSLH151	7/9/2000	6.97	776.00	0.0015	7.99	75.90	-0.53	261.00	1.32	0.72	3.66	0.04
HF010	6/28/1996	4.10	492.00	14.8000	33.00	0.00	2628.81	234.00	0.58	4.69	2.89	651.46
HF010	3/27/2000	6.21	257.00	46.3764	11.00	11.90	-224.66	81.50	0.78	0.25	0.50	382.51
HF010	8/21/2000	5.96	408.00	1.1831	6.82	3.75	19.55	167.00	0.19	0.74	1.87	17.90
HF020	6/28/1996	3.85	530.00	13.6000	85.00	0.00	6222.16	246.00	1.01	5.38	2.88	680.07
HF030	6/26/1996	5.69	125	1.32	0	23	-163.41	33	2.42	0.36	1.39	29.69
HF031	5/1/2000	6.49	103.00	1.6151	13.30	16.00	-23.47	32.10	0.98	0.36	0.56	16.57
HF040	4/30/2000	6.71	192.00	2.4790	0.00	44.50	-593.77	23.00	0.34	0.44	0.31	14.59
HF050	4/30/2000	6.94	269.00	1.5271	0.00	63.40	-521.12	34.60	0.19	0.41	0.17	6.35
HF060	7/18/1996	3.49	621.00	10.8000	48.00	0.00	2790.29	263.00	2.04	3.69	2.99	508.01
HF070	5/1/2000	5.68	34.60	1.5462	13.90	14.80	-7.49	29.60	1.98	0.40	0.89	27.31
HF080	4/30/2000	6.74	206.00	1.2552	0.00	49.10	-331.71	33.80	0.26	0.29	0.27	5.57
HF090	3/27/2000	4.53	384.00	28.8437	35.40	0.00	5495.89	141.00	4.88	0.93	1.10	1075.13
HF090	8/21/2000	3.33	914.00	1.9635	88.20	0.00	932.14	399.00	2.60	8.53	3.00	149.66
HF090	11/20/2000	6.86	194.00	21.6320	4.83	64.90	-6994.20	20.60	0.22	0.13	0.00	39.91
HF099	6/26/1996	2.83	1015.00	10.9000	140.00	0.00	8213.69	467.00	21.70	8.67	4.23	2034.40
HF100	4/30/2000	3.12	1660.00	0.0366	440.00	0.00	86.66	914.00	65.80	0.25	2.87	13.60
HF100	9/27/2000	2.90	1510.00	0.0295	336.00	0.00	53.35	819.00	46.90	30.40	2.63	12.72
HF110	4/10/2000	3.68	558.00	2.7570	63.30	0.00	939.34	173.00	19.80	0.48	0.99	316.30
HF110	8/30/2000	2.97	1230.00	0.2550	140.00	0.00	192.16	482.00	14.10	9.98	4.13	38.80
HF111	6/26/1996	6.43	120.00	0.4760	0.00	12.00	-30.74	43.00	1.84	0.10	1.04	7.65
HF112	6/26/1996	2.58	1913.00	1.4700	465.00	0.00	3679.20	1031.00	128.00	24.90	4.43	1247.56
HF112	3/30/2000	3.67	828.00	0.9269	108.00	0.00	538.82	261.00	35.60	1.50	1.43	192.65

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
HF113	7/18/1996	2.81	1845.00	0.8000	413.00	0.00	1778.38	935.00	118.00	15.10	4.30	592.94
HF114	9/27/2000	3.81	3010.00	0.0276	1327.00	0.00	197.13	2453.00	567.00	49.60	7.74	92.95
HF114	12/5/2000	3.59	3130.00	0.0000	1380.00	0.00	0.00	2577.00	579.00	49.10	7.65	0.00
HF115	12/5/2000	2.99	1540.00	0.1630	221.00	0.00	193.89	698.00	37.50	11.50	3.62	46.27
HF116	12/5/2000	3.32	3750.00	0.0000	1074.00	0.00	0.00	2774.00	525.00	9.42	7.56	0.00
HF120	6/21/1996	3.08	614.00	2.0700	109.00	0.00	1214.45	322.00	9.80	8.97	0.97	220.42
HF120	4/26/2000	3.90	341.00	1.5158	43.40	0.00	354.08	129.00	7.95	4.22	1.50	111.77
HF120	12/11/2000	2.70	672.00	0.0285	90.50	0.00	13.88	283.00	7.54	15.10	1.05	3.64
HF121	4/26/2000	5.96	109.00	0.0950	2.96	14.80	-6.05	23.00	0.23	0.25	1.09	0.80
HF130	6/21/1996	5.52	374.00	11.3000	0.00	6.00	-364.93	192.00	1.12	0.65	2.61	266.98
HF130	12/11/2000	3.25	658.00	0.0000	25.30	0.00	0.00	294.00	4.47	4.86	2.74	0.00
HF131	12/11/2000	2.46	1860.00	0.4880	354.00	0.00	929.84	1062.00	65.60	32.10	6.94	275.46
HF131	6/21/1996	2.85	1957.00	1.6900	295.00	0.00	2683.44	1200.00	21.70	19.80	8.80	458.55
HF140	6/13/1996	3.13	1351.00	5.4300	368.00	0.00	10755.52	635.00	3.04	22.00	6.20	915.05
HF140	4/26/2000	3.42	684.00	0.4996	66.60	0.00	179.09	274.00	12.20	5.16	2.88	54.55
HF140	8/21/2000	3.60	885.00	0.0352	106.00	0.00	20.08	441.00	26.70	6.27	3.46	6.92
HF140	12/11/2000	3.69	846.00	0.0056	70.20	0.00	2.11	437.00	27.90	11.30	4.56	1.32
HF150	6/13/1996	4.03	555.00	0.3590	80.00	0.00	154.59	105.00	2.13	3.90	2.89	17.27
HF150	4/26/2000	6.17	291.00	7.4218	2.00	18.70	-667.13	94.70	2.95	0.40	1.87	209.14
HF150	8/30/2000	5.30	570.00	0.6121	39.20	0.00	129.15	271.00	12.20	0.88	2.92	52.84
HF160	4/26/2000	6.24	220.00	6.3590	0.00	18.90	-646.89	89.70	2.01	0.66	1.69	149.52
HF170	4/25/2000	7.51	226.00	2.1528	0.00	30.50	-353.41	43.60	0.16	0.46	0.64	14.57
HF180	6/13/1996	3.37	593.00	8.3400	125.00	0.00	5611.25	185.00	6.90	7.40	2.55	758.05
HF180	3/30/2000	4.44	444.00	1.7214	43.80	0.00	405.83	156.00	6.16	2.26	2.54	101.77
HF180	8/21/2000	4.25	810.00	0.2850	135.00	0.00	207.09	419.00	49.00	4.32	4.25	88.51
HF190	6/26/1996	3.08	809.00	7.7800	91.00	0.00	3810.70	405.00	5.90	6.71	4.37	712.61
MSBM010	6/27/1996	5.68	318.00	89.6700	0.00	6.00	-2895.89	144.00	0.44	0.76	2.06	1576.88
MSBM010	4/10/2000	6.12	270.00	188.5300	21.60	8.46	13333.97	78.20	1.60	1.09	1.19	3945.90
MSBM010	11/14/2000	6.1	675	0	9.29	8.23	0.00	317	0.315	1.01	3.67	0.00
MSBM010	3/19/2001	6.52	281	95.1347	7.73	11	-1674.44	94.7	0.493	0.406	1.18	1066.91
MSBM020	5/1/2000	6.62	168.00	0.2520	0.00	32.90	-44.63	38.70	0.70	0.42	0.77	2.56
MSBM030	7/17/1996	6.90	284.00	0.4400	0.00	66.00	-156.31	50.00	1.12	0.32	0.19	3.87
MSBM030	4/30/2000	7.09	254.00	2.2549	0.00	59.50	-722.16	34.60	0.12	0.46	0.13	8.61
MSBM040	7/2/1996	4.39	468.00	76.3000	23.00	0.00	9445.74	192.00	0.99	1.93	2.95	2416.00
MSBM040	11/15/2000	6.13	659	0	4.36	8.3	0.00	321	0.242	0.629	3.54	0.00
MSBM040	3/19/2001	6.57	286	148.395	7.29	13	-4560.77908	95.5	0.495	0.411	1.15	1645.80

APPENDIX B – WATER QUALITY TABLES FOR PROPOSED TREATMENT SITES

Table 1 - Water quality for proposed treatment sites in East Branch

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
EB191	6/18/1996	4.31	1233.00	0.5160	132.00	0.00	366.61	655.00	0.10	14.00	7.30	59.57
EB191	10/2/2000	3.98	1360.00	0.0182	56.40	0.00	5.53	802.00	0.15	8.83	6.75	1.55
EB191	2/19/2001	4.63	1010.00	0.1950	34.40	2.33	33.66	609.00	0.25	5.45	4.62	10.86
EB193	6/18/1996	3.78	1264.00	0.5300	199.00	0.00	567.69	635.00	0.40	21.00	17.70	111.79
EB193	10/2/2000	3.20	1410.00	0.0568	115.00	0.00	35.16	787.00	4.55	11.00	23.00	11.81
EB193	12/13/2000	3.88	1530.00	0.0119	115.00	0.00	7.37	938.00	2.74	14.40	26.50	2.80
EB193	2/19/2001	4.55	1090.00	0.2850	76.30	0.96	115.57	667.00	1.22	5.31	13.50	30.79
EB194	6/18/1996	4.01	1229.00	0.4440	152.00	0.00	363.25	550.00	0.40	17.00	12.20	70.89
EB194	2/19/2001	4.46	956.00	0.3430	61.80	0.00	114.09	572.00	0.75	3.91	9.86	26.86
EB195	12/15/2000	4.80	1300.00	0.0403	43.80	2.13	9.04	771.00	0.00	4.41	8.00	2.70
EB195	10/2/2000	4.23	1270.00	0.0107	42.20	0.00	2.44	727.00	0.12	5.55	6.46	0.70
EB195	2/19/2001	4.61	738.00	0.0713	43.30	2.03	15.84	410.00	0.34	6.06	5.66	4.64
EB162	7/3/1996	2.51	3720.00	0.0870	1476.00	0.00	691.18	2923.00	322.00	48.80	9.10	178.29
EB169.4	5/23/2001	2.64	3310	0.223	631	0	757.39	1828	47	52.7	9.43	131.28
EB165	2/1/2001	7.01	1080.00	0.1200	8.27	113.00	-67.65	4878.00	0.08	0.33	0.17	0.38
EB169	2/1/2001	6.30	180.00	0.2663	5.55	21.20	-22.44	42.00	0.48	0.69	0.29	2.11
EB200	4/11/2000	4.56	1420.00	0.4226	106.00	0.00	241.13	676.00	6.05	16.40	10.80	75.80
EB200	8/30/2000	4.01	1650.00	0.0252	111.00	0.00	15.06	1004.00	0.14	16.20	15.10	4.27
EB200	2/6/2001	4.14	1330.00	0.0964	143.00	0.00	74.16	766.00	2.78	21.10	12.90	19.12
EB220	5/30/2000	3.08	2120.00	0.1643	288.00	0.00	254.69	1317.00	7.08	37.10	22.40	59.01
EB220	8/30/2000	2.99	2380.00	0.0418	336.00	0.00	75.56	1465.00	9.98	41.20	25.30	17.24
EB220	2/6/2001	3.12	2080.00	0.1347	309.00	0.00	224.03	1251.00	6.99	37.30	23.40	49.18
EB240	6/14/1996	3.35	1276.00	0.8230	201.00	0.00	890.39	560.00	3.80	19.00	10.90	149.61
EB240	4/16/2000	3.50	1380.00	0.3260	131.00	0.00	229.89	727.00	5.12	19.90	11.40	64.05
EB240	10/2/2000	3.17	1740.00	0.0224	157.00	0.00	18.93	1070.00	6.30	19.30	19.50	5.45
EB240	2/6/2001	3.46	1220.00	0.2230	110.00	0.00	132.03	654.00	2.72	15.30	10.50	34.31
EB260	5/30/2000	3.29	1020.00	0.0950	109.00	0.00	55.74	722.00	8.22	8.76	7.80	12.70
EB260	2/6/2001	3.48	905.00	0.0710	91.80	0.00	35.08	400.00	11.10	12.30	7.99	12.02
EB280	4/16/2000	3.10	2070.00	0.0336	328.00	0.00	59.32	1218.00	15.30	41.20	15.50	13.05
EB280	8/31/2000	2.91	2210.00	0.0045	270.00	0.00	6.55	1268.00	8.68	32.30	22.60	1.55
EB280	2/6/2001	3.04	1830.00	0.0025	225.00	0.00	3.01	1045.00	9.75	27.60	14.70	0.70

Table 2 - Water quality for proposed treatment sites in West Branch

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft^3/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
WB060	6/24/1996	4.88	250.00	9.1300	14.00	0.00	687.99	104.00	0.25	0.99	1.43	131.50
WB060	5/17/2000	3.35	1410.00	0.0950	168.00	0.00	85.90	749.00	1.18	14.60	33.70	25.36
WB060	10/3/2000	3.11	696.00	0.0088	116.00	0.00	5.47	329.00	0.19	19.60	8.10	1.32
WB070	6/24/1996	3.22	388.00	0.1560	72.00	0.00	60.46	170.00	0.48	2.96	6.20	8.11
WB070	5/16/2000	3.74	477.00	0.0089	62.90	0.00	3.01	187.00	0.32	9.16	3.60	0.63
WB070	10/16/2000	3.26	1630.00	0.0520	236.00	0.00	66.00	955.00	1.45	23.60	43.40	19.19
WB100	7/15/1996	3.59	727.00	0.0830	153.00	0.00	68.35	325.00	0.81	17.60	13.30	14.20
WB100	5/17/2000	3.81	830.00	0.0383	185.00	0.00	38.14	479.00	0.34	26.70	13.70	8.42
WB100	10/3/2000	3.24	1340.00	0.0144	319.00	0.00	24.73	840.00	0.85	51.10	28.90	6.28
WB050	5/16/2000	7.00	450.00	0.0064	0.00	106.00	-3.67	54.30	0.40	0.34	0.69	0.05
WB050	10/3/2000	2.63	959.00	0.0200	201.00	0.00	21.64	328.00	24.60	17.50	2.67	4.83

Table 3 - Water quality for proposed treatment sites in MSBC

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft^3/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
MSBC090	6/28/1996	4.45	574.00	0.4240	17.00	0.00	38.80	239.00	1.03	1.52	6.90	21.61
MSBC090	6/26/2000	5.13	888.00	0.0310	29.60	2.28	4.56	443.00	0.33	1.87	12.70	2.49
MSBC090	10/25/2000	4.28	1070.00	0.1630	86.00	0.00	75.45	597.00	0.43	7.50	16.40	21.39
MSBC110	6/28/2000	3.38	1410.00	0.0468	85.70	0.00	21.59	724.00	2.43	6.62	13.80	5.77
MSBC110	10/25/2000	3.10	2440.00	0.0468	180.00	0.00	45.34	1457.00	4.51	20.60	23.30	12.22
MSBC120	6/28/2000	2.87	2160.00	0.1100	268.00	0.00	158.68	1227.00	4.89	26.90	30.90	37.20
MSBC120	10/25/2000	2.75	2450.00	0.09	347.00	0.00	171.27	1498.00	5.03	36.90	35.90	38.50

Table 4 - Water quality for proposed treatment sites in Brushy Creek

NEW ID NO.	SAMPLE DATE	pH	COND. μS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
BC060	6/21/2000	2.74	3410.00	0.0300	1248.00	0.00	201.52	2363.00	403.00	59.40	35.80	80.62
BC060	10/18/2000	1.80	14700.00	0.0208	3088.00	0.00	345.72	2066.00	180.00	45.10	35.40	29.23
BC060	2/21/2001	2.68	2180.00	0.9910	635.00	0.00	3387.12	1391.00	202.00	31.90	22.50	1370.65
BC070	6/21/2000	2.85	1790.00	0.0751	191.00	0.00	77.21	831.00	3.12	18.60	20.50	17.10
BC070	10/18/2000	2.91	2150.00	0.0674	265.00	0.00	96.14	1144.00	7.58	19.40	26.40	19.41
BC070	2/28/2001	3.02	1350.00	0.7800	242.00	0.00	1016.00	823.00	8.11	25.70	22.10	235.24
BC090	7/1/1996	3.19	1159.00	0.1300	119.00	0.00	83.27	650.00	3.43	13.80	18.10	24.78
BC090	6/21/2000	2.95	1480.00	0.1870	171.00	0.00	172.12	687.00	3.16	16.20	17.50	37.18
BC090	10/18/2000	2.97	2220.00	0.0532	317.00	0.00	90.77	1292.00	11.10	27.50	33.40	20.66
BC090	2/21/2001	2.99	893.00	0.1860	139.00	0.00	139.16	480.00	5.12	17.50	11.50	34.23
BC111	7/16/1996	4.79	335.00	0.0920	20.00	0.00	9.90	107.00	0.97	1.44	4.29	3.33
BC111	10/24/2000	4.82	363.00	0.0065	31.60	2.80	1.00	146.00	0.31	2.12	3.94	0.22
BC113	7/16/1996	3.28	1781.00	0.0600	394.00	0.00	127.24	1260.00	1.91	46.30	19.40	21.88
BC113	10/24/2000	3.04	1060.00	0.0240	238.00	0.00	30.74	497.00	3.31	28.90	14.50	6.05
BC114	10/24/2000	3.34	489.00	0.0169	74.50	0.00	6.77	184.00	2.22	8.57	4.93	1.43
BC150	7/16/1996	2.81	2500.00	0.0310	1019.00	0.00	170.03	1701.00	61.00	103.00	79.00	40.64
BC150	6/7/2000	3.24	1640.00	0.0422	249.00	0.00	56.56	840.00	5.88	29.00	39.40	16.91
BC150	10/25/2000	3.00	1860.00	0.0266	324.00	0.00	46.42	980.00	4.74	38.00	43.80	12.43

Table 5 - Water quality for proposed treatment sites in Mainstem to Lake Hope section

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
MSLH121	6/27/1996	5.63	205.00	2.0100	28.00	0.00	302.93	74.00	0.59	0.10	0.82	16.37

Table 6 - Water quality for proposed treatment sites in Hewett Fork

NEW ID NO.	SAMPLE DATE	pH	COND. µS/cm	DISCHARGE ft³/sec.	ACIDITY mg/l	ALK. mg/l	ACIDITY LOADING lbs/day	SULFATE mg/l	IRON mg/l	ALUMINUM mg/l	MANGANESE mg/l	METALS LOADING lbs/day
HF120	06/21/96	3.08	614.00	2.07	109.00	0.00	1214.45	322.00	9.80	8.97	0.97	220.42
HF120	05/19/99	3.37	701.00	0.36	98.90	0.00	192.17	350.00	7.97	8.21	1.06	33.57
HF120	07/07/99	3.16	1480.00	0.03	225.00	0.00	35.12	848.00	6.33	20.40	3.92	4.79
HF120	08/05/99	3.24	947.00	0.12	138.00	0.00	90.62	508.00	5.75	14.60	2.20	14.84
HF120	10/12/99	3.06	1010.00	0.05	184.00	0.00	44.57	454.00	9.73	21.20	2.61	8.14
HF120	11/09/99	3.21	824.00	0.19	137.00	0.00	140.11	370.00	17.10	16.80	1.79	36.58
HF120	01/03/00	4.22	388.00	0.95	45.60	0.00	233.17	150.00	5.33	7.31	0.38	66.70
HF120	4/26/2000	3.90	341.00	1.52	43.40	0.00	354.08	129.00	7.95	4.22	1.50	111.77
HF120	12/11/2000	2.70	672.00	0.03	90.50	0.00	13.88	283.00	7.54	15.10	1.05	3.64
HF131	12/11/2000	2.46	1860.00	0.4880	354.00	0.00	929.84	1062.00	65.60	32.10	6.94	275.46
HF131	6/21/1996	2.85	1957.00	1.6900	295.00	0.00	2683.44	1200.00	21.70	19.80	8.80	458.55
HF140	6/13/1996	3.13	1351.00	5.4300	368.00	0.00	10755.52	635.00	3.04	22.00	6.20	915.05
HF140	4/26/2000	3.42	684.00	0.4996	66.60	0.00	179.09	274.00	12.20	5.16	2.88	54.55
HF140	8/21/2000	3.60	885.00	0.0352	106.00	0.00	20.08	441.00	26.70	6.27	3.46	6.92
HF140	12/11/2000	3.69	846.00	0.0056	70.20	0.00	2.11	437.00	27.90	11.30	4.56	1.32
HF180	6/13/1996	3.37	593.00	8.3400	125.00	0.00	5611.25	185.00	6.90	7.40	2.55	758.05
HF180	3/30/2000	4.44	444.00	1.7214	43.80	0.00	405.83	156.00	6.16	2.26	2.54	101.77
HF180	8/21/2000	4.25	810.00	0.2850	135.00	0.00	207.09	419.00	49.00	4.32	4.25	88.51

APPENDIX C - PHOTOGRAPHS OF PRIORITY RESTORATION SITES


An unreclaimed strip mine draining into WB 100 in West Branch, Hocking County.

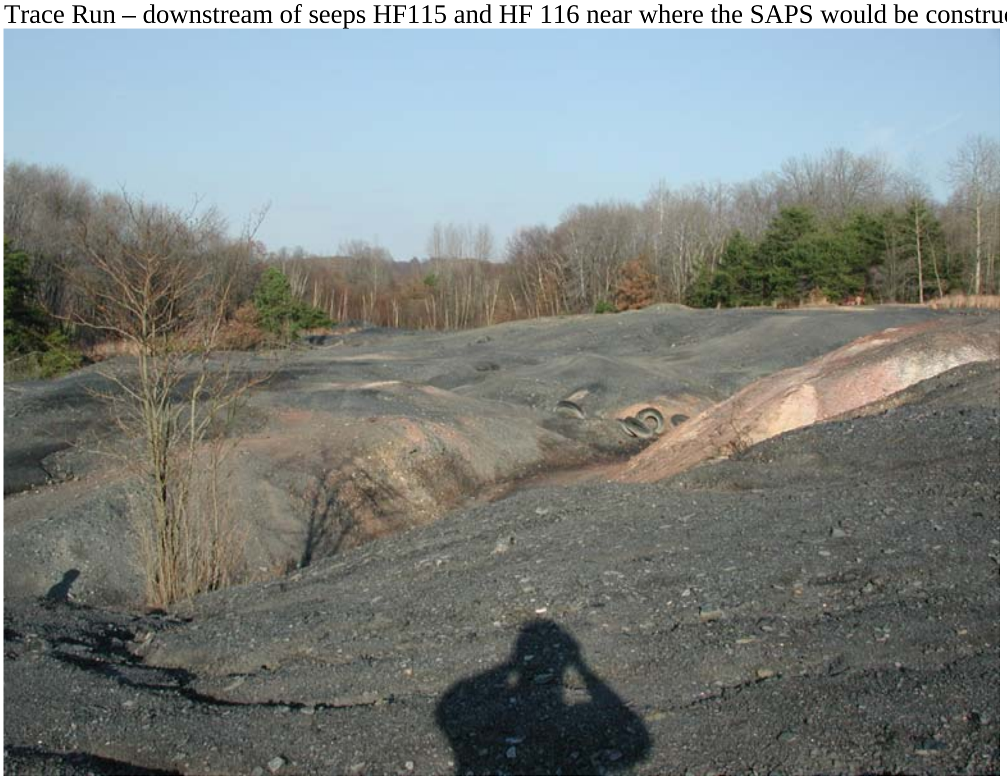

Coal refuse in the WB100 drainage.

Land reclaimed during in the early 1970's under the new reclamation program. The ground maintains vegetative ground cover, but water that infiltrates the surface quickly becomes exposed to toxic material and seeps out near a road cut. West Branch, along the Vinton/Hocking County line. (above and below)

Kennard Mine site discharge (HF 114) – Discharges into Trace Run then into Hewett Fork. Athens, County

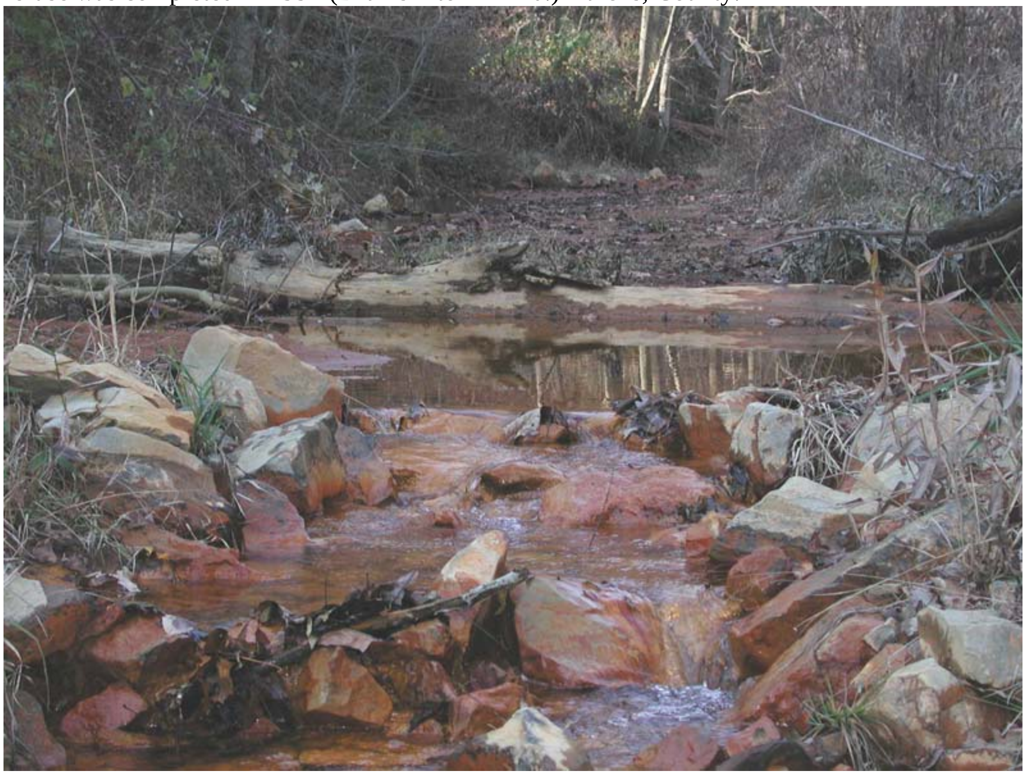
Downstream of the Kennard discharge in Trace Run the stream habitat is devastated.

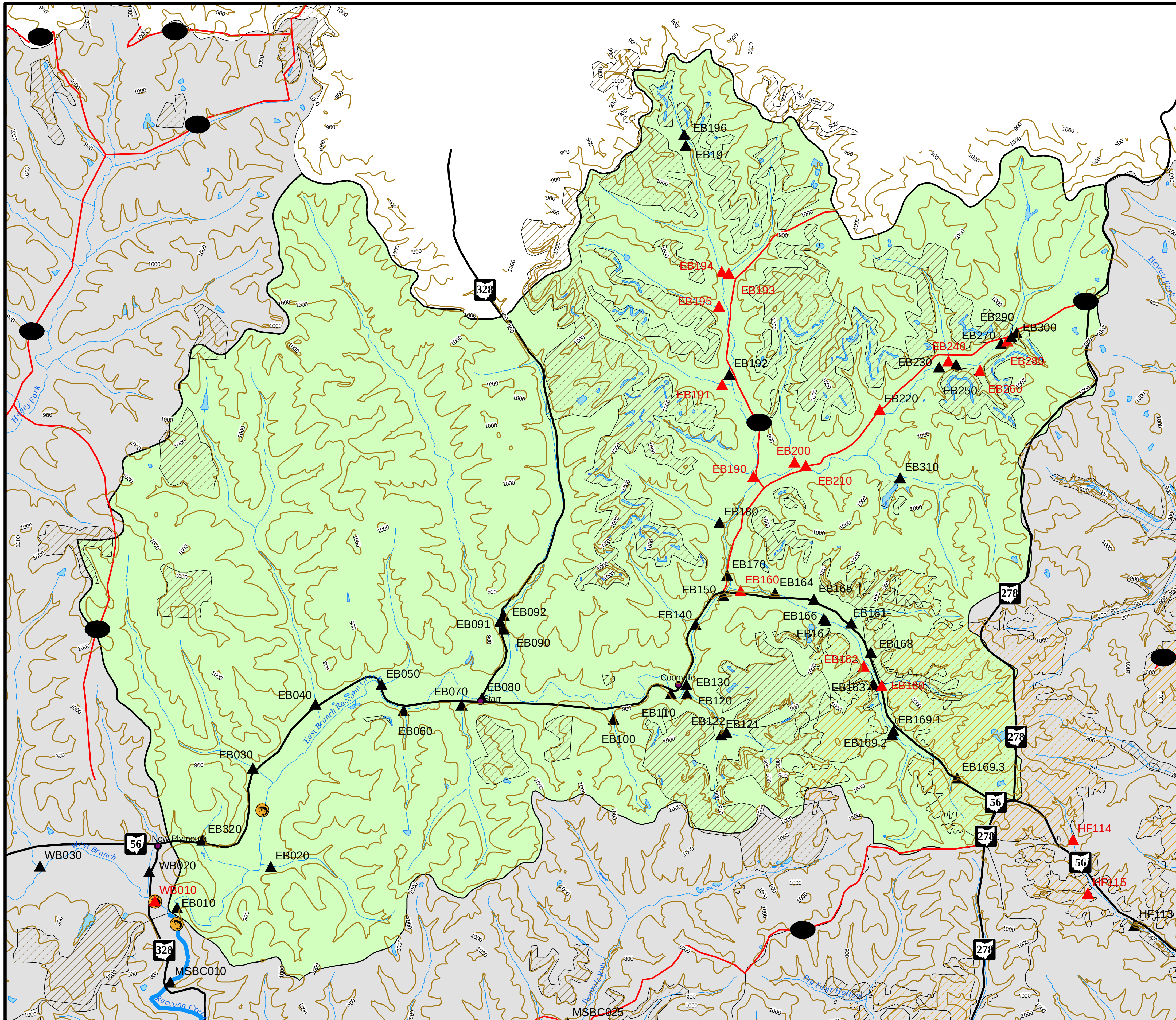
Trace Run – downstream of seeps HF115 and HF 116 near where the SAPS would be constructed.



The Orland Gob Pile


Seep along Carbondale Creek that continues to produce acid after conventional reclamation of nearby coal refuse was completed in 1997 (Drains into HF 120.) Athens, County.


Carbondale Creek, Athens County.



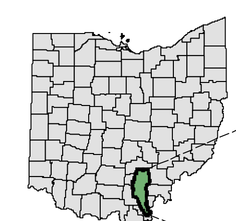
Raccoon Creek Headwaters

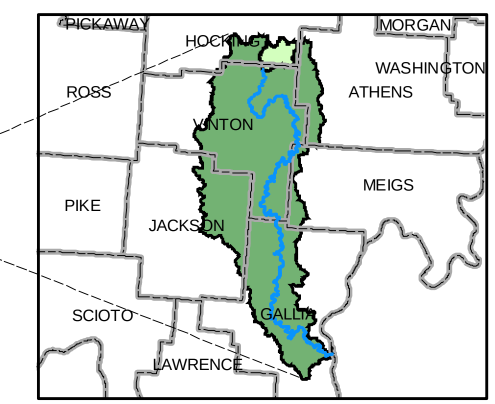
East Branch Drainage Basin

Map Features

- Sample Location
- Priority Sample Location
- Biologic Sample
- EPA Fish Sample
- EPA Macro Sample
- Headwaters
- East Branch
- Below Headwaters
- Deep Mines
- Surface Mines
- Raccoon Creek
- U.S. Highway
- State Highway
- County Road
- 100 Foot Contour

Scale in Miles: 0.5 0.25 0 0.5





RACCOON CREEK IMPROVEMENT COMMITTEE

Ohio GIS Net
Sources: PUCO. USGS 7.5 minute quadrangles.
Ohio Department of Natural Resources.
Map and data production for RCIC
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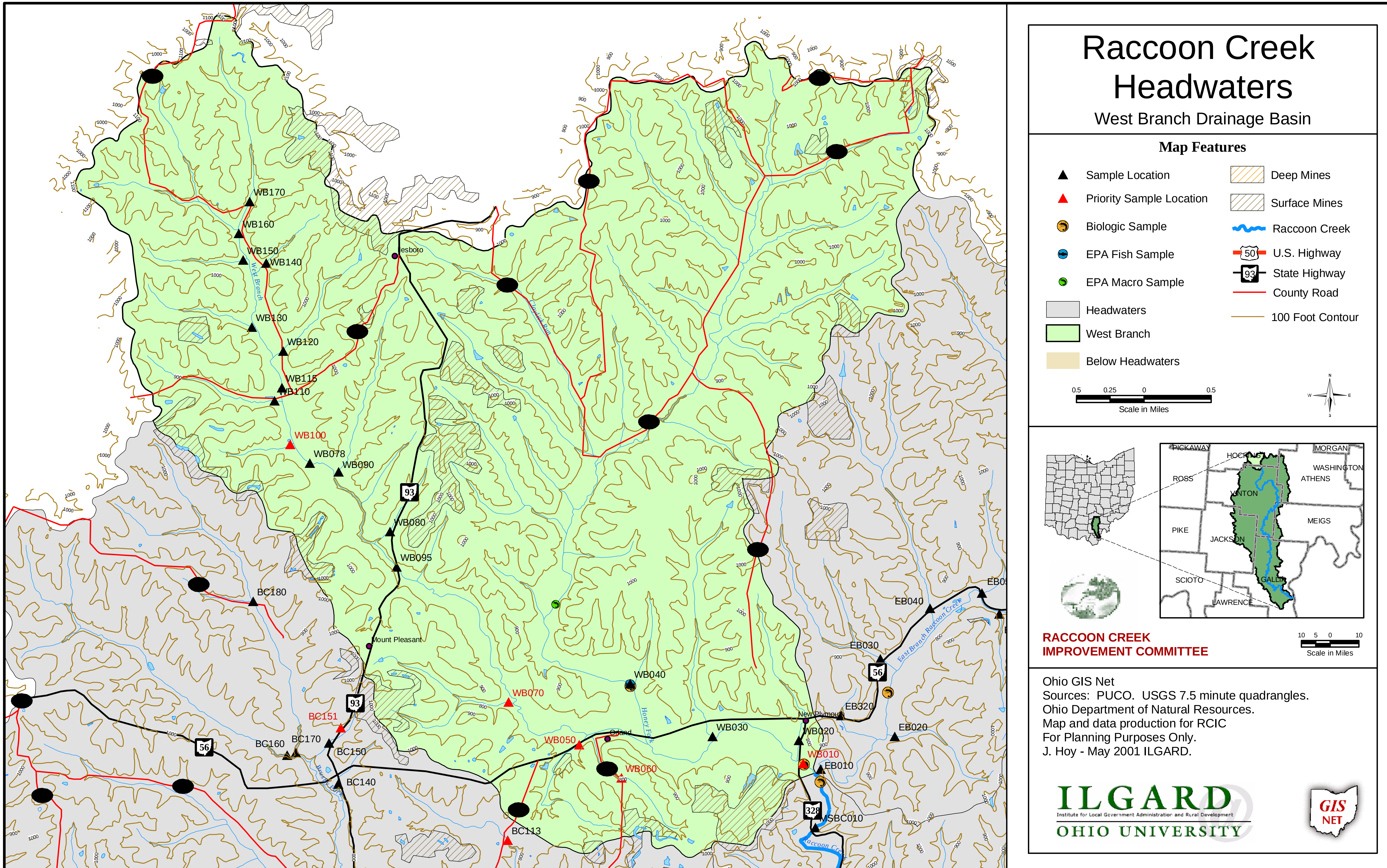

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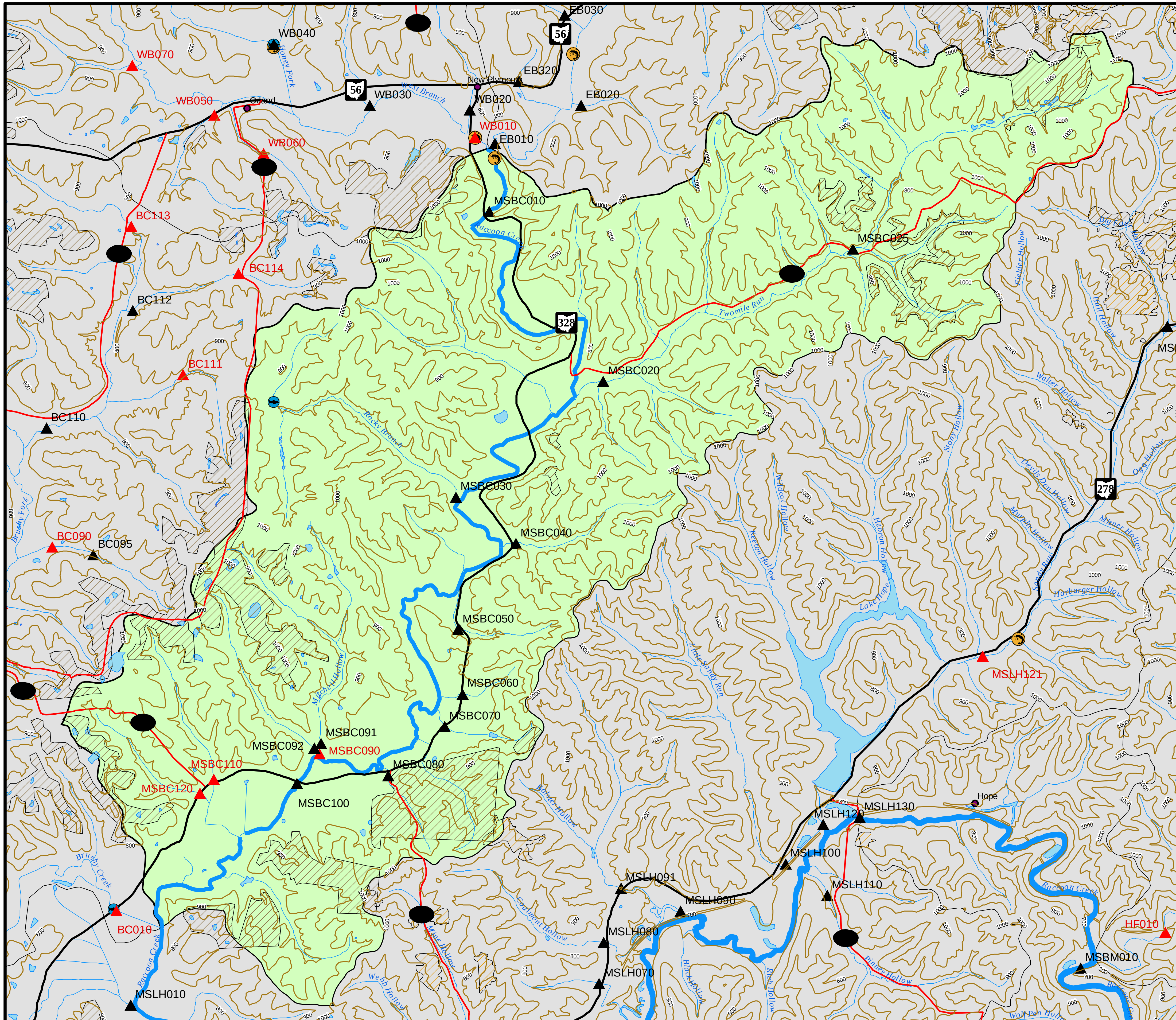


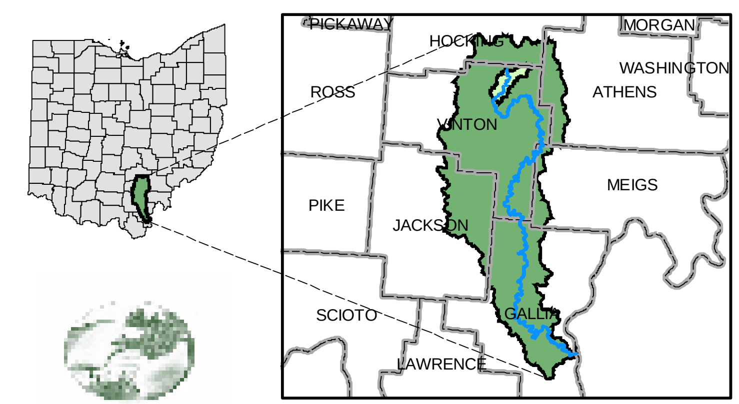
Raccoon Creek Headwaters

Confluence to Brushy Creek Drainage Basin

Map Features

- Sample Location
- Priority Sample Location
- Biologic Sample
- EPA Fish Sample
- EPA Macro Sample
- Headwaters
- Confluence - Brushy Creek
- Below Headwaters
- Deep Mines
- Surface Mines
- Raccoon Creek
- U.S. Highway
- State Highway
- County Road
- 100 Foot Contour

0.5 0.25 0 0.5
Scale in Miles



RACCOON CREEK
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10 5 0 10
Scale in Miles

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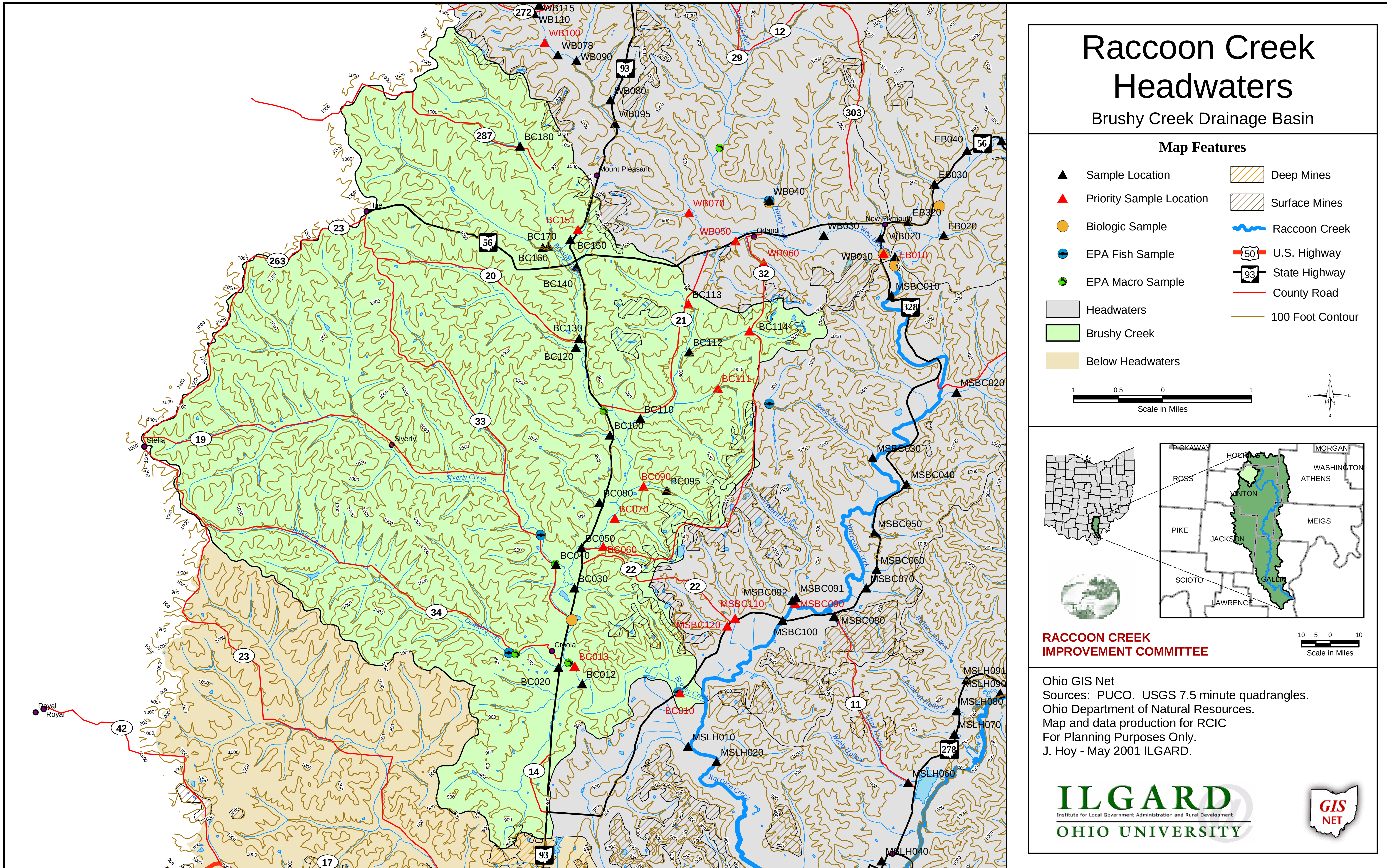

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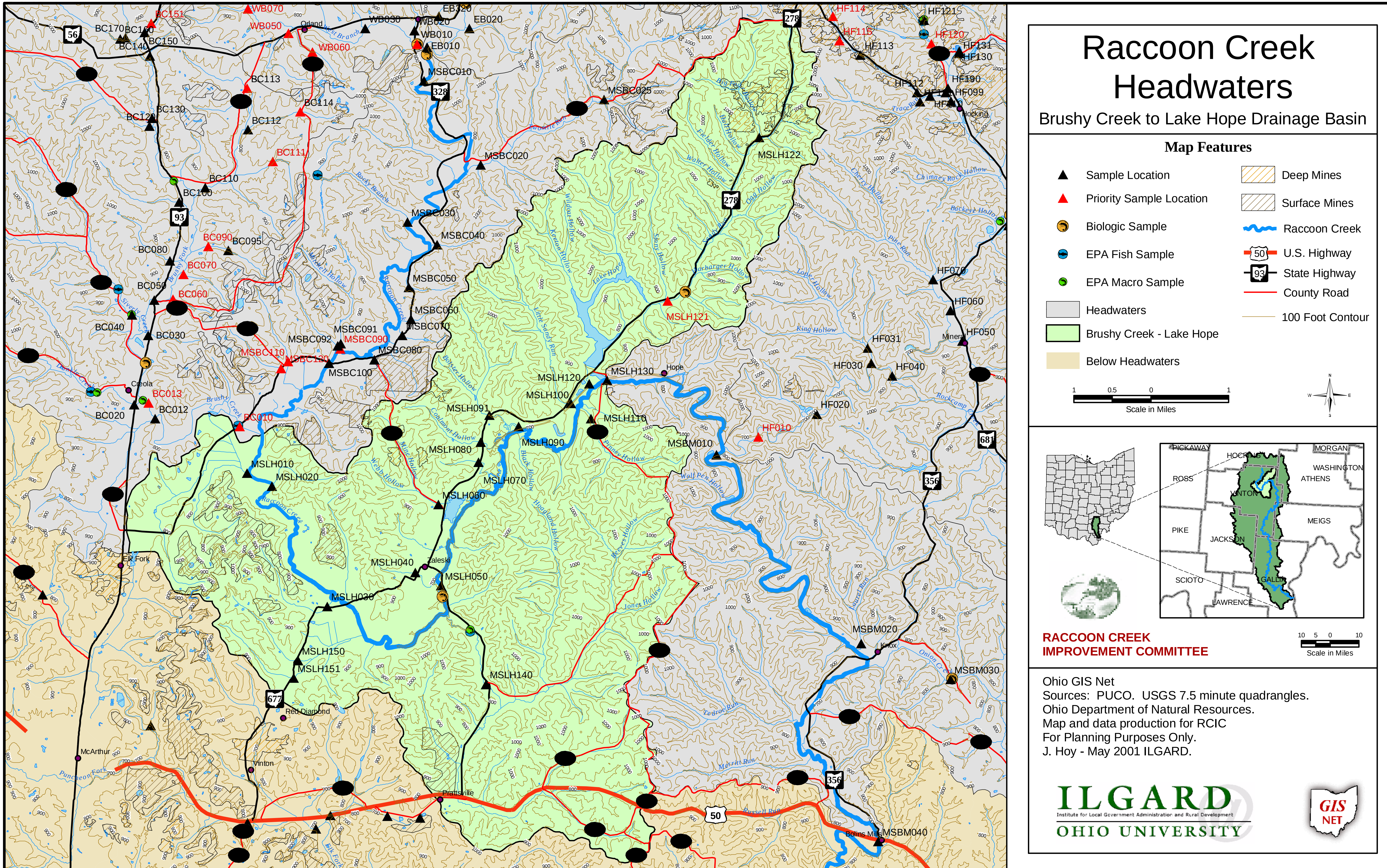

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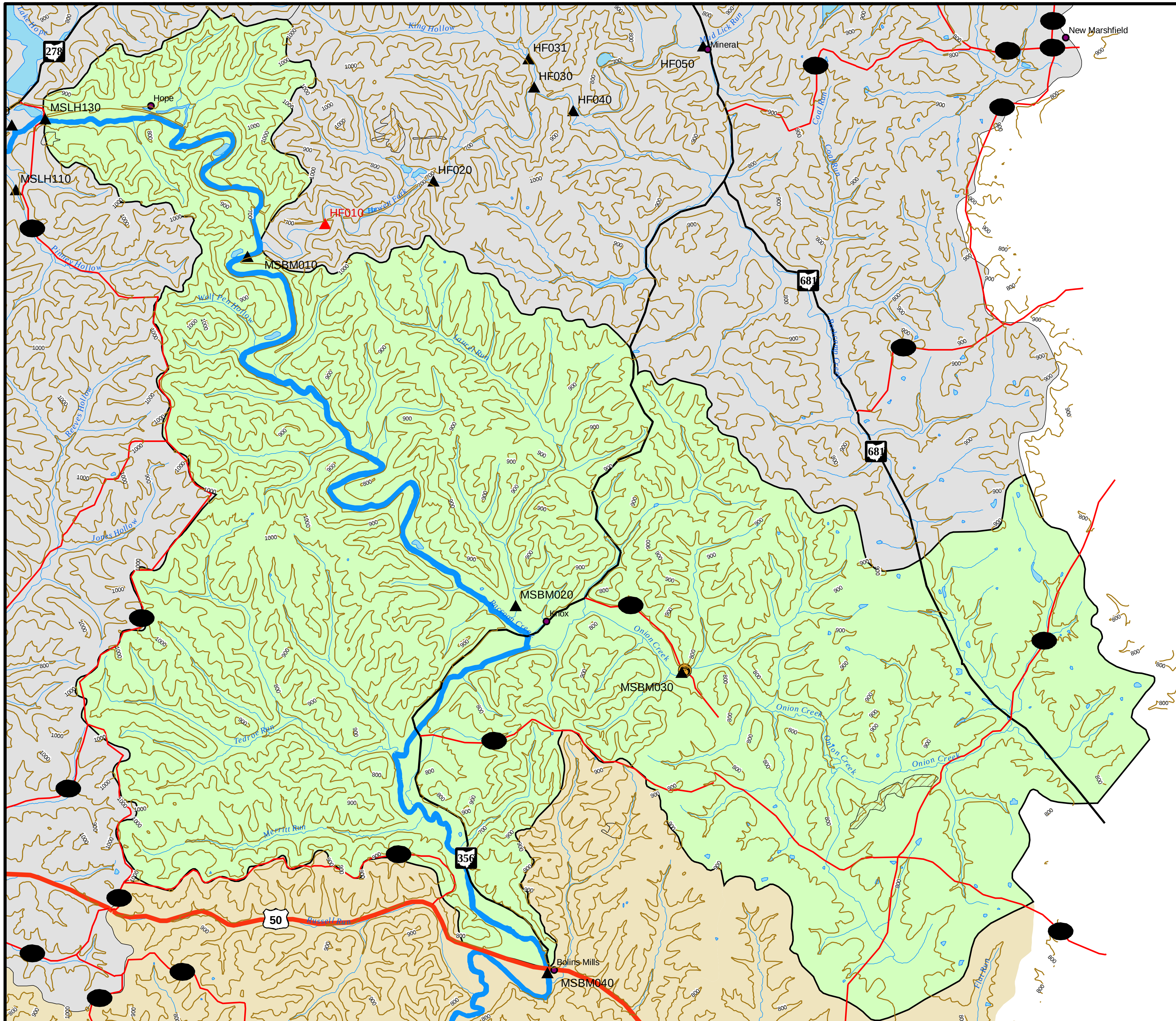


Raccoon Creek Headwaters

Lake Hope to Bolin Mills Drainage Basin

Map Features

Sample Location

Priority Sample Location

Biologic Sample

EPA Fish Sample

EPA Macro Sample

Headwaters

Lake Hope-Bolin Mills

Below Headwaters

Deep Mines

Surface Mines

Raccoon Creek

U.S. Highway

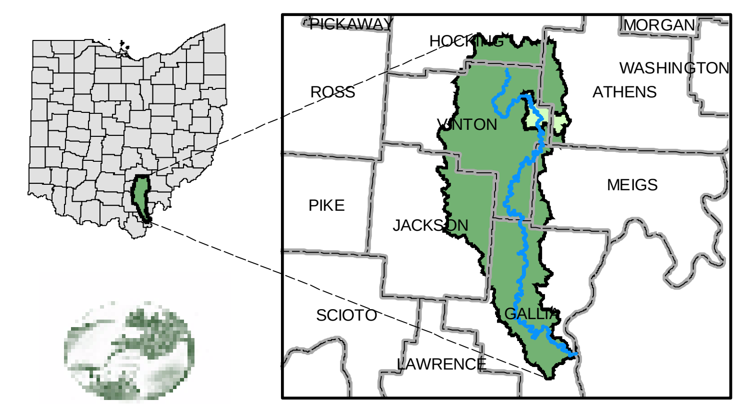
State Highway

County Road

100 Foot Contour

1 0.5 0 1

Scale in Miles



RACCOON CREEK IMPROVEMENT COMMITTEE

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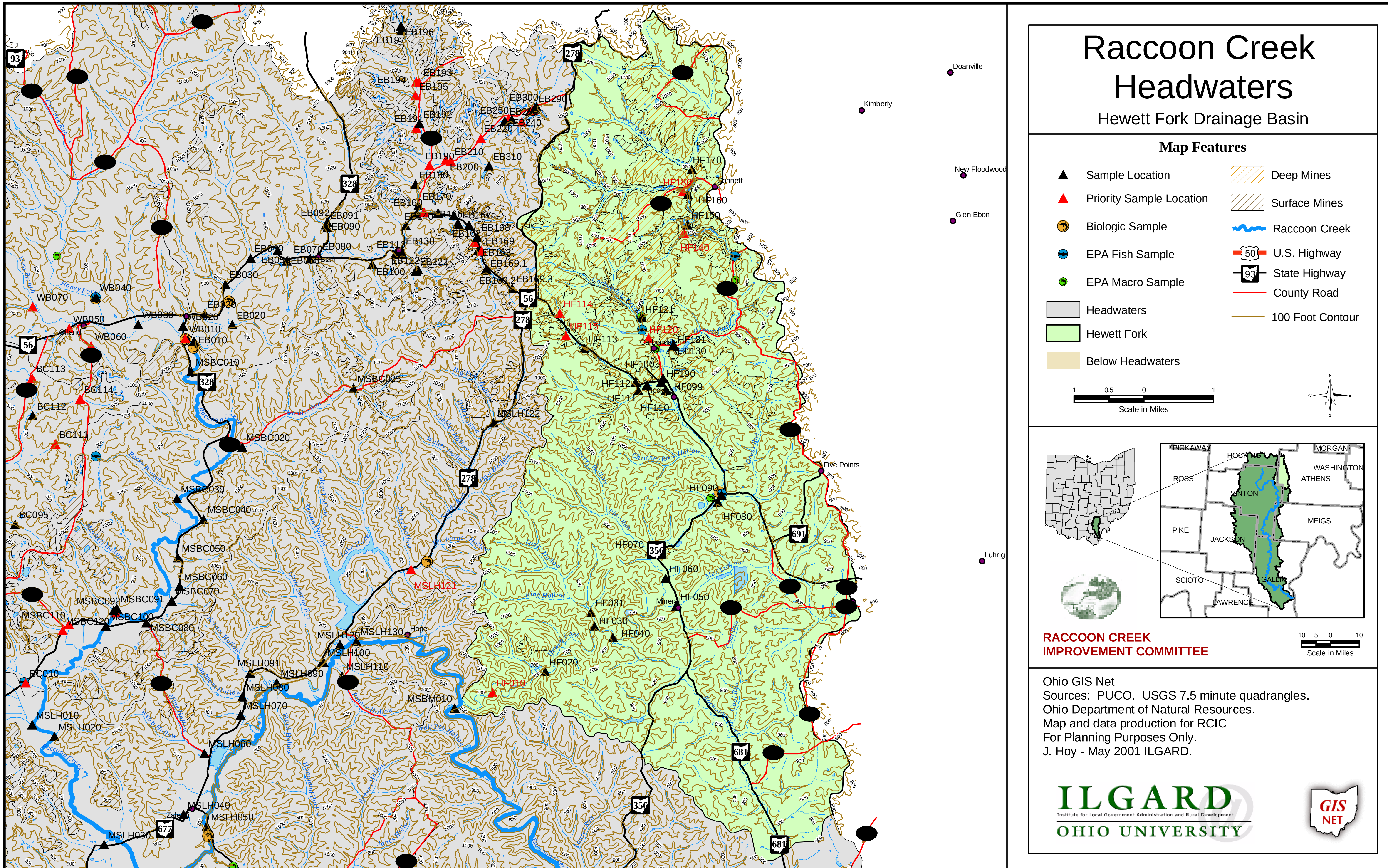

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